Economics and Roles of e-gas towards City Gas Decarbonization

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Yoshiaki SHIBATA

Senior Research Fellow,

Assistant Director and Manager, New Energy System Group

The Institute of Energy Economics, Japan

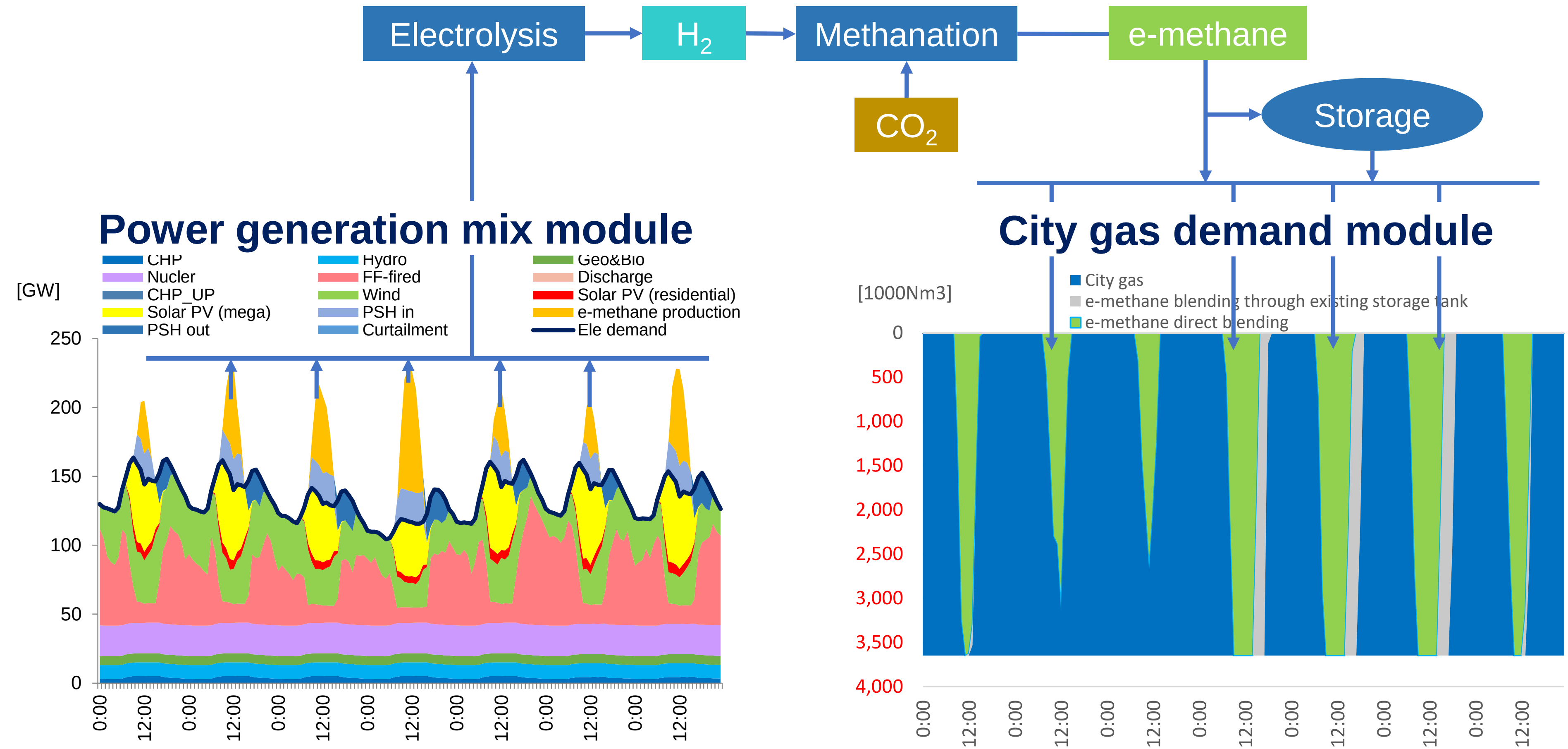
Introduction

- Why e-gas? e-gas = e-methane, synthesized from H_2 and CO_2
  - ✓ e-methane as carrier of hydrogen avoiding the risk of stranded assets of the existing city gas network.
  - ✓ Existing gas network for accommodating variable renewable energy converted to e-methane → Energy System Integration (Sector Coupling)

- This study
  - ✓ analyzes the economics of e-methane production from Japanese domestic renewable energy-derived hydrogen through hourly simulation model, and reveals the conditions that the domestic e-methane can be advantageous over e-methane produced from imported hydrogen.
  - ✓ discusses institutions required for e-methane, attribution of CO_2 emission reduction

Hourly Simulation

- Simulation model composed from power generation mix module and city gas demand module



Scenario

Variable Renewable Deployment Scenario

		Solar PV		
		100 GW	200 GW	300GW
Wind	30 GW			
	50 GW			
	100 GW		15 scenarios	
	200 GW			
	300 GW			

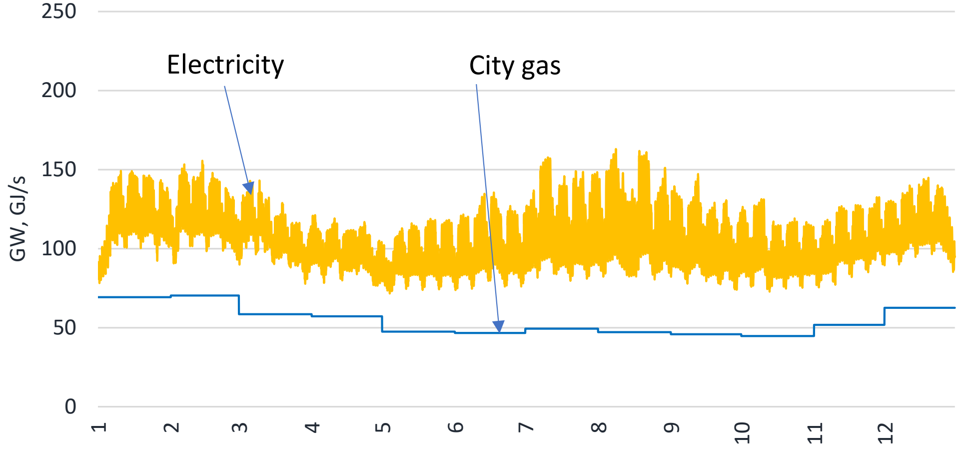
e-methane Blending Scenario

Acceptable calorific value of city gas (MJ/m^3)	Acceptable e-gas blending ratio (vol%)
39.8	100.0%
41.0	76.9%
42.0	57.7%
43.0	38.5%
44.0	19.2%
45.0	0%

Economics of e-methane Production

Assumptions

Hourly Profile of Electricity and City Gas Demand



Technical Performance

Electrolysis+Methanation	**18.0**	**kWh/Nm^3-CH_4**
Auxiliary	0.32	kWh/Nm^3-CH_4
Electricity for CO_2 capture	0.02	kWh/Nm^3-CH_4
Compressor (1MPa)	0.074	kWh/Nm^3-CH_4
Total	18.42	kWh/Nm^3-CH_4
Heat for CO_2 capture	3,549	kJ/Nm^3-CH_4
	(1,800)	MJ/t-CO_2

Storage Capacity of City Gas Infrastructure

Gas tank	**34**	**million Nm^3-CH_4**
Pipeline	38	million Nm^3-CH_4
Total	72	million Nm^3-CH_4

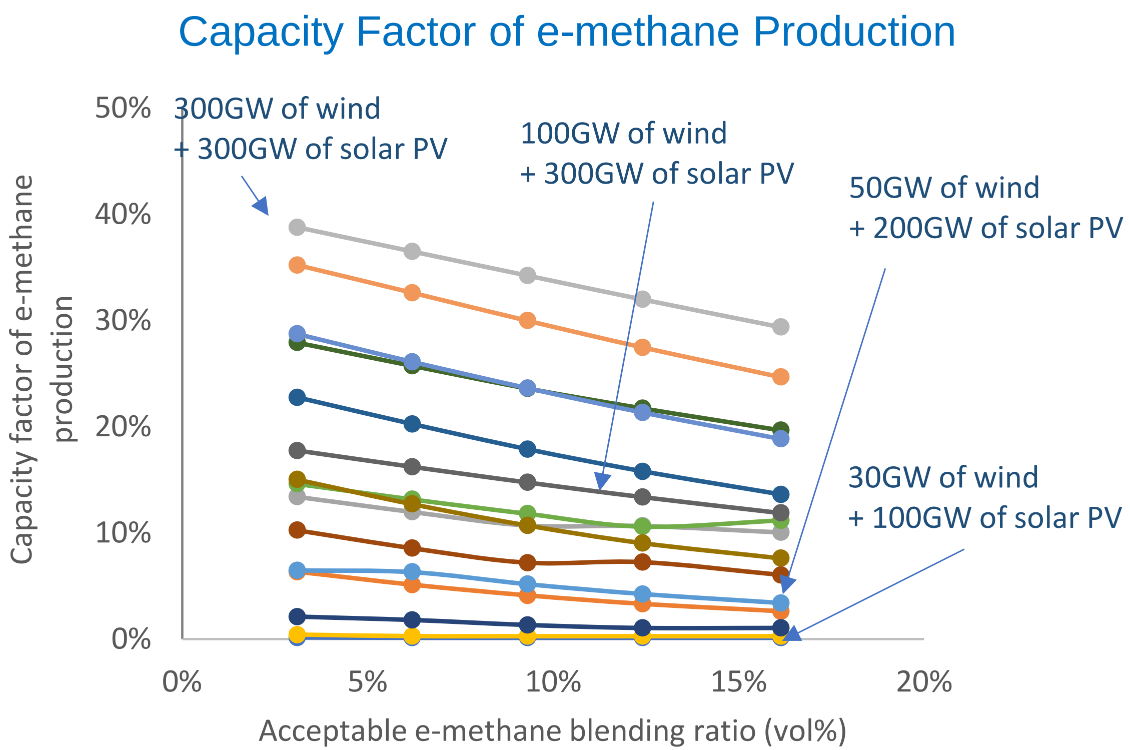
CAPEX

Electrolyzer	**215**	**1000JPY/(Nm^3-H_2/h)**
Methanation	500	1000JPY/(Nm^3-CH_4/h)
e-methane production	1360	1000JPY/(Nm^3-CH_4/h)
CCU (CO_2 capture and boiler)	134	million JPY/(t-CO_2/h)
	0.26	million JPY/(Nm^3-CH_4/h)

- Procurement cost of domestic renewable energy: JPY5/kWh (USD0.05/kWh)
- Imported hydrogen: JPY30/Nm^3-H_2 = JPY 330/kg-H_2 (USD3/kg-H_2)

Results

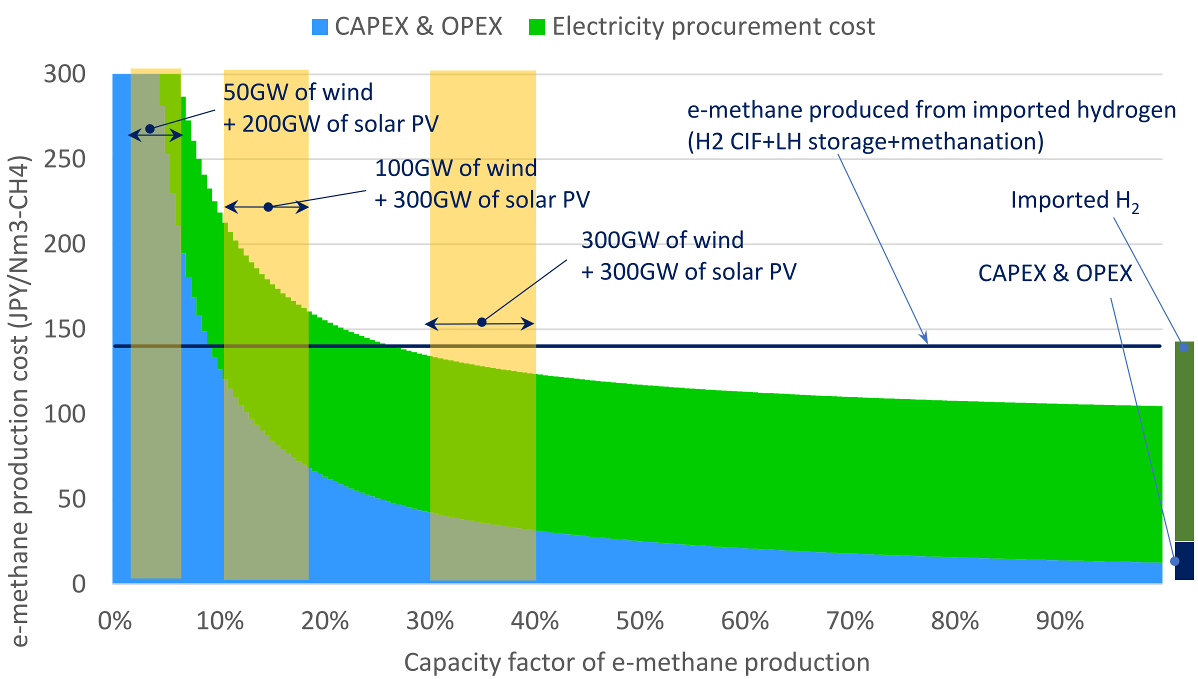
- The larger the scale of variable renewable energy deployment, the higher the capacity factor.
- The higher the acceptable e-methane blending ratio, the lower the capacity factor: larger capacity of e-methane production is required to meet the maximum acceptable level of e-methane.



Results

- The higher capacity factor derives from two factors; 1. increasing amount of variable renewable energy causes large scale surplus electricity. 2. capacity of electrolyzer and methanation can be minimized as determined by e-gas acceptability by city gas

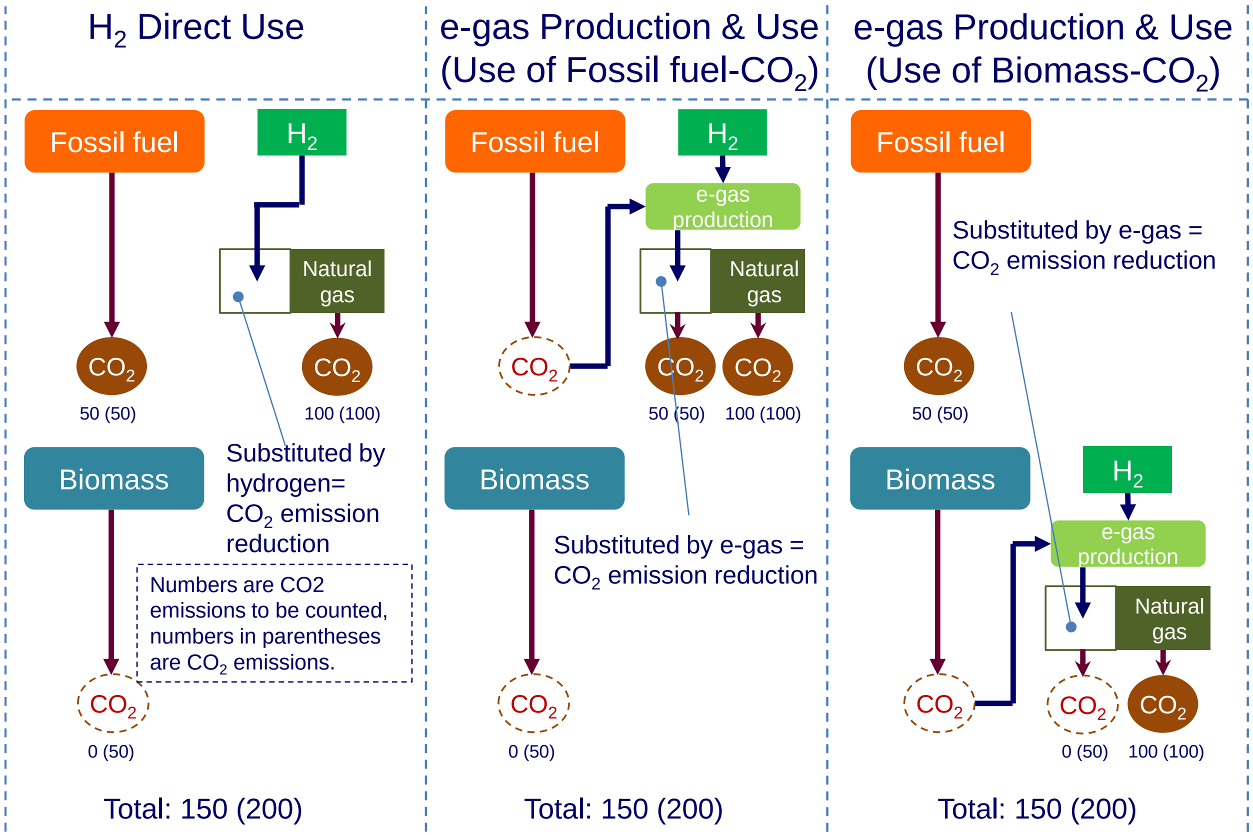
e-methane Production Cost



Note: The range of yellow shading means range of acceptable e-methane blending ratio.

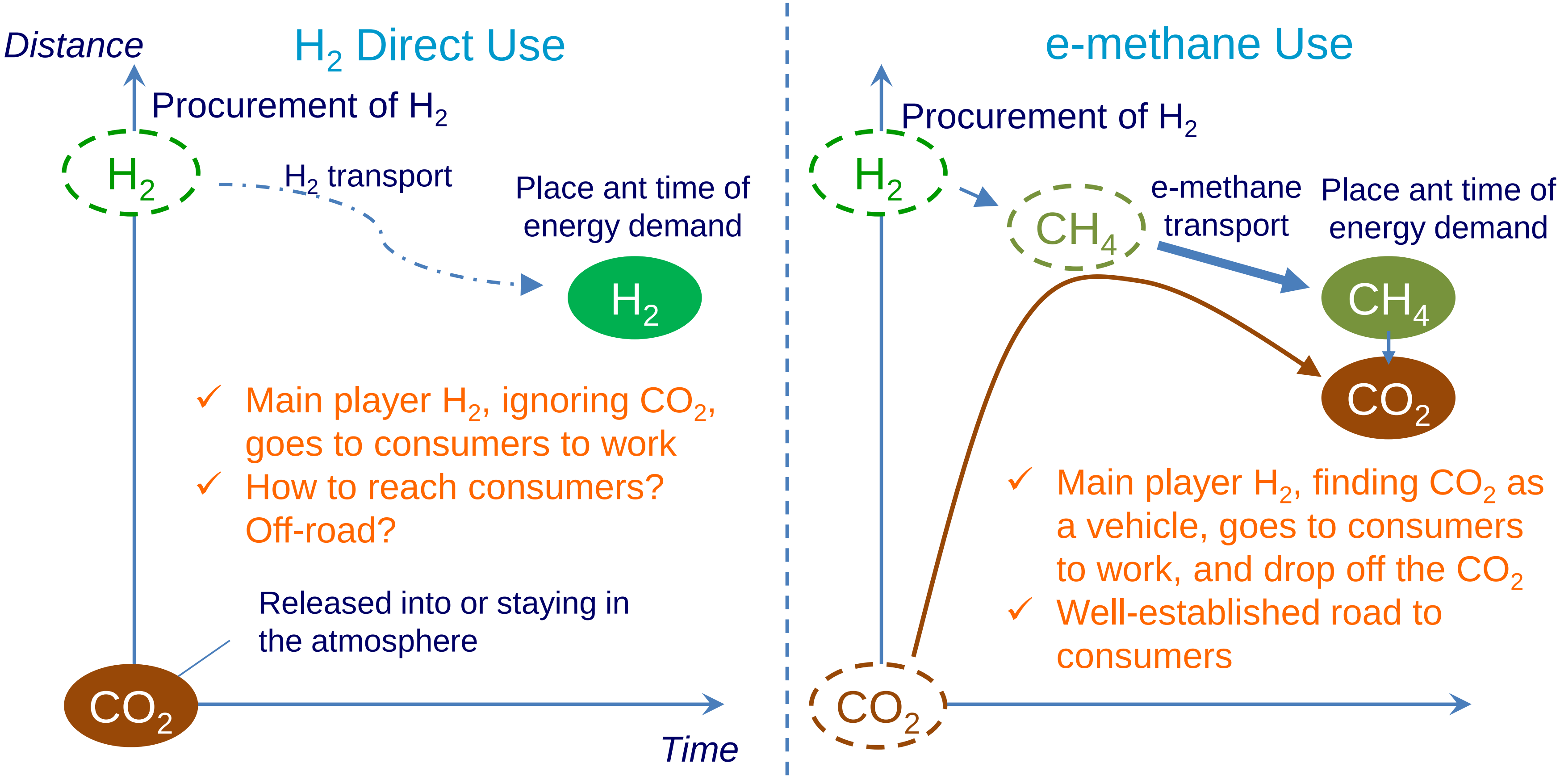
Revisiting the mechanism of e-methane

- Fundamental impact is not affected by the origin of CO_2 in producing and using e-methane. CO_2 emission reduction impact of e-methane is identical regardless of the origin of CO_2.



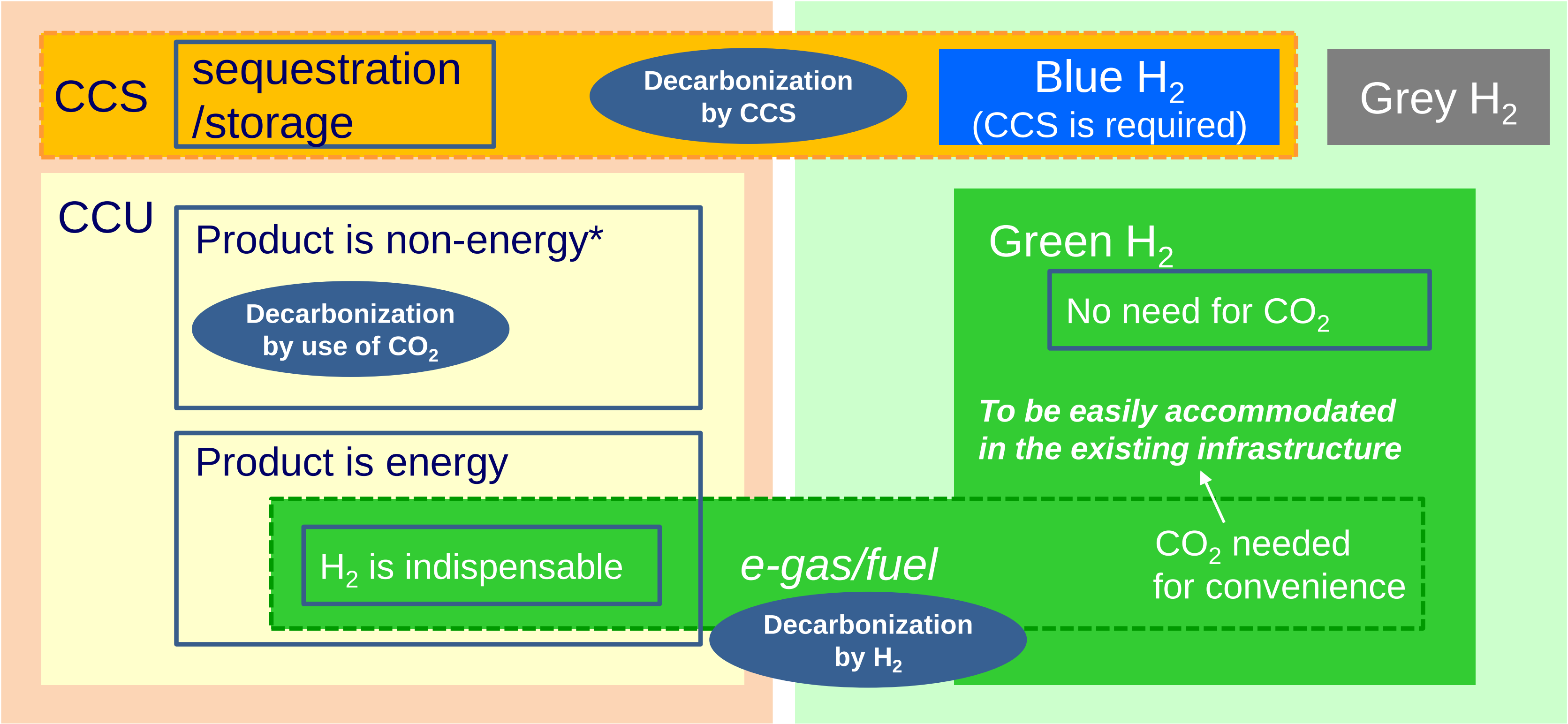
Revisiting the mechanism of e-methane

- e-methane is theoretically identical with hydrogen, e-methane is hydrogen carrier.



Categorization of CCS, CCU, Hydrogen and e-gas

- e-methane is theoretically identical with hydrogen, should NOT be categorized in CCU



* Most of chemicals require both of carbon and hydrogen

CO_2 Emission Reduction Attribution of e-methane

Q: Who contributes to the CO_2 emission reduction from e-methane?

A1: All for CO_2 emitter-provider

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- Unrealistic, as there is no incentive for e-methane producers/users.
- This may cause lock-in of fossil fuel use in CO_2 provider, in spite of the fact that there is no CO_2 emission reduction from CCU in e-methane production

A2: Shared between CO_2 emitter-provider and e-methane user

△ ?

- This may cause lock-in of fossil fuel use in CO_2 provider, in spite of the fact that there is no CO_2 emission reduction from CCU in e-methane production
- No theoretical grounds for allocation

A3: All for e-methane user

○

- H_2 is the main player and CO_2 is mere a supporting player in e-methane (e-methane = H_2)
- The logic that users of H_2 (= users of e-methane) contribute to CO_2 emission reduction is rational.

Summary

- Domestic renewable e-methane can be competitive with e-methane from imported hydrogen, if larger-scale renewable energy is deployed.
- Importing e-methane can be different option, using the existing LNG supply chain.

- e-methane is hydrogen carrier and "e-methane = H_2", which means no matter which CO_2 is used to produce e-methane. CO_2 is just captured, used and reemitted.
- CO_2 emission reduction by e-methane is = that by H_2. So, clearly all of the reduction is attributed to e-methane user, not CO_2 provider.
- e-methane's advantages lie in the fact that the existing infrastructure can be utilized.

Thank you

yoshiaki.shibata@edmc.ieej.or.jp