



Liquid Air Energy Storage secures £8M of Government funding for multi-MW demonstration

Highview Power Storage, Britain's pioneering Liquid Air Energy Storage developer, in collaboration with Viridor, has been awarded funding of around £8million for a 5MW/15MWh demonstration project by the Department of Energy and Climate Change.

5MW demonstrator

The funding will support the design, building and testing of a pre-commercial Liquid Air Energy Storage demonstration plant at one of Viridor's landfill sites. The plant will be connected to the national grid to demonstrate the technology's ability to provide electricity balancing services, and will also convert waste heat from Viridor's landfill gas engines into additional power. The project is scheduled to be operational by mid 2015.

"Storing energy will become increasingly important in the move towards a low carbon economy, and has the potential to save the energy system over £4 billion by 2050", said Energy Minister Greg Barker at the announcement on Thursday 13th February. "Energy storage systems are potentially revolutionary technologies - just imagine how much the energy system will change if we're able to manage supply and demand better by storing energy cost effectively, not to mention the benefits for British research and manufacturing industries."



Gregory Barker, Minister of State for Climate Change (DECC) (Middle), Ian Morrish, Viridor's Landfill Energy Director (Left) and Gareth Brett, CEO, Highview Power Storage (right)

Long duration energy storage

Liquid Air Energy Storage plants can be built to provide long duration energy storage at a range of scales, from around 5MW output and 15MWh of storage capacity to significantly more than 50MW output and 200MWh of capacity. Unlike pumped hydro or CAES, Liquid Air Energy Storage has no geographical constraints.

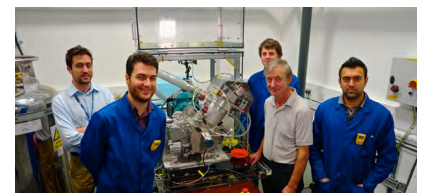
Highview's technology has previously been showcased at the Institution of Mechanical Engineers. Says Dr Tim Fox, Head of Energy at the Institution: "A significant attraction of the technology is that it builds on knowledge from one established industry, industrial gases, to provide a solution to the challenges of another, the energy sector, and makes use of existing component supply chains to enable rapid scale-up around the world."

World's first liquid air engine is making good progress

The Dearman Engine Company's liquid air engine successfully completed its 'shakedown' testing at the end of 2013. Planned upgrades to deliver increased power output and operating speed have been completed, and the engine is currently in a three-month programme of performance mapping.

On-vehicle testing

These milestones have been achieved as part of a TSB/IDP8-supported project to build and test a liquid air engine fitted in a commercial vehicle. The project consortium, which includes MIRA, Air Products and Loughborough University as well as Dearman, remains on track to have the first 'mule' testing vehicle operational by the Summer. This will demonstrate zero emission cold and power for transport applications, replacing the secondary diesel engine currently used to power refrigeration.



Peter Dearman, the inventive mind behind liquid air, with the Engineering Team at the DEC Lab.

Transport Refrigeration Units consume up to a fifth of the diesel on a refrigerated lorry, and can also produce many times more NOx and PM emissions than a modern diesel propulsion engine. The Dearman liquid air engine to be trialled by MIRA will eliminate local air pollution from refrigeration, reduce carbon emissions by about 50 tonnes CO₂ per truck per year, and cut annual fuel costs by £1,500. The liquid air engine is also quieter; noise is increasingly seen as a major problem for night-time deliveries in residential areas.

MIRA's Commercial Manager for Future Transport Technologies and Intelligent Mobility, Chris Reeves said: "MIRA is proud to lead a project delivering the world's first demonstration of a liquid air engine in a commercial vehicle. Liquid air is an exciting new energy vector and has the potential to make a major contribution to the low carbon challenge facing the transport sector."



A rendering of Highview and Viridor's 5MW 15MWh Liquid Air Energy Storage Project. © Highview Power Storage

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International Activity

As part of the Institution of Mechanical Engineers' investigation into the potential of liquid air in the developing world (see page 4), the Liquid Air Energy Network convened a round table in Tanzania.

The meeting of senior government figures, leading NGOs, the industrial gases industry and the Tanzanian Horticultural Association explored the practicability of introducing liquid air as a sustainable and affordable agricultural cold chain in a developing country. A further round table is being held in Chennai, India, with industry and academia.

Later this month Dearman has been invited to join an SMMT mission to Japan.

Overseas opportunities for Dearman Engine to be developed with McLarty Associates

McLarty Associates will be working with Dearman on developing overseas markets for the technology. McLarty is the strategic advisory firm headed by former Clinton White House Chief of Staff and Special Envoy for the Americas Thomas F. "Mack" McLarty III, former Deputy

The US is a leading market for energy storage, mandating deployment of GWhs of electricity and thermal storage by 2020.

Secretary of State John D. Negroponte, and President and Co-Founder Nelson W. Cunningham, who served in the White House as special advisor to President Clinton on Western Hemisphere affairs. Nelson was a member of the Obama-Biden Transition Team and an advisor during the campaign.

US opportunities for Liquid Air Energy Storage to be explored by Highview and leading US energy expert

Energy expert, David Sandalow, will work with Highview to explore US opportunities for Liquid Air Energy Storage. The US is a leading market for energy storage, mandating deployment of GWhs of electricity and thermal storage by 2020. Sandalow is a former US Under Secretary of Energy (Acting) and Assistant Secretary

for Policy & International Affairs. Prior to his appointment at the US DOE, he chaired the Energy & Climate Change Working Group at the Clinton Global Initiative.

Washington

The Liquid Air Energy Network met with NGOs and government, including Fintrac, World Vision, USAID and the US Department of Agriculture to discuss liquid air in the developing world. A series of events in Africa and Asia are planned through the year to further explore the potential of growing emerging markets.

University of Melbourne

The University of Melbourne is aiming to publish its report on the feasibility of introducing Liquid Air Energy Storage to Australia in Spring of this year.

The report is produced as part of an AU\$50,000 grant awarded following the success of the Centre for Low Carbon Futures report, 'Liquid air in the energy and transport systems', launched in May 2013 at the Royal Academy of Engineering, and is produced with support from Arup, a conference sponsor.

'Liquid Air on the commercial highway' a report by the Liquid Air Energy Network in partnership with Centre for Low Carbon Futures and University of Birmingham, co-funded by TSB to be launched 4th June

The adoption of liquid air technologies in heavy-duty vehicles could save Britain 1.3 billion litres of diesel and over a million tonnes of carbon by 2025. It could also reduce local air pollution dramatically: introducing liquid air trailer refrigeration alone would cut emissions of carcinogenic particulate matter by 180 tonnes per year, equivalent to taking 367,000 modern diesel lorries off the road. Spare industrial gas production capacity could fuel the 'liquid air highway' until 2019, but by 2025 liquid air supply could be a business worth £200 million per year.

These are some of the preliminary findings of 'Liquid Air on the commercial highway', a major new report from the Liquid Air Energy Network, Centre for Low Carbon Futures and University of Birmingham, to be published in early June at the SMMT.

This latest report, part funded by the Technology Strategy Board, specifically explores the potential benefits, impacts and policy implications of introducing liquid air in commercial vehicles in Britain. Detailed technical and economic modelling of specific vehicle concepts, supported with input from industry consultants, supermarket chains, bus companies and local authorities, will produce the first detailed analysis of what a 'liquid air highway' could look like, and how soon it could develop. The report analyses the financial, air quality, carbon savings of individual liquid air vehicles and fleets, and potential value to Britain in exports and jobs. It also explores the potential for bus companies, the supermarket sector and local authorities. The supply of liquid air is modelled regionally to test the ability of spare industrial gas production capacity to fuel field trials and early deployment; the production costs of liquid air are analysed to produce policy recommendations. The report also begins to develop a roadmap for liquid air transport technologies, reflecting discussions with an expanding group of industry and academic experts. Such a plan will help guide future investment in research and development.

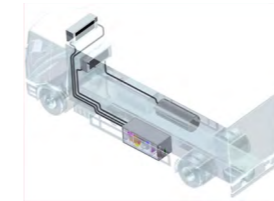
For further information about the launch or the report please contact alec.falconer@liquidair.org.uk



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Investment

Alongside significant government funding for liquid air, more than £20M to date, with further grants under consideration from Universities and commercial developers, a further £3.5M of private investment was committed to Highview and Dearman at the end of 2013. Total private investment to date is more than £20M



In demonstration, the Dearman engine, providing zero-emission power and cooling. A liquid air technology that has received UK Government funding.

and both companies are well placed to see the technologies through to pre-commercial demonstration.

Dearman Engine 1MW grid applications feasibility study

Dearman and the Centre for Low Carbon Futures have won a £150,000 feasibility study grant from the TSB to explore the potential for cryogenic small scale generation. The project will identify promising applications, technical feasibility, route to manufacture and the availability of liquid nitrogen and waste heat sources for sub-1MW generation. National Grid estimates balance capacity will rise from 3.5GW today to 8-13 GW by 2020.

Birmingham Centre for Cryogenic Energy Storage

Having received £6million in funding from EPSRC plus industrial matched funding, the Birmingham Centre for Cryogenic Energy Storage has now designed its cryogenic research facilities, which are expected to be completed during Summer 2014.

Total public and private investment in liquid air technologies is now more than £40million.

Green Commission Roadmap

The Centre for Low Carbon Futures released A Mini-Stern Review for Birmingham, which identifies potential carbon reduction measures. Following this, Birmingham's Green Commission Carbon Roadmap provides a framework towards cutting the city's carbon footprint 60% by 2027. The roadmap identifies the opportunities to transform Birmingham into a leading green city; and projects necessary to create a sustainable green growth economy. The grid scale energy storage centre is frequently highlighted throughout the Roadmap as putting Birmingham at the forefront of one of the UK's "eight great technologies" as referenced by David Willetts, Minister of State for Universities and Science.

Birmingham workshop - the 'joined up thinking'

The University of Birmingham and the Liquid Air Energy Network will host a round table with Birmingham City Council and local energy and transport businesses to explore the potential of liquid air to help the city develop a low carbon economy. The workshop in March will bring together a small group of core transport and grid regional stakeholders to consider how liquid air technologies can reduce carbon emissions, support economic growth and improve quality of life in Birmingham and the Midlands.

Newsnight Scotland

Liquid Air Energy Storage was highlighted on Newsnight Scotland following a report released by the Jimmy Reid Foundation. The report found that an investment of £1.5bn in energy storage could be funded from savings in constraint payments and lower capital costs, as well as creating 5,000 jobs in Scotland. The report also suggested that Scotland could deploy 32 100MW Liquid Air Energy Storage plants by 2020.



Alex Salmond, First Minister of Scotland, discussing energy storage on BBC Newsnight Scotland.

Three months in media

- Harnessing electricity from frozen air**
- £8million boost for liquid air**
- World's first liquid air engine is on schedule**
- Liquid air commercial vehicle potential**
- Report calls for energy storage system**
- Revolutionary zero-emission engine 'could save fleets thousands'**

Appointments



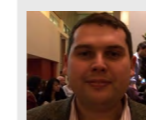
Professor Yulong Ding, Director of Birmingham Centre for Cryogenic Energy Storage

With Highview founders, Peter Dearman, Ferd Berger and Toby Peters, Yulong led the development and demonstration of Liquid Air Energy Storage. He will now be taking up the Chamberlain Chair at University of Birmingham. Yulong is also the founding Director of the Institute for Energy Storage Research at the Institute of Process Engineering, Chinese Academy of Sciences.



Dr Yongliang Li joins University of Birmingham and Birmingham Centre for Cryogenic Energy Storage as Lecturer

Yongliang obtained his PhD from the University of Leeds in 2011, in process simulation and optimisation of cryogenic energy storage technology. He will now focus on new thermal cycle development, energy storage, electrical power generation and CO₂ capture.



Michael Ayres joins LowCVP Members' Council

Michael, Dearman Engine Company COO, has joined the Members Council of the Low Carbon Vehicle Partnership, the public-private partnership that works to accelerate the shift to low carbon vehicles and create opportunities for British business. The Council is a permanent sub-committee of the Board, and helps ensure that the key concerns and priorities of members are heard. It is an important step that will help keep liquid air in the low carbon transport policy debate.

A major report launch and summit to discuss an urgent problem: Affordable, sustainable refrigeration for the developing world

Cold is the Achilles heel of the world's developing economies. In many rural areas, a lack of suitable cold storage and refrigerated transport (a 'cold chain') means substantial amounts of harvested food such as fruit, vegetables, fish, meat and dairy goes to waste. In warm countries such as India and those in sub-Saharan Africa post-harvest losses can range between 35 – 50% annually for perishable fruit and vegetables alone. In Tanzania, for example, 97% of meat is sold warm – never coming into contact with refrigeration - and less than a third of milk is ever chilled. This both holds back development and worsens poverty and hunger.

Cold chains growing fast

In the megacities of fast developing nations, such as Delhi and Beijing, however, cold chains are booming but powered by highly polluting diesel, which contributes to fatal smogs and rising greenhouse gas emissions. In India, for example, cold chain investment is forecast to total \$15 billion over the next five years. China's fleet of refrigerated trucks is expected to grow twelvefold to 365,000 over the next decade. What's needed is a sustainable and affordable alternative to the 'business as usual' cold chain.

In a year-long study led by Dr Tim Fox, Head of Energy and Environment, the Institution of Mechanical Engineers, the Institution has investigated the challenge of the cold chain and considered the potential of liquid air to help provide a 'clean technology leapfrog' to a sustainable solution for the developing world. The research programme for the study, in partnership with the Liquid Air Energy Network, included expert meetings and workshop events in India, Tanzania, the UK and USA to engage with development professionals, engineers, in-country farmers, NGOs, donor country Government officials, and key infrastructure players.



Air pollution has reached such severe levels that it is the cause of 3000 child deaths in Delhi each year.

What is the Liquid Air Energy Network?

Working with the Birmingham Centre for Cryogenic Energy Storage and the Centre for Low Carbon Futures, the Liquid Air Energy Network was founded by Toby Peters, co-founder of Highview Power Storage and the Dearman Engine Company, to explore the potential of liquid air as an energy vector, and to ensure Britain maintains its lead in this promising new technology and secures the full energy, environmental and economic benefits. Its research is conducted in collaboration with technology developers, industry, universities and partner organisations. Alongside the work in the UK, it is actively promoting the opportunity for liquid air in a number of key markets including the United States, China, India and Australia, as well as developing economies.

Liquid Air as a zero emission energy storage solution for grid and transport applications came to public prominence in 2012 when the Institution of Mechanical Engineers focused on it as an example of excellence in innovative British engineering. With the publication of a ground breaking report, *Liquid air in the energy and transport systems*, and conference at the Royal Academy of Engineering last year, it established its position in the mainstream of academic research and engineering thinking. It is now being developed by a growing circle of British companies, leading universities, and research bodies with significant Government support.

For more information, please contact Toby Peters - toby.peters@liquidair.org.uk

Leapfrog technology conference

On June 30th and July 1st 2014, the IMechE will host a major international summit to present its report on the challenges faced in sustainable cold chain development and discuss the necessary actions to catalyse a cleantech leapfrog in cold chain deployment.

Over the two days, the event will bring together a broad spectrum of international experts and stakeholders to consider why addressing the challenges of the cold chain matters and how the UK might help achieve it. It will explore the potential economic, social and environmental benefits of liquid air based cold chain technologies, in both newly emerging and rapidly industrialising economies, and ask what is needed to move from report to reality.

In the megacities of fast developing nations, such as Delhi and Beijing, cold chains are booming but powered by highly polluting diesel.

This London summit will be followed by an extended roadshow to India led by the IMechE to explore the full report and the conference findings with the Indian national and regional governments, industry, in-country farmers and producers, academics and engineers. Together, the route from report to reality will be developed further; the Institution's aim is to catalyse the necessary partners to deliver a field trial within 12 months.

The full programme will be published shortly. Day one will consist of three separate workshops ('The Cold Economy', 'Technology and Research Roadmap' and 'What can you do with a tank of cold?') while day two will be the conference and networking event at the IMechE, Birdcage Walk, London.

For more information or to reserve a seat for this key international summit & conference (July 1st), please contact Toby Peters or Jessica Lingwood - events@liquidair.org.uk

There will be no charge to attend; IMechE and LAEN want you to join us to explore the solution to this urgent problem.