XMEM
MEMBRANES

TAILOR MADE SOLUTIONS FOR
SEPARATION PROCESSES

Decarbonization and beyond : XMEM solutions for industrial sustainability

Camel Makhloufi

28th January 2025 – Eindhoven - Winterschool

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… btw, we’ll talk about policy, market , premium and just a bit about membranes

~~Decarbonization~~ Defossilization and beyond : XMEM solutions for industrial sustainability

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XMEM: Pioneering the Future of Energy and Sustainability

- **Who are we?**

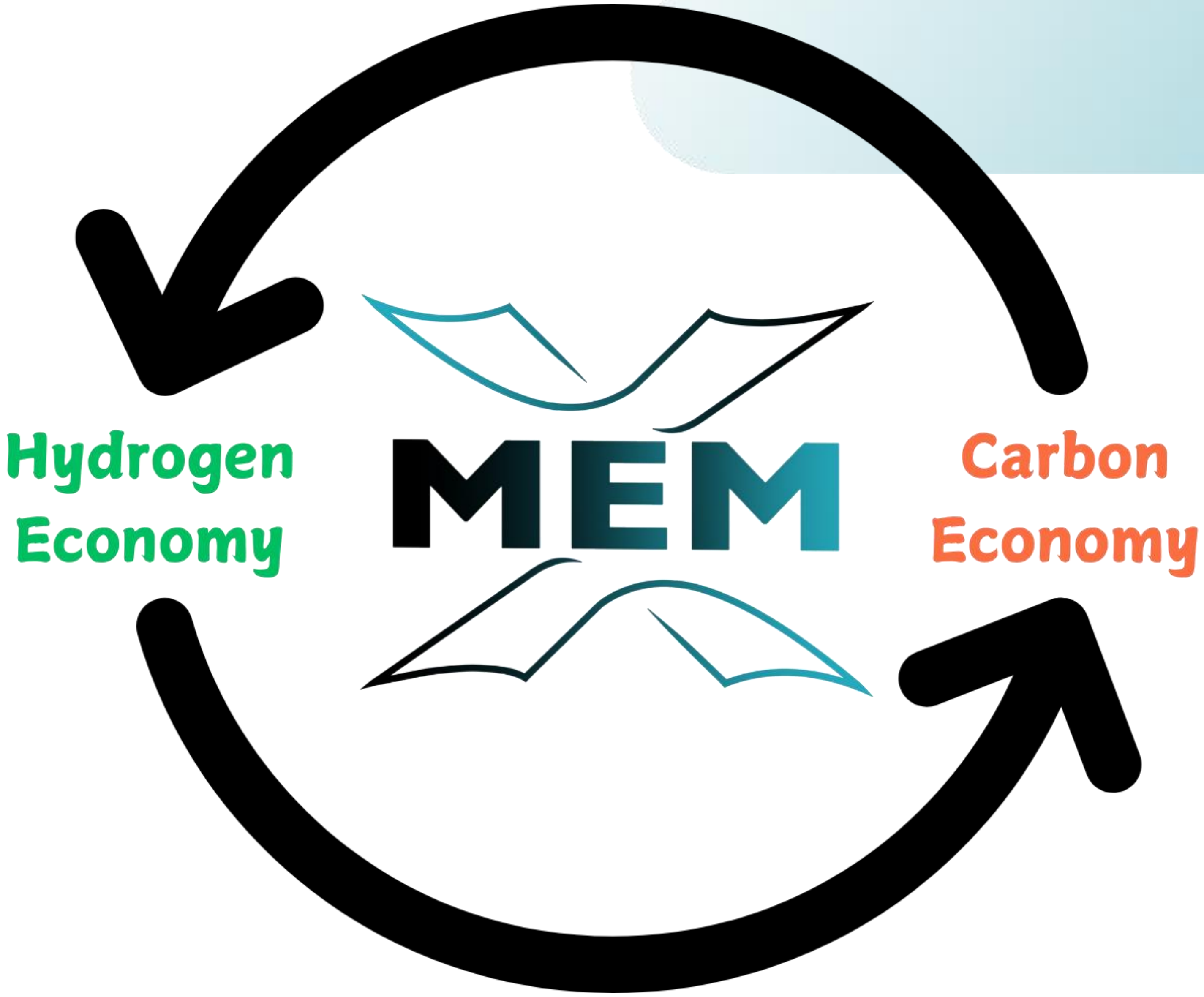
XMEM B.V. is a cleantech company created in 2024 and based in Eindhoven, building on over 15 years of pioneering R&D conducted at TU Eindhoven and Tecnalia

- **Ambition**

Delivering groundbreaking solutions based on our advanced carbon membrane for gas separation and defossilized fuel production

- **Why it matters?**

The global transition to a sustainable economy requires integrating electrification with circular carbon flows, leveraging both biogenic and non-biogenic carbon.



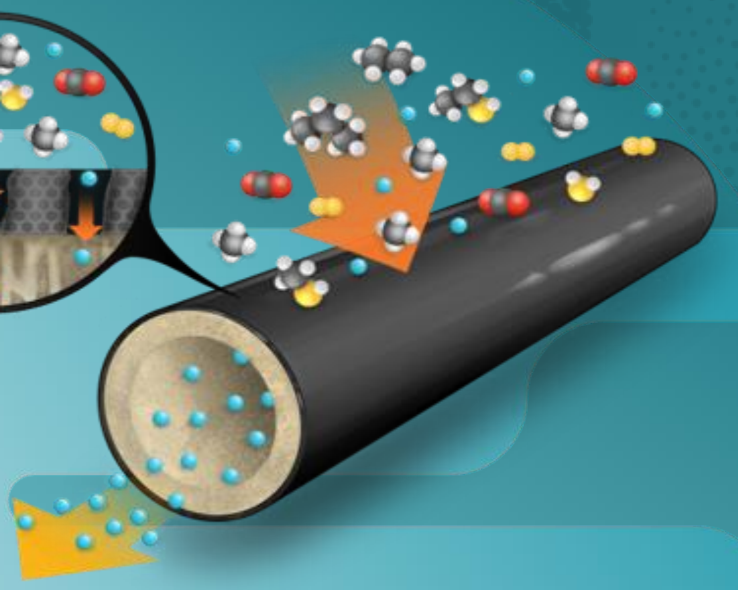
XMEM operates **at the nexus of the hydrogen and carbon economy**, acknowledging customers' diversity in resources, infrastructure, and policy.

We deliver cost-competitive and sustainable solutions to support their energy transition

OUR TECHNOLOGY

CARBON MOLECULAR SIEVE MEMBRANES

WHY CARBON MEMBRANES ARE BETTER THAN OTHER SEPARATION TECHNOLOGIES?



1. 3 MEMBRANE PRODUCT FAMILIES

- Dedicated to **gas separation (e.g CO2, H2, He)** and **membrane reactor (e/bio molecules)** applications
- 7 patents protecting the technology
- TRL 6-7 at system level

2. EXTREME CHEMICAL STABILITY

- Tolerates **pH of 0 to 14**
- Temperature range of **-20°C to 700°C**
- Wide pressure range, from **ultra vacuum to 120 bar**

3. TUNABLE PROPERTIES

- Pore size distribution
- Hydrophobicity / hydrophylicity

4. SUSTAINABLE WITH LOWER COST

- No critical raw material needed
- Easy to recycle

5. WIDE RANGE OF APPLICATIONS

- Tested for more than 22 applications related to carbon capture, biogas upgrading, ammonia synthesis and cracking, hydrogen deblending, helium recovery, methanol and DME synthesis, methanation, etc.

OUR TEAM

CAMEL MAKHLOUFI

CEO

FAUSTO GALLUCCI

CTO

ARASH MAMAGHANI

Technical director – Membrane Product

JON ZUNIGA

Business Advisor

ALFREDO PACHECO TANAKA

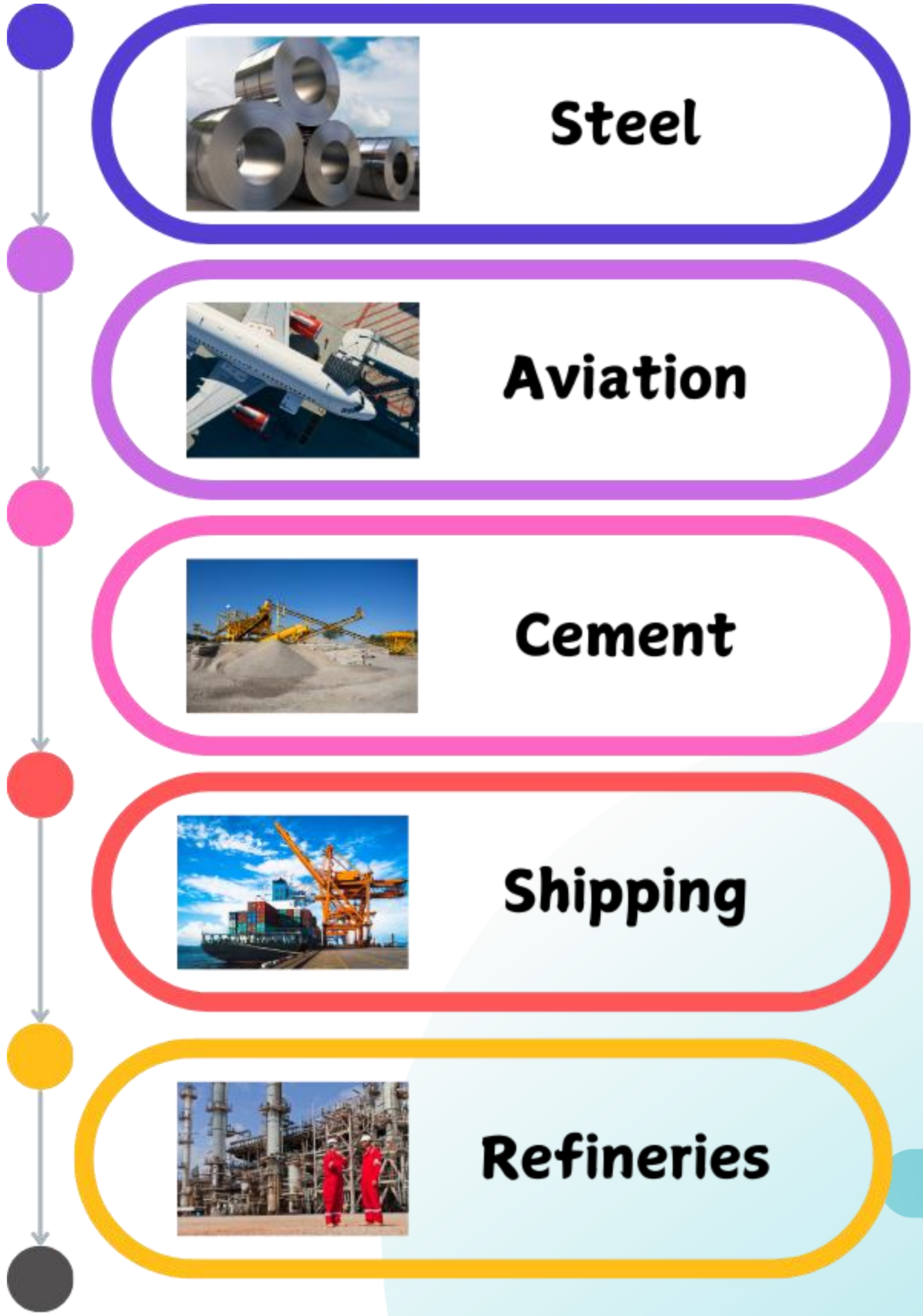
Technical Advisor

MARGOT LLOSA TANCO

Technical Advisor

Addressing the dual challenges of Climate change and Energy security

- **Context and challenges**
  - Unprecedented challenges: mitigating climate change, ensuring energy security, and managing resources sustainably.
  - Global warming impacts require urgent solutions, particularly decarbonizing hard-to-abate sectors (transport, industry, energy).
  - Europe`s dependence on imports for fossil fuels and critical resources creates environmental, economic, and strategic risks.
- **Dependency and risks**
  - 90% of EU natural gas is imported (€150B in 2022), shifting reliance from Russia to Norway/U.S.
  - Fertilizer imports surged by 117%, exposing agriculture to risks.
  - 97% of EU oil is imported (€300B in 2022), with record Russian LNG imports (16.5M tonnes in 2024).


Steel

Aviation

Cement

Shipping

Refineries

How Gas Price Instability Fuels Inflation?

- Unprecedented Gas Price Spike in 2022
  - Peak gas price: €235.5/MWh in 2022 (**over 767% the standard deviation** of pre-2021 prices).
  - Average price surge: €123.6/MWh compared to ~€27.14/MWh (pre-2021).
- Gas price increase due to both
  - **Supply disruptions** (e.g., Russian gas cuts) likely accounted for a larger share.
  - **Demand shocks** (e.g., precautionary stockpiling, economic recovery) in a context of inelastic demand and extreme weather also played a significant role.
- Broad Inflationary Impact
  - Each **10% gas price rise due to supply disruptions equivalent to 0,85% inflation** on energy, food, goods, and services
  - Each **10% gas price rise due to demand shock equivalent to 0,66% inflation** on energy, food, goods, and services

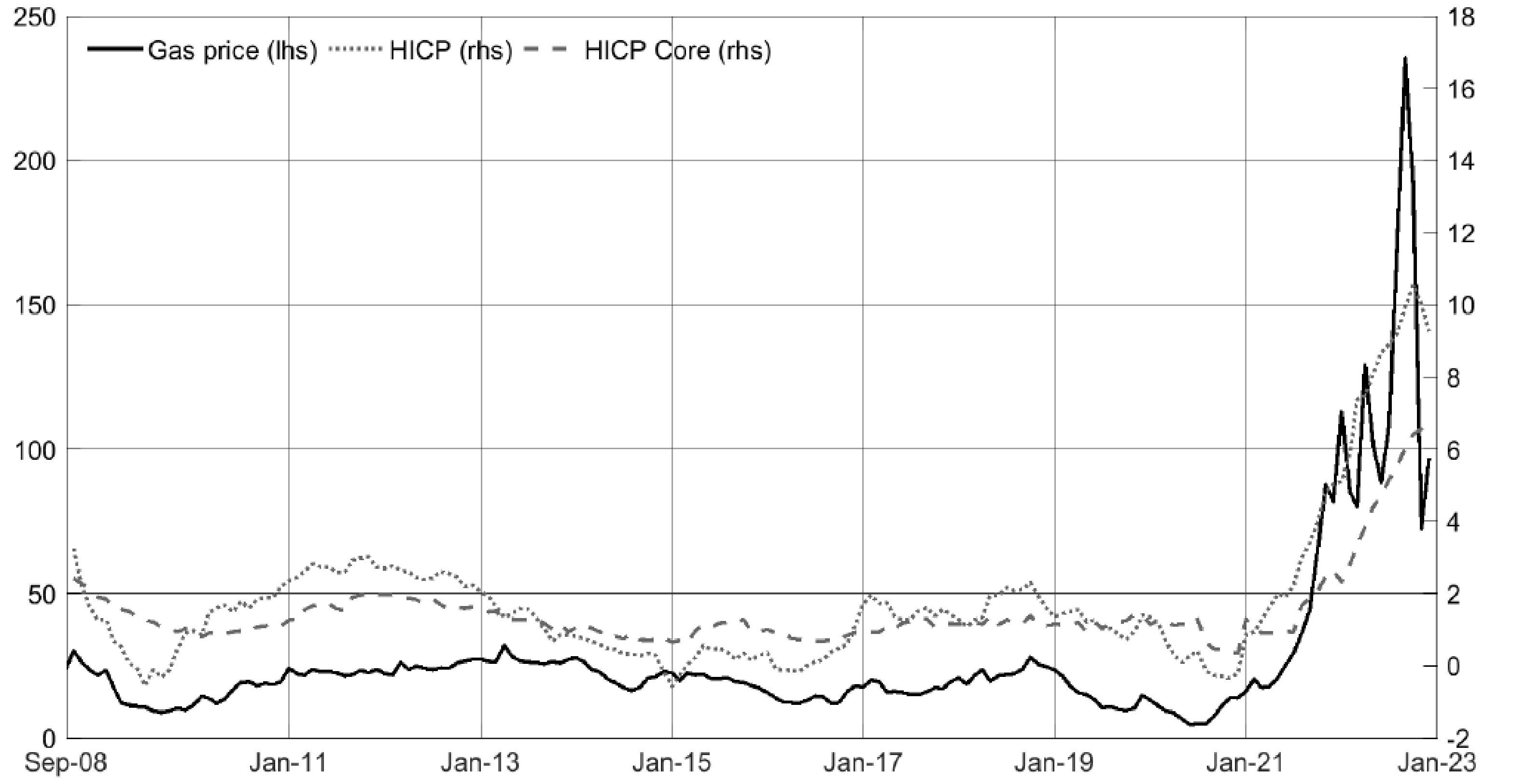
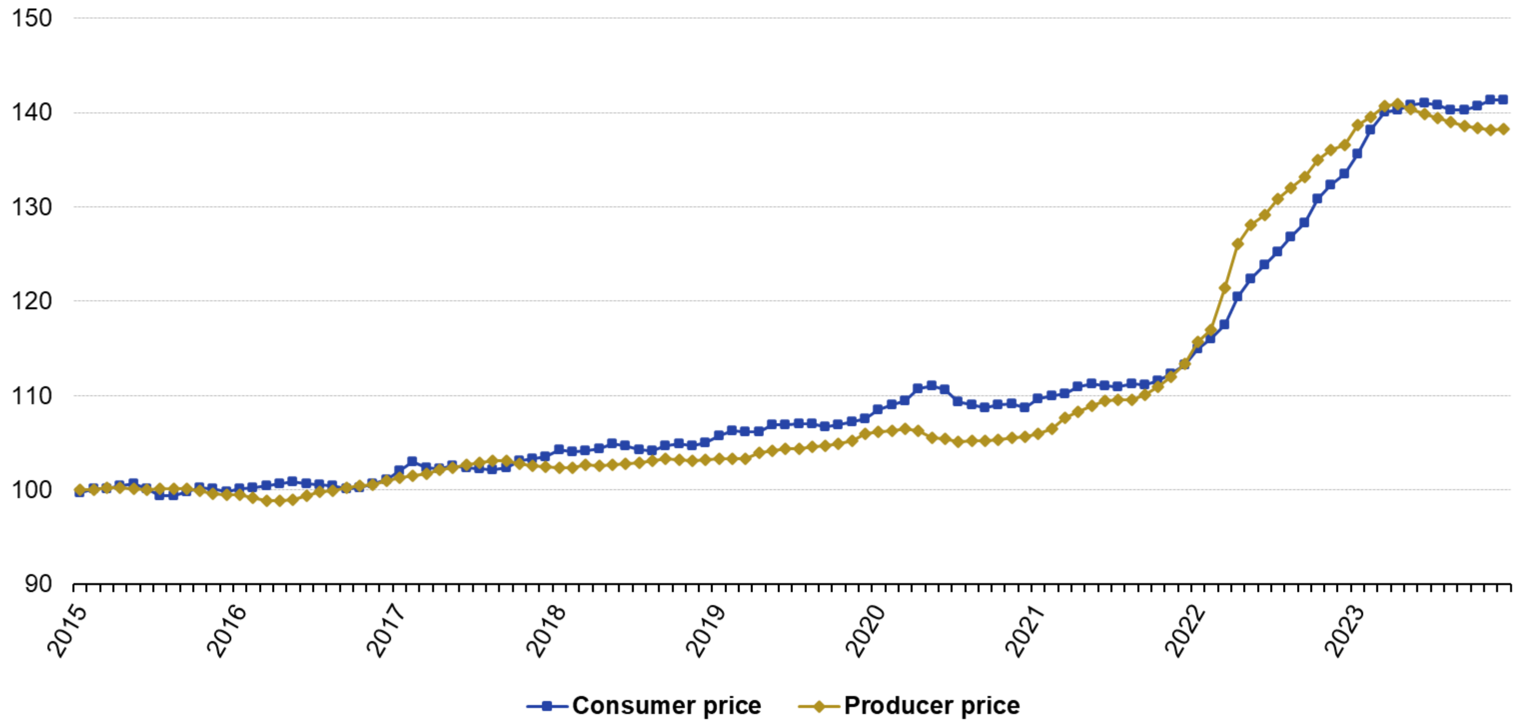


Figure 1: Gas price and euro area Harmonized Index of Consumer Prices.
Notes: The charts shows the Title Transfer Facility (TTF) gas price expressed in euros/MWh on the left-hand scale, and euro area HICP and HICP Core in year-on-year percentage changes on the right-hand scale.

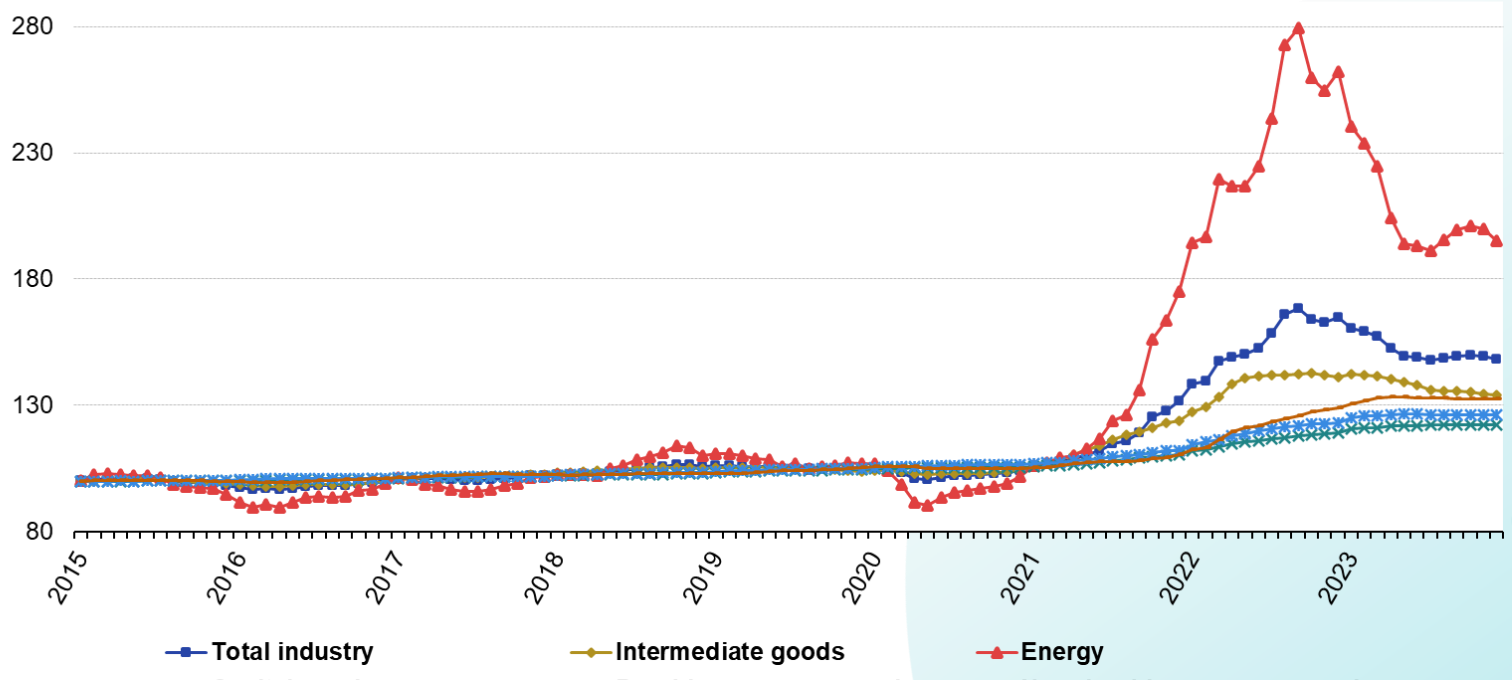
Energy Sector Vulnerability and Policy Responses

- **Energy Sector Dependency**
  - Gas prices account for 20% of EU energy production costs.
  - Surging gas prices in 2022 significantly increased energy costs across sectors.
- **Producer Price Increases (PPI)**
  - The Producer Price Index (PPI) measures the average rate of change in prices producers receive for their goods and services at the wholesale level.
    - It reflects cost pressures faced by producers, which often get passed on to consumers as inflation.
  - Energy PPI: +7.6% at the Peak of the supply shock
    - Reflects the rise in costs energy producers charge for electricity, heating, and natural gas.
  - Food PPI: +1.5% at its Peak of the supply shock
    - Tracks the increase in wholesale prices for food production
- **Policy intervention**
  - EU governments spent **€646 billion in 2022** to protect households and businesses from soaring energy costs

EU, Industrial producer price and consumer price for food products and beverages, 2015-2023, unadjusted data (2015 = 100)



EU, Domestic industrial producer prices - total and main industrial groupings (MIG) 2015 - 2023, unadjusted data (2015 = 100)



Source : European commission

EU's Comprehensive Strategy for Climate Neutrality

- Recognizing the Challenge
  - The EU tackles climate change and energy security under the **European Green Deal**. Goal: **Climate neutrality by 2050** with **economic resilience** and **sustainability**.
- Key Pillars
  - REPowerEU
    - Goal: Energy security, reduce gas imports.
    - Target of 10 million tonnes of imports from third party countries by 2030 with 4 MT/yr of green ammonia
    - Total investment cost are expected to be in the range € 335-471 billion, with € 200-300 billion needed for additional renewable electricity production (500TWh)
    - 35 bcm biomethane/year by 2030.Supported by anaerobic digestion, syngas methanation.
  - FIT for 55 with ambition to reduce by 55% CO2 emission compared to 1990 level
    - Encompassing key regulations and directives for industry, aviation and shipping
  - Farm to Fork
    - Target: Cut synthetic fertilizer use by 20%.
    - Promote biochar, sustainable farming, less import dependency.

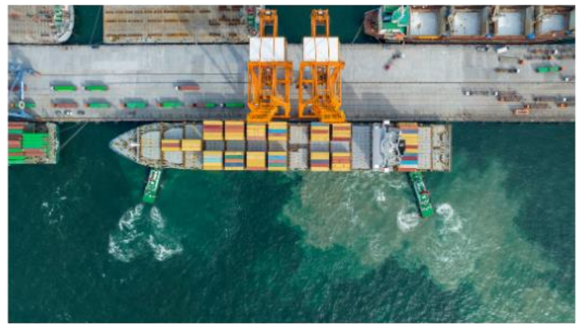
E-fuel and biofuel push through regulations

FIT for 55 – Renewable energy directive III

At least 42.5% of total energy consumption from renewables by 2030

5.5% of transport energy from advanced biofuels* and RFNBOs combined by 2030, with minimum 1% RFNBO*

42% of Hydrogen used in industry must be RFNBOs in 2030 , 60% by 2035



Indicative goal of at least 1.2 % of energy used in maritime transport to come from RFNBOs in 2030

X2 multiplier for advanced biofuels and RFNBOs . Additional multipliers in aviation and maritime transport: x1.2 for advanced biofuels and x1.5 for RFNBOs

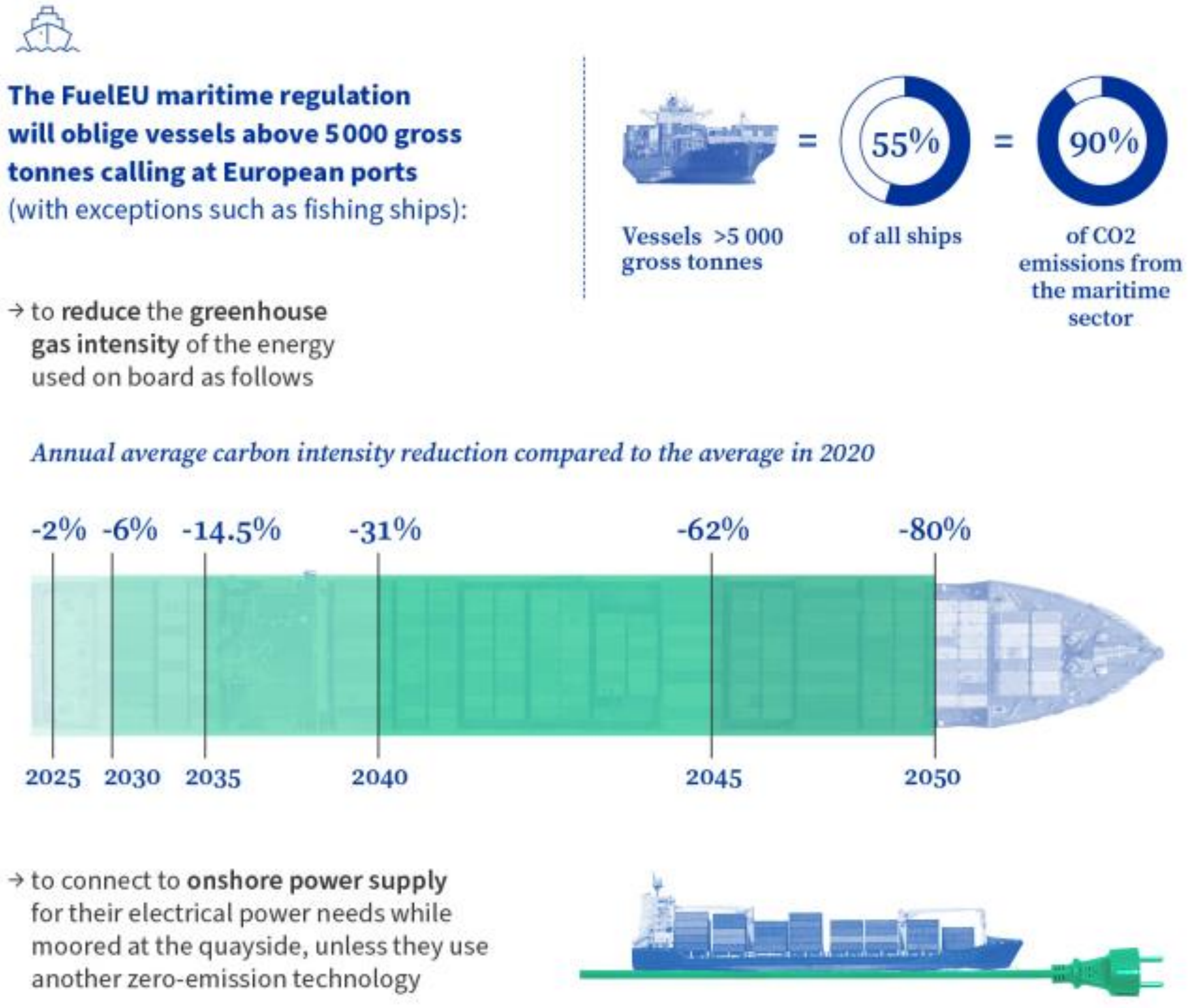
- *Advanced Biofuels: Produced from sustainable feedstocks like agricultural residues and waste materials (Annex IX, Part A).
- *RFNBOs (Renewable Fuels of Non-Biological Origin): Includes renewable hydrogen and hydrogen-derived fuels, such as synthetic e-fuels.

E-fuel and biofuel push through regulations

FIT for 55 – RefuelEU Aviation & FuelEU maritime

- **ReFuelEU Aviation**: Mandates the progressive uptake of sustainable aviation fuels (SAFs), targeting :
  - At least **2% SAF** by 2025, **6% by 2030**, and **70% by 2050**
  - Gradual integration of synthetic fuels (e-fuels), reaching **0.7% by 2030** and **35% by 2050**
  - Encourages the adoption of advanced biofuels and power-to-liquid fuels to reduce reliance on conventional jet fuel

- **FuelEU Maritime** sets maximum limits for the yearly average greenhouse gas (GHG) intensity of the energy used by ships above 5,000 gross tonnage calling at European ports
  - **2% GHG reduction by 2025**, increasing to **80% by 2050 (not only CO2 but also methane and Nox)**
  - Emissions are assessed over the entire lifecycle of the fuel (from "extraction" to combusiton)
  - Onshore power supply or alternative zero emission technologies from 1st January



The FuelEU maritime regulation will oblige vessels above 5 000 gross tonnes calling at European ports (with exceptions such as fishing ships):

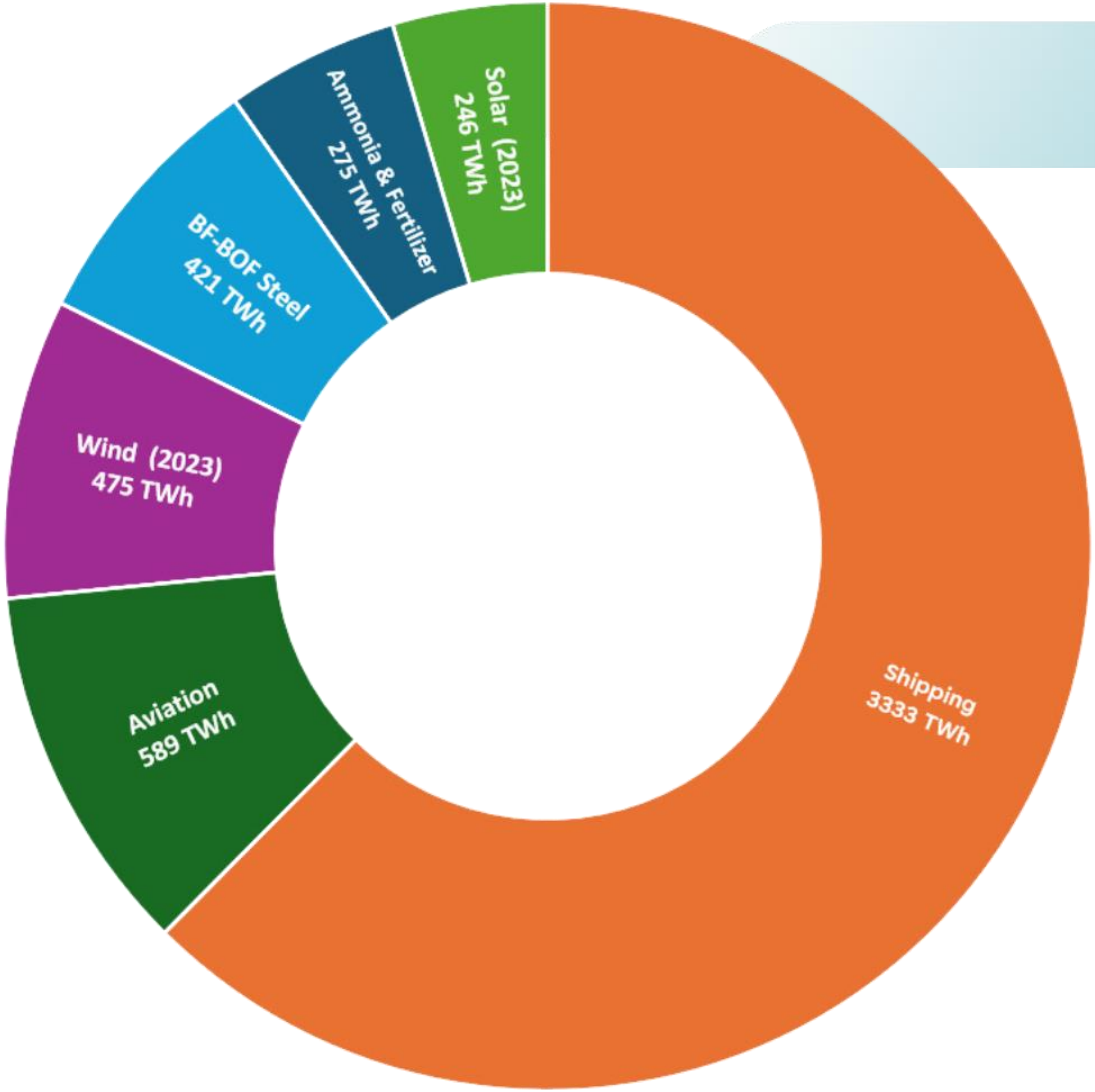
→ to **reduce the greenhouse gas intensity** of the energy used on board as follows

Annual average carbon intensity reduction compared to the average in 2020

→ to connect to **onshore power supply** for their electrical power needs while moored at the quayside, unless they use another zero-emission technology

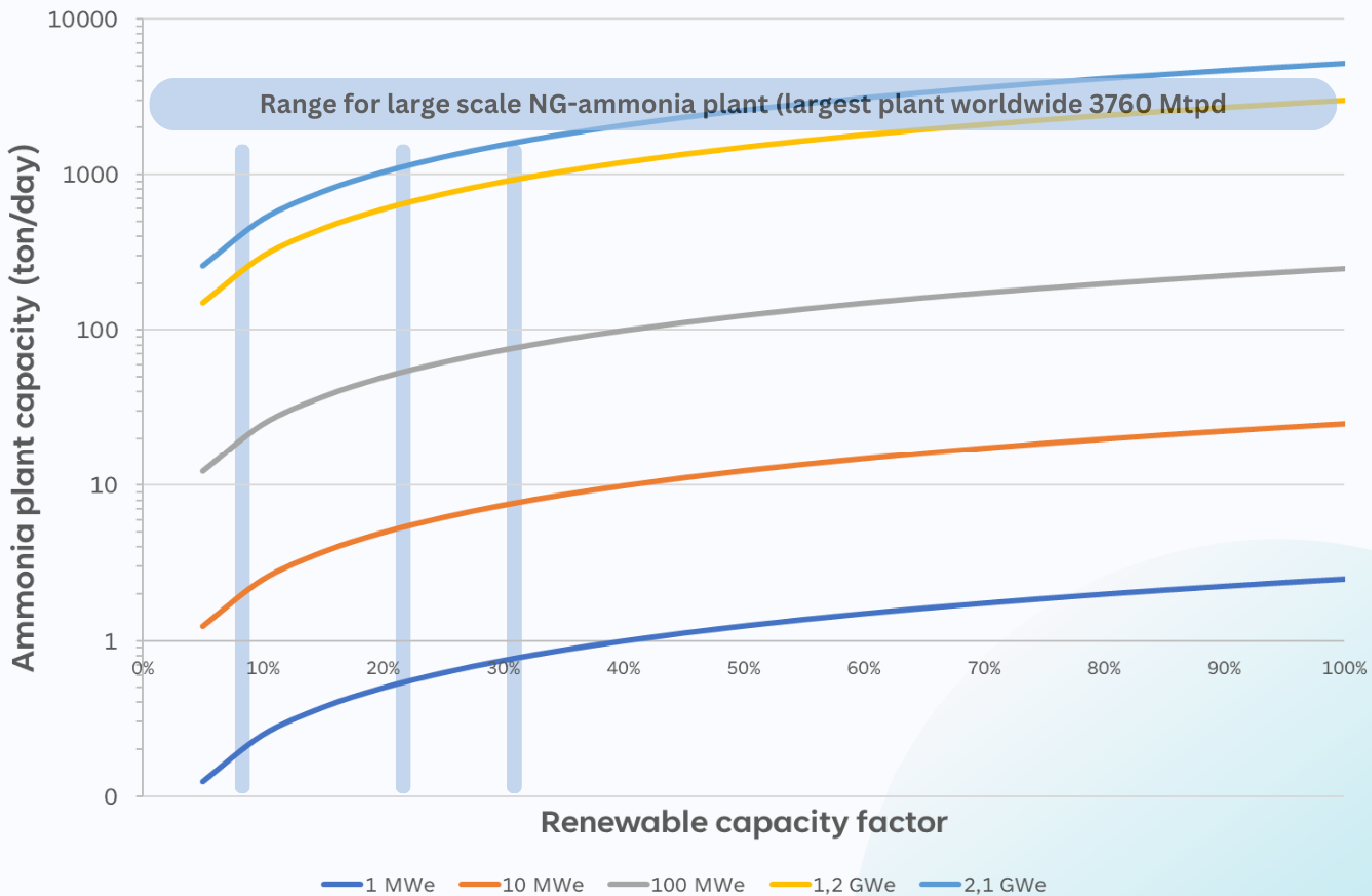
Energy demand for hard-to-abate industries : the magnitude of the problem

- Electricity demand in a full « Green Hydrogen » scenario for key hard-to-abate industries
- Wind and Solar cumulated generates in Europe around 1/5 of the energy needed to defossilize the shipping industry alone (2023 data)
- We will need a LOT of renewable, Biomass and Fuel to defossilize hard-to-abate industries

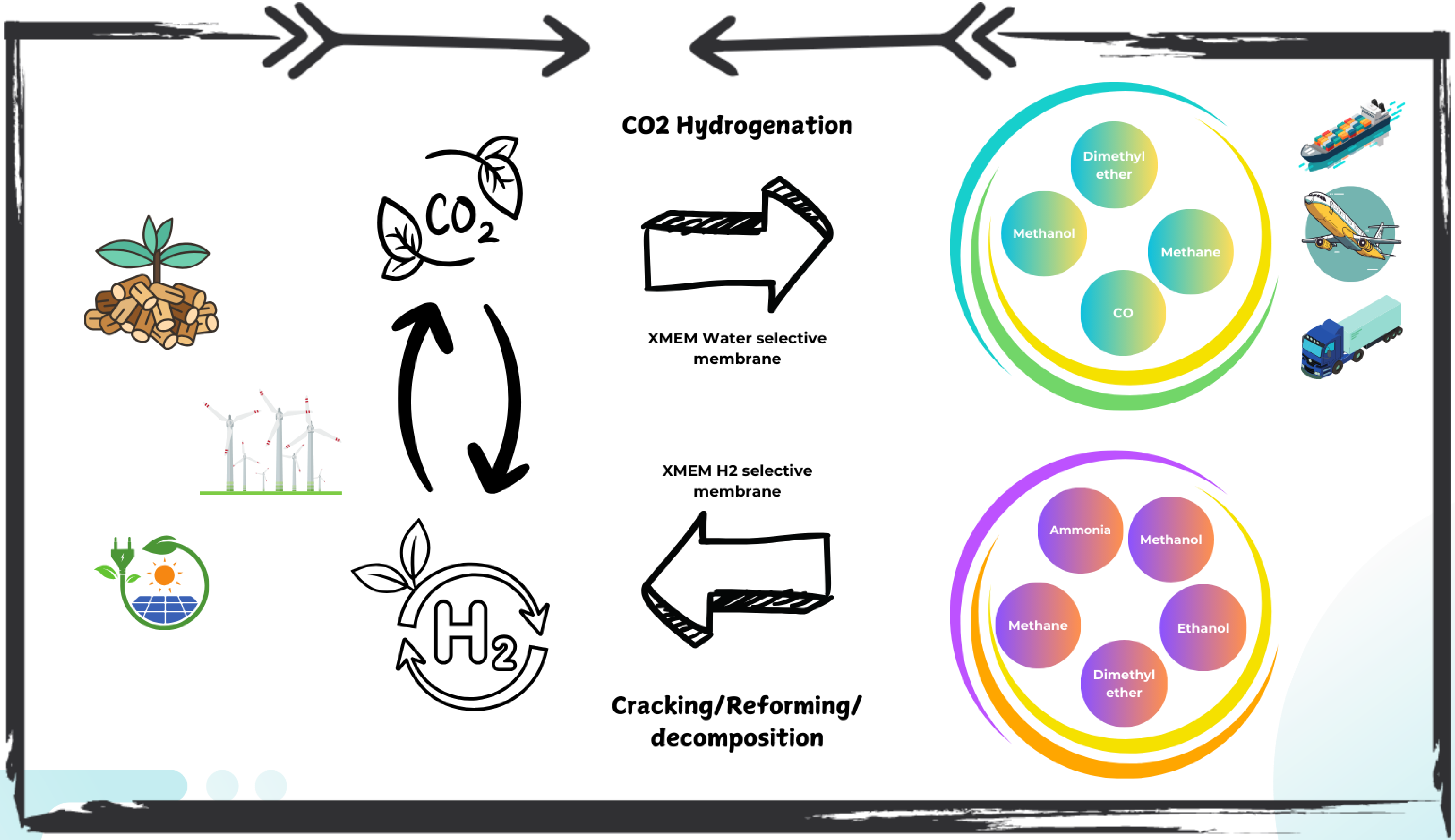


Defossilization imply modular and flexible catalytic systems: Renewables are intermittent but chemical plants are not

- The **largest fossil ammonia plant worldwide produce 3760 Mtpd** (SAFCO, ThyssenKrupp)
- Average solar capacity factor in Europe is 9,7%, onshore wind 23,7% and offshore around 30%
  - 1,2GWe PV installed capacity with the average European capacity factor would feed a 200-250 tons/day ammonia plant
  - 1,2GWe onshore wind : 1000ton/day for onshore wind
- Coping with **renewable additionality principles and reducing PPA cost** implies to develop flexible and modular e-molecules system with high turndown ratio



Membrane reactors can play a role in the defossilization of hard to abate industries...



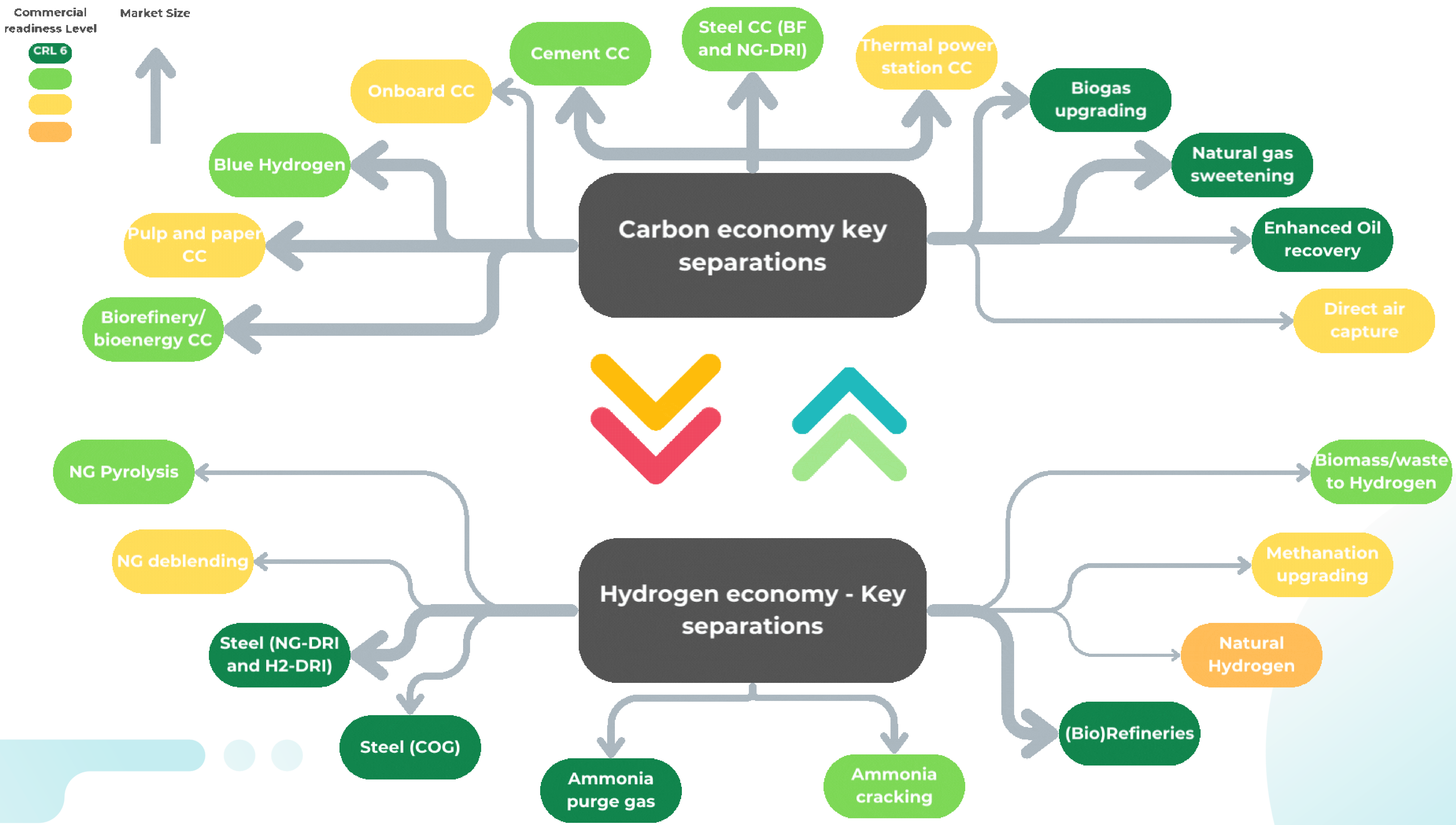
CO2 Hydrogenation

XMEM Water selective membrane

XMEM H2 selective membrane

Cracking/Reforming/ decomposition

…. As well as membrane gas separation



Commercial readiness Level

- CRL 6
- 🟩
- 🟨
- 🟧

Market Size ↑

Carbon economy key separations

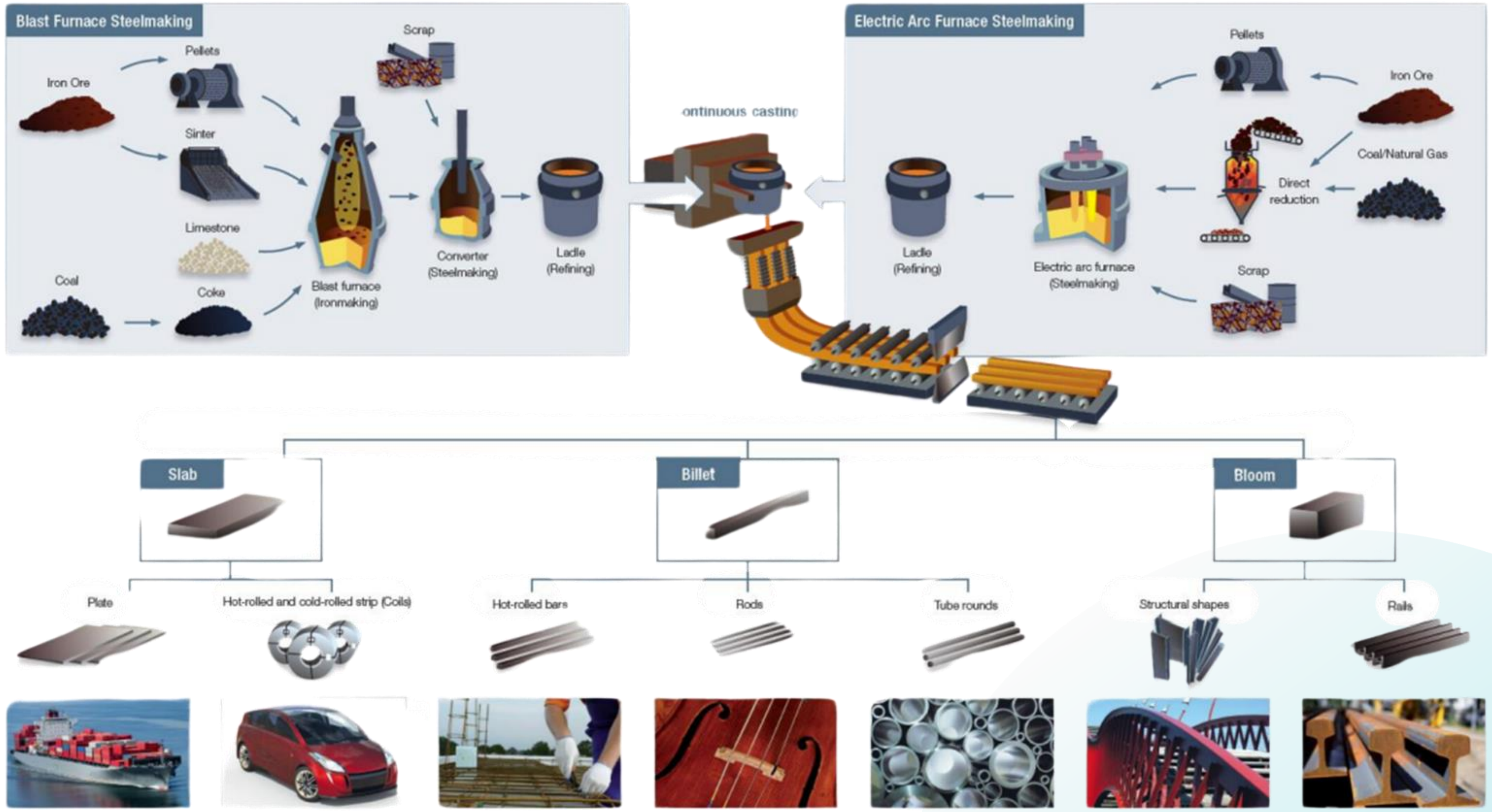
- Onboard CC
- Cement CC
- Steel CC (BF and NG-DRI)
- Thermal power station CC
- Biogas upgrading
- Natural gas sweetening
- Enhanced Oil recovery
- Direct air capture
- Blue Hydrogen
- Pulp and paper CC
- Biorefinery/ bioenergy CC

Hydrogen economy - Key separations

- NG Pyrolysis
- NG deblending
- Steel (NG-DRI and H2-DRI)
- Steel (COG)
- Ammonia purge gas
- Ammonia cracking
- (Bio)Refineries
- Natural Hydrogen
- Methanation upgrading
- Biomass/waste to Hydrogen

Defossilization of the steel industry

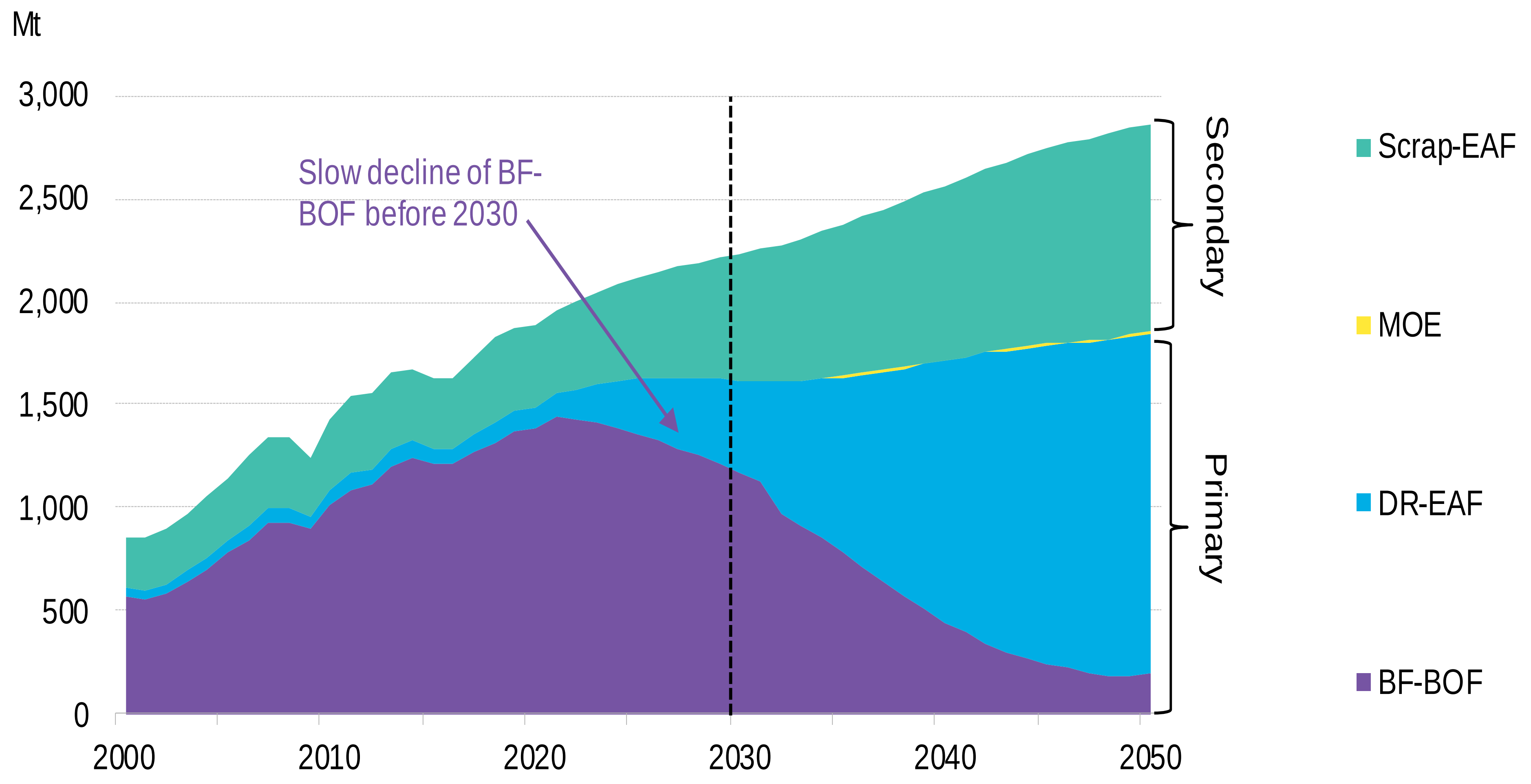
- **Blast Furnace (BF) Route**
  - **Production Share**: Accounts for **60% of Europe`s crude steel production**.
  - **Feedstock**: Iron ore, coal, and some scrap.
  - **CO2 Emissions**:
    - **~2.3 tons of CO2 per ton of steel** produced (~2 tons of CO2 per ton of crude steel in Europe).
    - High emissions due to coal being the primary reducing agent.
- **Electric Arc Furnace (EAF) Route:**
  - **Production Share**: Accounts for **40% of Europe`s crude steel production**.
  - **Feedstock**: Primarily scrap metal.
  - **CO2 Emissions**:
    - **~0.3 tons of CO2 per ton of steel** (when using renewable electricity).
    - Emissions are significantly lower than the BF route, largely dependent on the electricity source.



Source : WorldSteel association

Steel Industry Transformation: Decarbonization Under Regulatory Pressure

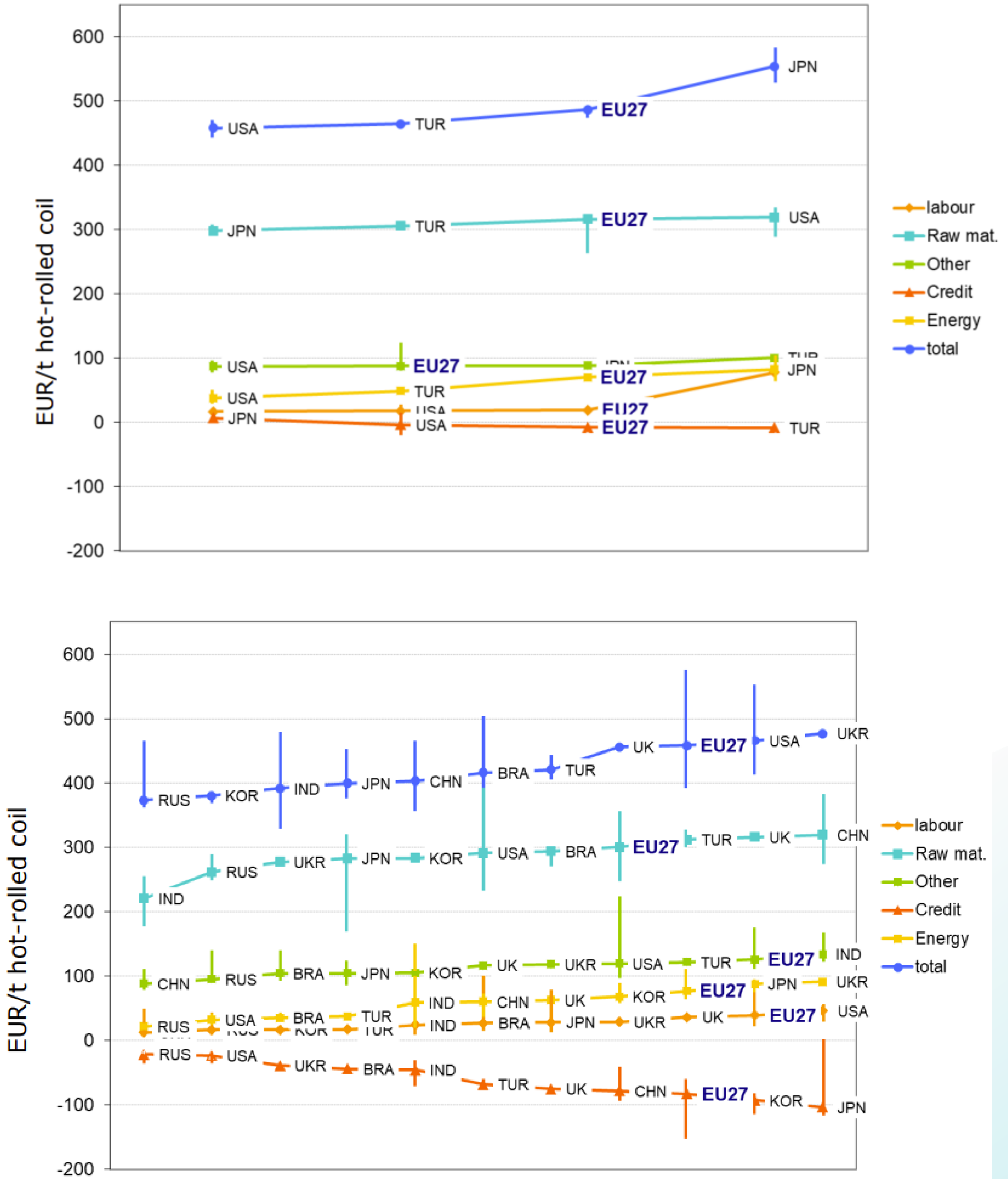
- **Upcoming Challenges for BF Infrastructure:**
  - 74% of European blast furnaces require significant reinvestments by 2030.
  - This aging infrastructure will lead to the progressive phase-out of blast furnaces.
- **Future of Steelmaking:** Direct Reduced Iron (DRI) and Electrical arc furnaces:
  - Produced using high-grade iron ore in shaft furnaces.
  - Set to replace BF pig iron as a primary input for steelmaking.
  - Increased Scrap Utilization:
  - More Electric Arc Furnaces (EAFs) will be deployed, significantly increasing scrap consumption.



Source: BloombergNEF. For a more detailed breakdown, see BNEF New Energy Outlook 2022 .MOE is molten oxide electrolysis.

Steel Industry Transformation: Decarbonization Under Regulatory Pressure

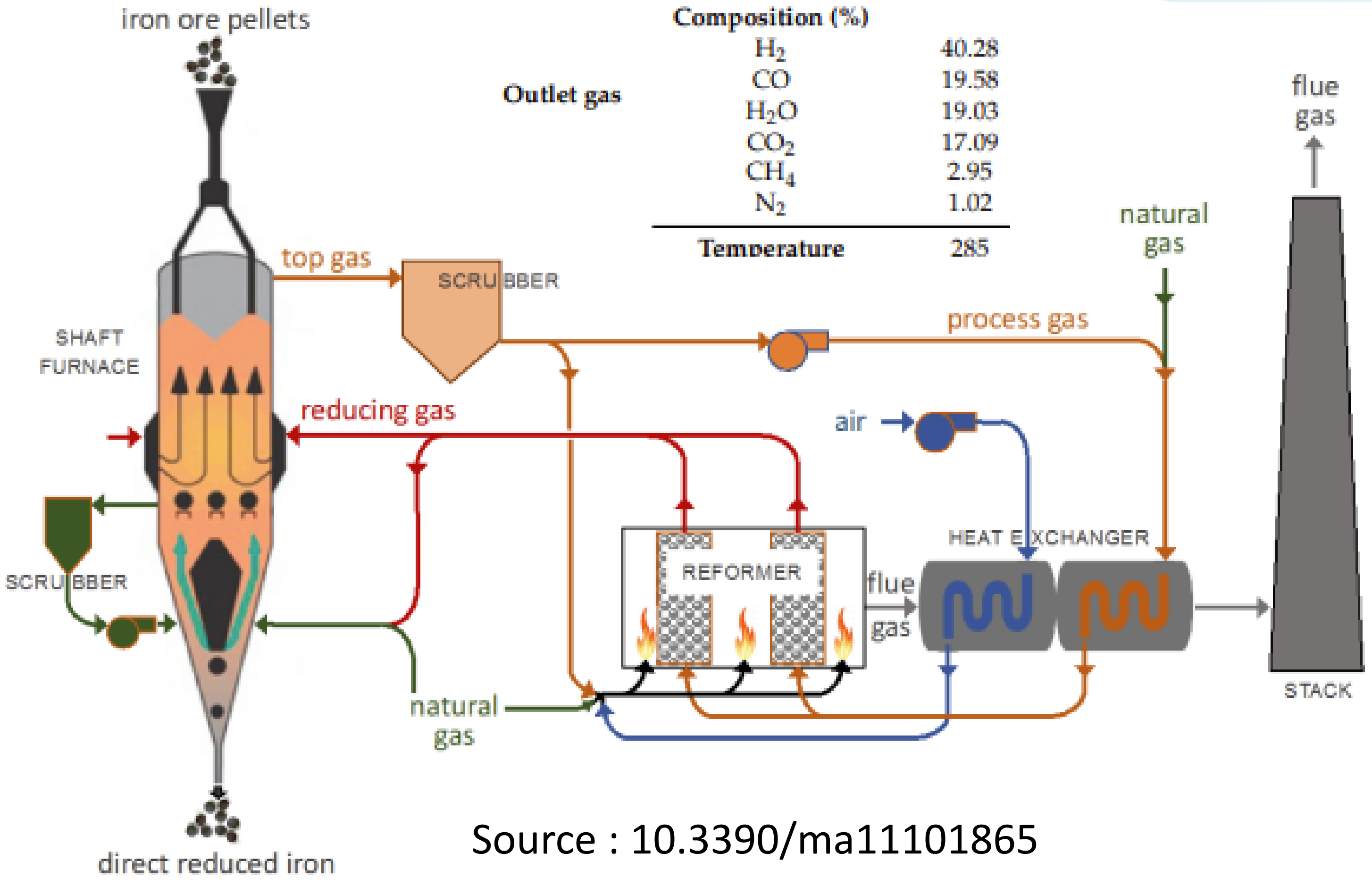
- **Coexistence of BF-BOF and NG/H_2 DRI Routes:**
  - BF-BOF and NG/H_2 DRI will coexist for at least the next 20 years to meet steel demand during the transition to low-carbon technologies
- **Competitiveness challenges**
  - Higher costs due to reliance on natural gas and limited hydrogen availability (H2-DRI/EAF projected to around 800 €/ton crude steel)
  - The cost of transitioning to hydrogen-based DRI is high, requiring large-scale renewable energy and hydrogen production.
- **Decarbonization priorities**
  - BF/BOF: Requires CCUS integration and process optimization (e.g., hydrogen injection) to reduce emissions.
  - NG/H_2 DRI: Transition from natural gas to hydrogen must maximize efficiency and cost-effectiveness.



HRC cost structure from BF (bottom) and EAF (left) – Source JRC

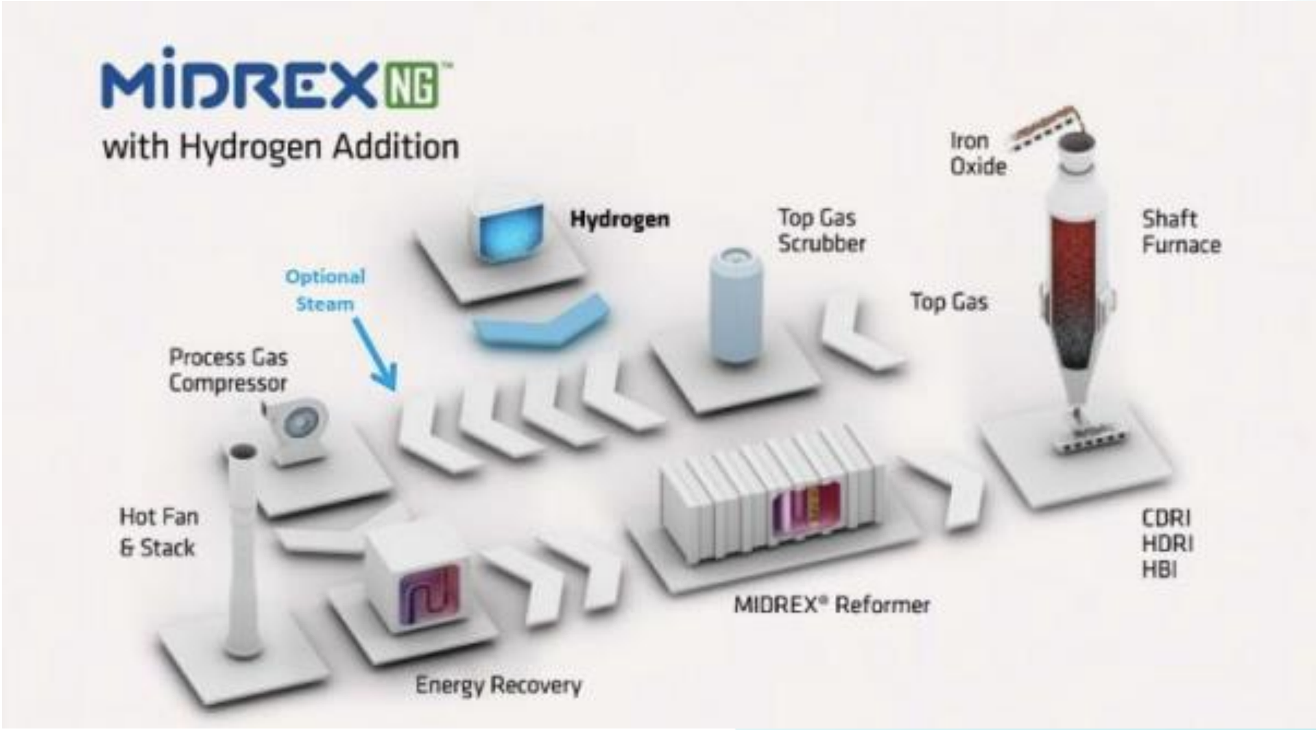
Introduction to the direct reduction iron concept

- Hot Briquetted Iron (HBI) is a substitute of sponge Iron and is produced from high grade iron ore pellets
- DRI is today produced using natural gas and around 10 new plants have been announced in Europe
- Transition by addition of green H2 or direct replacement is also proposed with several project ongoing in Europe
- In both cases, **separation are essential**
  - **CO2 capture is already implemented** in numerous NG/DRI plant by TENOVA
  - **Hydrogen recovery is essential** in H2/DRI plant to maintain adequate economics



Outlet gas	Composition (%)	
	H_2	40.28
	CO	19.58
	H_2O	19.03
	CO_2	17.09
	CH_4	2.95
	N_2	1.02
	Temperature	285

Source : 10.3390/ma11101865



Source : MIDREX

Selective CO_2 Separation Using Tailored Carbon Molecular Sieve Membranes

- Gas Composition Tested : Composition: 4% Hydrogen (H_2), 22.4% Carbon Dioxide (CO_2), 73.6% Nitrogen (N_2), Water vapor added via a humidifier to simulate real-world conditions.
- CO_2/N_2 Ideal Selectivity increased **up to 150 under operating conditions of 300°C and 20 bar** with functionalized membranes.
- **Functionalization with ethylenediamine** led to enhanced molecular sieving and CO_2 adsorption:
  - Reduced pore sizes.
  - Increased CO_2-permeance and adsorption sites.
- Functionalized CMSMs outperform non-functionalized ones, achieving selectivities beyond Robeson`s upper bound.

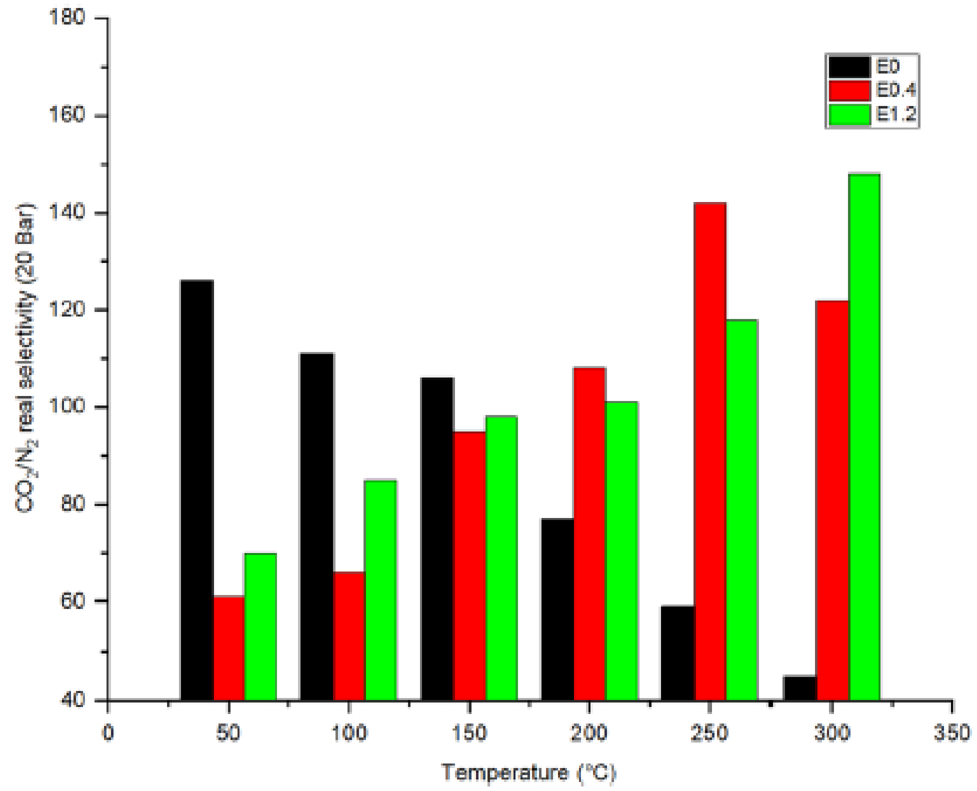


Fig. 9. Trends and the values of the observed CO_2/N_2 real selectivity in the permeate side versus temperature.

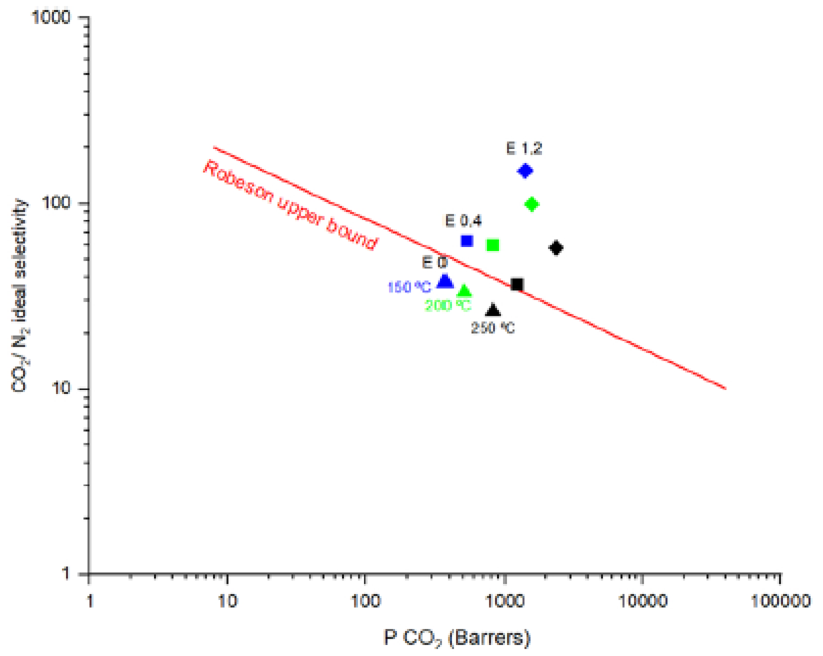
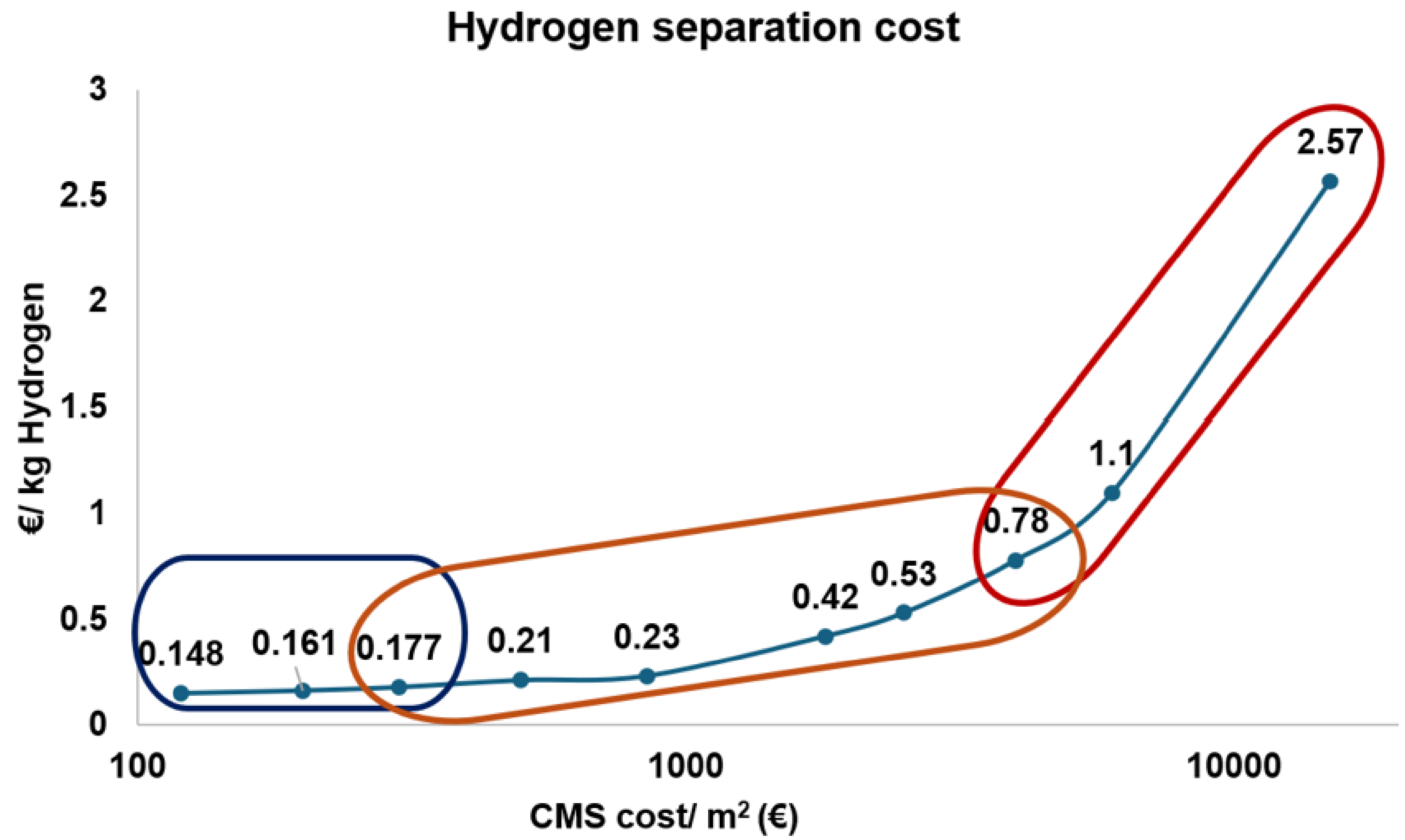


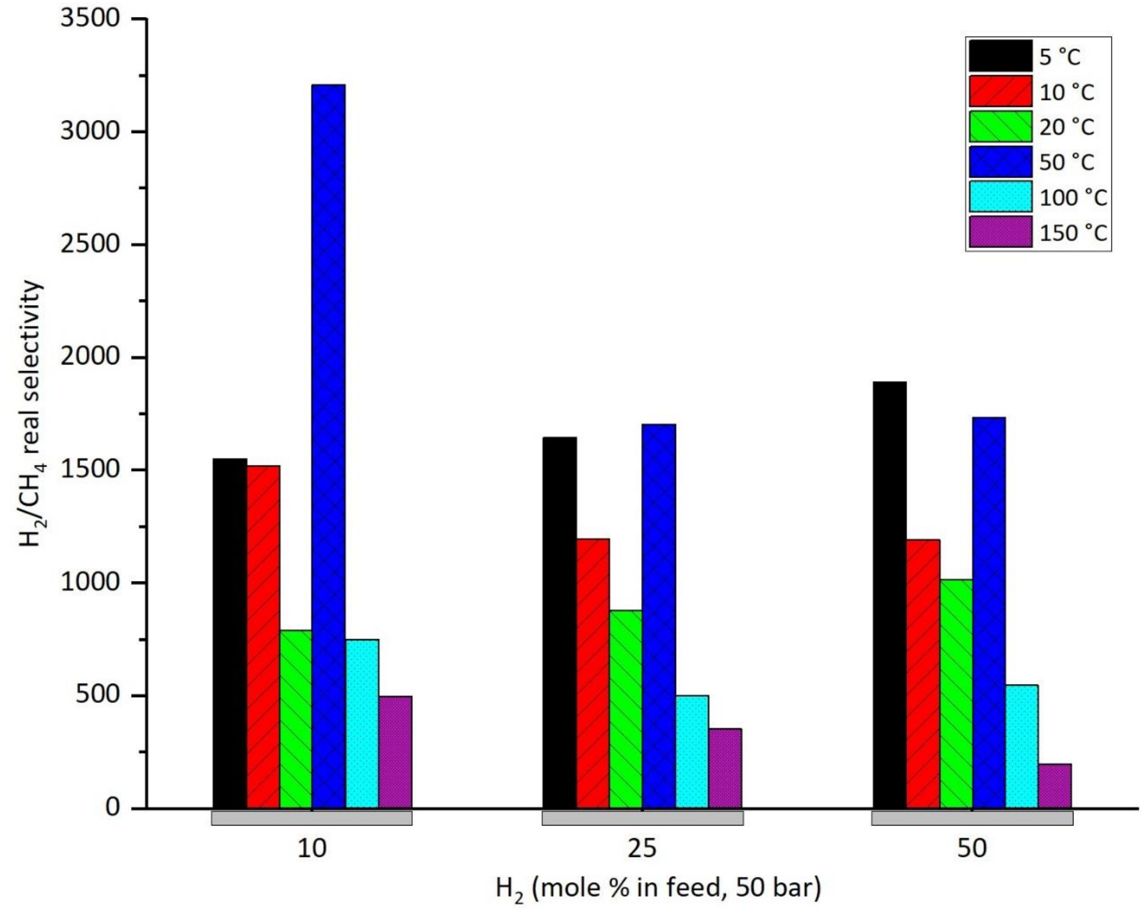
Fig. 11. The observed trends of CO_2/N_2 ideal selectivity; Robeson upper bound (data correspond to 20 bar operating pressure).

Hydrogen selective membrane for steel and other application. Example of deblending

- Hydrogen selectivities and deblending cost projection



Hydrogen separation cost for 20%/80% H2/CH4 - Hydrogen deblending from natural gas.

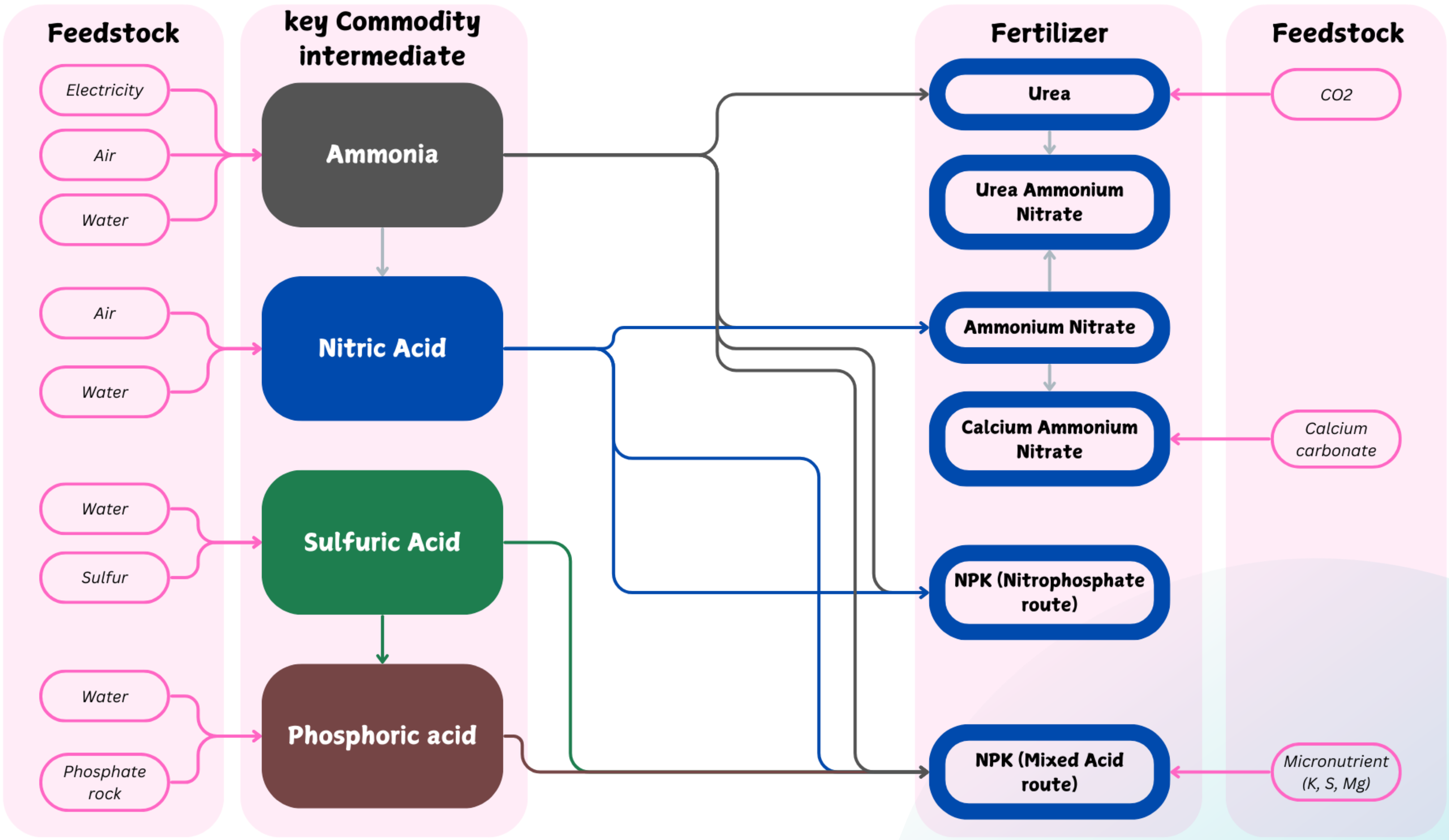


H_2 deblending

- Stable performance @ 5-150°C
- H2/CH4 selectivity up to 3200 at 50 °C

Ammonia: A Key Component in Fertilizers and Hydrogen Economy

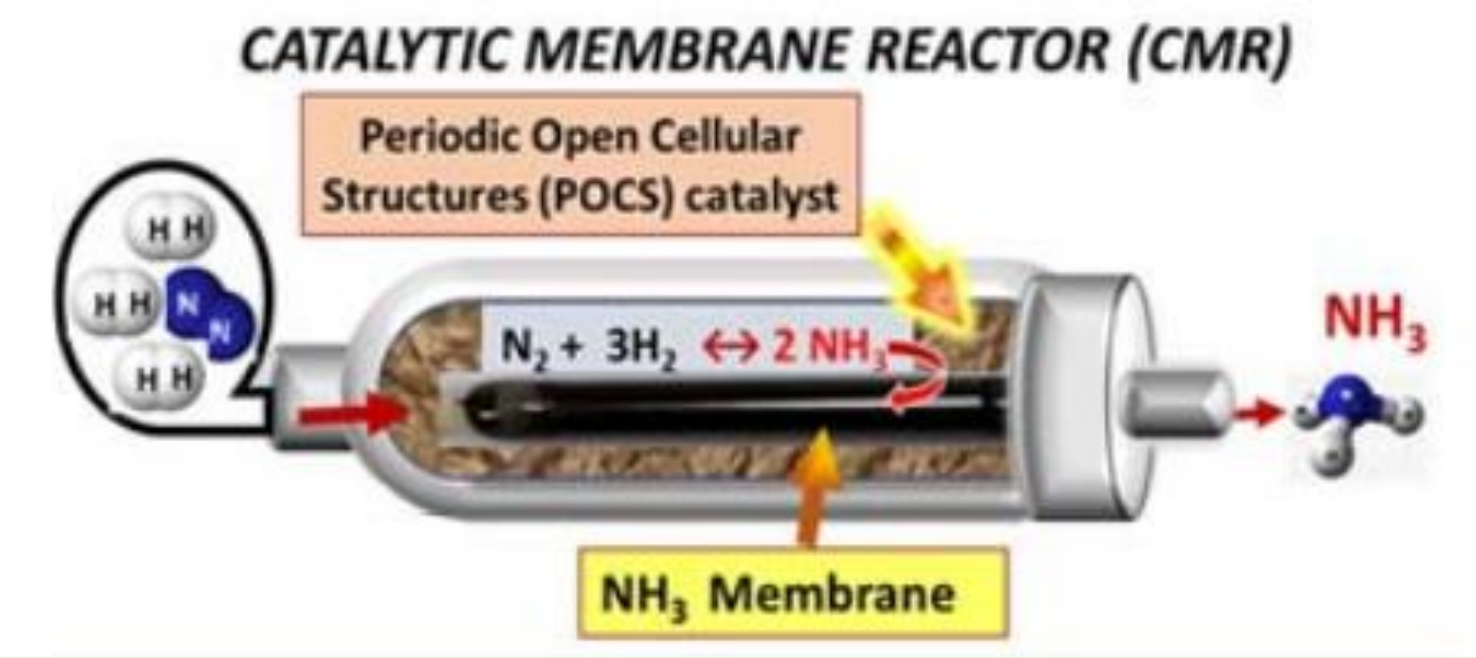
- **Ammonia (NH_3) is the foundation of all nitrogen fertilizers, containing the highest nitrogen concentration at 82%.**
- Fertilizer Processing: Environmental and practical concerns often lead to its conversion into products like **urea or nitrates before application.**
- **Supply Diversification:**
  - In 2021, the EU imported ~26 million tonnes of nitrogen fertilizers and intermediates (nitrogen and phosphates).
  - Heavy reliance on external suppliers highlights the urgent need to diversify ammonia supply sources to ensure stability and resilience.
  - **Typical US ammonia production cost around 250€/ton while current EU green ammonia pricing lies between 800 and 1500 €/ton**

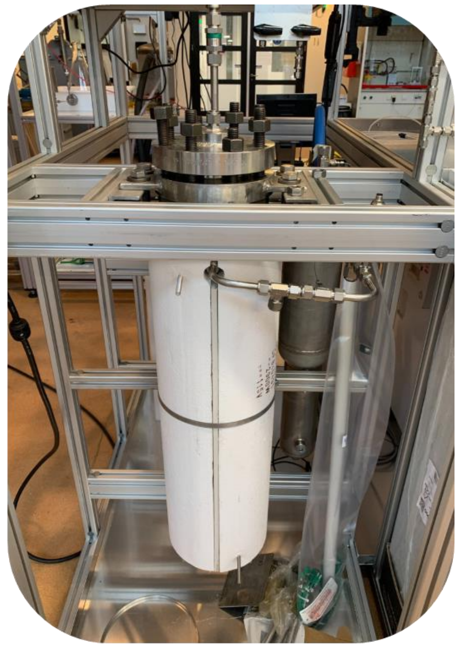


Carbon Membrane and membrane reactors for ammonia and fertilizers

Ammonia synthesis

AMBH2ER



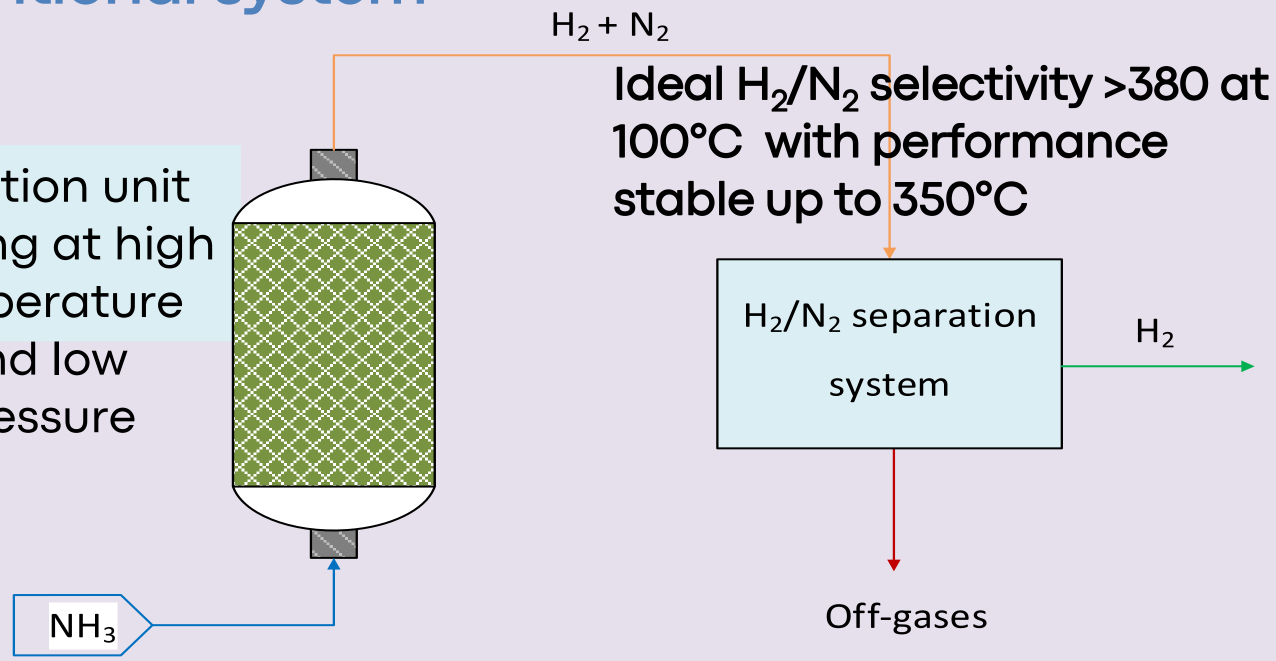


tecnalia
MEMBER OF BASQUE RESEARCH
& TECHNOLOGY ALLIANCE

TU/e EINDHOVEN UNIVERSITY TECHNOLOG

Ammonia Cracking

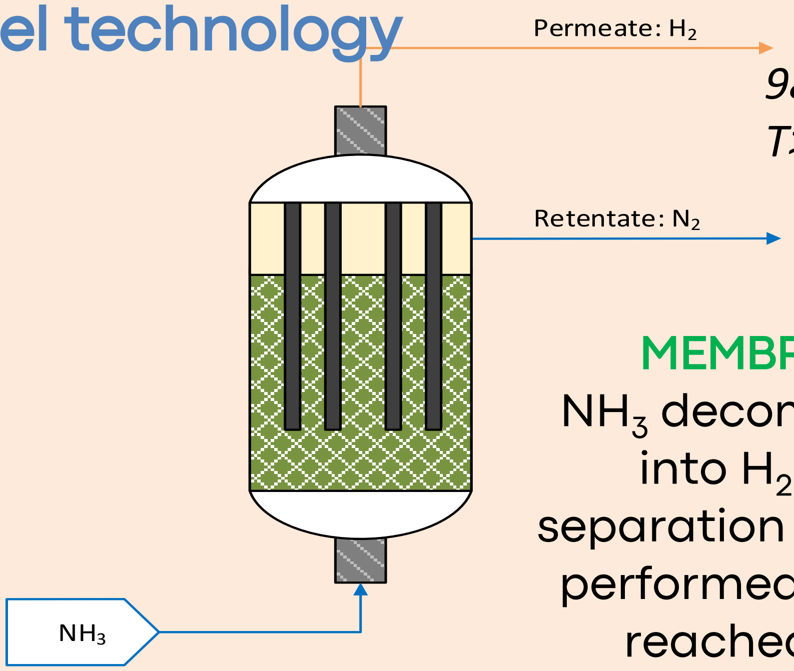
Conventional system



Reaction unit working at high temperature and low pressure

Ideal H_2/N_2 selectivity >380 at 100°C with performance stable up to 350°C

Novel technology



98% conversion for T>475°C

MEMBRANE REACTOR

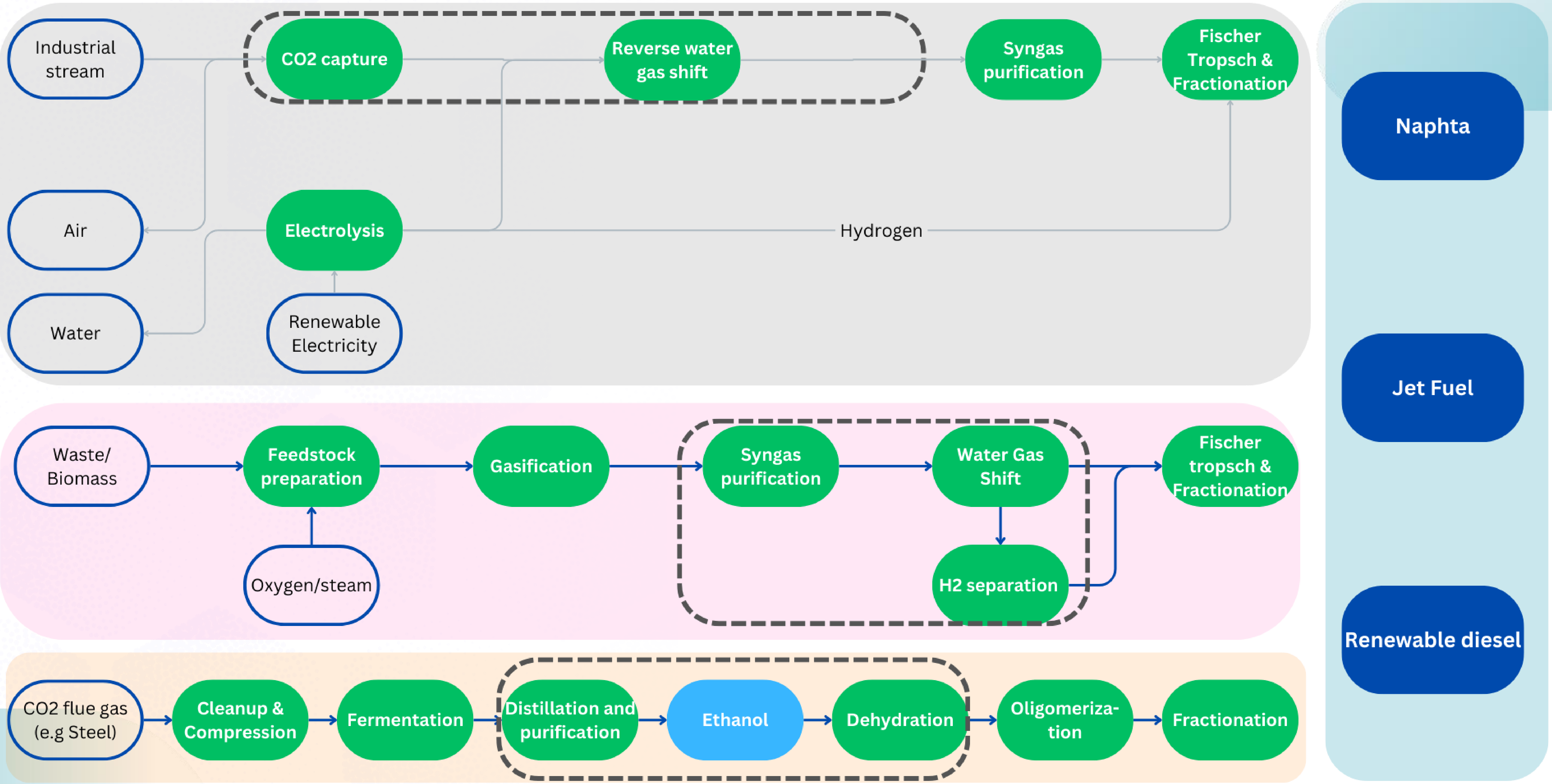
NH_3 decomposition reaction into H_2 and N_2 and H_2 separation are simultaneously performed, FC grade can be reached with polishing

Source : Carbon Molecular Sieve Membrane Reactors for Ammonia Cracking, V.Cechetto, G. Anello, A. Rahimalimamaghani and F. Gallucci, Processes 2024, 12, 1168. https://doi.org/10.3390/pr12061168

Sustainable Aviation Fuels (SAF): A Key to Decarbonizing Aviation

- **Sustainable Aviation Fuel (SAF) is a low-carbon alternative to traditional jet fuel, derived from sustainable feedstocks** like waste oils, agricultural residues, municipal solid waste, and renewable energy.
- Global SAF demand by 2050
  - Between 400 and 650 billions liters required annually (ICF report 2021, WEF-CST 2022)
  - Less than 300 million liters produced annually currently
- SAF Technologies and Adoption :
  - 142 facilities announced globally for 33 billion liters per year (Argus, 2023)
    - HEFA (Hydroprocessed Esters and Fatty Acids) dominates with 56 facilities globally, making it the most mature and widely adopted SAF technology.
    - Emerging technologies are gaining traction:
      - Power-to-Liquid (PtL): 27 facilities.
      - Alcohol-to-Jet (AtJ): 21 facilities.
      - Fischer-Tropsch (FT): 20 facilities.
      - Co-processing (integration of renewable feedstock into existing refineries): 13 facilities.
      - Pyrolysis: 1 facility.
  - Europe leads with the highest number of SAF facilities, followed by the Asia-Pacific region and the USA.

Pathways for Sustainable Aviation Fuel (SAF) Production



Industrial stream
CO2 capture
Reverse water gas shift
Syngas purification
Fischer Tropsch & Fractionation
Air
Electrolysis
Hydrogen
Water
Renewable Electricity

Waste/ Biomass
Feedstock preparation
Gasification
Syngas purification
Water Gas Shift
Fischer tropsch & Fractionation
Oxygen/steam
H2 separation

CO2 flue gas (e.g Steel)
Cleanup & Compression
Fermentation
Distillation and purification
Ethanol
Dehydration
Oligomerization
Fractionation

Naphta
Jet Fuel
Renewable diesel

Opportunities for membrane and membrane reactor

Economic and Production Insights for Sustainable Aviation Fuel (SAF)

- **Production Costs and Market Price**
  - Current SAF prices can reach **$3,400 per ton** (Argus Media, 2023), making them **3–6 times higher** than conventional jet fuel prices
- **Technology Comparisons**
  - Fischer-Tropsch (FT): Delivers 40% SAF from the total liquid output.
  - Alcohol-to-Jet (ATJ): Offers a higher yield, producing up to 70–90% SAF, depending on the process.
  - Remaining outputs include diesel, gasoline, and light hydrocarbons
  - ATJ and HEFA facilities can scale up to 1 billion liters per year due to their liquid feedstocks.
  - Gasification facilities remain smaller, constrained by solid biomass logistics, lower energy density, and yields.
- **Capital Investment Challenges**
  - Pioneer plants (first-generation facilities) require significantly higher capital investments compared to Nth plants (scaled, mature facilities).
  - Technologies like Power-to-Liquid (PtL) and gasification are the most capital-intensive, while HEFA remains cost-effective for near-term deployment.

Figure 1 Reference RFEUA prices for available aviation fuel supplied to the Union market in 2023

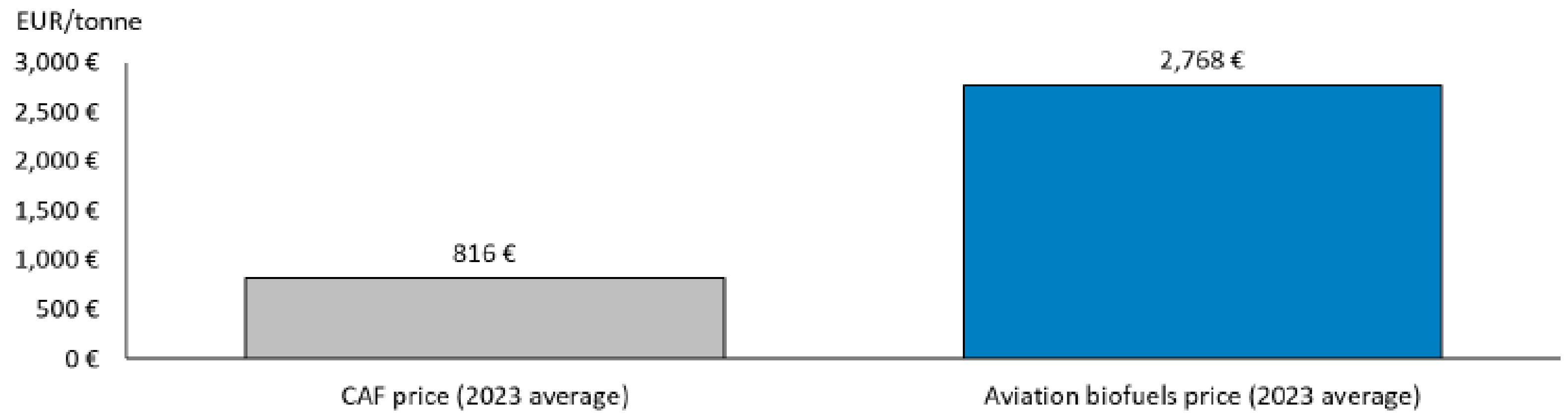
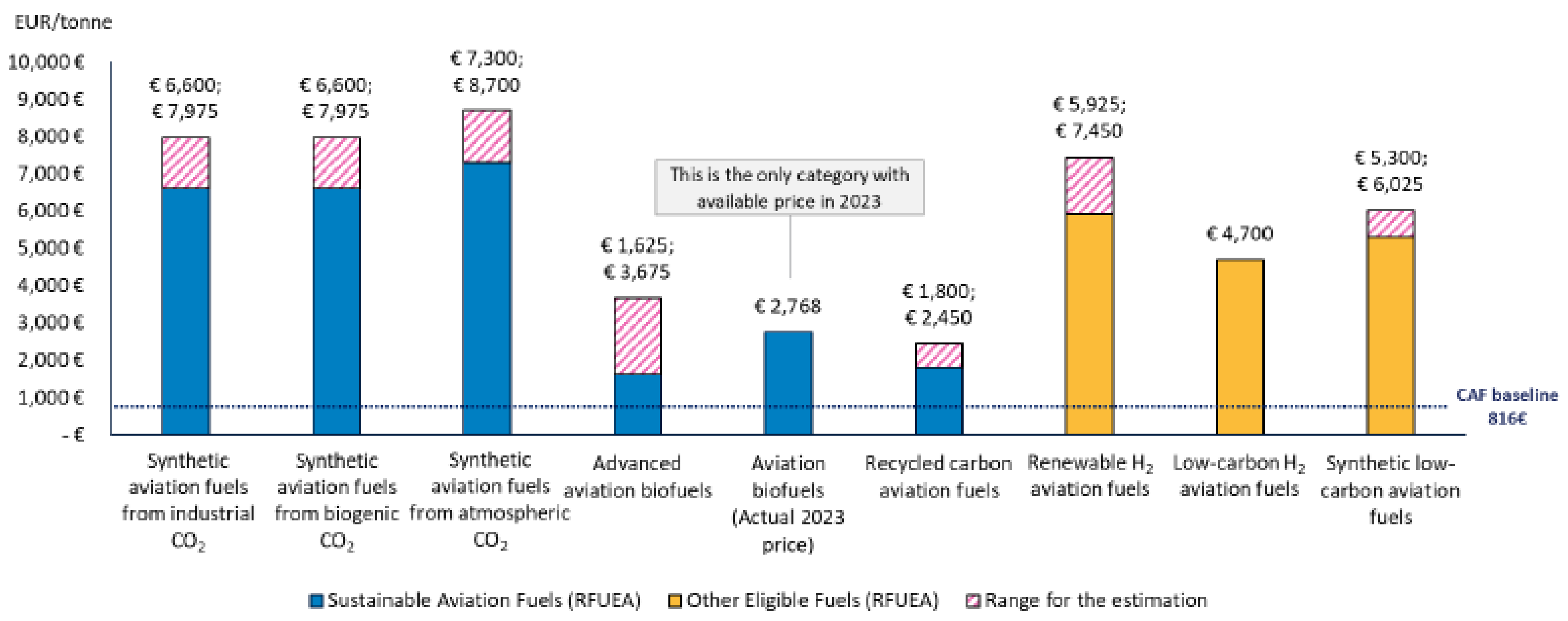


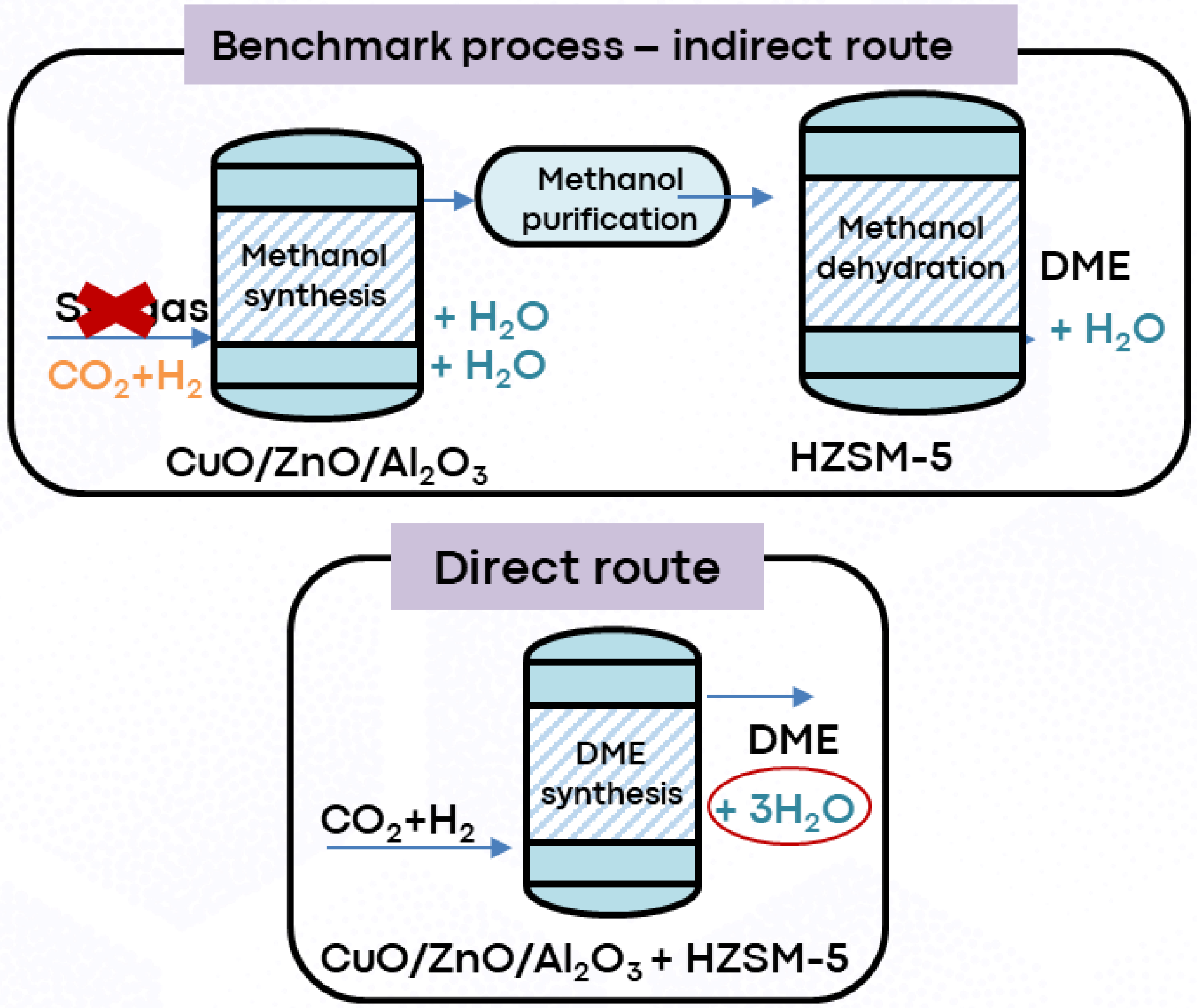
Figure 2 Production cost estimations for SAF and other eligible aviation fuels under RFEUA for 2023



Source : State of the EU SAF market in 2023, Fuel reference prices, SAF capacity assessments (2024), Europea Union Aviation Safety Agency

Water-selective membrane reactor for CO2 Hydrogenation reactions and (catalytic) water removal

Example of water selective membrane reactor (Case of DME – C2FUEL project)



Benchmark process – indirect route

~~Syngas~~

CO_2+H_2

Methanol synthesis

+ H_2O

+ H_2O

Methanol purification

Methanol dehydration

DME

+ H_2O

$CuO/ZnO/Al_2O_3$

HZSM-5

Direct route

CO_2+H_2

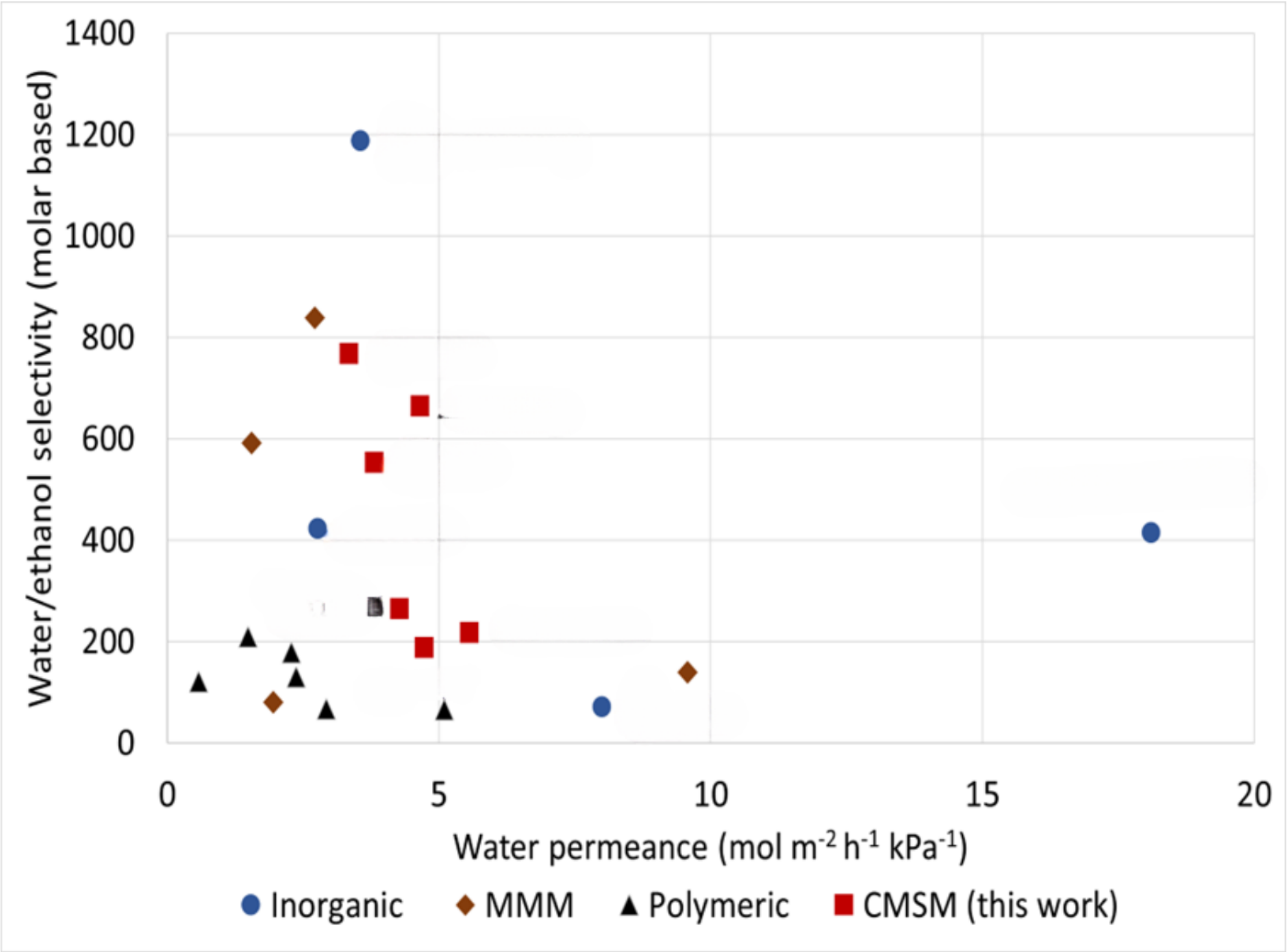
DME synthesis

DME

+ $3H_2O$

$CuO/ZnO/Al_2O_3$ + HZSM-5

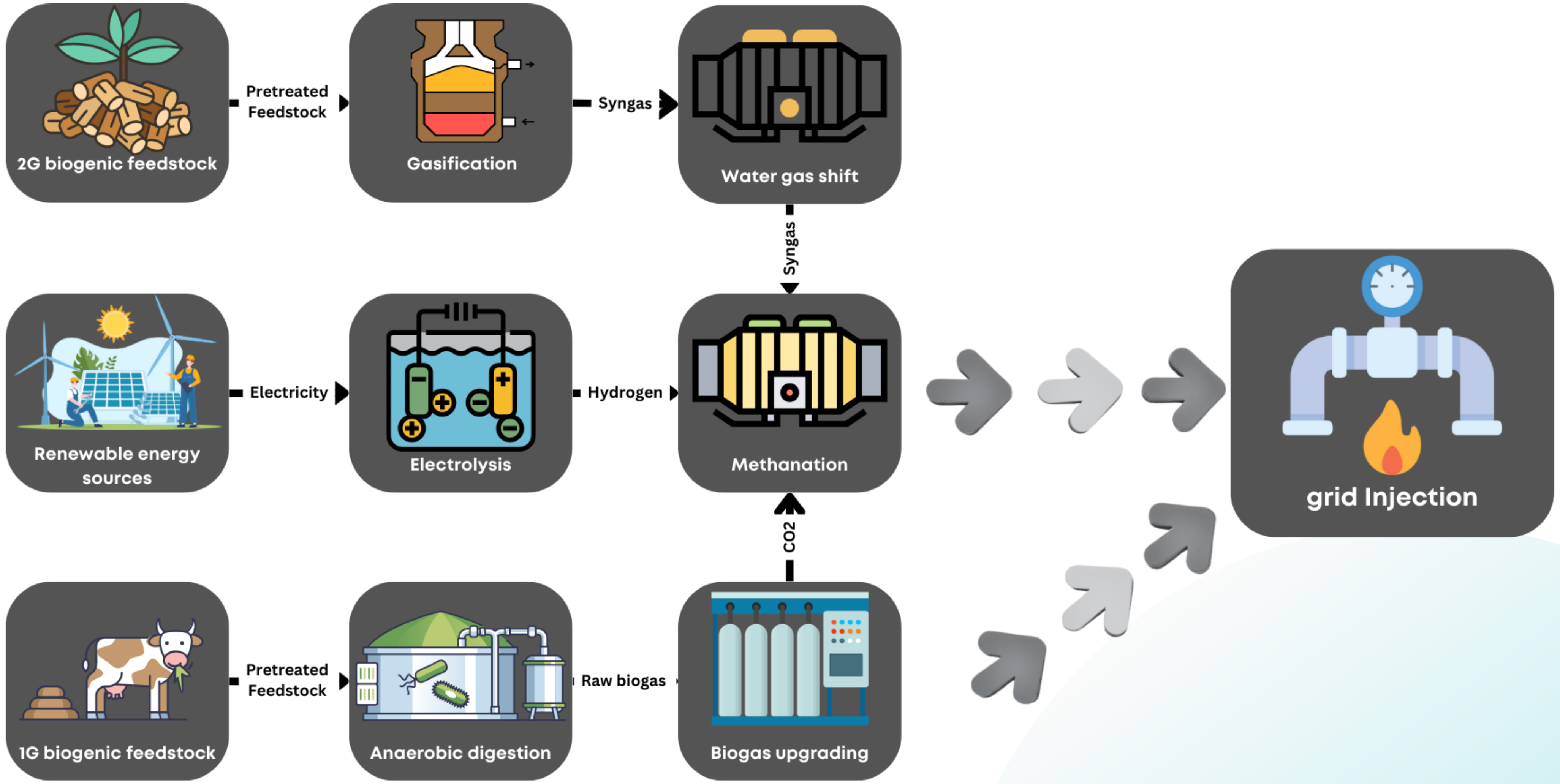
CMS membrane for ethanol dehydration and catalytic conversion



- Lower pressure, high conversion per pass (+35% CO2 conversion)
- Same principle for RWGS or methanol synthesis

Biomethane Production Potential in Europe by 2040

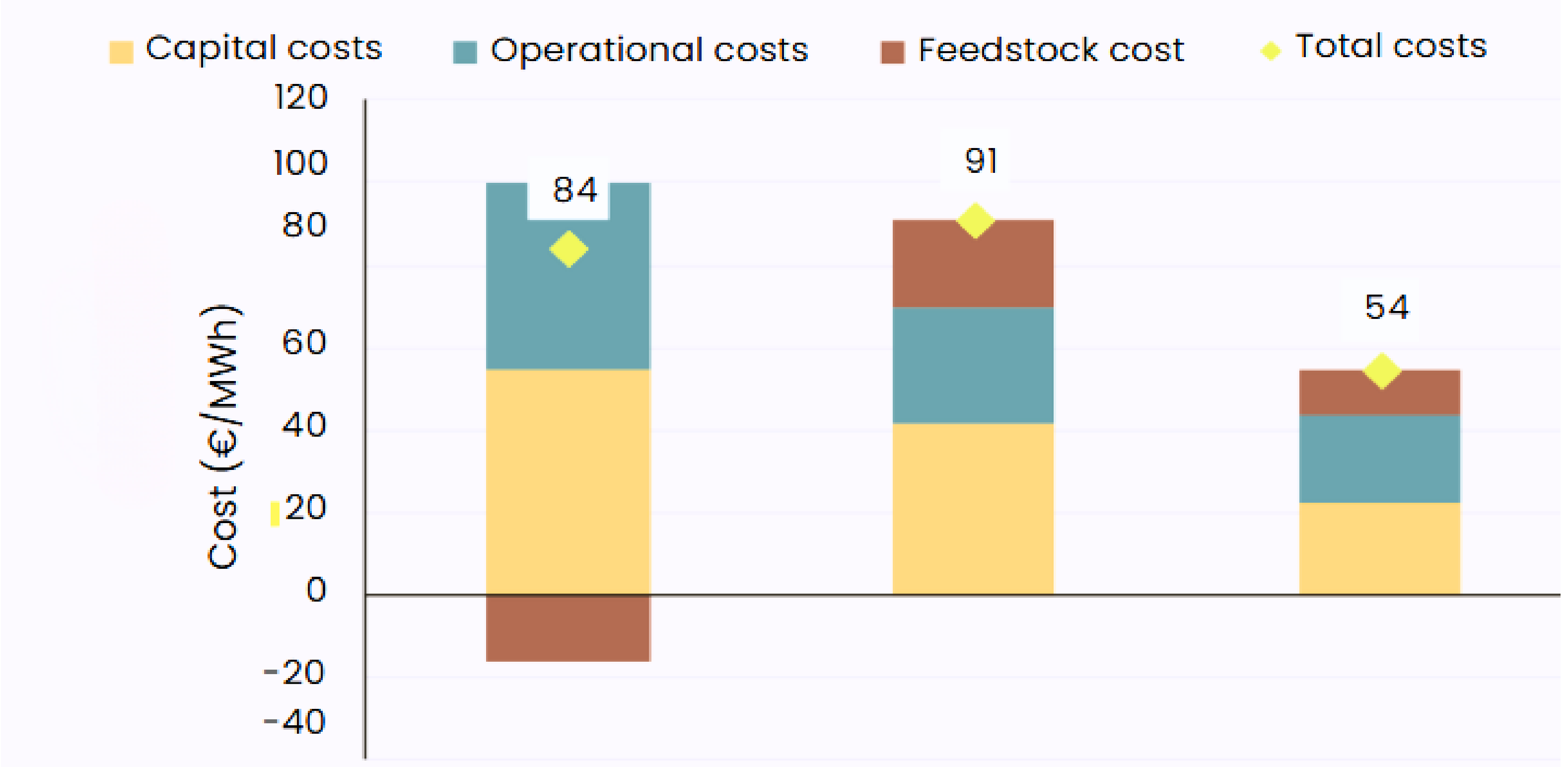
- By 2040, Europe could produce **111 billion cubic meters (bcm)** of biomethane annually, with **101 bcm** coming from EU-27 countries. This production is split between:
  - **Anaerobic Digestion (1G Biomethane):** 74 bcm (67% of total)
  - **Thermal Gasification (2G Biomethane):** 37 bcm (33% of total)
- As a comparison :
  - – A typical NG-ammonia plant (2000ton/day) consume 0,53 bcm/yr
  - – France consume annually 350 TWh of gas for heating equivalent to 32 bcm/yr



1G Biomethane production costs show large economies of scale

- Work performed by the biomethane industrial partnership to understand the status of 1G biomethane development in Europe
- Total Costs Range: €54–91/MWh, highlighting economies of scale in larger facilities.
- Cost Breakdown:
  - Capital Costs: Decrease significantly with scale.
  - Operational Costs: Remain stable across all sizes.
  - Feedstock Costs: Public feedstocks can lead to lower or negative costs.
- Facility Sizes:
  - Small (500–1,300 m³/h): ~€84/MWh (all feedstocks).Medium (300–780 m³/h): ~€91/MWh (excluding public feedstocks).Large (>2,000 m³/h): ~€54/MWh (economies of scale).

Total cost of biomethane production and upgrading



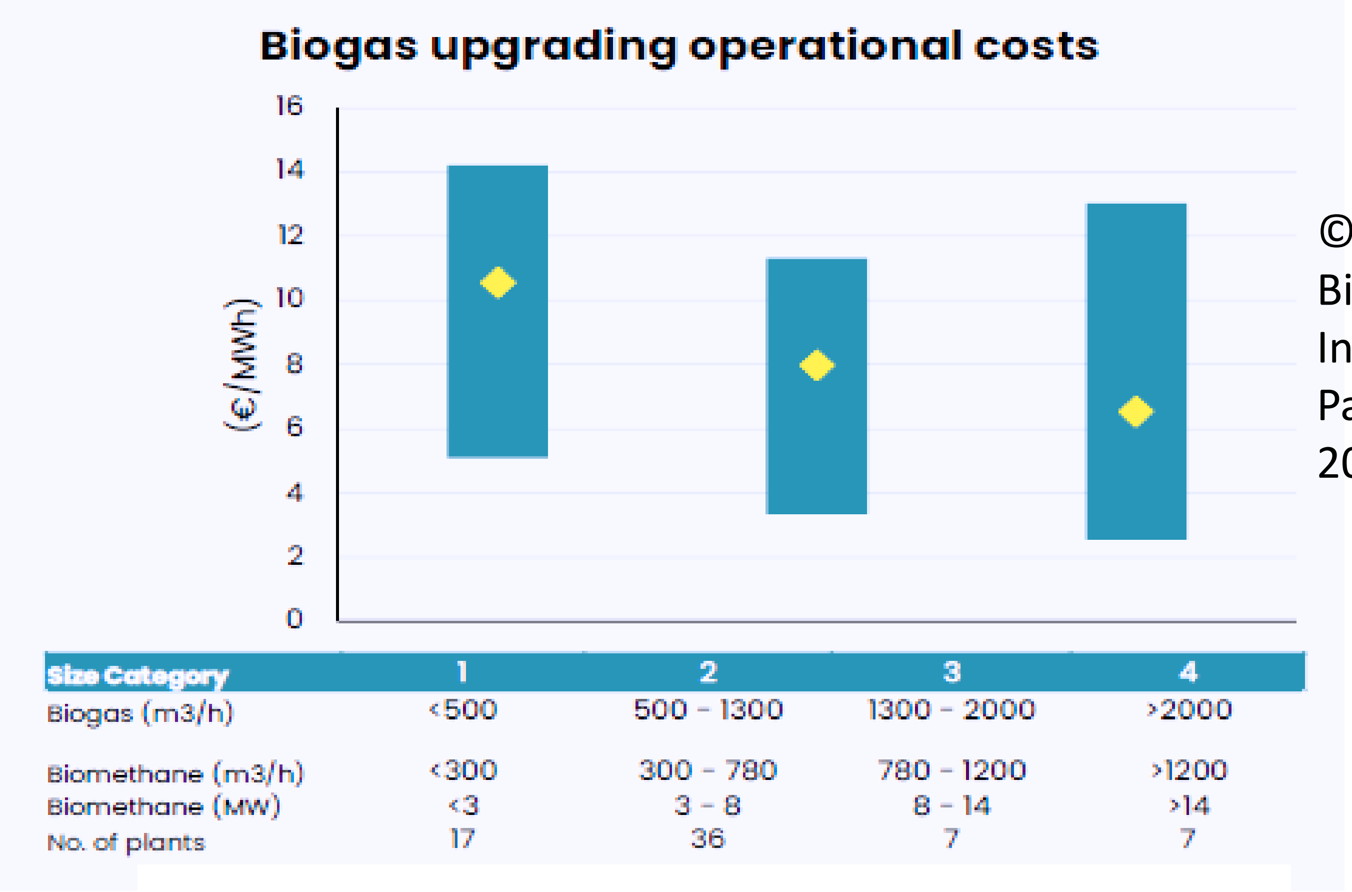
Size Category	2	2	4
Biogas (m3/h)	500 -1300	500 -1300	>2000
Biomethane (m3/h)	300 -780	300 -780	>1200
Biomethane (MW)	3 -8	3 -8	>14
Submission types	All feedstocks	Excluding public feedstocks*	All feedstocks

**Public feedstocks* are public waste streams which can be used as feedstocks but commonly require significant levels of pre-treatment, and thus come with no cost or a negative cost (gate fee)

Source : Biomethane Industrial Partnership 2023

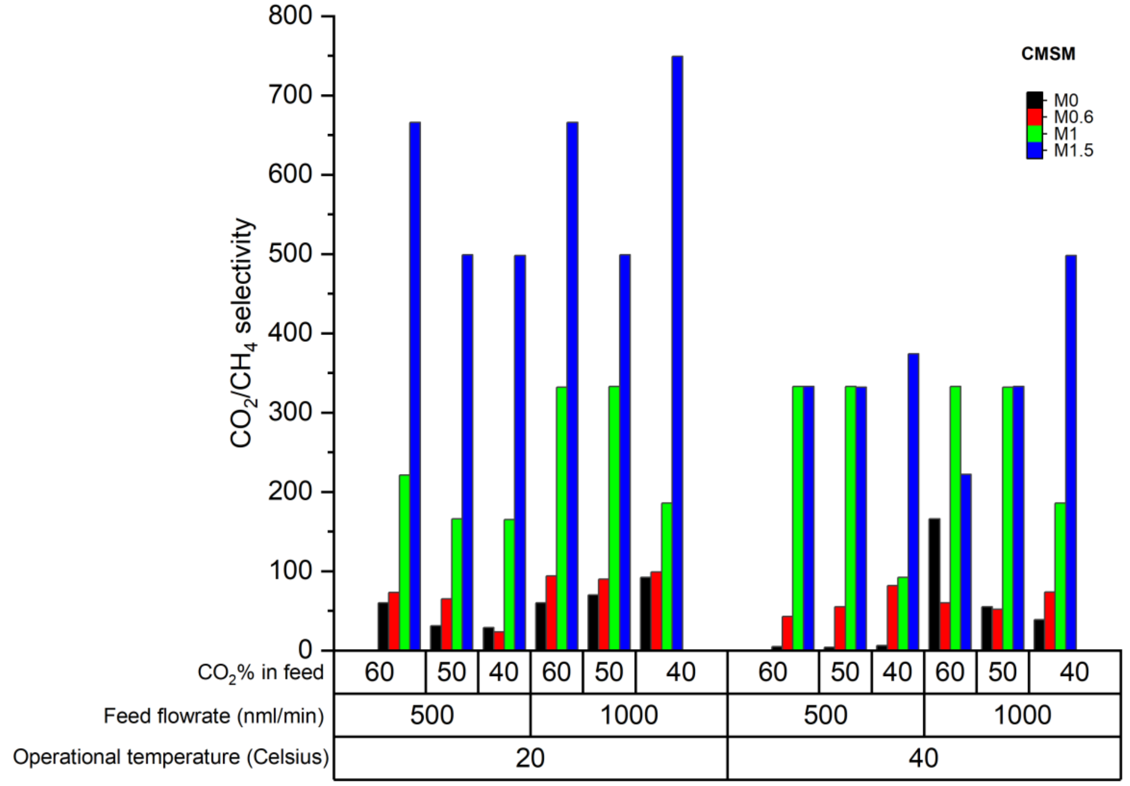
Biogas Upgrading: Costs and Essential Role in Biomethane Production

- Membrane Separation: Used in ~40% of facilities in 2021, accounting for 70% of CAPEX and 60% of OPEX submissions
- Upgrading capital costs decrease by ~33% as facility size increases.
- Upgrading operational cost reaches up to 13 €/MWh (more or less 1,3€/Nm3) for a 2000 Nm3/hr plant equivalent to 25% of the biomethane levelized cost
- Estimate from studies shows membrane biomethane upgrading at cost around 0,2 €/Nm3 for typical 60%/40% CH4/CO2 gas mixtures
- **XMEM membrane shows outstanding performances for biogas upgrading with selectivity >350 in mixed gas conditions (around one order of magnitude higher than existing commercial polymeric membranes)**



Size Category	1	2	3	4
Biogas (m3/h)	<500	500 - 1300	1300 - 2000	>2000
Biomethane (m3/h)	<300	300 - 780	780 - 1200	>1200
Biomethane (MW)	<3	3 - 8	8 - 14	>14
No. of plants	17	36	7	7

©Source : Biomethane Industrial Partnership 2023



XMEM, versatile membrane solutions for a Feedstock-Driven, Multi-Energy Vector Transition

- There is no single solution for the energy transition. Our future economy will integrate biogenic resources, electrification, carbon utilization, and hydrogen, reflecting the diverse approaches required for a sustainable transformation.

- Membrane and membrane reactors can play a key role in minimizing green premium on defossilized commodities improving recovery of valuable feedstock (e.g hydrogen, biogenic CO2) and allowing for flexible, efficient and compact e-/biofuel

- XMEM, TU/e and Tecnalia have developed a membrane product portfolio with outstanding performance for key separation and reaction valuable to the energy transition

- XMEM is currently working at upscaling membrane manufacturing reducing system capital cost by several fold aiming to produce membrane at scale by 2028

XMEM MEMBRANES

TAILOR MADE SOLUTIONS FOR
SEPARATION PROCESSES

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