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Techno-economic and Market Assessment of Decentralised Hydrogen Production Technologies for Early Markets in the UK

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1 Overview

The early phases of the mass market uptake of hydrogen as an energy vector in both transport and stationary applications will require the availability of decentralised hydrogen production technologies that satisfy the technical, economic and environmental requirements of these markets as they rapidly grow. Decentralised technologies that are closest to commercial viability are reforming of natural gas and of liquid bio-derived fuels, and water electrolysis. However, costs still need to come down and technical barriers remain; significant R&D activity is devoted internationally to addressing these problems by developing innovative systems, subsystems and components for hydrogen production and purification.

The recently funded, £5M UK EPSRC project “Delivery of Sustainable Hydrogen” focuses on the development and integration of innovative membranes and catalysts for hydrogen production and purification using fossil fuels, biomass and electricity as feedstock. As part of the project, a rigorous techno-economic, environmental and market assessment of these technologies is also being carried out. This paper will present preliminary results of the assessment, which uses a bottom-up, techno-economic modelling approach to investigate the potential role of improved decentralised hydrogen production technologies in enabling the developing of early mass markets.

The analysis is based on case studies, where specific market, geographic, policy and resource aspects are accounted for. The first case study will be based on London and more case studies will follow for other key locations in the UK. This provides a realistic approach to estimating the market potential of technologies and to defining minimum technical and economic targets for their initial commercialisation. Preliminary results from the London case study will be presented at the conference.

2 Methodology

The methodology used for the analysis is graphically represented in the Figure.

Demand scenarios are built based on current and future planned demonstration projects in London and likely follow-ups. The scenarios are developed by combining local policy and market drivers and barriers with technology development scenarios. Local policy and market drivers and barriers are investigated by means of interviews with key stakeholder as well as analysing relevant information and data available in the public domain. Technology development scenarios on the other hand are developed aided by the use of a simulation model originally described in [1] and also used in [2]. In particular, for the purposes of the present study the model is used to simulate endogenous learning in hydrogen fuel cell

powertrains technologies driven by the global uptake of hydrogen fuel cells in niche markets outside transport as well as in early transport markets and particularly urban buses.

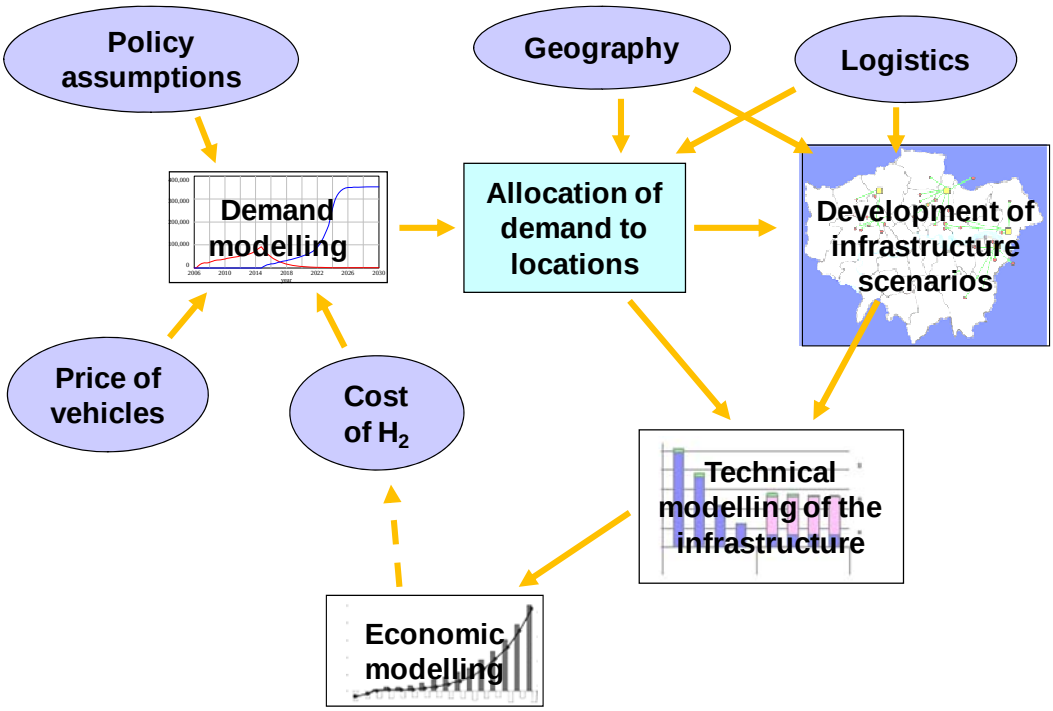

Figure: **Schematic representation of the methodology used for the techno-economic, environmental and market analysis of innovative decentralised hydrogen production technologies (adapted from [3]).**

The demand scenarios so obtained, characterised over both space and time, drive the development of local infrastructure scenarios. Possible hydrogen infrastructure options are considered, encompassing centralised, decentralised and on-site hydrogen production; however, only those options that are technically compatible with the hydrogen demand scenarios considered are selected and translated into detailed infrastructure build-up scenarios for further analysis. Choice of viable infrastructure scenarios is also informed by previous work carried out at Imperial College on hydrogen infrastructures for London, and particularly [4].

The subsequent techno-economic, environmental and financial analysis involves:

1. Detailed technical and economic characterisation of existing as well as prospective hydrogen production, purification and delivery technologies. Existing technologies are characterised based on techno-economic data available from the literature and, where possible, also on data acquired directly from industry; potential for technological learning and economies of scale is also assessed. Prospective technologies, and particularly those based on the innovative systems, subsystems and components being developed as part of the project “Delivery of Sustainable Hydrogen”, are characterised based on a combination of complementary methods,

encompassing basic scaling-up methods applied to laboratory-scale systems as well as Delphi-type surveys.

2. Development of a bottom-up hydrogen infrastructure techno-economic model and its use in the evaluation of technical, economic, environmental and financial performance and requirements of decentralised hydrogen production technologies under the demand and infrastructure scenarios previously discussed.

The bottom-up hydrogen infrastructure model is a spreadsheet scenario model which uses as main inputs the spatial and temporal hydrogen demand scenarios and also the techno-economic data of all the hydrogen production and delivery technologies that are relevant to the infrastructure scenarios considered. The model allows building a number of specific hydrogen production delivery-pathways that meet the demand for hydrogen over space and time; for each one of these pathways the model calculates key cost, emission and financial metrics for the various infrastructure components considered as well as for the cost of the hydrogen delivered, and can also be used to estimate minimum techno-economic parameters that individual production and delivery technologies need to meet in order to be commercially viable. As an example, keeping all techno-economic input data as constant, financial metrics such as Net Present Value, Payback Time and Internal Rate of Return of specific infrastructure components can be calculated. However, where uncertainty in technical input data is high, as is the case of prospective technologies, the levelised cost of hydrogen production can be set as constant, and cost and performance targets for the development of specific technologies can be explored using the model.

Finally, the results of the techno-economic, environmental and financial analysis carried out based on the infrastructure model will feedback into the demand and infrastructure scenarios, thus allowing to:

- estimate potential windows of opportunity for commercialisation of the decentralised hydrogen production technologies that are being developed as part of the project “Delivery of Sustainable Hydrogen”;
- define key technical and economic targets that, if achieved, would allow the technologies to maximise their market potential;
- estimate environmental benefits associated with the use of decentralised hydrogen production technologies as opposed to centralised options.

Work is still in progress and scenarios, techno-economic input data used in the model as well as preliminary results of the analysis will be available for presentation at the conference.

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