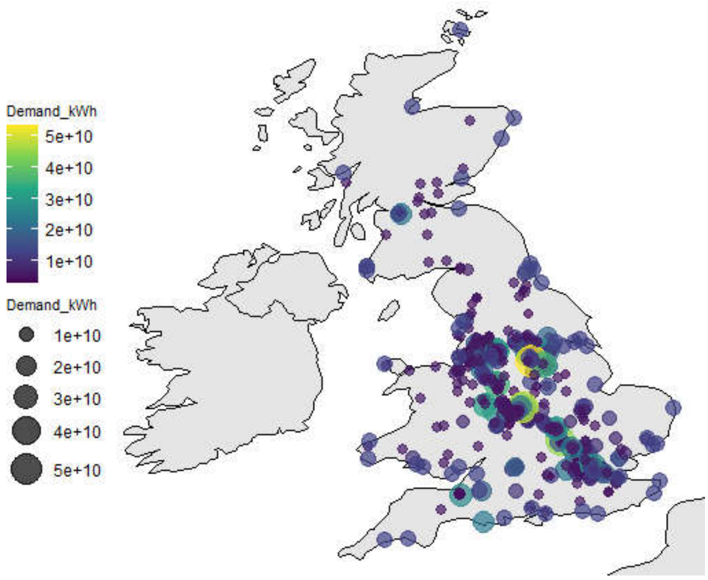
Executive Summary

The research project “Techno-economic feasibility study of hydrogen-fuelled freight transport”, led by the University of Kent, was supported by the UK's Engineering and Physical Sciences Research Council (EPSRC) through the Programme Grant EP/S032134/1 “A network for hydrogen-fuelled transportation (Network-H2)”. The work carried out over the duration of the project let to the development of a techno-economic model for understanding the economics of hydrogen utilisation for land-based freight transport in Great Britain (GB).

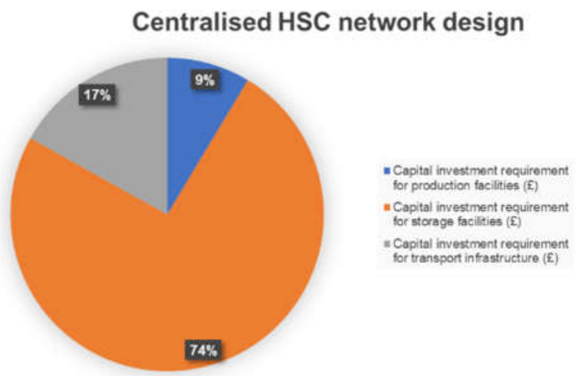
Demand-side scenarios representing Heavy Duty Vehicles (HDV) demand for hydrogen, and the potential network of hydrogen Refuelling Stations (RSs), as well as techno-economic and spatially-explicit scenarios representing situations with hydrogen production and storage in GB were developed and exercised against a two-stage optimisation-based modelling tool for linking road freight demand to Hydrogen Supply Chain (HSC). The developed methodology captures the complex interactions among various HSC entities corresponding to production, storage, transportation and distribution and identifies optimal strategic and operational configurations of the chain within the boundaries of each scenario constraints to satisfy road freight demand such that the ultimate cost of getting each kg of hydrogen to the downstream of HSC (i.e., hydrogen pumps) is minimised. A key distinctive feature of the developed modelling tool, on the other hand, pertains to its unique capability to integrate centralised and on-site hydrogen production decisions within a unified demand-driven optimisation framework. This capability has been exploited to generate and report first-hand insights regarding hydrogen utilisation by the road freight sector in GB.



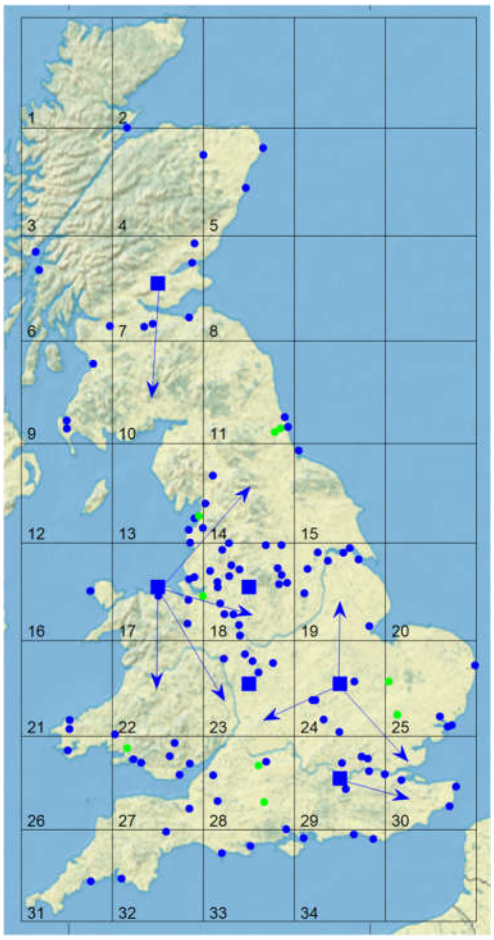
Technoeconomic hydrogen production data pertaining to the state-of-the-art and futuristic technologies for blue and green hydrogen production comprising Steam Methane Reformer with Carbon Capture, Usage and Storage (SMR with CCUS), Autothermal Reformer with Carbon Capture and Storage (ATR with CCUS), Autothermal Reformer with Gas Heated Reformer with Carbon Capture, Usage and Storage (ATR+GHR with CCUS), Alkaline Electrolysis (A-E), Proton Exchange Membrane Electrolysis (PEM-E) and Solid Oxide Electrolysis (SO-E) were included in all analyses carried out, and in almost all cases 300-MW ATR+GHR with CCUS turned out to be the most favourable hydrogen production technology and scale in optimal HSC network designs. Also, cost-effective underground hydrogen storage technologies including Underground Pipe Storage (UG-PS), Underground Lined Rock Cavern

(UG-LRC), and Underground Salt Cavern (UG-SC) alongside conventional overground storage technologies corresponding to Overground Compressed hydrogen gas tank at 700 MPa (OG-CH2 GT) were considered, and UG-PS was most often picked by the model as the preferred technology for hydrogen bulk storage.

The project results indicated that by far the largest proportion of HSC cost is dominated by the capital and operating cost of hydrogen storage, transport and distribution rather than that of hydrogen production. In a centralised HSC network design for the road freight demand in GB, only 9% of the total capital cost is required for establishing the needed hydrogen production facilities and the rest is spent on bulk hydrogen storage and transportation infrastructure, with storage cost dominating the scene.



On the other hand, simultaneous consideration of on-site and centralised hydrogen production decisions in the modelling tool developed by this project implies a significant opportunity for saving over £1.2 billion in the total capital cost required (i.e., around 27% reduction compared with centralised HSC) and over 17% reduction in the total daily operating cost of the HSC, by producing 72% of the required hydrogen on-site at RSs and only the remaining 28% in centralised production sites. This project also finds that while the HSC infrastructure needed for satisfying the refuelling need of the future hydrogen HDV fleet can be established with a rather manageable level of centrally planned investment, converting the HDV fleet into hydrogen powered HDVs requires significant investment commitments from freight forwarders that must be sufficiently incentivised and accelerated. The current possible savings in carbon costs (which is just around 0.5% of the fleet conversion investment required) is way far from sufficient to fully entice companies into net-zero options.



We identify a need for follow-on research work to focus further on the demand side and zoom in on operational level of HDV activities to identify technoeconomic requirements to accelerate hydrogen HDVs adoption by logistics, and develop economically viable pathways for gradual conversion of the freight fleet.