Assessing China's green hydrogen supply and end-use diffusion in hard-to-abate industries

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As an alternative fuel for industrial high-temperature heat and a clean feedstock for high-value-added chemicals production, the green hydrogen produced from water electrolysis using renewable electricity is of vital importance for the deep decarbonization of China's hard-to-abate industries inclusive of the blast furnace-basic oxygen furnace (BF-BOF) steelmaking, cement manufacturing and chemical production, which has been attracting increasingly close attention from policymakers and enterprises. Nevertheless, the deployment of green hydrogen infrastructures still lags far behind the level commensurate with China's carbon-neutral vision in 2060, due largely to the combined effects of cost challenges posed from the supply side and indeterminate diffusion prospects in end-use applications.

On the one hand, this study firstly evaluates China's techno-economical potential of green hydrogen supply based on onshore wind and solar PV generation with a high resolution of 1 km × 1 km grid, taking the land suitability criteria, socio-economic and environmental filters, various kinds of technology combinations, and cost reduction potential into account. Results show that some areas in Northeast China, North China and Northwest China would be abundant in green hydrogen supply potential and witness a stronger economic viability than the others. Furthermore, the proton-exchange membrane electrolyzer (PEM) production route is expected to achieve cost parity compared with the alkaline electrolyzer (ALK) production route in 2060, with the weighted-average levelized cost of hydrogen (LOCH) reaching about 1.4 USD/kg H_2 to meet the accumulative supply potential of 150 Mt H_2/yr.

On the other hand, this study assesses China's maximum end-use diffusion potential for green hydrogen in the industry sector based on current industrial layouts and plant-level techno-economic attributes of 2038 industrial plants, covering blast-furnace ironmaking, cement clinker manufacturing, ammonia synthesis, petroleum refining, methanol production, coal-to-liquids, coal-to-gas, coal-to-olefins and coal-to-ethylene glycol. Results show that a total end-use diffusion prospect of 108.9 Mt H_2/yr is identified for 313 hydrogen hubs, which presents a significant sectoral disparity and regional heterogeneity. Generally, East China enjoys relatively balanced shares for various kinds of hard-to-abate industries, while other regions tend to be particularly outstanding or weak in specific categories.

Making the most of the insights gained from the above analysis, this study classifies all the hydrogen hubs into 4 groups, namely the low-hanging fruit, the spare sources, the spare sinks and the free riders, with the individual LCOH and self-sufficiency of each hydrogen hub taken into account. Finally, a top-level strategy for scaling up shared hydrogen infrastructure networks is proposed considering various kinds of roles performed by these hydrogen hubs, which emphasizes the promotion of research, development and demonstration (RD & D) in the low-hanging fruit, the encouragement for technology transfer from the low-hanging fruit to the spare sources or sinks, and the support for establishing large-scale shared infrastructure networks.

Overall, this study assesses China's green hydrogen supply and end-use diffusion in hard-to-abate industries for the first time. By carefully analyzing the future LCOH trend, sectoral disparity and regional heterogeneity, this study preliminarily reveals a panorama of the hydrogen supply-demand layouts, which may be conducive for policymakers and enterprises to design and implement support measures for hydrogen deployment in a more targeted manner.

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