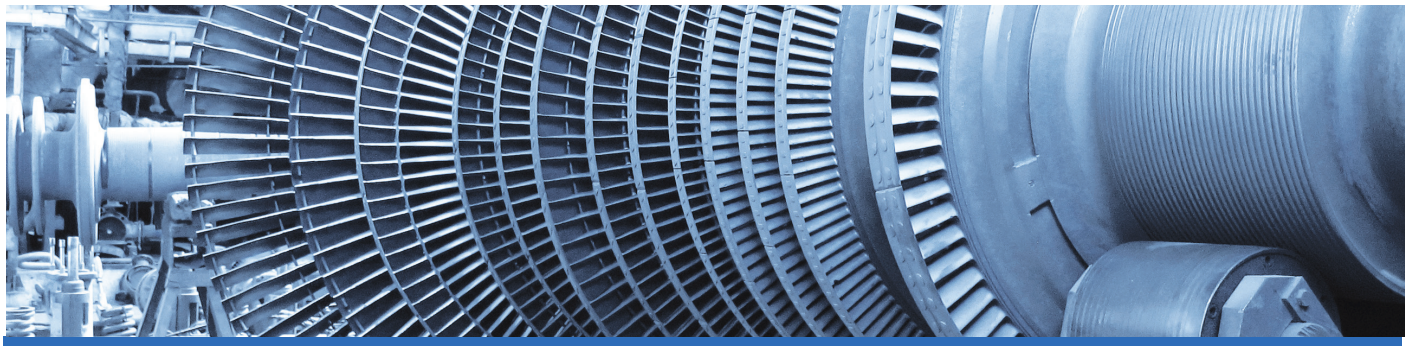
Liquid Air Energy Storage

European Association for Storage of Energy



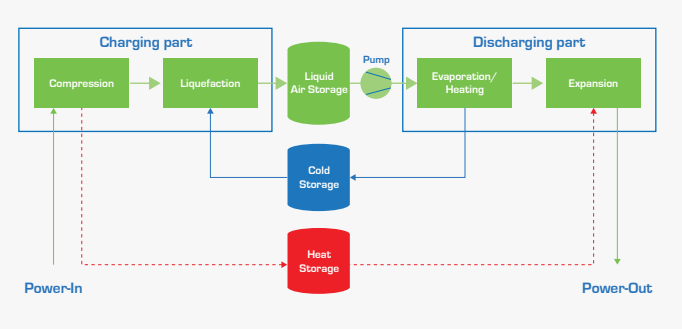
Mechanical Energy Storage

1. Technical description

A. Physical principles

A Liquid Air Energy Storage (LAES) system comprises a charging system, an energy store and a discharging system. The charging system is an industrial air liquefaction plant where electrical energy is used to reject heat from ambient air drawn from the environment, generating liquid air ("cryogen"). The liquid air is stored in an insulated tank at low pressure, which functions as the energy store. When power is required, liquid air is drawn from the tank, pumped to high pressure and evaporated. This produces gaseous air that can be used to drive a piston engine or turbine to do useful work that can be used to generate electricity. There are various categories of LAES technologies differentiated by the thermodynamic process used.

Illustration: Charging principle of LAES



B. Important components

The main components are the following:

- Compressors (integral to the liquefaction unit) driven by an electric motor
- Liquefaction unit
- Low pressure, insulated liquefied air-tank
- Evaporation unit
- Air expander
- Gas turbine (Optional)
- Electric generator
- Cold Storage (Optional)
- Heat Storage (Optional)

C. Key performance data

Power range	5 - 650 MW
Energy range	10 MWh - 7.8 GWh
Discharge time	2 - 24 hours
Cycle life	22,000 - 30,000 cycles
Life duration	30 - 40 years
Reaction time	≥ 5 min
Efficiency	50 - 100+ %
Energy (power) density	32 – 230 kWh/m^3
CAPEX: energy	60 - 600 €/kWh
CAPEX: power	500 – 3,500 €/kW

D. Design variants (non exhausitive)

The following design variants are possible:

- Gas turbine: liquid air is evaporated then combusted with the fuel (usually natural gas) and expanded through a gas turbine to generate electricity.
- Air expander: liquid air is evaporated and expanded using heat generated during air compression or from an adjacent industrial process in an air expander.
- Storage medium: air, nitrogen or other cryogens.

2. State of the art

MHPSE and the Linde Group have been jointly developing the LAES technology since 2012 and have developed a "Generation 1" system based upon commercially available components. Highview operated a grid connected 350kW/2.5MWh plant in Slough, Greater London, from 2010 to 2014. The project proved the capabilities of the system to utilise existing proven technologies and components. Some companies applied for patents regarding the LAES technology (e.g. Hitachi and Highview). The technology is very similar to CAES when considering the power island.

3. Future developments

Mitsubishi Hitachi Power Systems Europe and the Linde Group are planning to demonstrate a "Generation 1" LAES system in the near future and have started a development phase for "Generation 2" LAES system with higher availability, efficiency and lower CO_2 emissions.
Highview Power, in collaboration with Viridor a renewable energy and waste management company, is developing a 5MW LAES system. The system is being built (starting May 2015) alongside a landfill gas generation plant. In addition to providing energy storage, the liquid air plant will convert low-grade waste heat to power enhancing the thermal efficiency of a reciprocating engine.
GE and Highview Power are also exploring the integration of Highview's LAES technology in peaking power plants where GE gas turbines and gas engines are currently being (or will be) installed. The integration of LAES technology with GE's power plant equipment will provide customers with significant advantages, including improved start-up times and efficiency/heat rates, as well as offering waste-heat-to-power and energy storage capabilities.
Finally, the newly created Centre for Cryogenic Energy Storage at the University of Birmingham will focus its efforts on four main areas, namely; novel materials, thermodynamics and generation processes, systems integration, control and optimisation.

4. Relevance in Europe

Europe is the world's leader for this technology, as it is mainly being developed by four companies (namely Highview Power Storage in cooperation with GE Nuovo Pignone and Mitsubishi Hitachi Power Systems in cooperation with the Linde Group) located in the UK, Germany and Italy. LAES systems can be located near demand centres (or wherever it is required) and the technology has one of the lowest levelised costs of energy (LCOE). These characteristics make LAES an ideal technology to support the European energy strategy by helping to integrate renewable energy in a cost effective manner. Finally, the adoption of the LAES technology should result in additional benefits to the European economy, as most of the equipment and labour to build LAES plants can be sourced from local supply chains, creating both direct as well as indirect jobs in Europe. residual load.

5. Applications

Renewables integration

Network Reinforcement Deferral

Daily/weekly balancing

Demand Services

Security of Supply (Capacity Provision)

Reserve & other standard ancillary services

6. Sources of information

- EASE Members
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