ECONOMICS AND ROLES OF E-GAS TOWARDS CITY GAS DECARBONIZATION

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Overview

Besides biogas whose potential is limited compared to city gas demand volume, hydrogen and hydrogen-based methane (e-gas) are expected as options to decarbonize city gas through blending. Although hydrogen blending into the existing city gas network is drawing much attention mainly in Europe, it has been pointed out that hydrogen blending poses various technological and institutional issues.[1)] In order to avoid these challenegs, e-gas blending into the city gas network is also being addressed mainly in Japan, as e-gas is the major feedstock of city gas. The existing study[2)] shows that e-gas offers an economic advantage over hydrogen that needs new infrastructure. The other study[3)] also reveals an economic advantage of CHPs (combined heat and power) that uses e-gas over batteries as a measure of grid flexibility required when large-scale of variable renewable energy are connnected to the power grid. These studies put the focus on domestic production of e-gas synthesized from hydrogen from domestic renewable energy with a background that the gas network are increasingly drawing much attention as provider of capacity for energy storage and flexibility to mitigate intermittency of variable renewables through producing and accomodting either hydrogen or e-gas from surplus renewable electricity. This concept is called the Energy System Integration through Power to Gas that is expected as an enabler of decarbonization of the whole energy system through renewable energy.

On the other hand, there is another option for e-gas procurement; producing from imported hydrogen. This study compares the economics of e-gas production from domestic renewable energy-derived hydrogen and e-gas production from imported hydrogen. Based on the comparison, the conditions that the e-gas production from domestic renewable energy-derived hydrogen can be advantageous would be revelaed.

In addition to the above comparative economic analysis of e-gas, one of the most crucial institutional issues that may hamper the promotion of e-gas will be addressed. Due to the facts that the process from production to utilization of e-gas overstrides two technological fields, hydrogen and CCU (Carbon Capture and Utilization), and that CO_2 is inevitably reemitted upon utilization of e-gas, interpretation of the attribution of CO_2 emission reduction from e-gas would cause controversy. This study will discuss how rational institutions for promotion of e-gas should be structured.

Methods

The simulation model developed in the existing study[3)] is employed to figure out the economics of e-gas production from domestic renewable energy-derived hydrogen. This model is composed of power generation mix module and city gas demand module. The power generation mix module simulates hourly surplus electricity to be used for hydrogen production followed by e-gas production. The city gas module identifies the hourly e-gas volume that can be blended into city gas network. Scenarios are set for capacity (GW) of variable renewable energy (solar photovoltaics and wind), and city gas calorie tolerance that specifies acceptable e-gas volume. For the sake of simplicity, it is assumed that Japan is a single node. The CO_2 to be used for e-gas production comes from gas-fired power generation and biomass power generation, which are identified through the power generation mix module, and also from intensive large-scale industries[2)]. The CAPEX and OPEX for electrolyzer, methanation and carbon capture and electricity procurement cost are assumed. For the e-gas production from imported hydrogen, imported hydrogen cost is assumed.

Regarding rational institutions for promotion of e-gas, needs for revision of the current international CO_2 accounting scheme and new rules are proposed by revisiting the mechanism of e-gas and classifying hydrogen and CCU technologies from scientific approach. CO_2 procurement starategies for e-gas are also proposed.

Results

Results from the simulation observe that in the range from "300GW of solar PV + 100 GW of wind" to "300GW of solar PV + 300 GW of wind", a point where the cost of e-gas production from domestic renewable energy-derived hydrogen can compete with e-gas production from imported hydrogen exists. This is due to higher capacity factor of electrolyzer and methanation. The higher capacity factor derives from two factors. One of the factors is that increasing amount of variable renewable energy causes large scale surplus electricity. The other one is that capacity of electrolyzer and methanation can be minimized as determined by city gas calorie tolerance. However, it should be noted that the simulation results are highly dependent on the assumptions mainly on electricity procurement cost and imported hydrogen cost that have still uncertainty.

Based on the scientific clarification, the mechanism of e-gas is that; e-gas is synthesized from hydrogen and CO_2 that is captured from certain facilities. As the CO_2 that is emitted through the use (combustion) of e-gas is offset with the captured CO_2, the substitution of natural gas through the use of e-gas is the CO_2 reduction impact. In other words, as CO_2 is only captured, utilized, and re-emitted, the use of e-gas is essentially identical with the use of hydrogen. Accordingly, CO_2 emissions from e-gas are not problematic. Looking at this aspect from different point of view, it is obvious that the CCU process involved in the e-gas production and utilization does not have any CO_2 emission reduction impact as the CO_2 is eventually released into the atmosphere. Only hydrogen contributes to the CO_2 emission reduction. This can be interpreted that the CO_2 emitter-and-provider for e-gas production cannot have any CO_2 emission reduction and all of the CO_2 emission reduction impact can be attributable to the e-gas produer/user. Meanwhile, there might be an interpretation that e-gas cannot be realized without cooperation from CO_2 emitter-and-provider and so that the CO_2 emission reduction impact should be shared between CO_2 emitter-and-provider and e-gas produer/user. However, it should be noted that institutions established based on this interpretation may lead to lock-in of fossil fuel use for only producing e-gas, in spite of the fact that there is no CO_2 emission reduction impact from the CCU in the process of e-gas production and utilization. According to these analyses, it is highly recommended that e-gas producers should have their own CO_2 resources, either biomass or DAC (Direct Air Capture) facilities, in order to avoid these complicated discussions on attribution of CO_2 emission reduction.

Conclusions

The role of e-gas exists in how to transport and deliver hydrogen to the users while avoiding stranded assets of the existing city gas network. At the same time, the fact that the existing gas network can relatively easily accommodate renewable energy converted to e-gas should be emphasized. This is exactly a concept of Energy System Integrartion. Although cost reduction of renewable energy should be achieved to realize the Energy System Integrartion through e-gas, it should be remembered that the domestic e-gas production and utilization can bring about advantages in improvement in resiliency and energy security. Meanwhile, in order for e-gas to be introduced into the existing city gas network, there still remains complicated discussions on the attribution of CO_2 emission reduction. Recommended strategies for e-gas producers would be to secure their own CO_2 resouces such as biomass or DAC.

References

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