Precombustion CO_2 Capture: Development & Implementation

Increasing momentum…

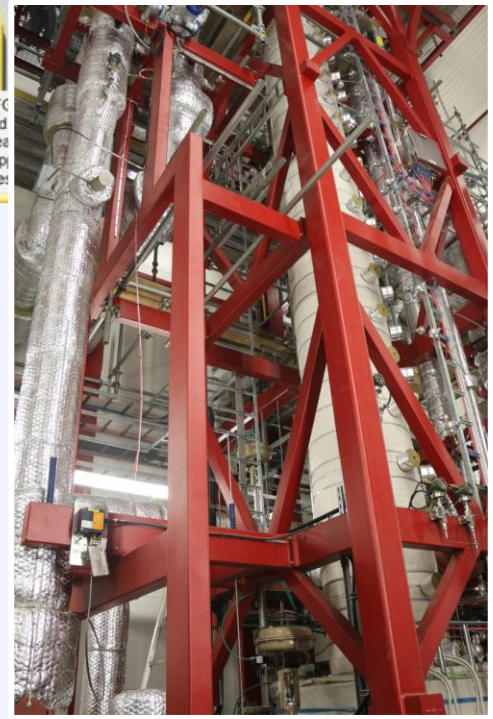
Dr Ir Jurriaan Boon | CATO Spring Event 2025, Rijswijk

Precombustion CO_2 Capture

- ✔ Process integration (temperature, pressure)
- ✔ Relatively high CO_2 concentrations
- ✔ Process intensification (reaction-separation)

- ▸ Blue hydrogen, ammonia
- ▸ CO_2 utilisation
- ▸ Negative emissions (BECCS)

Precombustion CO_2 Capture: R&D Projects (inexhaustive)



Solvents

- ExxonMobil low-carbon hydrogen production (2027-2028) 7Mtpa CO_2 (Baytown, Texas)

Adsorbents

- TDA WGS/CO_2 capture system for IGCC 16 Nm^3/h at Praxair (TRL 6/7)
- Sorption-enhanced gasification: thermochemical conversion of waste at VTT (Finland) with fluidised and fixed-bed gasification units, IFK Stuttgart (200-kWth scale) and TU Wien (100-kWth scale)
- Reforming and chemical looping – CASOH: Arcelor Mittal Gas Lab (Asturias, Spain) 300 Nm^3/h of blast furnace gas to hydrogen demonstrated at TRL7, single column
- Sorption-enhanced water-gas shift – SEWGS: STEPWISE project validated single column performance 800 Nm^3/h blast furnace gas at Swerim (Luleå, Sweden)

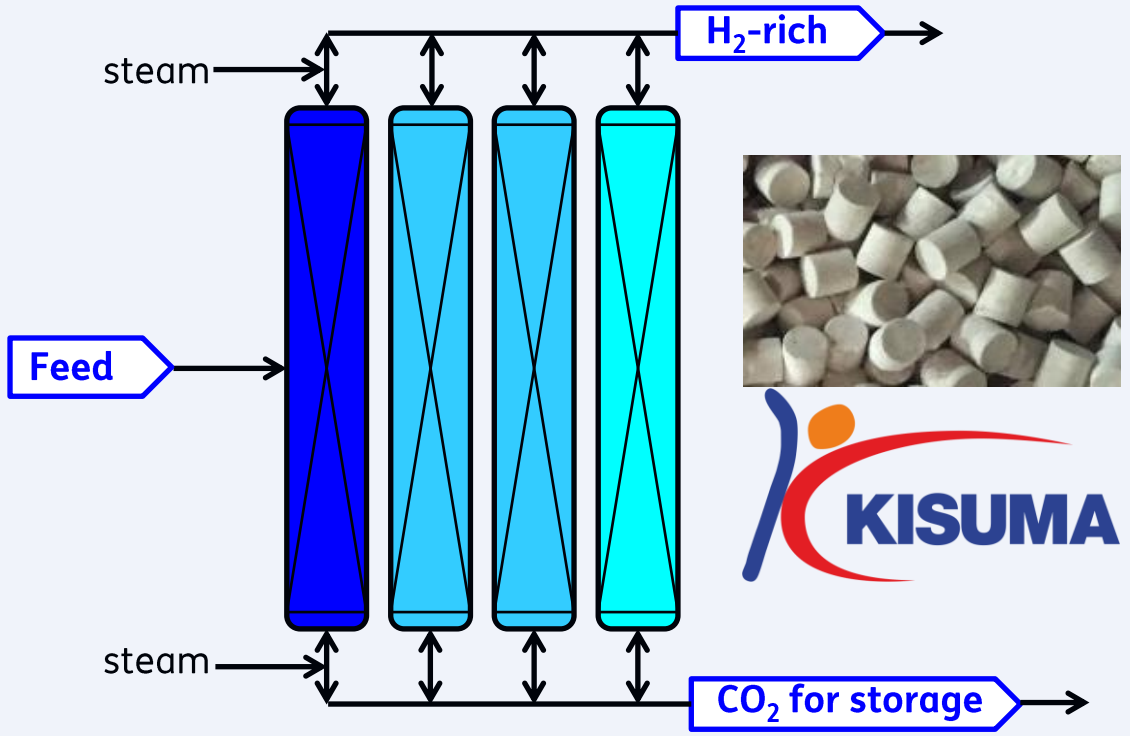
- Bukar, A. M., & Asif, M. (2024). Technology readiness level assessment of carbon capture and storage technologies. Renewable and Sustainable Energy Reviews, 200, 114578.
- Alptekin, G. O., Jayaraman, A., Bonnema, M., & Gribble, D. (2022). Integrated Water-Gas-Shift Pre-combustion Carbon Capture Process (No. TDA-R-2201-001-PhII-F). TDA Research, Inc., Golden, CO (United States).
- Fernandez, J. R., Alonso, M.,... & Abanades, J. C. (2025). Decarbonization of Blast Furnace Gases Using a Packed Bed of Ca-Cu Solids in a New TRL7 Pilot. Energies, 18(3), 675.
- Boon, J. (2023). Sorption-enhanced reactions as enablers for CO_2 capture and utilisation. *Current Opinion in Chemical Engineering, 40*, 100919.

Sorption-enhanced water-gas shift (SEWGS)

- TNO development for precombustion CO_2 capture
- Combining CO_2 separation with WGS reaction
- Kisuma Chemicals industrially sourced solid adsorbent
- Optimizing H_2/N_2 while removing CO_2
- Minimization of energy requirement
- INITIATE project: Nov. 2020 – Nov. 2025

  21.3 M€ EU funding

  https://www.initiate-project.eu/



KISUMA

Boon, J., Coenen, K., van Dijk, E., Cobden, P., Gallucci, F., & van Sint Annaland, M. (2017). Sorption-enhanced water–gas shift. In Advances in chemical engineering (Vol. 51, pp. 1-96). Academic Press.

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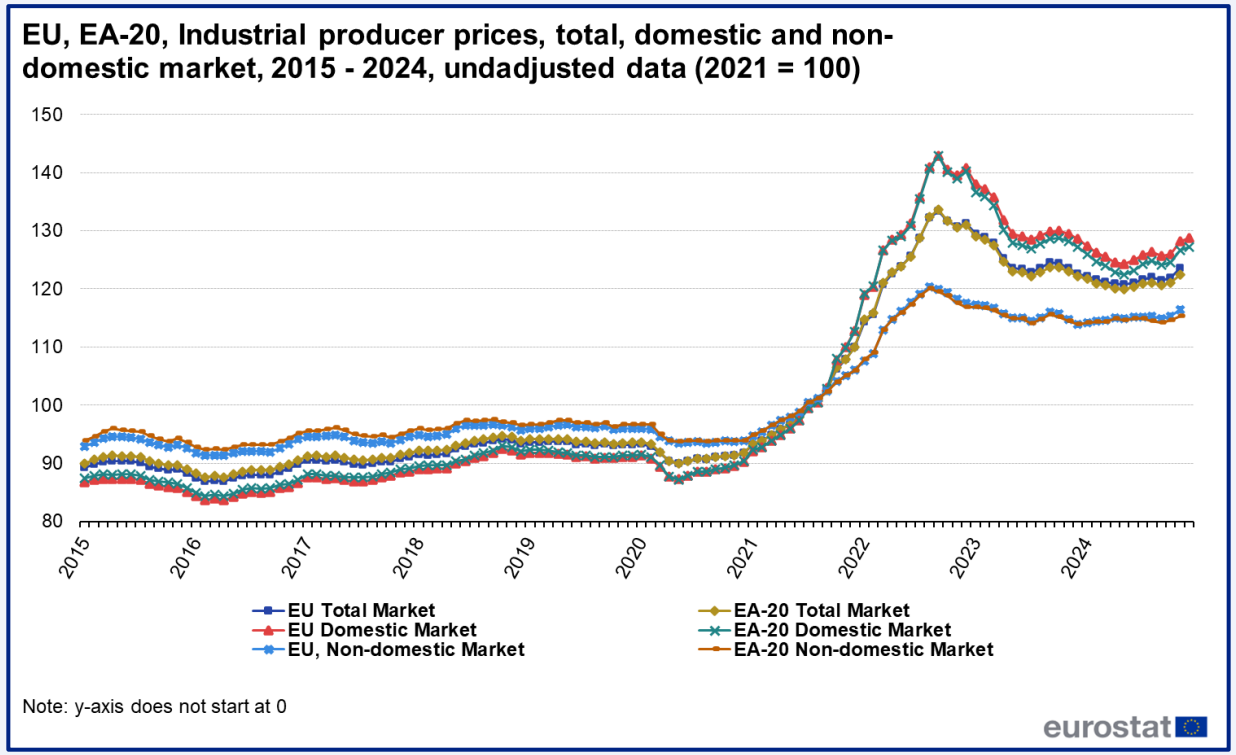
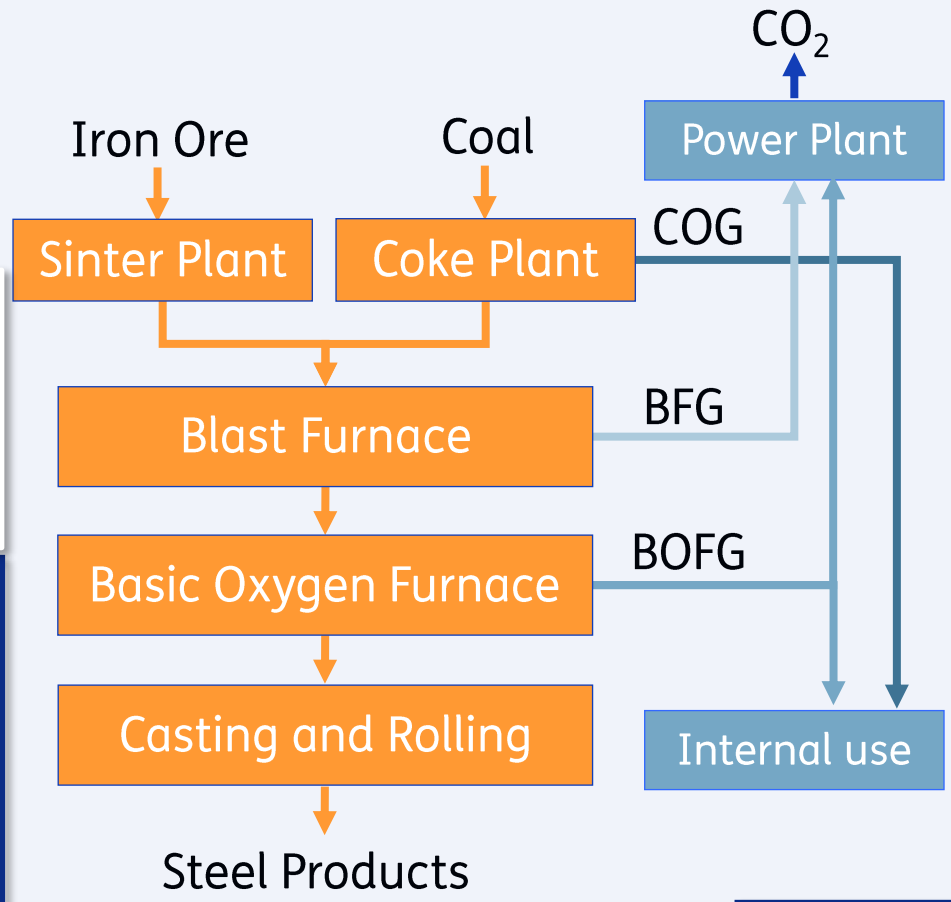


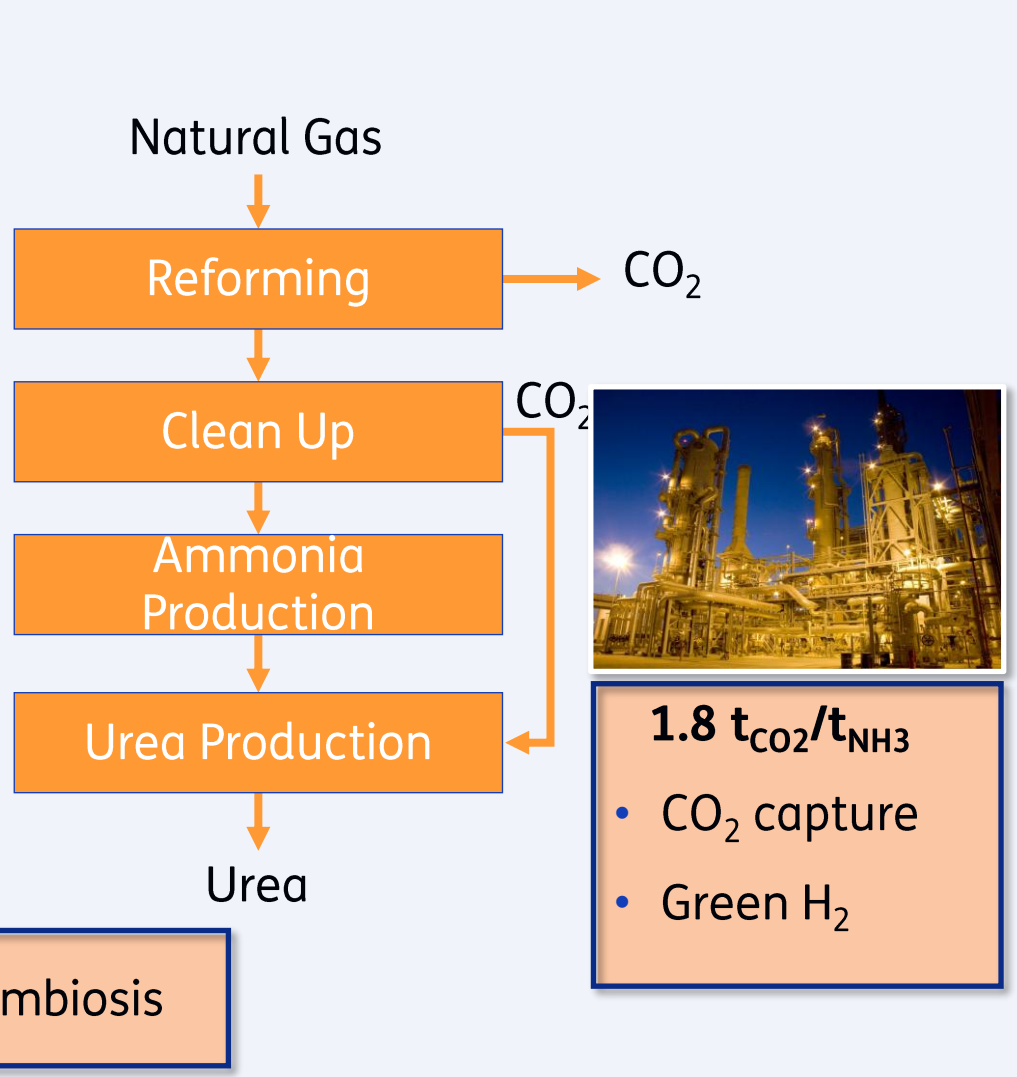
EUROSTAT - Industrial producer price index overview - Statistics Explained

INITIATE

2 t_{CO2}/t_{HRC}

- Coal → NG, H_2
- CO_2 capture
- More scrap
- Efficiency



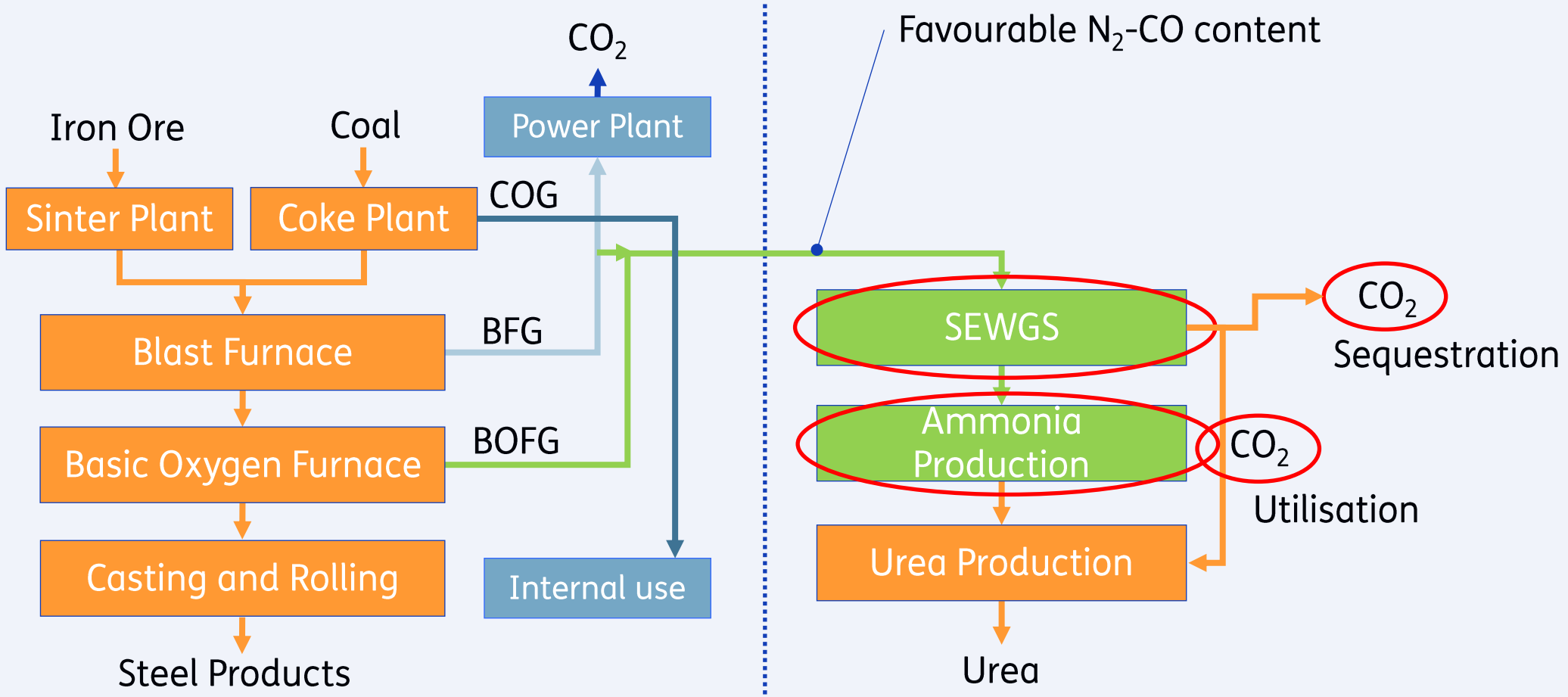


Industrial Symbiosis

1.8 t_{CO2}/t_{NH3}

- CO_2 capture
- Green H_2

INITIATE


CO_2
Favourable N_2-CO content
Iron Ore
Coal
Power Plant
Sinter Plant
Coke Plant
COG
Blast Furnace
BFG
Basic Oxygen Furnace
BOFG
Casting and Rolling
Internal use
Steel Products
SEWGS
CO_2
Sequestration
Ammonia Production
CO_2
Utilisation
Urea Production
Urea

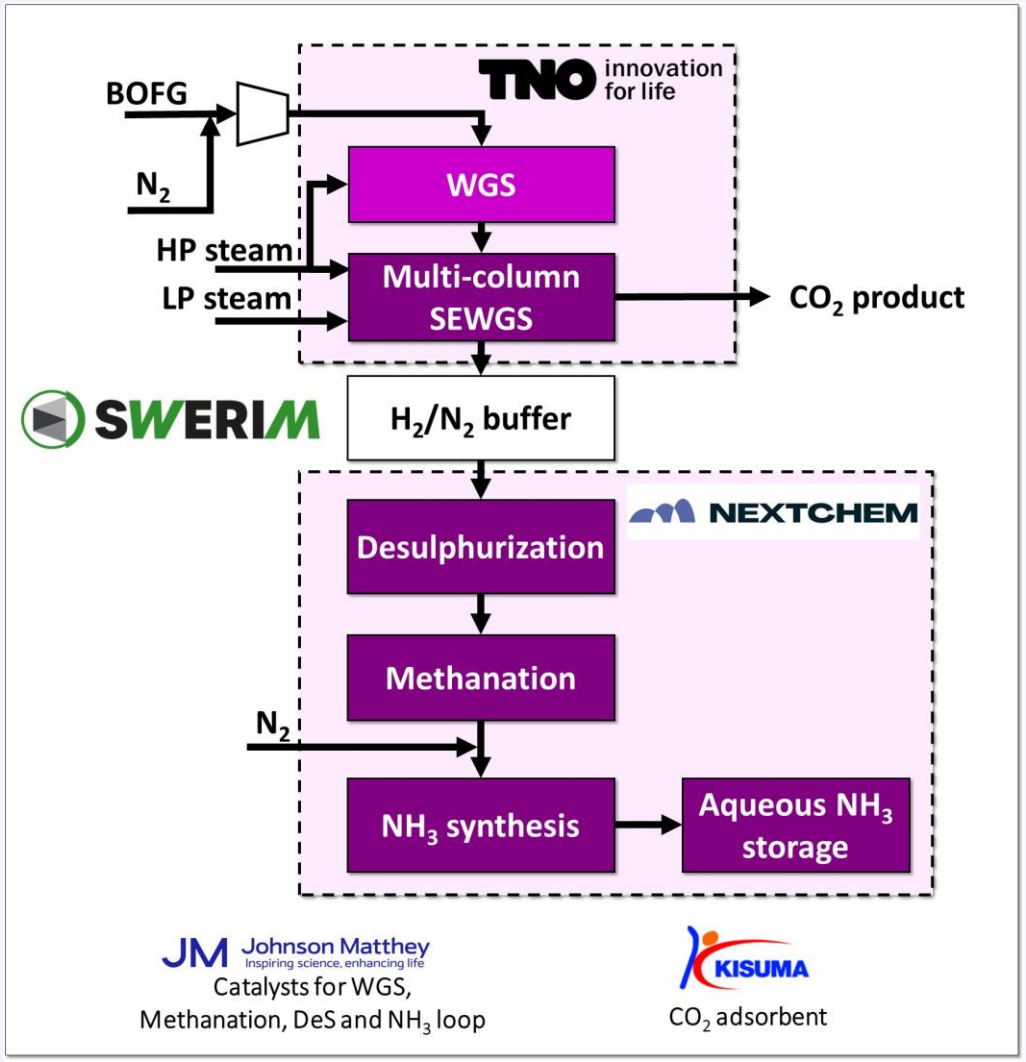
INITIATE: Technology demonstration

PILOT CONSTRUCTION

- Capacity 400 Nm^3/h BOFG for 2.6 t_{NH3}/d
- Design finalized
- Procurement and construction on-going

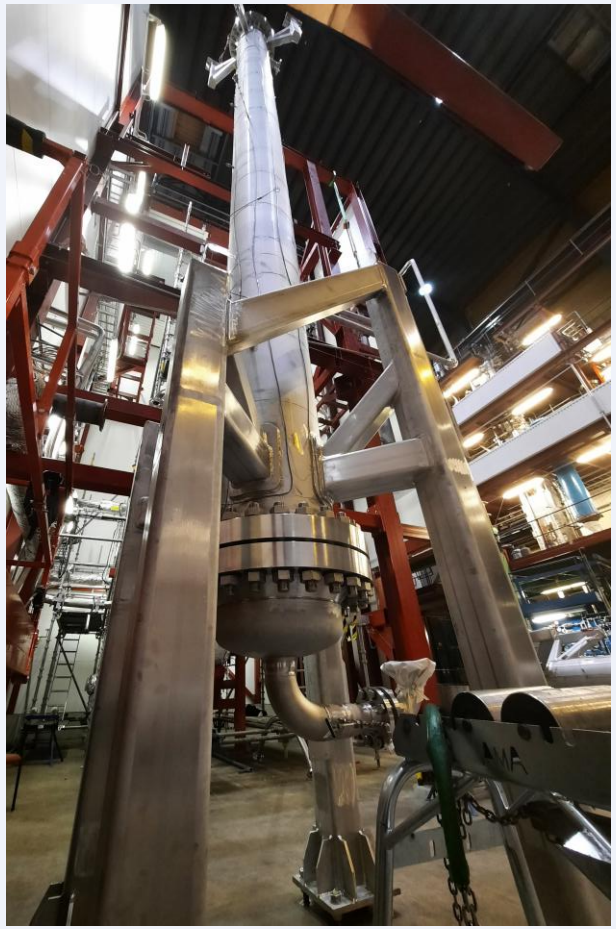
MAIN CHALLENGES

- Inflation driven cost increase
  - Scope reduction to 1.3 t_{NH3}/d

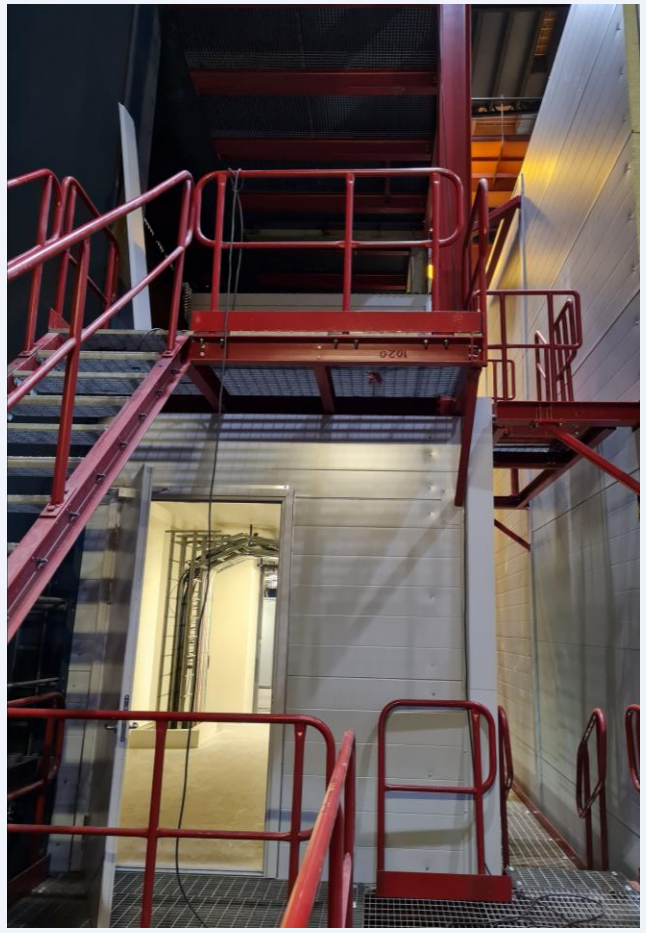


INITIATE: Technology demonstration

Hoisting the WGS reactor into place



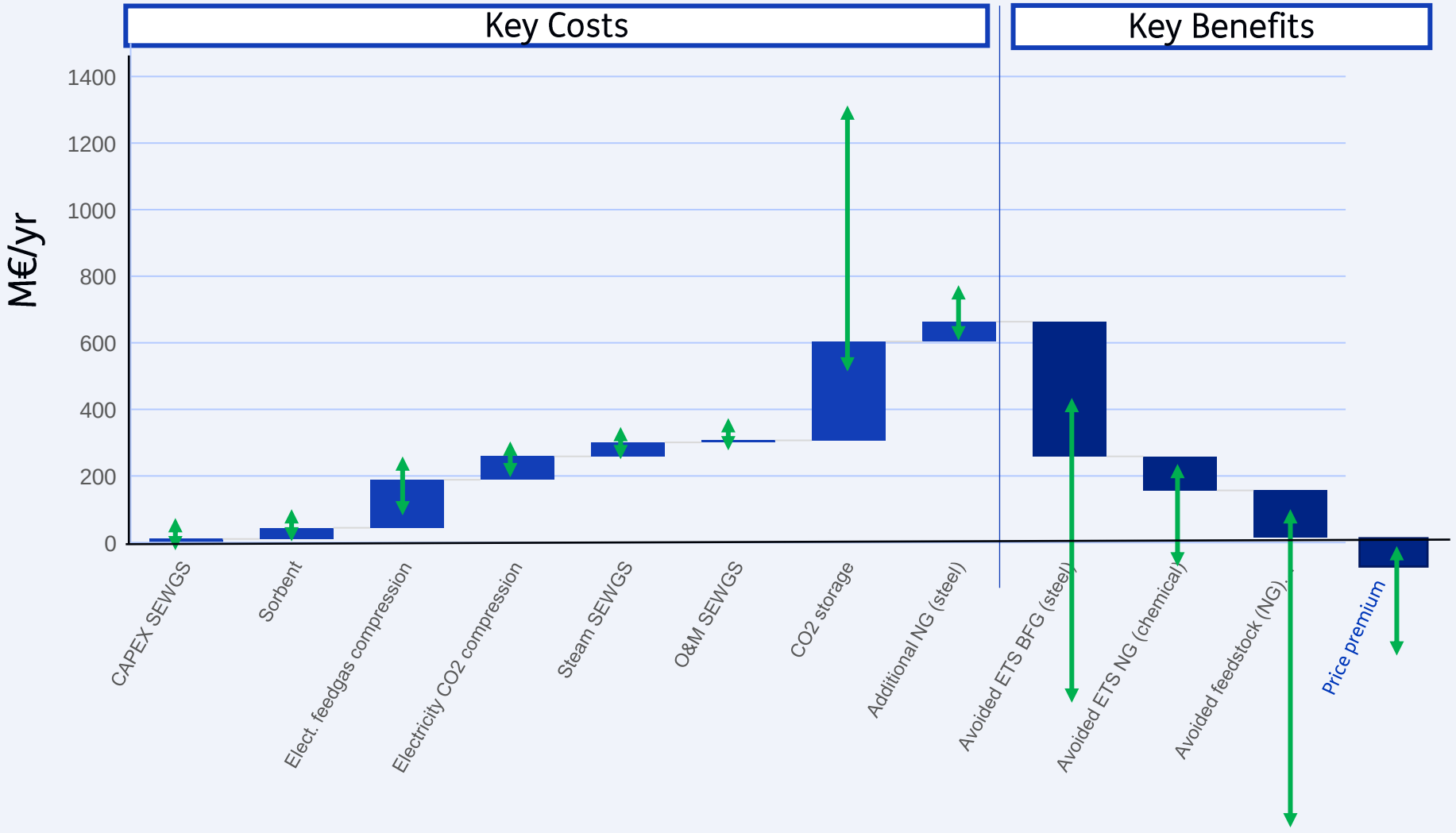
Positioning of SEWGS reactor 1



Utility rooms installation

Functional materials selected and in production

INITIATE: Delivering competitive CO_2 capture costs



Summary key uncertainties

Level	Key drivers and uncertainties
EU	• ETS price • CBAM / free allowances • RED3 fuels/chemicals
EU + local	• Legal • Extra price/value products • Subsidies
Local	• CO_2 storage costs, specs, availability • Market volume products • Green electricity / natural gas costs & availability • H_2 costs & availability
Internal (consortium)	• SEWGS OPEX • Production at scale • Chemical plant availability (CAPEX)

SEWGS: Steps towards the First of a Kind plant

- **Demonstration** – pilot under construction
- **Site identification** – inventory finalized, discussion on-going
- **Business plan** – long term implementation plan
- **IP&R, ownership, collaboration** – exploitation of results