CREA
Centre for Research on Energy and Clean Air

SFO°C
Solutions for Our Climate

° Report

Threat of Toxic Substances

Increased Particulate Matter and Health Hazards from Ammonia Co-firing

SFOC
Solutions for Our Climate

Solutions for Our Climate (SFOC) is a nonprofit organization established in 2016 for more effective climate action and energy transition. SFOC is led by legal, economic, financial, and environmental experts with experience in energy and climate policy and works closely with domestic and international partners.

Date of Publication	May 2024
Authors	Jamie Kelly (CREA) Seokhwan Jeong (SFOC) Dongjae Oh (SFOC)
Assistant	Seoyoon Kim (SFOC)
Inquiry	Seokhwan Jeong / seokhwan.jeong@forourclimate.org
Design	Nature Rhythm

Threat of Toxic Substances

Increased Particulate Matter and
Health Hazards from Ammonia Co-firing

CREA
Centre for Research on Energy and Clean Air

SFOC
Solutions for Our Climate

Summary

The ammonia-blended power generation method of coal-fired power plants, which is being promoted by the Japanese and South Korean governments, is being used as a means to sustain coal-fired power generation, contrary to the slogan of "carbon-free power generation." According to the Korean government's plan, by 2030, 20% ammonia co-firing (based on calorific value) will be applied to existing coal-fired power generators, but the remaining 80% will still be used as coal fuel, which means that the greenhouse gas reduction effect will be only 20%. Ammonia co-firing in coal-fired power plants justifies the extension of the lifespan of coal-fired power. However, this transition has the potential to reduce GHG emissions a maximum of only 20 %, and could have a huge adverse effect on air pollution

Ammonia is a toxic gas that is known to cause breathing difficulties, lung disease, and genetic dysfunction when inhaled. If ammonia is mixed into a coal-fired power plant, some of the input ammonia can be released into the atmosphere without being burned, and considering the government's plan to use 11 million tons of ammonia as fuel per year, even if only 0.1% of ammonia is emitted, 11,000 tons will be released into the atmosphere.

In addition, ammonia is a precursor to fine dust that forms fine dust in the atmosphere. As a result of calculating the fine dust emission for the power plants where the ammonia co-firing plan was announced, it was confirmed that the fine dust could be increased by 85% compared to the existing one by ammonia co-firing. **In particular, in the Chungnam region, where power plants are concentrated, if ammonia co-firing proceeds as currently planned, the amount of fine dust emitted is expected to increase significantly from 5,512 tons to 8,430 tons, which is equivalent to the effect of the construction of four new coal-fired power plants in the Chungnam region.**

Despite the adverse greenhouse gas effects of ammonia co-firing and the health threat posed by fine dust, the Korean government is encouraging ammonia co-firing through various incentives and subsidies, and these risks are expected to become more certain if ammonia blended generators are bid in the clean hydrogen power generation bidding market to be held this year.

The government should scrap the plan to use ammonia in coal-fired power plants and move

forward with efforts to end coal-fired power generation by 2030 as soon as possible. It is necessary to accelerate the transition to a power system centered on renewable energy rather than extending coal-fired power generation and, at the same time, shift policy support to utilize green hydrogen and green ammonia produced through renewable energy in the large-scale transportation and industrial sectors.

Table of Contents

1. Domestic and international status of ammonia co-firing

Ammonia co-firing is a technology that mixes and burns ammonia as an alternative fuel to coal in operating coal-fired power plants. Globally, this technology is being led by Japan, due to government support, industry collaboration, demonstration projects, international partnerships, and policy frameworks, all aimed at advancing this technology to reduce greenhouse gas emissions from coal-fired power plants. Currently, Japan's ammonia co-firing policy is reportedly led by JERA, Japan's largest power generation company[1], and Ishikawajima Harima Heavy Industries (IHI), a manufacturer of power generation equipment. Currently, the Japanese government is conducting a demonstration of 20% ammonia co-firing for Hekinan Thermal Power Plant Unit 4 (1GW) from 2024. In accordance with the support policy of the New Energy and Industrial Technology Development Organization (NEDO), it aims to demonstrate 50% co-firing by 2030.

Under Japan's co-firing plan, ammonia demand is expected to be around 30 million tonnes per year by 2050[2], most of which is expected to be procured through imports. Japan's largest importers of ammonia - Mitsui & Co. together with Mitsui Chemical, IHI, and Kansai Electric Power - plan to introduce ammonia import facilities throughout the area around Osaka.

Japan is not only promoting ammonia co-firing power generation in its own country but is also promoting the expansion of the application of ammonia co-firing to Southeast Asian countries such as Malaysia, Thailand, the Philippines, and Indonesia. This has raised concerns not only from civil society organizations in Japan, such as Japan Beyond Coal and Kiko Network, but also from global expert organizations, such as Bloomberg New Energy Finance (BNEF), Transition Zero, and E3G.

Extending the lifespan of coal-fired power plants by co-firing them with ammonia instead of shutting them down early raises several environmental concerns. The first is the concern of enormous greenhouse gas emissions. To reach the Paris Agreement's 1.5°C target, South Korea needs to shut down coal-fired power plants early by 2030 and transition to renewable energy, but ammonia co-firing could eventually lead to longer lifespans for coal-fired power plants. This is because even at a 20% fuel co-firing, which is still in the technical demonstration stage, the coal-fired power plants will still emit 80% of greenhouse gases.

Second, ammonia is a hazardous substance that is classified as a toxic substance, and it is feared that it will further harm the areas with a high concentration of coal-fired power plants and the residents in the vicinity. Coal-fired power plants emit nitrogen oxides and sulfur oxides in the combustion process of coal. Due to the emission of such harmful substances, it seriously threatens the health of residents. In addi-

1 JERA: A joint venture between TEPCO Fuel &Power, a subsidiary of TEPCO and Chubu Electronics, with 50% of the capital each investing.

2 Announcement by the Ministry of Economy, Trade and Industry of Japan (2021)

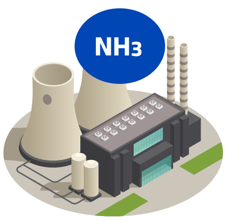
tion, there is concern that ammonia co-firing will cause additional health damage due to the leakage of ammonia, a toxic substance.

In the 2030 Nationally Determined Contributions (NDC) announced in October 2021, Korea plans to increase ammonia power generation to 3.6% (22.1 TWh) of total power generation by 2030. "Ammonia Demonstration Promotion Group" has been launched, demonstrating a strong commitment at the government and public enterprise levels to the promotion of ammonia co-firing. In particular, the government announced that it plans to complete a demonstration test of 20% ammonia co-firing for coal-fired power plants by 2027 and apply 20% ammonia co-firing to 24 coal-fired power plants, which is more than half of the total 43 coal-fired power plants, by 2030.

[Figure 1] Korean Government's Coal-Fired Power Plant Ammonia Co-Firing Plan

Coal plant

Coal + ammonia



Spreading co-firing generator	Commercializing co-firing generator	Conversion to carbon-free generator
2030	**2040**	**2050**
Ammonia	**Ammonia**	**Ammonia**
20% co-firing 24 units out of 43 units	**over 20% co-firing** Applied to 21 units	**100% ammonia firing** 7 units converted to carbon-free generator

* Reorganized by SFOC based on Ministry of Trade, Industry and Energy materials

Korea has introduced the "Clean Hydrogen Certification System" to accelerate the utilization of hydrogen and ammonia. Hydrogen, which emits less than 4 kg of greenhouse gas (CO_2eq) per its 1 kg production, will be eligible to participate in the "Clean Hydrogen Power Generation Bidding Market" to be implemented this year. The bidding market for clean hydrogen power generation will be conducted in a way that prebids for hydrogen/ammonia co-fired power generation will be implemented after three years, and the fixed and variable costs incurred for co-firing will be reflected in the bid price to compensate for the power generation costs.

In the issue brief "Analysis of Key Issues in the Clean Hydrogen Certification System," published in December last year, SFOC described the problems of the clean hydrogen certification system introduced by the government and ammonia co-firing. Based on the research methodology of the Finnish Center for Energy and Clean Air Research (CREA), an independent research institute specializing in scientific data-based air pollution research, on the Hekinan Power Plant in Japan (Air Quality Implications of Coal-Ammonia Co-Firing, 2023), this report focuses on the impact of the increase in fine dust and toxic substances caused by ammonia co-firing in coal power plants in Korea.

2. Types of fine dust emitted by the operation of coal-fired power plants

Coal-fired power generators generate electricity by burning coal fuel to turn the water entering the boiler into high-temperature and high-pressure steam, and then rotating the turbine under the pressure of this steam. Coal, which is a fuel, is transported to the inside of the boiler through a coal feeder and burned by a burner. The combustion of this fuel leads to the emissions of fine particulates (PM2.5), as well as nitrogen oxides (NOx) and sulfur oxides (SOx), which are precursors PM2.5[3]. Emissions of these pollutants are partially reduced through air pollution control measures such as electrostatic precipitators, denitrification and desulfurization facilities. As these air pollution control measures are not completely effective, and air pollution still escapes from the facility.

PM2.5, which is fine particulate matter, causes great damage, and it is mainly produced secondarily through the photochemical reaction of the precursors (NOx, SOx, NH_3). PM2.5 can cause various respiratory and cardiovascular diseases, including chronic pneumonia, ischemic heart disease, lower respiratory tract infections, and diabetes[4 5]. Worldwide, PM2.5 is known to contribute to 4~8 million premature deaths every year[6 7]. In addition to these premature deaths, other health diseases caused by fine particulate matter cost the global economy $8 trillion (equivalent to 6.1% of the world's gross domestic product)[8]. According to The State of Global Air 2020 report, more than 23,000 deaths in South Korea in 2019, or 7% of all deaths, were linked to deaths caused by air pollution.

Fine dust generated by coal-fired power plants in South Korea has also raised concerns about premature death. In a report published in 2020, SFOC estimated that air pollutants in South Korea could cause up to 24,777 premature deaths by the time all coal-fired power plants are shut down.

3 It refers to the causative agent that produces fine dust by photochemical reaction with other substances in the atmosphere.

4 Burnett et al. (2014), An integrated risk function for estimating the global burden of disease attributable to ambient fine particulate matter exposure, Environ Health Perspectives

5 Di et al. (2017), Air pollution and mortality in the medicare population, The New England Journal of Medicine

6 Lelieveld et al. (2015), The contribution of outdoor air pollution sources to premature mortality on a global scale, Nature

7 Burnett et al. (2018), Global estimates of mortality associated with long-term exposure to outdoor fine particulate matter, Proceedings of the National Academy of Sciences

8 World Bank (2022)

3. Effect of increasing fine dust due to ammonia co-firing

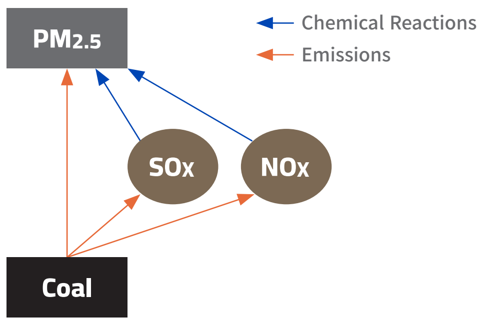
1) Main cause of increased particulate matter: atmospheric leakage of unburned ammonia

As explained above, PM2.5 is both emitted into the atmosphere as well as produced by precursors, such as SOx, NOx, and NH_3. When ammonia (NH_3) is used as fuel, unburned ammonia is generated that is discharged in the boiler in an unburned state, a phenomenon called "ammonia slip." In particular, ammonia (NH_3) in the atmosphere reacts with sulfate and nitrate to form fine particulate matter (PM2.5) in the form of ammonium sulfate and ammonium nitrate. According to previous research, the amount of ammonia slip can reach 0.1~25% of the total ammonia used[9][10].

Even if a coal power plant were to mix some of its fuel (20%) with ammonia, the amount of ammonia fuel required would be considerable. This is because the amount of energy per kilogram of ammonia is much lower compared to coal. For example, if we assume that 20% ammonia co-firing is applied to Yeongheung Thermal Power Plant #3~6, owned by Korea Southeast Power, the amount of ammonia required annually is as much as 2.45 million tons[11]. Thus, even if only 0.1% of ammonia is released into the atmosphere without burning, it is easy to see that 2,450 tons of ammonia is released into the atmosphere, which is non-ignorable.

Considering that the total emission of fine particles and it's precursors (PM2.5, SOx, NOx) as of 2022 was 4,315 tons of fine dust #3~6 of Yeongheung Thermal Power Plant, it can be considered that the 2,450 tons of ammonia emission by ammonia co-firing has a significant contribution to fine dust.

[Figure 2] Fine dust formation path in coal-fired power generation



[Figure 3] Fine dust formation path in ammonia co-firing

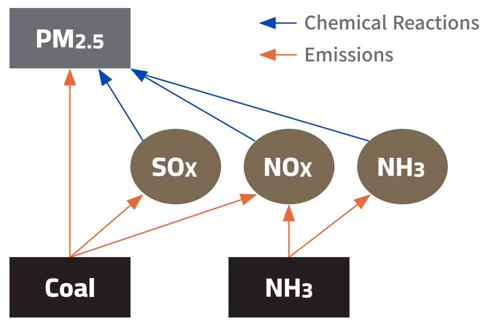


Image: Reconstructed by SFOC from CREA materials

9 Balcome et al. (2022), Total methane and CO_2 emissions from liquefied natural gas carrier ships: the first primary measurements, Environmental Science & Technology

10 DieselNet (2023), Selective catalytic reduction

11 As of 2022, it is assumed that ammonia will replace 20% of the calorific value of 9.7 million tons of coal used annually

2) Analysis methods

To calculate the scale of the increase in fine dust caused by ammonia co-firing in domestic coal-fired power generators, we obtained data on annual fine dust emissions and fuel consumption of existing coal-fired power generators[12]. Assuming that 20% of the calorific value from the annual coal consumption of each generator is covered by ammonia, the expected annual ammonia consumption for each generator was calculated[13]. The ratio of ammonia used to the amount of ammonia that slips and is discharged into the atmosphere was set as the most conservative standard (0.1%) among the previous studies. In addition, SOx, NOx, and PM2.5 generated by existing coal fuels are set to be reduced to 80% of the existing level according to the 20% ammonia blend.

In fact, NOx emissions may increase due to fuel NOx generation by ammonia, but this study excluded the effects of ammonia-induced fuel NOx to intensively analyze them. If fuel NOx is not properly removed from existing facilities, the actual emissions may be higher than the emissions analyzed in the report. In addition, the ammonia slip rate was set at the lowest standard (0.1%), so actual ammonia emissions may be higher.

Among the 24 coal-fired power plants included in the government's co-firing plan, only 14 domestic coal-fired power plants were officially announced through the media. The change in fine dust emissions caused by 20% ammonia co-firing was analyzed regarding Yeongheung (#3~6), Samcheok (#1~2), Yeosu (#1~2), Dangjin (#9~10), Taean (#9~10), and Shinboryeong (#1~2).

3) Changes in fine dust emissions by generator and region

Table 1 shows the annual emissions and increase rates of particulate matter substances (SOx, NOx, PM2.5, NH_3) before and after the application of 20% ammonia co-firing for each generator of 14 coal-fired power plants planned to apply 20% ammonia co-firing by 2030.

12 Based on 2022 KEPCO statistics and TMS measurement data

13 Assumption of the most conservative (least emitted) ammonia slip rate based on prior research

[Table 1] Particulate matter emission before and after applying ammonia 20% co-firing by each generator

Target Generator	Existing emissions (tons, 2022)					After 20% co-firing emissions (estimated value, tons)					Increase rate
	SOx	NOx	PM2.5	NH_3	Sum	SOx	NOx	PM2.5	NH_3	Sum	
Yeongheung #3	830	532	17	-	1,379	664	425	14	598	1,701	23%
Yeongheung #4	643	408	16	-	1,066	514	326	12	513	1,366	28%
Yeongheung #5	493	438	18	-	949	394	350	14	674	1,433	51%
Yeongheung #6	50	401	19	-	921	401	321	15	660	1,397	52%
Samcheok #1	235	450	29	-	714	188	360	23	652	1,223	71%
Samcheok #2	254	407	34	-	696	203	326	28	730	1,287	85%
Yeosu #1	18	254	4	-	276	14	203	4	237	458	66%
Yeosu #2	38	256	5	-	299	30	205	4	204	443	48%
Dangjin #9	616	469	11	-	1,096	493	375	9	854	1,731	58%
Dangjin #10	702	591	31	-	1,324	562	473	25	854	1,914	44%
Taean #9	249	429	9	-	688	199	343	7	429	979	42%
Taean #10	512	586	13	-	1,111	409	469	11	678	1,567	41%
Shinboryeong #1	524	271	12	-	807	419	217	10	744	1,390	72%
Shinboryeong #2	267	208	10	-	486	214	167	8	460	849	75%
Sum	5,881	5,702	230	-	11,813	4,705	4,561	184	8,289	17,739	50%

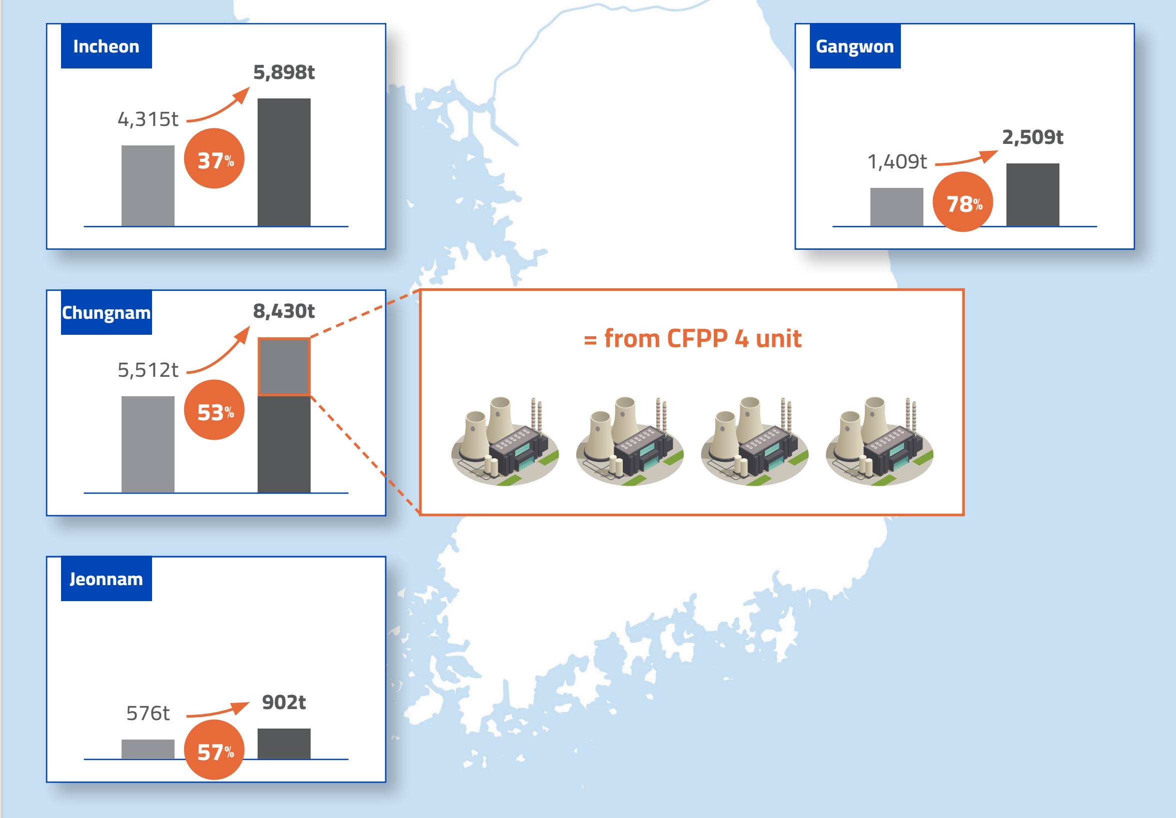
SOx, NOx, and PM2.5, which are mainly caused by coal raw materials, decreased slightly due to the substitution of ammonia, while NH_3 emissions from ammonia slip generated and the total fine dust emissions increased significantly in all cases. The total emission of fine dust has increased from 23% to 85%, and on average, it has increased to about 50% (about 1.5 times).

Based on the fine dust emissions of 14 individual generators planned for 20% ammonia co-firing, we also analyzed how the fine dust emissions by local metropolitan area changed [Figure 4].

In the Incheon area, where Yeongheung Thermal Power #3~6 is located, emissions increased by 37% from 4,315 tons to 5,898 tons, and in Gangwon, where Samcheok Thermal Power Units #1~2 are located, emissions increased by 78% from 1,409 tons to 2,509 tons. Jeonnam Province, where Yeosu Thermal Power Plant #1~2 is located, increased by 57% from 576 tons to 902 tons, while Chungnam Province, where Dangjin #9~10, Taean #9~10, and Sinboryeong #1~2 are located, increased by 53% from 5,512 tons to 8,430 tons, showing the highest fine dust emission among metropolitan local governments.

In particular, it can be found that the increase in fine dust in the Chungnam region due to the promotion of the co-firing plan is outstanding. Chungnam is about to shut down Taean Thermal Power Plant #1~2 next year, and considering that the annual fine dust emission of Taean Units #1~2 is 1,161 tons (as of 2022), it can be said that even if the two Taean thermal power plants are shut down next year, the ammonia co-firing of the remaining coal-fired power plants will emit additional fine dust equivalent to the effect of four new Taean thermal power plants, which will overshadow the efforts to shut down coal-fired power plants.

[Figure 4] Changes in fine dust emissions by ammonia co-firing by local governments



Ammonia (NH_3) slip, which is the cause of the increase in fine dust matter, is a phenomenon in which ammonia injected as fuel is discharged into the atmosphere without being burned; so, as explained above, the more ammonia is put into the generator, the more ammonia is slipped. As of 2022, the 14 coal-fired power plants analyzed in the study used 32.88 million tons of coal, and if ammonia accounts for 20% of the coal's calorific value, as much as 8.29 million tons of ammonia will be used as fuel. Considering the government's policy stance to expand carbon-free power generation, such as the upcoming opening of the "Clean Hydrogen Power Generation Bidding Market," the utilization rate and co-firing rate of coal power plants that apply ammonia co-firing will increase. This, in turn, may lead to an increase in the use of ammonia fuel, as well as an increase in the amount of fine dust generated in the area near the power plant.

Since fine dust stays in the atmosphere for a long time and can travel up to tens of kilometers, fine dust generated locally can affect the entire country. In addition, studies have shown that a 10μg/□ increase in the concentration of PM2.5 in the air increases the risk of lung cancer by 9%[14].

The dangers posed by the handling of the toxic substance ammonia and its leakage into the atmosphere cannot be ignored. Ammonia is a toxic gas that can be absorbed by the body through skin-to-skin contact and can cause breathing difficulties, lung dysfunction, and genetic defects15. According to the government's plan, 11 million tons of ammonia should be handled annually at the power plant, and the possibility of a safety threat to the workers of the plant cannot be ruled out in the process of handling large amounts of ammonia. In addition, as the above analysis shows, the amount of ammonia emitted into the atmosphere by ammonia co-firing is enormous, so it is necessary to withdraw the current ammonia co-firing policy to avoid threats to the safety of workers and the health of the community.

14 Research results of Inha University Hospital (2018)

15 Occupational Safety & Health Research Institute, Material Safety Data Sheet (MSDS)

4. Other problems of ammonia co-firing

1) Delay in the transition to renewable energy due to the maintenance of coal-fired power generation

The biggest problem with ammonia co-firing is that even if 20% is co-fired with ammonia in a coal-fired power generator, the remaining 80% must be generated using coal. In the case of Japan, which Korea considers as the benchmark, the demonstration is currently being carried out with a co-firing rate of only 20%, and Korea plans to continue power generation with the use of coal fuel until 2050 after applying a 20% ammonia co-firing ratio by 2030. In the end, the government's ammonia co-firing policy only has the meaning of a slogan of carbon-free power generation, but in reality, it can only be seen as a means to extend the lifespan of coal-fired power generation because it actually uses coal fuel as the main fuel.

One of the main reasons why renewable energy generation has not been promoted in Korea is that the system centered on large-capacity base power generation has been maintained for a long time, and there has not been enough institutional support for the power system focused on renewable energy. In such a situation, if the amount of ammonia co-fired power generation through coal-fired power generators is guaranteed, 80% of the coal-fired power generation will be included in the continuous operation, and it will be more difficult to transition to a power system focused on renewable energy as the existing power generation system cannot be changed.

According to a study by the Center for Global Sustainability at the University of Maryland in the U.S., South Korea must end all coal-fired power generation by 2035 in order to achieve a temperature rise within 1.5°C in line with the Paris Agreement[16]. Therefore, the government's plan to continue coal-based ammonia co-firing power generation by 2050 not only delays the transition to renewable energy but is also inconsistent with the 1.5°C of the Paris Agreement.

2) Hidden greenhouse gas emissions

In addition to greenhouse gas emissions from coal combustion, ammonia co-firing can also emit greenhouse gases during the production and procurement of ammonia as a fuel. The Korean government plans to import 9.27 million tons of green ammonia and blue ammonia from major countries such as Australia, Saudi Arabia, Oman, and the UAE by 2030[17], and in the case of blue ammonia, a huge amount of greenhouse gases are emitted if the greenhouse gas impact of the upstream process of LNG, a raw material,

16 UMD-CGS Korea energy plan assessment for CGS release (Sep. 2023)

17 The 1st basic plan for implementation of hydrogen economy (2021)

is included. U.S. Energy Economy·According to the Institute for Energy Economics and Financial Analysis (IEEFA), the carbon intensity ($kgCO_2e/kgH_2$) of blue hydrogen ranges from 3.4 $kgCO_2e/kgH_2$ up to 15.4 $kgCO_2e/kgH_2$, depending on the greenhouse gas life cycle criteria and upstream methane emission rate. Since ammonia is produced by synthesizing hydrogen, there may not be a substantial carbon reduction effect due to ammonia co-firing if there are many greenhouse gases generated during the production process of blue hydrogen.

In addition, greenhouse gases are also generated in the process of importing ammonia from overseas. Ammonia produced abroad is introduced in a liquefied state through an Ammonia Carrier, but since fossil fuels are still used as fuel for large ships, greenhouse gases can be emitted in the process of transporting ammonia by sea. According to the International Maritime Organization (IMO), greenhouse gas emissions from the shipping sector are a source that cannot be ignored, accounting for 3% of global greenhouse gas emissions. Until carbon-free ships are commercialized, the transportation of ammonia by sea will inevitably involve greenhouse gas emissions.

There is one more unknown greenhouse gas emission risk associated with ammonia co-firing. Nitrous oxide (N2O) is a greenhouse gas that has a greenhouse effect 273 times greater than carbon dioxide. In general, it is known that N2O is rarely produced in an environment with a combustion temperature of 1,400°C or higher, but once it is generated, it is not removed from existing environmental facilities[18], so even a small amount of emissions can offset the effect of reducing greenhouse gases by ammonia co-firing. Therefore, in order to prevent even a little N2O from being emitted, it is expected that additional facility improvements and management costs will be incurred.

3) An expensive and inefficient way

Ammonia co-firing is being promoted to replace existing coal fuel, but it is actually being used to continue the use of coal fuel because the government plans to make it possible to burn 100% ammonia only by 2050. In addition, even if 100% ammonia combustion becomes possible, it is expected that it will be difficult to establish itself as a solution due to high cost and low efficiency.

According to Bloomberg New Energy Finance (BNEF) 's comparative analysis of the levelized cost of electricity (LCOE) for ammonia co-firing and other power generation formats in Japan[19], ammonia-based power generation is expected to be more expensive than that of combined renewable energy and battery power generation by 2050. This outlook is due to the increase in operating costs (Opex), including high

18 Japan Electric Power Central Research Institute (2019), A study on the use of ammonia in existing thermal power plants

19 BNEF(2022), Japan's costly ammonia coal co-firing strategy

fuel costs, and the capital expenditures (Capex) required for ammonia co-firing, such as combustor modification and construction of fuel supply facilities.

In addition, the use of ammonia for power generation is also a huge loss in terms of efficiency. The entire process of ammonia production-liquefaction-storage-shipment-transportation-unloading-storage-regasification-fuel injection-power generation causes energy loss, especially about 60% loss in the power generation process, so it is not efficient to use ammonia for power generation.

BNEF emphasizes that when considering the use of ammonia, it is important to determine whether it is competitive with other approaches for decarbonization. Unlike applications that are difficult to replace the use of ammonia, such as fertilizer production, it is not advisable to apply ammonia in the power generation sector because there is a clear alternative power source called renewable energy in the power generation field.

5. Conclusion

This report presents the following policy recommendations regarding the ammonia co-firing policy of Korea's coal-fired power plants.

Cancellation of ammonia co-firing plan for coal-fired power plants: The leakage of ammonia into the atmosphere and the formation of fine dust may also increase the health threat to local residents. Ammonia is classified as a toxic substance and is known to cause breathing difficulties, lung disease, and genetic dysfunction when inhaled. If 11 million tons of ammonia per year is introduced and handled at the power plant according to the government's plan, there will be a threat to the safety of workers due to the handling of a large amount of toxic substance, and the health threat of local residents may also increase due to the leakage of ammonia into the atmosphere and the formation of fine dust. Furthermore, it will delay the timing of the coal phase-out, which is critical to addressing the escalating climate crisis, and justify massive GHG emissions from coal power for decades under the guise of "carbon-free power generation."

Push for early closure of coal-fired power plants by 2030: Germany-based climate think tank Climate Analytics has recommended that South Korea should close coal-fired power plants early by 2030 in order to meet the Paris Agreement's 1.5-degree target. This is because coal-fired power plants are not only the most greenhouse gas emission intensive but also there is an alternative, renewable energy. In addition, it is feared that the extension of the lifespan of coal-fired power plants due to ammonia co-firing will further strengthen the rigidity of Korea's electricity market, where renewable energy is planned. Governments and policymakers should not extend the life of coal-fired power plants through co-firing plans. We need to focus more on the process of selecting and solving the necessary issues for the speedy phase-out of coal.

Suspension of ammonia co-firing subsidy·support policy: Currently, huge government subsidies for demonstration projects and R&D budgets related to ammonia co-firing are being supported in the name of realizing 'carbon neutrality by 2050'. In addition, the Clean Hydrogen Certification System and the Clean Hydrogen Portfolio Standard (CHPS) contain measures to subsidize the production of fossil fuel-based ammonia and the power generation of ammonia co-firing, in fact, the institutional framework for the extension of the fossil fuel industry is being distorted. In order to make the most effective use of limited financial conditions to achieve carbon neutrality, government support and investment focused on renewable energy are urgently needed. Efforts are needed to correct the subsidies that are effectively extending the life of fossil fuels so that they can be leveraged to the large-scale transport and industrial sectors, which are areas where demand for renewable energy-based green hydrogen and green ammonia is needed.

References

- Ministry of Economy, Trade and Industry (2021)
- World Bank presentation materials (2022)
- CREA (2023), Air quality implications of coal-ammonia co-firing
- Research results of Inha University Hospital (2018)
- *UMD-CGS Korea energy plan assessment for CGS release* (Sep. 2023)
- BNEF (2022), Japan's costly ammonia coal co-firing strategy
- IEA (2021), Ammonia technology roadmap
- *The 1st basic plan for the implementation of the hydrogen economy* (2021)
- Burnett et al. (2014), *An integrated risk function for estimating the global burden of disease attributable to ambient fine particulate matter exposure*, Environ Health Perspect
- Di et al. (2017), *Air pollution and mortality in the medicare population*, New England Journal of Medicine
- Lelieveld et al. (2015), *The contribution of outdoor air pollution sources to premature mortality on a global scale*, Nature

Centre for Research on Energy and Clean Air

Solutions for Our Climate

Threat of Toxic Substances

Increased Particulate Matter and
Health Hazards from Ammonia Co-firing