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Key Points on the Use of Hydrogen and Ammonia for Power Generation

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As the world heads toward decarbonization, there are growing expectations for ammonia co-firing in coal-fired power generation. Sometimes criticized as a way to extend the life of coal-fired power, co-firing with ammonia reduces coal consumption and thus decreases CO_2 emissions. It is a means to gradually decarbonize while effectively utilizing existing coal-fired power plant infrastructure. The same is true for hydrogen co-firing in gas-fired power generation.

At first glance, this logic may appear to be correct. However, some aspects of using hydrogen and ammonia for power generation require careful thought, including where and from what source are hydrogen and ammonia produced and transported. The following presents a general discussion of these issues regardless of country or region.

The first approach is to use domestic blue hydrogen and ammonia for power generation in any country. For this to happen, CCS must be feasible in the relevant country, and two methodologies must be compared: using coal- or gas-fired power plants as they are but with a CCS system installed, and introducing hydrogen or ammonia production equipment, a CCS system, and a co-firing or mono-firing plant. Since CO_2 concentration is higher in the latter, in which CO_2 is separated and captured before combustion, than in the former, in which the process takes place after combustion, the CO_2 separation and capture costs may be lower for the latter. However, the former is considered to be more economical, as the latter requires additional capital investment for hydrogen or ammonia production and co-firing or mono-firing with hydrogen or ammonia, in addition to having lower overall conversion efficiency.

The next approach is to use domestic green hydrogen and ammonia for power generation in any country. In this case, it is obviously more economical to use renewable energy as electricity as it is to curb the consumption of fossil fuels for thermal power generation. Suppose that the CO_2 reduction effect of using renewable electricity directly is 100; the figure drops to about 50 when renewable electricity is converted to green hydrogen and then used to generate power, and to just 30 or so when it is converted into green ammonia for the same process.

It may also be possible to produce green hydrogen and ammonia from surplus or unused renewable energy, and to use them as fuel for power generation to decarbonize the synchronous power generation needed to balance supply and demand. In this case, however, it is necessary to verify the minimum necessary amount of synchronous generation for a variety of balancing capacity options available. Another possible usage of green hydrogen and ammonia is, if the domestic power grid is not adequately developed, to convert renewable electricity into those energies and transport them from distant areas as fuel for power generation; but whether to adopt this methodology should again be determined by comparing its economic efficiency with that of power grid enhancement. In any case, the option of using green hydrogen and ammonia derived from domestic renewables for power generation should be considered only after fully utilizing renewable energy in the form of electricity, and should not be selected if a country is still expanding its renewable energy capacity. We should also not forget biomass co-firing in coal-fired power as an option for decarbonizing synchronous power generation.

Japan is increasingly considering providing support for ammonia co-firing for coal-fired power generation and hydrogen power generation to countries seeking to introduce renewables, even though it is clearly not rational in terms of conversion efficiency as the above examples indicate.

The concept of using hydrogen and ammonia for power generation originated from circumstances unique to Japan. In Japan, where both renewable energy and CCS resources were deemed to be scarce, it was considered necessary to import large quantities of hydrogen to decarbonize the power supply. This gave rise to the idea of co-firing of ammonia, which is one type of hydrogen carrier, without converting it back into hydrogen because its combustion characteristics are similar to those of pulverized coal.

The most rational way to use hydrogen and ammonia varies depending on a country's circumstances. The use of hydrogen and ammonia for power generation arose from Japan's unique circumstances and therefore cannot be applied to other countries unconditionally. Japan must support other countries in using hydrogen and ammonia in a way that is rational for the particular country, taking into account the availability of renewable energy resources and CCS resources, as well as energy conversion efficiency and the possibility of introducing CCS. Many countries are expected to introduce renewables to the maximum extent possible for the time being for the further purpose of energy security. It may also be important to help other countries to establish a power-to-gas system as a means to integrate renewable energy into the grid, while considering the different roles to be played by batteries. The system uses water electrolysis to absorb surplus electricity and to provide balancing capability, and supplies the produced hydrogen to the demand whose emissions are hard to abate through electrification, such as high-temperature heat demand of industry. Japan is already beginning to fall behind the U.S. and Western countries in these areas; it must exercise strategic thinking in order to reduce the cost of hydrogen and ammonia it imports by helping other countries build power-to-gas systems.

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