Societal Penetration of Hydrogen into the Future Energy System: Impacts of Policy, Technology and Carbon Targets

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Under the Paris Agreement, rapid decarbonization of the energy system is a central tenet of limiting global temperature rises to within 2 degrees Celsius of pre-industrial levels and is critical toward limiting rises to under 1.5 degrees. According to the Intergovernmental Panel on Climate Change (IPCC), limiting global warming to 1.5 degrees implies net zero carbon dioxide emissions by the year 2050 incorporating a reduction in energy demand, decarbonizing electricity and other fuels, greater levels of electrification and complementary carbon dioxide (CO_2) removal activities. Under the auspices of the Paris Agreement, participating nations commit to reducing CO_2 through Nationally Determined Contributions (NDCs). These contributions vary by nation and incorporate the need to reach a global peak in greenhouse gas (GHG) emissions, followed by rapid reductions, cognizant of a difference in reduction capacity and parameters for developed and developing nations in achieving overall commitments.

The shift away from fossil-derived fuels will require their replacement with renewable alternatives, some of which are intermittent in nature, requiring augmentation of the electrical grid and measures for storage to ensure stability. Hydrogen has the potential to play a role in meeting this need, and the emergence of a 'hydrogen economy' through a number of decarbonization strategies including a reduced reliance on fossil fuels. While hydrogen may play a role in the future low-carbon energy system, no single solution is expected to meet global decarbonization targets. A combined approach, incorporating the continued use of fossil fuels alongside carbon capture and storage (CCS), and, potentially, negative emission technologies is most likely to engender a successful outcome.

The aim of this study is to employ a global energy economics optimization model to determine the potential societal penetration of hydrogen into the future energy system. This study identifies both production sources and use cases for hydrogen, considering the impacts of policy, geography, technology maturation and carbon targets to develop a timeline and scope for the future hydrogen economy.