GLOBAL GREEN HYDROGEN BUSINESS MODEL

SEMINAR| MAY. 2023

Synergy Consulting

SYNERGY CONSULTING INTRODUCTION

- GLOBAL EXPERIENCE

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U.S.A | India | Indonesia | Ireland | Japan | K.S.A | Republic of South Africa | Korea | U.A.E | U.K. | Uzbekistan

Reach

Across 70+ Countries	In 5 Continents	More than 400 Clients

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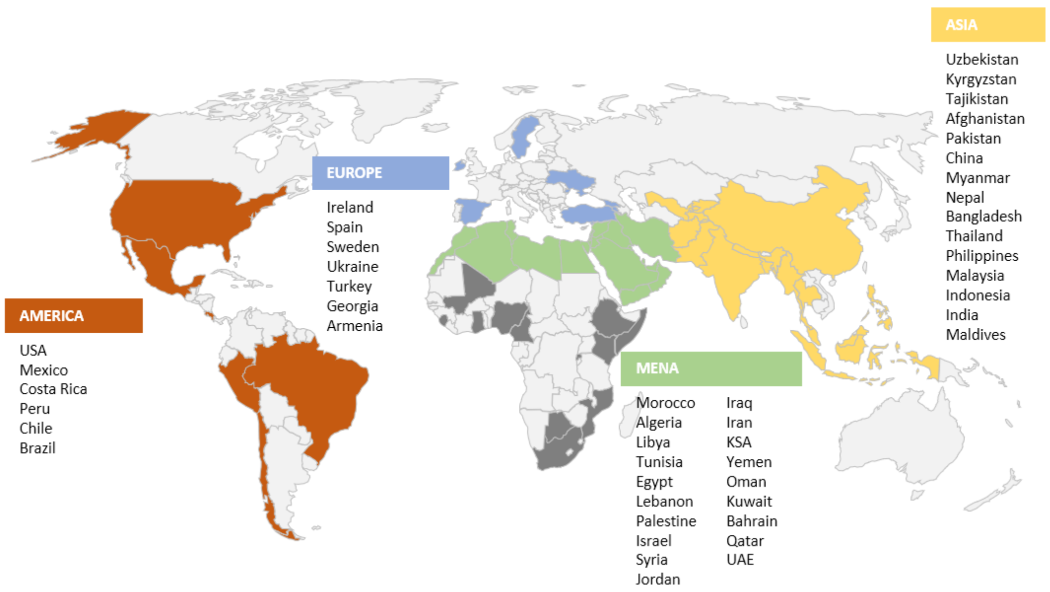
Financial Closure for deals worth **USD 70+ BN**	M&A Advisory for deals worth **USD 8+ BN**
Valuation and Due Diligence **200+ Deals**	Employee Strength **100+**



- BUSINESS SERVICES


Feasibility Study


ECA Advisory, DFI Advisory And Fund Raising


Financial Modeling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Project Finance & Bid Advisory


Mergers & Acquisitions

- SYNERGY KOREA

Synergy Korea has been cofounded by Synergy Consulting and David Kim in 2017.

Synergy Korea has provided financial and development advisory services for overseas infrastructure development projects promoted by public entities and private developers in Korea and are expanding the market recognition to Korean developers

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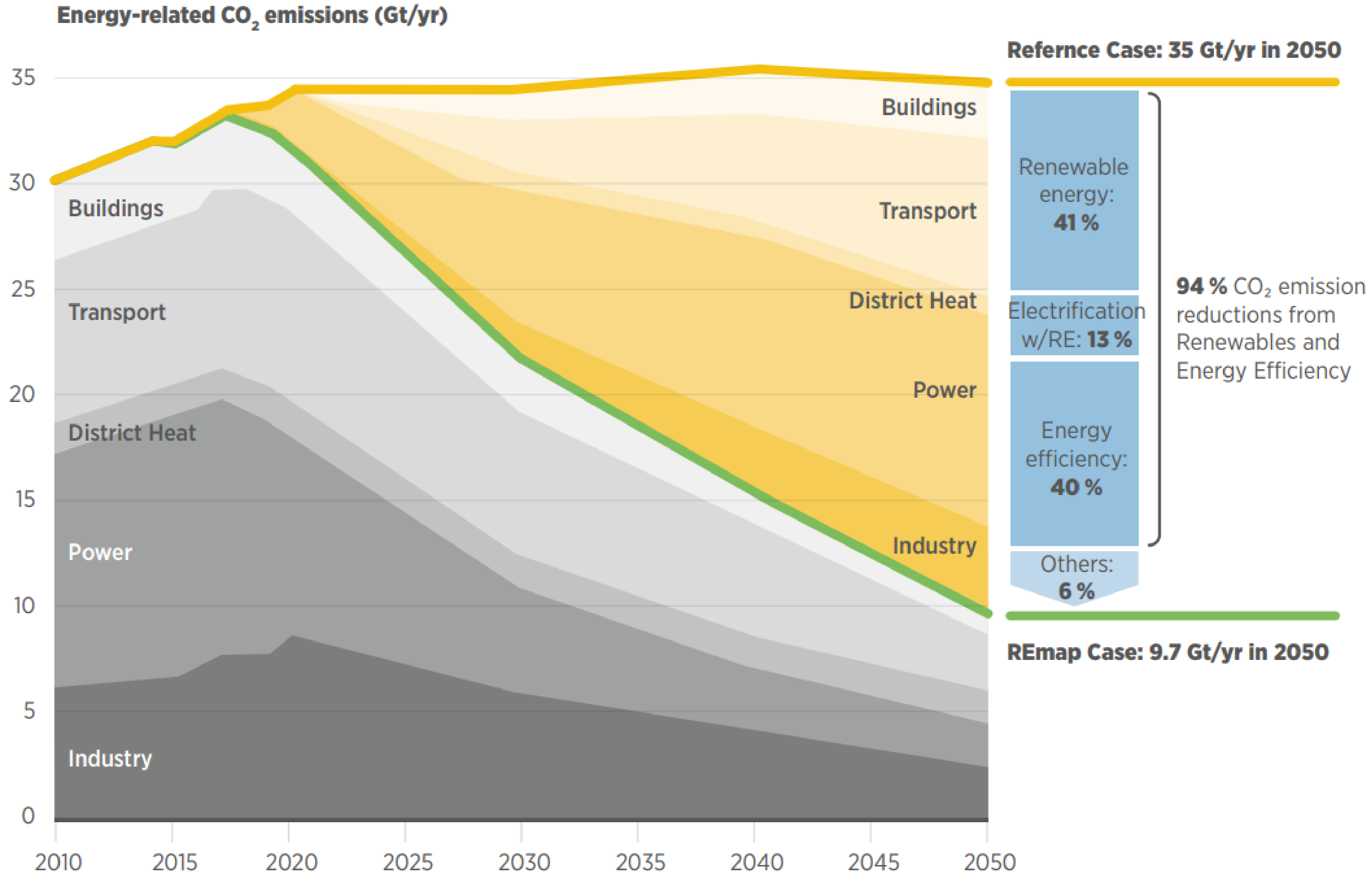
INTRODUCTION TO GREEN HYDROGEN & GREEN AMMONIA

1.1 Overview

Background(1/2)



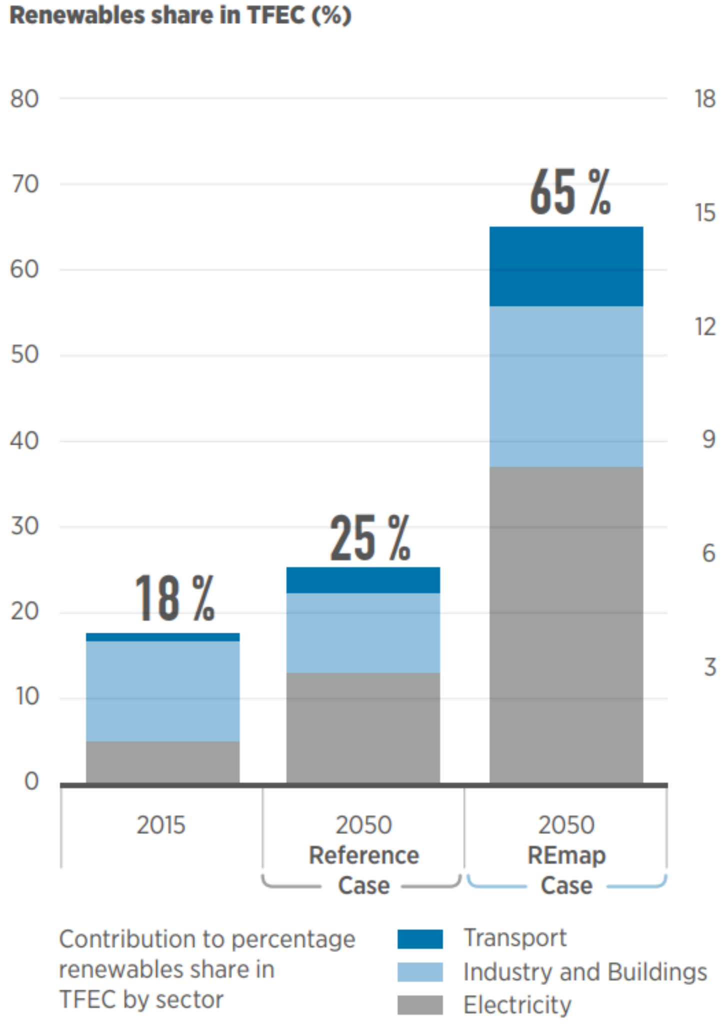
Source: IRENA

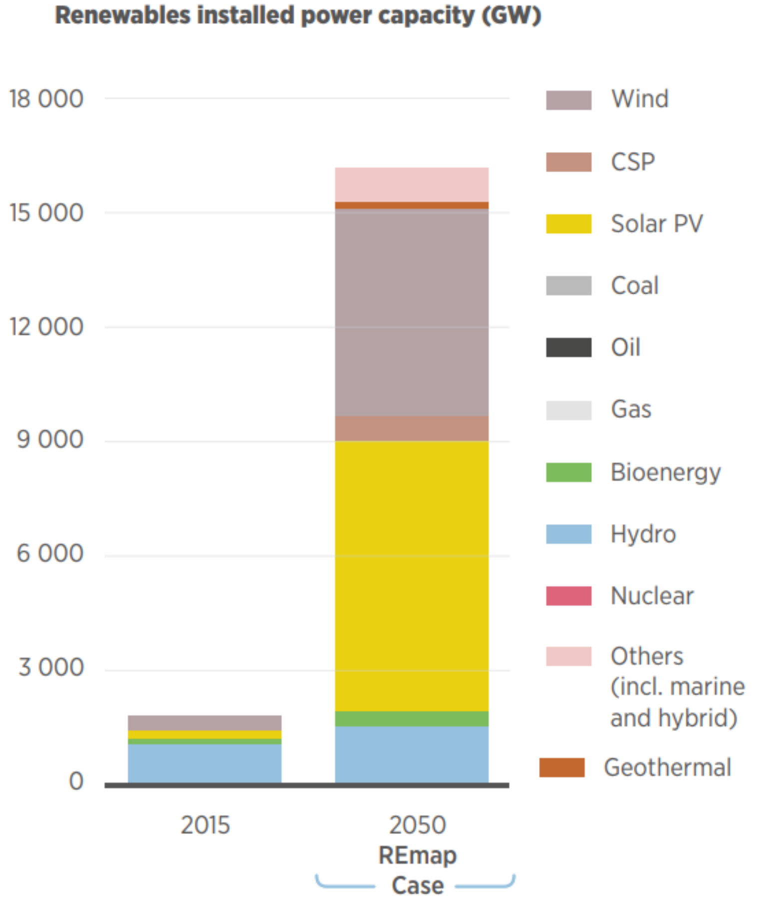
- ❑ Countries reaffirmed the Paris Agreement goal of limiting the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit it to 1.5 °C. And they went further, expressing “alarm and utmost concern that human activities have caused around 1.1 °C of warming to date, that impacts are already being felt in every region, and that carbon budgets consistent with achieving the Paris Agreement temperature goal are now small and being rapidly depleted.” They recognized that the impacts of climate change will be much lower at a temperature increase of 1.5 °C compared with 2 °C.

- ❑ To achieve this goal, we need to reduce CO2 by more than 70% compared to 2020.

1.1 Overview

Background(2/2)





So

Notes: CSP = concentrated solar power; GW = gigawatt; PV = photovoltaic; TFEC = total final energy consumption.

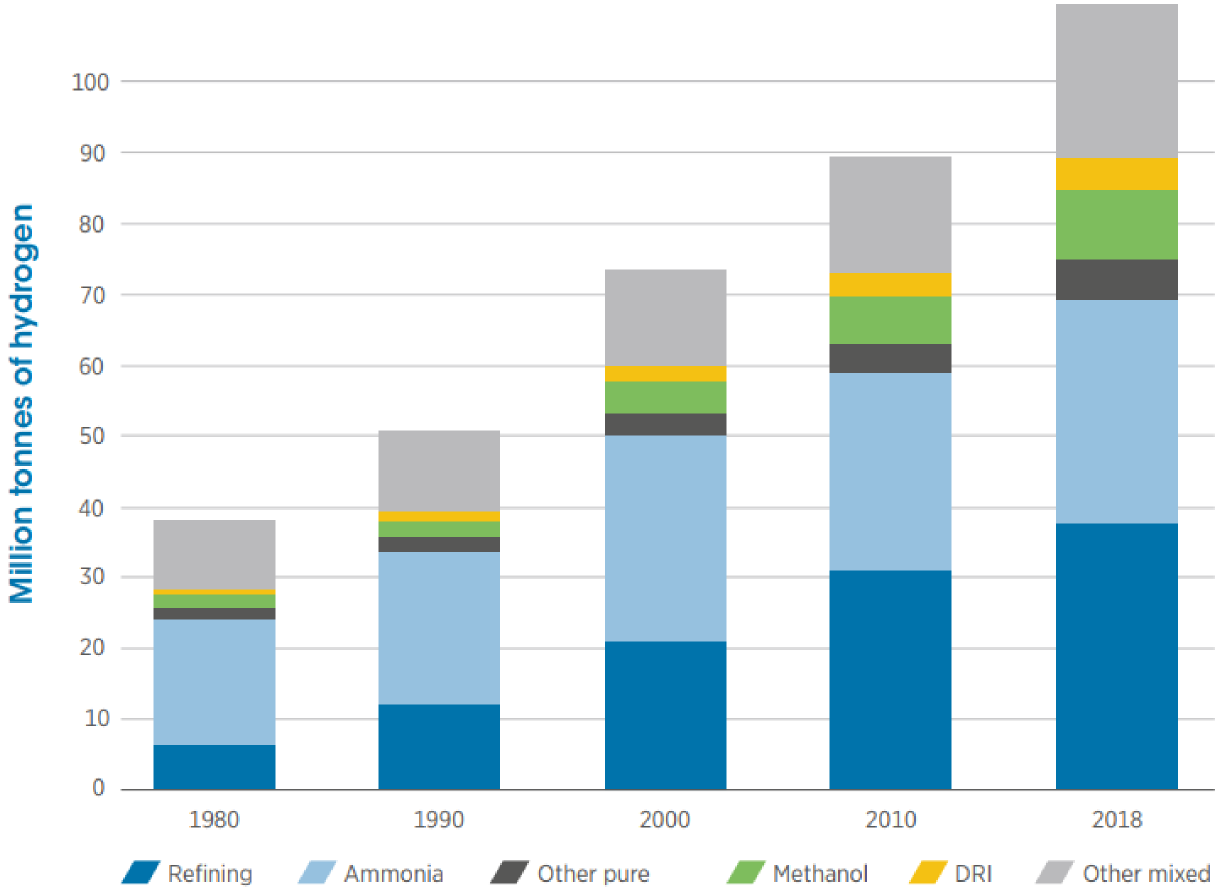
- ❑ To achieve the targets in the Paris Agreement, the global energy system must undergo a profound transformation from one largely based on fossil fuels to an efficient and renewable low-carbon energy system. According to analysis by the International Renewable Energy Agency over 90 % of the necessary global CO_2 emission reductions could come from these measures; renewable energy is expected to contribute 41 % of the required emission reductions directly and an additional 13 % through electrification To meet this objective, renewable energy's share of global final energy consumption needs to increase from 18 % today to 65 % in 2050.

- ❑ Variable renewable energy in the power system, in particular wind and solar, will make up the vast majority of generation capacity and capacity % of all electricity generation. The power system needs to become more flexible to economically integrate such large shares of variable generation.

1.1 Overview

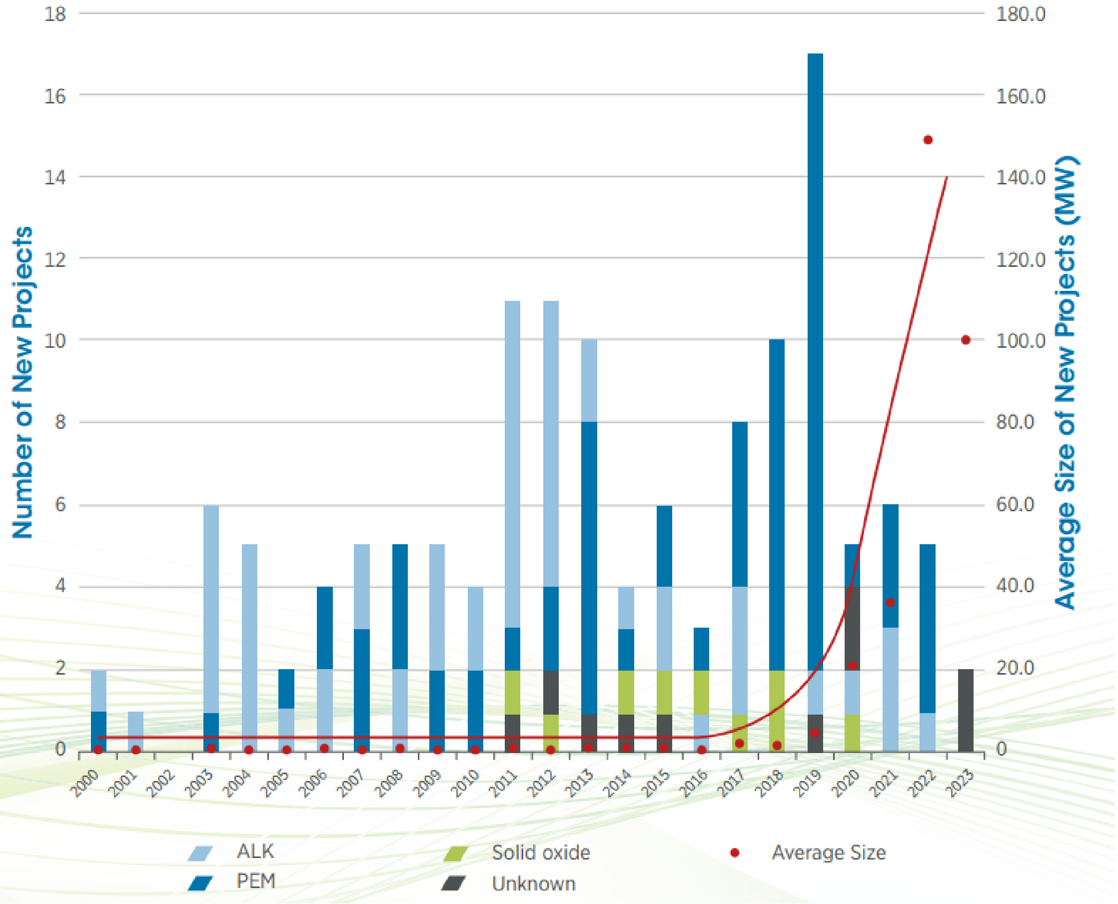
Green Hydrogen (1/2)

Global annual demand for hydrogen since 1980



Source: IEA

Timeline of power-to-hydrogen projects by electrolyser technology and project scale



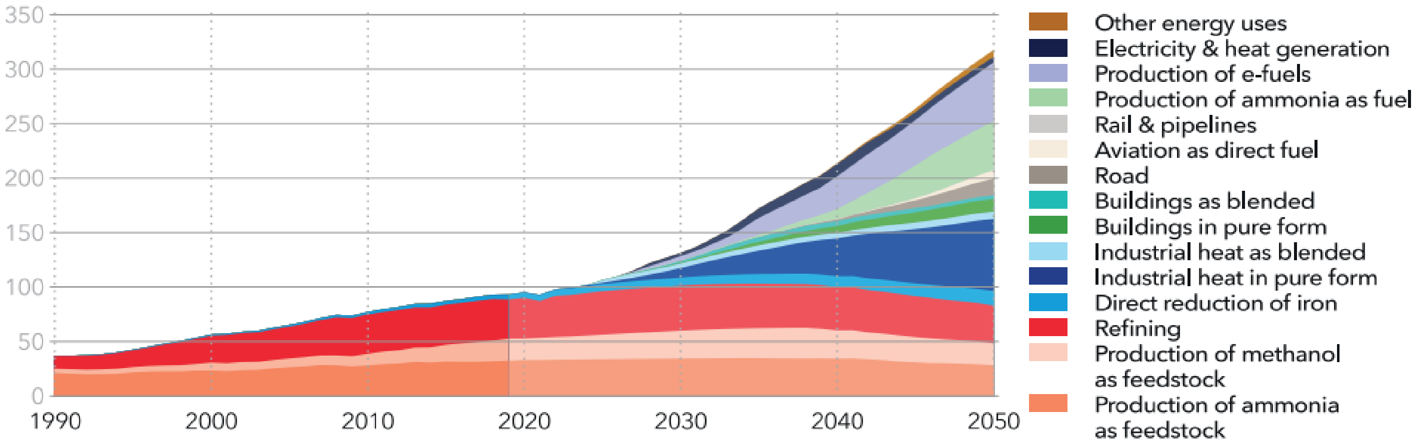
Source: Quarton and Samsatli and IRENA Database

1.1 Overview

Green Hydrogen (2/2)

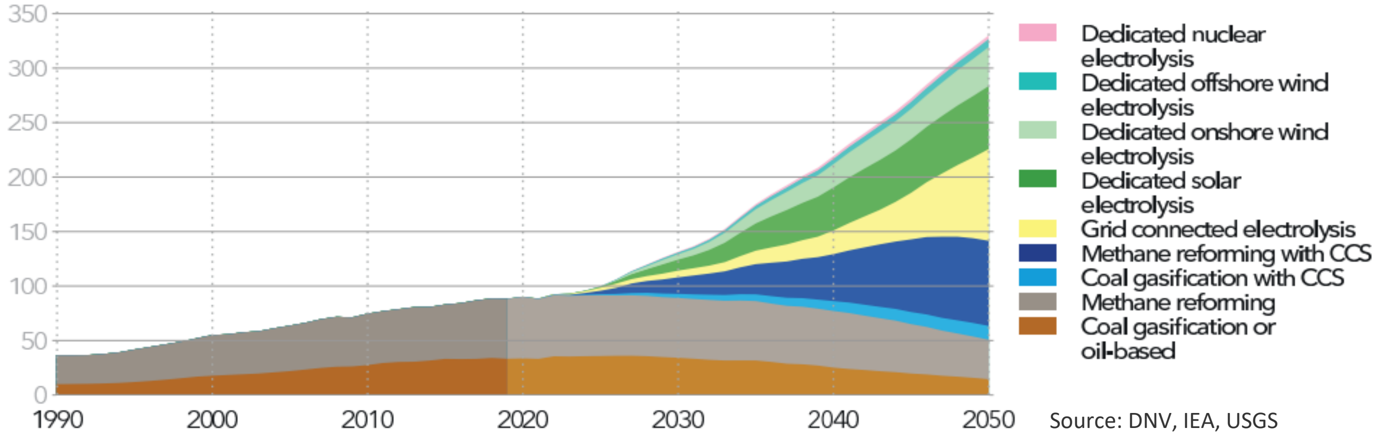
Global hydrogen demand by sector

Units: MtH_2/yr



World hydrogen production by production route

Units: MtH_2/yr



Source: DNV, IEA, USGS

Hydrogen Color Spectrum

GREEN
Hydrogen produced by electrolysis of water, using electricity from renewable sources like hydropower, wind, and solar. Zero carbon emissions are produced.

TURQUOISE
Hydrogen produced by the thermal splitting of methane (methane pyrolysis). Instead of CO_2, solid carbon is produced.

PINK/PURPLE/RED
Hydrogen produced by electrolysis using nuclear power.

BLACK/GRAY
Hydrogen extracted from natural gas using steam-methane reforming.

YELLOW
Hydrogen produced by electrolysis using grid electricity.

BLUE
Grey or brown hydrogen with its CO_2 sequestered or repurposed.

WHITE
Hydrogen produced as a byproduct of industrial processes.

BROWN
Hydrogen extracted from fossil fuels, usually coal, using gasification.

Source: NACFE

1.1 Overview

Unbalanced Supply and Demand of Hydrogen in Global Hydrogen Hub

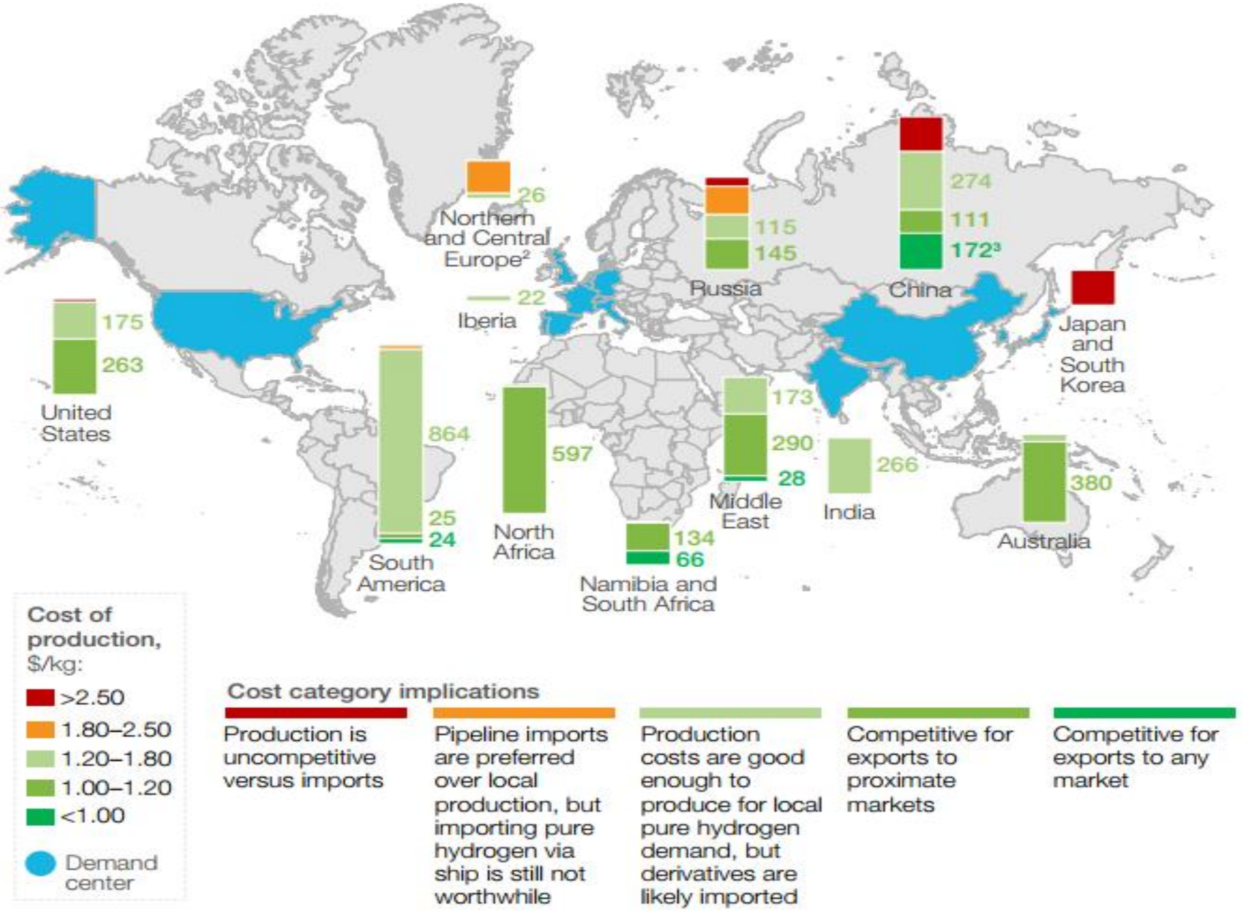
There is a mismatch between the best locations for hydrogen production and demand centers.

The production costs and commercial potential for each region vary widely and are driven by three main factors:

1. The levelized cost of hydrogen production, which is driven by local renewable resources and electrolyzer utilization or the local cost of methane and carbon capture and storage(CCS).

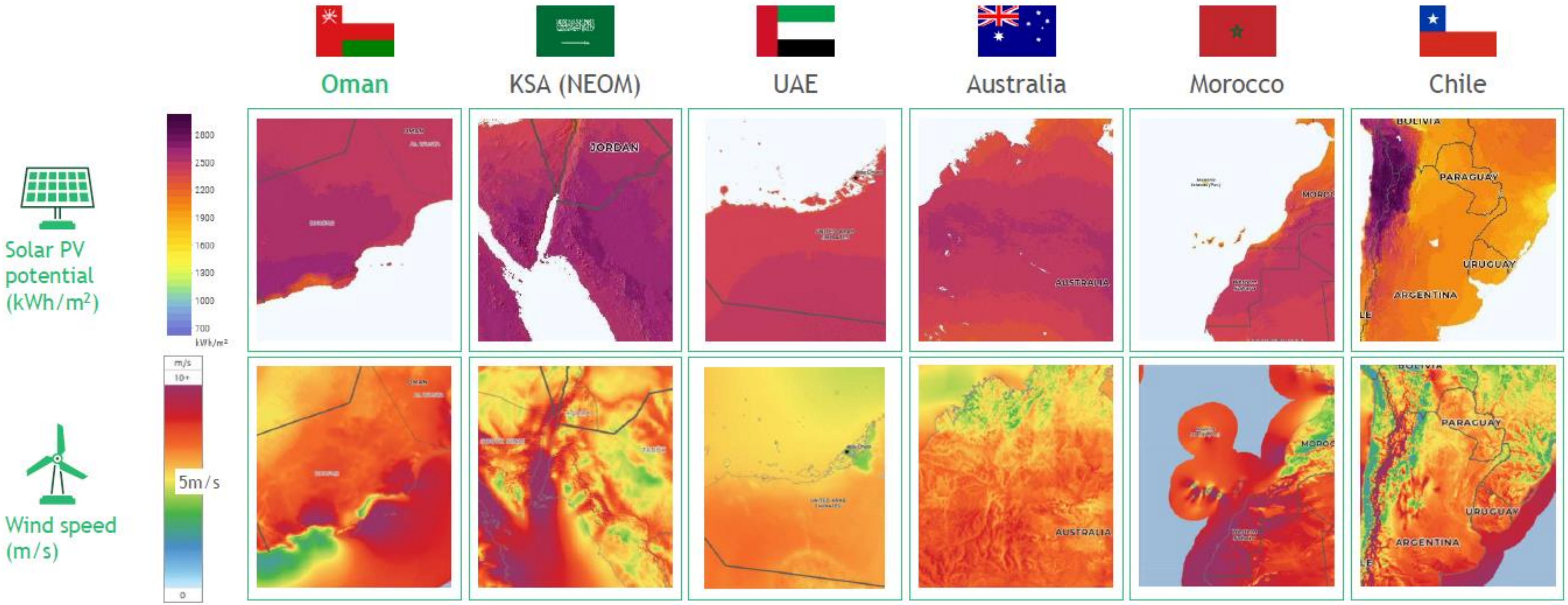
2. The availability and costs to access other critical feedstocks – for example, biogenic CO2 for synthetic fuels or high-quality iron re for direct reduced iron (DRI) used in green steel.

3. Country-specific factors, including the region's investment attractiveness(market efficiency, workforce availability, or country risk factor) and local public acceptance of building new infrastructure.



1.1 Overview

Favorable Geographies to Produce Large Scale Renewable



*Note: Global tilted irradiation at optimal angle

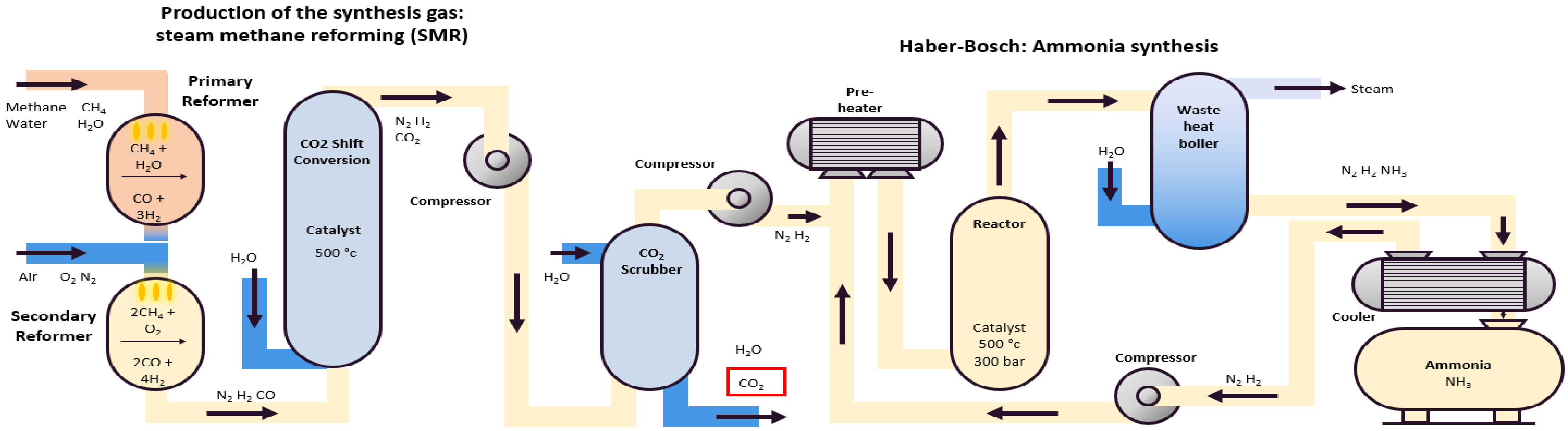
Source: Global solar atlas, Global wind atlas

1.2 Uses of Ammonia

About Ammonia

- Ammonia is a colorless gas with a characteristically pungent smell. It is lighter than air and is easily liquefied due to strong hydrogen bond.
- Traditionally ammonia is used as a building block for nitrogen fertilizers. It is also used in manufacturing of technical products e.g. low density (explosive) grade ammonium nitrate, acrylonitrile, caprolactam, isocyanates MDI/TDI (intermediates for textiles and plastics) and for selective catalytic reduction (SCR) uses in emissions control (largely by upgrading to urea).

Grey Ammonia Production Process



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1.2 Uses of Ammonia

Types of Production Processes : Grey/ Blue/ Green Ammonia Production Process

	Hydrogen Production	Ammonia Production	Remark
Grey Ammonia Production Process	$CH_4 \rightarrow H_2 + C$ **Steam Methane Reforming Process**	$H_2 + N_2 \rightarrow NH_3$ **Haber Bosch: Ammonia Synthesis**	• 2.87 tons of CO_2 produced per ton of NH_3 production, • Contributes to over 1% of global carbon emissions.
Blue Ammonia Production Process	$CH_4 \rightarrow H_2 + C$ Carbon Capture **Steam Methane Reforming Process**	$H_2 + N_2 \rightarrow NH_3$ **Haber Bosch: Ammonia Synthesis**	• Same production process as grey ammonia • Additional step of carbon capture and storage to prevent emissions to atmosphere • However, all of the CO_2 produced cannot be captured efficiently
Green Ammonia Production Process	$H_20 \rightarrow H_2 + O_2$ **Electrolysis**	$H_2 + N_2 \rightarrow NH_3$ **Haber Bosch: Ammonia Synthesis**	• Zero carbon emission

1.2 Uses of Ammonia – Existing Uses

Potential for Using Green Ammonia in Fertilizers

1. Green Ammonia itself, as a direct application, could be used as nitrogen fertilizer. Replacing Grey Ammonia with Green Ammonia offers the potential to produce carbon free nitrogen fertilizers.
2. Green Ammonia could also be used for the production of NPK compounds which are used as fertilizers in the agriculture industry.
3. Most of the potential for using Green Ammonia for the production of fertilizers will be concentrated in Europe.

Potential for Using Green Ammonia in Other Industrial Sectors

Industrial Uses of Ammonia

1. Caprolactam
2. Acrylonitrile
3. Methyl methacrylate (MMA)
4. Technical nitrates (explosives)
5. Uses as a NOx reagent

Several Green Ammonia projects in countries with substantial mining industries are planning to use Green Ammonia to produce nitrates. This is the case in Australia and Chile. However, market is small in Europe.

Producers of Acrylonitrile and Caprolactam, which are used to produce synthetic fibres, are looking at Green Ammonia to develop a carbon free source of fibres for the production of clothing and furnishings.

Ammonia is also increasingly used as a NOx reagent in large Selective Catalytic Reduction systems (SCR) installed in large stationary sources of this harmful gas, in particular coal power plants. The same system would be used to scrub NOx emitted from some of the potential new users of Green Ammonia such as ships and power plants.

1.2 Uses of Ammonia – New Uses(1/4)

Marine Fuel : IMO targets at least 40% reduction in CO2 by 2030

IMO 2030 Targets	• A reduction in average carbon intensity (CO_2 per tonne mile) of at least 40% by 2030. This is an improvement in the relative efficiency per tonne mile from the perspective of CO_2 emissions. This represents the IMO's medium term goal.
IMO 2050 Targets	• Necessitating a 50% reduction of GHG emissions from shipping by 2050. In order to meet this more aggressive target by 2050, zero carbon fuels will need to play a part in the fuel mix beyond 2030.

Around 15% of the fuel mix in 2040 is forecast to be zero carbon fuels on an energy basis. Zero carbon fuel vessels are expected to be delivered from 2030. This proportion will grow rapidly between 2040 and 2050.

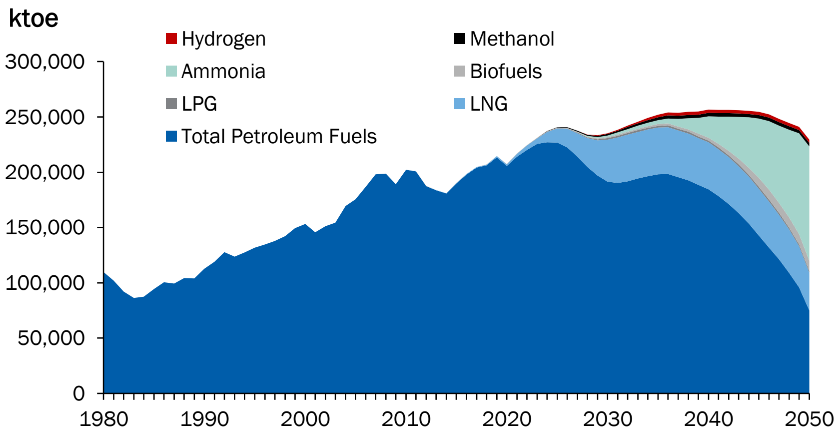
Green Ammonia AS Marine Fuel

- The most promising end use for ammonia is expected to be as a marine fuel. There is a growing interest for ammonia in the transportation sector as a shipping and marine fuel, due to its zero-sulphur content which results in lower emissions of particulates, improved air quality, and ensures compliance with IMO 2020 and IMO 2050. This is expected to mandate a 50% reduction in annual greenhouse gas emissions for shipping fuels.
- In terms of demand potential, there is a wide range of forecasts and estimates. According to DNV GL, ammonia can constitute 25% of marine fuels by 2050. The IEA also expects ammonia to account for an increasing percentage of marine fuel consumption.

Key advantages of Ammonia include:

1. High technological maturity
2. Existing transportation infrastructure
3. High energy efficiency (relative to other carbon free fuels)
4. Ammonia use has a 15% loss, whilst liquid hydrogen has a loss of 46%, from H_2 production to direct use at customer
5. Compressed hydrogen and batteries is practically unfeasible for energy storage on deep sea cargo. It could imply a loss of >50% of the storage volume of a 71kt container vessel

Relative energy density of potential marine fuels



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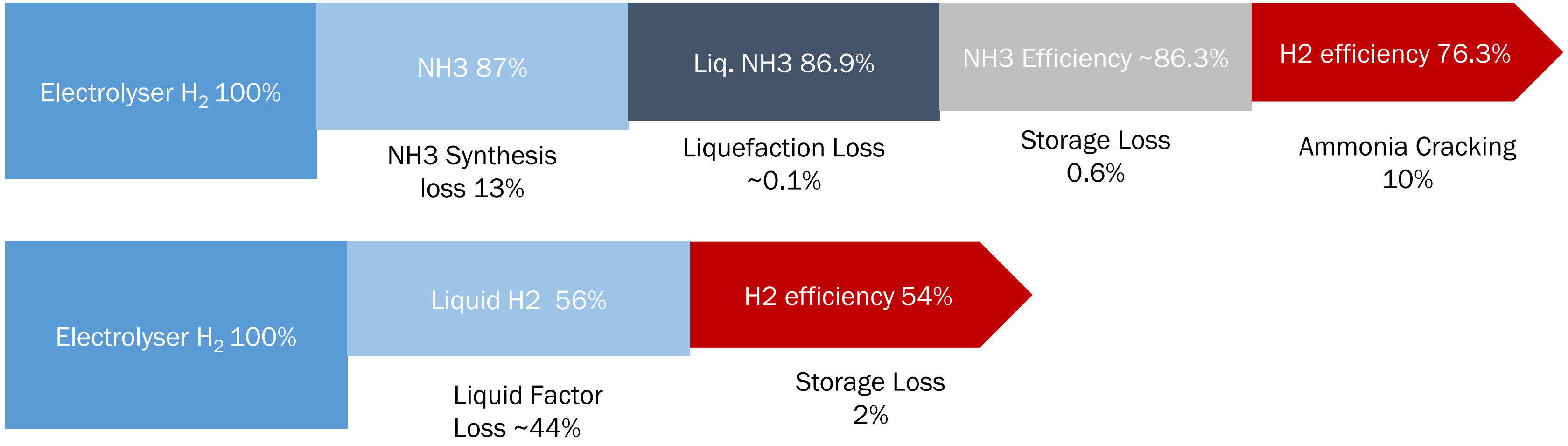
1.2 Uses of Ammonia – New Uses(2/4)

Marine Fuel : Ammonia VS Hydrogen



- Larger ships that carry freight over long distances need fuels with high energy density. Coastal short distance ships can use less energy dense fuels, making a switch to battery electric power technically feasible.
- Ammonia presents a better solution than the pure hydrogen as a marine fuel.

Company Level Investments in Ammonia Vessels

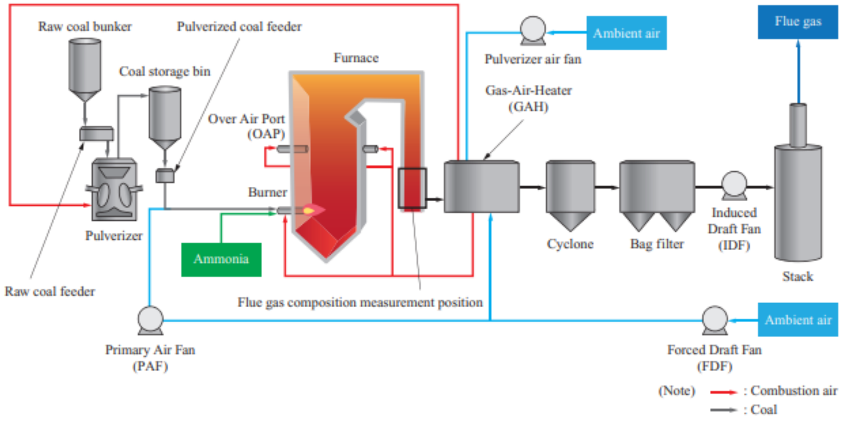
Hartmann Group MAN, OCI N.V	• MAN Energy Solutions, OCI N.V and the Hartmann group are collaborating to create ammonia fueled vessels by 2024. The vessels will be chartered by OCI, owned and operated by Hartmann group and powered by MAN ES engines.
Eidesvik Offshore Viking Energy	• Eidesvik Offshore Viking Energy along with Equinor is launching a full scale research project to test a propulsion solution based on fuel cells running on pure and emission free ammonia.
Yara, Trafigura	• Trafigura and Norway's Yara signed an MoU with an aim to supply the marine industry with carbon emissions free ammonia for fuel.
Hoegh Autoliners	• Hoegh Autoliners plans to add up to twelve vehicle carriers to its fleet that will be able to run on Green Ammonia. Each vessel would have a capacity of 9 100 car equivalent units.

1.2 Uses of Ammonia – New Uses(3/4)

Power Generation: Ammonia Co-firing to Decarbonize the Electricity Sector

- The scarcity of economically feasible options to decarbonize the existing thermal power fleet, which includes coal fired and natural gas fired power plants, has led the power industry to consider the use of hydrogen and ammonia as a means of decarbonizing the sector.
- As the combustion of ammonia releases no carbon emissions, the co firing of ammonia in existing fleet of coal fired power plants implies a reduction in emissions.
- The process is carried out as follows:
    1. Pulverized coal is introduced into the burner along with a supply of air.
    2. Ammonia is then introduced into the burner as a pure gas stream, and mixed around.

New delivery system for ammonia, to be introduced as a pure gas stream, has to be developed alongside existing coal delivery system.



Co-firing Targets: South Korean Government

Policy Support	• In November 2021, the Ministry of Trade, Energy and Industry (MOTIE) drafted a roadmap to 2030 and 2050, to boost ammonia and hydrogen use as a fuel for co-firing and power generation.
Goal	• MOTIE, South Korea is aiming to achieve a 20% ammonia co-firing rate at the country's coal and Liquified Natural Gas (LNG) fired power plants by 2030 and more than 30% hydrogen co-firing by 2025.
Long-term Targets	• In the case of hydrogen co-firing, MOTIE plans that 50% of the 150MW class co-firing demonstration will be completed by 2028, and more than 30% co-firing will be commercialized by 2035, and 30%-100% co-firing or total burning is targeted in 2040. • Ammonia power generation also plans to complete 20% co-fired demonstration by 2027 and to apply and commercialize 20% co-fired power generation to more than half (24 units) of all coal power plants (43 units) by 2030.

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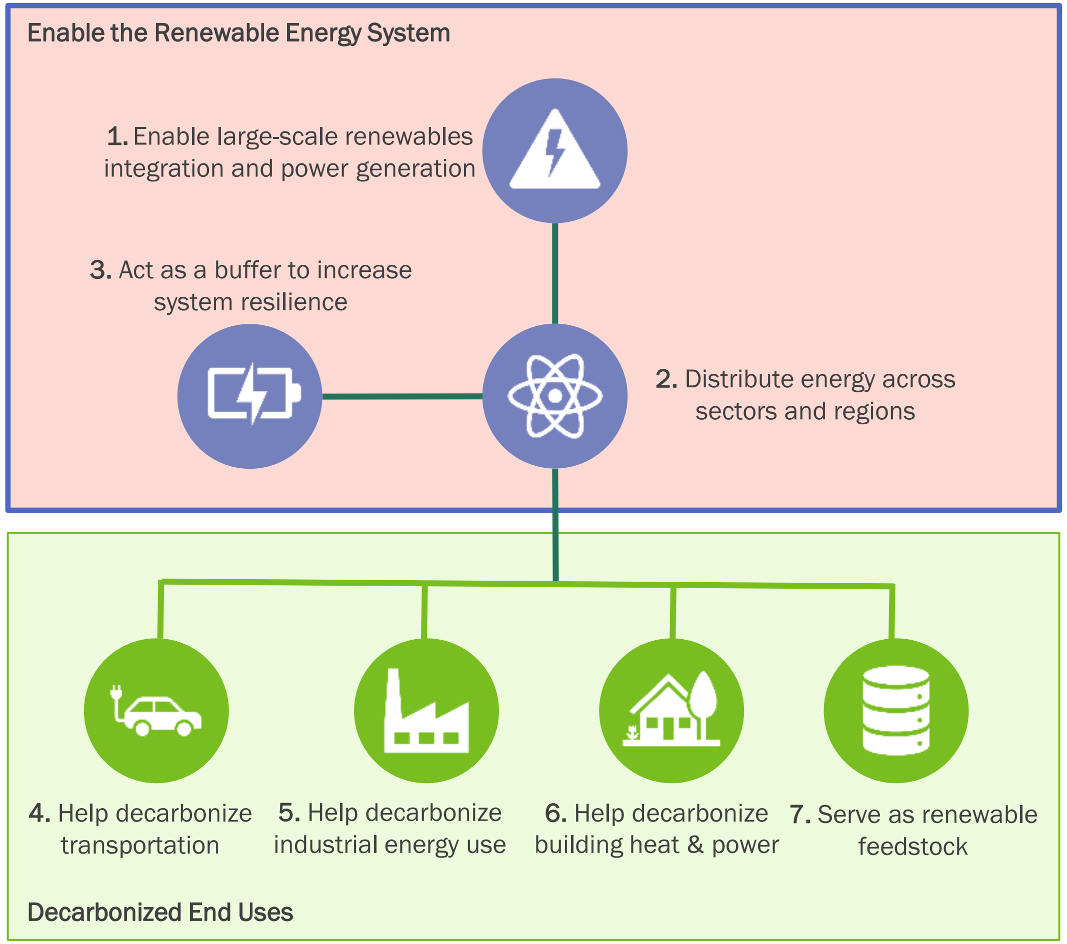
1.2 Uses of Ammonia – New Uses(4/4)

Indirect Use: Ammonia as a H2 Carrier

- Green Ammonia could also play a significant role simply as a hydrogen carrier, assuming ammonia cracking will become economically viable.
- The main reason why ammonia cracking is being considered is for the purpose of transporting hydrogen over long distances, which would be expensive and logistically challenging with hydrogen.
- As per the Paris Agreement, countries across the globe will strive towards keeping temperature increase below 1.5% of pre-industrial levels by 2030, backed by reduced CO_2 emission. More than 110 countries have a target to be carbon neutral by 2050.
- Green Ammonia can pave the way for a multi-industry shift towards ammonia consumption due to its highly efficient energy storage potential.
- When used as a fuel, Green Hydrogen produces no carbon emission - only water:
  - Hydrogen can be used for storing large amounts of energy over days or weeks or even months and hence it can also be used to transport renewable energy from one region to another,
  - It can be an option to decarbonize sectors where few alternative mitigation solution exist, such as long-distance transport (air travel/ shipping), iron and steel production,
  - Hydrogen would also eliminate local emission such as sulfur oxides, nitrogen oxides and particulate matter linked to smog formation, this can help in reduce pollution at urban center which houses large population.
- Declining LCOE for solar PV and wind energy coupled with cost effective modern electrolyzers have made it commercially feasible to produce Green Ammonia at competitive price.

Evolving Role of Hydrogen



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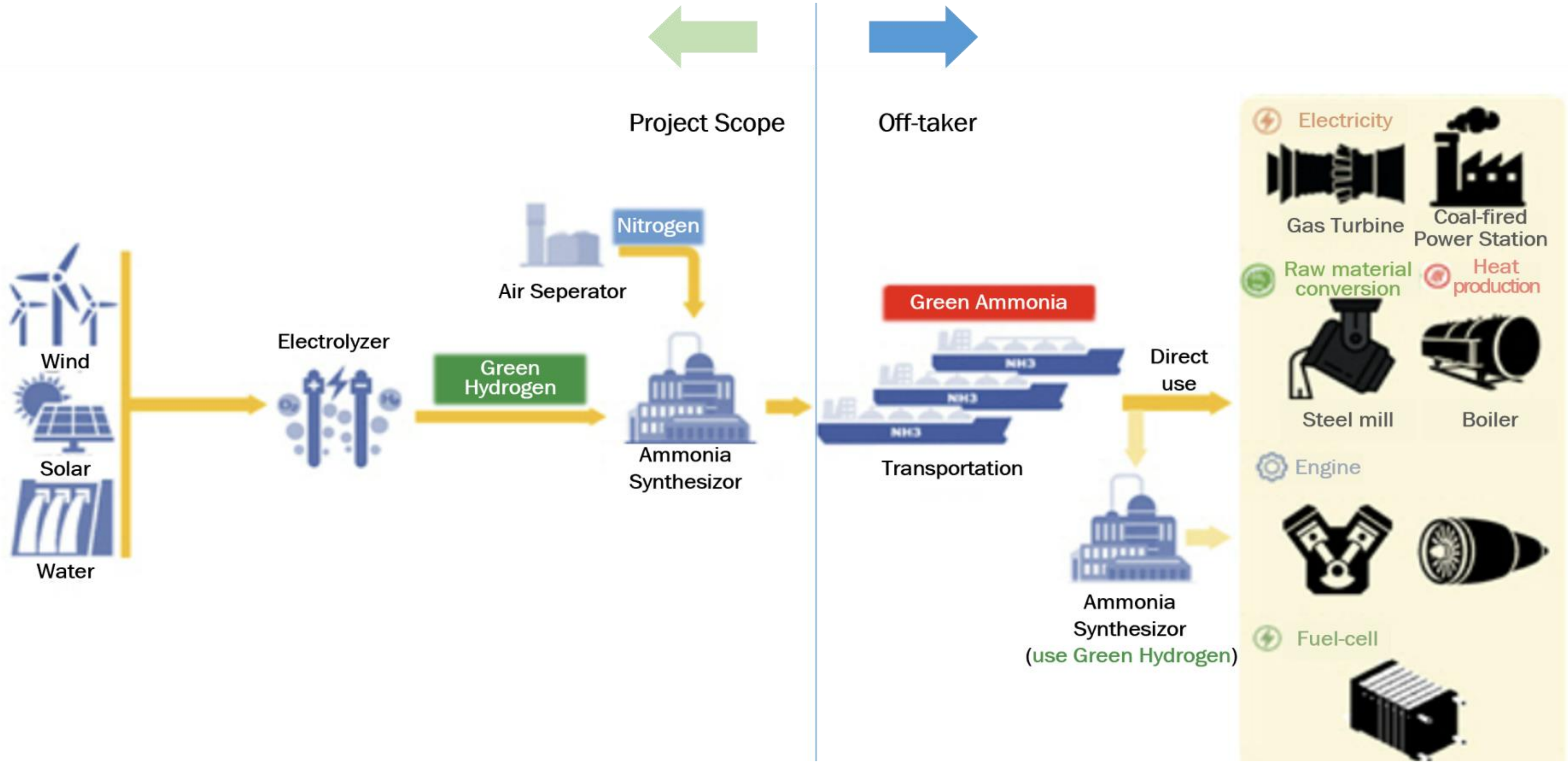
1.3 Application of Ammonia

Project Scheme

- The typical scope of green ammonia project is to produce green hydrogen by water electrolysis using renewable energy power, and to convert it into green ammonia to increase transportation and utilization of green hydrogen.
- In addition to co-firing or 100% ammonia combustion, which directly utilizes ammonia through transport using an ammonia transporter, the target area of the project is to enable hydrogen to be utilized through green hydrogen conversion through ammonia decomposition at the customer level

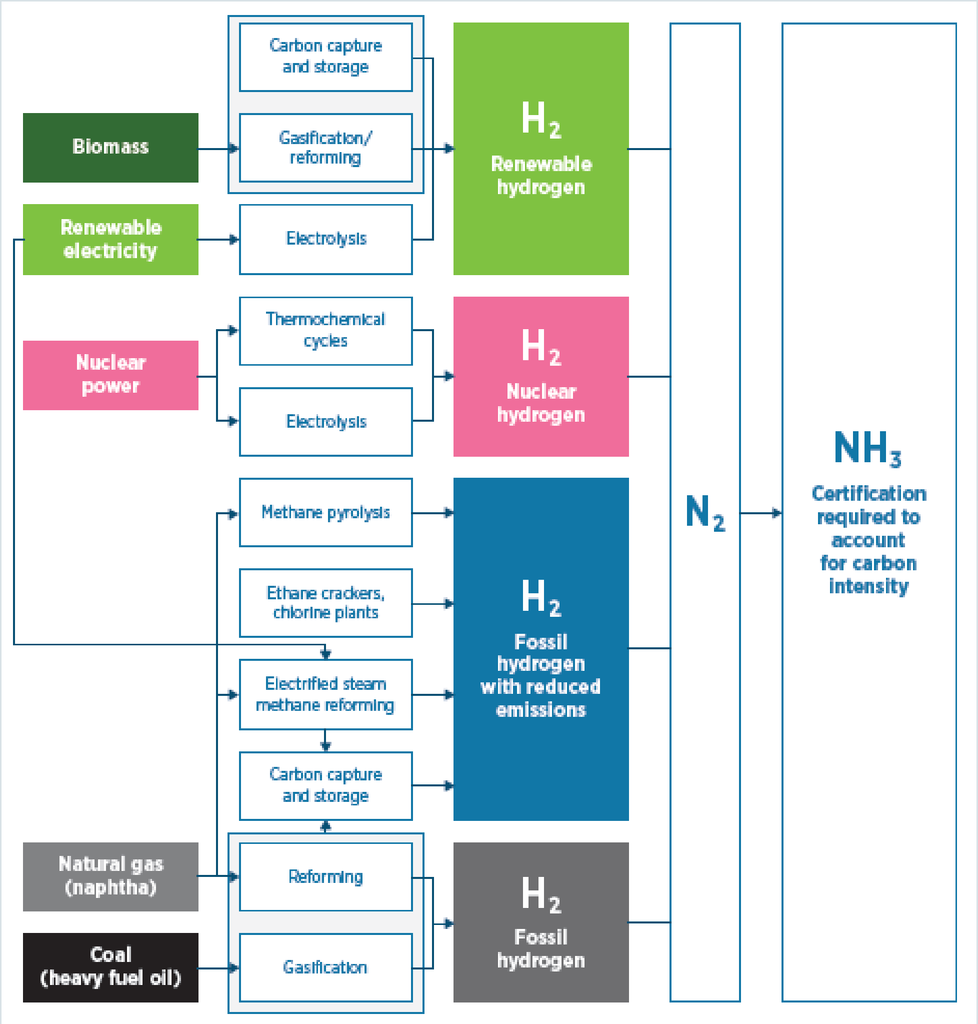


Source: IRENA

1.3 Application of Ammonia

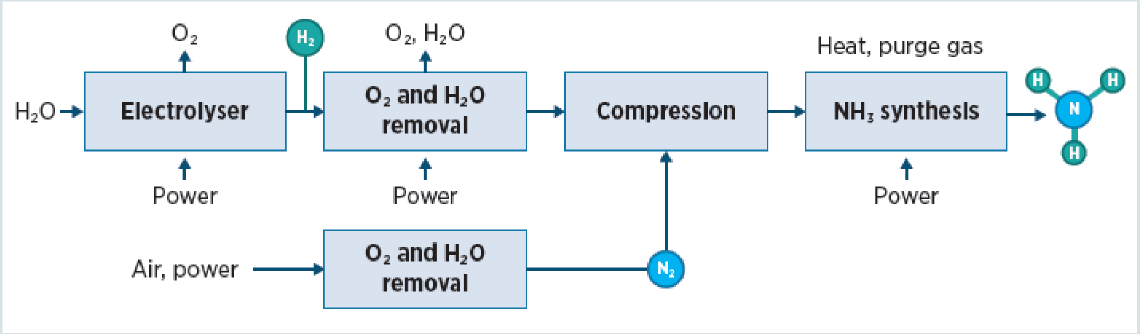
Global Status of the Green Ammonia Terminal

Production pathways of ammonia from various feedstocks



Source: IRENA

Schematic overview of steps involved in ammonia synthesis from water and air



- ❑ Hydrogen needs to be liquefied for transportation, but since these costs are very high, conversion to ammonia and transportation are currently being considered.

- ❑ Ammonia is easy to liquefy, and the system of international trade and transportation has been established at present. In addition, it not only serves as an intermediate medium, but also functions as a final product such as marine fuel.

1.3 Application of Ammonia

Global Status of the Green Ammonia Terminal

The status of the green ammonia terminal is as follows.

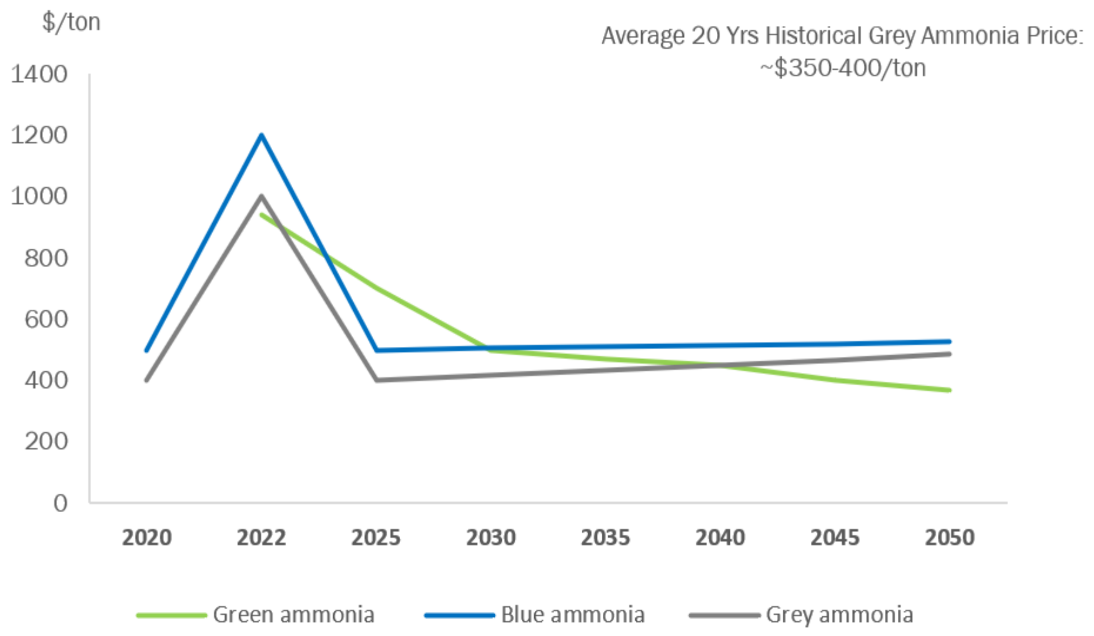
- ❑ There are more than 200 offshore ammonia terminals around the world. Ammonia storage tanks typically range from 15 to 30 kt, but also have a maximum size of 50 to 60 kt.
- ❑ More than 50% of the terminals are currently owned by large fertilizer producers, while the rest are owned by chemical corporations or trading companies. Large fertilizer companies account for the majority of total capacity.
- ❑ In the case of Korea, Ammonia terminals are operated in Incheon, Yeosu, and Ulsan.

Current Green Ammonia Terminals

1.3 Application of Ammonia

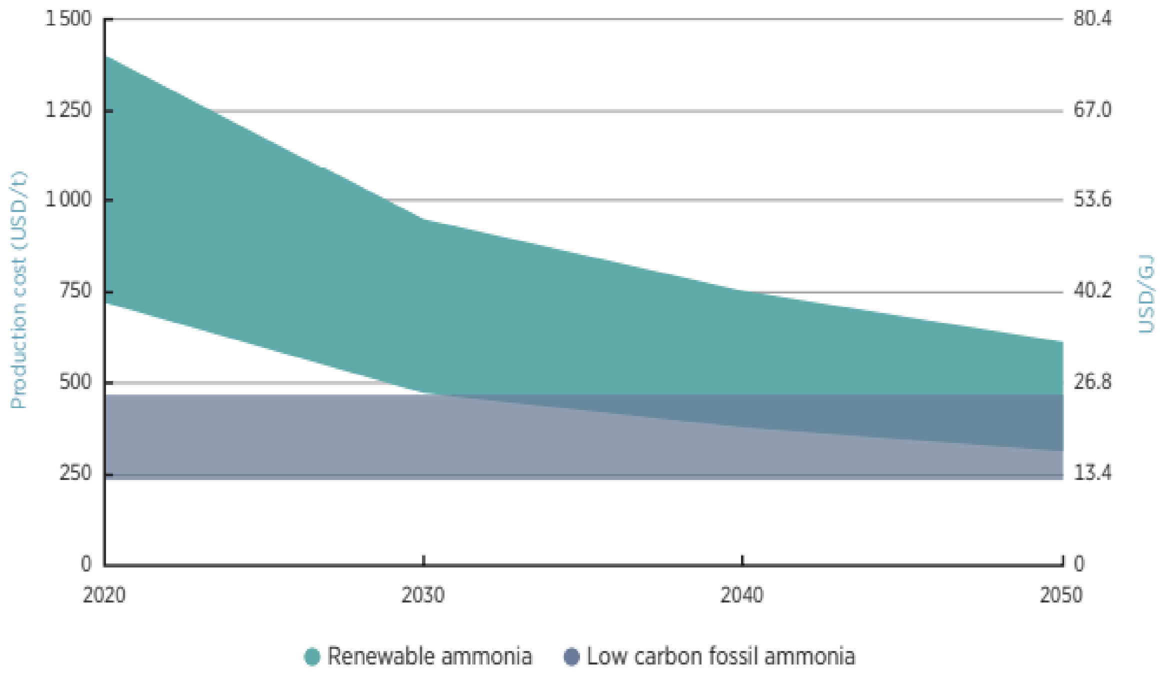
Ammonia Price Forecast

- ❑ Green Ammonia prices are expected to decrease over time, mainly due to the decrease in electrolyzer capital costs, and increase in efficiency for electrolyzer and other plant components.



Price of Green Ammonia

Ammonia Production Price Forecast



Current and future production costs of renewable ammonia, compared with production cost range for low-carbon fossil ammonia (USD 2-10/GJ) (Source: IRENA)

Ammonia Production Balance

	Renewable	Hydrogen	Ammonia	Remarks
Based on Ammonia	8.7 MWh	0.176MT	1 MT	
Based on Hydrogen	49.3 MWh	1MT	5.67MT	
Based on Renewable	1,000 MWh	20.2 MT	114.5 MT	

1.3 Application of Ammonia

Green Hydrogen Certification Standards

Public Regulatory Schemes

- LCHS (UK)
- Proposed revised RED II (EU)
- Japan Certification scheme
- dena Biogas-register (GER)
- Australian zero carbon certification scheme
- South Korean Hydrogen Economy Promotion and Hydrogen Safety Management Act
- China hydrogen alliance standard
- US Low carbon fuel standard

Private Voluntary Schemes

- ISCC PLUS
- CertifHy (EU)
- TÜV Süd CMS 70 GreenHydrogen +
- TÜV Rheinland Standard H2.21 Carbon-Neutral Hydrogen
- AEA Low-Carbon Certification Scheme
- Global green hydrogen standard

EU Taxonomy Requirement

- ❑ GHG emissions savings requirement of 73.4% for hydrogen [resulting in 3tCO2eq/tH2] and 70% for hydrogen-based synthetic fuels relative to a fossil fuel comparator of 94g CO2e/MJ
- ❑ Life-cycle GHG emissions savings are calculated using the methodology referred to in Article 28(5) of Directive (EU) 2018/2001 or, alternatively, using ISO 14067:2018 or ISO 14064-1:2018.
- ❑ Quantified life-cycle GHG emission savings are verified in line with Article 30 of Directive (EU) 2018/2001 where applicable, or by an independent third party

Other Consideration

- ❑ GO (Guarantee of Origins)
- ❑ REC (Renewable Energy Certificate), i-REC (International RECs)
- ❑ Korea ETS (Emission Trading Scheme), RPS/HPS
- ❑ Carbon tax : Adopted in a few EU countries

* Currently, there are no GO/REC/ETS schemes for green /blue ammonia

1.3 Application of Ammonia

Operation Considerations on Grid interactions

- Off grid: This mode of operations is independent of any external grid requirements i.e. the overall system would not be connected to the grid. In case of renewables shortfall BESS / H2 storage would supply energy, during hours when renewable generation is more than the load, the same would be utilized to charge BESS / H2 storage. This option is independent of the grid, thus has no risks of grid capacity being available or not.
- On grid export only: This mode of operations is considered as operating on off grid mode but interacting with grid to export curtailed solar / wind energy as much as possible considering the export capacity of the grid.
- On grid import export (limited): This mode of operation is considering interacting with the grid. In case of renewables shortfall grid would supply energy, during hours when renewable generation is more than the load, the same would be exported to grid to net off the imports. This option has medium risks involved considering that there are other similar projects of same nature which might also utilize the grid, which would lead to the reduction in the grid capacity available.
- On grid import export (unlimited): This mode considers import and export with grid without considering the impact of future renewable energy projects to be connected to the grid. This particular option has very high chances of not being occurring due to the assumptions that the renewables projects which are in bid stage or planned stage by Grid Operator would not be realized.

Category	Off-grid	On-grid
Strength	Minimize the impact of external factors Minimal or no certification risk	Reduced investment and lower electricity costs
Weakness	Oversized investments and high electricity costs	Increased uncertainty due to external factors

1.3 Application of Ammonia

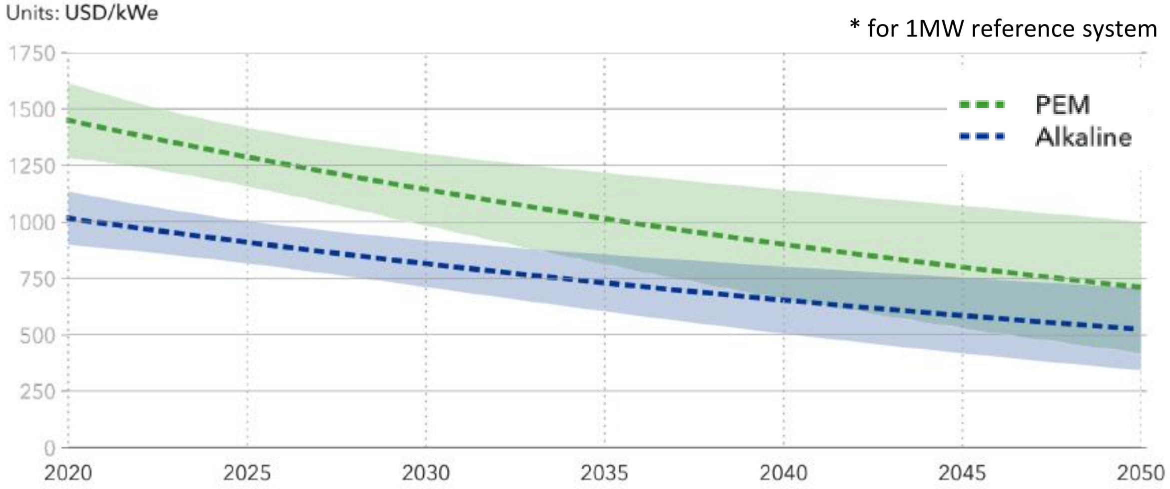
Comparison of Electrolyzer Technologies

	Alkaline (Pressurized Alkaline)	PEM	SOEC	AEM
Efficiency (kWh/Nm3)[2]	4.7 - 4.3 (4.7 - 4.3)	4.8 - 4.5	3.6 - 3.38	4.8 (stack only)
Stack lifetime (hrs)[2]	80,000 - 100,000 (80,000 - 100,000)	80,000- 100,000	20,000->20,000	5,000
Flexibility (time to reach nominal capacity[2]	Minutes (<10s)	<1s	<1sC	<1s
Pressure (bar)[2]	Atm (<40 - <70)	<40 - <70	Atm <20	<35
Commercial status[2]	Available (Available)	Available	Available 2022-2024	Under development

Economics of PEM and Alkaline Technologies

	Alkaline		PEM	
	2020	Target 2050	2020	Target 2050
Load range (%)	15-100	5-300	5-120	5-300
Capital costs (stack) minimum 1 MW [USD/kW]	270	<100	400	<100
Capital costs (system) minimum 10 MW [USD/kW]	500-1000	<200	700-1400	<200

Electrolyser CAPEX by technology



1.3 Application of Ammonia

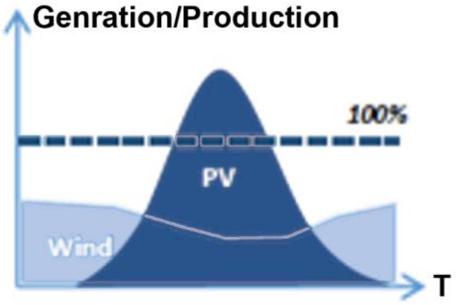
Mode of Operation : BASE LOAD / PEAK OFF-PEAK / FLEXIBLE

- **Base load operation:** In base load operation it is considered that at each and every hour during the 8760 hours of a year, the load to be supplied to the process plant is constant. At any given hour in case of renewables not being sufficient to supply the load the energy needs to be either brought from BESS / H2 storage / grid. The system needs to be designed in a way that during hours when sufficient renewables is available it should be more than the required load, so that it can be used to charge BESS / H2 storage or export to grid to make it grid neutral.

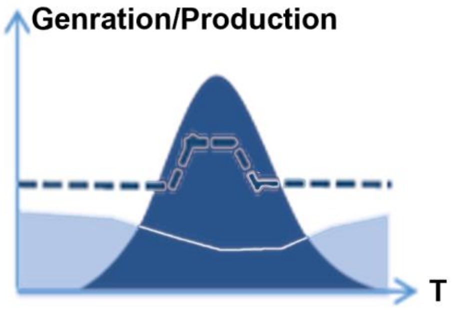
- **Peak off Peak operation:** In peak off peak operation, it is considered that during each day at off peak time the load will be reduced to 30% of its maximum load and during the peak time the load will be increased to its maximum load requirement.

- **Flexible operation:** In flexible operation the process loads to the plant are operated in a way to match the renewables generation profiles. During hours when there is no generation the load reaches the minimum which is 30% of the maximum load. This minimum load is supplied by BESS / H2 storage / grid based upon the design considerations. In other hours the load is adjusted to match the renewables generation profile.

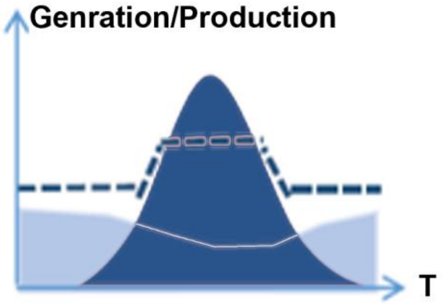
❑ Baseload



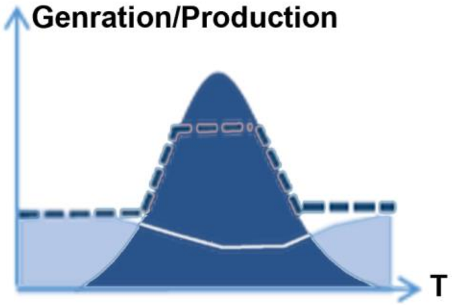
❑ Peak/Off-Peak



❑ Flexible



❑ H2 Storage - Flexible



2 GREEN HYDROGEN/AMMONIA BANKABILITY ISSUES

2.1 Bankability Issues (1/2)

A. Off-take Structuring

Bankability Perspective

- **Fixed price** (vs on the spot prices of natural gas/oil in the case of traditional grey hydrogen contracts)
- **Long term** (longer than tenor of debt) to recover high Capex – major component of project cost
- **Termination protection** for SPV and off-takers to be mutually decided – important consideration for bankability
- SPV should target **take-or-pay** structure of payment

Off-taker Perspective

- **Input price** based (vs offtake price dependent on natural gas/oil price)
- **Short term** or **lower fixed tariffs**

Challenges in Pricing

- SPV's **cash flow forecasting** becomes challenging with input price-based contracts
- Unavailability of historical green ammonia price trends
- Green ammonia **prices expected to go down** with enhancement of large-scale electrolyzer technology (higher efficiency & lower prices)

B. Technology Risk

Key Risks

- **Modular electrolyzers working together at utility scale** do not have a lot of precedents
- Effective ways to store electricity generated from **renewable energy**
- Effects of **intermittent operation** of Utility-scale electrolyzers on operating life and stability
- Few companies have experience in constructing and operating **integrated facilities**
- **Interfacing risk** between renewable generation and electrolyzers / ammonia synthesizers

C. Generic Lender Requirement

Key Issues

- Green Ammonia long-term contract party is likely to be a **private company** and unable to provide a **revenue guarantee**
- **DSCR** with adequate buffer, **DSRA** accounts, **restrictions on dividends** in case of DSCRs falling beyond certain thresholds

2.1 BANKABILITY ISSUES (2/2)

D. Debt Cover Requirement

Key Issues

- To cover technology risk for this new type of project, international commercial lenders would likely require **ECA** (or credible private insurance) **commercial covers** for SPV's debt obligations.
- Lenders expected to benefit from ECA cover in case the project terminates due to commercial/political risks
- **Political cover** may also be needed for certain jurisdictions.

E. Land Availability

Key Requirements

- **Large enough land at low cost** for large-scale renewable energy installations
- **Adjacent to sea and port** for desalination facilities and efficient ammonia export
- Sufficient electricity demand and grid facilities in the vicinity for efficient operation through the **grid network**
- Land parcel should have good **solar irradiation** and/or **wind speed** for efficient renewable generation

F. Sponsor Experience

Key Issues

- In the Green Ammonia Project – a new and large-scale project – **sponsor's role** is very important
- In addition to **business development experience,** primary interest will be whether a sponsor is also an end user with **direct off-taking intentions**

From Bankability perspective, Lenders would look at:

- Sponsors' **international experience**
- Sponsors' **local experience** in project country
- Sponsors' **balance sheet size** and **history of operations**
- Whether equity investors are **private** company or **government** owned
- **Relationship with bank**, etc.

3

FINANCIAL CONSIDERATIONS

3.1 Offtake Structure

Tariff Structure

HISTORICAL STRUCTURE

- Production costs for grey ammonia depend heavily on input natural gas prices
- Hence, **grey ammonia** offtake pricing closely linked to spot price indexes for natural gas/oil
- This structure allows recovery of major portion of production costs for the producer

CURRENT MARKET

- **Green ammonia** SPVs are trying to enter into long term fixed price take-or-pay offtake contracts with creditworthy offtakers
- This offtake structure is needed to recover the high fixed capex/opex costs for green ammonia projects, and for ensuring the project's bankability

FUTURE EXPECTATIONS

- Given adequate global green ammonia demand, and sufficient successfully completed utility scale projects, pricing may revert to spot structure
- Lenders would gain comfort on technology risk from the completed GA precedents, and on market risk from substantial demand for GA

Other Offtake Considerations

OFFTAKE TENOR

❖ Based on the offered offtake prices for the project, the sponsors need to decide whether it would be beneficial to "lock-in" the rate for the long term or short term
❖ Further, generally, lenders seek a "tail" offtake period post the debt repayment period

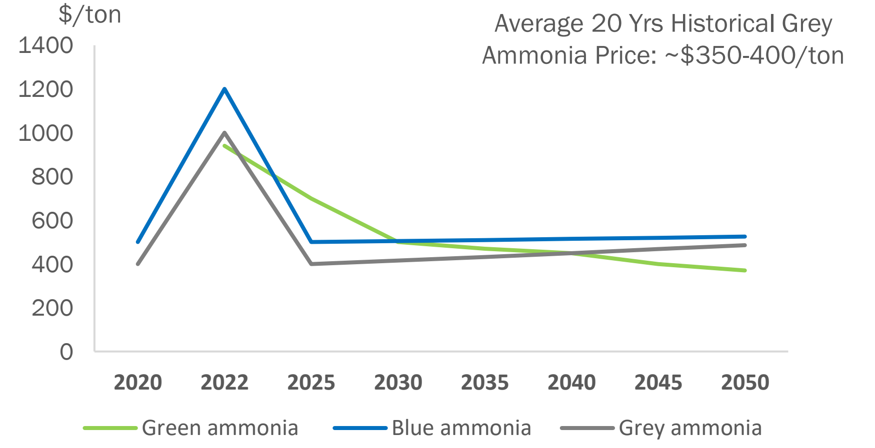
INFLATION PROTECTION

❖ To protect the SPV's operating margins, the tariff can be adjusted periodically to recover inflated operating costs
❖ This would shift the risk of inflation to the offtaker, and ultimately, the end-users

FREQUENCY OF OFFTAKE

❖ Ammonia storage capacity would depend on project size and offtake frequency
❖ In case of multiple offtakers, ammonia pick up may need to be done with a lower frequency or using smaller vessels, which may lead to higher costs for transportation

Price Forecast



Green Ammonia prices are expected to decrease over time, mainly due to the decrease in electrolyzer capital costs, and increase in efficiency for electrolyzer and other plant components

3.2 Potential Sources of Financing

Local Commercial Lenders

- ❑ Local commercial banks can provide debt on an uncovered basis, but in some countries, they may have limited liquidity and/or DD capabilities
- ❑ In countries with lower credit ratings, the local lenders' financing costs would generally be higher than debt from ECA-covered international lenders

International Commercial Lenders

- ❑ Debt structuring flexibility can be high
- ❑ In countries with lower credit rating or projects with high technology risk, insurance covers from Political Risk Insurers (PRIs) or Export Credit Agencies (ECAs) may be needed for financing from these lenders
- ❑ Closing time for debt arrangement can be shorter

Development Finance Institutions (DFI)

- ❑ DFIs can participate in projects with higher political and technology risk on an uncovered basis, and may be able to bring in b-lenders as well. However, DFIs generally lend to projects in lower-income countries only
- ❑ The DD process for DFIs can be longer. Debt structuring flexibility for DFIs would be limited

Export Credit Agencies (Direct Lending)

- ❑ ECAs provide political and commercial debt covers to projects, based on goods, services and/or equity sourced from parent countries
- ❑ Some ECAs can also provide debt directly to the project, based on certain equipment/equity sourcing requirements

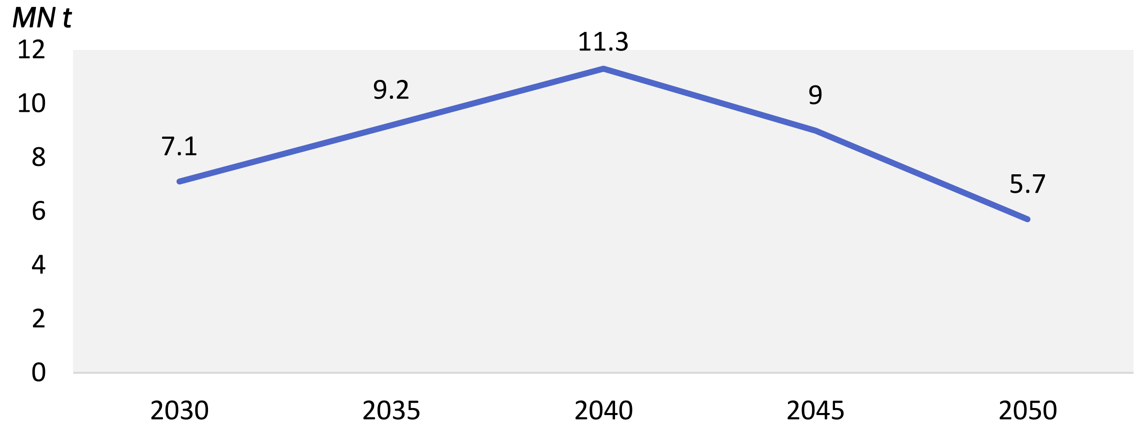
Green bonds can be a potential source of refinancing financing once project completion has been achieved, and its operations stabilized

	Local Commercial Lenders	International Commercial Lenders	ECAs	DFIs
Liquidity	◑	◕	◑	◑
Due Diligence Process Duration	◕	◑	◔	◔
Financial Structuring Flexibility	◕	◕	◔	◔

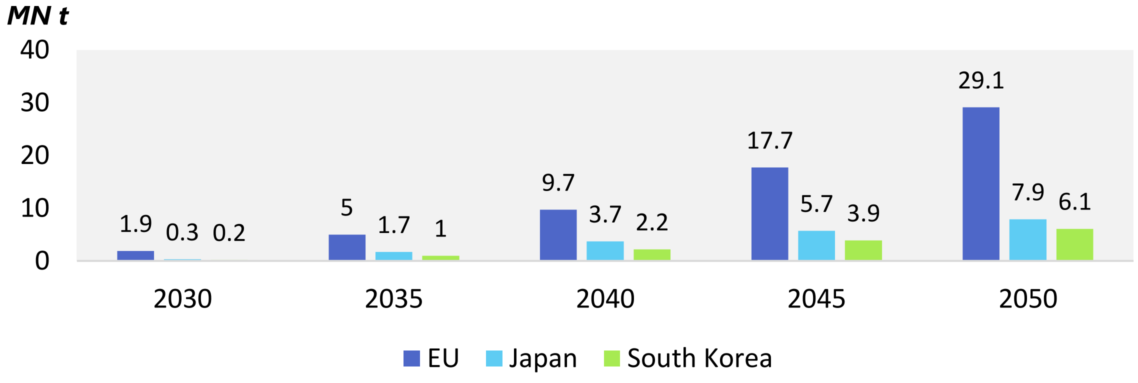
4 KOREAN PERSPECTIVE

4.1 Main Issues of Green Ammonia

Estimated Future Ammonia Demand in Co-firing



Estimated Future Ammonia Demand as a H_2 Carrier



Source: First Basic Plan for the Implementation of the Hydrogen Economy, KOREA (11.26.2021)

In Power Generation

- South Korea proposed ammonia-coal co-firing in efforts to reduce greenhouse gas emissions.
- Assuming a constant 20% co-firing rate in coal-fired plants from 2030 to 2050, domestic ammonia demand could be higher in the earlier years, at 7.1 million t/yr in 2030, and reach its peak at 11.3 million t/yr in 2040.
- However, the demand would decrease to 5.7 million t/yr in 2050.
    - Underlying the decline in ammonia demand from 2040 onwards is an aging coal-fired fleet, with increasing capacity being retired in the long run.
    - No replacement beyond announced capacity additions is assumed.

As H2 Carrier

- To decarbonize the transportation sector, Korea is evaluating cross-regional hydrogen supply pathways to meet the future hydrogen demand.
- Ammonia is currently the most competitive option (technical difficulty, cost, and volume efficiency wise) for transporting hydrogen with other options being MCH and liquefied hydrogen.
- Korea's projected demand for ammonia as a H_2 carrier is expected to rise from 0.2 MN tons in 2030 to 6.1 MN tons by 2050.

As a Marine Fuel

- Korea is preparing technical base for ammonia-fueled ships with goals to commercialize in 2024

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4.2 Key Government Regulations To Promote Green Hydrogen & Ammonia (1/2)

Hydrogen & Ammonia Use in Power Generation Roadmap

	Present	2030	2050
Hydrogen Demand		3.53 t	13.5 t
Power Generation		48 TWh	288 TWh
Key Milestones		Ammonia 20% co-firing	Ammonia total burning
		H_2 50% co-firing	H_2 30%-100% co-firing

NDC Upward Plan & Recent PDP 10th Direction (2030 Target, in TWh)

Category		Nuclear	Coal	LNG	Renewable	Carbon-free	Ect.	Total
9th	Generation	146.4	175.1	136.6	121.7	-	6.0	585.8
	Mix	25.0%	29.9%	23.3%	20.8%	-	1.0%	100%
NDC Increase Plan	Generation	146.4	133.2	119.5	185.2	22.1	6.0	612.4
	Mix	23.9%	21.8%	19.5%	30.2%	3.6%	1.0%	100%
10th	Generation	201.7	130.3	128.2	132.3	13.9	8.6	615.0
	Mix	32.4%	19.7%	22.9%	21.6%	2.1%	1.3%	100%

Ammonia Power Generation Plan

- Establish fuel supply infrastructure for 4 commercial coal power plants
- Complete a technical demonstration of 20% co-fired power generation by 2027
- Apply and commercialize 20% co-fired power generation to more than half (24 units) of all coal power plants (43 units) by 2030
- A complete shift to total burning by 2050 following a gradual increase in the ammonia co-firing rate

H2 Power Generation Plan

- Complete the demonstration of 50% of the 150MW class hydrogen co-firing in LNG turbines by 2028
- Commercialize more than 30% co-firing power generation by 2035
- 30 to 100% co-firing or total burning targeted in 2040

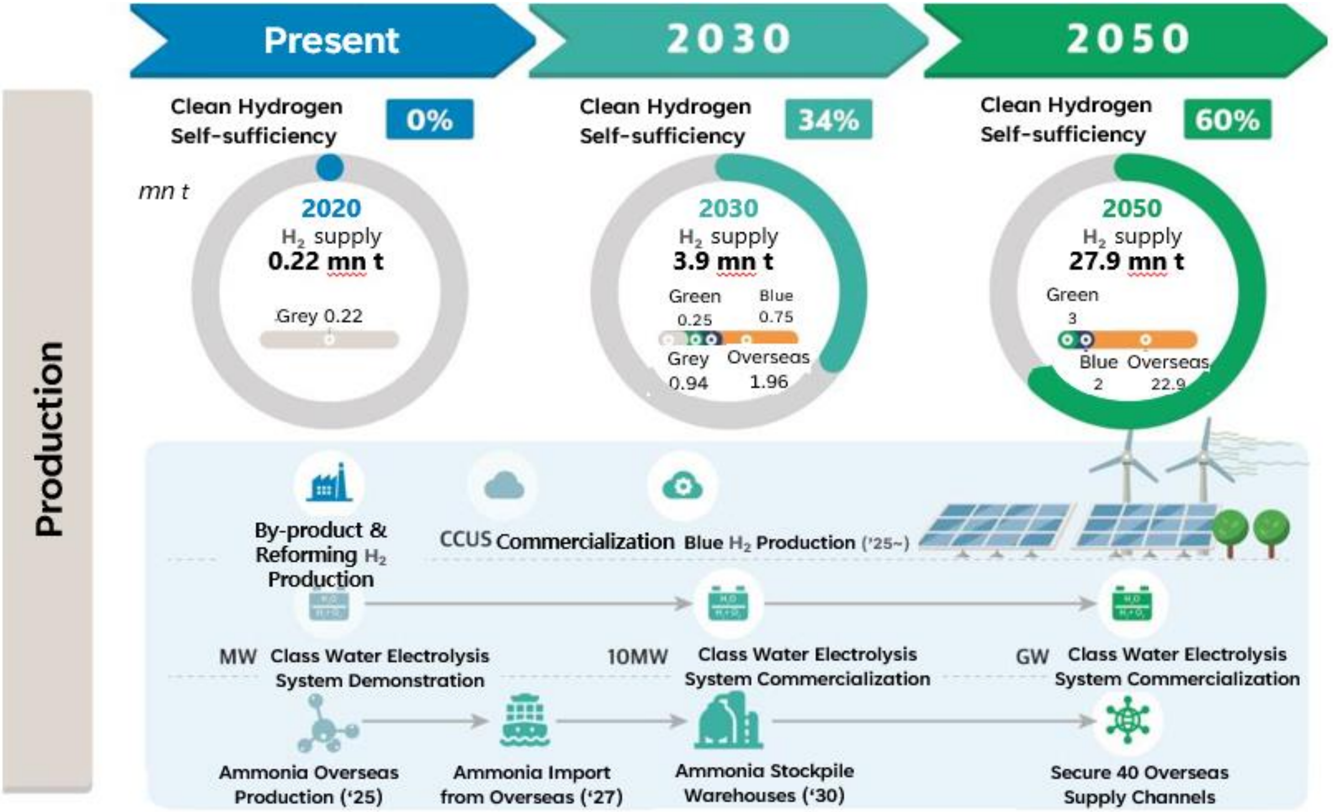
Demand Creation & System Reform

For competitive production of Green Hydrogen Generation System:

- Introduce a mandatory Hydrogen Energy Portfolio Standards (HPS) to grow the market for hydrogen.
- Convert into a Clean Hydrogen Energy Portfolio Standards (CHPS) once clean hydrogen is deployable.

4.2 Key Government Regulations To Promote Green Hydrogen & Ammonia (2/2)

Green Hydrogen Roadmap



Source: First Basic Plan for the Implementation of the Hydrogen Economy, KOREA (26.11.2021)

Green Hydrogen Strategy Overview

Korean government announced 'First Basic Plan for Implementation of the Hydrogen Economy' in November 2021 to focus more on producing and importing green hydrogen.

1. Accelerate the development of large-scale water electrolysis technologies
2. Create infrastructure for imported hydrogen shifting the focus of supply to Green Hydrogen

The recent announcement of a Korean consortium's KRW 1.2 trillion investment in a Green Hydrogen and Ammonia plant in the UAE is a prime example of this strategy.

2030 Hydrogen & Ammonia Power Production Forecast

Category	Fuel Quantity	Power Production	Co-Firing with
Hydrogen	300,000 t	6.1TWh	LNG
Ammonia	2,960,000 t	6.9TWh	Coal

As per introduction of fuel and intention of companies, co-firing of Hydrogen and Ammonia are introduced.

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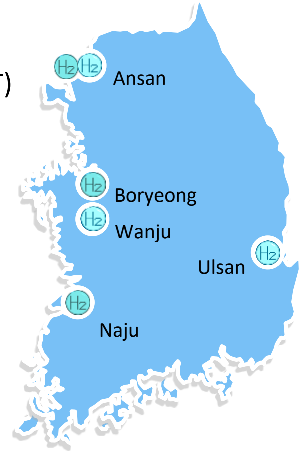
4.3 Key Government Initiatives To Enable Green Hydrogen & Ammonia (1/2)

Hydrogen Pilot Cities

In December 2020, the Ministry of Land, Infrastructure and Transport (MOLIT) announced plans to build hydrogen pilot cities in Ulsan, Ansan and Wanju.

Fund Allocation	Completion Status	Implementation challenges
KWR 105 BN	As of May 2022: ○ Ulsan – 65% ○ Ansan – 34% ○ Wanju – 16%	MOLIT highlighted delay in progress due to following reasons: ○ Public complaints ○ Regulatory challenges ○ Lack of marketability
Target Date		
2022		



Green Hydrogen Pilot Cities

As 'Green' Hydrogen from electrolysis is on the longer-term agenda of the government, Naju, Boryeong and Arsan have been selected as Pilot cities.

Objective of pilot cities	Government support
These three cities have been selected as the cities for installation of large-scale water electrolysis systems.	R&D projects for water electrolysis installation connected to renewable energy 1. KEPCO n Naju 2. KOMIPO in Boryeong

Hydrogen Refuelling Stations ("HRS")

- As of mid-2022, 162 HRS are operating in Korea.
- Majority are 'truck-in' stations where the hydrogen is brought in by tube trailer from a supplier such as Deokyang or SPG.
- There are four operational HRS with on-site SMR commissioned during 2020-2022.
- Due to the low profitability of HRS operations, the municipalities operate almost all HRS.

HYNET (수소에너지네트워크[주])

- **Goal:** To build 100 HRS by 2022. Completed: 60 (2020-21) Planned: 40 (for 2022)
- **Overview:** SPC set up in 2019 by 13 companies (currently 11) interested in the hydrogen sector
- **Govt. support:** Government Subsidy: 50%
- **Investments:** Investment: KRW 135 BN

KOHYGEN

- **Goal:** Build Operate HRS based on HyNet model for passenger, heavy-duty vehicles (buses, trucks etc.)
- **Overview:** SPC set up in 2021 by 9 companies, mainly operators of petrol and LNG stations
- **Progress:** In the process of building three HRS with a capacity of 1,000 kg/day each and has applied for government approvals for an additional six HRS to be built in 2022.

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4.3 Key Government Initiatives To Enable Green Hydrogen & Ammonia (2/2)

For Ensuring Stable Hydrogen Supply and Demand

- Set up stockpile warehouses
- Set up international hydrogen exchanges
- Promote green hydrogen projects using domestic capital & technology to secure >40 hydrogen supply chains by 2050.

Hub and Spoke Network

1. One of Korea's main strategies for rolling out hydrogen infrastructure in the future to ensure stable supply
2. Replace the current Tube trailers network with a hydrogen pipeline network linking hub & spokes wherever feasible.
3. KOGAS and MOTIE, the 2 essential procurement authorities of hydrogen for HRS plan to install SMR equipment at HRS to transport hydrogen at nearby stations.
4. By 2025, KOGAS and MOTIE plan to roll out hydrogen hub and spoke networks in nine cities such as Incheon, Ansan, Daejeon, and Ulsan.

For Enabling Use of Hydrogen

Industries	**Build Infrastructure**	Hydrogen ports & pipelines near LNG, coal power plants, industrial complexes, & major production bases.
	Integration of hydrogen-based processes	Starting with high greenhouse gas emissions ones, such as steel, petrochemical, and cement companies.
Transportation	**Enhancing use of hydrogen-based vehicles**	• Improvement in the production capacity of hydrogen vehicles. • Expand the use of hydrogen to various mobility services such as ships, drones, and trams.
	Increase number of HRS	Convergence of hydrogen charging stations at gas & LPG stations with an aim to secure >2,000 HRS by 2050.
	Convert port-based vehicles	Convert ships, vehicles & equipment in ports into hydrogen-based through incentives like reduction in rent, port usage fees.
Strategic Changes	**Expand hydrogen R&D**	Each ministry to expand the hydrogen technology development scope & conduct integrated demonstrations.
	Launch Global Hydrogen Association	• To strengthen cooperation between domestic & foreign companies • Establish safety standards and obtain global standards.

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THANK YOU