Chapter 4

Conclusions

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Conclusions

1. The Potential of Fuel Ammonia Will Keep Growing

In the energy sector, ammonia was originally intended to be used as a 'carrier' or a means of hydrogen transport. However, with a technology that allows direct combustion without cracking into hydrogen and nitrogen, the cost of co-firing in coal-fired power plants has become much lower, and ammonia's potential as a fuel has greatly expanded. As of June 2022, two coal-fired power plants in Japan are conducting demonstration tests of 20% co-firing. Furthermore, there is also a plan to increase the co-firing rate to 50% soon. If coal-fired power plants can raise their co-firing ratio to 50%, their carbon intensity will be on the same level as that of gas-fired power plants, and their value as a low-carbon power source will be significantly enhanced. This study mainly examined the potential of ammonia as a fuel for co-firing in power plants (coal-fired power generation). However, ammonia can also be used as a fuel for industrial heat and maritime transportation; thus, its demand potential will not be limited to power sector use.

Power demand in Asia is highly likely to keep growing in ASEAN countries. Several existing coal-fired power plants, on the other hand, have been built in recent years, and the average age of the coal power generation units is young in Asia. While coal-fired power plants should be closed as early as possible to achieve carbon neutrality and avoid catastrophic economic impacts caused by climate change, ASEAN countries could not afford to close such younger units without fully utilising and recovering their investment cost. However, it is challenging to substitute coal power generation units with zero-emission power sources, such as renewable and nuclear, and to develop incremental new generation capacities to meet the growing demand. Therefore, it is a realistic option to keep using existing coal-fired power plants with as few GHG emissions as possible. In this regard, co-firing ammonia with coal at existing units can perfectly meet this goal. Therefore, ammonia co-firing is an indispensable technology for ASEAN countries to achieve carbon neutrality in the future.

2. Addressing the Challenges to Fully Cultivate the Benefits of Fuel Ammonia

To fully enjoy the potential benefits of utilising fuel ammonia in ASEAN, several challenges need to be overcome.

First, the biggest challenge is the development of large-scale infrastructures for the use of ammonia as a fuel. Those infrastructures will include, but not be limited to, the ammonia production plant and storage facilities, berths and loading facilities for ammonia loading, large ammonia tankers for long-distance international transport, unloading and storage facilities at receiving sites, and replacement of existing burners for co-firing operations. In addition to these infrastructures, in the case of blue ammonia, made from fossil fuels, CCS facilities to capture the CO_2 generated during production and underground storage also need to be developed. During the introduction phase of ammonia, existing infrastructures for fertiliser production can be utilised. But once a full-scale introduction to the power sector begins, infrastructure for fuel ammonia must be developed from scratch to minimise the impact on the existing ammonia supply chain and market. Because such investments will take time, early investment decisions are necessary to utilise fuel ammonia quickly.

Second, supply cost must be reduced. This study shows that fuel ammonia is still expensive compared to existing fuels. Although the supply cost of ammonia is expected to decrease through economies of scale, learning curve effects, and logistics optimisation, a considerable cost reduction is still required to make it affordable for many ASEAN countries. In this regard, policy support will be necessary for consumer countries to promote the adoption of ammonia. For example, many countries currently adopt a feed-in tariff system to introduce renewable energy into their power generation mix. Similar policy support can be arranged for fuel ammonia because it is also a zero-emission fuel like renewable energy.

Third, HSE (health, safety, and environment) in ammonia supply must be ensured. Ammonia is a toxic substance and must be handled with great care by operators with specialised knowledge. Ammonia also has an odor, so sufficient leakage prevention measures must be taken. Ammonia is a commodity globally traded as a feedstock for fertiliser production and is utilised without serious HSE problems. When ammonia is used to generate power, a larger amount than when it is used as a feedstock for fertiliser must be transported and handled. However, the fertiliser manufacturing plants have already established appropriate standards and procedures to process ammonia safely, and such existing practices can be referred to and

adopted for power generation. In addition to toxicity and odor issues, ammonia is also known to increase NO_x emissions. But NO_x emissions can be controlled by devising an optimal combustion mode and installing an additional denitrification facility if needed. The knowledge and expertise on the proper combustion and control of the emissions will be accumulated as its operation continues.

Fourth, the impact of fuel ammonia used on other related product markets must be minimised. Since the Asian population is expected to continue to grow, demand for ammonia as a fertiliser feedstock is also expected to increase. In this context, if ammonia demand rises as fuel increases, competition over ammonia supply may occur between the fertiliser and power sectors. The adverse effects of this unwanted competition must be minimised. As for ammonia demand in the power sector, many countries will adopt policies to introduce ammonia for power generation with some numerical targets set. Its demand thus can be forecasted with a certain degree of certainty. In the future, the outlook for future ammonia demand must be regularly reviewed, and the results shared internationally so that the supply chain can be developed in a manner commensurate with future demand and avoid unwanted effects on the entire ammonia market.

3. Future Tasks

This study was not able to fully examine several important research items, which should be left for future research.

First, the ammonia supply potential in the ASEAN region needs to be elaborated more in detail. This study covered ammonia supply projects in the Americas, Australia, and the Middle East, but did not examine the production potential in the ASEAN region. In the future, fuel ammonia production may become more active in ASEAN because of domestic industrial development and energy security. Although the cost of production in ASEAN may be higher than in the Middle East or Australia, several governments in the region have expressed interest in strategically increasing ammonia production in the future as a domestically produced zero-emissions fuel. The production potential of hydrogen in each country must also be assessed to determine the production potential of ammonia in each country. Energy policymakers in the region will be highly interested in such a detailed assessment of hydrogen and ammonia potential in ASEAN.

Second, the economic evaluation of ammonia co-firing should be further expanded and detailed. In this study, only an economic evaluation of coal co-firing was conducted. But it is highly likely that co-firing with natural gas–fired power plants and mono-firing of ammonia will be introduced. Further detailed analysis is needed to determine the cost advantages (or disadvantages) of these various forms of ammonia use compared to, for example, renewable energy plus storage batteries or natural gas combined cycle power generation with CCUS.

Third and finally, a policy framework for promoting the introduction of ammonia should also be evaluated. Simply leaving it to market mechanism will not bring hydrogen and ammonia to the market. In the same way, governments adopted generous introduction policies when introducing renewable energy, government policy intervention is essential when introducing fuel ammonia. For example, a contract for difference policy, in which a specific price level or premium is set against the market transaction price, is being considered in Europe. The appropriate policy framework in the ASEAN context should also be explored in the future.