Not All Hydrogen is Clean:

Key Issues Regarding South Korea's Clean Hydrogen Certification

° Issue Brief

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Next year, the Korean government will introduce a **"Clean Hydrogen Certification System"** to incentivize the use of clean hydrogen. The purpose of the clean hydrogen certification system is to contribute to carbon neutrality by promoting domestic clean hydrogen. However, the government's current definition of **"clean hydrogen" includes hydrogen based on fossil fuels,** which goes against the original purpose of carbon neutrality and is unlikely to contribute to greenhouse gas reduction. In addition, the **"Clean Hydrogen Power Generation Bidding Market" will include hydrogen/ammonia fossil fuel co-firing power generator as a participant,** which is expected to cause many problems.

This brief aims to point out the limitations of the "Clean Hydrogen Certification System" and the "Clean Hydrogen Power Generation Bidding Market" currently being considered by the government and suggest ways to improve them.

Hydrogen is being recognized as a next-generation energy source because it does not contain carbon molecules and thus does not emit carbon dioxide. Therefore, hydrogen has great potential to address climate change as it can be applied to various fields that currently generate carbon and lead to greenhouse gas (GHG) reduction. However, not all hydrogen contributes to GHG reduction, and it can even have a negative impact on the climate depending on the production method or the utilization.

1. Types of hydrogen

- Depending on the production process, hydrogen can be categorized into three main types (green hydrogen, blue hydrogen, and gray hydrogen).

Table 1. Classification of hydrogen according to the production process

Type	Hydrogen Production Methods	
Green Hydrogen	Electrolysis	Hydrogen produced by electrolyzing water using electricity generated from renewable energy.

Blue Hydrogen	Fossil fuel reforming + Carbon capture and storage (CCS)	Hydrogen produced by capturing and storing carbon dioxide (CO_2) from the reforming process of fossil fuels to make hydrogen.
Gray Hydrogen	Fossil fuel reforming	Hydrogen produced by reforming fossil fuels
	Byproduct gas refining	Hydrogen generated as a byproduct of process in petrochemicals, steel, etc.
Ammonia (Hydrogen compound)	Hydrogen synthesis	Classified in the same way as the raw hydrogen (Green ammonia, blue ammonia, gray ammonia)

2. The concept of clean hydrogen

- Hydrogen with GHG emissions below a certain level during production or import.

* Recognized as clean hydrogen if the CO_2 equivalent (CO_2eq) generated to produce 1 kg of hydrogen is 4 kg or less, according to the government's announcement.

3. Incentive policies for clean hydrogen

- Clean Hydrogen Certification System: Certification system for clean hydrogen to provide incentives according to the tiers.
- Clean Hydrogen Portfolio Standard (CHPS): A system announced by the government to facilitate clean hydrogen-fueled power trade in clean hydrogen power bid market.

4. Potential and limitations in hydrogen utilization

- Potential for hydrogen utilization: power generation (fuel cell, hydrogen/ammonia co-firing), transportation (hydrogen car, shipping), industry (steel, petro chemical), etc.
- Limitations: The effectiveness in reducing GHGs may vary, possibly even having negative impacts depending on the hydrogen's production method or utilization
☞ Criteria for clean hydrogen and its utilization become vital.

5. Issue analysis for Clean Hydrogen Certification System

Issue 1. Criteria for Clean Hydrogen Certification System

- Although green hydrogen is the only hydrogen that does not emit GHGs, the government's current draft for the Clean Hydrogen Certification System is insufficient to incentivize domestic green hydrogen production competitiveness .

- Other limitations of the criteria for clean hydrogen include the exclusion of GHG emissions from transportation and the amount of energy required to convert the ammonia or liquefied hydrogen into hydrogen.

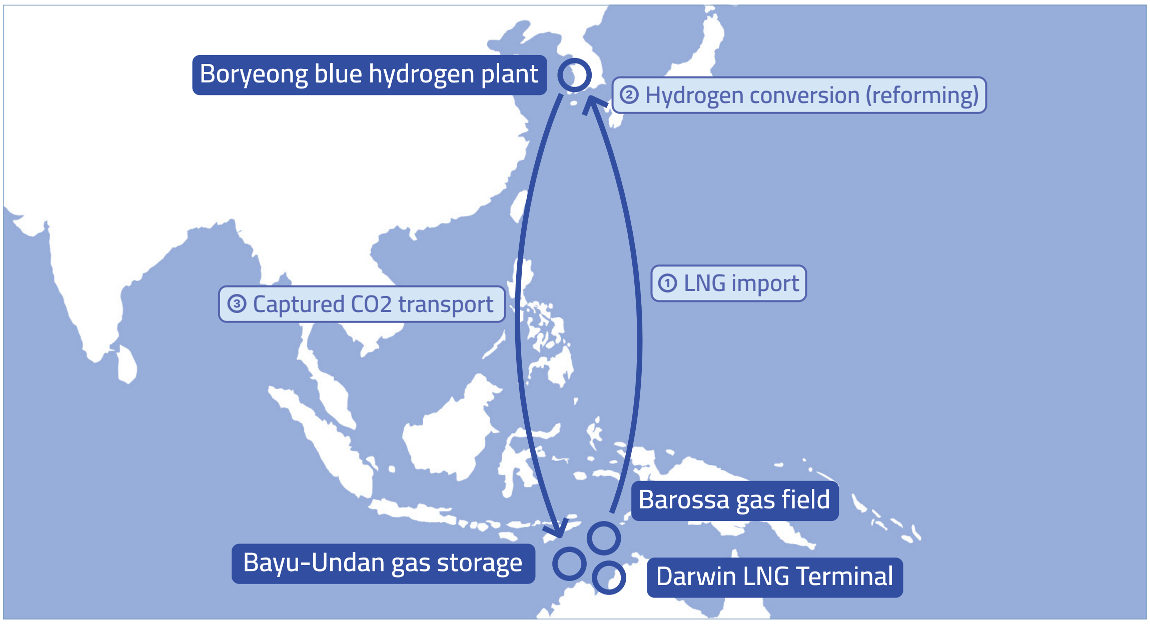
Table 2. Draft for clean hydrogen tiers and corresponding technology groups[1]

Tiers (kgCO2eq/kgH2)	Main applicable technologies by tier
Tier 1 (~0.1)	Domestic and overseas green hydrogen (100% renewable energy for hydrogen production)
Tier 2 (0.1~1)	Domestic and overseas nuclear-produced hydrogen, and overseas green hydrogen utilizing some grid power for hydrogen production (Some power mix utilization for system stabilization)
Tier 3 (1~2)	Blue hydrogen from PNG with 90%+ carbon capture and with other additional emissions reductions (Reduction from raw material production, use of low-carbon electricity)
Tier 4 (2~4)	Blue hydrogen produced with 90%+ carbon capture (Utilizing average gas field + grid power)

- Blue hydrogen, in particular, may cause numerous controversies if classified as clean hydrogen because the full impact of GHGs caused by fugitive methane emissions from the extraction and transportation of gas is yet to be clearly resolved. Also, not all GHG emissions from the capture, liquefication, transportation, and storage of CO2 during blue hydrogen production (Steam Methane Reforming+CCS) have been considered.

1 Korea Energy Economics Institute presentation materials (Nov. 02, 2023.)

Figure 1. Boryeong blue hydrogen plant plan (provided from Solutions for Our Climate)

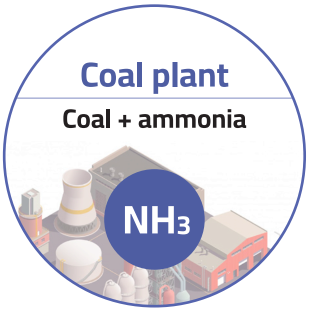


* Boryeong blue hydrogen plant project led by Korea Midland Power (KOMIPO) and SK E&S: LNG imported from the Barossa gas field is reformed into blue hydrogen, and the byproduct CO_2 is stored in the closed Bayu-Undan gas field. GHG emissions from LNG import and CCS process are not considered.

Issue 2. Inclusion of hydrogen/ammonia co-firing power generation in the "Clean Hydrogen Power Bid Market"

- There are two main types of co-firing generation: ① mixing hydrogen with LNG for gas turbine generation, ② boiler (steam turbine) generation mixing ammonia and coal.
- Mixing hydrogen and ammonia with conventional fossil fuels should be excluded from the clean hydrogen bidding market as it prolongs the existing fossil fuel-based generation.
- According to the government's policy announcement, ammonia co-firing power generation is especially ill-suited to be categorized as clean energy, considering its use of coal until 2050.

Figure 2. Ammonia co-firing generation roadmap
(reorganized by Solutions for Our Climate based on Ministry of Trade, Industry and Energy materials)



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

- Japan and Korea are leading the development of ammonia co-firing generation technology. The international community, including Bloomberg New Energy Finance (BNEF), Transition Zero, E3G, Kiko Network, etc., is concerned about the spread of this technology.

< Main issues with ammonia co-firing generation >

① Prolonged coal-fired power generation

- Center for Global Sustainability of the University of Maryland analyzed that Korea should phase out all coal power generation by 2035 to achieve its target for the Paris Agreement's global 1.5°C trajectory.[2]

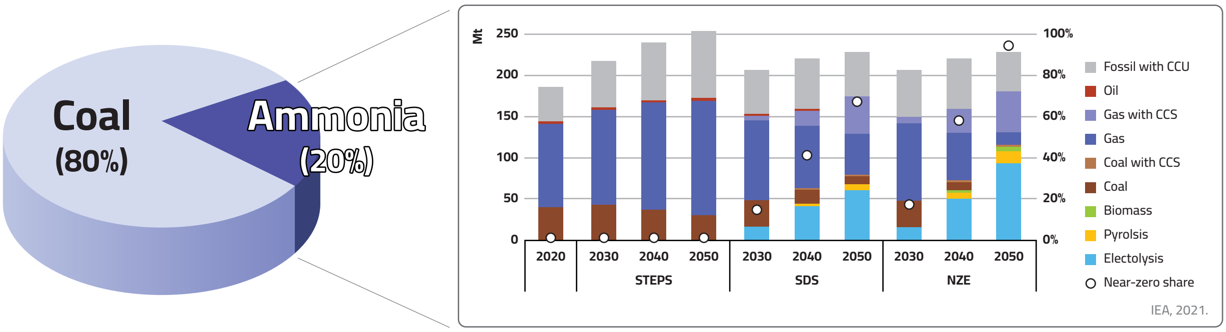
- According to the government's ammonia co-firing plan, coal power generation is expected to continue until 2050, and the pressure to recover the cost of investment in power generation facilities will lead to efforts to secure utilization rates, hindering the early retirement of coal power plants.

② Unclear effectiveness on GHG reduction

- Even if ammonia replaces 20% of coal during power generation, the remaining 80% would still rely on coal, making little difference. Besides, IEA's projections show that even by 2030, most ammonia production will still rely on fossil fuels.

2 Korea Energy Economics Institute presentation materials (Nov. 02, 2023.)

Figure 4. Ammonia production-based technology prospect for 2030
(reorganized from IEA 2021 materials)

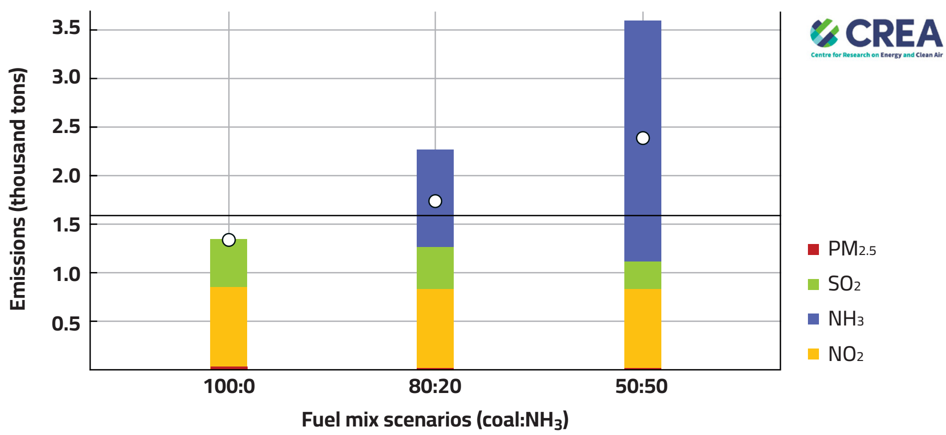


- Hence, there are doubts about the actual effectiveness of ammonia in reducing emissions when taking into account the life cycle emissions of fossil fuel-based ammonia and the possibility of methane leakage.

③ Increased fine dust

- According to a report from the Centre for Research on Energy and Clean Air (CREA)[3], ultrafine particulate matter emission (PM2.5, SO2, NO2, NH3) is expected to increase by 30% when co-firing ammonia than solely relying on coal.

Figure 5. Fine dust matter emission by fuel mix ratios (CREA materials from 2023)



- Ammonia spreading in the air is likely to threaten the local community, considering the majority of increase in ultrafine particulate matter come from ammonia.

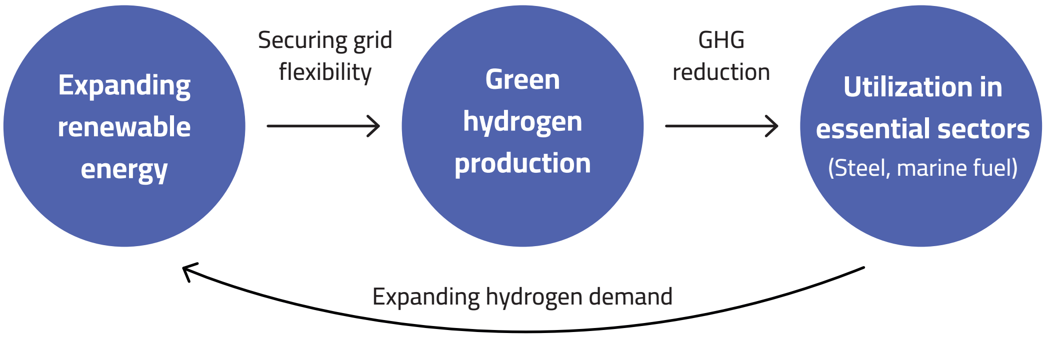
3 CREA(2023), Air Quality Implications of Coal-Ammonia Co-Firing

- The increase in fine dust resulting from ammonia co-firing power generation will lead to residents' health concerns and additional costs for facilities, piling up installation costs and exacerbating stranded asset issues from coal-fired power.

6. Conclusion

- There is a need for a thorough examination process to determine the actual GHG emissions reduction effect of each hydrogen category, considering the purpose of implementing the Clean Hydrogen Certification System.
- Blue hydrogen with unclear amounts of GHG emissions, including methane leakage during production, should be excluded from the clean hydrogen standard, and the government must establish a virtuous cycle with green hydrogen-focused policies that lead to the proliferation of renewable energy.
- Also, policies should focus on utilizing hydrogen in hard-to-abate industries rather than dwelling on expanding hydrogen demand.

Figure 6. Virtuous cycle centered around green hydrogen
(Provided by Solutions for Our Climate)



- The government must exclude hydrogen/ammonia co-firing power generation from the Clean Hydrogen Power Generation Bidding Market, promptly phase out from coal-fired power generation, and accelerate discussions on expanding renewable energy and a distributed power system.

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Solutions for Our Climate (SFOC) is an independent policy research
and advocacy group that aims to make emissions trajectories across Asia compatible
with the paris Agreement 1.5°C warming target.