CAMPFIRE

New Ammonia Technologies for Decarbonization of Shipping and Sustainable Economic Value Chains

Leading Sustainable Shipping Technologies Forum, 25 June, Hamburg

Dr. Angela Kruth, Speaker and Coordinator CAMPFIRE Alliance, CAMPFIRE AG, Poppendorf

Mecklenburg Vorpommern
MV tut gut.

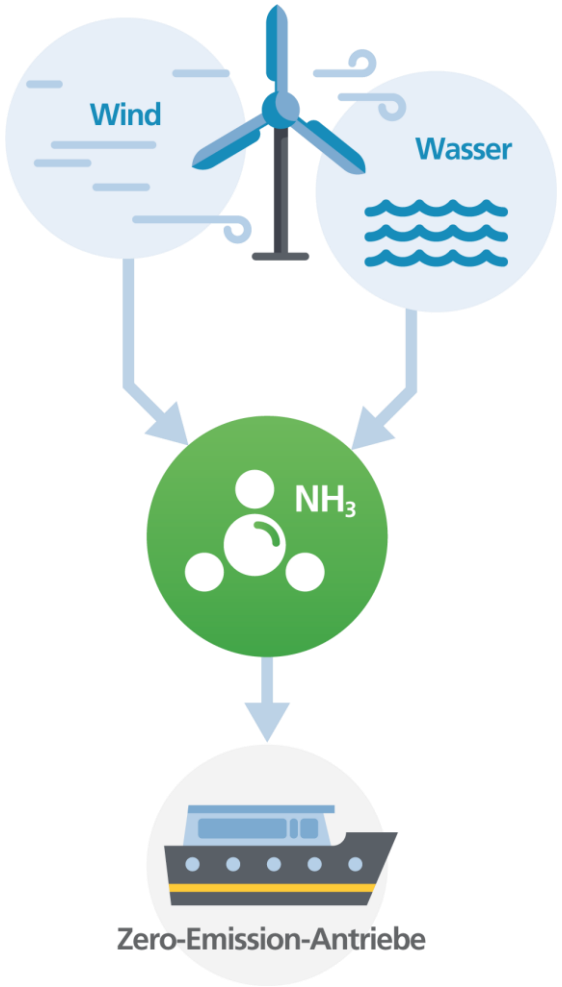
Federal Ministry of Education and Research

wir! Wandel durch Innovation in der Region

Leitprojekt TransHyDE

CAMPFIRE Vision

Innovation Field Green Ammonia Energy Technologies



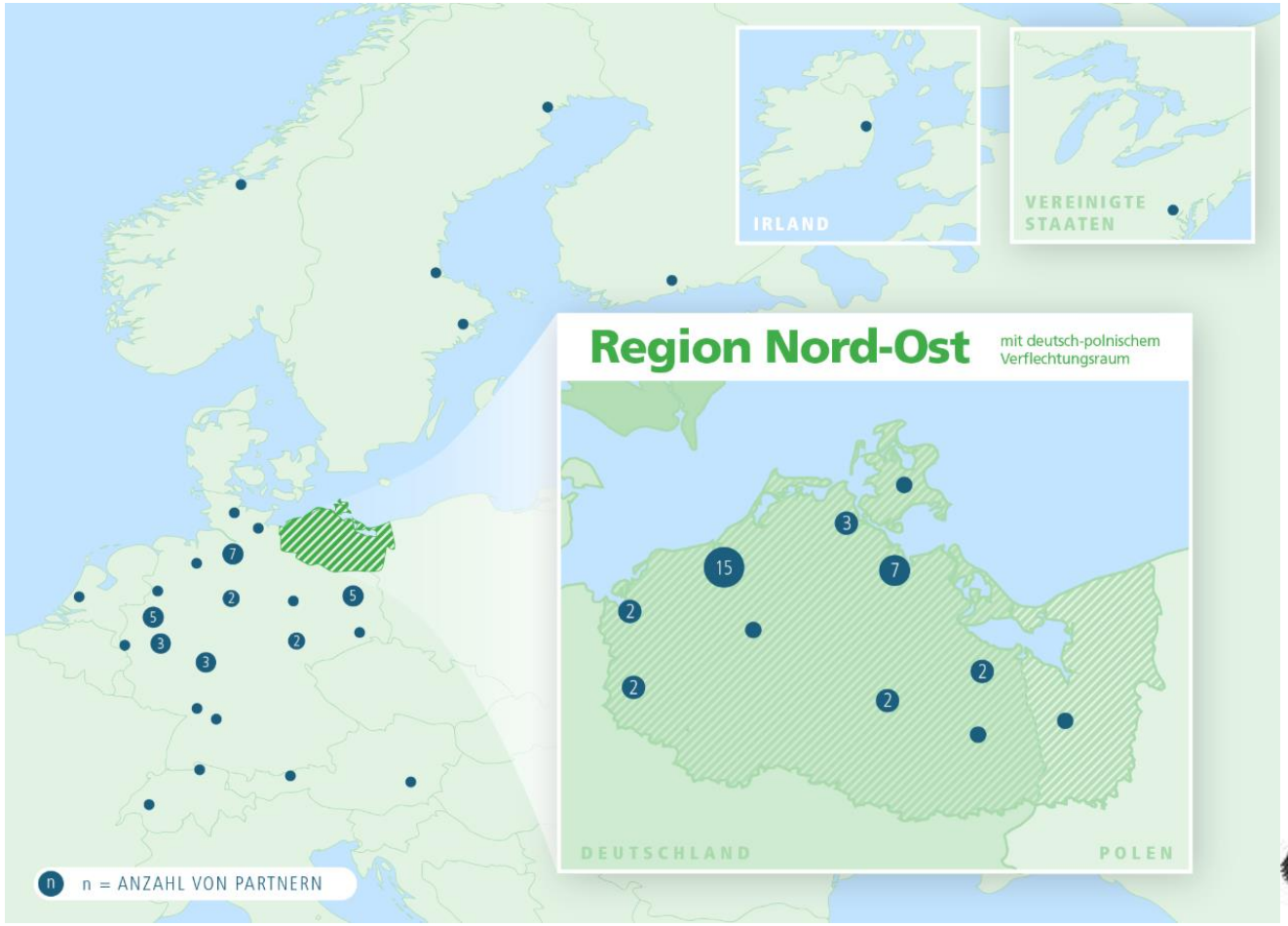
- decentral **production of green ammonia** from air, water and renewable energy
- utilization in **zero-emission marine drives** and **landside energy supply**
- technical solutions for **ammonia import** and **bunkering**
- Development of **legal framework and public acceptance**

wir! Wandel durch Innovation in der Region

Federal Ministry of Education and Research

Leitprojekt TransHyDE

CAMPFIRE Partner Alliance



The CAMPFIRE alliance has currently > 80 partners with focus in Region North-East, Germany:

- 58 industry partners
- 22 research institutes and agencies

Aiming at development of technologies for a green ammonia ecosystem

- 27 collaborative projects, supported by funding > 66 Mio. €

Federal Ministry of Education and Research
wir! Wandel durch Innovation in der Region
Leitprojekt TransHyDE
Supported by: Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag

Ammonia as new energy vector and maritime fuel

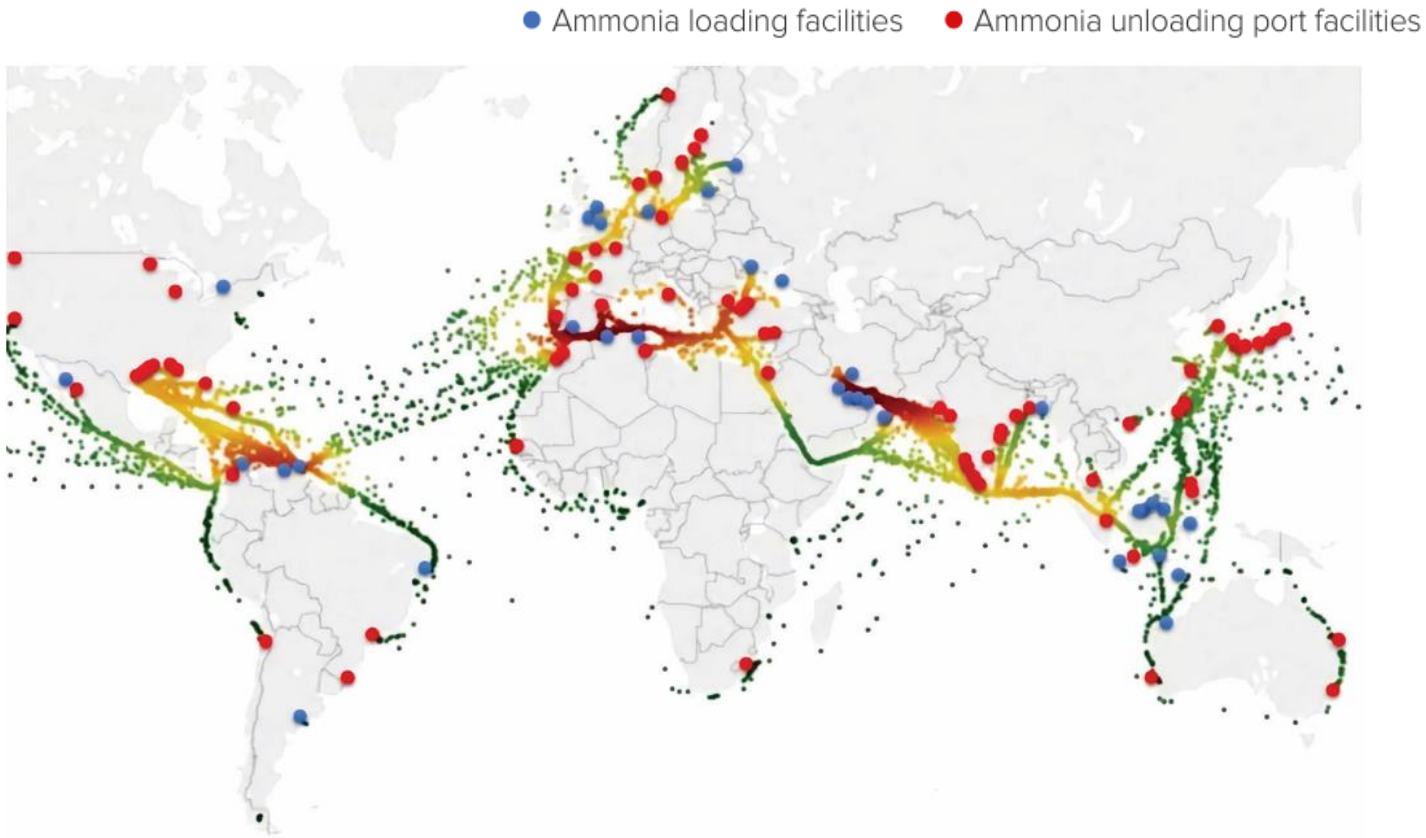
As a new global energy vector ammonia is opening the path to a carbon-free economy. It also already as a mature worldwide infrastructure.

Status today:
World wide production:
180 Mio tons per year

Globally transported:
18 Mio tons per year

196 ports with existing ammonia terminals for export and import and shipping routes

Established knowhow, standards, regulations, technologies and trainings concepts



Ammonia: zero-carbon fertiliser, fuel and energy store Issued: February 2020 DES5711, ISBN: 978-1-78252-448-9 © The Royal Society

Low-emission ammonia projects

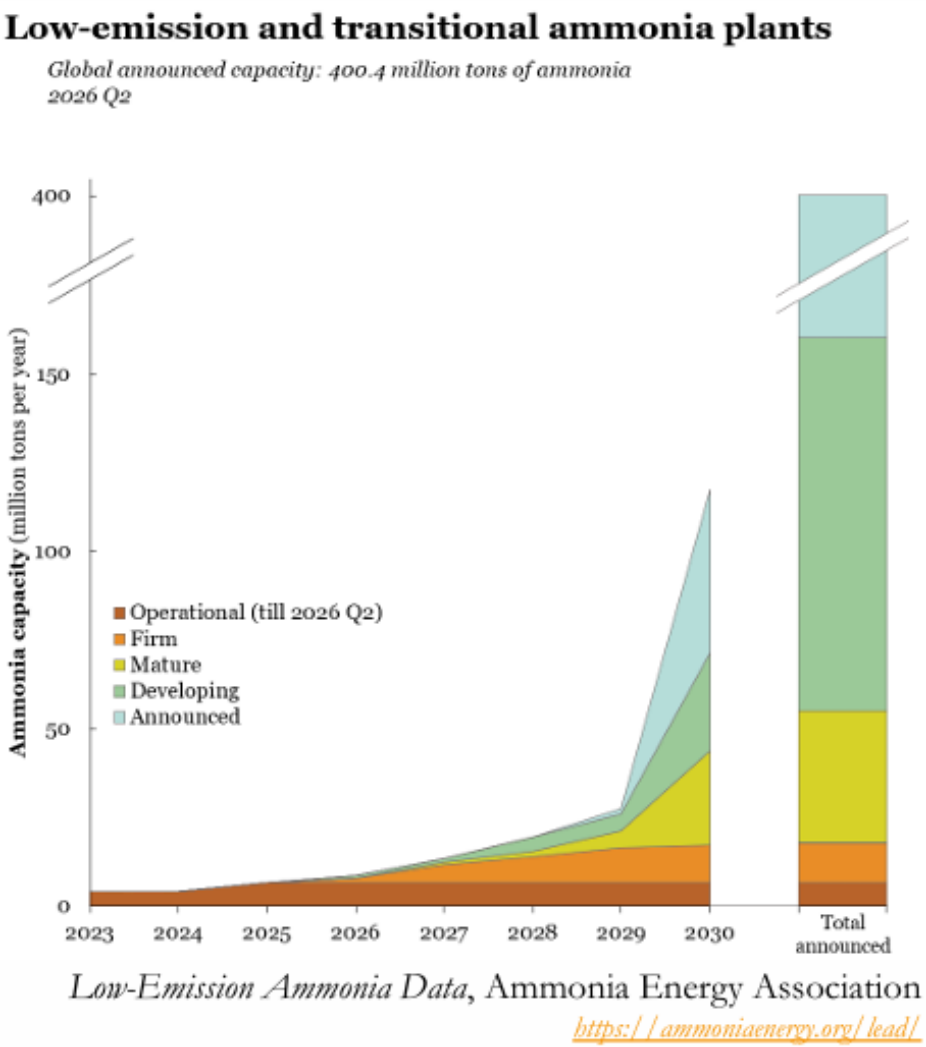
AMMONIA ENERGY ASSOCIATION

<u>May 2026:</u>
400.4 million tons (MT) of Low-emission ammonia have been announced!

By 2030, 43.6 MT could become operational:

- 6.5 MT is already operational up to 2026 Q2)
- 10.6 MT is under construction / Final Investment Decision
- 26.5 MT is mature (Offtakers / EPC selected / FEED)

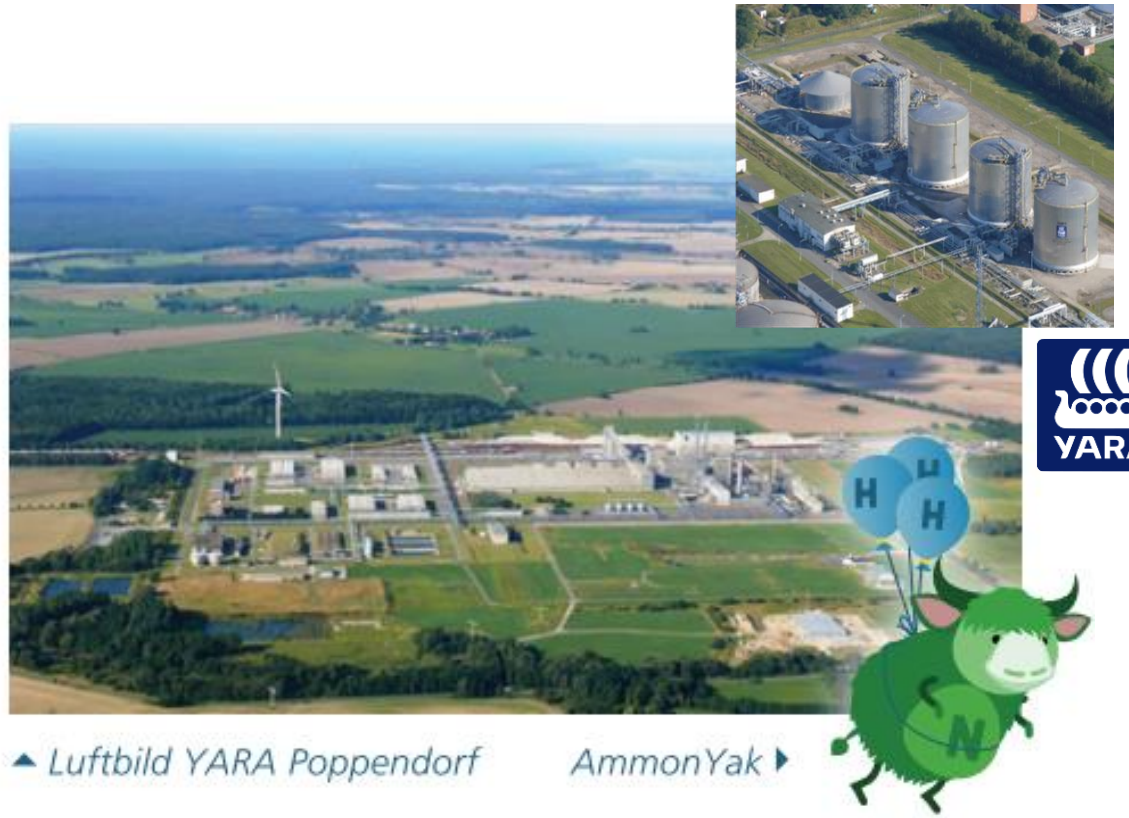
In total, 240.2 MT is classified as Announced with few public details. Another 105.2 MT is developing



Green Ammonia ChemPark with CAMPFIRE Open Innovation Lab

3 Pillars:

- Industrial focus for companies utilizing infrastructure at site
- Incubator and development environment for start-ups & SMEs and their partners
- Research activities within the framework of public funded joint projects



Leitprojekt TransHyDE
Bundesministerium für Bildung und Forschung
wir! Wandel durch Innovation in der Region
Mecklenburg Vorpommern MV tut gut.
GREATER ROSTOCK
DIE ROSTOCKER WASSERSTOFFINITIATIVE

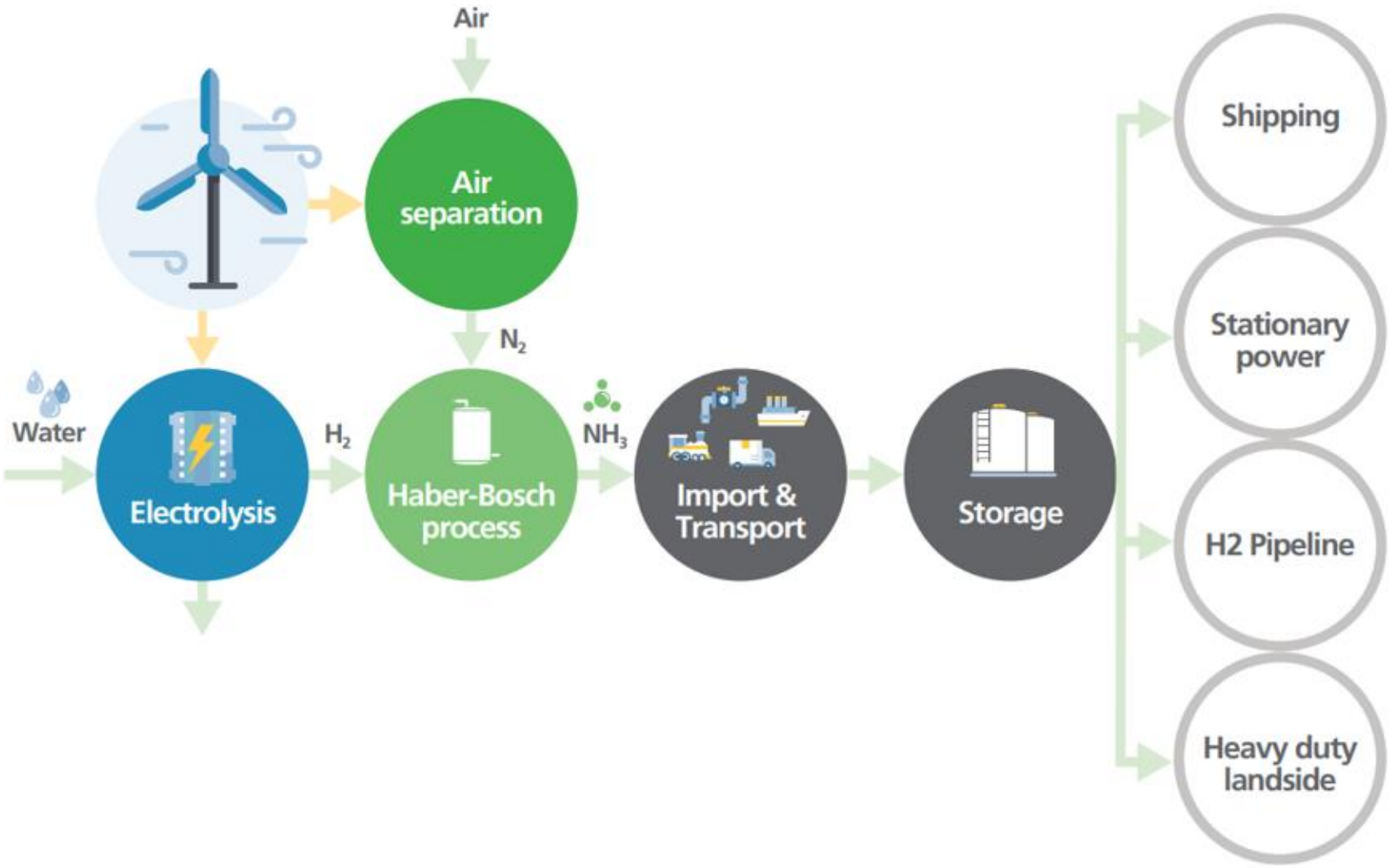
Green Ammonia ChemPark with CAMPFIRE Open Innovation Lab

Media supply for ammonia-to-power and power-to-ammonia (pay industrial prices per use)

- Ammonia up to 3 t/h
- Ammonia evaporator up to 500 kg/h
- Ultrapure water up to 2 t/h
- Nitrogen generation plant (PSA)
- 10 MW electrical connection capacity
- 400 V supply up to 2 MW
- Fire and gas warning systems
- 24/7 operation, factory fire department

The site has 5,000 m² of open-air laboratory space available for the development and trial operation of containerized energy systems.

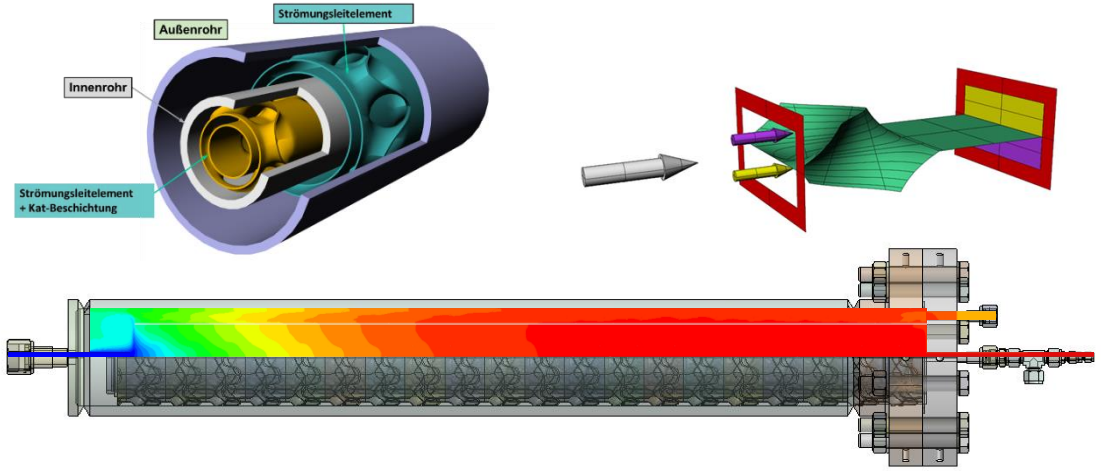
Ammonia Eco System Development

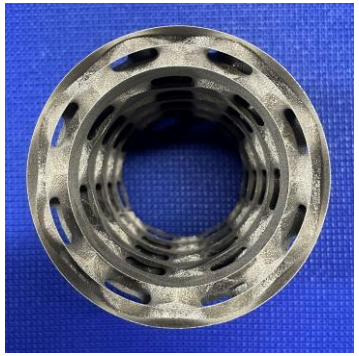


Power-to-Ammonia

Microstructured reactor for decentralised ammonia synthesis (medium-load plant)

- 100 kW demonstrator for the load-flexible production of ammonia up to 15 MW of regionally generated renewable energy in an industrial environment
- Microstructured load-flexible reactor with high efficiency through heat recuperation





KIT SLE reactor for flexible ammonia production

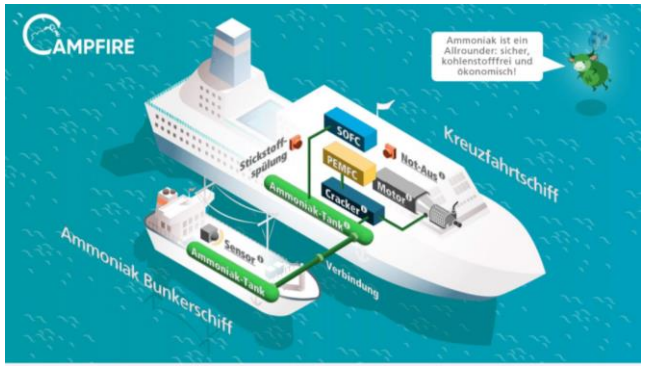
Ammonia-2-Power

Sports yacht with NH3-powered 15 kW cracker gas engine as secondary drive and SOFC on-board power supply

Retrofitting of the ammonia bunker ship “Odin” with NH3 cracker-350 kW motor drive

GreenBaltic Cruising: Evaluation of an NH3-powered cracker fuel cell propulsion system for an Aida cruise ship

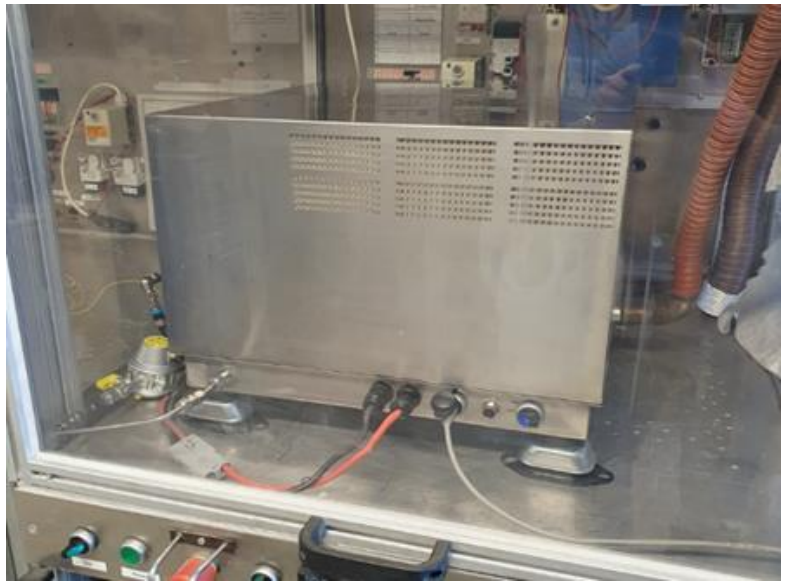
Process optimization and safety management of accident scenarios involving ammonia



Ammonia-2-Power

750 W Direct Ammonia SOFC Module for Hotel Power Supply

350 kW full motor for operation with ammonia for use in inland waterway transport



Ammonia-2-Power

1 MW CHP demonstration plant with two 150 kW cracker modules and exhaust treatment

Leitprojekt TransHyDE

JENBACHER INNIO · LCC · hugengineering. A FAURECIA COMPANY · ZBT · WB ENGINEERING

Ammonia-2-Power

- 10 kW metal supported SOFC stack scaled to 100 kW modules: modular and scalable to multi-MW installations
- High efficiency, inherent robustness to transportation and cyclic operation
- Proven system architecture
- Flexibility to customise the design

Low SOFC operational temperature of 430 to 650 °C

4 global manufacturing partners

e.g. Weichai: leading supplier of conventional gas engines

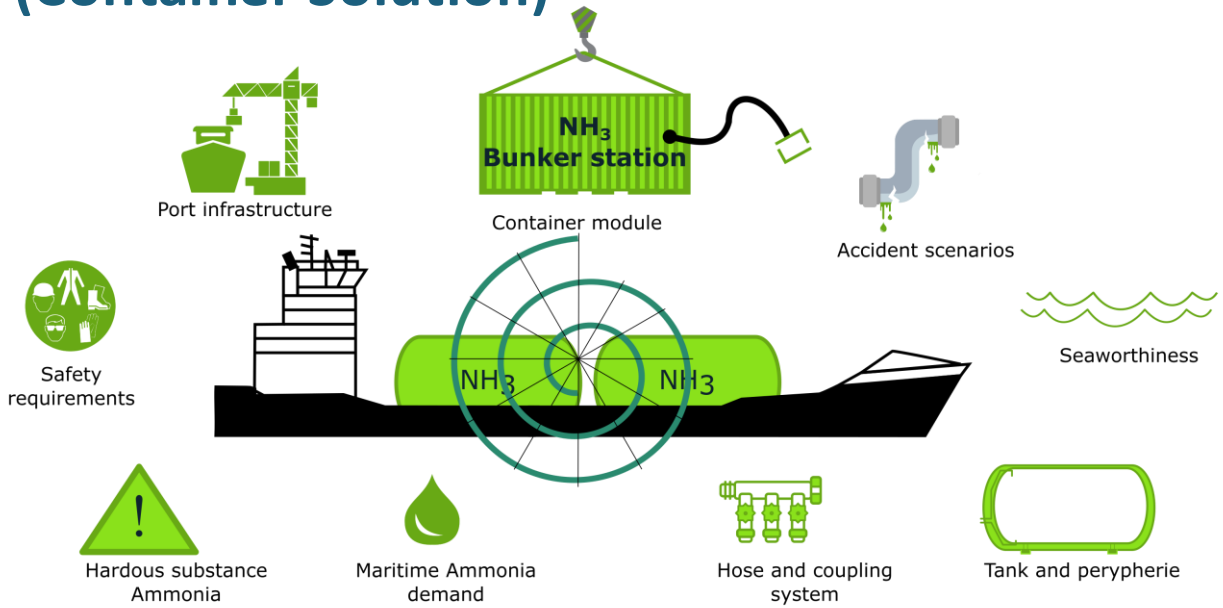
https://www.ceres.tech/

Flexible Ammonia Bunkering Station

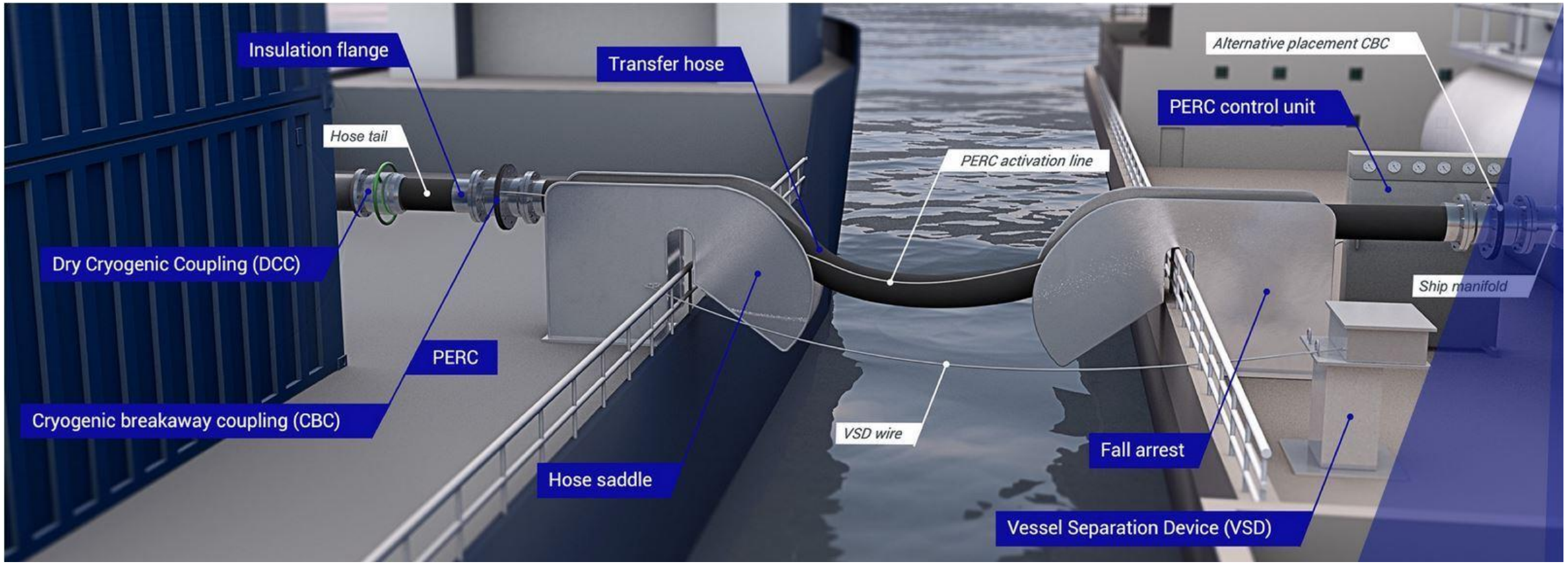
Supply of Ships with Ammonia as Fuel

Ship-to-Ship (Bunkerbarge) and Truck-to-Ship (Container Solution)

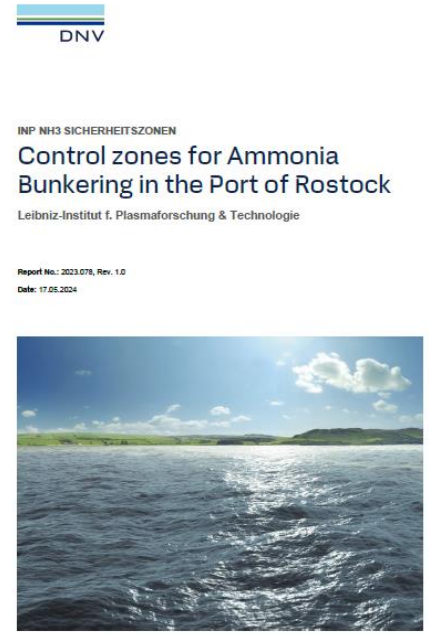
- Seaworthy bunker barge with flexible application spectrum
- Tank and periphery ammonia refueling system



Hose and Coupling



Development of Legal Framework for Ammonia Fuel



Roadmap for legal frame development for ammonia as energy vector

1. Infrastructure for green ammonia as a matter of overriding public interest
2. Defining the term 'green ammonia'
3. Amend the licensing requirements for facilities producing hydrogen via cracking processes
4. Work towards adapting the transport of dangerous goods at international level
5. Initiate CE certification and standardisation for ammonia technologies
6. Bringing standardisation and legislation in shipping into line with the state of the art
7. Abolish preferential treatment for the use of fossil fuels in shipping
8. Introduce an international pricing system for GHG emissions from shipping
9. Take ammonia infrastructure into account in legislation and the designation of priority and infrastructure areas

Legal analysis of the transport of ammonia by road, rail, inland waterway and pipeline

- status quo analysis
- analysis of obstacle
- recommendations for action

Legal barriers and areas requiring change in Germany

non-pipeline transport (road, rail, inland waterway shipping)

- Complex regulatory framework with comprehensive safety requirements
- Permissibility of the transport of cold-liquidised ammonia only by waterway
- No priority for freight transport when transporting ammonia

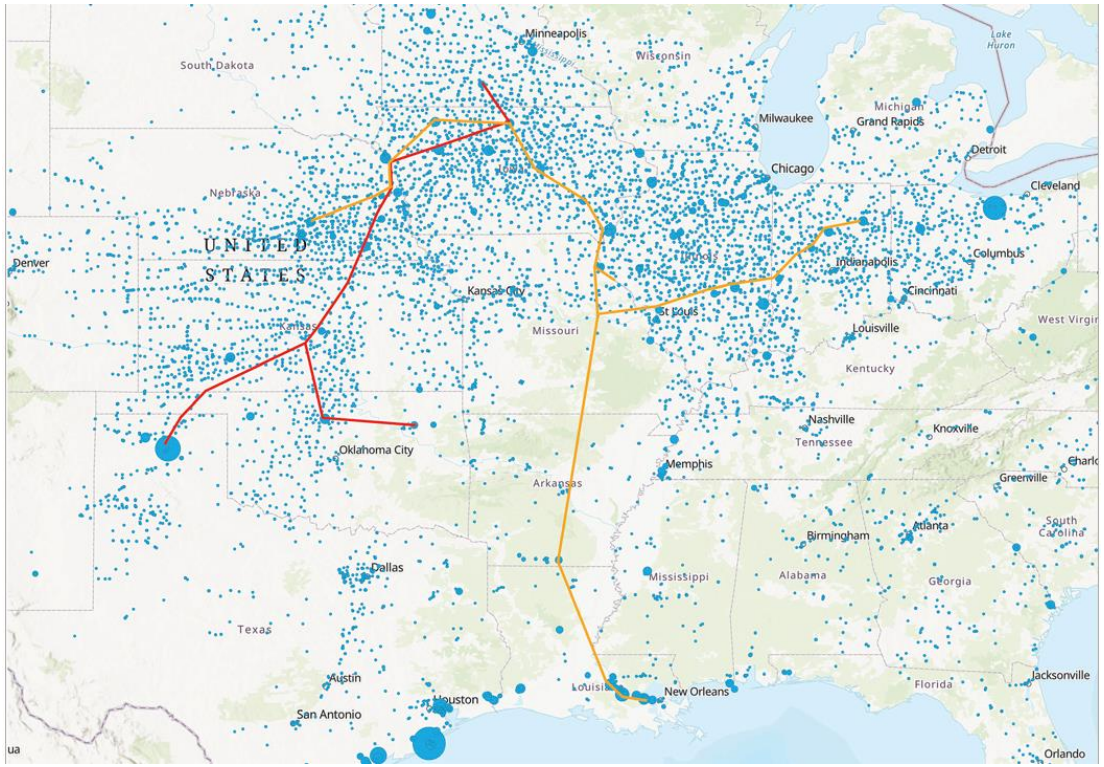
Pipeline transport

- Lengthy proceedings, many legislative amendments required at state level

https://usercontent.one/wp/www.ikem.de/wp-content/uploads/2024/12/20241202_CF11_1_TransHyDE-Rechtsrahmen_Ammoniaktransportloesungen.pdf?media=1781017257

Legal analysis of the transport of ammonia by road, rail, inland waterway and pipeline

Liquefied ammonia storage and pipeline distribution networks in the US Mid-West.



Ammonia: zero-carbon fertiliser, fuel and energy store
Issued: February 2020 DES5711, ISBN: 978-1-78252-448-9
© The Royal Society

- ammonia is mainly applied directly into the soil as fertilizer: over 10,000 ammonia storage sites and presence of ammonia facilities in cities
- 11 states are connected by 6 – 8-inch carbon steel pipes with regularly spaced pumping stations, transporting around 2 million tonnes of ammonia per year

orange line
Kaneb pipeline: 2,000 miles

red line
Magellan Midstream pipeline: 1,100 miles

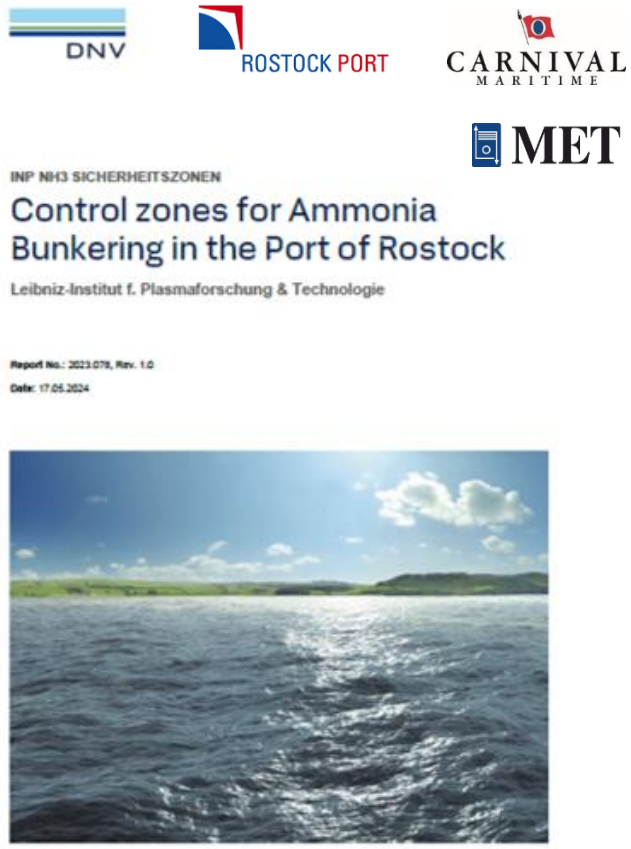
Legal framework for Authorisation of ammonia as a fuel in inland waterway and maritime shipping

- Ammonia refuelling stations or bunkering stations require numerous permits under various areas of law
  - legislation on air pollution control
  - building regulations
  - water management
  - health and safety
  - Chemicals
  - ..
- lack of standardised regulations for refuelling permits
- legal uncertainty regarding the permissibility of placing the fuel on the market

→ **regulation and refuelling permits**

→ **standardised regulations at state level**

→ **establishment of quality standards for ammonia as a fuel**



https://www.ikem.de/projekt/campfire/ammoniak-bunkerstationen/#

contact: angela.kruth@wir-campfire.de

Liability issues relating to the uncontrolled release of ammonia into water (accidents)’

- Liability issues arising from the use of ammonia as a marine fuel
- Areas:
  - Public-law liability for environmental damage caused by ammonia leaks
  - Criminal liability
  - Civil liability

- ➢ In maritime shipping, existing regulatory gap in that ammonia fuel not covered by existing liability conventions.
- ➢ Liability issues arising from an ammonia leak falls within the scope of national law.

→ **Fragmentation of the legal situation threatens to create a patchwork of unilaterally adopted national regulations. This causes uncertainty and unpredictability for users of ammonia fuel.**

https://www.ikem.de/publikation/haftungsfragen-bei-unkontrolliertem-eintrag-von-ammoniak-in-wasser/

CAMPFIRE | THANKS

CONTACT:

Dr. Angela Kruth
CAMPFIRE AG
Werkstrasse 1
18184 Poppendorf
Email: angela.kruth@wir-campfire.de

GEFÖRDERT VOM

Bundesministerium
für Bildung
und Forschung

wir! Wandel durch
Innovation
in der Region

www.wir-campfire.de