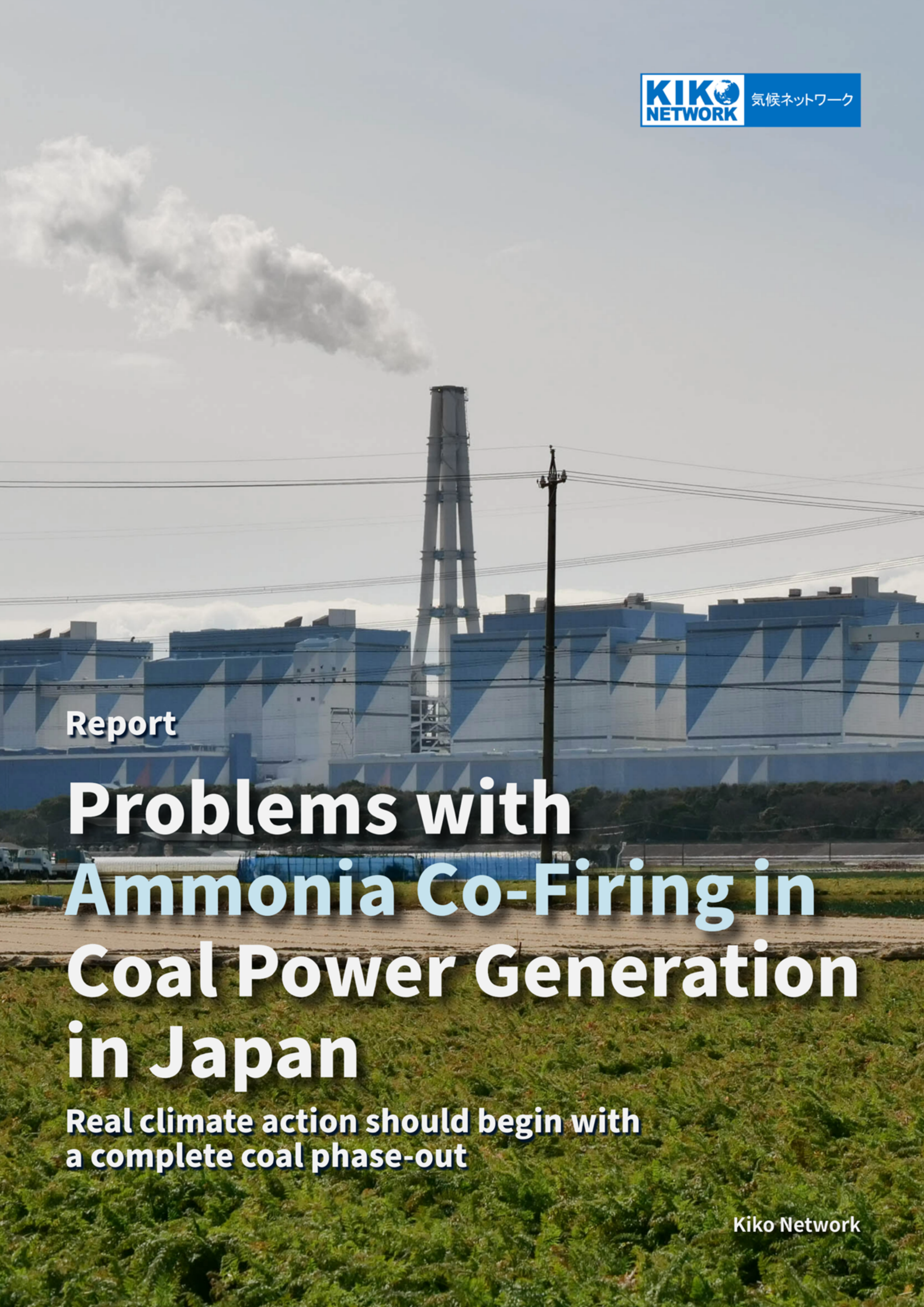


KIKO NETWORK 気候ネットワーク

Report

Problems with Ammonia Co-Firing in Coal Power Generation in Japan

Real climate action should begin with a complete coal phase-out

Kiko Network

1. Introduction

In response to the escalating climate crisis and the need to transition the nation's energy policies, the Japanese government has made the introduction of "fuel ammonia" one pillar of its decarbonization strategy (GX strategy), and is promoting policies focused on the co-firing with ammonia in coal-fired power generation. In 2023, Kiko Network released a "Position paper on fuel ammonia: Japan's "Zero Emissions" thermal power will extend the life of coal and accelerate climate change," pointing out the following issues.

- The ammonia production process produces massive greenhouse gas emissions, and notably, ammonia derived from fossil fuels ("blue ammonia") cannot be expected to deliver any substantial impact on emission reductions.
- Ammonia co-firing in coal-fired power generation comes with technical challenges such as decreased generation efficiency and increased NO_2 emissions, and may run counter to decarbonization efforts.
- The deployment of ammonia fuel requires substantial public funding, which could hinder investment in essential decarbonization technologies such as renewable energy, electrification, and battery storage.
- Policies that lack internationally-consistent definitions and alignment regarding emissions reductions risk being regarded as greenwashing.

However, the government subsequently expanded and institutionalized its fuel ammonia policy, strengthening financial and institutional backing. In addition to the "capacity market," which defines existing coal and nuclear power as supply capacity and supports those sources, the "Long-Term Decarbonization Power Source Auction" launched in FY2023 supports the installation and retrofitting of ammonia co-firing equipment at coal-fired power plants, effectively extending the life of coal-fired power generation. Furthermore, the government adopted the 7th Strategic Energy Plan in 2025, reaffirming the continuation of previous policies and emphasizing the promotion of a transition to fuel ammonia as part of the decarbonization agenda.

In light of these policies, this report re-examines the current status and issues with ammonia co-firing policies for coal-fired power generation, and clarifies the need for a policy shift based on scientific evidence and international alignment.

2. Current status and expansion of ammonia fuel policy

(1) The policy background behind the government's expansion of ammonia co-firing with coal

In 2021, the government described ammonia fuel as a "zero-emission fuel that does not emit CO_2 when combusted" in the interim report of the Public-Private Council on the Introduction of Fuel Ammonia,[1] setting domestic demand targets of 3 million tonnes per year by 2030 and 30 million tonnes per year by 2050. This corresponds to 20% co-firing at six coal-fired power units (each with 1 gigawatt [GW] capacity) by 2030, equivalent to 1.2 GW, and assumes the full-scale deployment of ammonia-fired power generation, including 100% ammonia-firing, by 2050. The New Energy and Industrial Technology Development Organization (NEDO)'s Green Innovation Fund has allocated up to 71.27 billion yen (approx. USD 456.9 million) for building a fuel ammonia supply chain, with the goal of reducing ammonia supply cost to the high 10 yen range (below 20 yen) per Nm^3 by 2030. By 2050, Japan aims for its domestic companies to lead the development of a global ammonia supply chain with a scale of 100 million tonnes per year; establishing these domestic and international supply systems remains a central pillar of the nation's policy.

In 2022, amendments to the Act on Sophisticated Methods of Energy Supply Structures (“Sophisticated Methods Act”) and the Energy Conservation Act designated hydrogen and its derivatives (ammonia) as non-fossil energy sources. As a result, transition is promoted on both the supply and demand sides, with the Sophisticated Method Act applying to the supply side and Energy Conservation Act to the demand side. The Sophisticated Methods Act sets a target for FY2030 of “in principle, at least 44%” as the non-fossil power source ratio. In the electricity sector, it assigns this ratio target to retail electricity business operators, etc. (Specified Energy Supply Business Operators), rather than electricity generators, and obliges them to submit plans to achieve it. The 44% non-fossil target was derived by subtracting coal (26%), LNG (27%), and oil (3%) from the FY2030 power mix under the 5th Strategic Energy Plan (i.e., thermal power accounting for roughly 56% in total), and although the 6th Strategic Energy Plan later revised the 2030 power mix to coal 19%, LNG 20%, and oil 2%, the 44% non-fossil target remained unchanged.

(2) Support for ammonia co-firing through the Long-Term Decarbonization Power Source Auction

The Long-Term Decarbonization Power Source Auction effectively operates as a subsidy scheme promoting ammonia co-firing in existing coal plants. The system guarantees 20 years of revenue for new or retrofitted decarbonized power sources and began full-scale operation in FY2024. Under this system, the installation or retrofitting of ammonia co-firing equipment at coal-fired power plants is considered “decarbonized power sources.”

The retrofitting of co-firing equipment is estimated at approximately 25 billion yen per coal-fired power unit, and converting to mono-firing combustion is estimated at 150 billion yen. Capital investments to deploy co-firing in Japan by 2030 are anticipated to be around 150 billion yen (equivalent of six units of 1GW capacity units). The auctions are intended to improve investment predictability and support investment decisions in new power sources. The auctions target the retrofitting of thermal power plants with equipment to enable ammonia co-firing, and successful bids can count on stable capacity revenue for 20 years from the start of operation. These costs are borne by electricity retailers and ultimately recovered through consumer electricity bills.

Additionally, parties bidding in the auctions for thermal power projects are required to submit a “Decarbonization Roadmap toward 2050.” Operators that have won bids for these projects have submitted such a roadmap for each power plant, listing numerous conditions to realize them, including securing investment recovery by applying this auction system, successful development and demonstration of co-firing and mono-firing technologies, obtaining financing from financial institutions, establishing of fuel supply chains, and favorable carbon pricing and economic viability.[2]

These conditions depend largely on external factors beyond operators’ control. For example, delays in the development and deployment of ammonia production projects and carbon capture and storage (CCS) would delay the start of co-firing. Also, the use of blue or green ammonia will be subject to a “comprehensive assessment” based on market conditions. Combined, these factors give the authorities significant administrative discretion. As a result, although the roadmap submission is "mandatory," progress is conditioned on government frameworks and market developments, effectively diluting operator responsibility. The roadmaps amount to little more than empty statements, making carbon neutrality by 2050 just wishful thinking.

The results of the two Auctions held to date include a total of six units across four locations with a combined total generation capacity of 4.6 GW, and an awarded capacity of approximately 0.865 GW for ammonia co-firing (Figure 1).

Figure 1. Coal-fired power plants awarded in Long-Term Decarbonization Power Source Auctions (FY2023, FY2024)

Bidder	Plant awarded	Capacity awarded (kW)	Total generation capacity	Bid year	Start of co-firing (20%)	Start of co-firing (50%)	Type of ammonia
JERA	Hekinan, Unit 4	187,334	1 GW	FY 2023	FY 2027	Mid-2030s	Blue → By the 2040s, blue & green
JERA	Hekinan, Unit 5	187,315	1 GW	FY 2023	FY 2027	Early 2030s	
Kobelco Power Kobe	Kobe, Unit 1	131,433	700 MW	FY 2023	FY 2029		Initially mainly blue, gradual shift to green
Kobelco Power Kobe	Kobe, Unit 2	132,000	700 MW	FY 2023	FY 2029		
Hokkaido Electric Power	Tomatō-Atsuma, Unit 4	132,200	700 MW	FY 2023	FY 2030	Late 2030s	Blue and green
Shikoku Electric Power	Saijo, Unit 1	94,600	500 MW	FY 2024	FY 2030	Late 2030s	Blue → Blue or green
Total		864,882	4.6 GW				

Prepared by Kiko Network

In the first two auctions, bidding results fell well short of the initial assumption that up to 1 GW of thermal power capacity would be retrofitted. In the first round, three projects were awarded, totaling 825 megawatts (MW), while in the second round only one project, totaling 95 MW, was awarded. In response to the sluggish bidding, the auction framework was substantially revised from the third round onward. These revisions included a significant increase in the auction price cap and a relaxation of conditions, effectively introducing preferential treatment for thermal power retrofits, as outlined below.

Inclusion of variable costs (fuel and operating costs)

Previously, the calculated price was limited to fixed costs such as construction costs. Under the revised framework, however, for thermal power retrofits involving hydrogen or ammonia mono-firing or co-firing, as well as CCS, the inclusion of variable costs—such as fuel and operating costs—has been allowed.

Substantial increase in the auction price cap

As construction costs for power generation facilities rose sharply due to soaring material prices, rising interest rates, and yen depreciation, the previous auction price cap (averaging 100,000 yen per kilowatt [kW] per year) proved insufficient to ensure project viability, discouraging operators from bidding. In response, the average auction price cap has been increased across the board to 200,000 yen per kW per year starting from the third auction round. In addition, for hydrogen or ammonia mono-firing or co-firing and CCS-equipped thermal power generation, variable costs are incorporated to bridge the price gap with lower-cost fuels such as LNG and coal. As a result, the average auction price cap is further raised to 400,000 yen per kW per year. This is approximately four to five times the cost level of battery storage (76,205–80,657 yen per kW per year).

Automatic adjustment of the winning bid price

For hydrogen and its derivatives (ammonia) mono-firing or co-firing, as well as CCS-equipped thermal power generation, variable costs are calculated as part of the bid price at the time of bidding. During the support period, these costs may be automatically adjusted upward or downward at the beginning of each fiscal year in response to factors such as exchange rate fluctuations. As a result, the awarded price may increase substantially after project commencement. Taken together, these measures strongly incentivize investment in ammonia co-firing and related thermal power retrofits.

(3) Support for ammonia co-firing through the Hydrogen Price-Gap Subsidy Program

The Hydrogen Society Promotion Act (2024) recognizes that hydrogen and ammonia remain far more expensive than fossil fuels, making voluntary switching economically unviable and limiting market uptake. To address this gap, the government (through the Japan Organization for Metals and Energy Security, JOGMEC) established a mechanism to compensate for the price differential between conventional fuels and hydrogen or ammonia. By lowering initial cost barriers, the scheme aims to accelerate early deployment and market formation.

This Hydrogen Price-Gap Subsidy Program (also referred to as the Price-Gap Support Scheme)—effectively a public risk-sharing mechanism comparable to a contract for difference (CfD)—transfers a substantial portion of commercial risk from private to the public sector, with 3 trillion yen (approx. USD 19.2 billion) of the GX public funding being earmarked for this purpose. For fuel ammonia, the costs associated with introducing co-firing in power generation are also eligible for support insofar as they do not overlap with the Long-Term Decarbonization Power Source Auction framework. However, the institutional design of the scheme is complex, and the scope of eligible support remains limited. As a result, only two projects have been certified to date, and none involve thermal power generation.

3. Re-examination of technical and environmental challenges

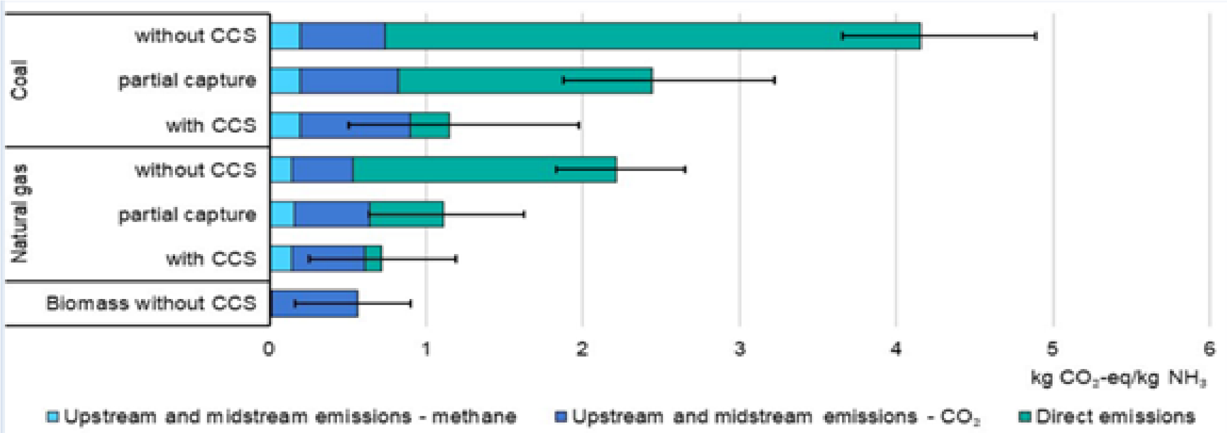
(1) Technical challenges of ammonia co-firing and limits to emissions reduction effects

Ammonia is not a natural resource but a “product” manufactured primarily from fossil fuels such as natural gas and coal. Large quantities of CO_2 are emitted during production, and as shown in Figure 2, carbon intensity varies significantly depending on whether coal or natural gas is used as feedstock.

The Hydrogen Society Promotion Act defines “low-carbon hydrogen and its derivatives” based on specific standards; for ammonia, the threshold is set as 0.87 kg-CO_2/kg-NH_3. At present, production facilities equipped with CCS are extremely limited. Even where CCS is deployed, capture rates are estimated at only 60–70%.

To meet the required standard, even ammonia produced from natural gas would require CCS capture rates exceeding 90%, presenting a significant technical barrier.

Figure 2. Emissions intensity of various ammonia production processes (2021)



Source: Towards hydrogen definitions based on their emissions Intensity, IEA, 2021 (p. 44)

(2) Emission reduction effects of ammonia co-firing in coal power plants are negligible

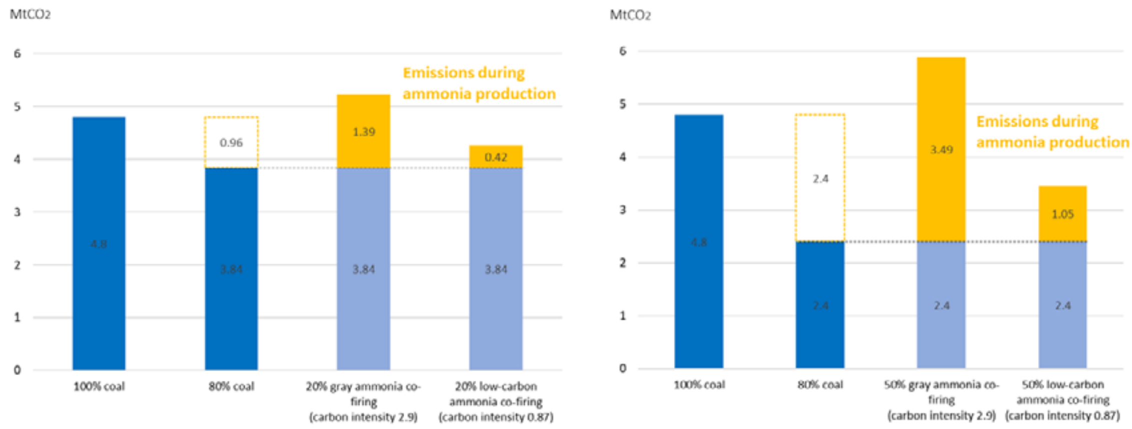
It is often claimed that co-firing 20% ammonia reduces CO2 emissions at the power plant by 20%. However, Kiko Network's recalculation of the emission reduction effects from a lifecycle perspective (Figure 3), shows that even co-firing 20% “low-carbon ammonia” (meeting the standard) results in a mere 12% reduction. In the case of gray ammonia, total CO2 emissions may actually increase compared to coal-only combustion. Furthermore, with 50% co-firing, low-carbon ammonia achieves only a 29% reduction, while gray ammonia would result in higher emissions than at a 20% co-firing rate.

(3) Transitioning to ammonia mono-firing: Potential vs. Reality

The government and power utilities have established a policy to eventually transition to ammonia mono-firing. However, mono-firing technology is not yet established, and it is difficult to argue that co-firing technology provides a direct pathway to it. Even at JERA’s Hekinan Thermal Power Plant (Unit 4 and 5) and Kobelco’s Kobe Thermal Power Station—both of which were selected in the Long-Term Decarbonization Power Source Auctions, deployment plans remain limited to 20–50% co-firing with blue ammonia in the near term. There are currently no concrete prospects for a transition to 100% ammonia mono-firing.

Regarding technical feasibility, the automaker Mazda had been moving forward with plans to replace a coal-fired power unit at its headquarters with an ammonia mono-fired gas turbine. Although they had initiated the environmental impact assessment (EIA) process, they announced a comprehensive review of the project in September 2025, effectively withdrawing the mono-firing concept. This reversal is believed to be driven by concerns over stable fuel procurement and economic viability. Such a cases illustrates that transitioning from co-firing to mono-firing remains a formidable challenge, both technically and economically.

Figure 3. Change in annual CO2 emissions considering carbon intensity (ammonia co-firing at 20% on left, 50% on right)



Note: Assumes a model coal-fired power plant with 1 GW capacity and a 70% capacity factor. Comparison basis: Carbon intensity of 2.9 kg-CO_2/kg-NH_3 (gray ammonia) and 0.87 kg-CO_2/kg-NH_3 (low-carbon ammonia). The second value from the left represents direct emissions from the power plant during co-firing. The government explains that 20% co-firing simply results in a 20% reduction (at the stack).

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4. Risks of ammonia accidents and leaks

(1) Ammonia properties and hazards

Ammonia is a highly toxic and hazardous substance. Contact with skin or eyes can cause severe damage, and inhalation can result in serious respiratory health impacts. Environmental contamination and adverse effects on organisms in the event of leakage have also been noted. In addition, it is flammable and poses the risk of explosion when exposed to heat.

(2) Serious accidents in the United States

Ammonia leakage incidents have occurred in Japan and in other countries. A recent example is an accident at CF Industries in Yazoo City, Mississippi, on November 5, 2025.[3] An explosion at a chemical plant produced a large yellow-brown plume, and surrounding roads were closed due to an ammonia release. Although no fatalities or injuries were reported, nearby residents were forced to evacuate. The facility is capable of storing up to 48,000 tonnes of ammonia, although the exact volume involved in the accident has not been disclosed. While CF Industries currently focuses primarily on the production of ammonia for agricultural use, the company has stated its intention to expand into applications for power generation. Japanese companies JERA and Mitsui & Co. have announced plans to invest in the CF Industries' Blue Point project, which involves the development of a low-carbon ammonia production facility in Louisiana.[4]

In addition, on November 12, 2025, an accident occurred in Oklahoma, where ammonia leaked from a tanker truck carrying 11,340 kilograms of fertilizer-grade ammonia, releasing the gas around a hotel where the vehicle was parked.[5] As a result, 34 people were hospitalized after exposure to ammonia, several of whom were admitted to intensive care. Five responding police officers reportedly suffered chemical burns to their throats, and approximately 500–600 nearby residents were evacuated.

(3) Accidents at overseas suppliers and local opposition

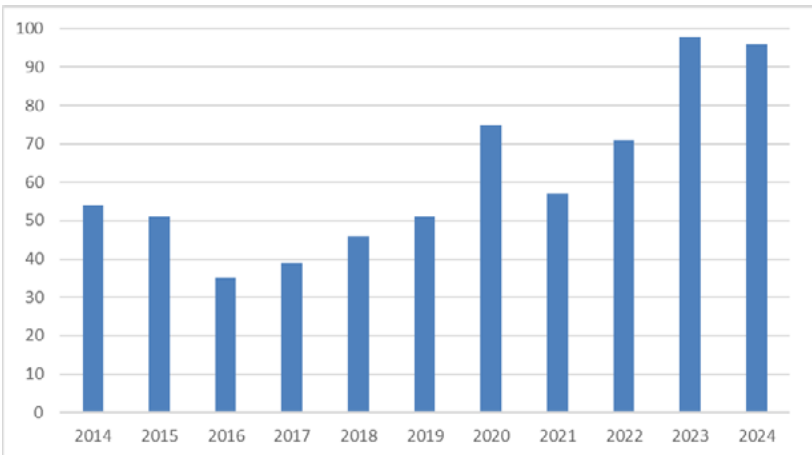
There are cases where overseas ammonia producers partnered with Japanese firms have a history of frequent leakage accidents. For instance, the Green Ammonia Initiative from Aceh (GAIA) in Indonesia (involving Itochu Corporation and Toyo Engineering) recorded nine ammonia leakage incidents between 2010 and 2025.[6] These incidents affected 2,000 people, causing severe health issues including vomiting, dyspnea (difficulty breathing), fainting, and respiratory disorders. During major leak events in April 2010, March 2015, and January 2023, dozens of residents—including infants, women, and the elderly—required treatment in intensive care units.

The Indonesian Forum for the Environment (WALHI/FoE Indonesia) has pointed out that the company has failed to demonstrate proper accountability. WALHI further argues that while the project is branded as “green,” the electrolysis process relies on Indonesia’s national grid, which has a high share of coal-fired power. Consequently, they contend the ammonia is effectively fossil-fuel derived and are calling for the project’s cancellation.[7]

(4) Ammonia-related accidents in Japan

Domestic accidents related to ammonia leaks also occur annually in Japan (Figure 4). In 2006 and 2009, fatal accidents occurred due to leaks of ammonia used as a refrigerant.[8] [9]

Figure 4. Number of incidents associated with ammonia leaks (Japan)



* Ammonia only. Does not include mixed gases, etc.

Prepared by Kiko Network from High-Pressure Gas Safety Institute database.

Furthermore, during the Great East Japan Earthquake in 2011, an ammonia production facility was damaged by the tsunami, resulting in the total release of liquefied ammonia from its storage tanks. According to the High Pressure Gas Safety Institute of Japan (KHK) database, several leaks are reported each year within the electric power industry alone.

Most recently, on December 4, 2025, JERA—the company leading ammonia co-firing trials at Hekinan—reported an ammonia leak at its Higashi-Ohgishima Thermal Power Station in Kawasaki. JERA stated that the leak occurred at a valve on the receiving pipe of an on-site liquefied ammonia tank.[10]

(5) Deployment without rigorous verification of safety, risk, or environmental impact

Although ammonia has a long history of commercial use in fertilizers and a wealth of international expertise has been accumulated regarding its handling, the reality is that leaks and accidents remain frequent (the cases cited above are just a few select examples).

As ammonia scales as a fuel for power generation, global trade volume will likely surge, leading to the entry of new players unfamiliar with its hazardous properties. While thermal power plants already use ammonia for denitrification (DeNOx), the transition to fuel-scale use requires exhaustive safety measures—not only within the plants but across the entire supply chain, including production sites, international and domestic logistics, and local government emergency response.

Hastily commercializing ammonia co-firing under these conditions would be exceptionally dangerous and demands cautious judgment and comprehensive verification. It is a grave concern that the installation of ammonia co-firing equipment at coal power plants is being advanced without even a discussion on the necessity of environmental impact assessments.

5. Recommendations: Shift toward genuine decarbonization policies

On November 17, 2025, the South Korean government officially joined the Powering Past Coal Alliance (PPCA) and pledged to phase out domestic coal-fired power by 2040. Crucially, Seoul also announced a total review of its subsidy programs, including those for ammonia co-firing. Until now, Japan and South Korea were effectively the only two nations institutionally promoting ammonia co-firing as a “decarbonization technology.” With South Korea’s pivot, Japan is becoming an international outlier, increasingly isolated on the global stage.

To avert the climate crisis and meet the 1.5°C target of the Paris Agreement, there is no room for delay. Developed nations are required to phase out coal power by 2030; there is simply no space for coal life-extension measures. Nevertheless, Japan continues to promote ammonia co-firing under the guise of decarbonization.

As demonstrated in this report, ammonia production is highly carbon-intensive. Fossil-fuel-derived “gray ammonia” can actually increase lifecycle emissions compared to coal-only combustion. Even “low-carbon ammonia" that meets government standards achieves only a marginal 12% reduction at a 20% co-firing rate, rendering it an ineffective climate solution.

Furthermore, support mechanisms such as the Long-Term Decarbonization Power Source Auctions and the Hydrogen Price Gap Subsidy Program impose a fiscal burden far greater than anticipated. In these auctions, the price cap for ammonia is set at twice the level of other power sources to incentivize bidding. Funneling massive public funds into a technology that fails to deliver meaningful emission reductions is unacceptable.

Japan must abandon these high-cost, low-impact measures and commit to a clear exit from coal. A truly sustainable decarbonization strategy requires the phased and planned retirement of existing coal plants and an accelerated transition to proven, effective technologies: renewable energy, electrification, and energy storage. A fundamental policy pivot is urgent to restore international trust and fulfill Japan's climate responsibilities.

Notes

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Cover photo: Hekinan Thermal Power Station, Aichi Prefecture, Japan (2023)

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