Round Table 1 – Liquid Air and the Electricity Grid

11th March 2013
Institution of Mechanical Engineers

Participants	Company
Professor Ian Arbon (Chair)	Institution of Mechanical Engineers
Anthony Price	Electricity Storage Network
Tim Evison	Messer Group GmbH
Peter Lattaway	Atlas Copco
Phil Carter	UK LNG National Grid
Steve Leech	Siemens plc
David Richardson	Costain
Malcolm Twist	Digital Applications International Ltd
Scott Edsall	ABB Ltd
John Raquet	Spiritus Consulting
Steve Cooper	Spiritus Consulting
David Boardman	University of Birmingham
Toby Peters	Liquid Air Energy Network / Highview Power Storage
Gareth Brett	Highview Power Storage
Matthew Barnett	Highview Power Storage

1. Size of market opportunity

Worldwide generating capacity is estimated to be 5,066GW, with 200GW of new capacity added each year. Of total capacity, Pumped Hydro Storage accounted for 98GW in 2005 and 140GW in 2011. Such is the need for storage that, despite the geographical limitations of Pumped Hydro Storage, 7GW of capacity is being added every year.

Even the most conservative estimates suggest that there is a sizeable market opportunity for energy storage vectors. If we consider that new conventional plant investments total 200GW every year, a mere 10% share of this for storage would amount to 20GW per year.

In the UK, there is 22GW of renewable energy in the pipeline for 2020. Providing storage equal to just 10% of this would still mean a 2GW opportunity by 2020. The participants in the discussion felt that this was a reasonable requirement as:

- 10% of intermittent renewable build targets – some research suggests we should build storage equal to 30% of renewable energy to firm the intermittency
- 2GW is approximately 50% of National Grid's expected new demand for balancing and reserve services of 4.5GW by 2020
- 2GW of new storage increases total energy storage to about 0.5% of total generation capacity
- Imperial College London calculate that there is a 2GW UK market for distributed storage based on value streams of £100/ kW a year for bulk storage and £160/kW a year for distributed storage.

At the more cautious end of the estimates, liquid air could account for one quarter of the UK storage market, i.e. 500MW. However, the consensus on the table was that this estimate did not adequately take into account liquid air's strong position over competing technologies and the mature supply chain.

2. Benefits of Liquid Air Energy Storage (LAES)

Key advantages of liquid air put forward included:

- LAES plants could be located anywhere since the technology is not constrained by climate or geographical features.

- First plants could be built at existing air separation plants, suggesting a quick route to market.

- The plants can be built at scale and deployed using the existing supply chain; all of which have adequate capacity to deliver in excess of 500MW over the next seven years; (from start to finish one of these plants could be brought on stream in 20-22 months).

- It was noted that LAES plants should be long-lived since they generate no combustion products and there exists a wide range of high alloy steels available to combat any corrosion; all the major industrial gas companies operate large scale air separation plants that are more than 40 years old.

- The equipment used in a LAES plant comes from a mature manufacturing and operational background and as such would be expected to operate with very high levels of reliability and availability; plant on-line times in the air separation industry are in the region of 99.5%.

- Attendees noted that for a LAES plant installed at a standalone site, the unit could be stopped, started and monitored from a remote location.

- LAES plants do not require scarce materials nor is there any significant recycling challenge. Participants were keen to emphasise the good life cycle of the 'carbon footprint' at LAES plants.

- A key benefit was that cost and production are not dependent on exotic minerals.

- LAES has the ability to integrate with other processes by harnessing waste heat or cold. There is a significant opportunity here, especially when considering LAES integration with LNG regasification points.

- LAES benefits from flexibility of system and ability to relocate.

The round table suggested that the main challenge facing liquid air is convincing operators to change their mind set. The existing market is overwhelmingly dominated by highly mature technologies and, as a result, operators have developed specific cultures. Convincing a DNO to leave a liquid air plant unmanned when all the incumbent technologies require regular heavy manpower may be a barrier to entry. However, given the trends in policy, this task may not rest entirely with liquid air. Push factors from the UK government could uproot this culture through incentives or regulations.

3. Comparison to competitors

In comparison with competitors, there was wide agreement that liquid air has a strong position.

Liquid air is cheaper than existing technologies and critically its capital costs are lower than those of Pumped Hydro Storage, the incumbent technology and ~30% that of a fully installed battery. It was felt that Compressed Air Energy Storage (CAES) is the only technology that could compete with liquid air costs. However, CAES needs to be 'adiabatic' (thermodynamically isolated so there is no heat exchange with surroundings) to be effective, which imposes additional costs.

The flexibility of the liquid air technology is also an advantage over competitors. The potential for Pumped Hydro Storage and Compressed Air Storage, seen as the two major competitors to liquid air, is capped in the UK where there are few suitable natural locations. A liquid air plant is the most versatile amongst competitors as there are no physical limits to where it can be located and it can be re-located with relative ease.

The participants were keen to stress that one of the main advantages of liquid air over competitors is that it is the only existing technology that harnesses waste heat.

4. Value to UK PLC

The major components for a LAES facility such as the turbines and generator sets, compressors and motors, cryogenic pumps would probably be manufactured overseas.

The round table was keen to point out that the inlet air cleaning skid, storage vessels, cold store vessels, high voltage electrics, cold box manufacture and all interconnecting pipework could be sourced from the UK.

Although a large amount of manufacturing capability has been relocated overseas, the UK does maintain a significant capability to design, integrate and package individual process units and machines into complete operational facilities.

Adding the design, civil and site construction work to the UK manufacture could result in approximately 50-60% of the value of an installation originating in the UK. The round table agreed that the UK would not necessarily capture all of the value as it is now commonplace to outsource manufacturing to countries such Brazil, Russia, India and China, where costs can be half those in the UK. However, other factors such as transport, efficiency, reliability and communications can affect the balance.

The participants felt that in overseas markets, the main potential UK export would probably be engineering design, system integration and project management, which can be high value. However, the approach would differ between markets. Some countries where technical capabilities are low may require 'turnkey' plants; others may need only technology licencing and engineering consultancy.

One important point raised by attendees was that liquid air could be complementary to the existing petrochemical industry in Scotland. It was identified that there is significant overlap between the skills and supply chain required in the petrochemical industry and that needed for liquid air energy storage and that strong petrochemical industry in the UK makes it an ideal engineering base to deliver Liquid Air Energy Storage.

5. Challenges / policy

Liquid air has a clear opportunity in storage and is well placed amongst competitors to stake out a large market share. Participants emphasised the need to move to market as quickly as possible so as to take advantage of UK policy goals set for 2020. A number of speakers stressed that it still takes a considerable amount of time for projects to overcome inertia. Liquid air technologies therefore need to get moving now.

6. Conclusions

The round table was keen to emphasise:

- Even the most conservative estimates suggest a significant opportunity for liquid air as a storage technology. Within the UK alone, the round table agreed that there should be an energy storage market of at least 2GW by 2020. Liquid air could achieve 500MW in market share, with some attendees suggesting that this figure could be significantly higher.

- The supply chain for Liquid Air Energy Storage technology is mature, global and extensive, and the UK has the industrial capacity to deliver more than half the value of an LAES plant. The participants agreed that current UK and international supply chain is capable of delivering these levels of capacity without creating a bottleneck.

- In a discussion on the benefits of liquid air, participants were keen to draw attention to the flexibility of the technology. Liquid air is not limited by geography or climate, meaning a plant can be built in a wide variety of locations. This is a particular advantage over most viable competitor technologies - Pumped Hydro Storage and Compressed Air Storage - both of which are limited by the landscape.

- Nitrogen is currently viewed as a waste product in the 10 air separation plants in the UK. Attendees also emphasised that the UK LNG import terminals produce waste cold. If a liquid air plant was deployed alongside the liquefaction plants or LNG terminals it could improve the efficiency significantly.

- The participants spent much time discussing the benefits of the ‘clean’ and easily accessibly materials needed to produce a liquid air plant. This was an advantage over batteries in particular, since governments can easily manipulate the lithium supply. Moreover, the durability of the materials used will mean minimum maintenance of the plant is required. Attendees suggested a lifespan of 40 years is normal for a plant made of such materials.

- Costs were another key advantage of liquid air. Based on the pilot plant, Liquid Air Energy Storage would have first-in-class capex costs of £1500/kW with reasonable expectation of upwards of 15% cost reduction.

- The final topic discussed was the value that liquid air storage could add to the UK plc. Whilst attendees noted that UK manufacturing is now much reduced, they were keen to stress the UK has a lot to offer in terms of engineering innovation. Even with much manufacturing done overseas, attendees thought 60% of the value of a new LAES plant could still be captured by the UK. Moreover, there are significant gains to be had if we consider the opportunity for the existing petrochemical industry in Scotland. (This is the subject of MSc study at Strathclyde University and a future Round Table).

- Convincing policy makers to support liquid air remains the major challenge. Policy support will be necessary for liquid air to be adopted as a legitimate storage technology. Incorporating liquid air into policy will also be useful in helping convince end users.