THE ROLE OF HYDROGEN FOR ZERO CARBON EMISSIONS

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Overview

Hydrogen has been promoted in last decade as one of energy carrier that able to decarbonize the hard to electrify sectors (e.g.: steel, cement, and chemical industries), store energy from intermittent renewable power sources and be adopted as a chemical feedstock. Hydrogen can be produced typically by renewables and fossil fuels with Carbon Capture and Storage (CCS). To increase more convenient uses of hydrogen, ammonia, and synthetic fuels (synthetic methane and liquid fuels) will play important roles. This paper objective is to conduct systematic review on the cost and climate change impact on hydrogen supply chain. There are several pathways towards the zero carbon emissions where hydrogen could play important role in those hard to abate industries. As countries search for context-specific tools and solutions for achieving clean energy transitions, low carbon hydrogen (H_2) and ammonia (NH_3) are emerging fuel options for cofiring. A few Asian countries have stated explicit targets for the use of hydrogen or ammonia in the power sector. Japan is aiming to use 0.3 Mt/yr of hydrogen and 3 Mt/yr of ammonia in the power sector by 2030. Korea has a target of 1.5 GW installed fuel cell capacity in the power sector by 2022 and of 15 GW by 2040.

Methods

This study will conduct review on existing studies on the techno economic assessment (TEA) and life cycle assessment (LCA) to assess the economic and environmental impact on hydrogen supply chain (production, transport, and storage). The hydrogen was supplied by fossil fuels (coal, oil, and gas), renewable energy (biomass, hydropower, solar and wind) as well as nuclear. The transport data was obtained from air, sea, and road transport modes. Hydrogen was stored as ammonia or liquid and gasses hydrogen. The systematic review will be based on input data that was obtained from published papers and reports during the latest period 2020 to 2022.

Results

Natural gas-based hydrogen emits 8- 9-ton CO_2/ ton H_2. Coal gasification emits 1.7-to-3.1-ton CO_2/ ton H_2. Still the lowest emission is in chemical looping reforming 0.54-ton CO_2/ ton H_2. Combination of torrefied biomass and CCS results will bring negative emissions -23.7-ton CO_2/ ton H_2. Overall ranges 30-ton CO_2/ ton H_2 to -23.7-ton CO_2/ ton H_2. CO_2 avoidance cost range 7€ / t CO_2 - 130 € / t CO_2.

Conclusions

To reach zero carbon emissions hydrogen supply chain is only achievable by the present of renewable based energy sources. In term of cost, the cost under $0.04/kWh will be needed for electrolysis derived fuels to be competitive with fossil fuel. Hence, soon the lower cost of water electrolysis will provide a potential carbon neutral alternative for providing hydrogen for these reactions.

References

Akimoto K. Sano, F., Oda, J., Kanaboshi, H., Nakano, Y. (2021) Climate change mitigation measures for global net-zero emissions and the roles of CO_2 capture and utilization and direct air capture, Energy and Climate Change, 2.

Mueller, L., Katelhoen, A., Bringezu, S. McCoy, S., Suh, S. Edwards, R., Sick, V., Kaiser, S., Cueller-Franca, R, El Khamlichi, A., Lee, J.H., von der Asses, N., Bardow, A. (2020) The carbon footprint of the carbon feedstock CO_2, Energy and Environmental Science, 13.

Haslam G.H., Jupesta J., Parayil, G. (2012). Assessing Fuel Cell Vehicle Innovation and the Role of Policy in Japan, Korea, and China, International Journal of Hydrogen Energy, 37.

MIT (2022) The Future of Energy Storage, MIT Press.

IEA (2021) The Role of Low-Carbon Fuels in the Clean Energy Transitions of the Power Sector, IEA.