HYDROGEN STRATEGY TOWARDS ENERGY TRANSITION: COMPARATIVE ANALYSIS OF UK AND GERMANY

Saheed Bello, Energy Policy Research Group, Cambridge Judge Business School, University of Cambridge, United Kingdom
Phone: +447405804586, e-mail: s.bello@jbs.cam.ac.uk
David Reiner, Energy Policy Research Group, Cambridge Judge Business School, University of Cambridge, United Kingdom
Phone: +44 (0)1223 339616, e-mail: d.reiner@jbs.cam.ac.uk

Overview

To meet Paris Agreement targets of keeping global temperatures well below 2°C, more ambitious efforts are required to decarbonize the hard-to-abate sectors such as energy-intensive industries. For such sectors in particular, low-carbon hydrogen is seen as having an important role in supporting the future green energy transition (Van de Graaf et al. 2020; Pingkuo and Xue, 2022), boosting the integration of renewables into the power system by providing long-duration energy storage to ensure higher grid flexibility (Cheng and Lee, 2022). For the case of Germany, hydrogen has been put forward both to reduce wind electricity curtailments and residual peak demand (Michalski et al., 2017) as well as strengthening national energy security to mitigate concerns over natural gas supply (Belova et al., 2023).

These potential advantages of hydrogen have stimulated a variety of initiatives at international, national, and regional levels across different stakeholders such as steel companies, hydrogen manufacturers, government agencies, energy companies and research centres to flag hydrogen energy advancement. Despite still being at the early stage of hydrogen economy, a growing number of countries including the UK and Germany have published their national hydrogen strategies that state the contribution of potential hydrogen industry to their decarbonization objectives.

However, considering different potential economic and climate outcomes associated with changing the hydrogen industry value chains, it is important to understand how these countries might use their policy tools, sources of supply and storage, and sectoral priorities to encourage low-carbon hydrogen development in achieving their net zero targets. Thus, we attempt to provide a better understanding of potential hydrogen development opportunities and impediments as well as appropriate policy responses, by performing a critical evaluation of British and German hydrogen strategies. The UK and Germany were chosen because they are among pioneers in both net zero ambitions and low-carbon hydrogen, and are the two largest economies in Europe. In so doing, we contribute to the existing studies (Esily et al. 2022; Pingkuo and Xue, 2022) by incorporating the UK into studies of hydrogen strategy; and improving the existing quantifiable assessment criteria developed by Aditiya and Aziz (2022) to include hydrogen infrastructure capacity, and utilize hydrogen-specific data on research and development spending and more appropriate measures for public acceptance. Based on these approaches, we provide evidence-based recommendations for policymakers in response to future hydrogen barriers.

Method

We employ the institution-economic-technology-behaviour (IETB) framework of Pingkuo and Xue (2022) that covers hydrogen production (the upstream segment), storage and delivery (the downstream segment), and hydrogen- applications (the downstream segment). Then, we quantitatively evaluate the extent to which the two countries can adopt hydrogen based on key techno-socio-economy indicators we have evaluated such as: (a) domestic energy capacity, which reflects the capacity of the current energy resource to satisfy energy demand; (b) storage and transport capacity; (c) technical capacity that production efficiency and CO_2 reduction performance; (d) economic growth; and (e) public acceptance, which defines the level of social security and energy affordability. These indicators will cover 1997 (year of introducing Kyoto Protocol) through 2022 and will be gathered from different data sources such as World Bank, UK Data Service, International Energy Agency (IEA), World Energy Council, and EPRG public survey research. We utilize this time series data to build an autoregressive distributed lag (ARDL) model that performs well for a small sample size and is robust to stationarity (Sweidan, 2023) to identify potential drivers of hydrogen uptake which is proxied by the hydrogen consumption, for each country. The general ARDL hydrogen deployment model is specified as follows:

$$Y_t = \alpha + \sum_{k=1}^{p} Y_{t-k} + \sum_{j=0}^{q} X_{t-j} + \varepsilon_t \quad (1)$$

Where Y_t denotes hydrogen deployment, X_t stands for a list of techno-socio-economy indicators (e.g., R&D expenditure, GDP, electricity price, population), $\alpha, \beta,$ and δ represent the model's estimated parameters, ε_t is the error term. We extend eq. (1) to capture short and long-run drivers in eq. (2):

$$\Delta Y_t = \alpha_0 + \sum_{k=1}^{p} \vartheta_k \Delta Y_{t-k} + \sum_{j=0}^{q} \gamma_k \Delta X_{t-j} + \sum_{k=1}^{p} \theta_k Y_{t-k} + \sum_{j=0}^{q} \pi_j X_{t-j} + \varepsilon_t \quad (2)$$

Where Δ stands for the first difference operator, γ_k denotes the short-run parameters while π_j represents long-run parameters normalized by θ_k. We then test the long-run relationship among these variables following the method of Pesaran et al. (2001).

Results

Based on a preliminary review of the existing literature on hydrogen strategy, we identify a wide range of possible future hydrogen development pathways. In the short term, hydrogen growth will be limited by infrastructure buildout that may require a decade or more. This would provide more opportunities for blue hydrogen (based on natural gas with carbon capture and storage) in the near term since green hydrogen (produced via electrolysis using renewable energy) to meet much of the potential demand for low-carbon hydrogen by 2035 (AFry, 2022). However, the potential development of a global hydrogen market which would facilitate cost-effective production and trade of hydrogen, has prompted bilateral agreements among countries to support R&D and deployment programmes in the hydrogen industry value chains. Few developed countries such as Germany and Japan have taken stronger actions in this regard due their trade orientations. For instance, Germany has already established a list of ten potential trading partners for green hydrogen production and downstream products, while the UK has adopted a more self-sufficient approach and has only reached one bilateral agreement with Chile (World Energy Council, 2022) although it might leverage its Commonwealth ties to achieve greater global engagement as a hydrogen leader.

Conclusions

A critical evaluation of the UK and Germany hydrogen strategies is needed to begin to understand the feasibility and costs of national net zero targets. We conduct a preliminary review of the hydrogen strategy literature, which will be extended to more extensive reviews of these strategies based on the IETB framework which covers: (i) hydrogen cost targets; (ii) monetary and non-monetary measures to support hydrogen development; (iii) social issues for hydrogen development; (iv) sectoral priorities for hydrogen applications etc. Then, we will use our quantified assessment criteria and econometric model to identify potential drivers and barriers to hydrogen deployment, and suggest appropriate policy responses to address these impediments.

References

Aditiya, H. B., & Aziz, M. (2021). Prospect of hydrogen energy in Asia-Pacific: A perspective review on techno-socio-economy nexus. *International Journal of Hydrogen Energy*, *46*(71), 35027-35056.

Afry (2022): Net Zero Power and Hydrogen: Capacity Requirements for Flexibility (AFRY)

https://www.theccc.org.uk/publication/net-zero-power-and-hydrogen-capacity-requirements-for-flexibility-afry/

Belova, A., Quittkat, C., Lehotský, L., Knodt, M., Osička, J., & Kemmerzell, J. (2023). The more the merrier? Actors and ideas in the evolution of German hydrogen policy discourse. *Energy Research & Social Science*, *97*, 102965.

Cheng, W., & Lee, S. (2022). How green are the national hydrogen strategies? *Sustainability*, *14*(3), 1930.

Esily, R. R., Chi, Y., Ibrahiem, D. M., & Chen, Y. (2022). Hydrogen strategy in decarbonization era: Egypt as a case study. *International Journal of Hydrogen Energy*.

Michalski, J., Bünger, U., Crotogino, F., Donadei, S., Schneider, G. S., Pregger, T., & Heide, D. (2017). Hydrogen generation by electrolysis and storage in salt caverns: Potentials, economics and systems aspects with regard to the German energy transition. *International Journal of Hydrogen Energy*, *42*(19), 13427-13443.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of applied econometrics*, *16*(3), 289-326.

Pingkuo, L., & Xue, H. (2022). Comparative analysis on similarities and differences of hydrogen energy development in the World's top 4 largest economies: A novel framework. *International Journal of Hydrogen Energy*, *47*(16), 9485-9503.

Sweidan, O. D. (2021). The geopolitical risk effect on the US renewable energy deployment. *Journal of Cleaner Production*, *293*, 126189.

Van de Graaf, T., Overland, I., Scholten, D., & Westphal, K. (2020). The new oil? The geopolitics and international governance of hydrogen. *Energy Research & Social Science*, *70*, 101667.

World Energy Council (2022). Hydrogen strategy report. https://www.worldenergy.org/publications/entry/working-paper-hydrogen-on-the-horizon-national-hydrogen-strategies