Response to the ‘Consultation on an EU Strategy for liquefied natural gas and gas storage’

Dearman

We are grateful for the opportunity to respond to this European Commission consultation. We will confine our responses to the following questions: 11, 12, and 18.

Our response to question 11 is with respect to the technological developments we anticipate in coming years. With question 12, we believe there is a case that sustainable improvements to current and future LNG import terminals to lower the EU’s carbon emissions and improve European air quality. Further, we believe that our suggestions could both help mitigate the risk of the lock-in effects and minimise operators’ risk of investing in stranded assets outlined in question 18.

Key points

- Liquefied Natural Gas is gas ‘packaged in cold’. Typically, this cold gets thrown away when regasified – but it has a significant value, both economic *and* environmental, that should be recovered, not wasted.

- LNG’s price premium over pipeline gas can be significantly mitigated by fully exploiting this cold. By doing so, the value per tonne of LNG increases by 12% - lowering the risks of capital investment.

- There are certain ‘inside the fence’ uses for LNG cold within import terminals, but local requirements are far less than the amount of cold available. Liquid air produced cheaply using wasted LNG cold could be transported easily and safely, allowing the cold to be used far from the original point of import.

- A 600 tonne air liquefaction plant co-located with an LNG import terminal – which could comfortably be supplied with waste cold from regasification – would save more than 320,000 tonnes of carbon dioxide over a 25 year lifespan.

- EU countries are missing out on an opportunity to improve the security, affordability and sustainability of their energy supply; as well as the chance to help improve air quality, lower carbon emissions and increase the value recovered from each unit of imported LNG.

- Dearman anticipates that rather than diverting investment into renewable technologies or investing in stranded assets, the EU could in fact assist the transition to a low carbon European energy system by supporting the exploitation of waste cold.

Full Response

Question 11: Is waste cold technologically recoverable?

Dearman believes that there is a technological opportunity to recover cold currently wasted in the regasification of LNG – and that this is based around mature industrial gases technologies that have been around for over a century.

Each tonne of LNG contains the cold energy equivalent of 240kWh, in addition to its chemical energy, and typically 80% of this cold energy is thrown away. With EU LNG imports expected to double to more than 80 million tonnes per year by 2020, representing cold energy of almost 20TWh, it is vital to find productive uses for LNG waste cold.[1]

Recovering waste cold is not a novel idea – in fact cold recovery has been used extensively in Japan. The Osaka Gas power plant in Osaka Prefecture, for example, uses the waste cold in applications that range from the production of dry ice and cryogenic crushing to the generation of additional power in a Rankine cycle expansion process.

Large users of cold in the EU such as data centres could be located close to LNG plants to access its waste cold 'over the fence', lowering their costs for cooling. But to make use of as much of the waste cold as possible, it needs to be transformed into a storable and transportable form, allowing it to be used in vehicles and at remote locations.

One way to achieve this is through liquid air. When LNG is re-gasified from its liquid state at -162C to enter the gas grid, the cold it gives off can be recycled through a co-located air liquefaction plant to help produce liquid air or nitrogen at around -196C. A 600 tonne air liquefaction (costing €23m) plant co-located with an LNG import terminal would offer a combined NPV of more than €20m and an Internal Rate of Return (IRR) of 26%.

As a result, it would be an attractive option for private investors – a sustainable technological innovation returning a profit without subsidy. Dearman believes that the European Union could lead the way and reduce barriers to uptake by requiring new LNG import terminals to – at a minimum – investigate waste cold recovery. Support may also be required in the nascent phases of the project – EU funding for a demonstration project would be beneficial to help cross the 'valley of death' for new technologies.

Question 12: Sustainability and the demand for waste cold

Our analysis was done using the Isle of Grain LNG terminal in the UK as a reference case, and determined that a 600 tonne per day air liquefaction plant would save more than 320,000 tonnes of carbon dioxide over a 25-year lifespan, however industrial gas plants commonly last up to 40 years. Dearman believes that a significant proportion of European LNG plants would be capable of supporting a unit of this size – and others, such as the Qatari terminal at South Hook and other high volume plants could support a far larger plant sizing: consequently enjoying better financial and carbon returns.

Once converted into liquid air, LNG waste cold could be used in applications as diverse as static and vehicle refrigeration, heat hybrid truck and bus propulsion engines, zero-emission emergency electricity generation, and bulk energy storage and grid balancing. These applications would reduce diesel consumption, greenhouse gas emissions and local air pollution – presenting the EU with the opportunity to minimise LNG's sustainability issues – carbon emissions, boil-off venting etc – as well as improving quality of life in Europe's cities.

Above all, as energy systems develop, liquid air technologies provide the opportunity to harness, collect and transport cold to where is needed by end users – enabling them to access cooling efficiently, rather than having to utilise electricity to generate cooling, while it is being disposed of elsewhere in the system.

This could play a significant role in delivering more flexible energy systems which provide end users with the most appropriate energy service to meet their needs.

<u>Question 18: Mitigating the risk of lock-in effects</u>

Dearman believes that using waste cold to serve applications that require cold is inherently a more efficient process than burning diesel or using electrical energy to achieve the same result.

We examined the best use of waste cold by conducting an economic and CO2 analysis using an example UK LNG terminal; and valued waste cold as a commodity to verify this hypothesis. Results of this study suggest that waste cold provides total revenue of €467/MWh when it is used to produce liquid air and when the cryogen is subsequently used for the provision of cold services. Of this, €143/MWh-waste cold is profit.

In terms of the additional value contained per tonne of imported LNG, we determined that additional cold and power revenue would amount to approximately €40 – **increasing the overall value of every tonne of LNG by 12%** over average prices during 2014-15, a significant proportion of which is profit.[ii]

With capital expenditure for regasification terminals in the hundreds of millions of euros – the first phase of South Hook alone cost €553m – mitigating investment risks adds additional significant flexibility for EU states in planning their future energy mix. Similarly, increasing the revenue derived from imported gas minimises the risk of stranded assets by helping mitigate a terminal's exposure to price volatility. Additionally, since liquid air technologies will in the future be fuelled by renewably generated fuel; Dearman anticipates that rather than diverting investment into renewable technologies, the EU could in fact assist the transition to a low carbon European energy system by supporting the exploitation of waste cold.

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Annex - About Dearman and Liquid Air

Dearman is a global technology company delivering clean 'cold and power'. Dearman technology uniquely harnesses liquid air to deliver zero-emission power and cooling. It is developing and demonstrating a portfolio of proprietary technologies, products and services, which deliver significant reductions in operating cost, fuel usage and emissions, at low capital cost.

How we deliver clean and sustainable cold is a major issue, given the global challenges of food scarcity, changing demographics and growing energy demand. Dearman, with its cutting-edge clean cold and power technology, and world class engineering know-how, is well placed to make the world a cleaner and cooler place.

What is Liquid Air?

Air can be turned into a liquid by cooling it to around -196C using standard industrial equipment. 700 litres of ambient air becomes about 1 litre of liquid air, which can then be stored in an unpressurised insulated vessel. When heat (including ambient or low grade waste heat) is reintroduced to liquid air it boils and turns back into a gas, expanding 700 times in volume. This expansion can be used to drive a piston engine or turbine to do useful work. The main potential applications are in electricity storage, transport and the recovery of waste heat. Liquid air or liquid nitrogen could be used in a number of emerging technologies including: static and vehicle refrigeration, heat hybrid truck and bus propulsion engines, zero-emission emergency electricity generation, and bulk energy storage and grid balancing.

The Dearman engine

The Dearman engine is a novel piston engine powered by the phase-change expansion of liquid air or liquid nitrogen. In principle it works just like a steam engine only 300°C colder. It was invented by Peter Dearman, a classic British 'garden shed' inventor, and is being developed by the Dearman Engine Company (DEC) to perform a variety of roles.

Because it produces both power and cooling from the same unit of 'fuel', the Dearman engine can serve as an efficient and zero-emission transport refrigeration engine to replace the highly polluting secondary diesel units used on trucks today. The Dearman refrigeration engine is now in on-vehicle trials with MIRA, and will go into commercial field trials in 2015 and larger-scale international trials in 2016.

Modelling shows the engine would repay its investment within three months. Because liquid air boils at -194°C (and liquid nitrogen at -196°C), its work output can be raised by the addition of waste heat from another source. This means the Dearman engine can be combined with a diesel engine or hydrogen fuel cell to form a 'heat hybrid', where waste heat and cold are exchanged between the engines to increase the efficiency of both and reduce fuel consumption. Modelling suggests this arrangement would turn waste heat into extra power at practical conversion efficiencies approaching 50%, and reduce bus and truck diesel consumption by 25%.

A consortium including Dearman, Air Products, MIRA, Cenex, TRL, The Manufacturing Technology Centre and The Proving Factory has been awarded nearly £2 million by Innovate UK to build a heat hybrid prototype by 2016 while further developing and testing is being undertaken at the Birmingham Centre for Cryogenic Energy Storage.

In the future, the Dearman engine could also be used as a stand-alone propulsion engine for smaller, shorter distance vehicles such as auto-rickshaws ('tuk tuks') in developing countries, where the exhaust of clean cold air would provide 'free' air conditioning.

It could also be used as a static back-up electricity generator to replace highly polluting diesel gen-sets. Cryogenic expansion engines have existed for over a century, but the Dearman engine is novel because it uses a heat exchange fluid (made of water and glycol – just like conventional radiator fluid) to promote rapid and efficient re-gasification inside the engine cylinder.

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[i] http://www.euractiv.com/sections/energy/europes-lng-imports-set-double-2020-iea-says-315138

[ii] E4tech study.