Decarbonising vehicle fleets - the case for hydrogen

The transport sector needs to deliver large emission reductions to reach carbon neutrality. It contributes 24% of global CO_2 emissions, of which 74.5% is from road vehicles, with passenger vehicles contributing 45.1% and heavy goods vehicles 29.4%[1]. In the UK, transport was responsible for 27% of greenhouse gas emissions in 2019. Of this, 55% was from cars, 16% from HGVs, 16% vans, and 3% buses[2].

The only way for carbon neutrality to be achieved is through adoption of alternative fuel sources. A range of fuel options is essential as there is a wide variety of transport modes with different requirements that need to be decarbonised. One such fuel option is hydrogen produced from low carbon sources, which can be used directly in internal combustion engines (ICEs), in fuel cells to supply electricity, or as a feedstock to produce other green energy vectors.

For many fleet operators in the transport sector, replacement of vehicles with fuel cell technology is an expensive solution. There are also environmental disbenefits attached to scrappage of existing fleets and manufacture of replacement fleets, which impact on whole life cycle costs. The retrofitting of conventional internal combustion engines (H_2-ICEs) to run on hydrogen can eliminate pollutants including GHGs, CO and NOx. The main modifications to the vehicles involve hydrogen storage in the vehicle and integrating gas injectors into the engine.

One such fleet operator is the UK's Ministry of Defence (MOD). The VITAL project (Defence Innovation Fund, 2021-24) is developing a sustainable Living Lab at RAF Leeming in the North Yorkshire region with its partners RAF Leeming and Newcastle University. The key goal of ViTAL is to identify solutions to decarbonise the airbase. To achieve this, the VITAL project team is exploring the role new energy vectors, including hydrogen, could play.

ViTAL links closely with the Tees Valley Hydrogen Hub project (Innovate UK, 2021-22) centred on the nearby location of Teesside. This initiative brings together ULEMCo, RAF Leeming, Tees Valley International Airport, Newcastle University and Emission Analytics to convert a diesel airside tow tug vehicle (SCHOPF MATT tractor) to an electric hybrid H_2-ICE, proving the technological concept and quantifying the elimination of tailpipe emissions of diverse pollutants (utilising PEMs equipment) whilst demonstrating replication of real-world airside duty cycles.

This paper presents the findings of the Tees Valley Hydrogen Hub project, which suggest that retrofitting conventional ICEs to run on hydrogen may be a viable solution, at least in the short to medium term. Moreover, the technology could be important in establishing a demand for hydrogen, offering a potentially cost-effective route to zero tailpipe emissions through retention of existing vehicle fleets without adversely affecting duty cycles. Stimulating demand for hydrogen in this way could serve to make other hydrogen technology, such as fuel cells, more economically viable. Such an interim and cost-effective solution will still contribute to decarbonisation targets through reducing tailpipe emissions and may be the most viable solution for fleet operators such as the MOD.

The paper also outlines proposed future research looking at retrofitting larger engines synonymous with the MOD's 'green fleet' and a variety of heavy goods vehicles used in the haulage, construction and agriculture industries.

[1] Ritchie & Roser (2020), Energy: Transport, London: Our World in Data (IEA)

[2] DfT (2021), Decarbonising Transport: A Better, Greener Britain, London: Department for Transport