Power to Methane: Prospects and Challenges in Japan

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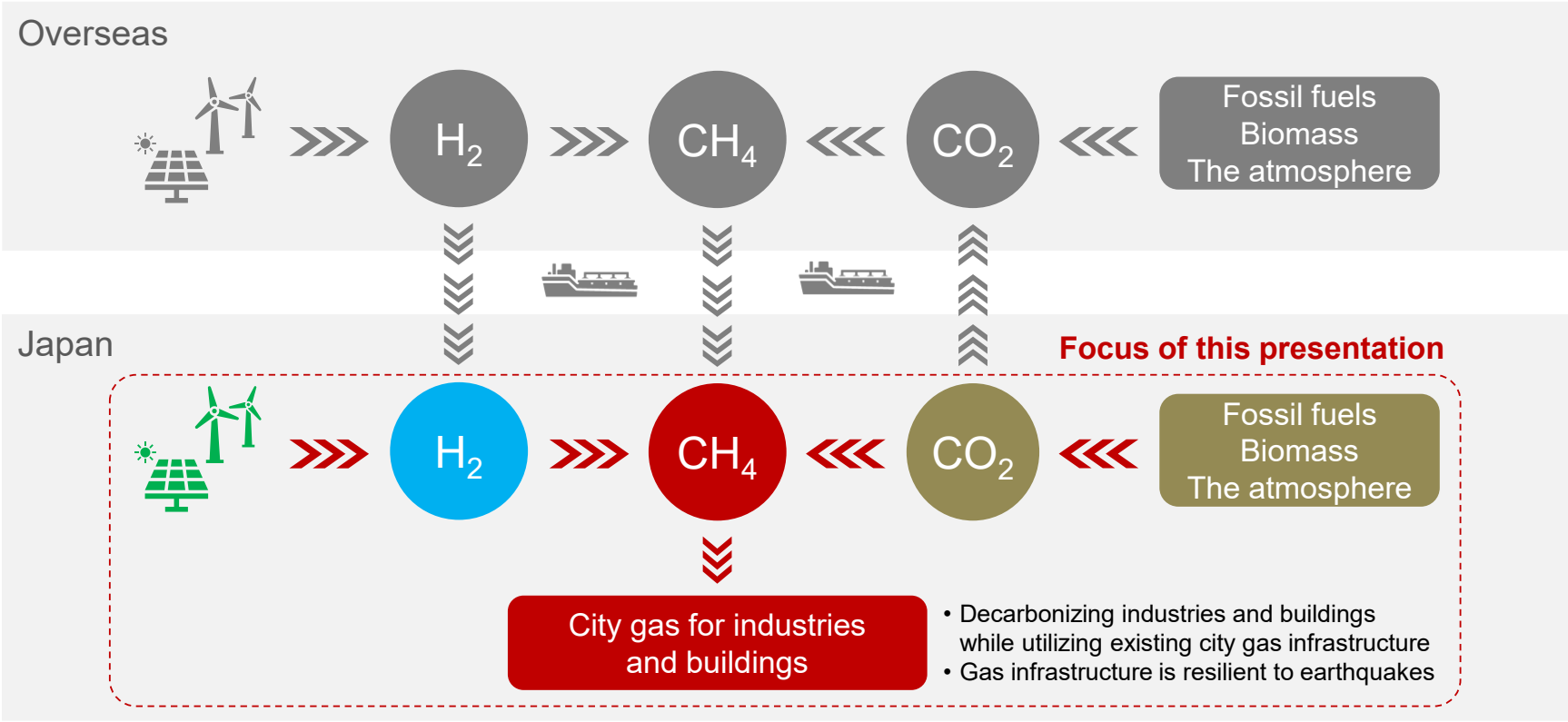
Concept of synthetic methane supply in Japan

- Synthetic methane is an option for decarbonizing heat use in industries and buildings.
  It is receiving much attention in Japan because of its compatibility with existing city gas systems
- There is a wide variety of methane synthesis systems: it can be produced in Japan or overseas.

Synthetic methane system



Source: IEEJ. Note: H_2=hydrogen, CH_4=methane.

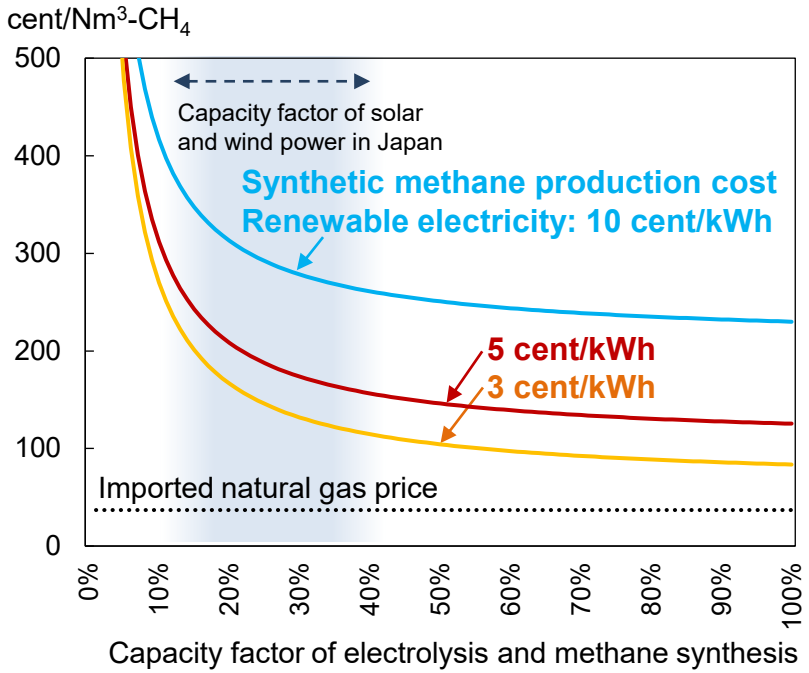
Production cost of renewable-based methane

- Low-cost renewable electricity and high-capacity factors of “Power to Methane” facilities are critical for producing synthetic methane with a cost-competitive advantage against imported natural gas
- Strong carbon policies improve the relative competitiveness of renewables-based methane

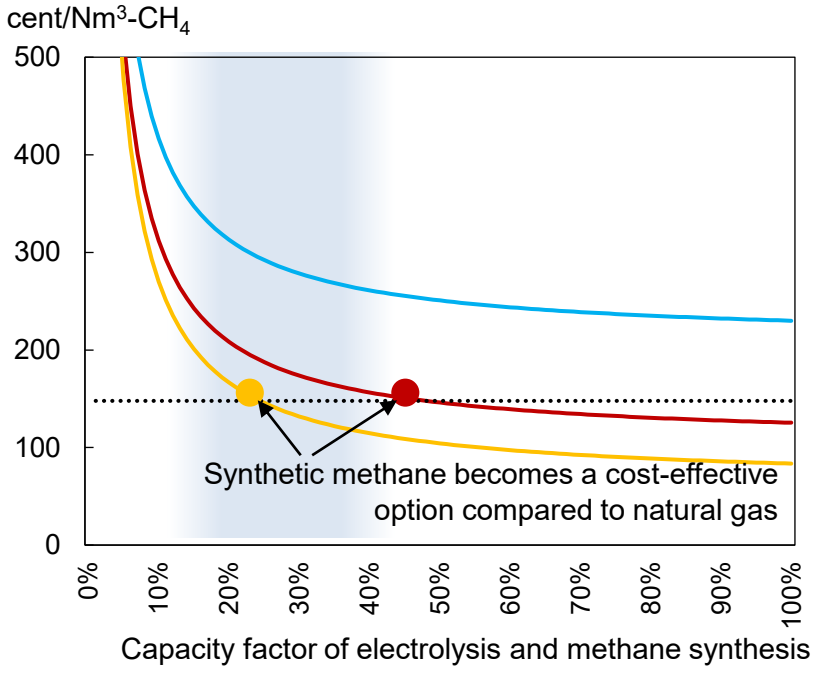
Synthetic methane production costs

Assuming water electrolysis and methane synthesis in Japan in the long-term

(a) Without carbon price



(b) Carbon price: 500 USD/tCO_2



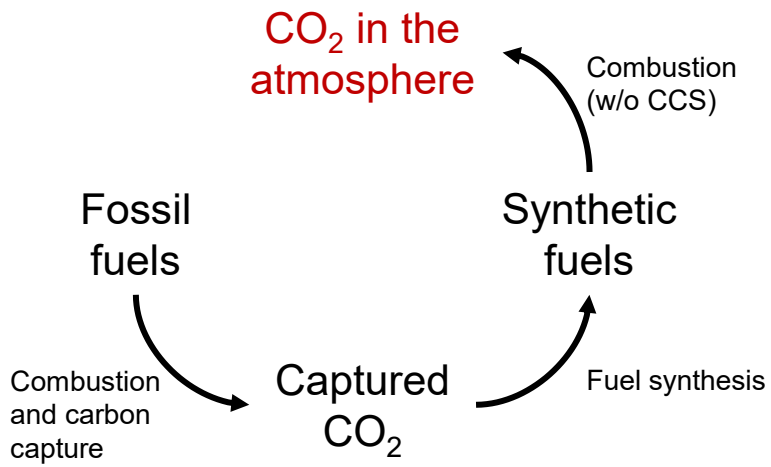
Source: IEEJ analysis. Assumed natural gas price is 37cents/Nm^3-CH_4 (about 10USD/MMBtu). CO_2 is assumed to be captured from the atmosphere. Cost assumptions are based on IEA “Future of Hydrogen”.

Source of carbon for methane synthesis

- The origin of carbon used for synthetic fuels would matter in achieving net zero emissions
- Even when re-used, CO_2 from fossil fuel combustions will eventually be emitted into the atmosphere. Carbon circulates by utilizing CO_2 from biomass combustion or the atmosphere.

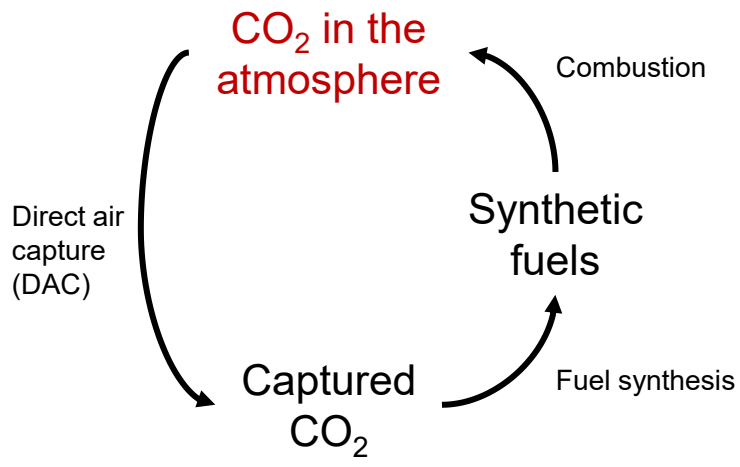
Carbon flow of a synthetic fuel system

(a) Carbon source: fossil fuels



- CO_2 from fossil fuels would be abundantly available at relatively low cost during the transition period
- Yet, it would face institutional challenges from CO_2 emissions accounting perspectives

(b) Carbon source: the atmosphere (DAC)



- Energy-related CO_2 emissions from this system can be net zero.
- Direct air capture consumes large amounts of heat and power. Thus, a decarbonized energy supply is critical.

Source: Otsuki & Shibata (2021), https://eneken.ieej.or.jp/data/9551.pdf (in Japanese), https://eneken.ieej.or.jp/data/9757.pdf (in English)

Conclusion

Synthetic methane is an option for decarbonizing heat use while utilizing existing infrastructure, although it faces challenges associated with cost and carbon source.

Low-cost renewable electricity and high-capacity factors of "Power to Methane" facilities are critical to produce renewables-based methane at a competitive cost

- Cost-competitive, dedicated renewable power plants for "Power to Methane" would be necessary for large-scale introduction. This will be a challenge for synthetic methane producers in Japan
- Curtailed electricity may be available at very low prices; yet it appears to be available only for limited hours in a year, resulting in a low-capacity factor

CO_2 from biomass combustions and the atmosphere would be important carbon sources for synthetic methane production in a carbon-neutral world

- Yet, biomass supply potential can be a barrier in Japan. Technological developments are necessary for direct air capture
- Carbon procurement strategies would be important; for example, utilizing abundant and low-cost CO_2 from fossil fuels in the transition period and shifting to the atmosphere in the longer-term

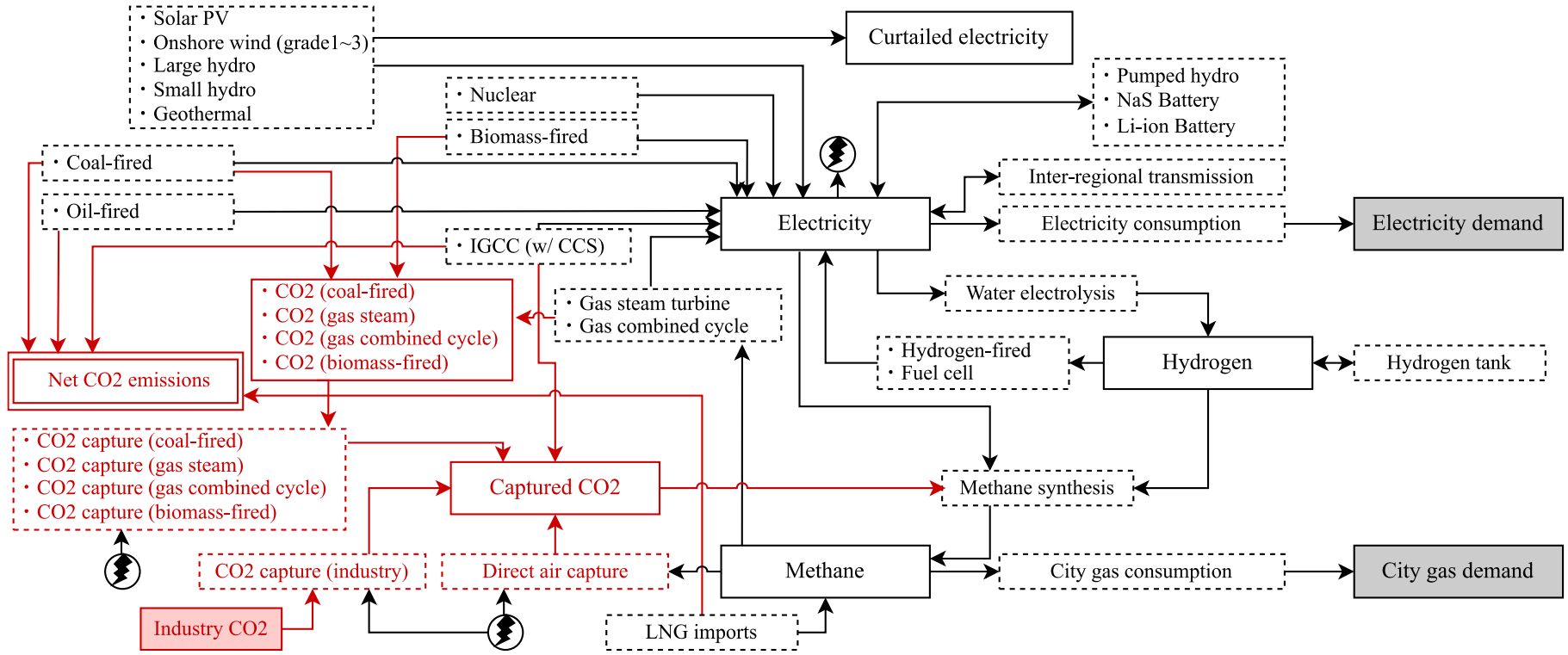
There is no "silver bullet" for Japan to achieve carbon neutrality. R&D and policy support for methanation are critical for broadening Japan's mitigation options

- Importing synthetic methane from renewable-rich countries would be another option for Japan

Modeling and analysis of synthetic methane in Japan

- Cost-competitiveness of water electrolysis and methane synthesis in Japan has been estimated using an electricity and city gas supply model (Otsuki & Shibata, 2020)
- Electricity and city gas supply is optimized on an hourly basis

Electricity and city gas supply model



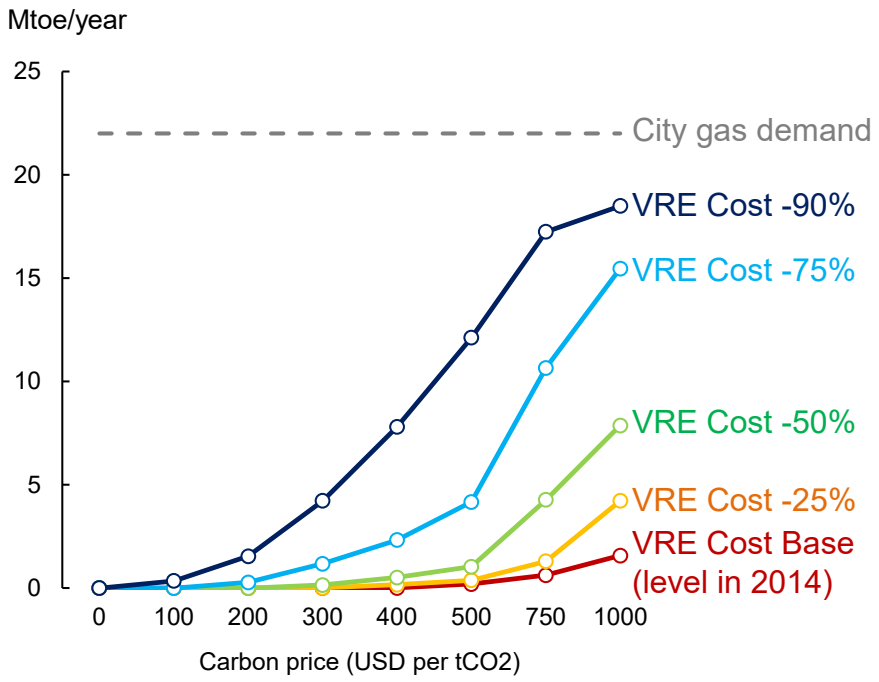
Source: Otsuki & Shibata (2020), “Prospects for Methanation in Japan: Techno-economic Assessment on a CO2 capture, Water Electrolysis and Sabatier Reaction System Using an Electricity and City Gas Supply Model”, https://doi.org/10.24778/jjser.41.6_266 (in Japanese)

Key simulation results

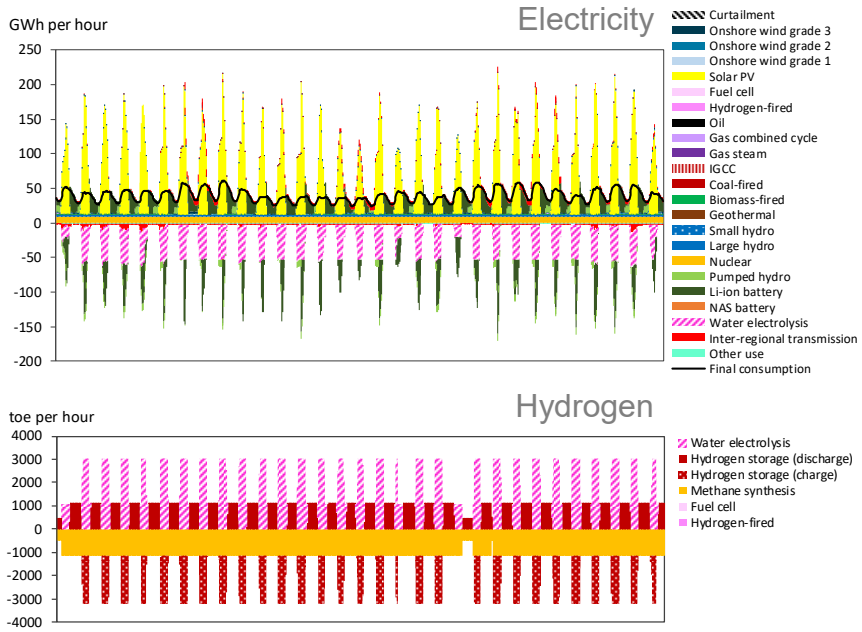
- Cost reduction of variable renewable energy (VRE) and high carbon prices (such as 75% cost reduction from the level in 2014 and 500 USD/tCO_2) would be crucial for boosting the deployment of methane synthesis in Japan

Simulation results

(a) Produced synthetic methane in Japan



(b) Electricity and hydrogen balance in May, Tokyo (VRE Cost -90% & 1000 USD/tCO_2)



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Thank you for your kind attention!

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