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Study on global hydrogen demand-supply including detailed industry sectors using the energy model GRAPE

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Abstract

Being an energy carrier that does not emit CO2 when used, hydrogen has considerable potential to contribute to the decarbonization of the sectors in the global energy system. Since the carbon neutrality targets have been set from the viewpoints of climate change, this nature has made hydrogen a special focus of attention in terms of decarbonization. Although there are numerous competing technologies to provide heat and power, the advantages of hydrogen in energy applications varies based on the features of each industry. The goal of this study is to better understand how constraints on CO2 emissions and other assumptions affect regional and global hydrogen demand.

The GRAPE model [1] is an integrated assessment model that consists of energy, land-use, economy, and climate change modules. This model aggregates the countries and regions into 15 regions. The GRAPE model analyzes energy demand-supply at global and regional levels for long-term including the amount of hydrogen demand until 2070. The model determines an energy supply-demand structure that meets CO2 emission constraints and other constraints so as to minimize the global energy system cost as the objective function as the linear programming.

Hydrogen is produced using the primary and secondary energy resources in each region from 2025 as well as imported from outside the region using hydrogen carriers such as liquefied hydrogen. The cost of hydrogen varies depending on the primary energy source used for hydrogen production, ranging from about 30 JPY/Nm^3 to 40 JPY/Nm^3 at the gate of the receiving terminal in Japan. Our previous study shows that the introduction of CO2-free hydrogen would improve energy security and other indicators under economic rationality [2].

In addition to the application of the GRAPE model to the hydrogen demand analysis, the energy supply-demand structure in Japan was analyzed using the TIMES-Japan model with detailed technology options [3]. The results of energy and hydrogen demand by technology in each sector were used as input data for the GRAPE model to obtain the global energy demand-supply structure.

The stationary sector, which is the non-electricity demand of the several industrial, building, and domestic sectors, was subdivided to consider the hydrogen demand in each subdivided sector such as steel and ammonia production. The results of sensitivity analysis and the influence of assumptions on hydrogen demand especially in the industrial sector will be presented at the workshop.

References

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