

RoK-China-Japan

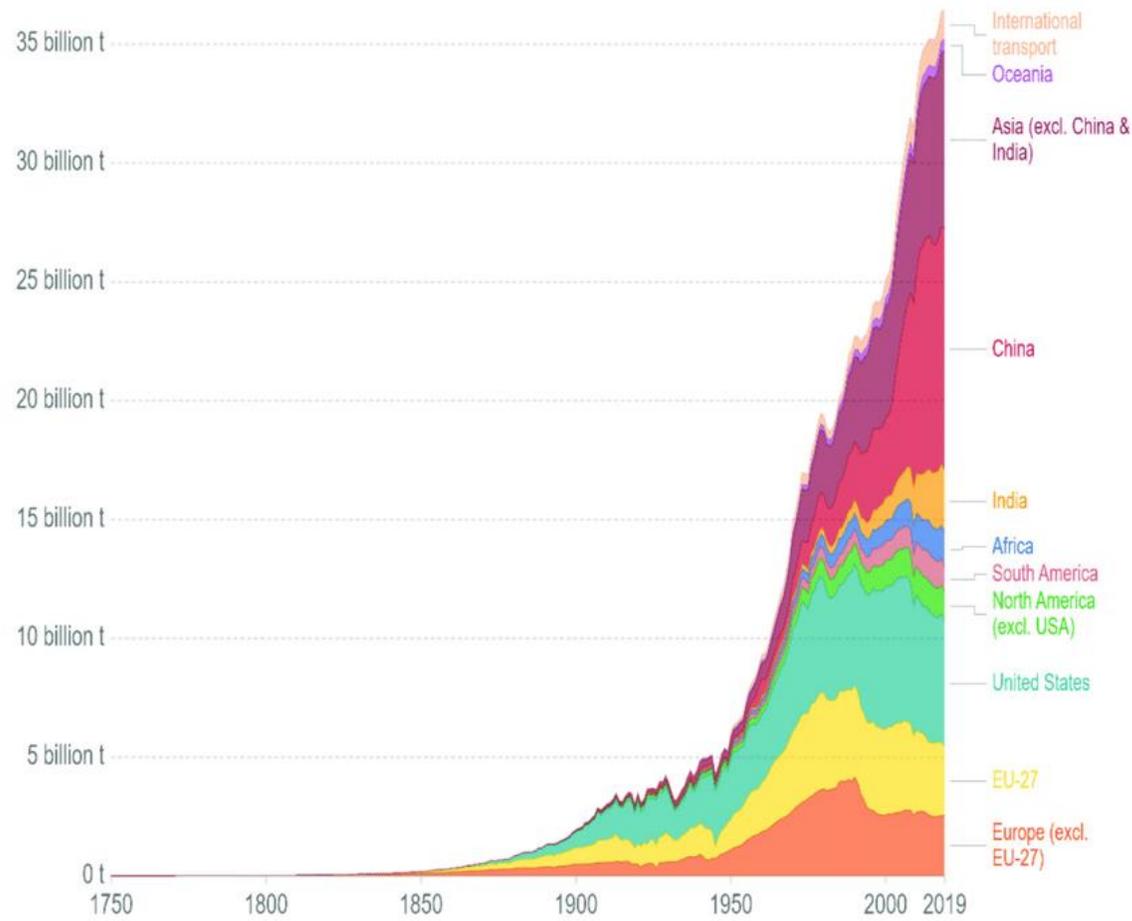
Reduce CO2 by
Ammonia and Nuclear Power

Jan. 17, 2021

East Asia Foundation Conference on CJK Cooperation

Jooho Whang

Self-Portraits



Research Gate

China > US > Europe >
.....> Japan > Korea

China

Emissions tripled since 2000
Reduced carbon intensity by 45%
compared to 2005
Peak emissions around 2030

Japan

Targeted, in 2010, reducing by 25% by 2020
and 80% by 2050.
Fukushima incident derailed targets

Korea

Announced, in 2009, reducing by 4% below
2005 levels by 2020.
In reality, emissions increased >30% by 2019

Prospects

by Wood Mackenzie, 2020

China capacity details (GW)			
	2020	2060 base case	2060 Carbon neutral
Coal	1,098	-710	-810
Gas turbine	106	+210	+150
CCS	0	+9	+90
Alternative fuel (H ₂ , NH ₃)	0	+150	+670
Nuclear	49	+280	+615
Hydro	349	+70	+250
Wind	234	+1,300	+2,030
Solar	195	+1,650	+4,500
Storage	38	+970	+3,080

Japan capacity details (GW)			
	2020	2050 base case	2050 Carbon neutral
Coal	45	-20	-40
Gas turbine	85	-20	-70
CCS	0	0	+10
Alternative fuel (H ₂ , NH ₃)	0	0	+130
Nuclear	7	+5	+20
Hydro	23	0	5
Wind	5	+40	+180
Solar	55	+145	+450
Storage	28	+40	+240

South Korea capacity details (GW)			
	2020	2050 base case	2050 Carbon neutral
Coal	35	-15	-15
Gas turbine	41	+1	-5
CCS	0	0	+25
Alternative fuel (H ₂ , NH ₃)	0	0	+135
Nuclear	26	-15	+15
Hydro	2	0	0
Wind	2	+30	+75
Solar	14	+35	+600
Storage	6	+35	+300

US\$ 6.4 trillion, H2/Ammonia +670GW, Nuclear +615 GW

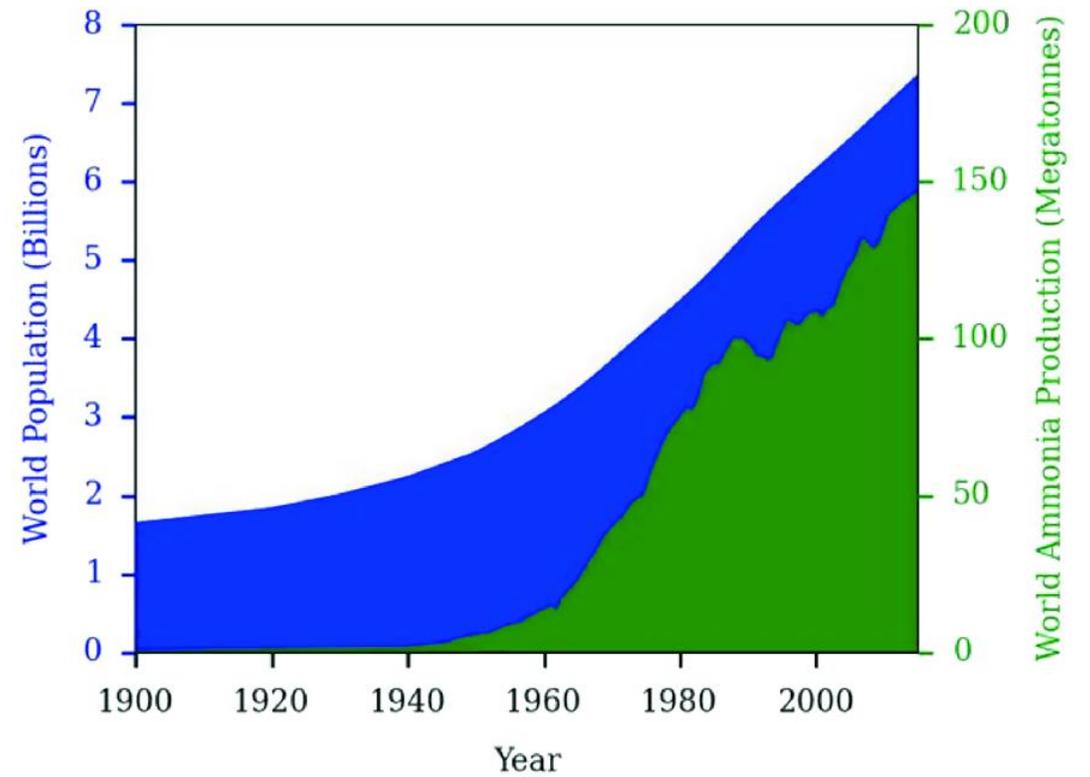
US\$ 1.4 trillion, H2/Ammonia +130GW, Nuclear +20 GW

US\$ 1.4 trillion, H2/Ammonia +135GW, Nuclear +15 GW

Ammonia

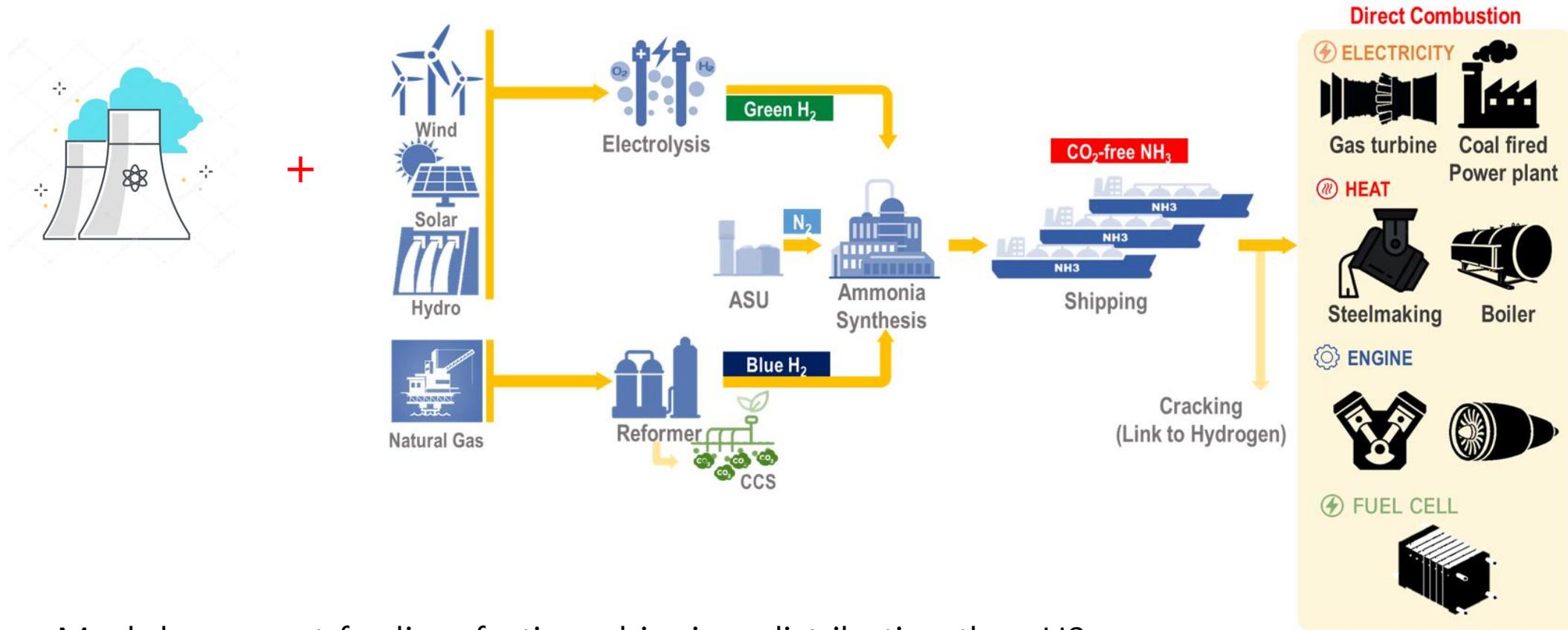


Fertilizer broke the Principle of Population



Springer Link

Ammonia Value Chain



Much lower cost for liquefaction, shipping, distribution than H2

Ammonia



Ammonia Bus Fleet in Belgium, 1943



NH₃ powered Car, Auto Hire International

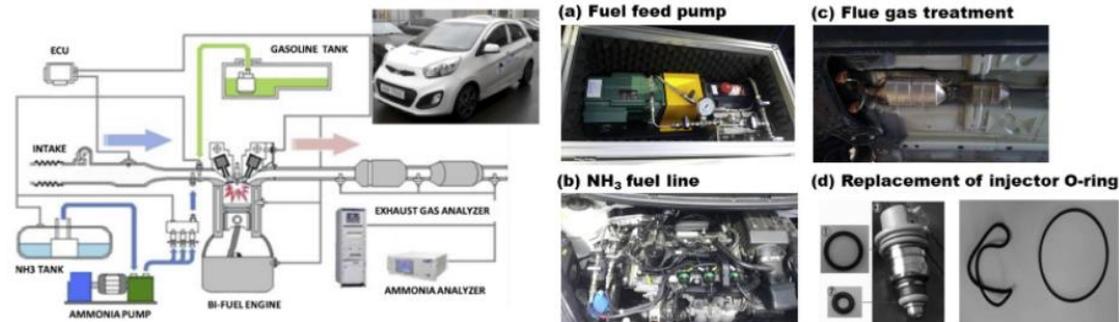


Fig. 14. Ammonia based engine for transportation in Korea. Modified from [22].

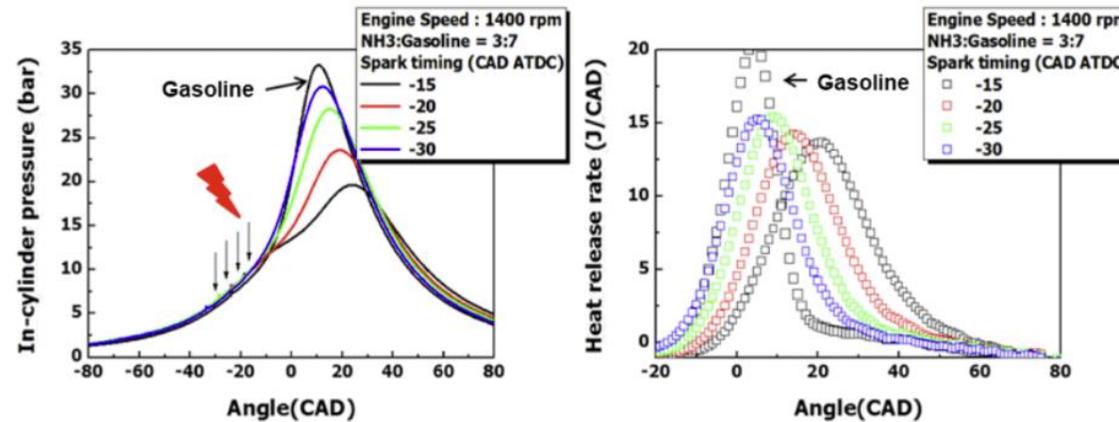


Fig. 15. Combustion characteristics diagram of ammonia-gasoline mixture. (a) combustion pressure, (b) heat release rate.



40MW NH₃ Turbine, MHI



Offshore Energy

China

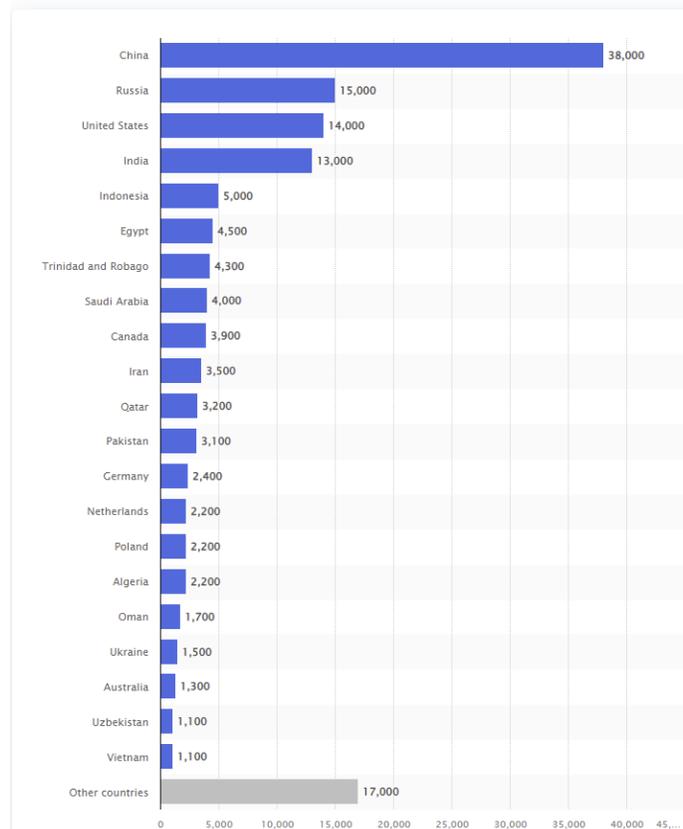
Photochemical smog: CO₂ is not the only issue in China.



China

Producer of 1/3 World Ammonia

Ammonia production worldwide in 2020, by country
(in 1,000 metric tons)



Statistica

“Dirty” coal-fed ammonia-urea plants in China are being closed faster than they are being replaced.

Tomorrow’s technology: electrochemical ammonia synthesis

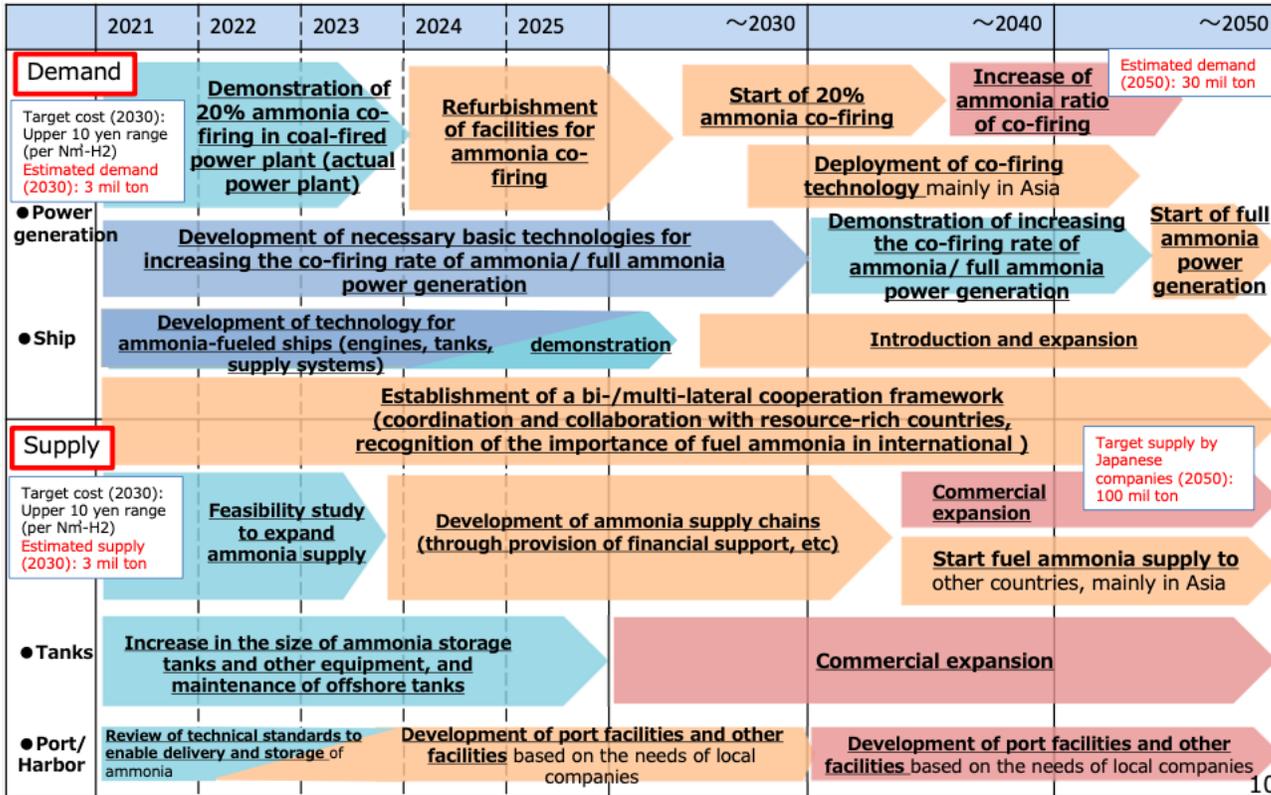
At the same time, Chinese academics are publishing more research papers on next-generation ammonia synthesis technologies than academics from any other country, possibly even including the United States.

Ammonia Energy Association

Japan

Japan's Road Map for Fuel Ammonia

(Japan's Green Growth Strategy: Dec 2020, Public-Private Council: Feb 2021)



Demand: 3 mil ton by 2030, 30 mil ton by 2050
Supply by Japanese companies: 100 mil ton

Australia and Japan: Old Friends, New Opportunities Decarbonising the region with hydrogen and ammonia

Breakfast Webinar, 8AM AEST, Tuesday 5 October



Presented by the Australian Hydrogen Council (AHC) and the Ammonia Energy Association Australia (AEA Australia), with support from the Australia Japan Business Co-operation Committee (AJBCC).

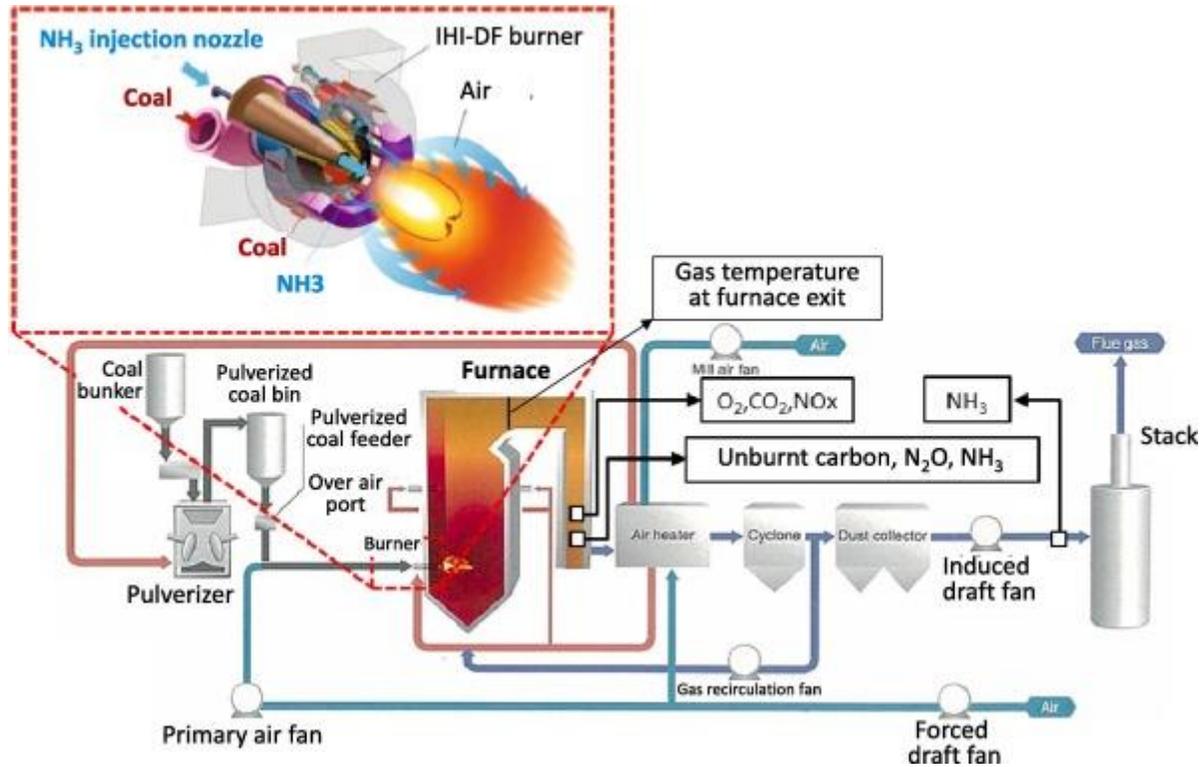


Saudi Aramco, produced the fuel, which it does by converting hydrocarbons into hydrogen and then ammonia, and capturing the carbon dioxide byproduct. Japan will receive 40 tons of blue ammonia in the first shipment, Aramco said.

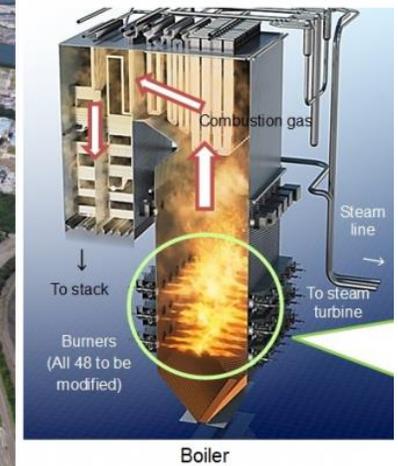
أرامكو السعودية
Saudi Aramco

Japan

Ammonia Demonstration



Science Direct



Ammonia co-firing started in June, 2021,
Gas to Power Journal

Korea

- Hydrogen Demand and Supply
 - Fuel Cell Car, 6.2 million, 1,200 station y 2040
 - Power Generation 14 GW, Building 2.1 GW
 - H2 Production 5.26 mil ton/yr at 3,000 won/kg
- NDC 2030: Ammonia Power Generation 22.1TWh
- Carbon Neutral Scenario by 2050: 13.8~21.5% Power Generation by H2+NH3
- Ammonia co-firing (20%) by 2030, H2 co-firing(30%) by 2035

Korea

GS Energy to import ADNOC's blue hydrogen to South Korea

Mitsui and GS Energy to Join TA'ZIZ in World-Scale Low-Carbon Blue Ammonia Project



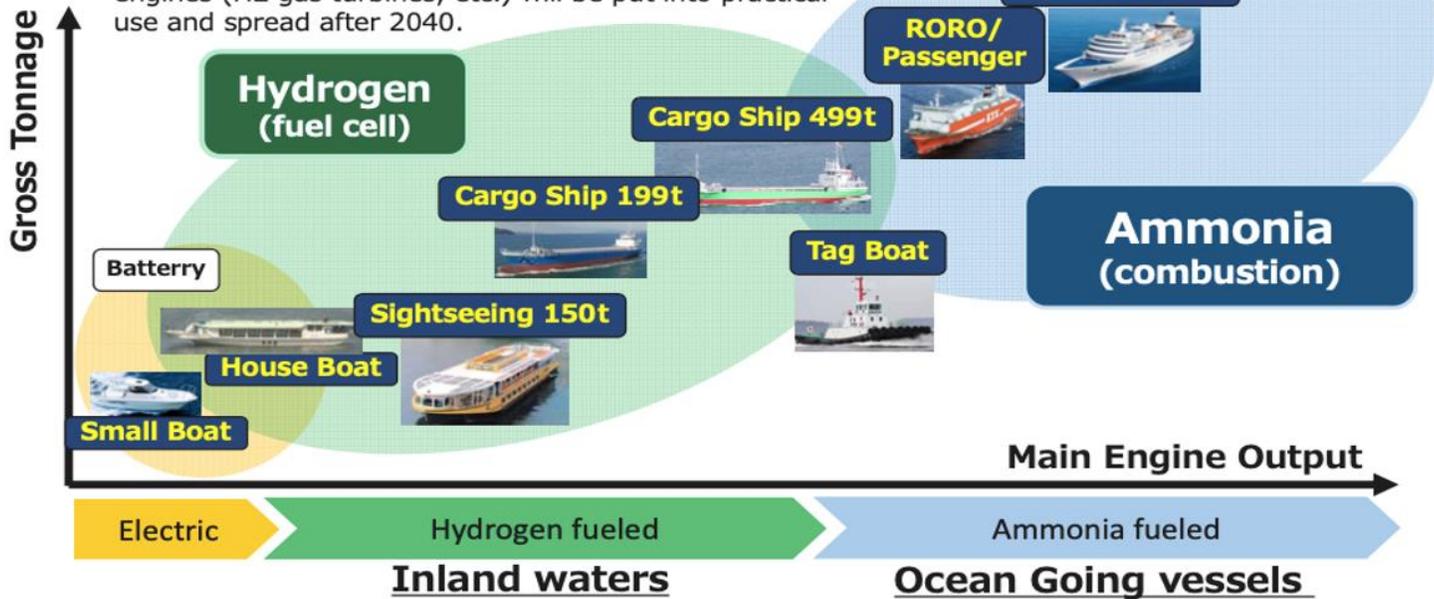
Korea

Hydrogen and Ammonia Playing Different Roles in 2030s



Due to engine output size, ammonia combustion is expected to be suitable for ocean going vessels

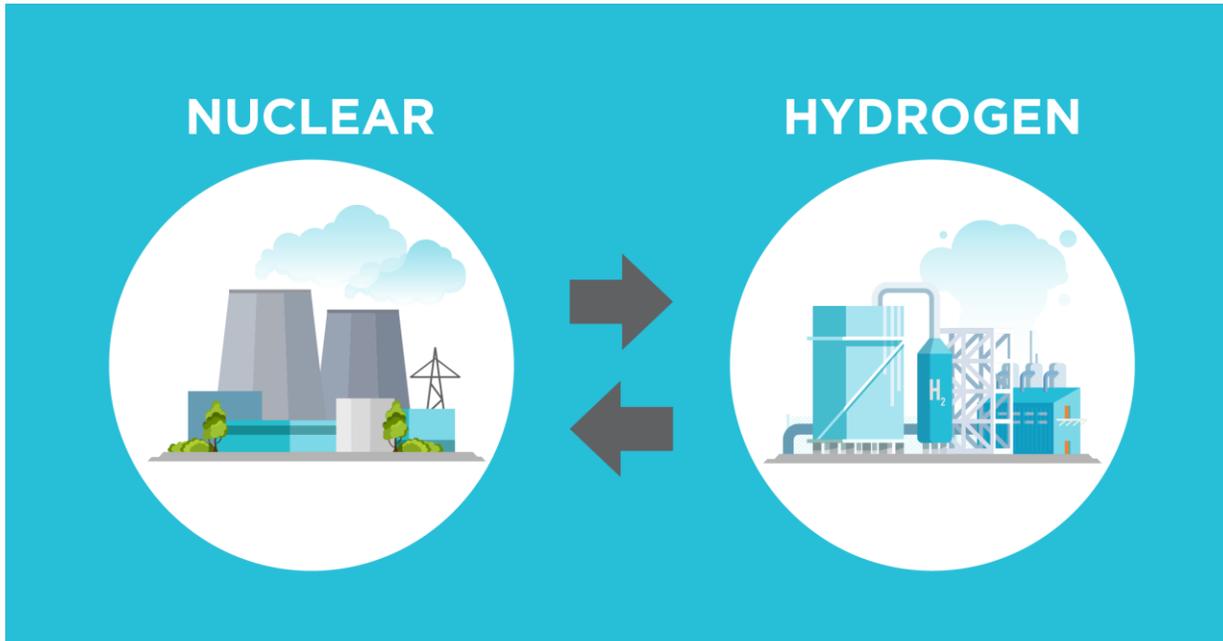
We predict that liquefied hydrogen fuel combustion engines (H2 gas turbines, etc.) will be put into practical use and spread after 2040.



3 Korean Ship Builders to Commercialize NH3 and H2 Ships by 2025



Korea



The infographic features a blue background with two white circles. The left circle is labeled 'NUCLEAR' and contains an illustration of a nuclear power plant with two cooling towers and a power line. The right circle is labeled 'HYDROGEN' and contains an illustration of a hydrogen production facility with a large blue tank labeled 'H₂' and various pipes. Two dark grey arrows point from the nuclear plant to the hydrogen facility and back, indicating a bidirectional relationship.

Department of Energy

DOE Announces \$20 Million to Produce Clean Hydrogen From Nuclear Power

OCTOBER 7, 2021



Cooperation for Hydrogen Production by Electrolysis and Electrochemical Production of Ammonia

Let's think about it

Ammonia production spends ~2% of world energy consumption now.
It emits as much CO₂ as Korea does and will consume more energy in the future.

Ammonia finds many applications in reducing CO₂.

China, Japan and Korea need to develop economic ways to produce Carbon-free
Ammonia.

1 GW Nuclear Power, operating 24 hours 7days a week, may produce
250,000~350,000 tonH₂/yr.