30 ans

16è Rencontres

DE LA FERTILISATION RAISONNÉE ET DE L'ANALYSE

21, 22 et 23 novembre 2023

Palais des congrès de Tours

16è Rencontres

DE LA FERTILISATION RAISONNÉE ET DE L'ANALYSE

Decarbonizing the Fertilizer Industry

Dr. Antoine Hoxha, Director General

comifer
Comité Français d'Étude et de Développement de la Fertilisation Raisonnée

Fertilizers Europe

Gemas
Groupement d'études méthodologiques pour l'analyse des sols

European Fertilizer Industry Ambitions

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2026	2040	2050
		
Decarbonisation masterplan by 2026	**70% GHG emission reduction by 2040**	**Climate-neutral by 2050**

Fertilizers Europe

Source: Roadmap for the European Fertilizer Industry

About Fertilizers Europe

Fertilizers Europe represents the interests of the majority of mineral fertilizer manufacturers in the European Union.

- 16 fertilizer manufacturers

- 9 national fertilizer associations.

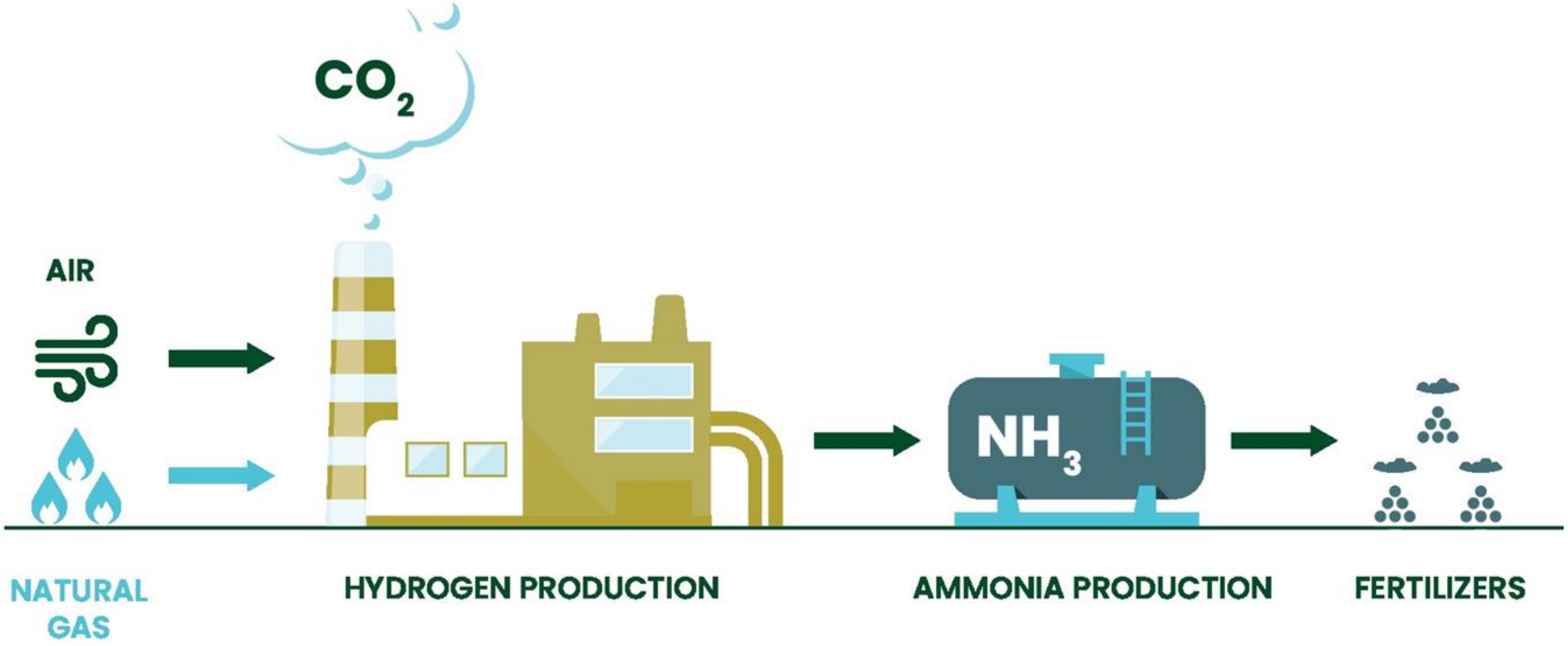
Overview

- **Roadmap 2050**
  - **- Technologies**
  - **- Pathways**
  - **- Archetypes**

- **Role of ammonia in the transition**

- **What else ?**

Traditional Ammonia Production



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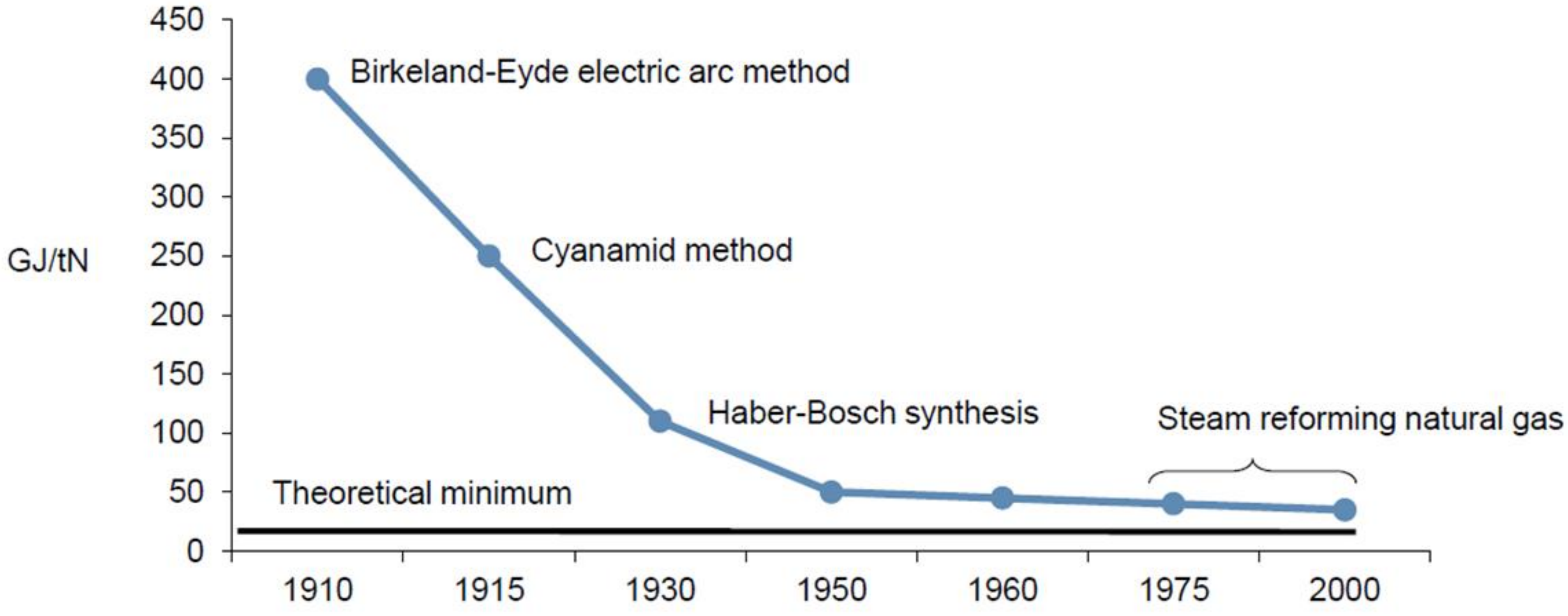
Nitrogen technology evolution



Overview of the conventional production of N- fertilizers

The roadmap focuses on ammonia production from hydrogen and nitrogen, including the energy-intensive production of the intermediate hydrogen.

Focus of this roadmap

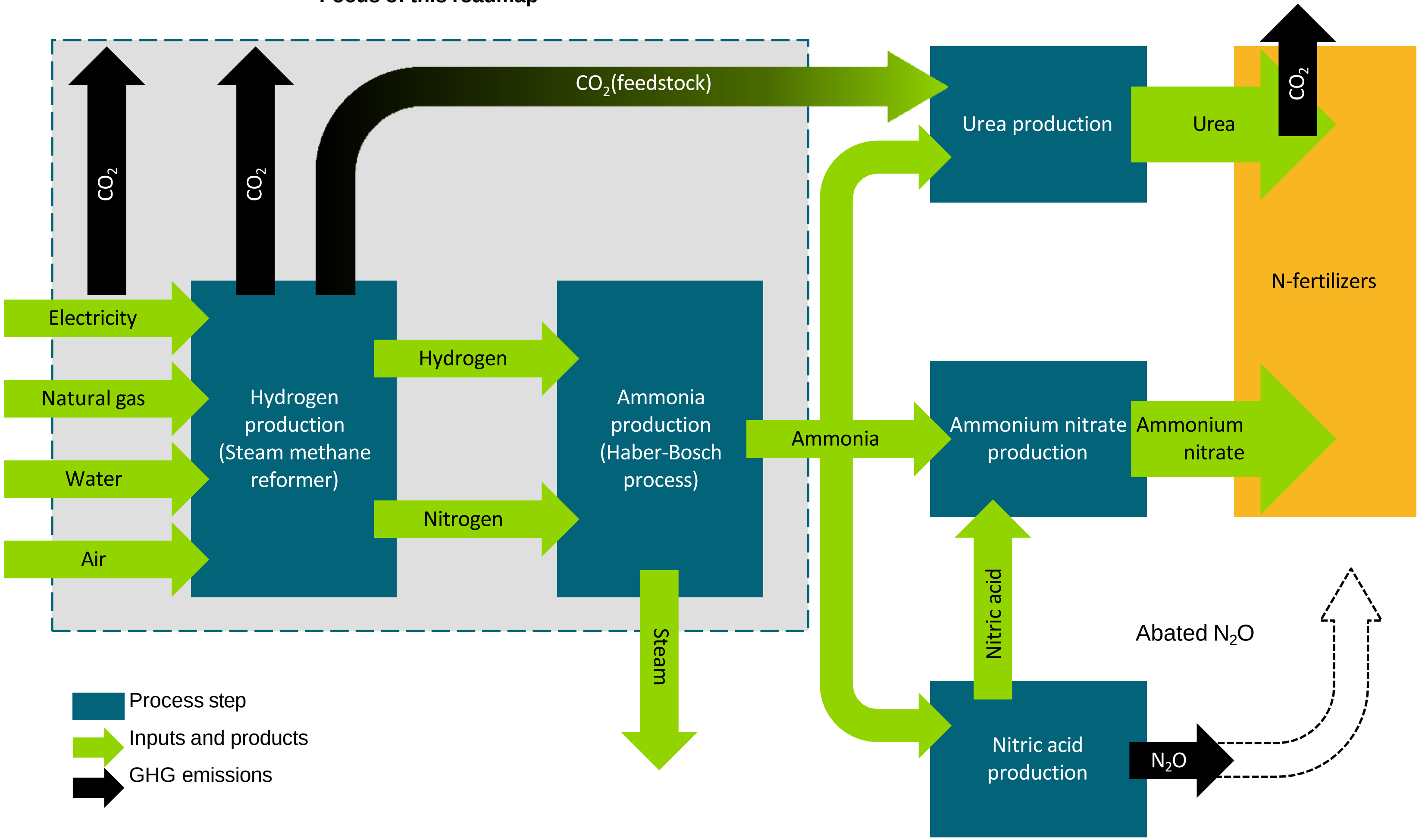
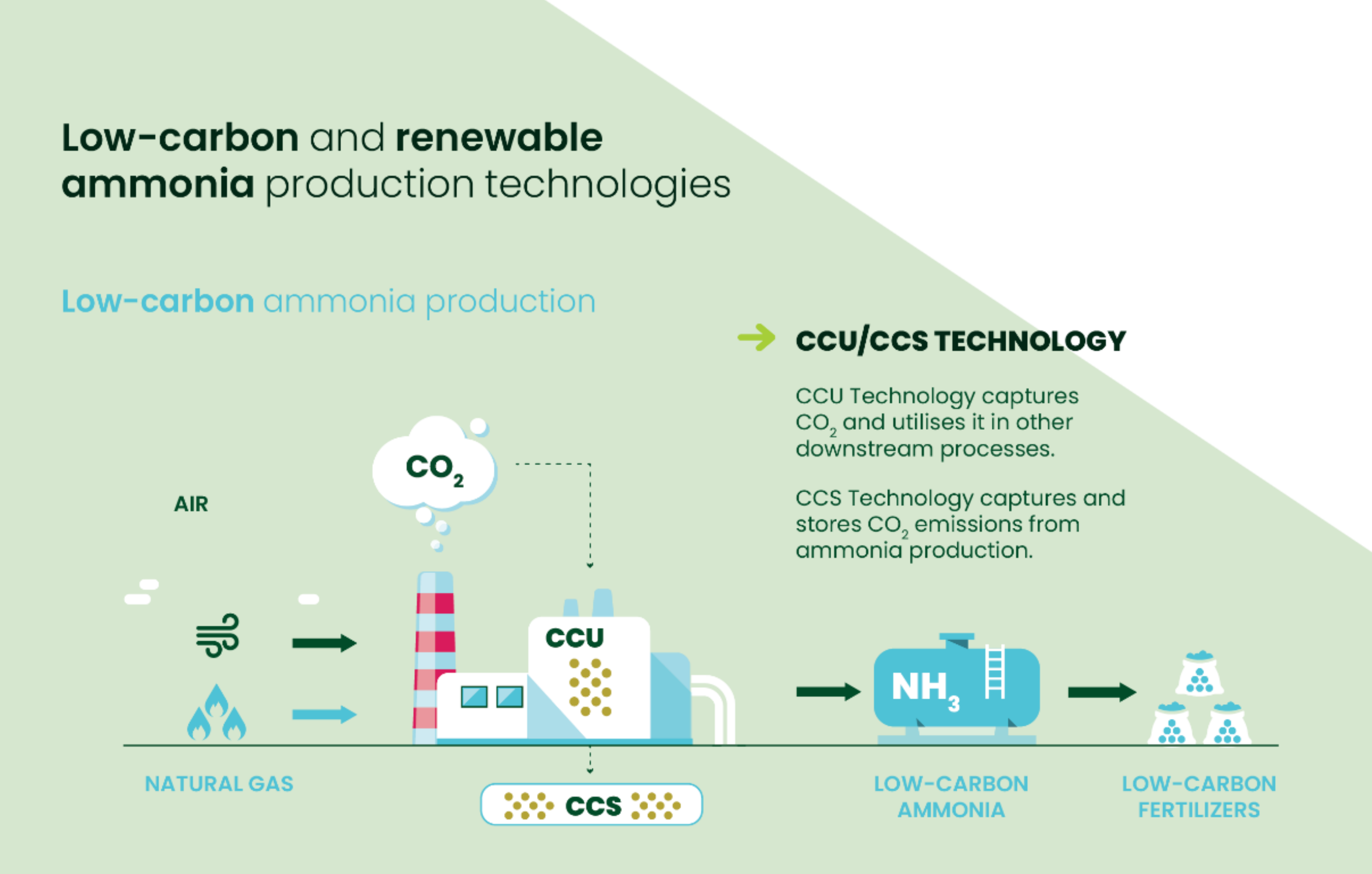


Figure 1: Overview of the conventional production of N-fertilizers

Source: Roadmap for the European Fertilizer Industry

Low Carbon Ammonia Production



Source: Roadmap for the European Fertilizer Industry

Cost of Ammonia Production based on gas

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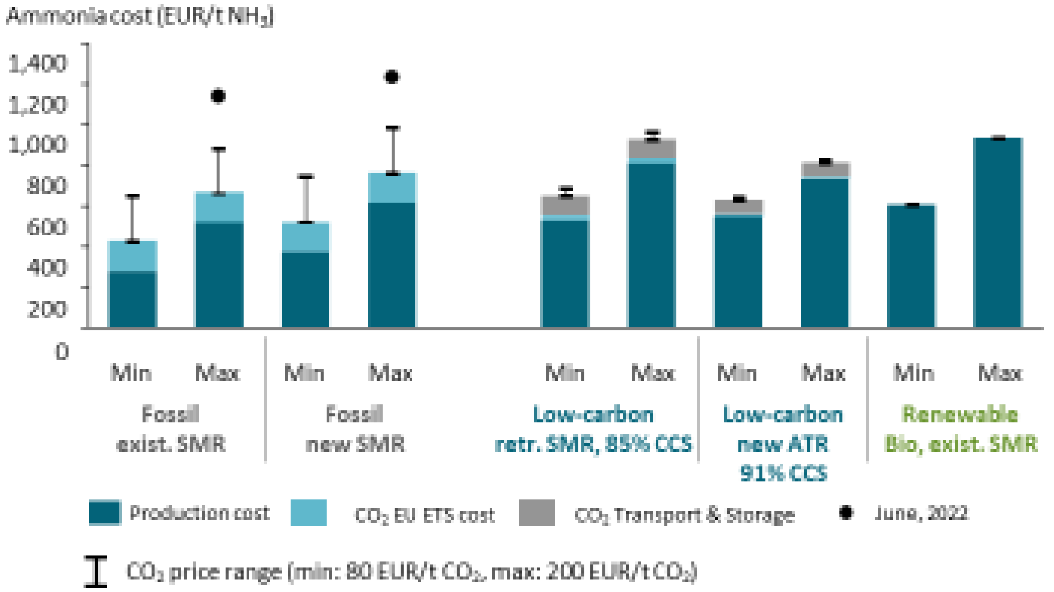
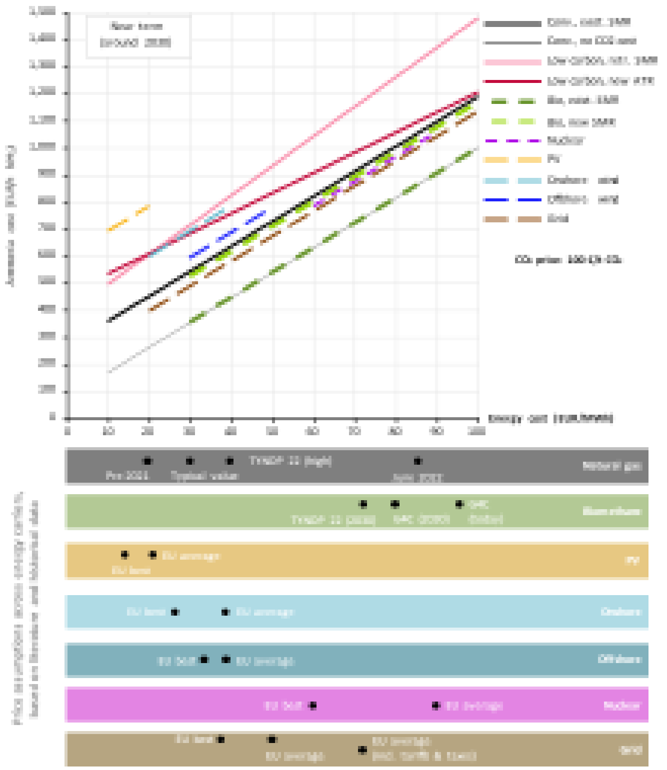
Ammonia cost based on conventional and low-carbon based hydrogen (in EUR/t NH_3)



Notes: Natural gas: Min = 15 EUR/MWh, Max = 40 EUR/MWh; Biomethane: Min = 50 EUR/MWh, Max = 86 EUR/MWh; Transport & storage cost of 50 EUR/t CO_2 assumed for low-carbon hydrogen; June 2022 indicates the price level in this month of 87 EUR/MWh for natural gas and 80 EUR/t CO_2 from EU ETS. The biomethane option is based on production costs (LCOB). It is to consider, that the biomethane market price is very unlikely to fall below the market price for natural gas (incl. EU-ETS CO2 cost), even if its levelized cost would be lower.

Ammonia cost comparing all hydrogen options (in EUR/t NH_3) in the near term (around 2030)[1]

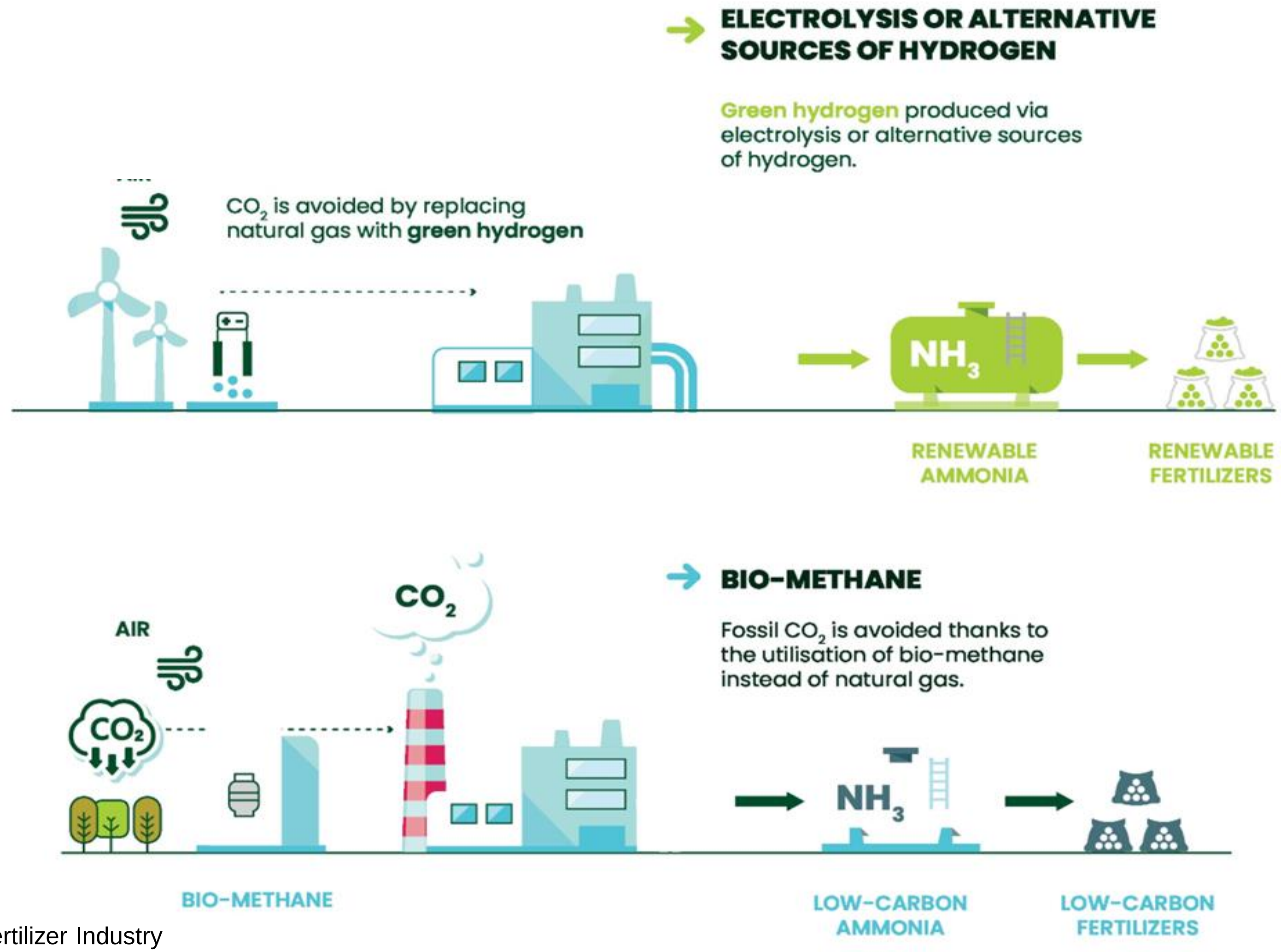
Broader range[2] of natural gas and bio prices



Fertilizers Europe

Source: Roadmap for the European Fertilizer Industry

Renewable Ammonia Production



Source: Roadmap for the European Fertilizer Industry

Cost of Ammonia Production based on electricity

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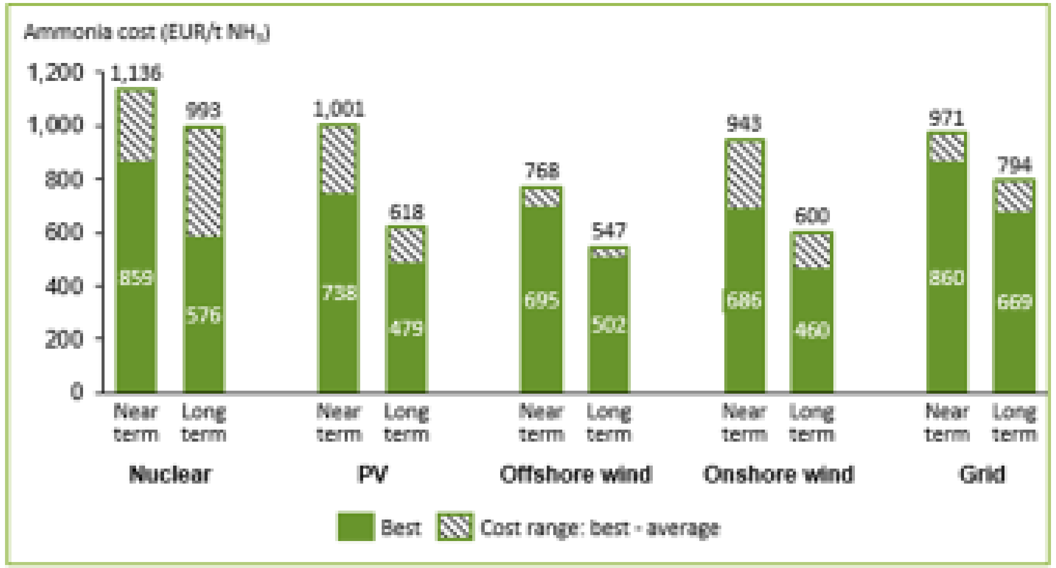
Source: Roadmap for the European Fertilizer Industry

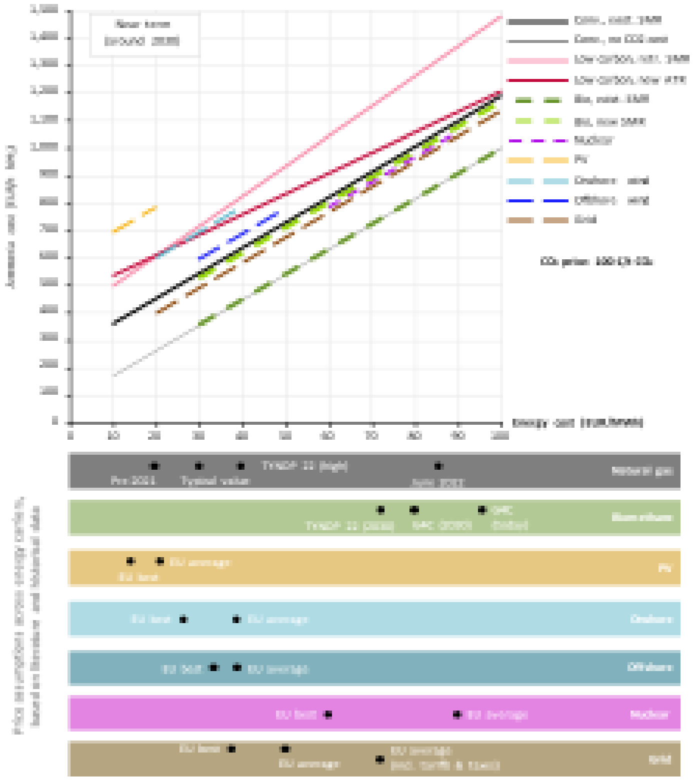
Ammonia cost based on renewable and nuclear electricity (in EUR/t NH_3)[1]



Ammonia cost based on renewable and nuclear electricity-based hydrogen, with best case and average as upper and lower boundary (in EUR/t NH_3). Near term grid costs are based on the marginal price in the electricity market in 2025 for national trends. Current costs are significantly higher.

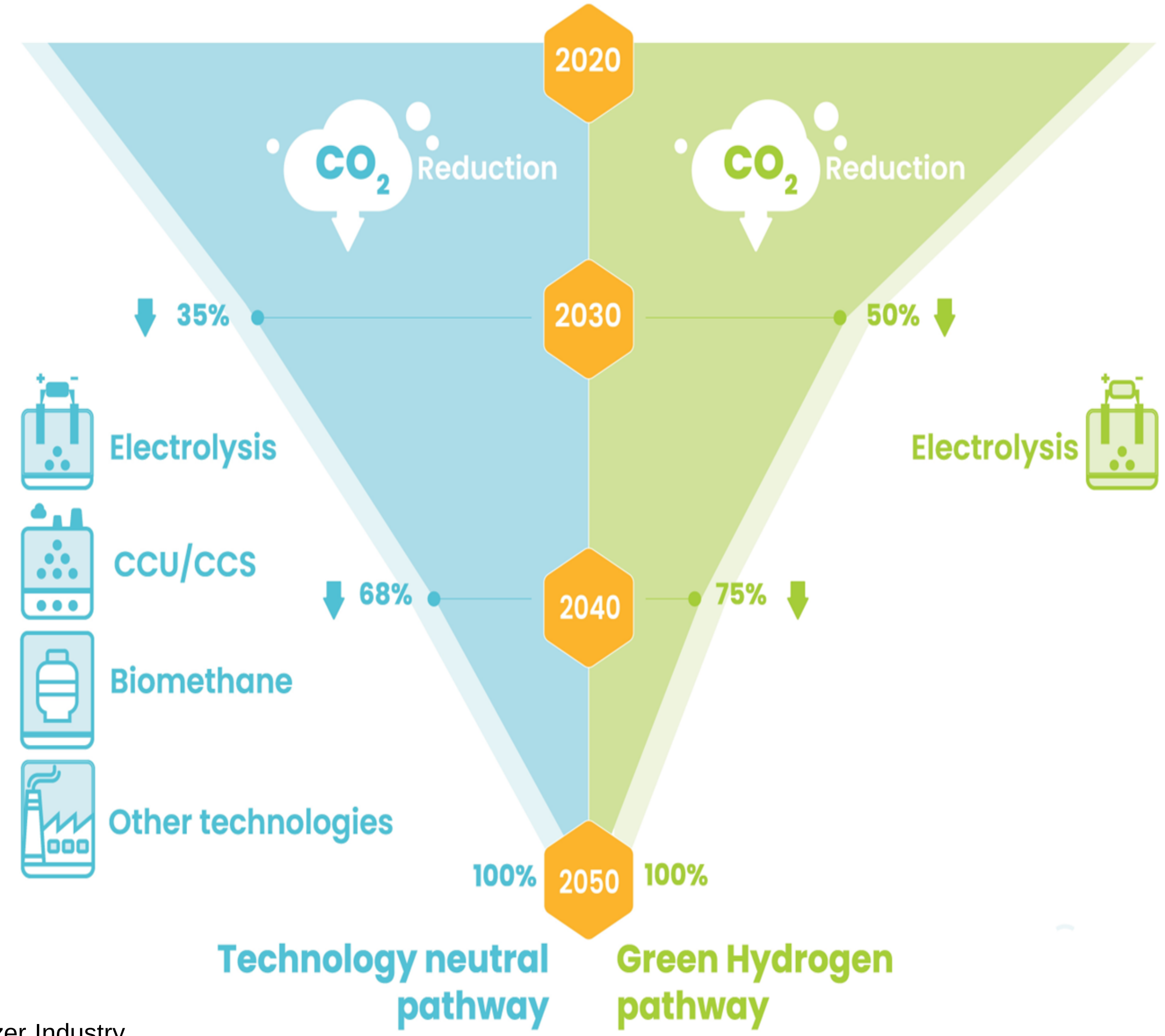
Ammonia cost comparing all hydrogen options (in EUR/t NH_3) in the near term (around 2030)[2]

Broader range[3] of electricity prices



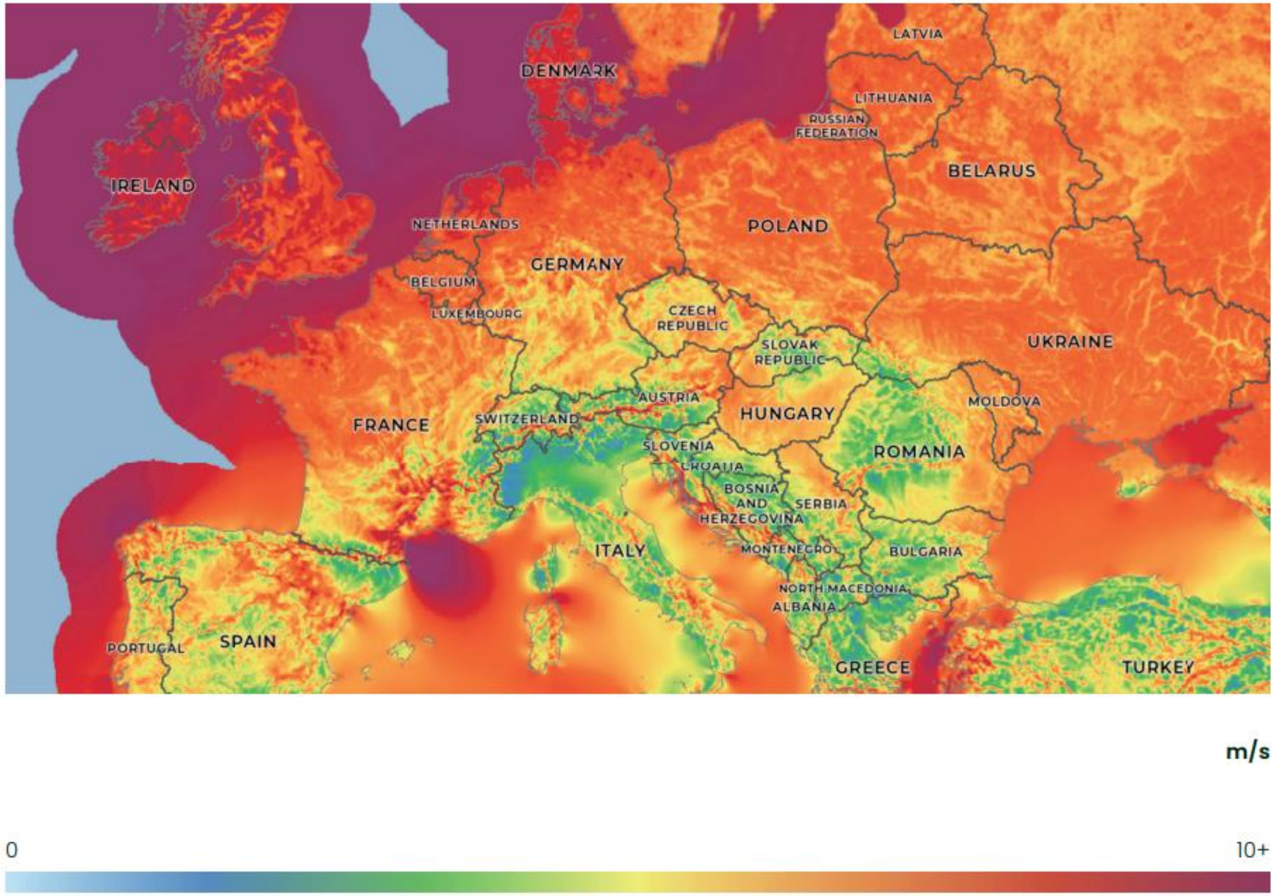
Fertilizers Europe

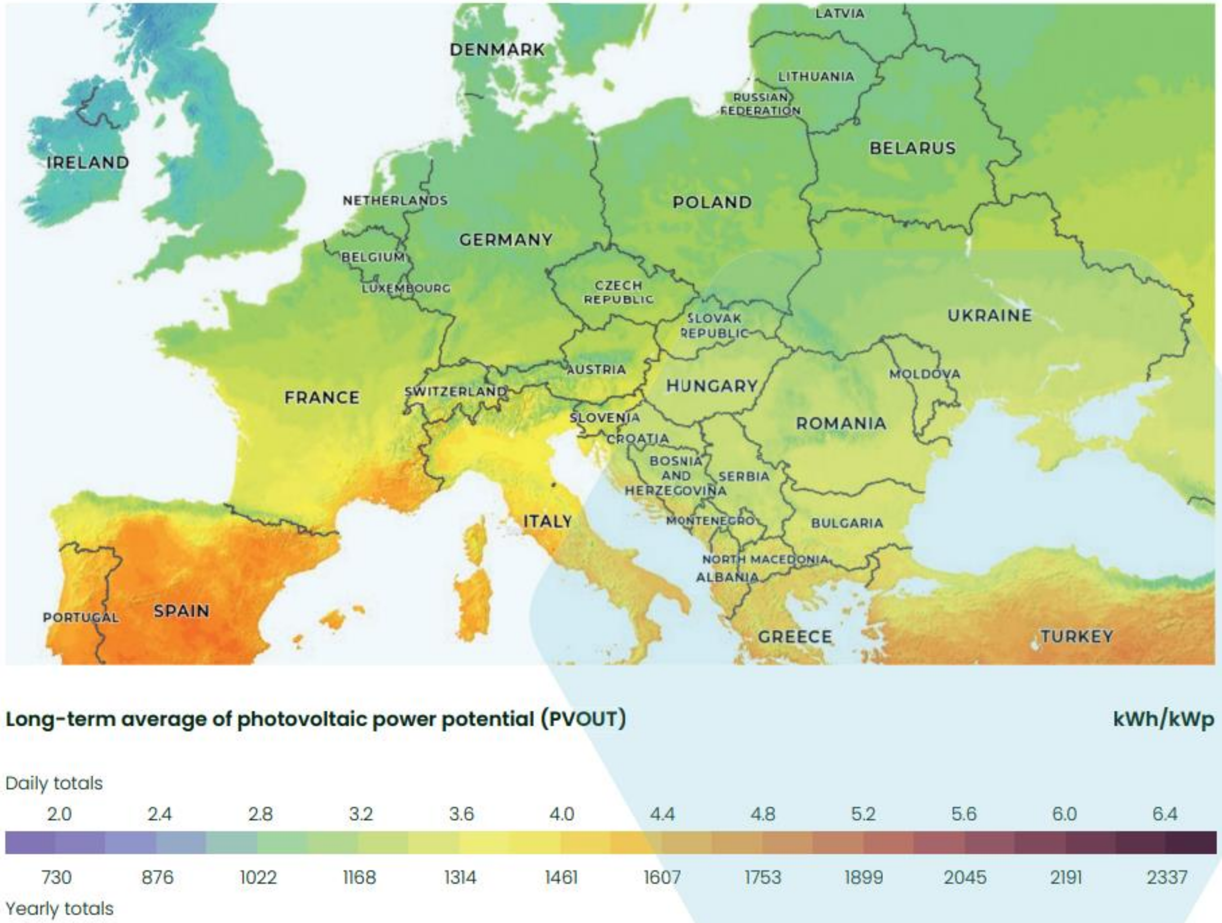
Pathways to a decarbonised future



Source: Roadmap for the European Fertilizer Industry

Wind potential in the EU



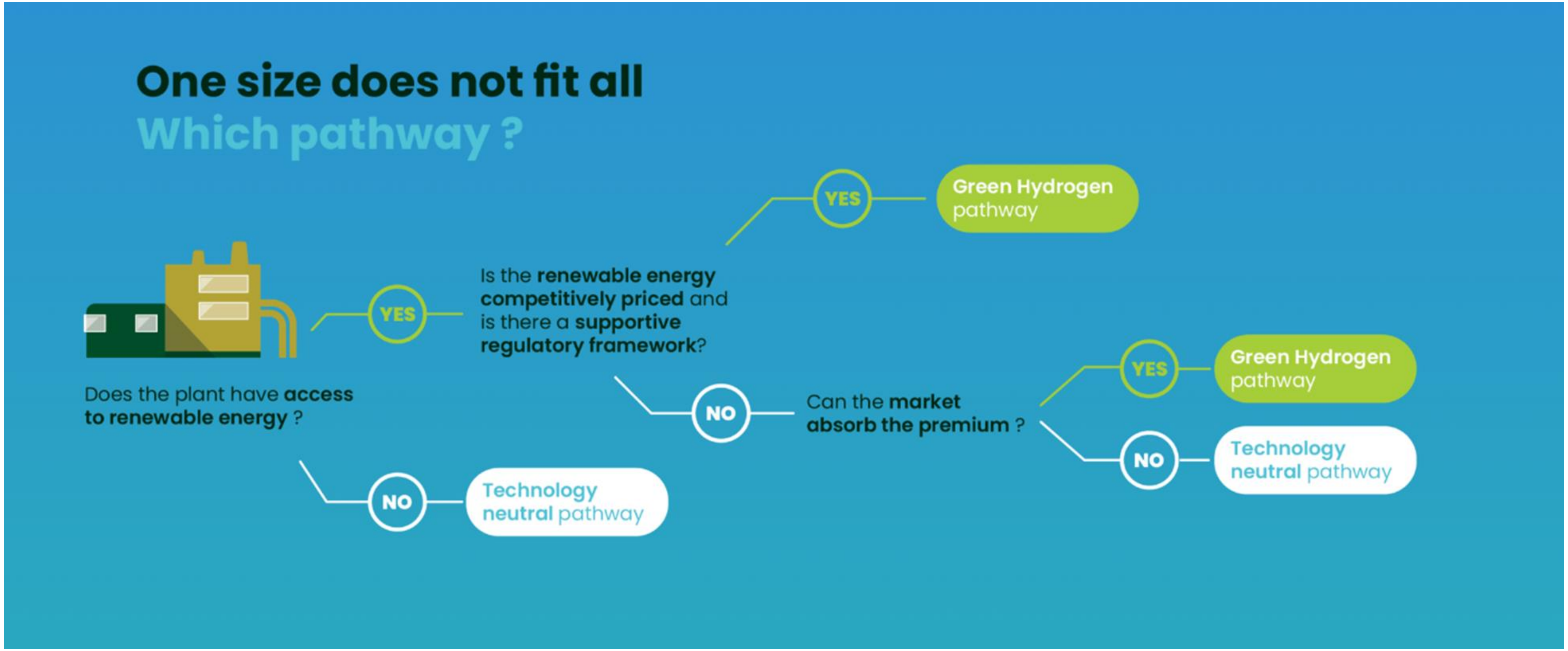


Photovoltaic Power Potential by Country
Source: Global Solar Atlas (Solargis, World Bank Group)

Fertilizers Europe

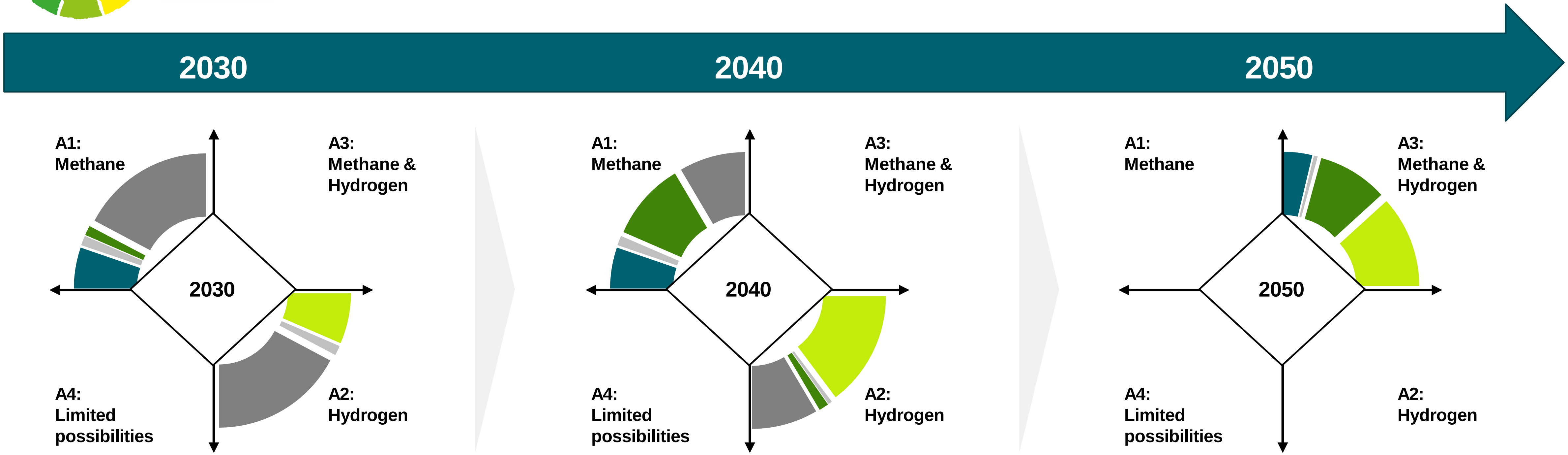
Source: Roadmap for the European Fertilizer Industry

Which pathaway?

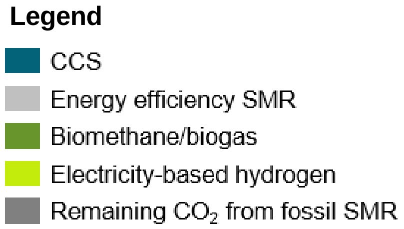


Source: Roadmap for the European Fertilizer Industry

Transition pathaway for technology neutral trajectory 1



- *A plant in archetype 1 has access to biomethane and/or CO2 infrastructure*
- *A plant in archetype 2 has access to hydrogen, either from abundant competitively priced renewable electricity, or from a hydrogen pipeline grid.*



Source: Roadmap for the European Fertilizer Industry

Cost of technological transition

€17 billion

electrolysers only

€3 billion

a hydrogen pipeline network

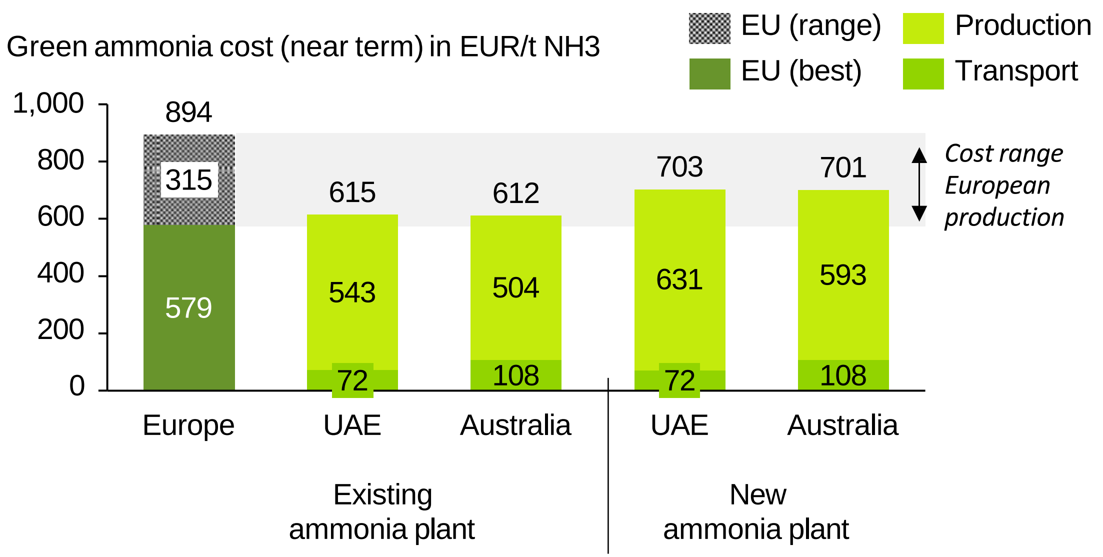
€64 billion

for offshore wind parks

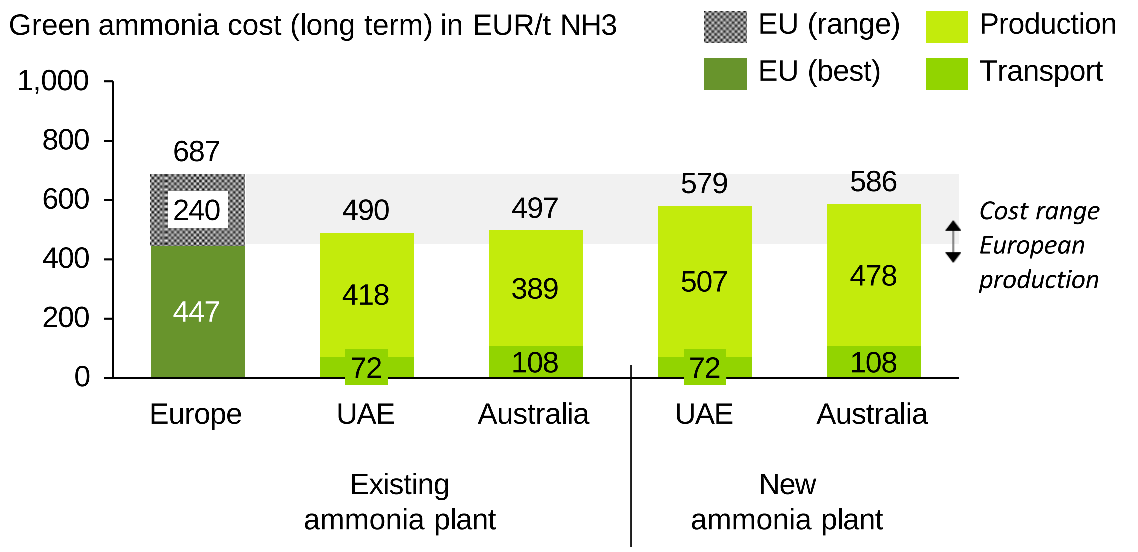
Source: Roadmap for the European Fertilizer Industry

Ammonia can be imported but creates dependency

Cost of imported green ammonia (near-term)



Cost of imported green ammonia (long-term)



Source: Roadmap for the European Fertilizer Industry

Broader role of ammonia in the energy transition

Not just fertilizers

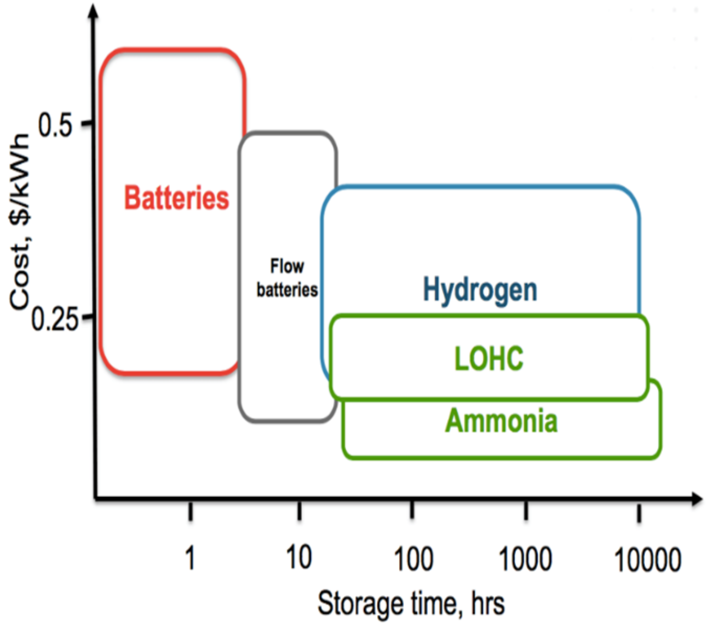
Ammonia as energy carrier

Power and heat generation
Replacing coal and natural gas in both baseload applications and peaker plants to provide stability in the grid with a high penetration of intermittent solar and wind power.

High temperature heat in industrial processes
As for example the German company Aurubis is currently exploring the use of ammonia for the production of copper in the anode furnace displacing natural gas.[1]

Shipping fuel
Ammonia, next to renewable methanol, is proposed to replace heavy fuel oil and LNG as a marine fuel for international shipping.

As a transport vector for hydrogen
Ammonia can be an effective medium to ship hydrogen, and there may be situations where storage of ammonia is cheaper and easier than storage of hydrogen.



Source: Roadmap for the European Fertilizer Industry

30.000 TONNES of Ammonia = 150 GWh

30 ans

Challenges and solutions

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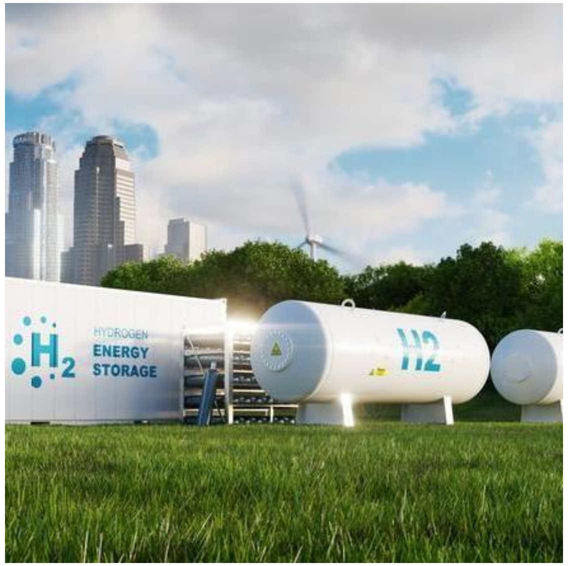
Gemas
Groupement d'études méthodologiques pour l'analyse des sols

Challenges



Business cases

The need for profitable business cases for the investments required.

Scaling up

The need to scale up the technologies and to learn how to operate these new technologies (at scale), so that their cost decrease.

Lead times

The lead times for investments, in combination with the current uncertainty about the (future) business case.

Intermittency

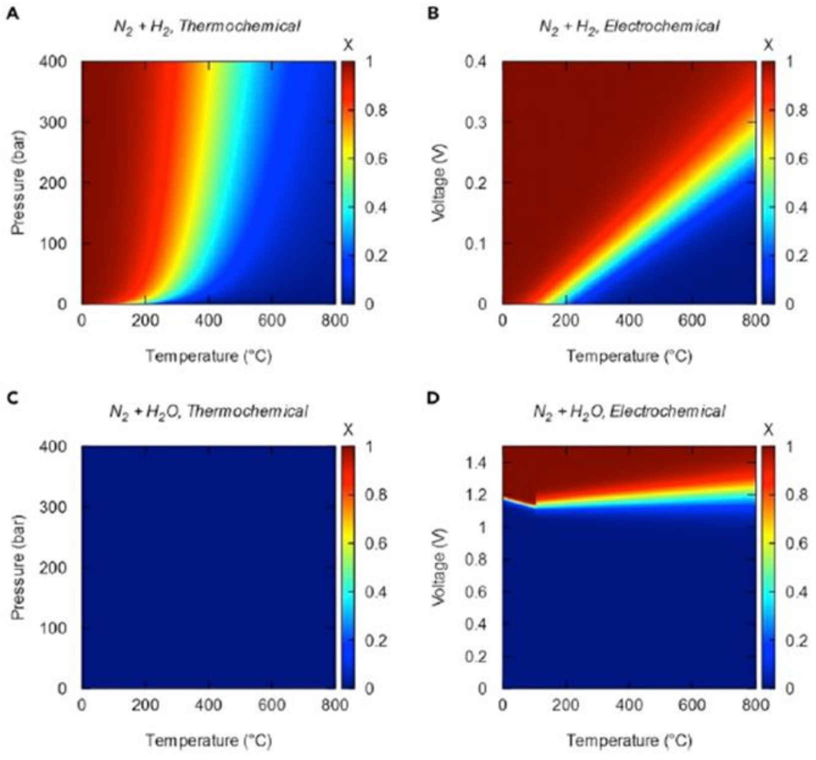
Dealing with the intermittency of generation of renewable electricity.

What else ?

MIT (Manthiram Lab)

Electrochemical Ammonia Synthesis

- Electrocatalysts
- Replace pressure with voltage, reaction at mild temperature/pressure
- Equilibrium conversions
  - Left: Thermochemical
    Right: Electrochemical
  - Top: $N_2 + H_2 \rightarrow NH_3$
    Bottom: $N_2 + H_2O \rightarrow NH_3$



CERTH / Aristotle University (Stoukides)

Electrochemical Ammonia Synthesis

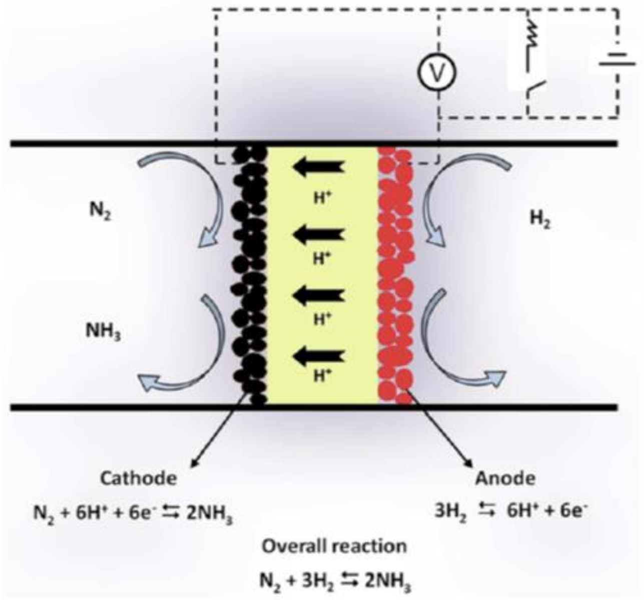


FIGURE 1 | Schematic diagram of a solid state H^+ conducting cell used for NH_3. Synthesis from its elements.

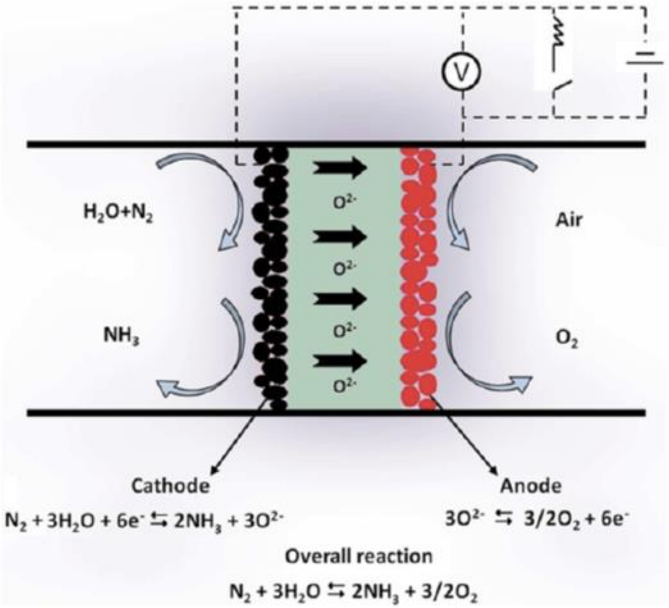


FIGURE 2 | Schematic diagram of NH_3 synthesis in an O^{2-} cell.

Technological developments further away

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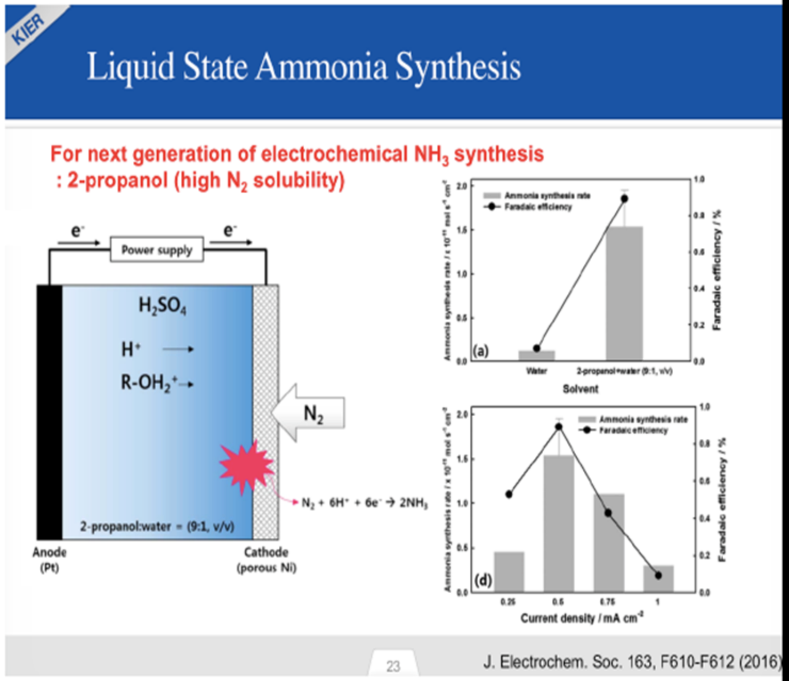
KIER (Korea Institute of Energy Research)
Electrochemical Ammonia Synthesis

- Solid State Ammonia Synthesis (SSAS)
  - 2012: 10^{-12} mol cm^{-2} sec^{-1}
  - 2015: 10^{-10} mol cm^{-2} sec^{-1}
- Molten Salt Ammonia Synthesis (MSAS)
  - 2016: 3 x 10^{-8} mol cm^{-2} sec^{-1}
- Liquid State Ammonia Synthesis (LSAS)
  - 2019: 10^{-7} mol cm^{-2} sec^{-1}
    - Current Density: 500 mA/cm^2
    - Faradaic Efficiency: 50%
    - Electrode Area: 400 $m^2 sec^{-1}$
- "Giddey Commercial Benchmark" = 10^{-6} mol cm^{-2} sec^{-1}, at >50% FE



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Stanford University / TU Denmark
Electrochemical Ammonia, Stepwise

- 3-step cycle omits hydrogen (H_2)
  1. LiOH electrolysis
  2. Li nitridation
  3. Li_3N hydrolysis
- Catalyst H selectivity is irrelevant
- 2017, lab-scale production
- 88.5% current efficiency to ammonia at industrial current density

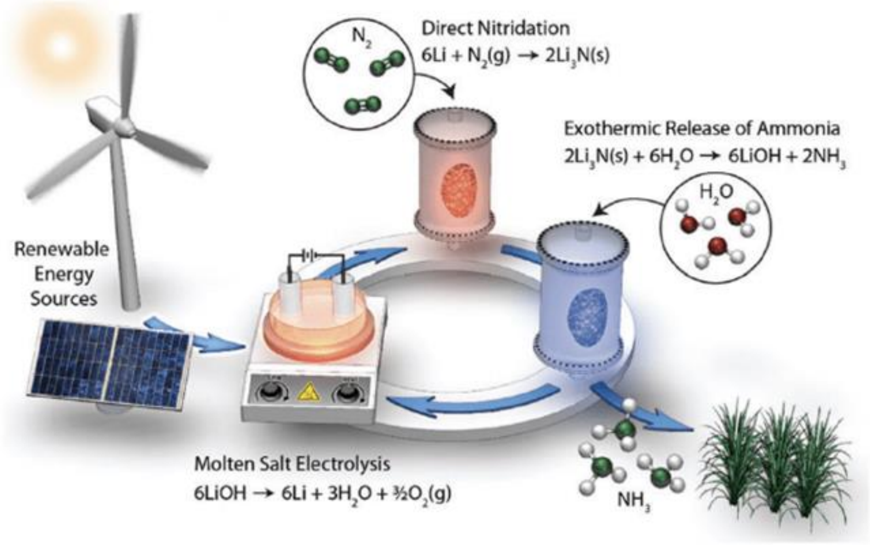
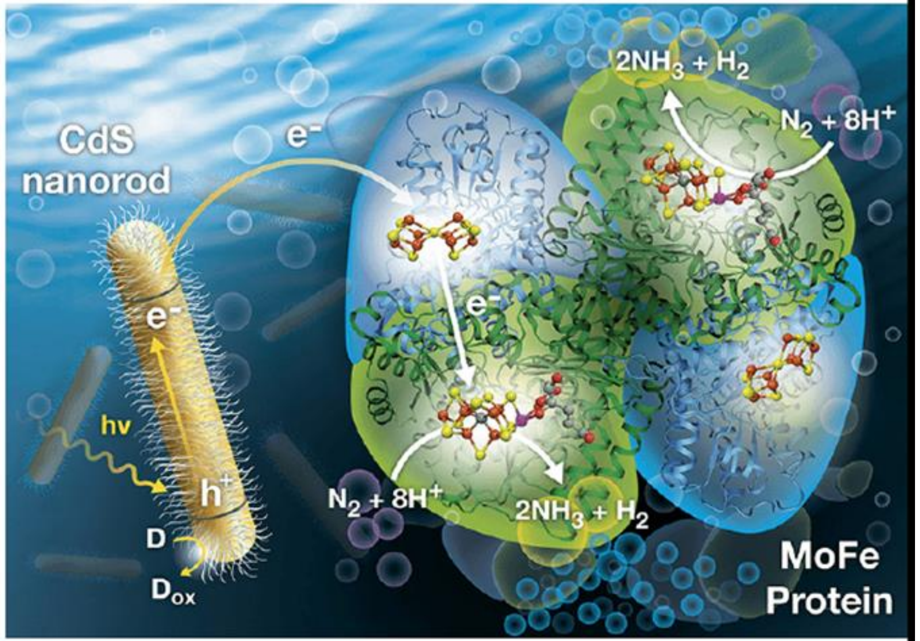


Fig. 1 Sustainable ammonia synthesis concept cycle.

Technological developments further away

NREL (US Department of Energy)
Next Generation: Biotech, Nanotech

- Engineering the nitrogenase enzyme
- Photocatalyst, cadmium sulfide (CdS)
- 2017, lab-scale production
- 63% efficient compared to ATP



Technological development further away

Joyn Bio: Bayer / Ginkgo Bioworks JV
Microbial engineering, soil biome

- GMO soil microbes, engineered to fix nitrogen for non-legume crops, delivered in seed coatings
- Announced September 2017, Launched March 2018
- $100 million USD, Series A financing
- Initial target: 2022

"These crops might be able to fertilize themselves some day."

BAYER

GINKGO BIOWORKS™ THE ORGANISM COMPANY

30 ans

The future is exciting !

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