ROLE OF SYNTHETIC METHANE FOR THE CARBON NEUTRALITY AND THE TRANSITION IN GASEOUS FUELS

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Overview

For achieving carbon neutrality (CN), several kinds of options should be considered for cost-efficient measures. Hydrogen can be produced typically by renewables and fossil fuels with CCS, and will also be an important option in some countries including Japan. To increase more convenient uses of hydrogen, ammonia and synthetic fuels (synthetic methane and liquid fuels) will also play important roles. This paper focuses particularly on the role of synthetic methane for the CN and the transition in gaseous fuels. In order to quantitatively analyze the roles of the synthetic methane under several uncertainties not only in the technology improvements of methanation, but also in other technology improvements and social constraints, an integrated assessment model (IAM) which considers a number of technologies in energy supply and demand, and covers entire world until 2100 is employed. According to the analyses, synthetic methane is an important option with co-generation systems for achieving the CN by 2050, particularly in Japan. In many of the scenarios assumed in this study, synthetic methane will be a cost efficient measure, while electrification and hydrogen uses are also important. Overseas synthetic methane uses will decrease the emission reduction costs in Japan greatly. There are several pathways toward the CN in gaseous fuels, and it is important to consider the entire energy system for seeking economical measures .

Methods

Using a global energy systems model DNE21+ (Dynamic New Earth 21 plus), one of the IAMs, the emission reduction measures for carbon neutrality by 2050 are analyzed in this study. DNE21+ is a global model with consistencies across 54 countries and regions, and intertemporal years up to 2100 (see e.g., Akimoto et al. 2021). In the model, global warming response measures for approximately 500 specific technologies can be evaluated in detail; energy supply technologies, such as electricity, hydrogen-based energies such as hydrogen, ammonia, synthetic gas, and synthetic liquid fuel, and CO_2 capture, utilization and storage (CCUS), and energy demand-side technologies in iron and steel, cement, paper and pulp, chemical, aluminum, transport, and some appliances of

Table 1 Assumed scenarios for the sensitivity to the outlooks of methanation, hydrogen, and CCUS

Scenario	Technology assumption	CO_2 transport to overseas	DAC
[1] Domestic methanation	Domestic production of synthetic methane will be economically implemented due to the assumed conditions of no imports of synthetic methane	No	Yes
[2] Oversea methanation	Import of synthetic methane from overseas is a major methanation option.	No	Yes
[3] Mixed measures of CCUS	Larger potentials for CDR will help to offset domestic CO_2 emissions in the sectors which have high emission reduction costs, thanks to larger potentials to transport captured CO_2 to overseas as well as domestic CO_2 storage.	Yes: max. 91 $MtCO_2$/yr in 2050 for Japan	Yes
[4] LNG-CCU cycle	DAC is not available, and CO_2 storage potentials are smaller than those in other scenarios (maximum potentials of annual domestic CO_2 storage in 2050 is less by 20% compared with those in other scenarios). Importance of recycling CO_2 could be increased.	No	No
[5] hydrogen use	15% of hydrogen can be supplied by the existing city gas pipelines. 85% of total city gas consumptions should be supplied by hydrogen.	No	Yes
[6] New hydrogen infrastructure	85% of total city gas consumptions should be supplied by hydrogen through new hydrogen infrastructure including pipelines.	No	Yes
[7] Deep electrification	Building and transport sectors should be fully electrified.	No	Yes

building sector are modeled with bottom-up treatments. In gas sectors, gas co-generation systems are also modelled explicitly in the model. Comprehensive and quantitative analyses on energy systems across sectors, regions/countries, and time points can be conducted.

The global emissions for below 1.5 °C and net-zero GHG emissions by 2050 for major developed countries including Japan are assumed for all of the scenarios. In order to analyze the economic conditions particularly of synthetic methane in Japan considering the global energy systems, several scenarios are assumed as shown in Table 1. For all of the scenarios, the maximum share of nuclear power in 2050 is assumed to be 10% of total electricity in Japan. The maximum potential of CO_2 storage in Japan is assumed to be 91 $MtCO_2$/yr in 2050. In addition, higher cost reductions in renewables, and hydrogen and synthetic methane productions are assumed compared with those in the Reference scenario of the CN analyses in Akimoto and Sano (2021).

Results

Figure 1 shows the primary energy supply in Japan for the CN in 2050. There are no feasible solutions for the scenario [4], and the feasibility of this CO_2 recycling system will be very limited, because CO_2 works as a medium for hydrogen utilization and then recycling CO_2 and LNG which provides the CO_2 are limited. In all of the assumed scenarios except the scenario [4], deployments of synthetic methane will be economical in 2050 in Japan. In the scenario [1], large renewables and hydrogen imports can be observed, and a large part of them contributes to producing synthetic methane and synthetic liquid fuels within Japan. On the contrary, large amounts of synthetic methane will be imported from overseas in the scenarios [2] and [3]. Larger amounts of oil and natural gas without CCS in the scenario [3] can be observed than those in the scenario [2], thanks to the emission offset opportunities of DACCS including the CO_2 storage in overseas. The energy systems costs in 2050 in Japan in the scenario [3] are the lowest, and those in the scenario [2] are the second lowest among the assumed scenarios in this study. For example, the additional annual costs for the scenarios [1], [6], and [7] in Japan are 67, 43, and 104 billion USD/yr, respectively, compared to those in the scenario [3]. Each hydrogen direct use and deeper electrification is one of the CN options, however, synthetic methane options will bring cheaper opportunities for the CN, with effective uses of existing gas-related infrastructure.

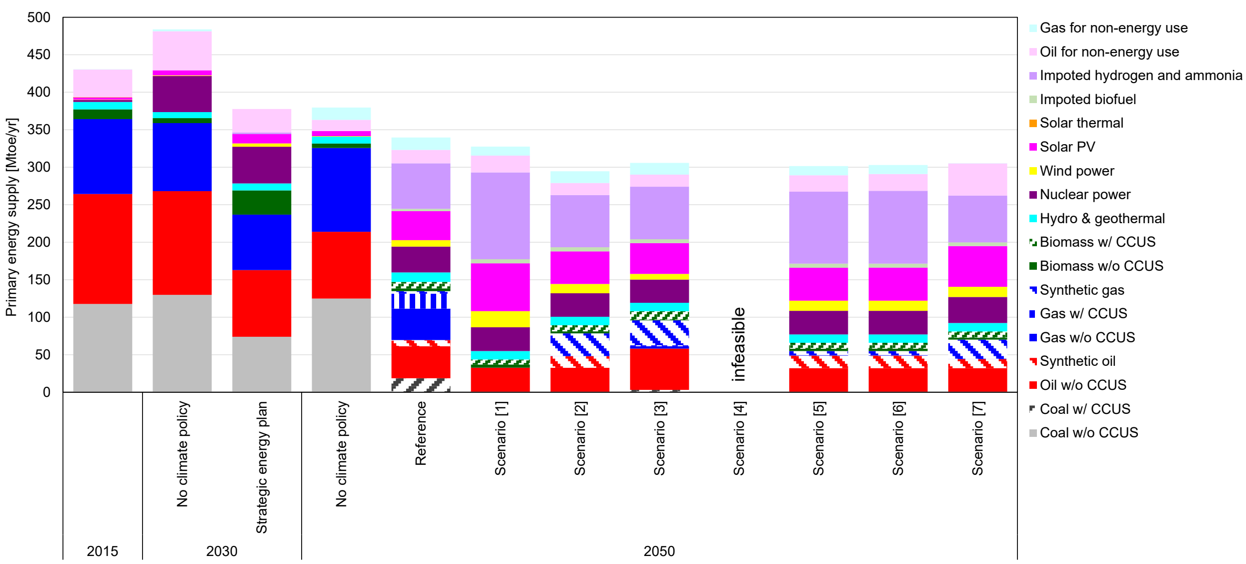

Figure 1 Primary energy supply in Japan for the CN in 2050 under the different assumed scenarios. "Strategic enegy plan" and "Reference" is provided by the Government of Japan, and Akimoto and Sano (2021), respectively.

Conclusions

There can be several kinds of options even for achieving the CN. According to the analyses by using an IAM, renewable energy will play a significant role in the achievement; however, CCUS will also play an important role. In addition to direct uses of hydrogen, synthetic methane including the imports from oversea will be a cost-efficient measure and contribute to the cost reductions for the CN in Japan.

References

Akimoto K. et al., (2021), Energy and Climate Change, 2.

Akimoto K. and Sano F. (2021). https://www.rite.or.jp/system/en/latestanalysis/2021/06/2050carbonneutrality.html