Ammonia activities in South Korea

Clean Fuel Laboratory
Climate Change Division
Korea Institute of Energy Research

Yoon, Hyung Chul

Source: DNV

NDC target in South Korea

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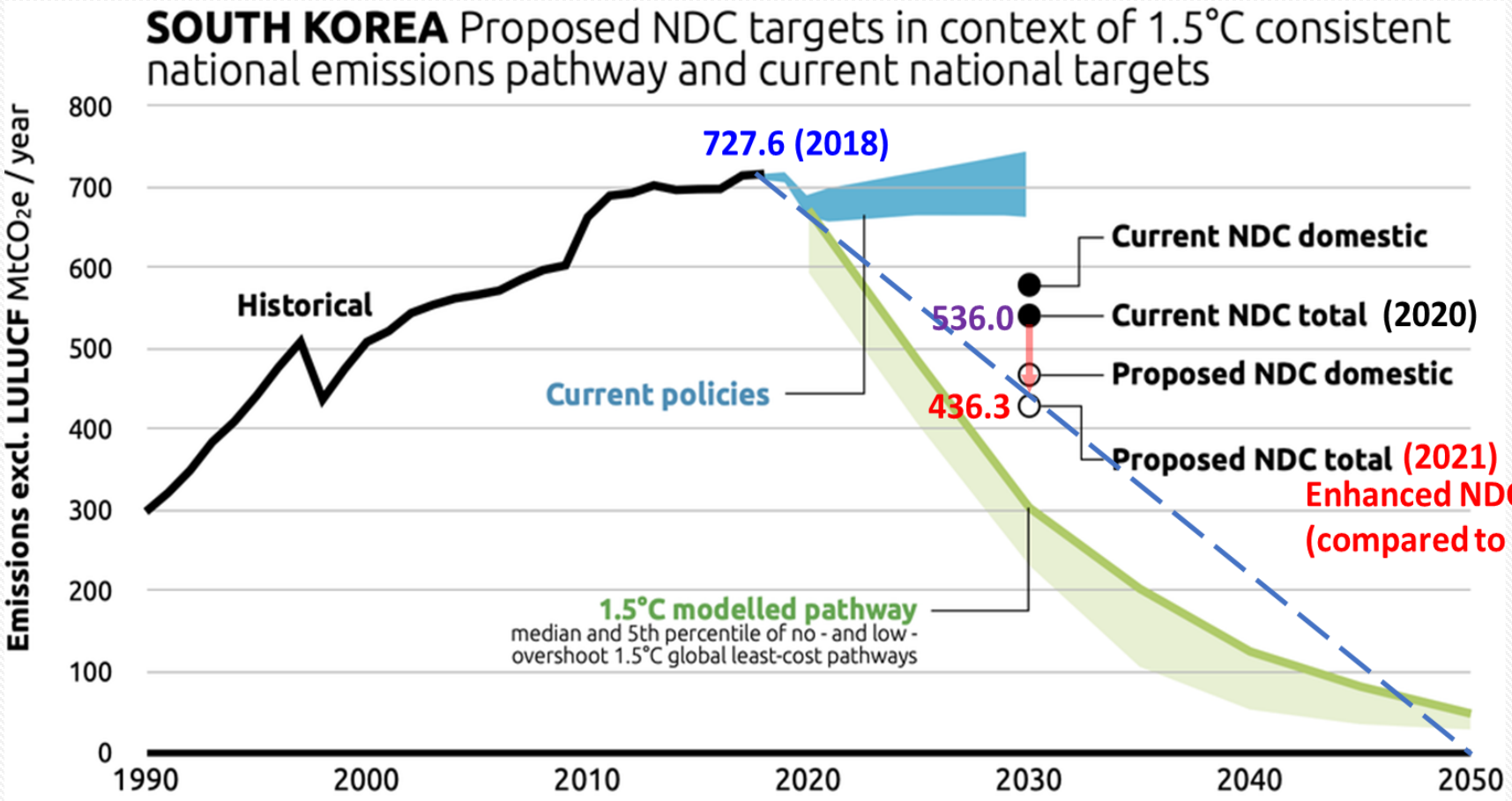

Source: Dr. Min Jung Lee, KIER

GHG reduction strategies

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● KOREA

2018

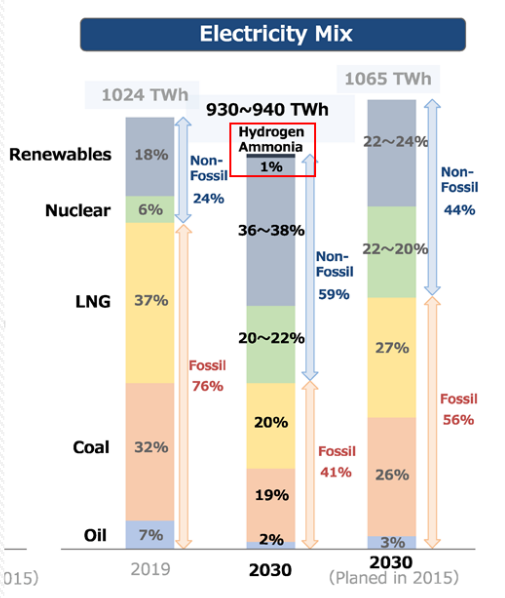
	Nuclear	Coal	LNG	Renewable	Oil	Hydro	Total
Capacity [TWh]	133.5	239.0	152.9	35.6	5.7	3.9	570.7
Ratio [%]	23.4	41.9	26.8	6.2	1.0	0.7	100

2030

	Nuclear	Coal	LNG	Renewable	Ammonia	Hydro & etc.	Total
Capacity [TWh]	146.4	133.2	119.5	185.2	22.1	6.0	612.4
Ratio [%]	23.9	21.8	19.5	30.2	3.6	1.0	100

10 million tons of NH3

● JAPAN



9~10 TWh NH3 & H2
3 million tons of NH3

Source: Dr. Min Jung Lee, KIER

Hydrogen/ammonia demand

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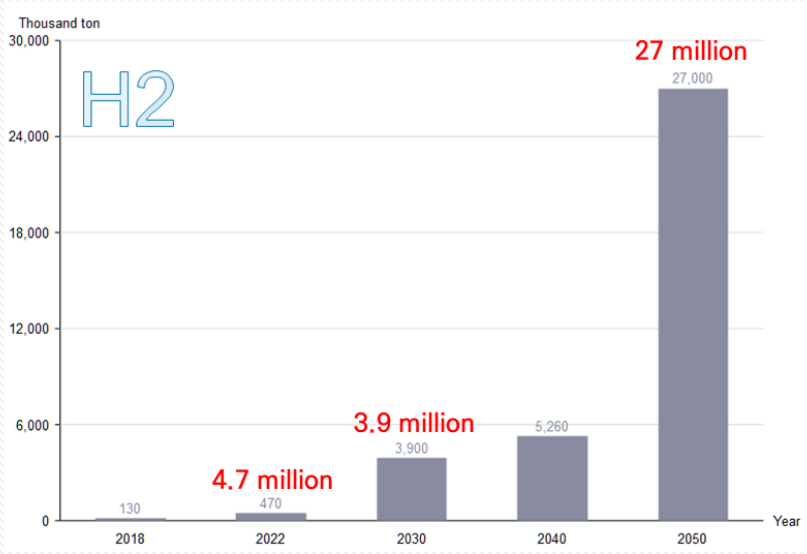
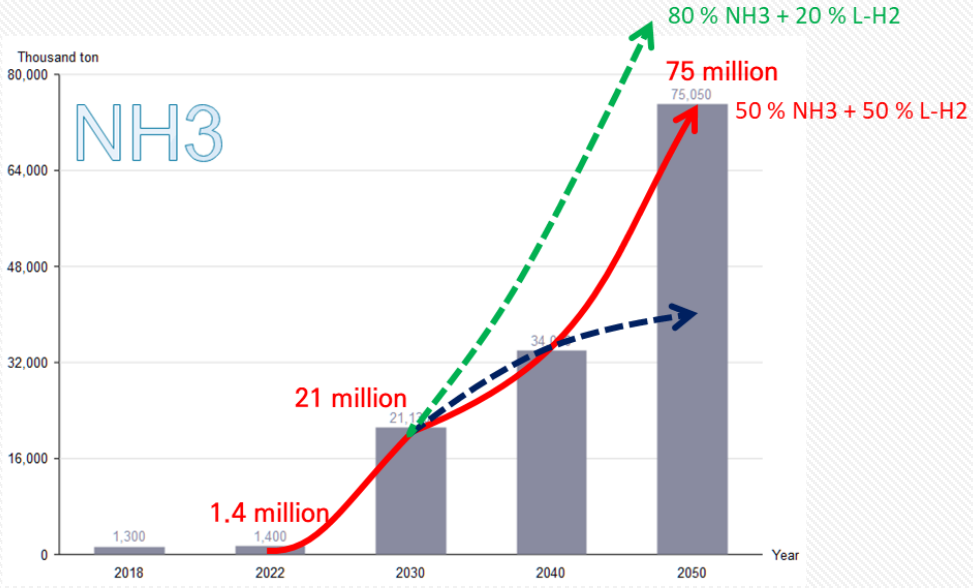
Hydrogen/Ammonia Demand in Korea (2030–2050)

(Unit: Thousand ton, %)

Year	Activating the Hydrogen Economy Roadmap (2019.1.)	Hydrogen Economic Performance and Hydrogen Leading National Vision (2021.10.07)	Updated 2030 NDC (2021.10.18.)	2050 Carbon Neutrality scenario (2021.10.18.)	1st Hydrogen Economy Implementation Basic Plan (2021.11.26.)	Overseas Hydrogen Amount of introduction	As Ammonia Hydrogen transport rate	Ammonia Demand (Hydrogen carrier)*	Ammonia Demand (Carbon Free Fuel)
2018	130								
2022	470								
2030		3,900	1,940		3,900	1,960	100 %	11,130	10,000
2040	5,260								
2050		27,000		27,400		22,900	50 %	65,050	>10,000





Source: Dr. Min Jung Lee, KIER

Revised hydrogen law on June, 2022

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HYDROGEN ECONOMY PROMOTION AND HYDROGEN SAFETY MANAGEMENT ACT

The term "hydrogen industry" means an industry related to hydrogen, such as the production, storage, transportation, refueling, sales of hydrogen, equipment utilizing hydrogen such as fuel cells and hydrogen turbines, and the manufacture of products, parts, materials, and equipment used therefor;

7-2. The term "clean hydrogen" means hydrogen or a hydrogen compound certified pursuant to Article 25-2, which falls under any of the following items:

A. Carbon-free hydrogen: Hydrogen that does not emit greenhouse gases (hereinafter referred to as "greenhouse gases") under Article 2-5 of the Framework Act on Carbon Neutralization and Green Growth for Climate Crisis Response, etc.

B. Low-carbon hydrogen: Hydrogen that emits greenhouse gases below the standards prescribed by Presidential Decree in the process of producing and importing hydrogen

C. Low-carbon hydrogen compounds: Hydrogen compounds produced for the transportation, etc. of hydrogen that emit greenhouse gases below the standards prescribed by Presidential Decree in the process of production, import, etc.

Revised hydrogen law on June, 2022

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Article 25-2. Certification of clean hydrogen

Article 25-3 Notification for the production of clean hydrogen

Article 25-4 Designation of a clean hydrogen certification agency

Article 25-5 Obligation to sell and use clean hydrogen

Article 25-6 Purchase, supply, etc. of hydrogen for power generation

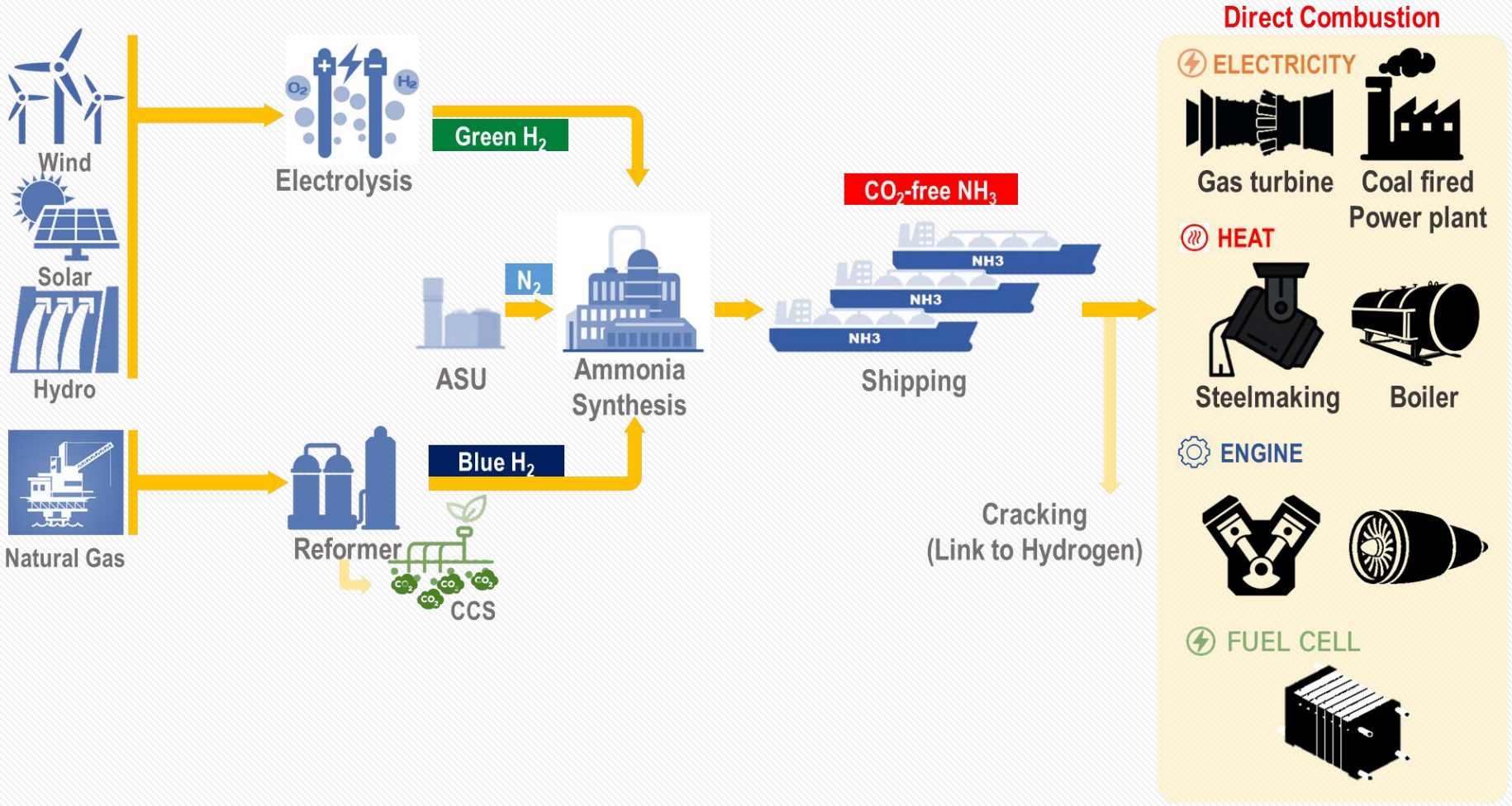
Article 25-7 Designation, etc. of a bid market management agency

Article 25-8 Additional Fine

Go to https://www.law.go.kr and search for hydrogen act for details

Background

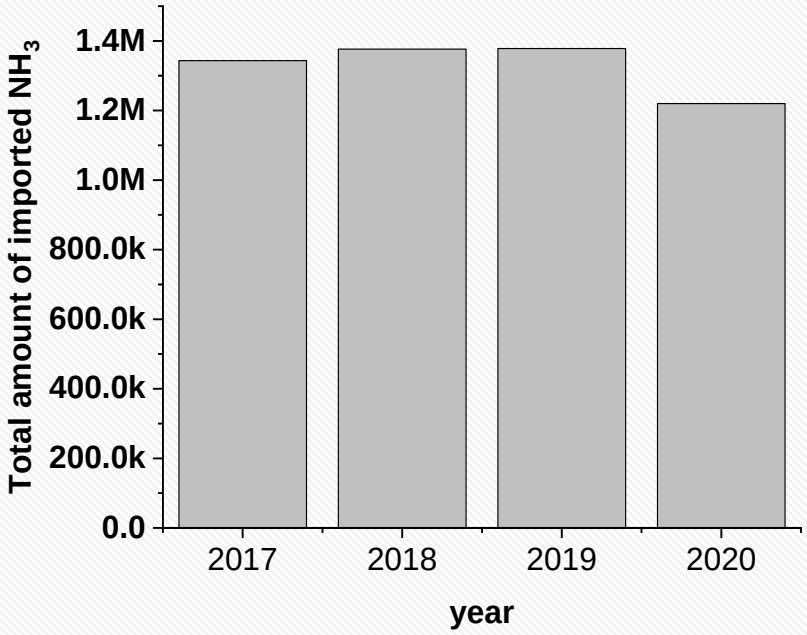
CO_2-free ammonia value chain

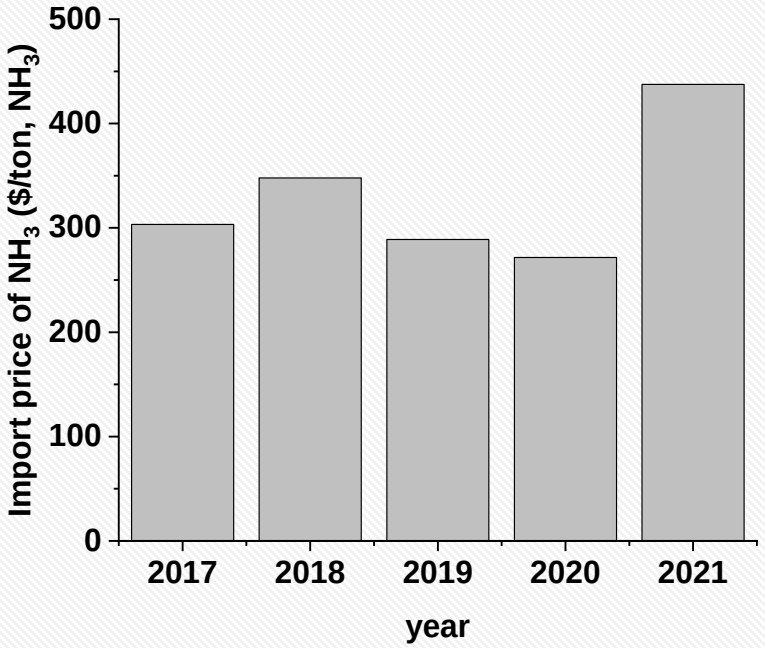


Background

Ammonia market in South Korea

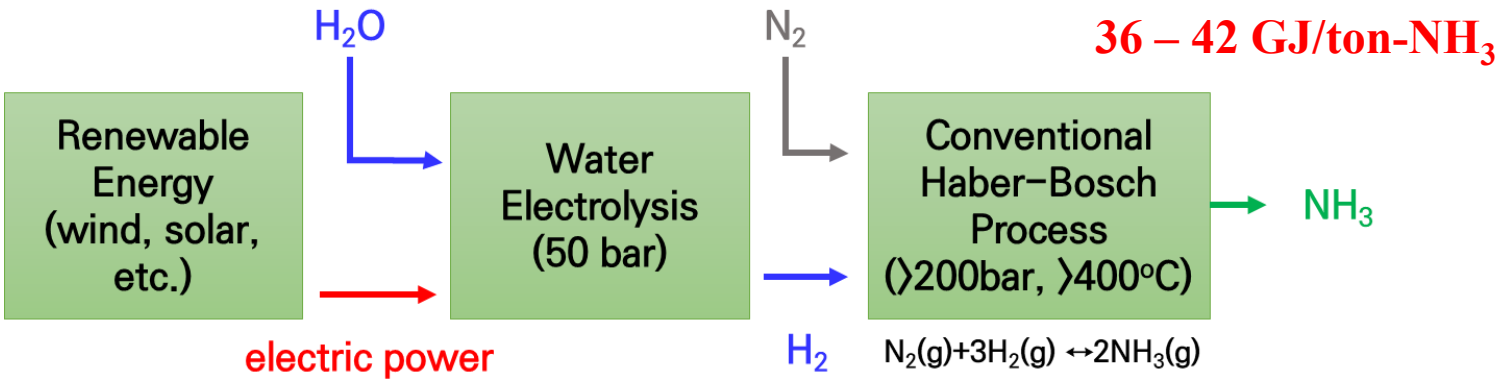
- Current demand of ammonia in S. Korea: 1.3 million ton/yr (avg. tariff: 0.93%)
  - In 2019, South Korea imported $ 434M in Ammonia, mainly from Saudi Arabia ($178M), Indonesia ($126M), Trinidad and Tobago ($79.3M), Australia ($20.6M), and Oman ($8.46M). (source: oec.world)



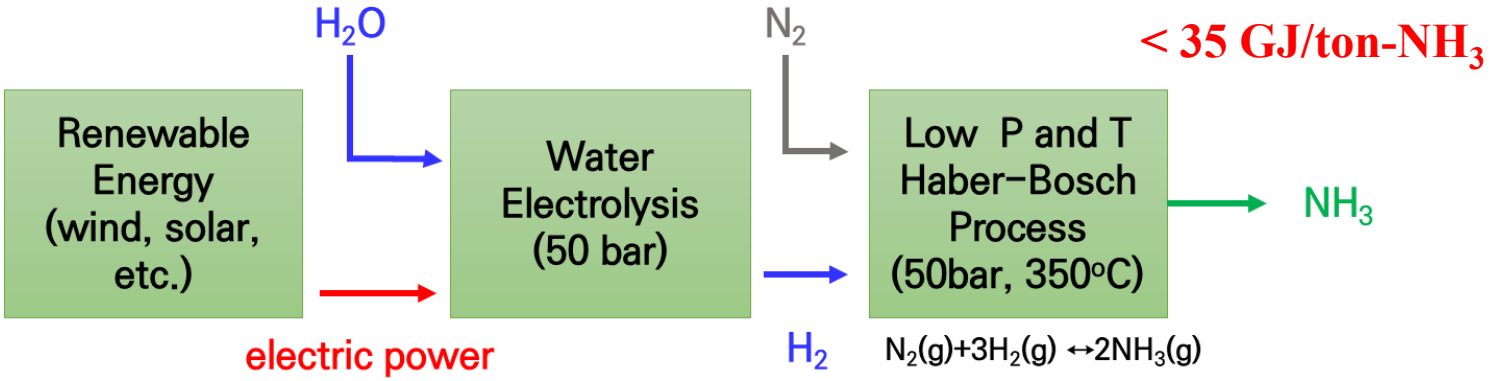


Source: unipass.customs.go.kr

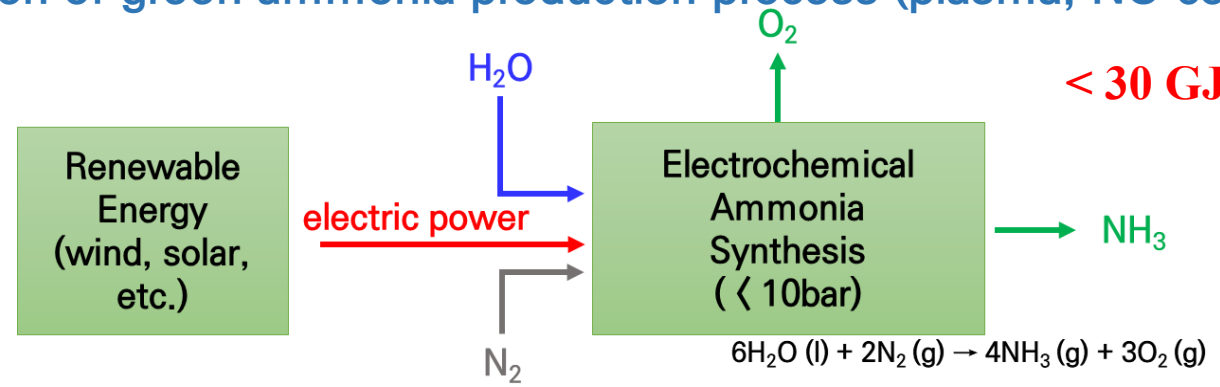
☐ 1st generation of green ammonia production process



☐ 2nd generation of green ammonia production process



☐ 3rd generation of green ammonia production process (plasma, NO conversion, etc.)



R&D on ammonia synthesis

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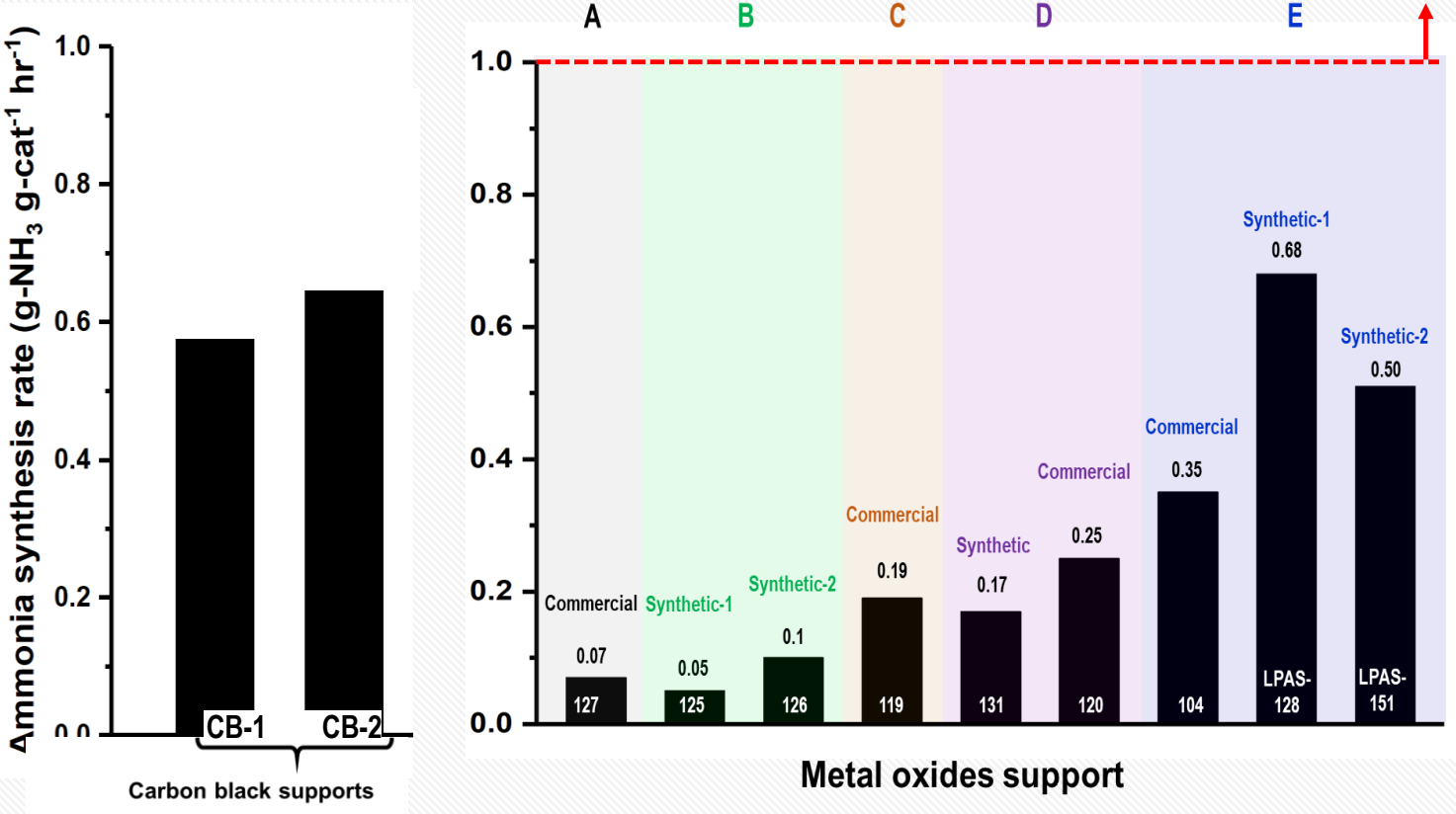
Development of catalyst and system for low-P and low-T ammonia synthesis in Korea

- Faster plant start-up, downsize catalyst volume, reactor size, low cost of catalyst
- Reducing pressure and amount of hydrogen storage in a buffer system
- Below results were obtained at 50 bar and 400°C

close to equilibrium



R&D on ammonia synthesis

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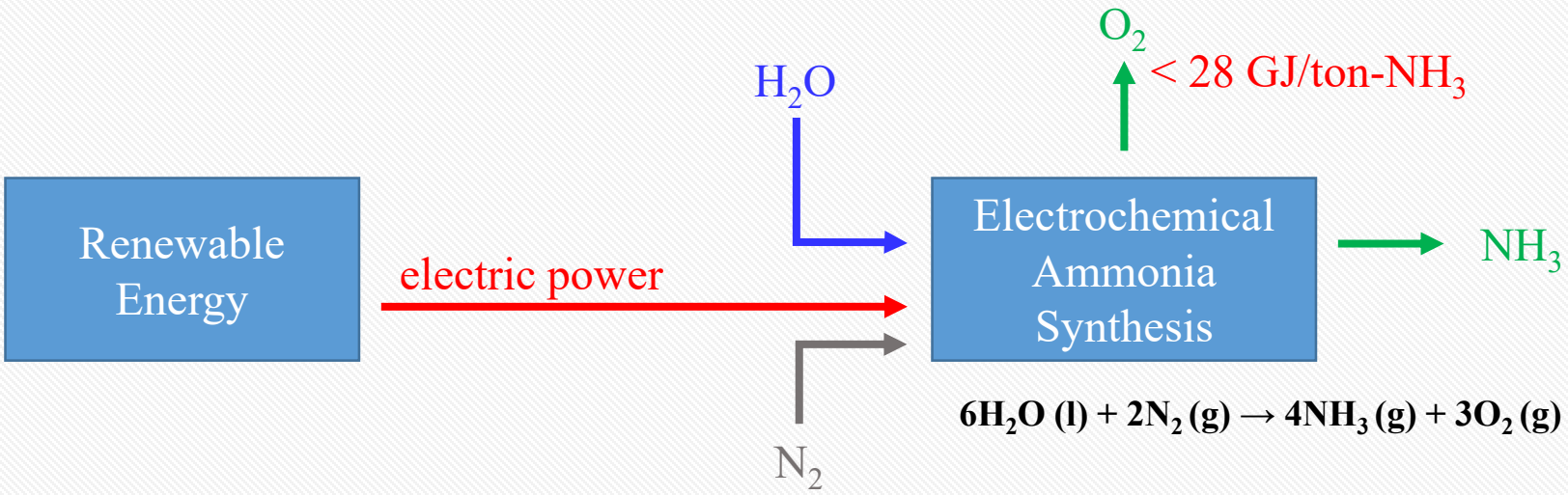
Electrochemical synthesis of ammonia at low-temperature and atmospheric pressure



$$6H_2O\ (l) + 2N_2\ (g) \rightarrow 4NH_3\ (g) + 3O_2\ (g)$$

* Direct synthesis of ammonia reduces complexity and energy intensity

- **Operation at atmospheric pressure for ammonia synthesis**

  Estimate of total energy consumption would be less than 28 GJ/ton-NH3

  * Long-term R&D is required (TRL 2 ~ 3)

- **One of the main issues is that electrochemical nitrogen reduction reaction(NRR) is competitive with hydrogen evolution reaction(HER).**
- **We must find an electrocatalysts with high selectivity and activity for NRR.**

R&D on ammonia synthesis

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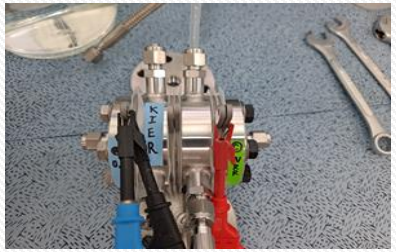
Electrochemical synthesis of ammonia at low-temperature and low-pressure

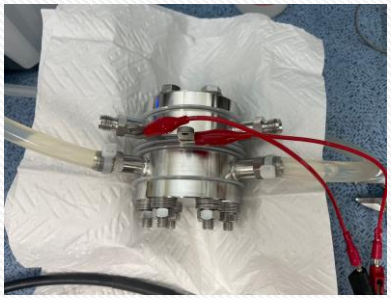
- **Our final goal: > 10^{-7} mol/cm^2/sec, 90% faradaic efficiency**

Highly selective e-catalyst



High-pressure cell system

Plasma-assisted activation of nitrogen
NOx to NH3



Lithium-mediated reaction

R&D on NH_3 decomposition

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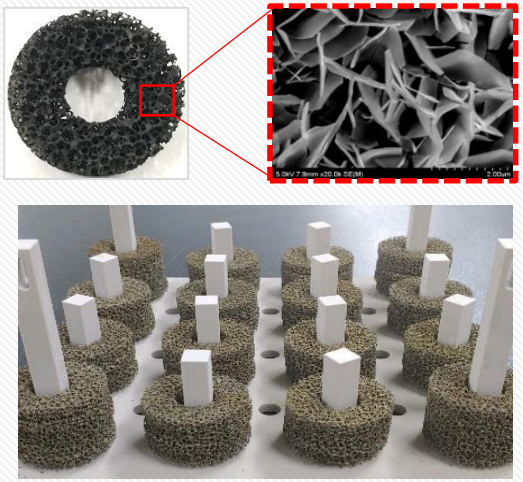
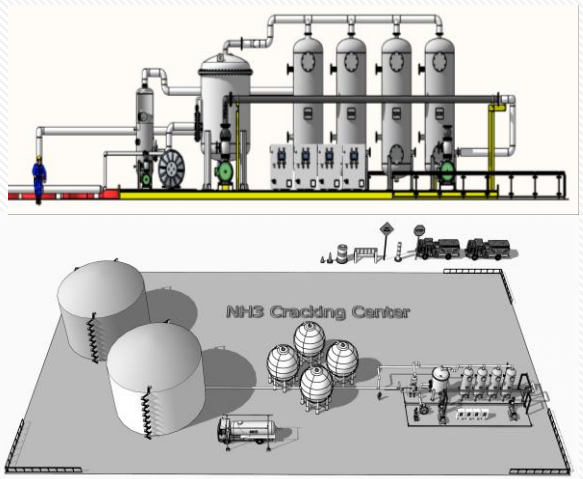
Project Leader: Dr. Unho Jung, KIER

- **Metal foam catalyst** prepared by proprietary coating technology improved activity and heat transfer
- NH_3 decomposition reactor for **20 Nm^3/h high-purity H_2 production was developed**
- Development of **H_2 1,000 Nm^3/h class NH_3 decomposition system** is underway and is planned to be completed **by 2025**

Ru coated metal foam catalyst	NH_3 decomposition reactor (H_2 20Nm^3/h)	NH_3 decomposition system (H_2 1,000Nm^3/h)





R&D on NH_3 decomposition

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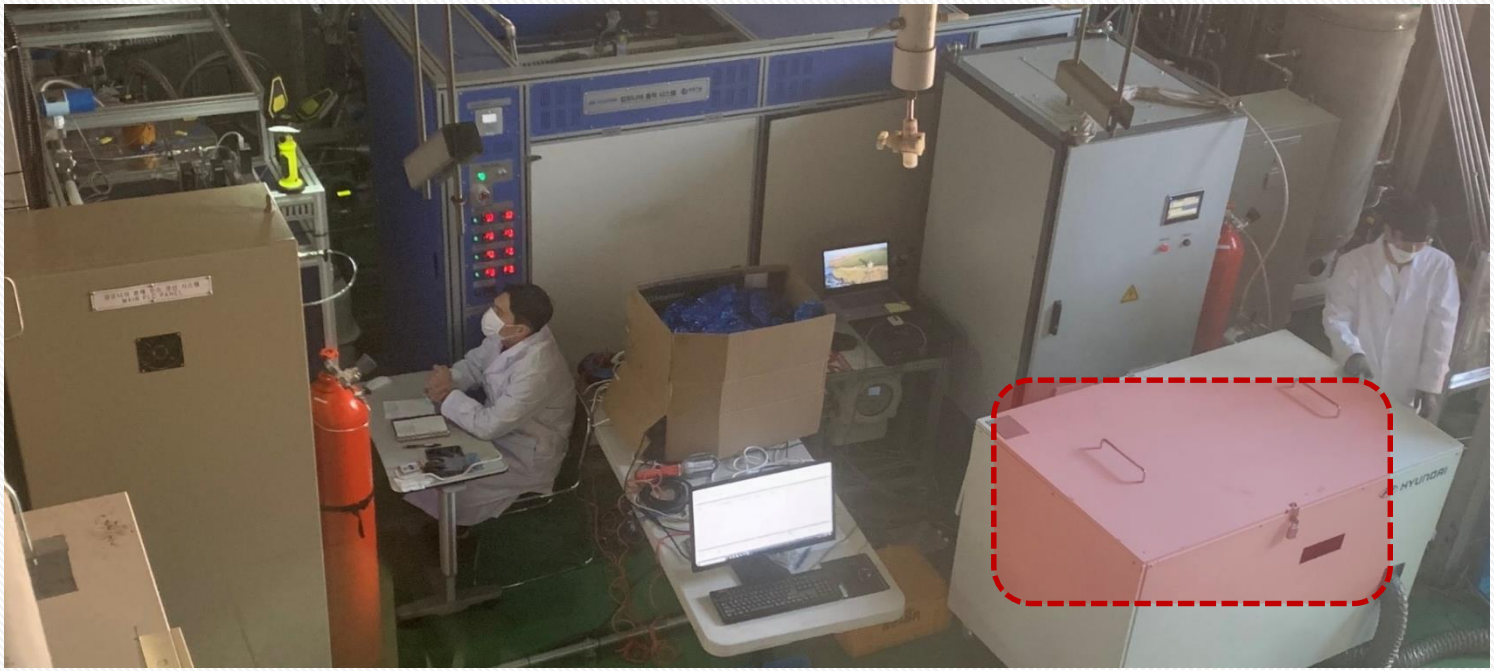
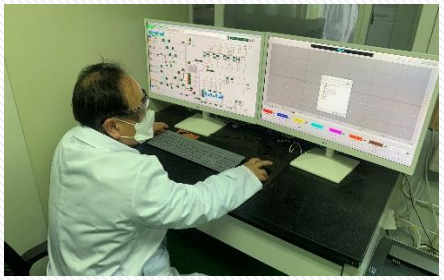
Project Leader: Dr. Unho Jung, KIER

- 20 Nm^3/h (approx. 43 kg/day) of high-purity H_2 production (< 0.1 ppm NH_3) tests for a PEM fuel cell were **completed in May 2021.**





R&D on NH_3 combustion

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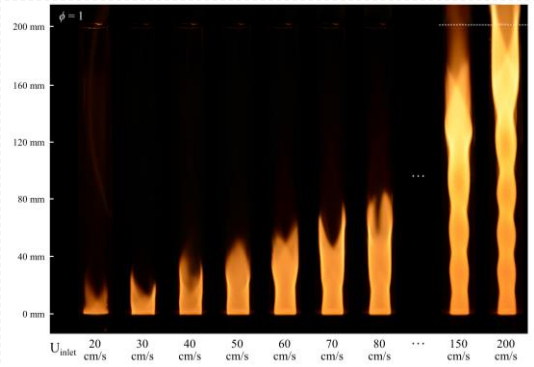
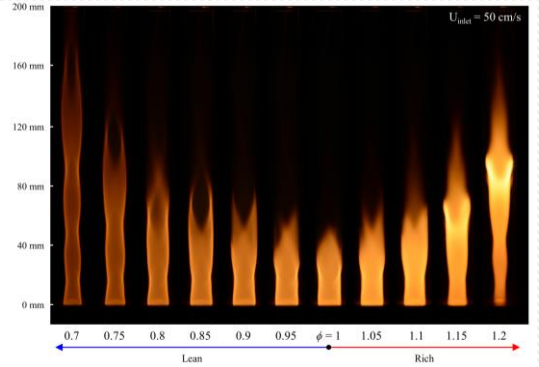
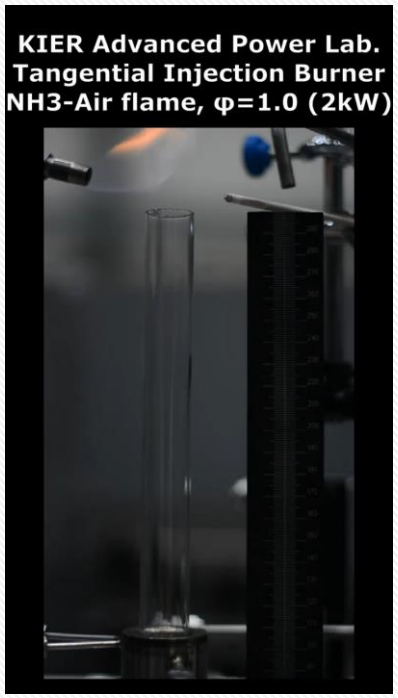
Project Leader: Dr. Min Jung Lee, KIER

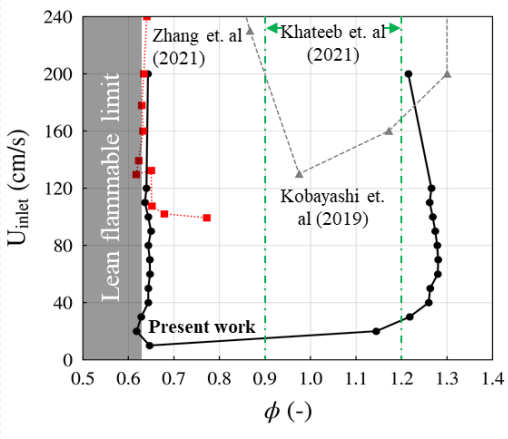


[Variation of inlet flow velocity]



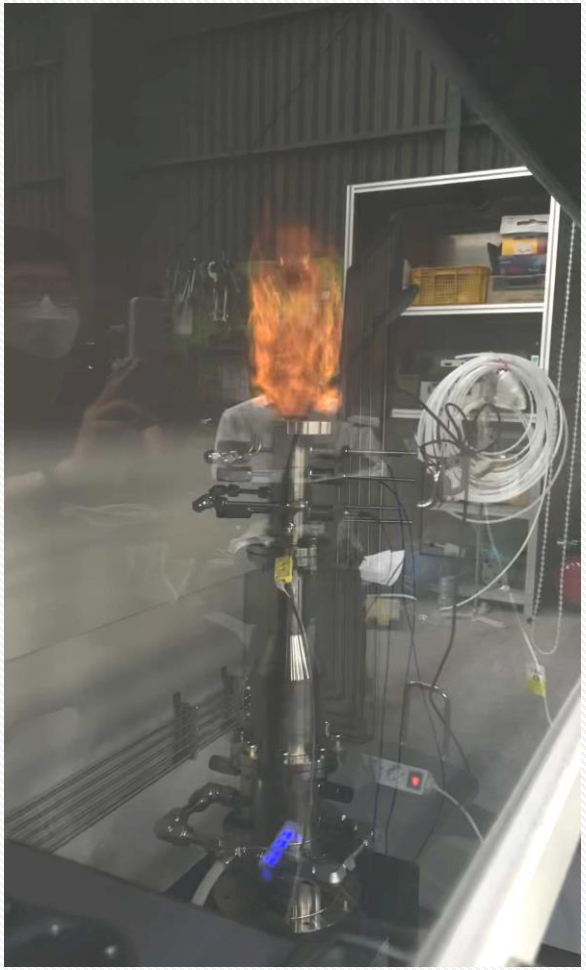
[Variation of equivalence ratio]





[NH3-Air Flame stability map]

Real time



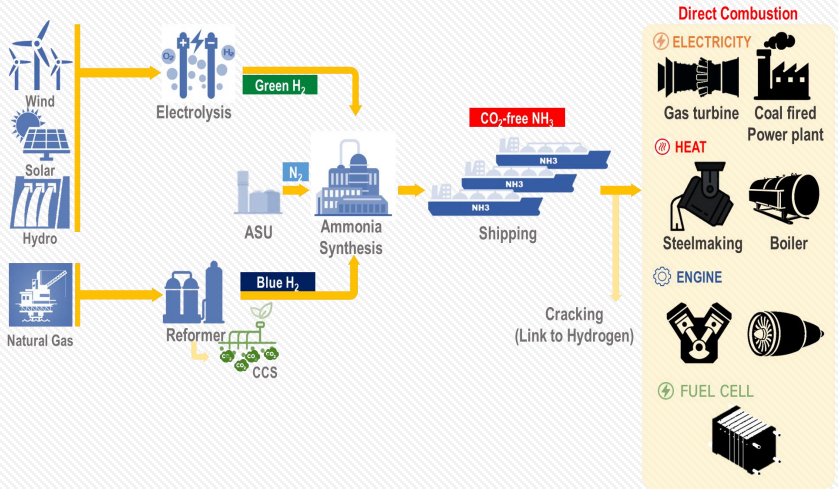
Korea Clean Ammonia Association

- Korea Clean Ammonia Association
  : established on 14 October 2021

  : Total 36 members

- Technology, Certification, Standardization, Policy, International Divisions

- Ultimate goal



Korea Clean Ammonia Association

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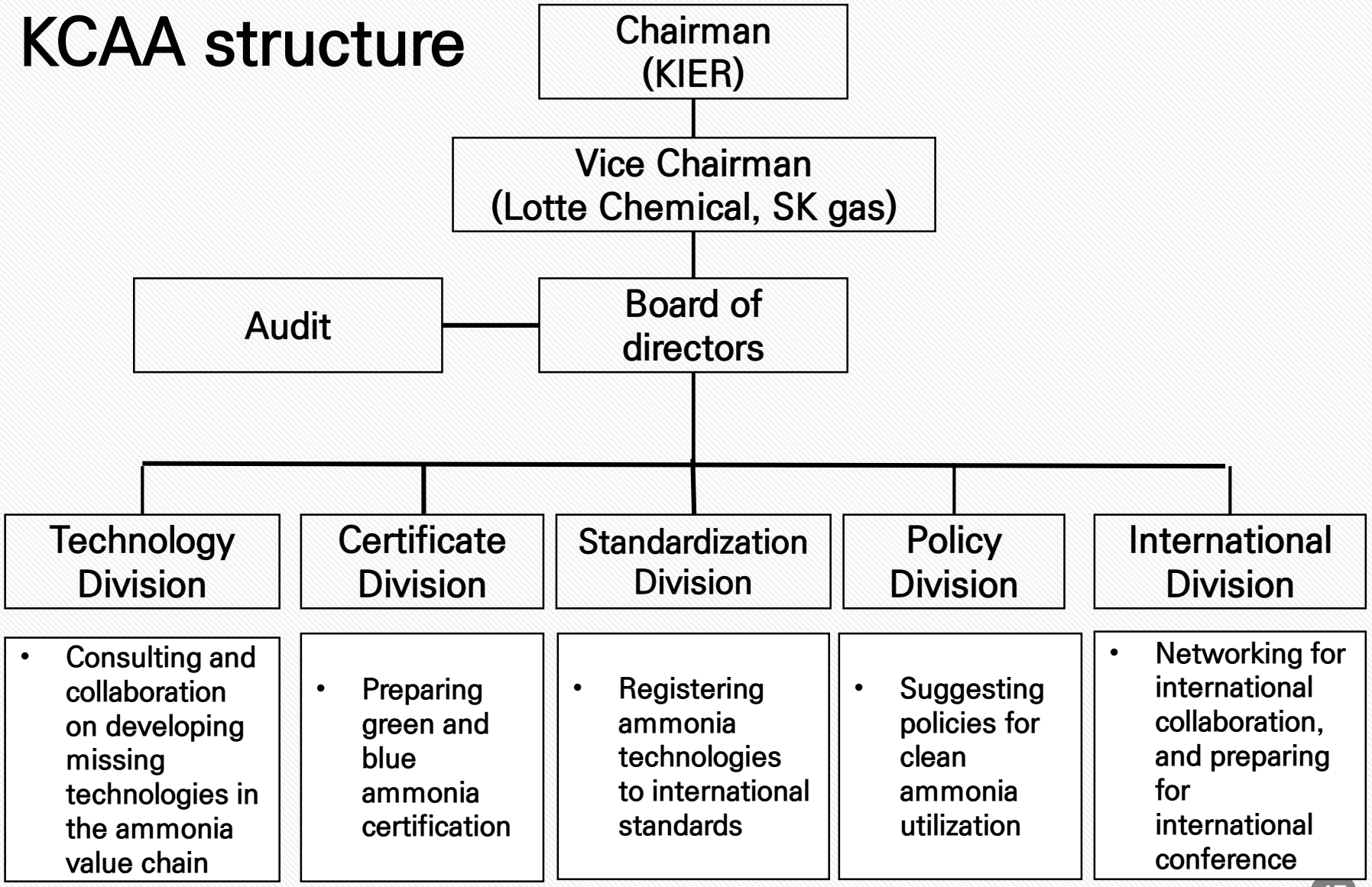
KCAA structure



Closing remark

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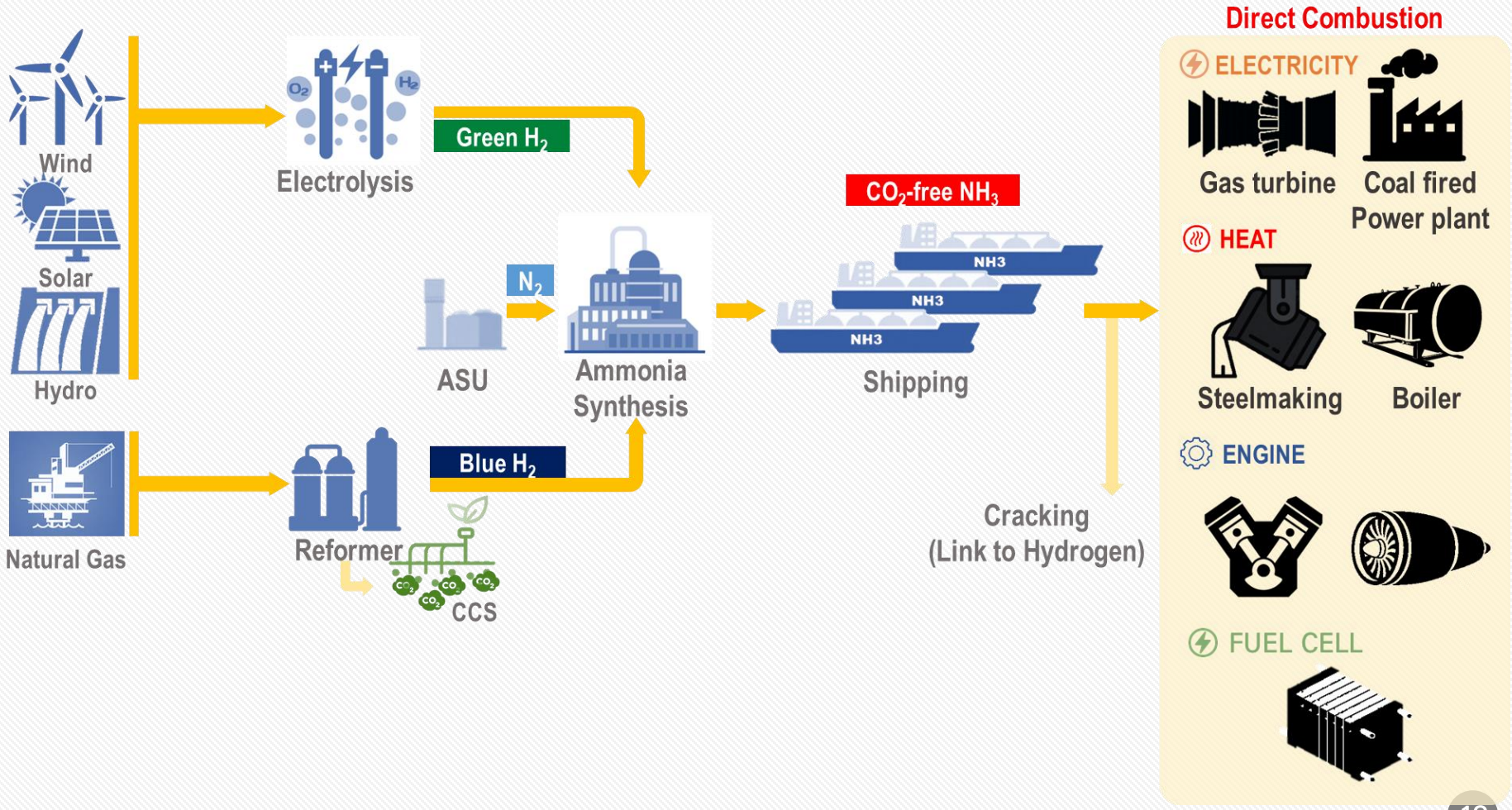
We are open to collaboration to construct the ammonia value chain together!



Thank you for your attention

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