

Hydrogen Refuelling Station Requirements for UK Long-haul Decarbonisation

Piers Johnston, Dr Molly Haugen, Dr Daniel Ainalis, and Dr Adam Boies

University of Cambridge, Cambridge, UK CB2 1PZ

The upfront infrastructure investment for electric road systems (ERS) are anticipated to be large for decarbonising the heavy good sector with electric energy. The alternative fuel vector for decarbonising heavy goods vehicles (HGVs) on a national scale is hydrogen. The aim of this research is to answer two main questions:

1. "What is the energy production to energy use cost for a national HGV-HRS network?"
2. "How does the cost of a HGV-HRS network compare to decarbonising the HGV sector with ERS?"

The life cycle cost (LCC) and levelized cost of hydrogen production (LCOH) in the UK for both the near future (2030), and long-term case (2050) are used as benchmarks for three production hydrogen production methods: decentralised hydrogen production at the HRS location via electrolysis (DCE), centralised large-scale electrolysis (CE), and centralised steam methane reforming with carbon capture and storage (SMR-CCS). A portfolio of HGV-HRSs were analysed in this research, ranging from a refuelling capacity of 600 kg/day and 20 HGVs/day up to a capacity of 18,000 kg/day and 600 HGVs daily.

The second part of this analysis expands this costing model to evaluate the cost of a hydrogen refuelling network in England. This model includes the infrastructure and costs for production, transportation, and distribution. This method uses energy-based calculations to determine the infrastructure requirements to meet the total energy demand between the present and 2050, as well as a flow-based model to identify roads or 'hubs' of high HGV volume to locate the refuelling infrastructure. It was assumed all infrastructure would be located on the strategic road network (SRN), and traffic count data from the DfT were used to identify regions of high HGV activity. This analysis was done on a regional basis, based on the 9 regions of England to determine the utilisation of each section of the SRN in more detail.

The network analysis found that a total of 462 HGV stations are required to meet the total hydrogen energy demand in 2050 of various size. It was found that centralised electrolysis had the largest total capital investment of £17.0 bn by 2050, followed by DCE at £15.4 bn, with SMR-CCS the lowest at £13.1 bn. However, when comparing total annual costs including the operating and replacement costs, it was found that DCE had the highest annual costs of £6.47 bn/yr and a LCOH of 5.30 £/kgH₂, with CE at £6.05 bn/yr and a LCOH of 4.96 £/kgH₂. SMR-CCS remained the lowest with a total annual cost of £3.61 bn/yr and a LCOH of just under 3 £/kgH₂.

These results are compared to research by Ainalis et al. on decarbonising the UK's long-haul HGV sector. Whilst the initial capital investments may be only slightly higher, the large operating costs and lower efficiency of hydrogen production, transportation, and storage recommend that an ERS may be the more economical option overall.