Hydrogen Partnership Austria
Ammoniak – Workshop 3. Juni 2025

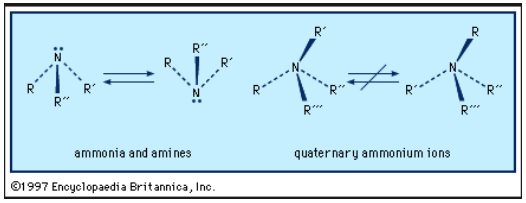
Herstellungsprozess, Lagerung, Weiter-verwendung und geplante Innovationen

Leonhard Werner / LAT Nitrogen Linz

LAT Nitrogen

Ammonia Basis Facts

The ammonia molecule has a trigonal pyramidal shape. It is a colorless, poisonous gas with a sharp, penetrating odor.
Boiling point is −33.35 °C → liquid handling under pressure. High heat of vaporization (23.3 kJ/mole at Bp).Very solvable in water forming a weak alkaline.



Production volume: 200 Mio. t/year

Applications:

- Base material for fertilizers and explosives
- Textile industry (PA, Nylon, ..)
- Hardening of metals
- Cleaning products, food industry
- Refrigerant in big cooling units
- Technical application for Urea, Melamine and Resins

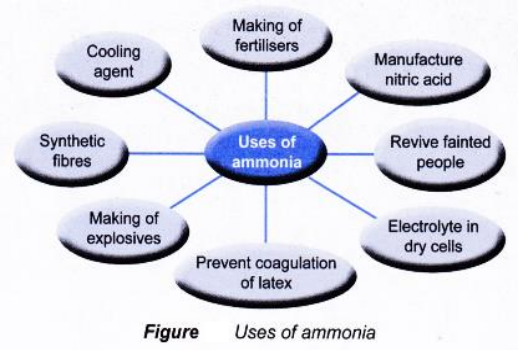


Figure *Uses of ammonia*

Future potential: Marine fuel, energy carrier
Shift from a Nitrogen Carrier to a Hydrogen Carrier !

LAT Nitrogen

History of Ammonia Process

The invention changing life of mankind

Limited access of Germany to Salpeter from Norway and Chile (English monopoly)

Shortfall of nitrates for ammunition and fertilization (nation starving)

Extensive research to get fix nitrogen from air

Invention across the journey:

- Principle of catalysis (Alwin Mitasch)
- Ammonia synthesis with Fe catalysis (Fritz Haber)
- High pressure process technology (Karl Bosch)
- First industrial plants built by IG Farben (LU1913, Leuna 1916)

$3\ H_2 + N_2 \leftrightharpoons 2\ NH_3 \quad \Delta H°_{27\ °C} = -46.35\ kJ/mol$

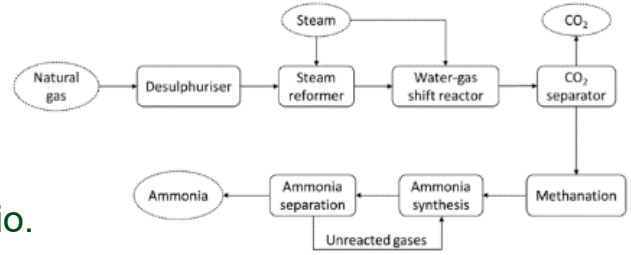
Hydrogen production by water gas shift reaction process used in steel industry.
Nitrogen introduction via air separating unit

Energy demand: 60 - 90 GJ/t ammonia

Many scientists regard this invention a most remarkable for mankind in the 20th century !

State of the Art Ammonia Production

Single Train Ammonia Process with SMR*



- 6 step catalytic reaction (intermediate synthesis gas 60% hydrogen)
- Basis NG, water & air (direct introduction) → CAPEX € 300 – 500 Mio.
- Final products: ammonia & carbon dioxide → used in urea production
- Allowing stand-alone setup (excess steam used for turbine drives)
- Cogeneration used to balance steam grid of plant
- Majority of plants are built according this principles
- Energy demand 28-45 GJ/t (depending on maturity of technology)

- **Key is working continuously on reduction of energy demand!**

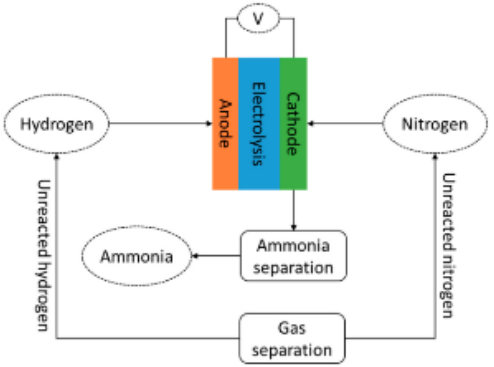
* Process based on natural gas has been invented by M.W. Kellogg 1960

LAT Nitrogen

Green Alternative

Hydrogen Nitrogen Based Loops

- Hydrogen is produced by electrolysis → several technologies (alkaline, PEM, …) with different degree of maturity
- Nitrogen needs to be separated from air (air separating unit)
- Energy demand app. 31 – 37 GJ/t (electricity)
- Air separation & ammonia synthesis are mature technologies
- CAPEX € 500 – 800 Mio. (decreasing)
- Usage of existing ammonia synthesis loops can be considered → compression, synthesis pressure, …
- Energy balance of process has less degree of freedom (efficient use of exothermic heat of reaction)



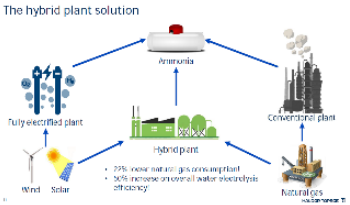
LAT Nitrogen

LAT Nitrogen Approach

Hybrid Plant with increased energy efficiency

- Continuous effort for onsite energy optimization → e.g. Heat Highway projects

- 1st step: integrating „green“ hydrogen with on site electrolysis into existing conventional ammonia plants
  - Hydrogen feed → reduced duty primary reformer
  - CO_2 reduction potential 10 % (substitution of NG) with 60 MW electrolysis JV with Verbund → Green ammonia Linz
  - Switch natural gas & electricity on short notice → electrical grid regulation
  - Project waiting on OPEX funding decision by Austrian government



- Parallel to GrAmLi we can utilize Biogas to produce Green Ammonia

- 2nd step: utilization of „green“ hydrogen from pipeline into existing smaller ammonia plant. Hydrogen / nitrogen feed → removal of front end
  - Massive change in complex technology → demanding prototype development form technology and economically point of view

- **Existing units and infrastructure can be efficiently used !**

Storage & Handling of Ammonia

100 Years of experience

- Liquefied ammonia can be stored & handled safely
- Storage capacity Linz: 10.000 t atmospheric + 400 t pressurized (14 bars)
- Storage under pressure or atmospheric (refrigeration need)
- Boil off & effort is minimal compared to liquefied hydrogen
- Annual rail transport in western Europe 1,5 Mio. – 2 Mio. tons

SAFETY

We care for each other!

We assess risks before acting

We strive for zero incidents/ accidents

We keep our workspace clean and tidy

RESPECT

We value diversity

We treat nature with respect

We act ethically in everything we do – it is the basis for all our (inter)actions

We work together respectfully and trustfully

ENGAGEMENT

We reach company goals through ownership and team- work

We respect our processes and improve where possible

We seek solutions that make a difference for our stakeholders

We recognize outstanding contributions

Our values drive our actions

Ammoniak Transport per Zug

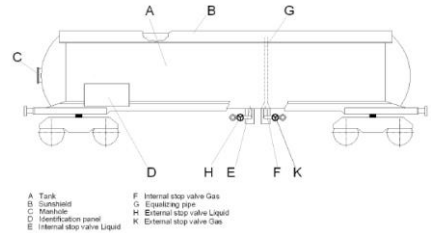
Klaus Hofstadler

3. Juni 2025

LAT Nitrogen

Ammoniak Transport per Zug
Top Priorität ist ein SICHERER Transport

UN Transport classification & Labeling – RID



Sicherheit !

Kundenanforderungen

Transportmanagement

Be-/Entladestationen

Planung

Landesgrenzen

Mitarbeiterschulung

Ammoniakkesselwaggon

Ganzzüge

Anschlüsse/Kupplungen (WECO-ISO/ACME – Flansch)

Kesselwaggon Flotte

Kontinuierliche Transporte

Lagertank Verfügbarkeit

Schienen /Trassenplanung

Terminal Management

Übersicht Ammoniak Transporte von Agrofert

Agrofert Ammoniak Transportes (Inbound und Outbound) werden durchgeführt mit Kesselwagen, River Barges (Rhein), Sea vessels und Pipeline.

Standort	Zugtransporte	River Barges	Deep Sea Vessel	Pipeline
Linz	X			(X)
Ottmarsheim	X	X		X
Grand Quevilly	X		X	(X)
Grandpuits	X			
Duslo	X			
Lovo	X			
SKW	X			

Quellen für Informationen über Ammoniak Transporte

- https://www.ammoniaeurope.com/

- https://www.fertilizerseurope.com/

- https://ammoniaenergy.org/topics/ammonia-transportatior

- https://sqas.docs.cefic.org/safety%20guidelines/transporting-ammonia_byrail-by-efma-2007-guidelines-_road-substance/

Summary für Ammoniak Transport mit Kesselwagen

- **Sicherheit hat oberste Priorität!**
- Mit **gut definierten Prozessen**, **gut ausgebildeten** und **regelmäßig trainierten Mitarbeitern** ist ein sicherer Transport von Ammoniak möglich (Beispiel LAT Nitrogen Linz)
- Eine **gute Planung** und **effektive Steuerung** (kontinuierliche Transporte) ist notwendig, um flexibel auf Veränderungen reagieren zu können
- Die **Ammoniaktransport Mengen sind derzeit im Steigen** (z.B. Kostenvorteile) und werden weiter steigen, da für den Import von grünem Ammoniak/Wasserstoff (über lange Strecken) der Schienentransport eine vergleichsweise günstige Option darstellt

Our values drive our actions

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LAT Nitrogen

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Transport of ammonia by maritime and inland vessels

Cristian Chiriță
viadonau – Österreichische Wasserstraßen-GmbH

Hydrogen Partnership Austria

Ammoniak-Workshop

Linz, 3. Juni 2025

Agenda

- Ammonia data sheet
- Rules and regulations
- Maritime transport
- Inland transport
- Ports and terminals
- Special procedures
- Conclusions

Ammonia data sheet

Colourless, toxic, corrosive, reactive gas

Strong noxious odour

Boiling point: – 33.4 °C

Freezing point: - 77.7 °C

Auto-ignition temperature: 651 °C

Requires high energy for ignition

Density: 0.708 kg/m^3 @ 20 °C

Odour threshold: 1 – 50 ppm in humans

8 hour TWA: 20 ppm

15 min STEL: 50 ppm

H221	Flammable gases, Category 2
H280	Gases under pressure, Liquefied gases
H314	Causes severe skin burns and eye damage.
H318	Causes serious eye damage
H331	Toxic if inhaled
H400	Very toxic to aquatic life
H411	Toxic to aquatic life with long-lasting effects

Labelling according to Regulation (EC) No. 1272/2008

GHS04 GHS05 GHS06 GHS09

Rules and regulations for transport by ship

IGC Code – International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk

ADN 2025 - European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways

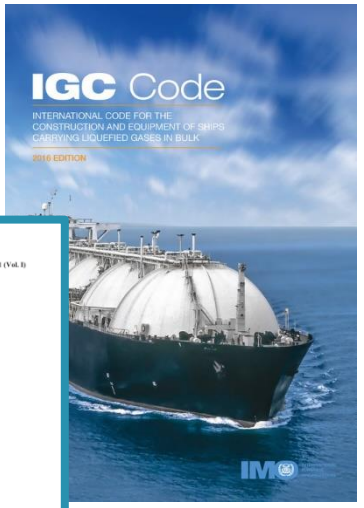
ISGINTT – International Safety Guide for Inland Navigation Tank-barges and Terminals

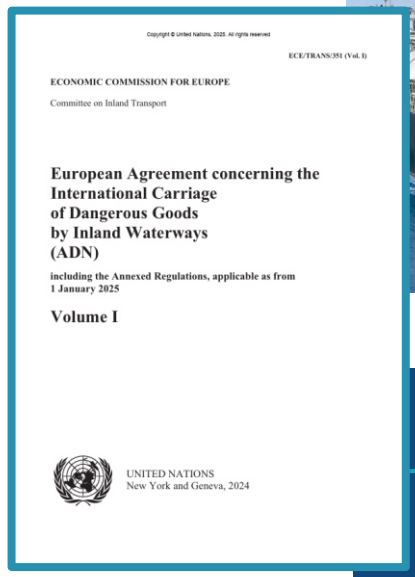
UN1005 – Ammonia, anhydrous

- Toxic and corrosive gas (2TC),
- Particularly dangerous for water bodies (N1)
- Transport via portable tanks (T50), pressure equipment (P200)
- Allowed in tankers and packaged form (T) for inland shipping.

UN9000 – Refrigerated ammonia

- Cryogenic liquefied toxic and corrosive gas (3TC)
- Only allowed to be transported in tanker vessels





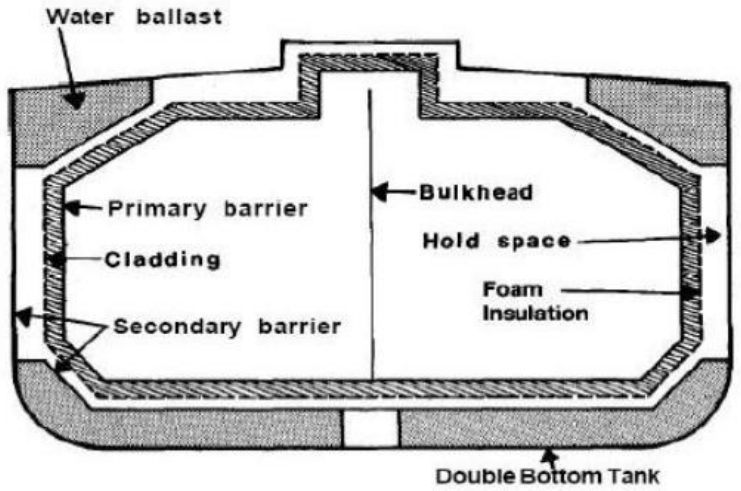
Maritime containment systems

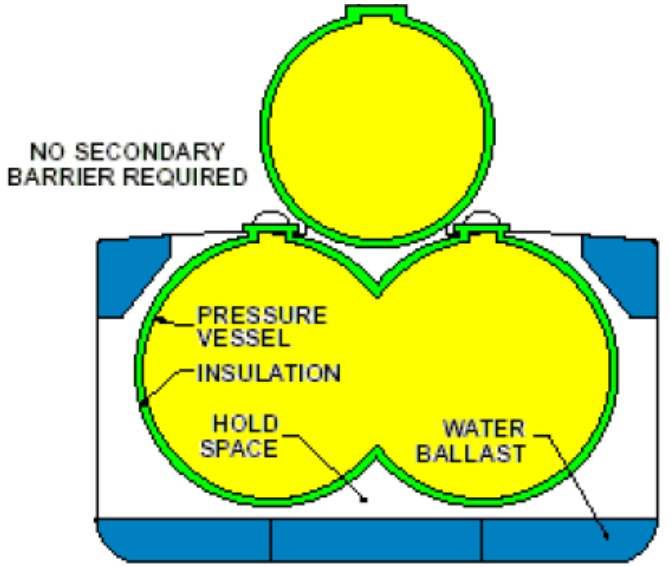
Storage and maritime transport modes:

- Fully refrigerated (near atmospheric pressure @ –33°C)
- Semi-pressurised (5 to 7 barg @ –0°C)
- Pressurised (18 barg @ ambient temperature)
- All types of IMO IGC tanks can be used
  - Corrosivity → second barrier material (special steel)
  - Reactivity with the insulations
  - Toxicity → venting

Vessels

- Fully refrigerated LPG ships (most common)
  - Capacities 15 000 m^3 to 100 000 m^3
  - Type A prismatic tanks - internal centreline bulkhead
    Secondary barrier - ship's hull
- Semi-pressurised ships
  - Capacities 2 500 m^3 to 15 000 m^3
  - Independent type C tanks





Maritime vessels for transport of ammonia

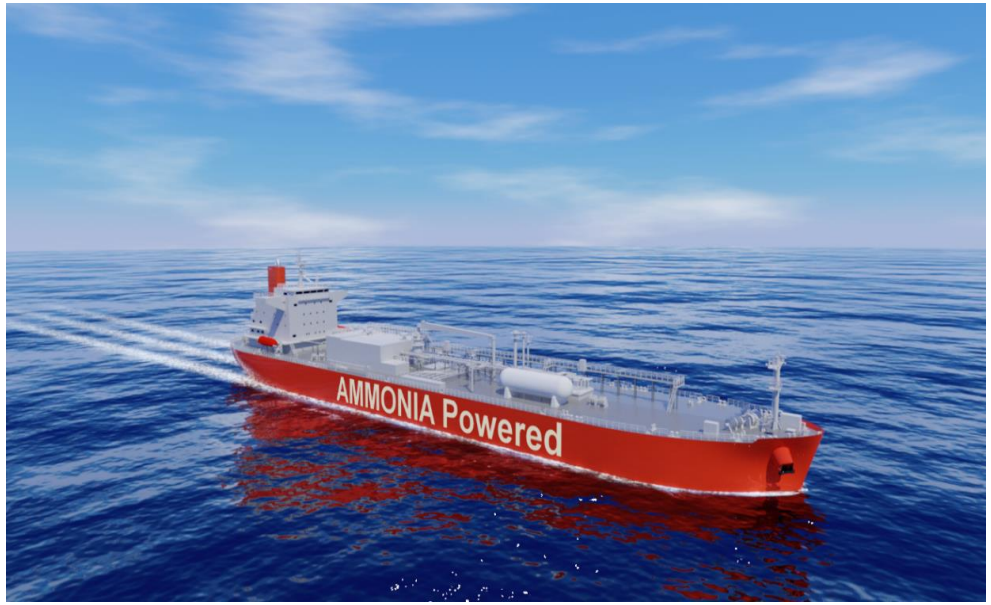
Gas Amethyst

Length overall: 229.90 m
Breadth: 37.20 m
Draft: 11.65 m
Tank capacity: 86 953 m^3
Dual-fuel diesel/LPG engine

©Kawasaki Heavy Industries

MOL,Tsuneishi & Mitsui Project

Length overall: Approx. 180.00 m
Breadth: Approx. 30.00 m
Depth: Approx. 19.00 m
Tank capacity: Approx. 40 000 m^3
Dual-fuel ammonia engine (MITSUI-MAN B&W)

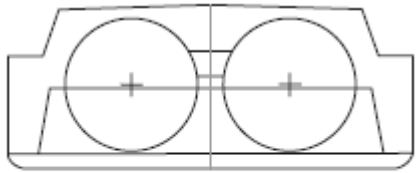


© Mitsui O.S.K. Lines

Containment systems for inland vessels

UN 1005 –Ammonia anhydrous (2TC)

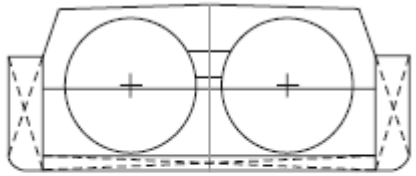
- Pressure cargo tanks - independent
- Water-spray system, manifold connection with quick closing valve
- Maximum degree of filling of the cargo tank 91 %
- Stress crack corrosion in carbon-manganese or nickel steel
- Post-weld treatment for stress relieving



Type G Cargo tank design 1,
Type of cargo tank 1
(also by flush-deck)

UN 9000 – Ammonia deeply refrigerated (3TC)

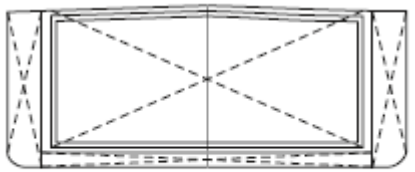
- Pressure cargo tanks - independent
- Maximum degree of filling of the cargo tank 95 %
- Refrigeration system, water-spray system
- Manifold connection with quick closing valve



Type G Cargo tank design 1,
Type of cargo tank 1
(also by flush-deck)

UN 9000 – Ammonia anhydrous deeply refrigerated (3TC)

- Closed membrane cargo tanks
- Maximum degree of filling of the cargo tank 95 %
- Refrigeration system, water-spray system
- Manifold connection with quick closing valve



Type G Cargo tanks design 2,
Type of cargo tank 4

Inland vessels for transport of ammonia

HGK Pioneer

Length overall: 135.0 m
Breadth: 17.5 m
Low-water optimized design
Diesel-electric propulsion
Cargoes:

- cold liquefied (–33 °C)
- pressure liquefied (18 barg)

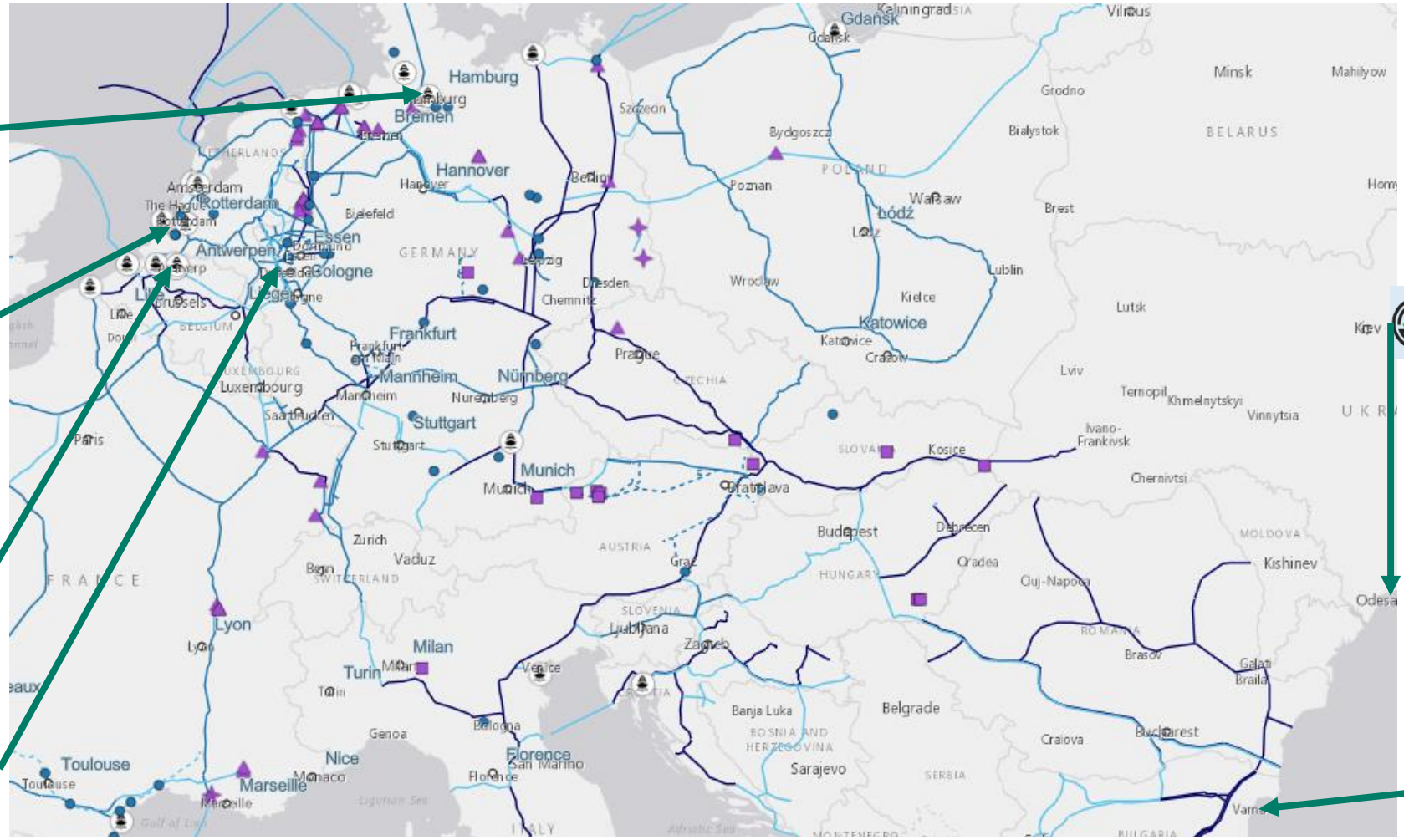
© HGK Shipping GmbH

UNION XIV

Length overall: 106 m
Breadth: 11.45 m
Draft: 2.80 m
Tank capacity: 2 271 m^3
4 independent pressure cargo tanks

© Union Shipping

Ports and terminals



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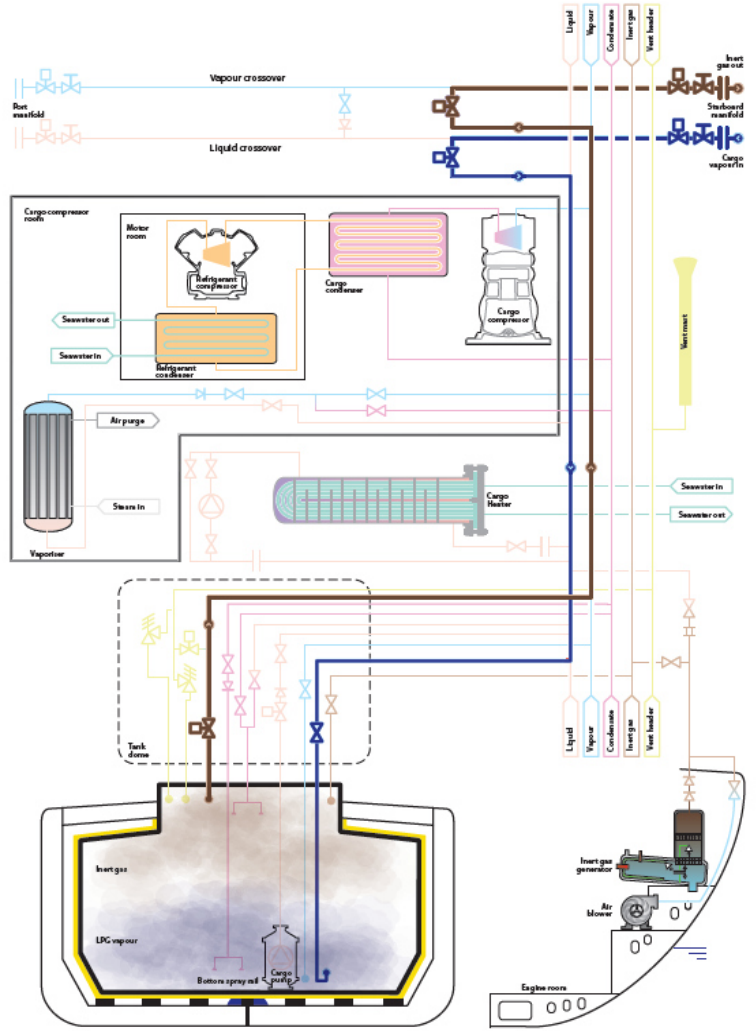
Ammonia special procedures - ISGINTT

- Ship's tanks need to be inerted with nitrogen
  - Spray loading → risk of static charge
  - NH_3 reacts with CO_2 → carbamates
  - Mixtures NH_3+ air → accelerate stress corrosion
- Gassing-up using cargo vapours from shore
- In absence of VRL – method for gassing-up is available
- Particular attention to:
  - Settings of cargo tank relief valves
  - High-pressure alarms
  - Compressors and re-liquefication equipment
  - Gas-detection system
  - Alarms and controls
  - Maximum loading rates
  - Closely monitoring of tank pressures, temperatures, liquid levels and inter barrier spaces
- Special procedures for aeration/switching from NH_3 to LPG
- H_2O + NH3 vapour → Unsafe → Vacuum



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Conclusions

- The physical and chemical properties of NH_3 raise significant challenges to its shipment by vessels.
- Safety by design, standard procedures and appropriate training are used to mitigate risks.
- Both the maritime and inland gas tanker fleets can be expanded if the demand increases.
- Long-term contracts would accelerate the upsizing of the fleet.
- Several projects for NH_3 terminals in seaports are underway.
- NH_3 is also becoming increasingly interesting for the inland ports.

viadonau

Thank you for your attention!

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AustriaEnergy

Developing a Green Way of Energy

June 2025 – HyPA event Linz - Austria

Company Snapshot

AustriaEnergy Group founded in Vienna, Austria in 2006, subsidiaries and offices in Europe and Latin America.

Subsidiaries since 2006 in Spain, since 2009 in Italy, 2011 in Bulgaria and 2013 in Chile.

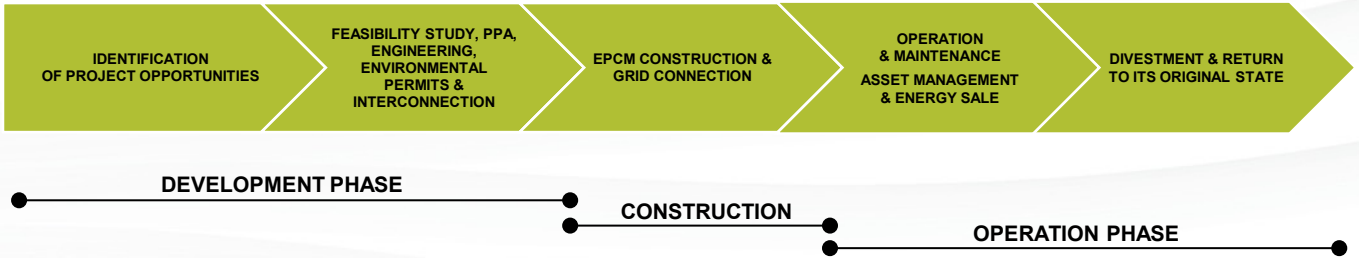
Since its commencement focused on the development, construction (EPCM), operation & management of renewable power plants with more than 1000MW

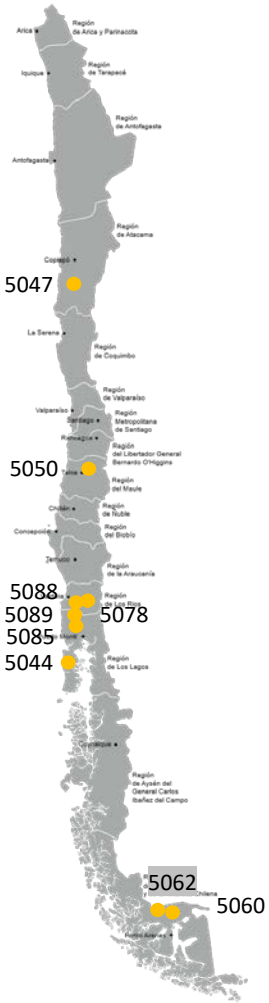
The Group has got an extensive practical experience managing all the processes involved in the entire life cycle of a renewable project, starting from development, throughout construction and operation.

Currently, the Group is evaluating to expand to markets such as Colombia, Peru among others.

AustriaEnergy offers:

- Project Development
- Construction (EPCM)
- Operation & Maintenance
- Asset Management





Current Project Pipeline

Project #	Project Name	Technology	Expected RtB	Expected COD	Capacity [MW]
5044	PE Ancud	Wind	Q1-Q2/2025	Q1/2027	133
5047	PV Sol de Algarrobal	Photovoltaic + BESS	Q4/2027	Q3/2029	350
5050	PV El Retiro	Photovoltaic + BESS	Q1/2027	Q1/2030	240
5078	PE El Parron	Wind + BESS	Q4/2028	Q2/2030	120
5085	PE Amadeus	Wind + BESS	Q4/2028	Q2/2030	250
5088	PE Danubio	Wind + BESS	Q4/2028	Q2/2030	120
5089	PE Viena	Wind + BESS	Q1/2028	Q3/2029	100
5060	HNH – 1° Phase	Green Ammonia	Q2/2027	Q2/2030	1.400
5060	HNH – 2° Phase	Green Ammonia	Q4/2028	Q4/2031	2.100
5062	Ammonia Austral Chile	Green Ammonia	Q1/2029 Q1/2031(1)	2031 2033(1)	5.400
TOTAL POWER					10. 213

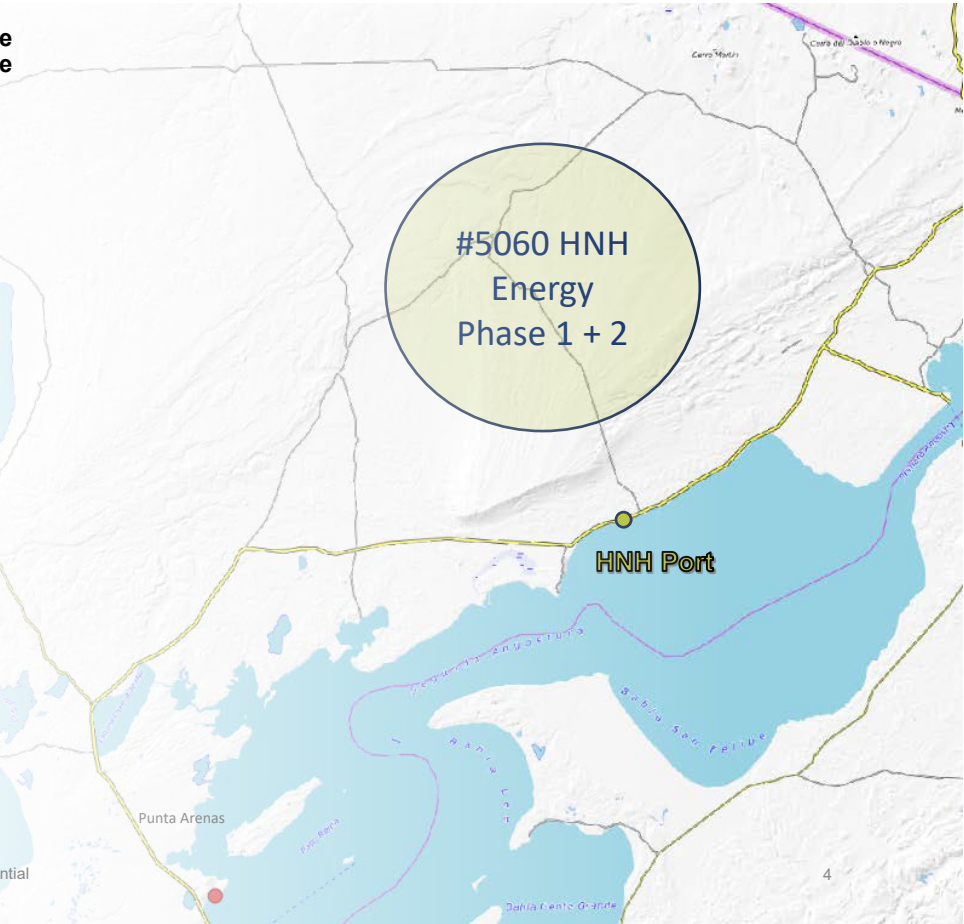
- Part which is to be financed by AustriaEnergy
  Green cells indicate the Equity CAPEX

(1) RtB and COD expected for the two project phases

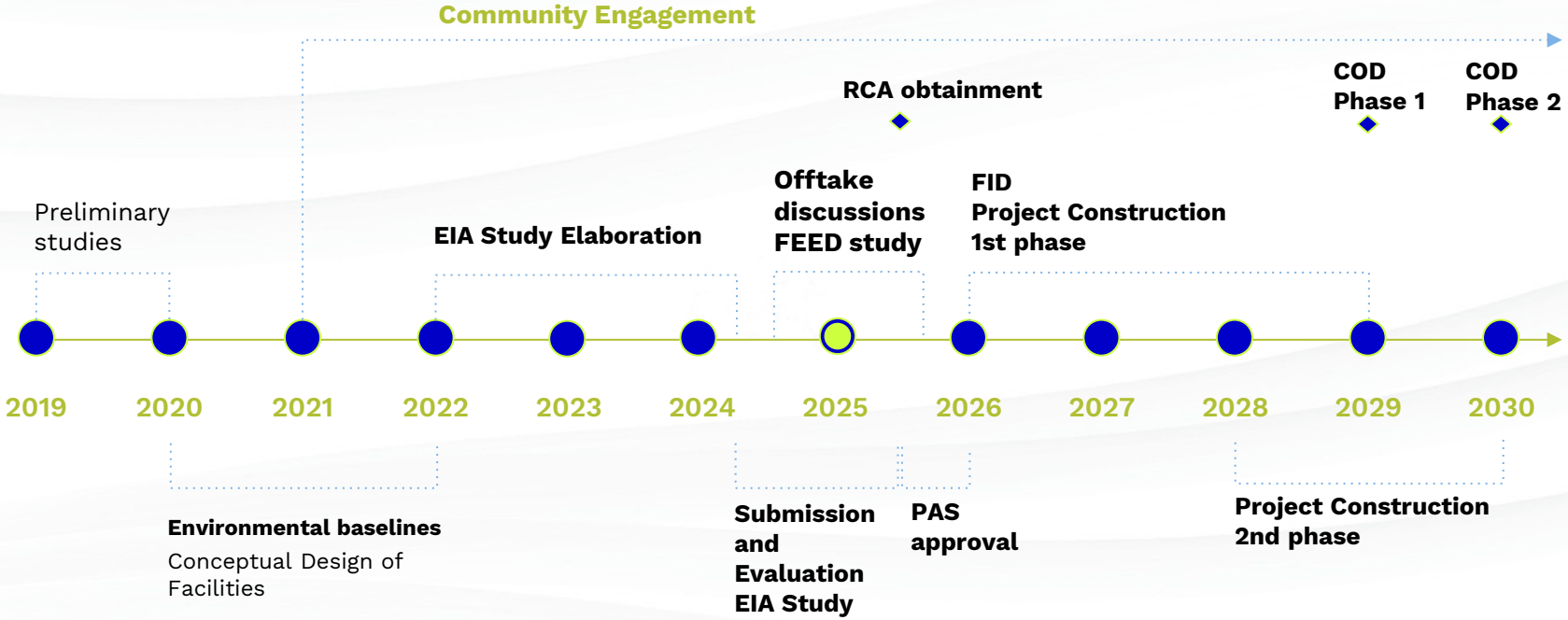
HNH Energy Phase 1 + 2

The project is situated in the San Gregorio municipality within the Magallanes and Antarctica region, approximately 99 kilometers from the regional capital, Punta Arenas

	Phase 1	Phase 1+2
WF Capacity	1.4 GW	3.5 GW
WF Capacity Factor	55%	52%
Electrolysis Capacity	1 GW	3 GW
H2 Production	120 kTon	291 kTon
NH3 Production	575 kTon	1.4 MTon



HNH Energy Project Timeline



ÖKOWIND
ERNEUERBARE ENERGIEERZEUGUNGS GMBH

CIP
COPENHAGEN INFRASTRUCTURE PARTNERS

AustriaEnergy

ÖKOWIND
ERNEUERBARE ENERGIEERZEUGUNGS GMBH

CIP
COPENHAGEN INFRASTRUCTURE PARTNERS

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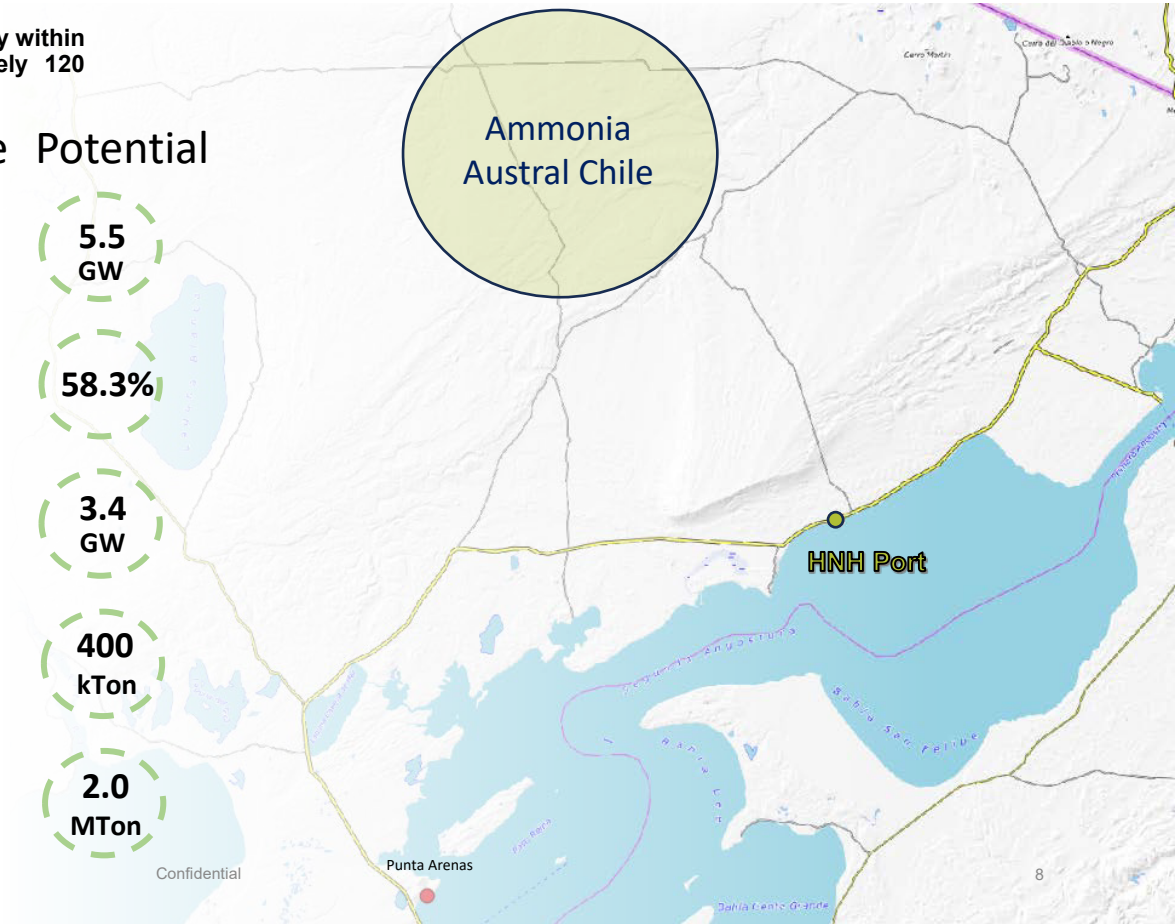
HNHENERGY

Ammonia Austral Chile

The project is situated in the San Gregorio municipality within the Magallanes and Antarctica region, approximately 120 kilometers from the regional capital, Punta Arenas

	Base case	Potential
WF Capacity	4.4 GW	5.5 GW
WF Capacity Factor	58.3%	58.3%
Electrolysis Capacity	2.7 GW	3.4 GW
H2 Production	320 kTon	400 kTon
NH3 Production	1.6 MTon	2.0 MTon



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NH3- MARKET, COST AND ECONOMICS

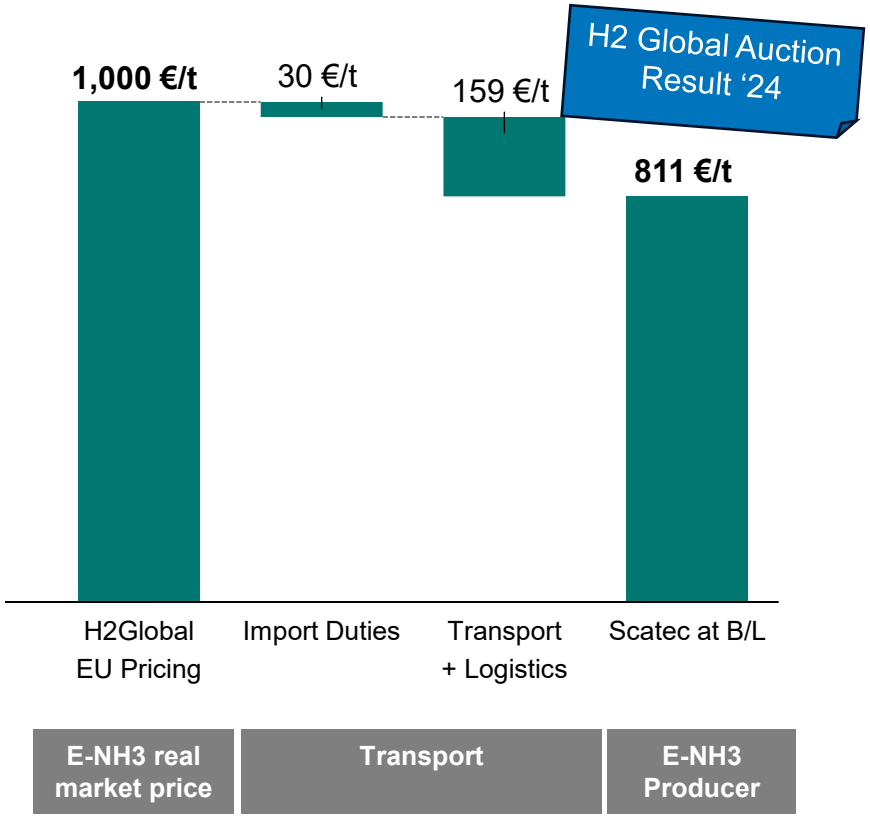
CONSIDERATIONS

LINZ, 03. JUNE 2025, R. GRZEMBA

Topics

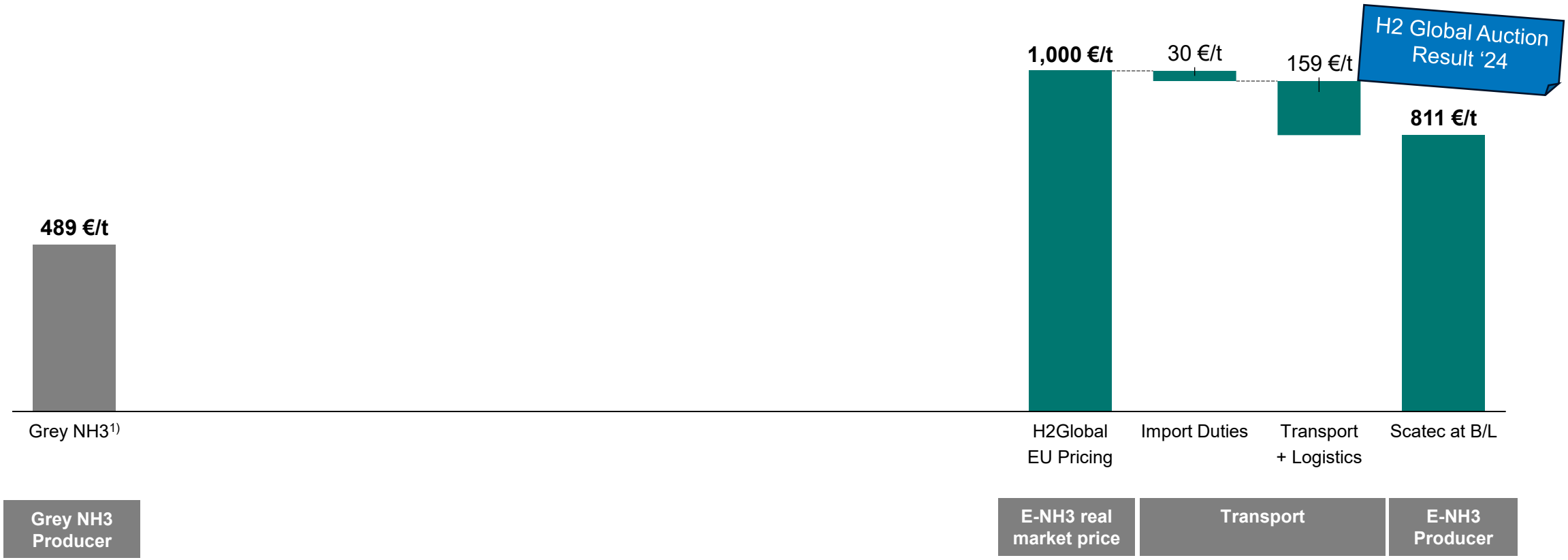
1. Market Observation
2. Underlaying Instruments and Regulation
3. Andritz and P2X

H2 GLOBAL AUCTION CLEARED AT 1’000 €/T AMMONIA; PROJECT HAS NOT REACHED FID



1) S&P Platts price NH3 Western Europe 27.05.2025,Ship & Bunker; 2) MS currently not penalizing Industry Targets; 3) EUA future price 27.05.2025: 71.6€/CO2, Assumed 2.4tonnes CO2 per 1 tonne of NH3 4) H2Global results as per press release

GREY NH3 HALF THE PRICE OF GREEN



1) S&P Platts price NH3 Western Europe 27.05.2025,Ship & Bunker; 2) MS currently not penalizing Industry Targets; 3) EUA future price 27.05.2025: 71.6€/CO2, Assumed 2.4tonnes CO2 per 1 tonne of NH3

NH3 IN PRIMARY INDUSTRY TODAY: CARBON PRICING ISN'T CLOSING THE GAP, GREY NH_3 REMAINS 1/3 CHEAPER

1) S&P Platts price NH3 Western Europe 27.05.2025,Ship & Bunker; 2) MS currently not penalizing Industry Targets; 3) EUA future price 27.05.2025: 71.6€ t/CO2, Assumed 2.4tonnes CO2 per 1 tonne of NH3

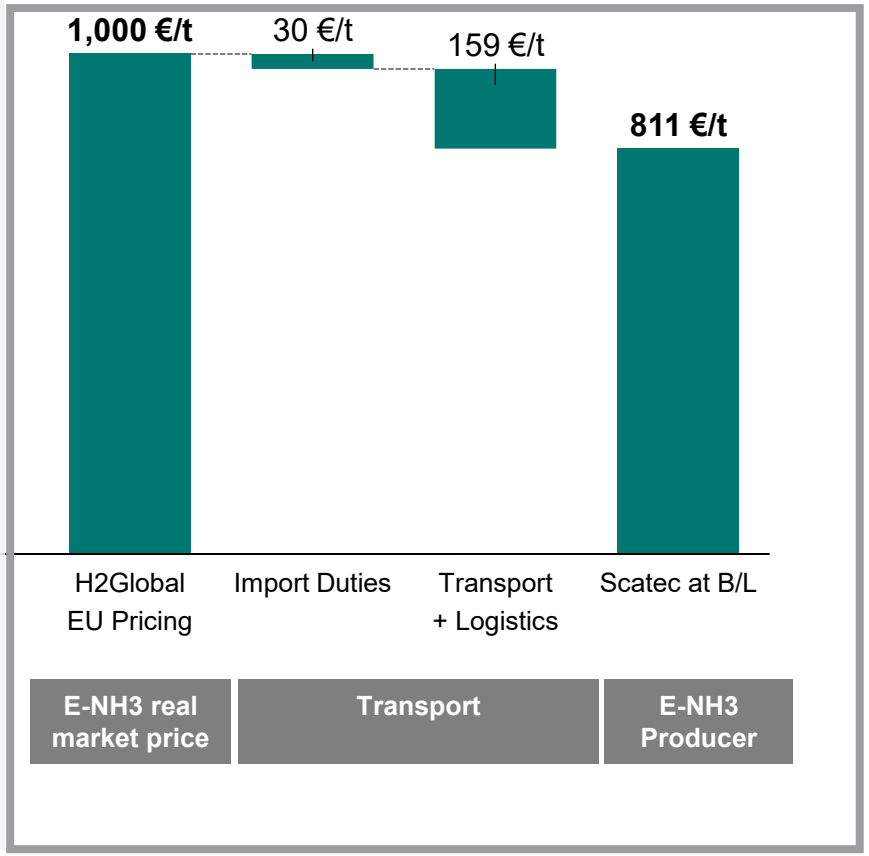
PRODUCTION VIEW: DRIVING DOWN E-NH3 COSTS THROUGH OPTIMIZATION AND FUNDING

Location (Project Developer/Owner):
- Cheap Electricity
- High FLH

Engineering (EPC)
- Optimized Complex
- CAPEX Reduction
- OPEX Reduction through Smart Integration

Financing (Banks)
- Access to good/very good financing conditions

Subsidies (Governments)
- CAPEX Funding (e.g. IPCEI)
- OPEX Funding (e.g. H2-Bank)
- Tax-Credits



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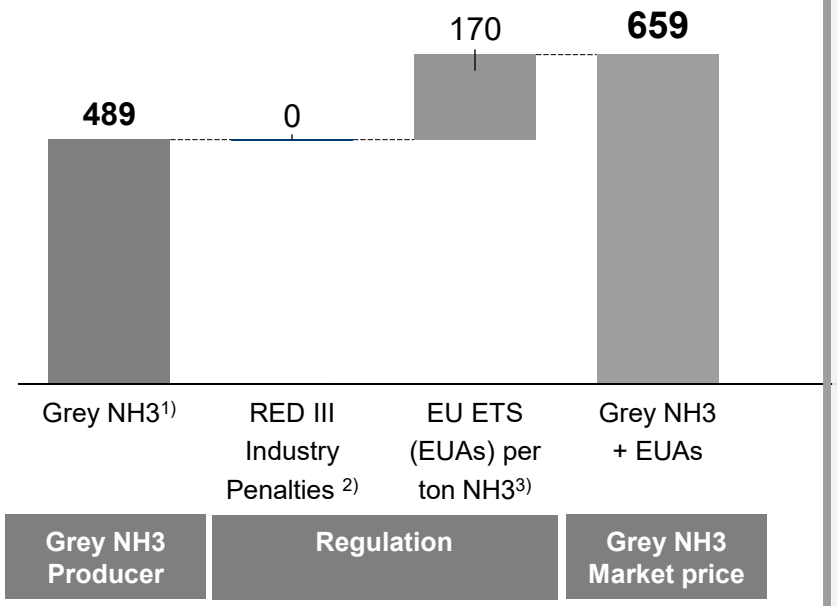
RELIANCE ON NG EXPOSES GREY NH_3 TO PRICE AND POLICY RISK



Grey NH3:
- NG Price Development

→ ~1.0 t NG per 1.0t NH3 (project dependent)

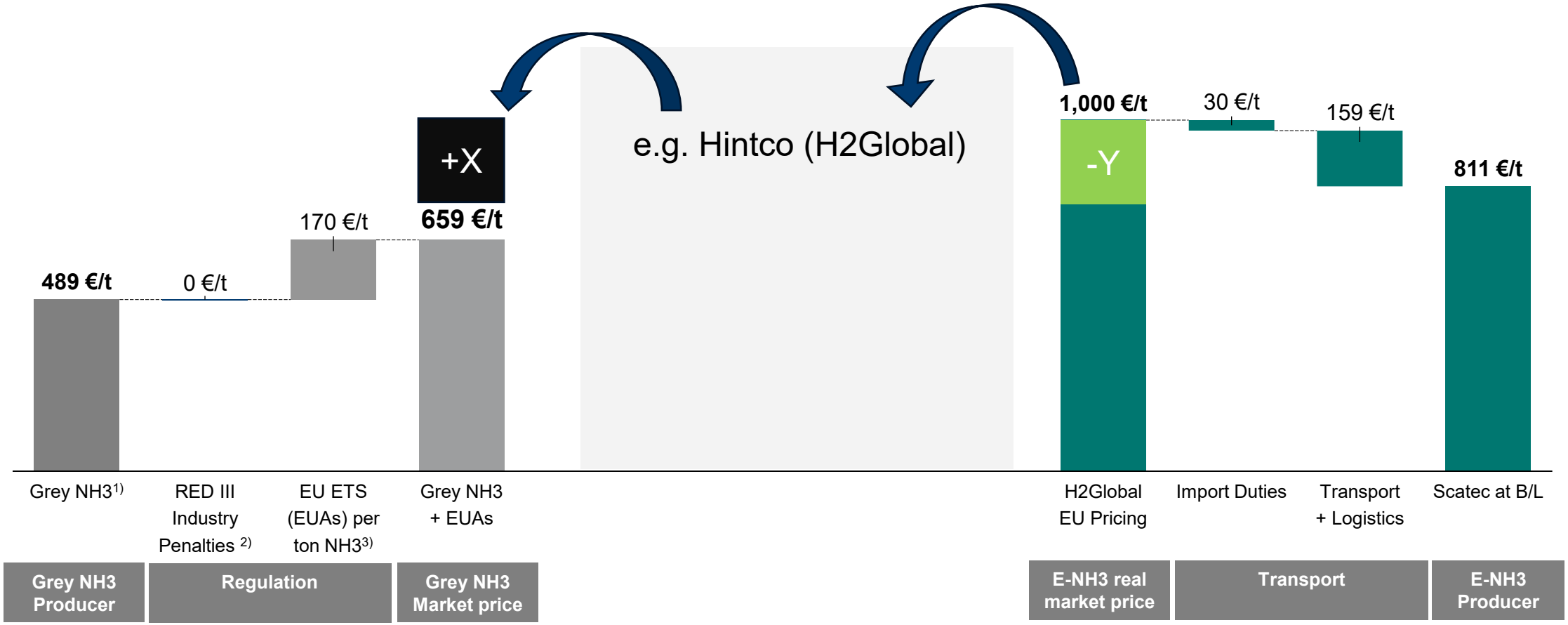
RED III Implementation
- Status in MS, most are delayed
- Penalties on 42% target?

CO2 Price
- Ramp-Up of EUA Price

→ 2.4 t/CO2e per 1.0 t/NH3 (project dependent)

1) S&P Platts price NH3 Western Europe 27.05.2025,Ship & Bunker; 2) MS currently not penalizing Industry Targets; 3) EUA future price 27.05.2025: 71.6€/CO2, Assumed 2.4tonnes CO2 per 1 tonne of NH3

INSTRUMENTS, SUCH AS CFD TO CLOSE THE REMAINDER



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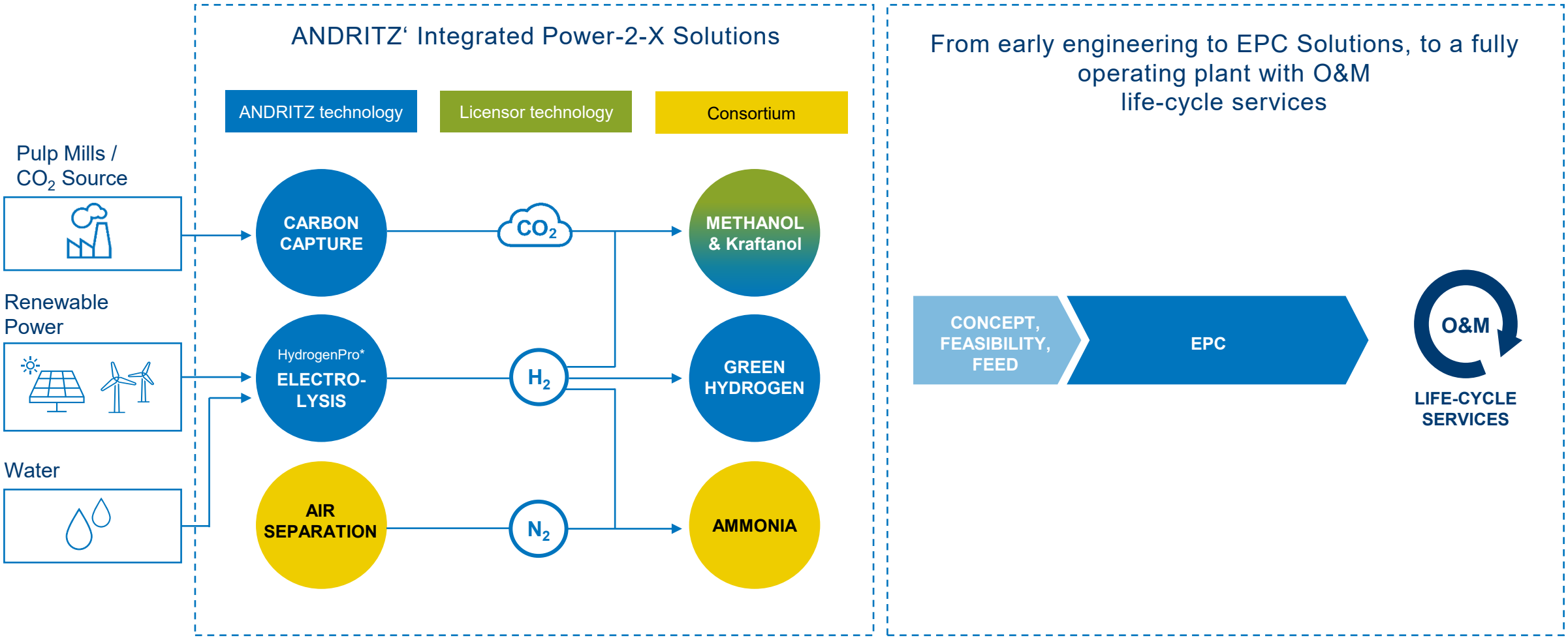
Andritz & P2X:

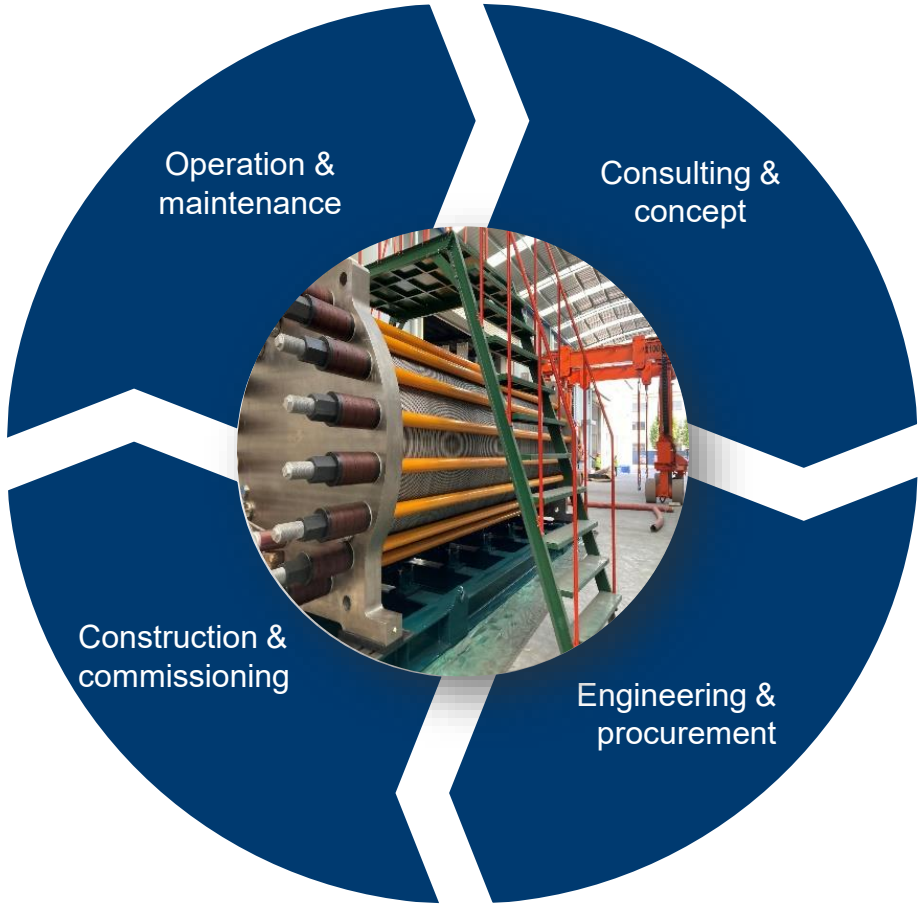
ANDRITZ P2X OFFERING



*ANDRITZ minority shareholder

FROM AN IDEA TO AN OPERATING PLANT

We lead every execution aspect, ensuring efficient and effective project deliveries



We deliver technology-focused, complete EPC solutions, including early engineering consulting services. Concurrently, we offer LTSA (long-term service agreements) for operation and maintenance

YOUR TRUSTED PARTNER FOR P2X

Clear and responsive communication is the cornerstone of our partnerships, ensuring we understand and meet your needs

DELIVERING PLANTS WITH PERFORMANCE GUARANTEES

As a solution provider, we utilize proprietary technology, in-house core components and expert integration engineering, allowing us to offer performance guarantees for entire plants.

INCREASING VALUE FROM THE START

Our long-term service agreements (LTSA) emphasize operation + maintenance services through digital solutions. Our Metris platform enhances plant performance management, predictive maintenance, and autonomous operations, ensuring the production targets are met.

ANDRITZ P2X SOLUTIONS

LEADING THE WAY IN INTEGRATION ENGINEERING

Our excellence in integration engineering ensures optimized initial investments and ongoing operational costs without compromising quality, safety or performance.

FOSTERING CUSTOMER PROXIMITY

Clear and responsive communication is the cornerstone of our partnerships, ensuring we understand and meet your needs. With a presence in 280 locations worldwide, we can efficiently build P2X solutions at any location specified by the customer.

JOINING FORCES WITH INDUSTRY LEADERS TO DRIVE GREEN TRANSITION

We aim for active discussion and collaboration with industry associations

HYDROGEN AUSTRIA

Hydrogen Europe™

Fraunhofer ISE

HyCentA

Hy PA Hydrogen Partnership Austria

H2 cluster FINLAND

AeH2 ASOCIACIÓN ESPAÑOLA DEL HIDRÓGENO

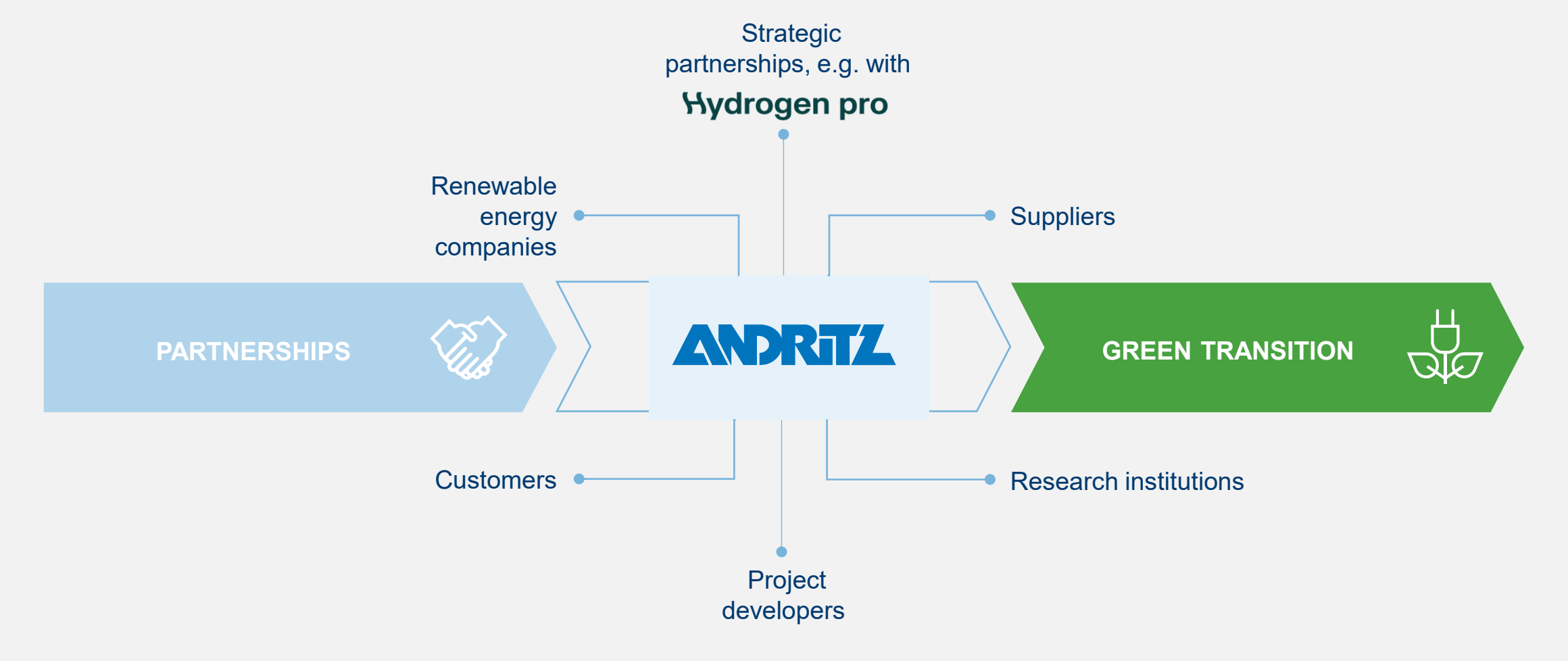
Dii Associated Partner

VDMA Power-to-X for Applications

WIVA P&G Energy Model Region

NOBODY CAN DO IT ALONE

Partnerships are required to reach best levelized cost of product



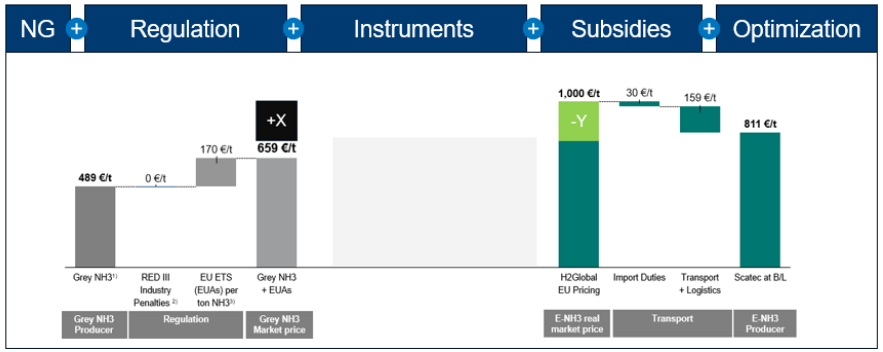
WHAT CAN BE LEARNED FOR OTHER PTX AND HYDROGEN PROJECTS?

July ’24: Wiva Erfahrungsaustausch:

- **Understand each Projects Value Chain!**
- **Understand the Use-Case!**
- **Understand each Projects Market: Which Levelized Cost are to be archived?**

May ‘25:

- **Regulation!**
- **Broader Market View**



Green hydrogen FOR THE CHANGE

WE REDUCE GREENHOUSE GASES WITH EFFICIENT GREEN HYDROGEN PLANTS

ANDRITZ

ENGINEERED SUCCESS

RICHARD GRZEMBA
Manager Market Development
Green Hydrogen, Renewable Fuels and PtX
ANDRITZ ENVIRONMENT & ENERGY

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