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Hydrogen

Use cases for Heavy industry, Aviation, Shipping and HGVs

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WHY IS HYDROGEN BEING CONSIDERED FOR USE IN HEAVY INDUSTRY, SHIPPING AND HGVs?

The freight and heavy industry sector contributes a significant proportion of global carbon emissions and as carbon taxes and similar penalties begin to take hold, running costs in these industries are set to rise. One solution to decarbonising these industries is electrification. However, as will be discussed, many of the heavy industries are not well suited to this. Hydrogen fuel cells require large amounts of storage space for the hydrogen tanks. Therefore, because space is at less of a premium in HGVs and heavy vehicles compared with passenger vehicles; hydrogen is more suited for these larger vehicles. Throughout this paper the scientific use case of hydrogen and industry specific analysis will be explored.

SCIENTIFIC OVERVIEW OF USE CASE – HOW DOES HYDROGEN FIT INTO THESE INDUSTRIES?

Hydrogen fuel cells

This method uses the electrochemical recombination of hydrogen with oxygen to produce electricity; the only direct product is water. Technology is moving into a commercial stage now with operating temperature of cells approaching 200°C. Fuel cells boast excellent efficiency of up to 80% compared with traditional fossil fuels which have an efficiency of order 25%[1]. However, fuel cells still require an electric motor and in-situ hydrogen storage for use. If the hydrogen is stored as a compressed gas, then it presents both a safety risk and will fill a large space.

1 Energy Environ. Sci., 2019,12, 463-491
Kumar, A. and Sehgal, M., "Hydrogen Fuel Cell Technology for a Sustainable Future: A Review," SAE Technical Paper 2018-01-1307, 2018

Due to these requirements fuel cells are a highly expensive technology; costs will fall as technology matures and investment continues, but this is longer-term. The lack of moving parts does result in lower maintenance costs compared with combustion engines due to lower wear and tear.

Hydrogen combustion engine

This method is very similar to the conventional combustion of fossil fuels we use currently, a very mature technology with recent development minimising NOx production – previously one of the downsides to hydrogen internal combustion. The efficiency of this method is roughly equal to that of combustion engines (between 25% and 30%).

Combusting hydrogen allows current drivetrains to be used leading to far lower costs, it is also very competitive with fossil fuel vehicles due to maturity of technology. Furthermore, it also has low build cost of the engine compared with a fuel cell.

INDIVIDUAL USE CASE ASSESSMENT

Aviation

Aviation shows little to no promise in utilising hydrogen the next 10 years when it comes to long haul flights. A handful of ventures are claiming to be developing short haul passenger flights but making these commercially viable is still a distant prospect.[2] [3]

Opportunities

Building the infrastructure early on will give a dominant market position and, due to the lack of competition in the infrastructure space for this industry, it would give a solid head-start for development of both infrastructure and expertise.

Risks

Any investment into this sector is a long-term affair. Multiple companies are already developing needed technology, however, due to the infancy of this technology, there is likely little uptake for infrastructure in the near future.

Stirling Infrastructure's View

Aviation is too early in its hydrogen development to begin significant infrastructure development.

Heavy Machinery – Excavators, forklifts, and dump trucks etc.

Both the construction and mining industry present examples of successful hydrogen implementation. Several of these are due to difficulty providing fossil fuels to site, so production of hydrogen in-situ by electrolysis from wind or solar power is more economically viable. There is a use case for both fuel cells and combustion engines.

Opportunities

The difficulty with electrification in this sector comes from the long working days of many machines (running double shifts up to 18 hours). Electrification would incur a massive increase in weight of machines due to the large batteries required. Long charge times of electrified vehicles also compare poorly with the 5 to 10-minute hydrogen refuelling time. However, combustion engines are currently approximately a third of the cost compared with fuel cells – which gives combustion engines a near term advantage.

In order to maintain refuelling stations on site, this would require the development of hydrogen distribution hubs when local production is not possible. Mining favours local production due to long term fuelling requirement of the site.[4]

Risks

The cost of green hydrogen is high, yet this will decrease as the level of distribution increases. To minimise costs, hydrogen solutions must be rolled out on a large scale. For a large scale roll out to be successful, massive subsidies are required and due to the lack of government policy commitments regarding hydrogen solutions the risks associated with this are heightened. There is no consensus on

2 Iea.org
3 Zeroavia.com
4 jcb.com

the best path to take as different market leaders are presenting different solutions. Furthermore, the only current commercial example of hydrogen in this industry is use in a microgrid. Although a microgrid presents a demonstration of the concept it lacks the size to demonstrate economic viability for a large-scale rollout. As such further confirmation projects would be required to push the industry towards a hydrogen economy.

Stirling Infrastructure's View

Heavy industry shows promise with hydrogen due to fast refuelling times compared with electric equivalents. Hydrogen combustion engines seem a more economical route at first although, in the future it is possible fuel cells could become cost competitive. The issue surrounding delivery of hydrogen and cost of the fuel for the end user remains to be resolved however the need for subsidy to enable implementation is a certainty.

HGVs

With hydrogen trucking fleets already in operation on a pay by use basis, the concept is proven. The large-scale implementation is planned in certain geographies however many countries are yet to release a full strategy. Some countries have highly aggressive FCEV deployment targets, such as Japan, and with a majority of FCEVs predicted to be HGVs due to the lower premium on space the outlook is positive.[5] Currently Japanese manufacturer, Hyundai, is in partnership with a Swiss firm whereby they operate a FCEV trucking fleet on a pay by use basis to lower costs to the end user.

Opportunities

The HGV sector places greater demand on refuelling time, range and reliability than the passenger market where cost and space are at a premium. The competition is between fuel cells and combustion engines however, several companies have already formed partnerships to bring economic viability to fuel cell trucks which can cost three times that of a diesel truck and twice that of an electric counterpart. There is far less development in the HGV combustion engine space with respect to hydrogen than we see in the heavy machinery sector.

Market leaders are keen to press the roll out of fuel cell trucks compared with hydrogen combustion engines. With many refuelling stations under development. Furthermore, HGV routes are pre-planned and as such a relatively small number of refuelling depots would be required compared to the passenger vehicle market. These depots would likely be larger in scale with several market leaders suggesting in situ hydrogen generation from renewable grid supply or island type nearby renewable supply.[6]

Risks

The lack of consensus behind refuelling and hydrogen storage both on the trucks and at depots is cause for concern as a large scale roll out would require a universal supply. The current leading view is to use liquified hydrogen on board the trucks as the universal fuel with no on-board reformation of hydrogen required. Whilst at the depots to reform/generate hydrogen from either a loaded carrier source or electrolyser. The development of any infrastructure in this industry will still require massive subsidy due to the high cost of the fuel cell trucks and the hydrogen industry to fuel them. If this is provided in the geography in question it would seem a sensible investment.[7]

Stirling Infrastructure's View

Hydrogen takes the edge over electric vehicles however high initial costs and lack of supply network on a national level for fuelling present initial difficulty. There are commercial examples of partnerships taking on the capital expenditure and leasing trucks out alongside providing the fuel to them in order to encourage use and prove the concept. The trucks themselves work well with the only sticking point being subsidy requirement for the operation.

5 Tesla.com
6 Iea.org
7 Ourworldindata.org

Shipping

A strong use case similar to the other heavy industry due to the carbon intensity of the industry. However the lack of ships capable of running on the fuel makes the need to implement infrastructure in ports and alike obsolete. It is widely accepted large freight ships which run on hydrogen will not be commercially available for at least a decade.

Opportunities

Small scale ferries are in operation and under development with several cargo sized ships reportedly under development for delivery within the next five years. These are however all one-off pilot projects to prove a concept and as such commercial viability will not be reached for a minimum of 15 years. Once again ships have massive capacity for fuel storage and batteries are not a solution for energy storage. Alongside this the storage on ships could be carried out using a LOHC or other hydrogen storage medium due to the space on board allowing for a reforming device. The Shipping industry is a prolific carbon producer globally therefore a large push on this industry to carbon zero is required to reach Paris agreement goals. Retrofitting of hydrogen technology is also a possibility.[8]

Risks

Any investment into the industry is a very early play relying on subsidies which are currently not present. Although electrification of ships is highly impractical it remains to be seen how hydrogen can fill the gap given a lack of consensus on the technology which is best placed. The fuel cell, combustion engine debate is in its early stages within this industry. Furthermore, the discussion on which form of hydrogen to fuel ships with is even less mature making refuelling investment a shot in the dark without a prior purchase agreement of fuel.[9]

Stirling Infrastructure's View

There is an excellent reason to push the shipping industry to carbon zero given its global impact. The relative ease of refuelling infrastructure due to well defined routes and port locations further supports the use case. Globally there is a lack of ships capable of using the fuel and with little consensus on the position of hydrogen in the sector it is too early for significant investment.

8 Swzmaritime.nl
9 statkraft.com

FOR FURTHER INFORMATION

This paper provides insights into allocating capital into the hydrogen value chain.

The firm provides a comprehensive range of services which includes M&A transaction services and raising both debt and equity to finance hydrogen projects globally.

For further information please contact:

Stirling Infrastructure Partners Limited
84 Brook Street
London
W1K 5EH
Tel: +44 (0)20 7629 3030

contact@stirlinginfrastructure.com
www.stirlinginfrastructure.com

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