ROUND TABLE

Opportunities for Liquid Air in the City of Leeds

BDO, 1 Bridgewater Place, Leeds, 25th September

Executive Summary

Hosted by BDO, the Round Table was convened to explore with key regional public and private sector organizations the role that liquid air could play in Leeds. The session began with a short introduction to the transport and grid applications of liquid air, which led to a lively discussion of the environmental, societal and economic benefits.

It was felt valuable to have liquid air included in strategic planning, while several specific proposals emerged to advance our understanding of the overall potential for Leeds, including plans for a feasibility and impact system level study by the Centre for Low Carbon Futures (CLCF) and the Liquid Air Energy Network (LAEN); further engagement with the food industry in the region via the local authorities; and ideas for specific technology demonstration projects.

Alec Shelbrooke MP briefed the meeting and led a closed –and lively - discussion on developments in UK energy policy.

Outputs

Drawing together the threads of the discussion, the meeting agreed a framework through which to view local action on liquid air:

Level 1 – Integration of liquid air into the national and international energy and transport systems

Level 2 – The mapping of the national plan to the regional level

Level 3 – Individual demonstration projects

It was agreed that these tiers should be developed concurrently, and delegates were enthused by the idea of Leeds taking the lead in mapping liquid air at a city level.

Demonstration projects (Level 3) will be developed soon, and Leeds could provide a fertile test-bed. Interesting proposals included:

- *Distribution Hub – Wakefield*
- *Food and Drinks Sector*
- *Liquid air plant at Leeds General Infirmary*
- *Refuse and other commercial vehicles with auxiliary loads*

It was agreed:

- CLCF and LAEN would develop a study of the potential for a ‘liquid air economy’ in Leeds
- DEC and LAEN should engage with the Leeds ‘food cluster’ over the potential for liquid air in transport refrigeration
- further meetings should be held to progress the various potential demonstration projects

Attendees

Simon Pringle	BDO LLP (Chair)
Kevin Schofield	BDO LLP (Chair)
Toby Peters	LAEN
Melanie Taylor	Leeds City Region
Dr Dongsheng Wen	Leeds University
Prof. Andrew Heyes	Leeds University
Alec Shelbrooke MP	UK Parliament (Elmet and Rothwell)
Ryan Stephenson	UK Parliament
Karl Milner	Leeds Teaching Hospitals
Dr Jonathan Radcliffe	CLCF
Dr Derek Charters	Motor Industry Research Association
David Cherry	Leeds City Council
Steve Saunders	ARUP
Adam Chase	E4tech
Steve Tonkinson	Veolia Transdev
Richard Piper	Gordons LLP
David Heath	Clugston
Paul Roberts	Metro
Nick Coad	Sand Walk
James Connal	Westbourne
David Strahan	LAEN
Alec Falconer	LAEN

Toby Peters (LAEN) – Liquid air technologies

Background to liquid air

Liquid air is a proven energy storage technology that could play a critical role in Britain's low-carbon energy future. The use of liquid air for grid-based energy storage could increase UK energy security and cut greenhouse gas emissions but also create a new industry worth at least £1bn pa and 22,000 jobs to the UK. Liquid air technologies could also significantly increase the efficiency of road vehicles, particularly in Britain's fleets of buses, vans and refrigerated lorries and provide further economic benefit to the UK.

Liquid air came to prominence in 2013 with a report from the CLCF (the collaborative organisation that focuses on sustainability for competitive advantage) comprising the Universities of Leeds, Birmingham, Hull, Sheffield and York. The CLCF commissioned and published the groundbreaking report, *Liquid air in the energy and transport systems: Opportunities for industry and innovation in the UK,* launched at a conference hosted by the Royal Academy of Engineering. Contributors to the nine-month study included National Grid, Arup, Ricardo, Messer Group, Spiritus Consulting and academics from leading UK Universities including Birmingham.

The CLCF report found that liquid air could:

- Provide a cost-effective means of storing grid electricity in bulk to help balance intermittent renewable generation and reduce grid emissions, creating 22,000 jobs and an industry worth at least £1bn pa
- Reduce diesel consumption in buses or freight vehicles by 25% using a liquid air / diesel hybrid
- Cut emissions from refrigeration on food lorries by 80% based on current grid average electricity
- Strengthen UK energy security: a single gasometer-style tank of liquid air could make good the loss of 5GW of wind power for three hours - equivalent to almost 10% of the UK's peak electricity needs

- Replace diesel gensets to provide zero-emission back-up and reserve services, and harvest waste-heat from industrial processes
- Provide zero-emission vehicles and power solutions in mining and other industries.

Recent developments in liquid air

- Over the summer, the University of Birmingham won a £6m grant from the Engineering and Physical Sciences Research Council to create a new Centre for Cryogenic Energy Storage.
- A consortium of the Dearman engine Company (DEC), MIRA, Air Products and Loughborough University has won an IDP8 grant from the Technology Strategy Board to build and test a liquid air engine fitted in a commercial vehicle. The first-of-a-kind project will demonstrate the Dearman engine on a refrigerated truck providing zero-emission cooling and power during 2014.
- LAEN has been established to ensure that the UK captures the full environmental, energy and economic benefits of liquid air, and maintains its current international lead in this promising new industry.

Liquid air in Leeds

While liquid air is not a "silver bullet", there are opportunities for the Leeds City Region to make use of the distinctive features of liquid air technologies and help the area to improve air quality and energy security. Investment in liquid air technologies could help to deliver jobs to the Leeds City Region since the area has a strong background in research, mechanical engineering and cryogenics.

Discussion

TRANSPORT

Leeds City Council is investing in low-emission vehicles and their associated infrastructure. This has included electric vehicles, rapid recharging points, bio-methane projects and hybrid buses. The main driver has been to improve air quality in Leeds, with a particular focus on mono-nitrogen oxides (NO_x), which are bad for health and regulated by Defra. NO_x emissions are not directly correlated to carbon emissions, but are related to the load on an engine. As a result, liquid air and similar technologies are of particular interest since they can "give shape" to engine load.

Research is still in progress on emissions in Leeds, and a feasibility study is being done to look at creating a low-emission zone in the city centre. The aim of this study is to assess whether such a zone would provide any substantial health benefits. Various sources of pollution were discussed, including diesel 'gensets', taxis, delivery and refuse vehicles, and buses. Buses alone account for 41% of emissions within the ring-road according to local research. Vehicles where liquid air presents an early opportunity were discussed in greater detail.

Refrigerated Transport

A proof-of-concept test engine providing combined cooling and power is already being built by a consortium of the Dearman Engine Company, Loughborough University, MIRA and Air Products with IDP8 funding, and will be in demonstration in 2014. Commercial partners will be required for subsequent field trials, and Leeds City Region has the highest concentration of food and drinks retailers in the UK. This 'food cluster' could make a fertile test-bed for liquid air transport refrigeration, and further engagement should be pursued.

Vehicles with Auxiliary Power

Refuse vehicles were raised as an example of "low hanging fruit" given their very high fuel consumption of 3 miles per gallon. Fuel economy is worsened by the need to operate the compactor while the vehicle is moving. It would be relatively easy to install a liquid air engine to drive the compactor's hydraulic pump, separate from the main powertrain, and this could be a good candidate for an early demonstration project.

Leeds has recently made investments in liquid bio-methane fuelled refuse vehicles and has been pleased with the results so far. However, it was pointed out that gas engines are less efficient than diesels and emit more waste heat, which could represent another opportunity for liquid air. The number of gas refuse vehicles is limited by the size of the single gas refuelling station, but gas is projected to play a bigger future in the energy mix of the city in future, and this provides an opportunity for research into liquid air in duel fuel vehicles.

Similarly, delivery vehicles for fuel or flour were raised as a potential demonstration projects, since they also require auxiliary pump to load and unload their cargo. The engineers around the table felt this could be very worthwhile, and relatively quick to set up, since it would involve only the auxiliary load, not the entire powertrain. They agreed the idea should be pursued as a priority.

Buses

The low-emission vehicles procured so far by Leeds City Council have been expensive, so there was particular interest in E4tech modeling that shows a rapid payback period for the Dearman engine hybrid bus. The short payback periods are due to substantial fuel savings, and because the Dearman engine is a "spanners and hammers" technology. Costs could fall further with the use of new materials such as plastics – since the engine operates at ambient temperatures. The 'exhaust' of a Dearman engine is cold, clean air and can be used to provide 'free' air-conditioning which forms a large part of the 'hotel-load' on a bus.

Given the short payback periods projected for the technology, industry representatives were asked to list the drivers for adoption. It was suggested the main motivation would be reduced fuel costs. Fuel savings alone would be sufficient to drive adoption among commercial transport operators, since fuel represents 35–38% of total costs (up from 31-34% a few years ago), but bus operators would need to demonstrate that cost savings would also benefit passengers. Bus operators would also need to be confident of the reliability of the technology since running an on-time service is paramount.

GRID

Leeds General Infirmary was agreed to be an interesting potential opportunity for liquid air, since it maintains its own diesel generator and is a net exporter to the grid, operates its own fleet of buses and ambulances, and already receives deliveries of cryogenic gases every week. Adoption of liquid air technologies would reduce air pollution and could result in a citywide improvement in health. However, it was also agreed that there may be reluctance among health service managers to trial novel technologies since security of supply is paramount.

Alternatively, one delegate had recently visited a number of chemical manufacturers in and around Leeds and felt that these could be an interesting test-bed for liquid air technologies. Most chemical manufacturers already have a tank of liquid nitrogen on site, along with untapped sources of waste heat. These could be used as the basis of distributed liquid air energy storage or generating plants, which could participate in the Short Term Operating Reserve (STOR) market. Multiple sites could collaborate and sell their reserve capacity and output as a "virtual power-station", along the lines of demand response aggregators such as Kiwi Power in London. This approach could prevent the need to build a fossil fuel peaking power station.