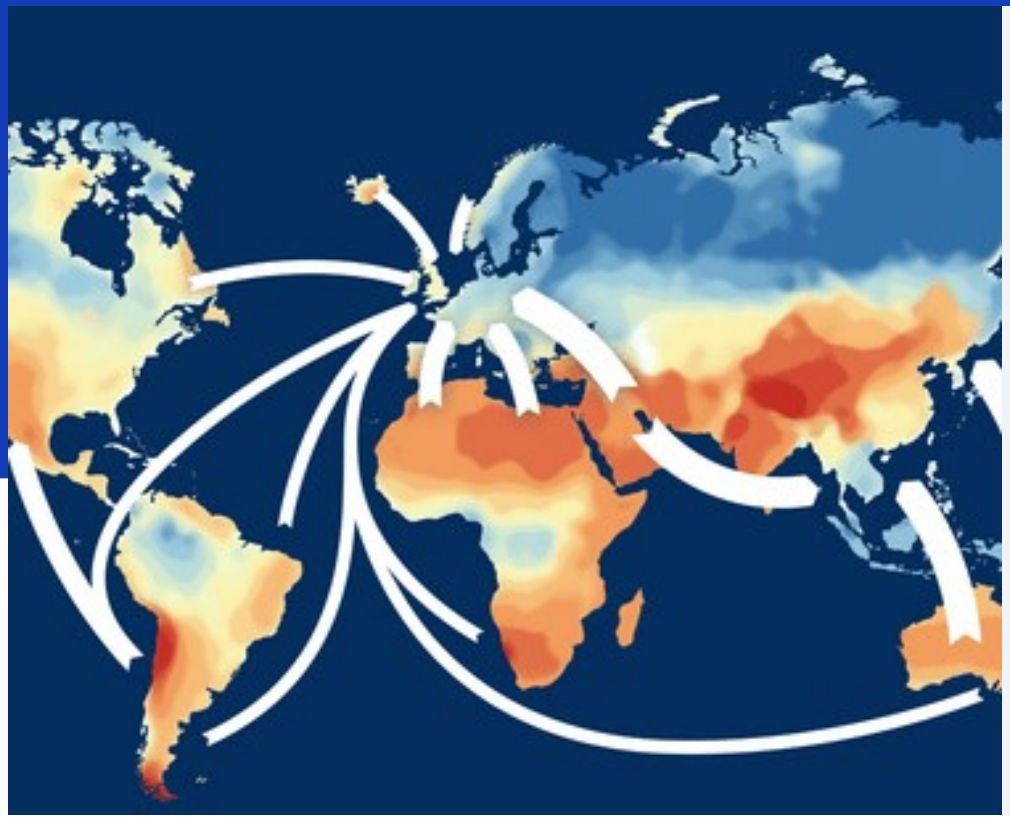
SHIP>NL sessie II

Drs. M.C.M. Rijkers

Start presentation

TNO innovation for life

Agenda SHIP>NL sessie 21 februari 2024



1. Welkom
2. Deep dive: Relaunching Ammonia From Fertilizer to Energy Carrier in Northwest Europe
   Roelof Stam & Coby van der Linde | CIEP
3. Afsluiting

Huisregels

- Camera aan, microfoon op ‘mute’
- Vragen?
  - Plaats verduidelijkingsvragen in de meeting chat; of
  - Steek je hand op!
- De moderator zorgt ervoor dat je vraag beantwoord wordt (eventueel achteraf).
- Slides worden na de sessie gedeeld en zijn te vinden op SHIPNL: Sustainable Hydrogen Import Program Netherlands | Nationaal Waterstof Programma

- We bespreken uiteraard geen marktgevoelige zaken.

- Chatham house rules: De besproken informatie mag gedeeld worden, maar zonder de spreker te onthullen.

Meerjarig kennisprogramma met 5 lijnen

- **In deze sessie:**

1 Technisch economisch	2 Beleid	3 Markt	4 Internationaal	5 Omgeving
▪ Inzicht in importketens productie-conversie-transport-opslag-reconversie-gebruik	▪ Impact van 'Fit for 55', REDII, Delegated acts, ETS/CBAM, etc.	▪ Marktmodellen: bilaterale contracten, vrije handel, waterstofbeurs	▪ Samenwerking met omringende EU/niet-EU importlanden om corridors te ontwikkelen	▪ Ruimtegebruik van ketenelementen
▪ Vraagontwikkeling, scenario's	▪ Impact van certificering en CO2 allocatie: emissiefactoren, LCA ketenanalyse, etc.	▪ Internationale handelsstromen: verwachte vraag- en aanbodvolumes en transportstromen	▪ Concurrentie met omringende EU/niet-EU importlanden	▪ Veiligheid: brandbaarheid, zorgwekkende stoffen, risicocontouren, etc
▪ Infrastructuur & systeemintegratie: corridors, benutten bestaande infra.	▪ Financiering en stimulering (EU & NL): IPCEI, PCI, TEN-E, JTF, EIB, Horizon Europe, MOOI, DEI, MIEK, SDE++, etc	▪ Importtarieven, trade agreements en handelsbeperkingen, WTO, etc.	▪ Geopolitieke aspecten: strategische voorraden, afhankelijkheid, politieke stabiliteit van exportlanden	▪ Milieu: stikstof, lekkage
▪ Technology assessments, R&D				▪ Maatschappelijke acceptatie
				▪ MVO / samenhang met SDG's in exportlanden

Nationaal Congres Waterstofveiligheid op 3 april 2024

- Organisatoren: Het Nationaal Waterstof Programma, NLHydrogen en TKI Nieuw Gas | Topsector Energie
- Datum: woensdag 3 april 2024 van 10.00 - 18.00 uur
- Locatie: De Loods, Treubstraat 31, Rijswijk
- Entree: Gratis
- Programma:
  - Waterstof Veiligheid Innovatie Programma (WVIP) geeft een overzicht van 4 jaar innoveren op dit thema.
  - Plenair panel
  - Twee workshoprondes waarin je kunt kiezen uit diverse thema's, zoals veiligheidsaspecten bij waterstofproductie, waterstofinfrastructuur, opslag van waterstof, allerlei toepassingen en beleid.
- Er is voldoende tijd in het programma om te netwerken.
- Nationaal Congres Waterstofveiligheid (topsectorenergie.nl)

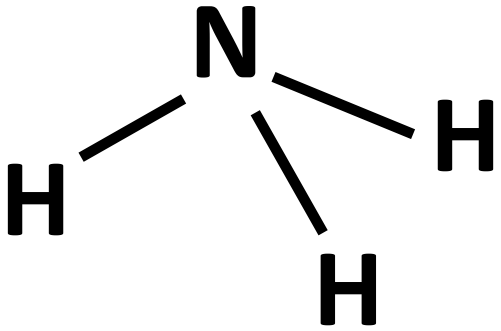
Relaunching Ammonia From Fertilizer to Energy Carrier in Northwest Europe

- Roelof Stam & Coby van der Linde | CIEP

CLINGENDAEL INTERNATIONAL ENERGY PROGRAMME | CIEP

Relaunching Ammonia:

From Fertilizer to Energy Carrier in Northwest Europe

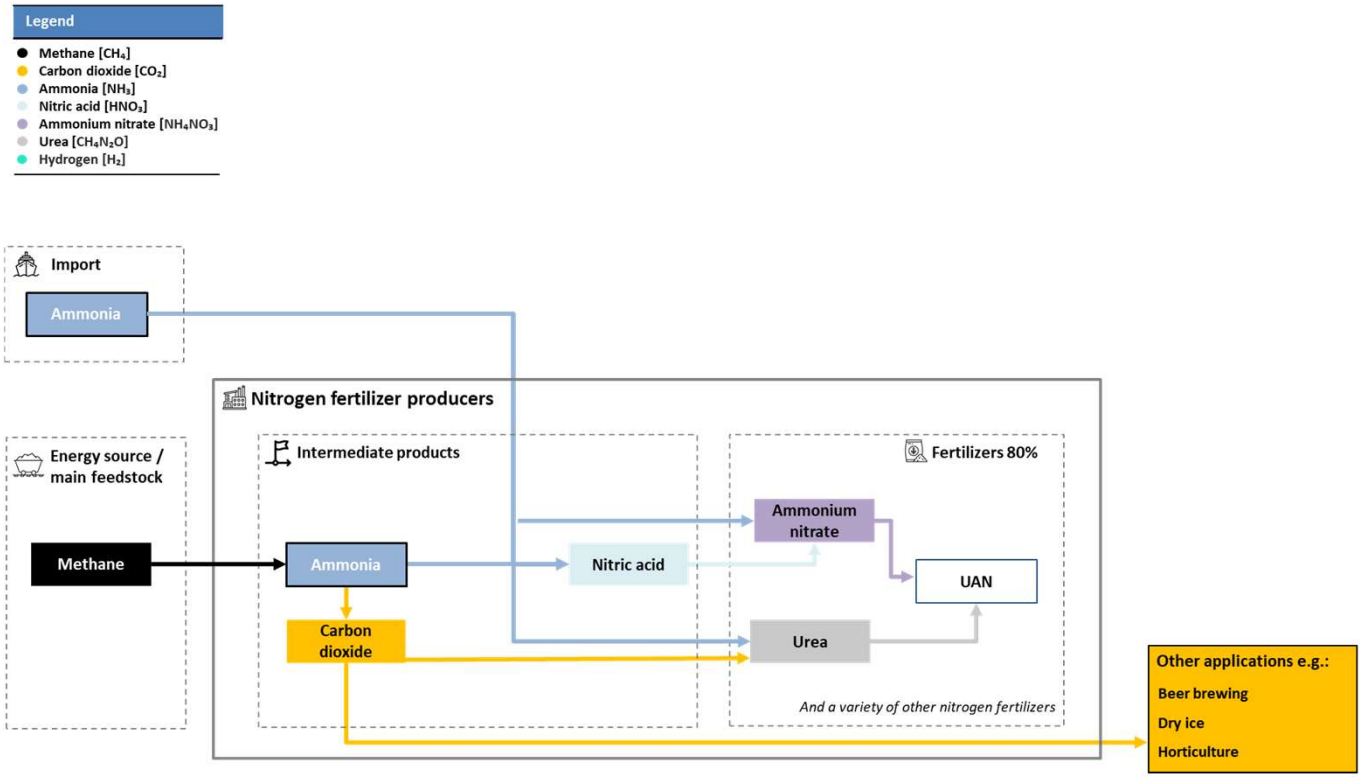


The changing role of ammonia in Northwest Europe, and how the existing ammonia ecosystem in the region may be leveraged to facilitate ammonia's integration as an energy carrier and low-carbon fuel.

Roelof Stam, Researcher at CIEP

Content

Current ammonia supply chain in Northwest Europe



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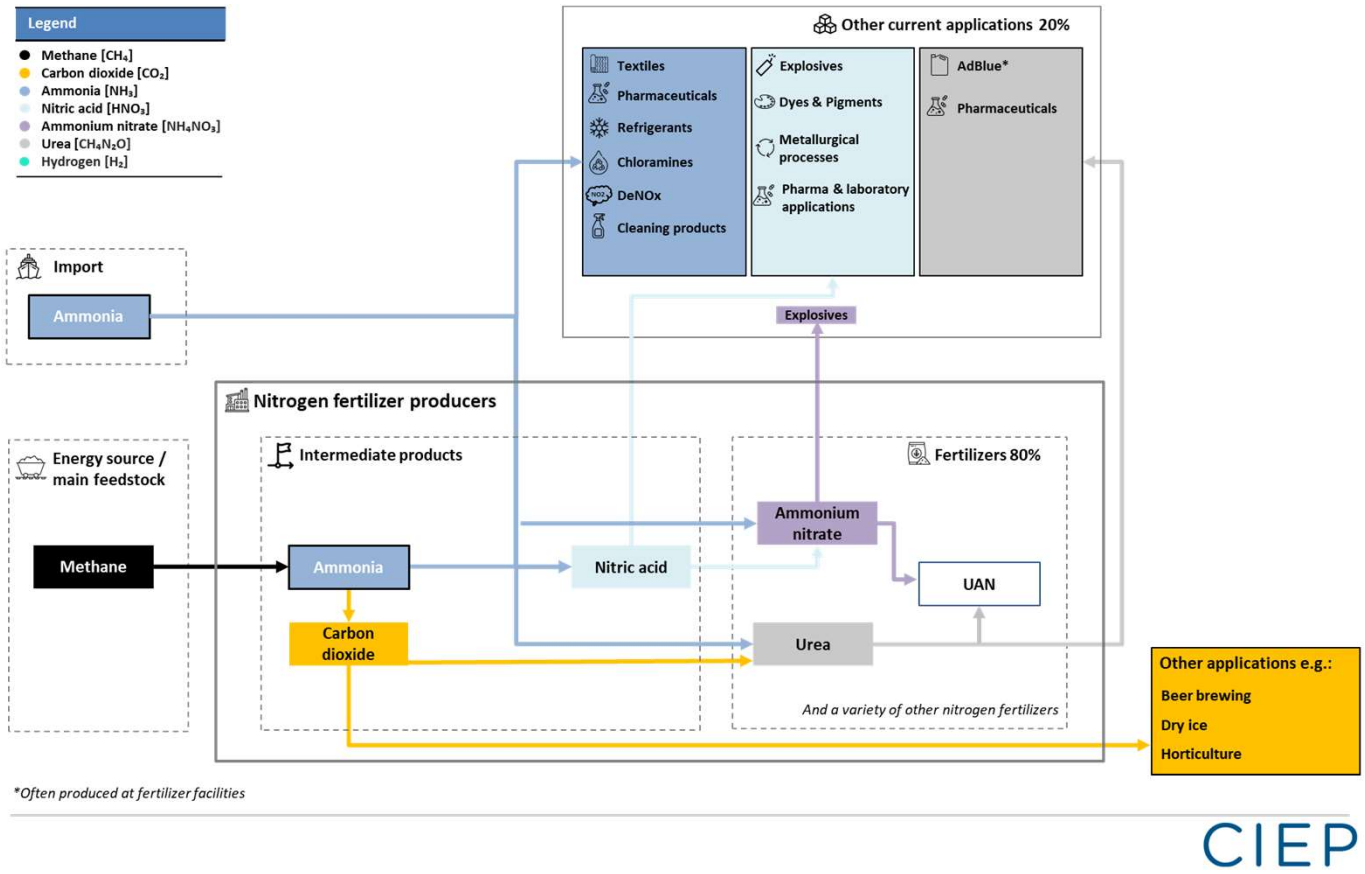
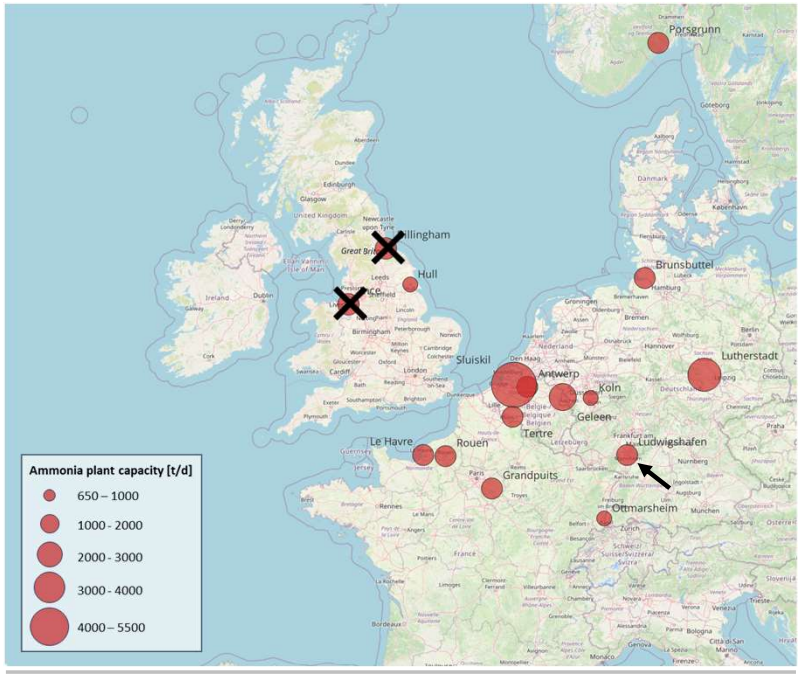
Current ammonia supply chain in Northwest Europe



The effects of the 2022 energy crisis on the nitrogen fertilizer industry in the region

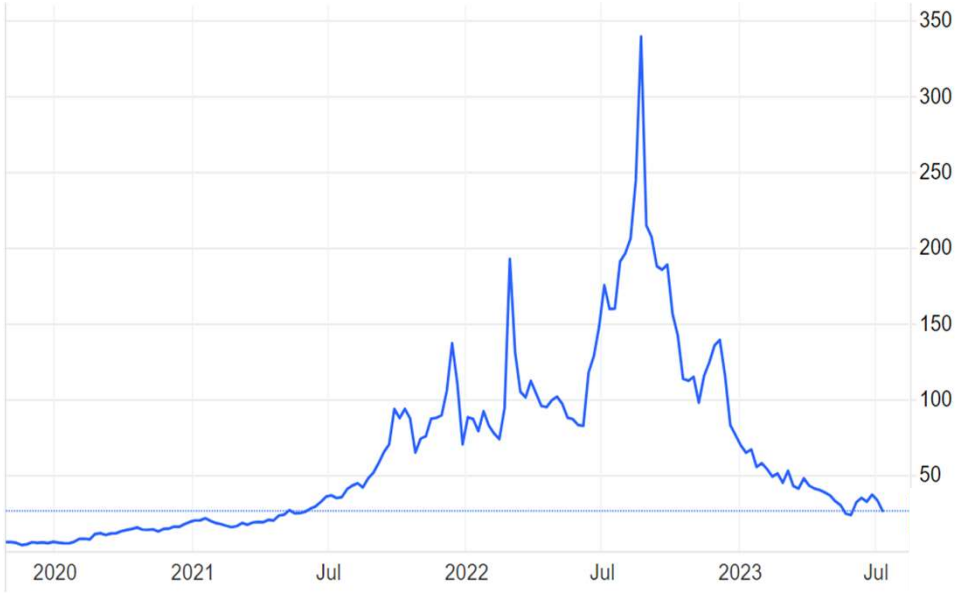
A permanent reduction in ammonia production capacity due to the closure of multiple facilities.

Ammonia plants in Northwest Europe



Made by CIEP, data from: DECHEMA (2022)

Natural gas prices EU, at the Title Transfer Facility (TTF)



Source: Trading Economics (2023). EU Natural Gas.

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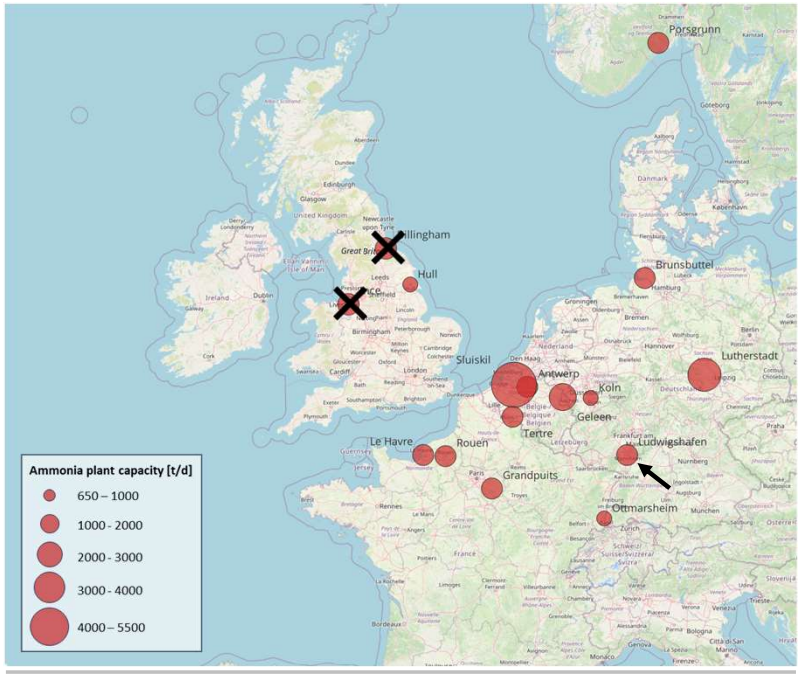

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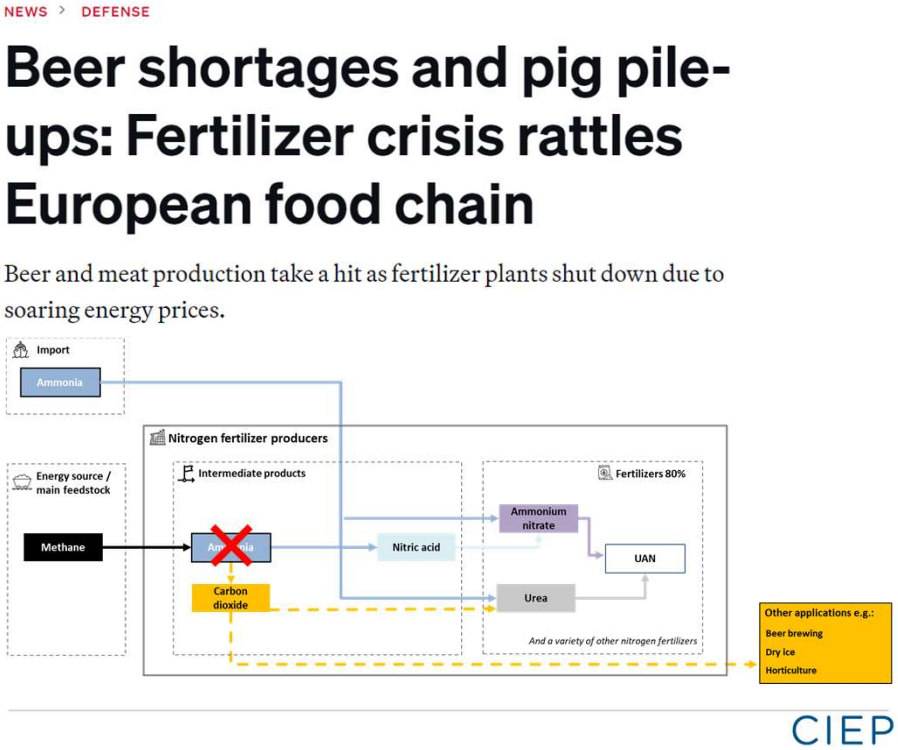

NEWS > DEFENSE

Beer shortages and pig pile-ups: Fertilizer crisis rattles European food chain

Beer and meat production take a hit as fertilizer plants shut down due to soaring energy prices.

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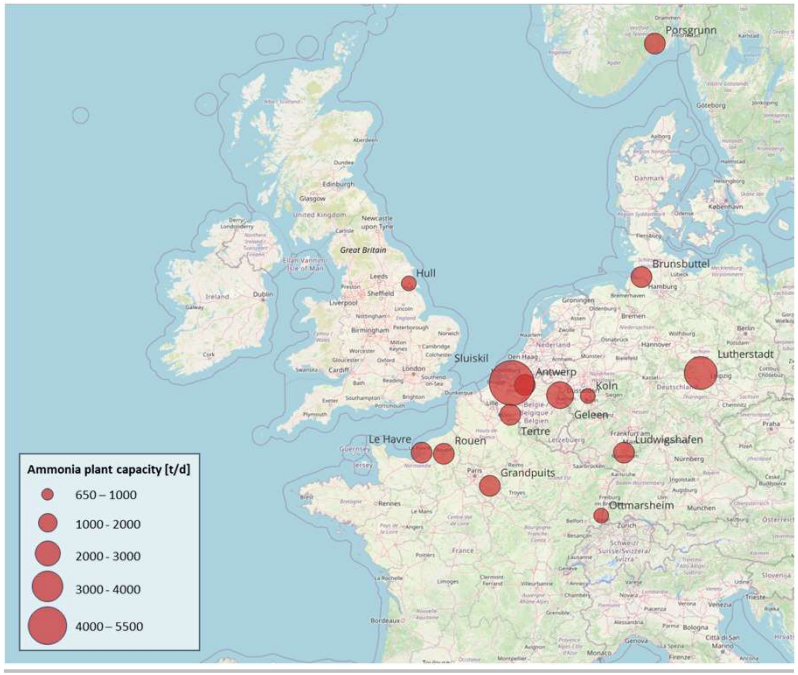
The effects of the 2022 energy crisis on the nitrogen fertilizer industry in the region

More than 70% of ammonia production capacity temporarily curtailed in August 2022, due to high gas prices.

Ammonia plants in Northwest Europe



Made by CIEP, data from: DECHEMA (2022)

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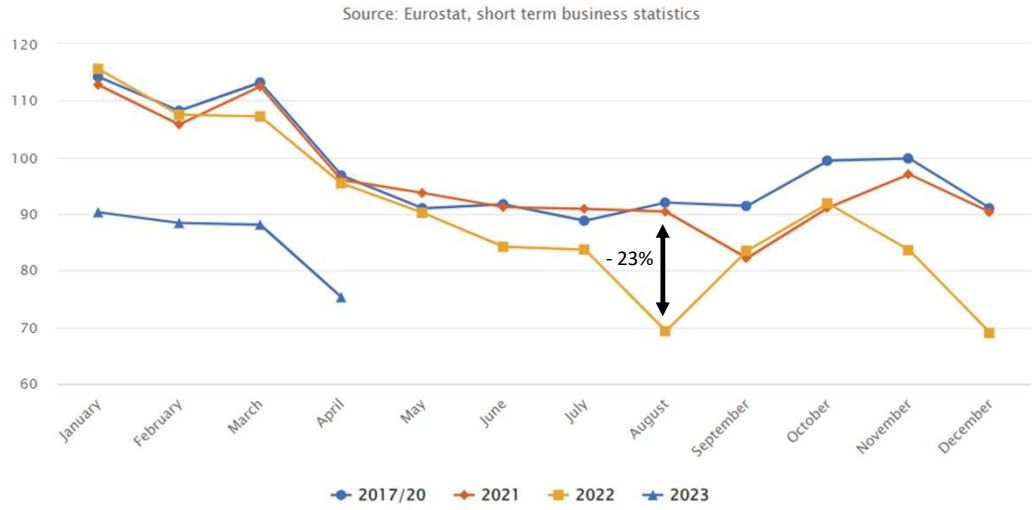
Monthly index of production in volume of fertilisers and nitrogen compounds (EU-19)

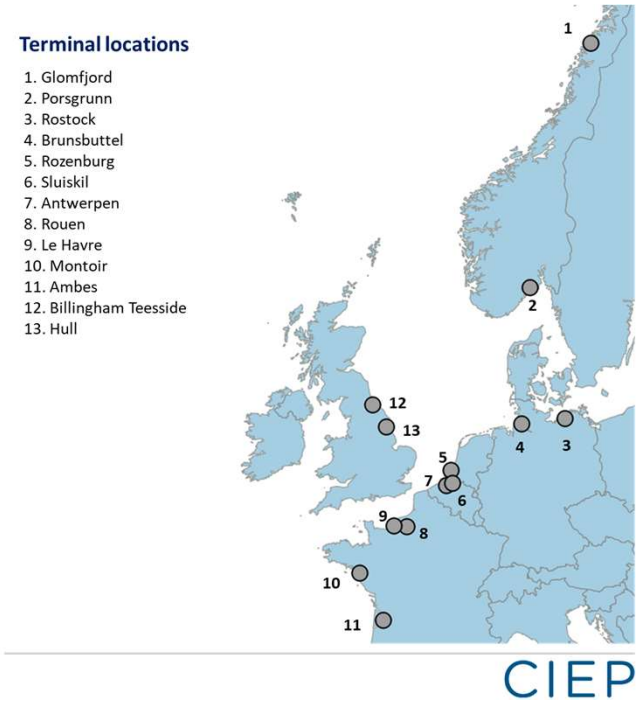


Source: Eurostat (2023)

Ammonia terminals in NW Europe

Although notable import capacity is already available in Northwest Europe, import capacity will need to increase substantially if ammonia will indeed play a role in overseas energy transportation.

Northwest European ammonia terminals



Made by CIEP, Data from: Alternative fuel insights (2023)

In 2019, Northwest Europe imported about 2.4 Mt ammonia

Expanding capacity

Back on the envelope calculation

Caveats of the 10Mt hydrogen import target of the EU for 2030:

1. **Import volume** of ammonia would need to increase with a **factor 14** before 2030*

   Obstacles:
   - *Permitting process*
   - *Safety issues*
   - *Space constraints*

   Part of the solution: repurposing old infrastructure

   * It is assumed 85% of the h2 import target will be imported in the form of NH3, because currently 85% of the H2 export projects focus on NH3 as carrier, the rest of the assumptions can be found in the paper: https://www.clingendaelenergy.com/publications/publication/relaunching-ammonia-from-fertilizer-to-energy-in-northwest-europe

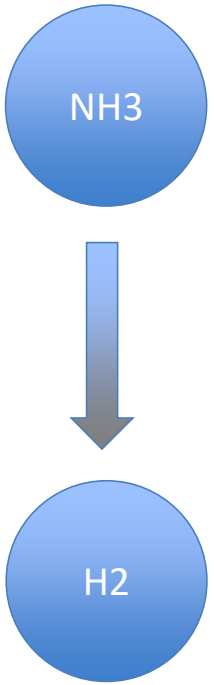
2. **Availability of targeted volume** in 2030 is unlikely
   - Hydrogen Europe estimates 5 Mt available for EU (optimistic)

Cracking at the coast, inland or not at all?

Why convert near a port where it is brought ashore:
Economies of scale, the available infrastructure (storage tanks, jetty's, pipeline entry points) and nearby demand centres.

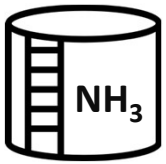
Why convert later in the supply chain, or not at all:

- Countries might want to prefer conversion facilities themselves for security of supply/ strategic reasons
- Space constraints at or nearby ports
- Ammonia transport and storage is often easier due to its higher boiling temperature and higher volumetric energy density, crack close to demand
- When direct use of ammonia is preferred

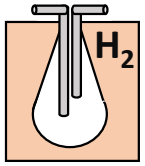


Aboveground ammonia storage

Above surface storage of ammonia could be a good addition to the planned subsurface hydrogen storage to fulfil the Northwest European energy storage needs. Whether this will play a role depends primarily on regulation.



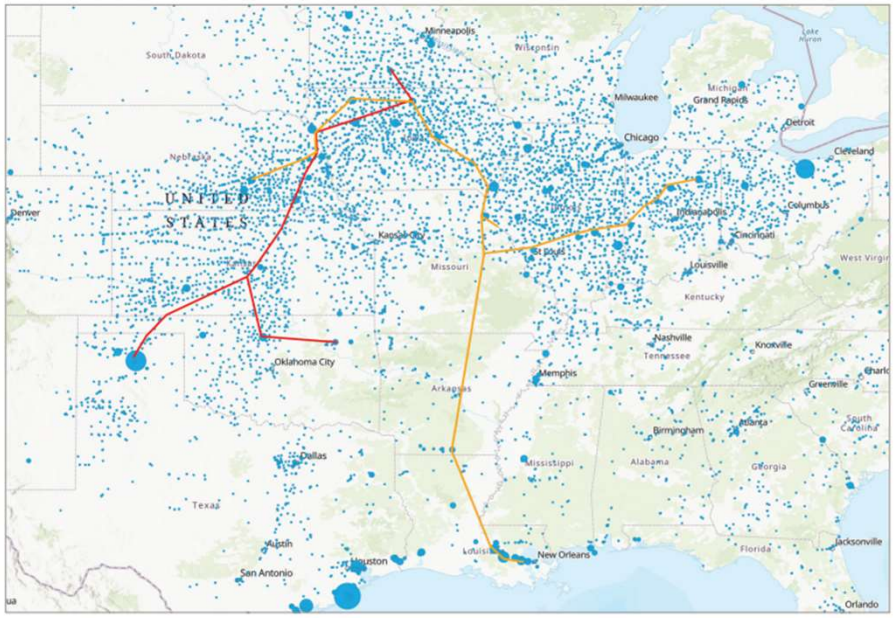
Ammonia storage tank:
50,000 tonnes (260 GWh)



Hydrogen salt cavern:
6-9,000 tonnes (200- 300 GWh)

Tesla model S battery:
100 kWh (2.6 million batteries = 1 NH_3 tank)

The US ammonia network
5,000km+ pipelines and 10,000+ storage facilities



Note: The Magellan Midstream pipeline will be decommissioned in 2020.
Circle areas are indicative of ammonia tonnage. The largest circles correspond to 100,000 tonne facilities.

Source: The Royal Society (2020)

Underground ammonia storage

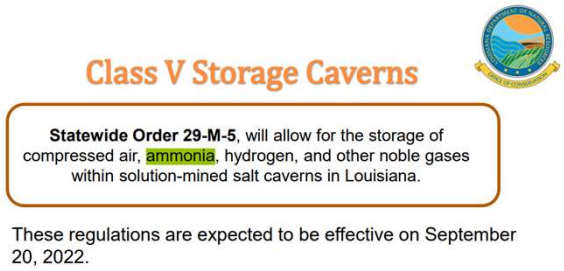
Although research in this area has been limited, it is theoretically feasible to repurpose some of the subsurface storage facilities currently utilized for gas to store ammonia. This offers several advantages over storing hydrogen, including significantly increased storage potential.

Rock caverns

- Since 1986 a **refrigerated ammonia cavern** in operation, in Glomfjord, Norway, storing 60,000 m3 at -33 degrees (≈250GWh)
- **Dupont operated a hard rock cavern** to store ammonia, in Gibbstown, New Jersey
- Most weathered or fractured rock are suitable, but **expensive**

Salt caverns

- First **patent** for storing ammonia in salt caverns originates from 1954.
- **Unclear whether a salt cavern is currently used** to store ammonia
- Uncertainty regarding **geochemical reaction in reservoir** and **toxicity hazards**



Further research is necessary to better understand safety risks

Ammonia as fuel

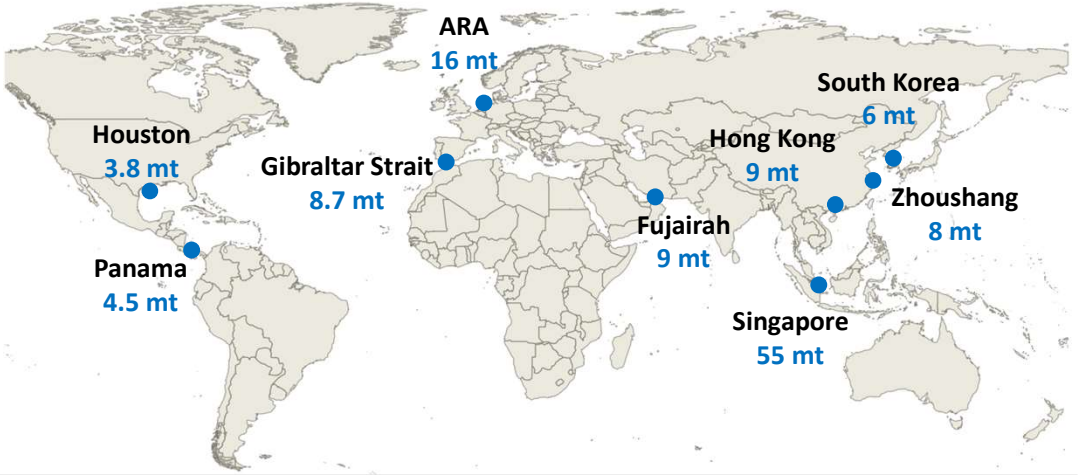
For many applications ammonia is not considered to be the fuel of first choice, due to its toxicity, challenging combustion characteristics, technological immaturity or simply because better alternatives are available. However, ammonia is regarded a promising fuel for ships and possibly power plants for flexible supply.

- First 2 and 4 stroke ammonia engines are expected in the coming years, followed by the first ammonia power ships

- In Japan co-firing up to 20% ammonia (energy value) has been successfully tested in multiple coal-fired prototypes. IHI corporation has demonstrated co-firing of 70% ammonia in an existing 2 MW gas turbine.
- Developments of coal and gas powerplants fully operating on ammonia are on its way

Ammonia as a low-carbon fuel in the NW European maritime bunker sector

Current global bunker market



Source: Repsol (2021)

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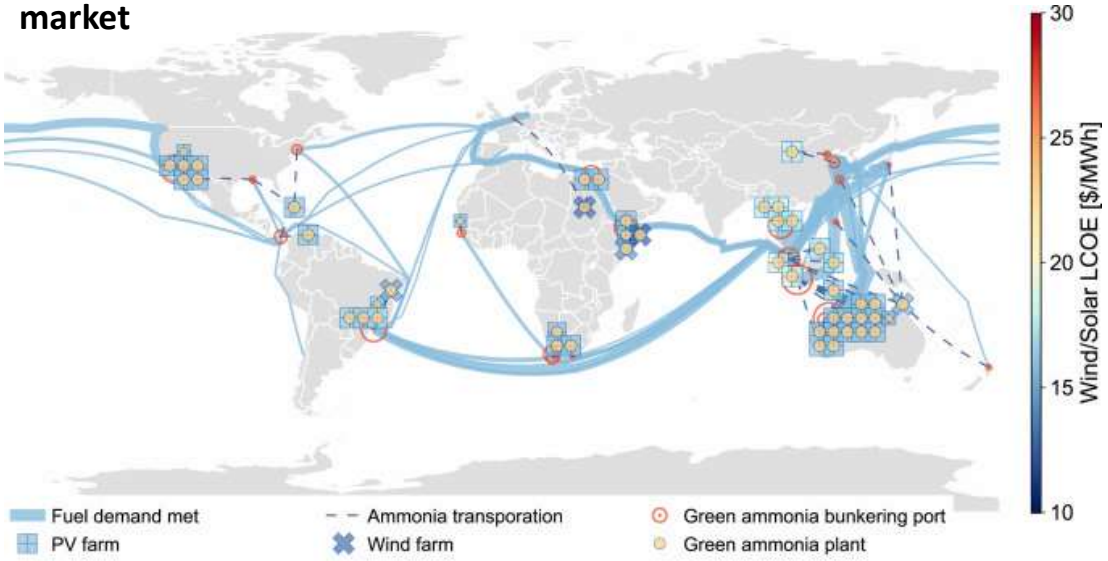
Rotterdam might be well positioned to continue an important role in global ammonia bunker market because:

- Strategic position along major trade routes
- High trade activity
- Large energy cluster
- Existing infrastructure and storage facilities
- Near major industrial centres

Ammonia as a low-carbon fuel in the NW European maritime bunker sector

Techno-economic analysis of a potential future ammonia bunker market



Source: Hunchu Wang et al., (2023). Ammonia-based green corridors for sustainable maritime transportation. https://www.sciencedirect.com/science/article/abs/pii/B9780323851596500981

Modelling ideal ammonia trading routes/ bunker locations based on the cheapest E-production/ammonia costs and main consumption markets shows:

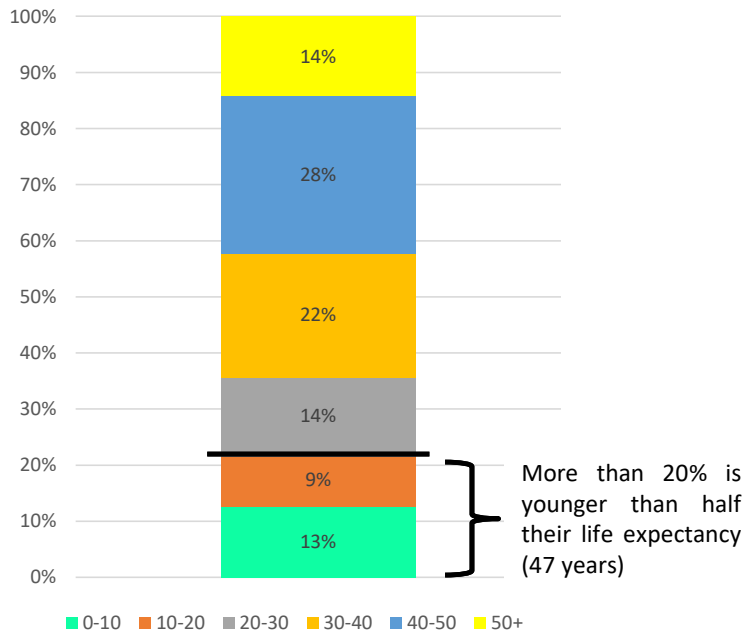
- No bunker ports in Europe.
- Port of Aden (but in Yemen?) and Suez Canal as potential bunker ports. (Neom close to Suez Canal entrance).
- But oil and gas developments show that in addition to techno-economic logic, government intervention and geopolitics also determine developments.
- Moreover, other H2 carriers (f.i. methanol) may compete in future with ammonia. This could create a different bunkering logic.

It remains to be seen how ports in Northwest Europe will compare with bunkering ports that have access to cheap renewables in the future ammonia bunkering market.

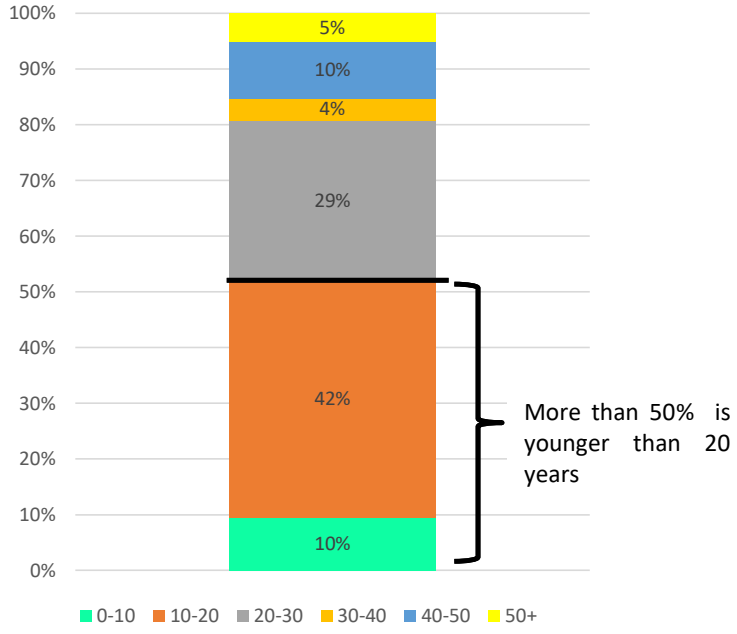
Ammonia as a low-carbon fuel in NW European power sector

A substantial part of the coal and gas-fired power plants in Northwest Europe are still rather young and are potentially good candidates to be retrofitted to (co-)fire low-carbon ammonia or hydrogen. However, the REACH regulation forms a barrier to large scale ammonia use.

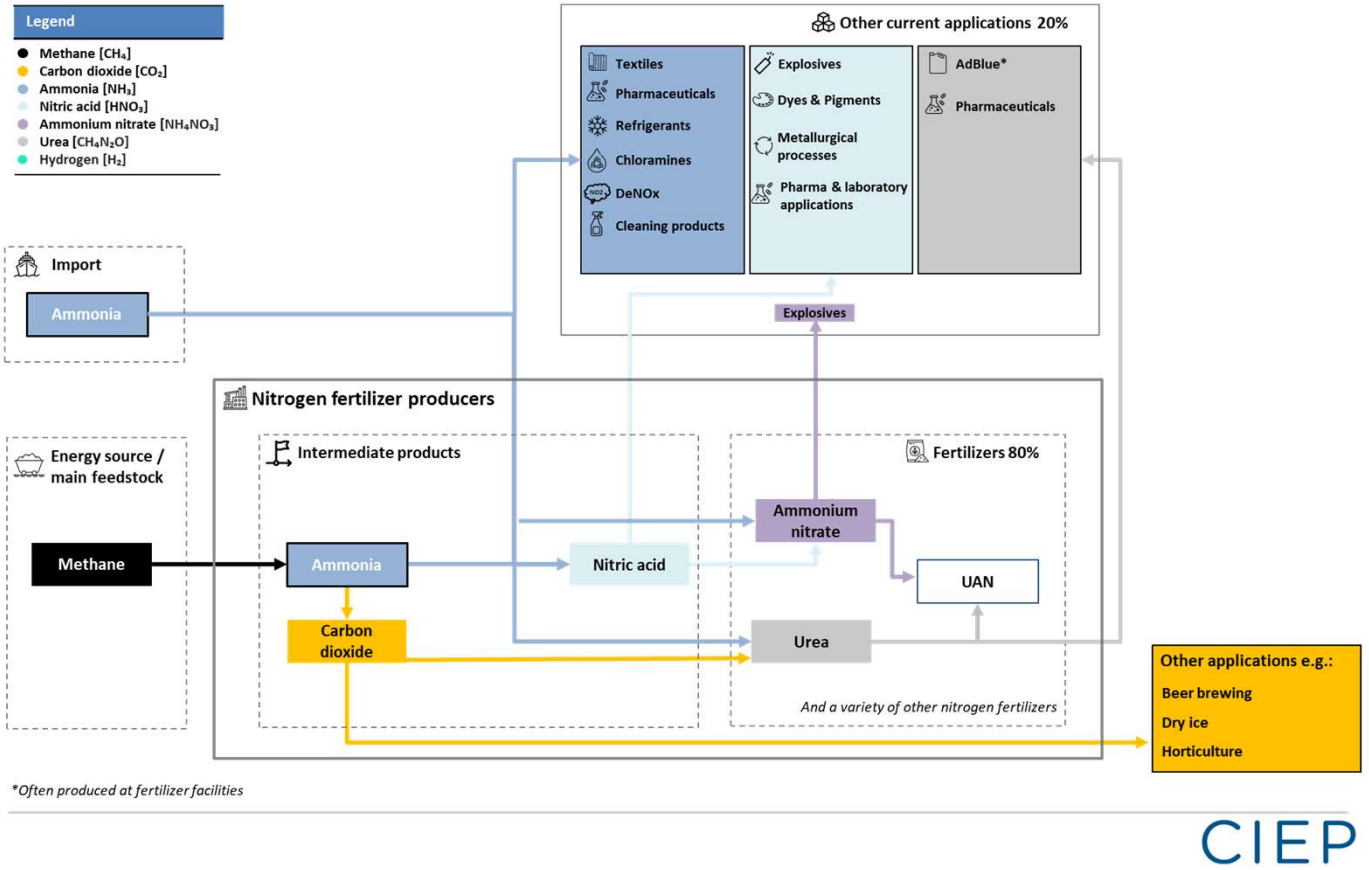
Percentage of coal-fired power capacity in NW EU by age



Percentage of gas-fired power capacity in NW EU by age



The changing ammonia supply chain in NW EU



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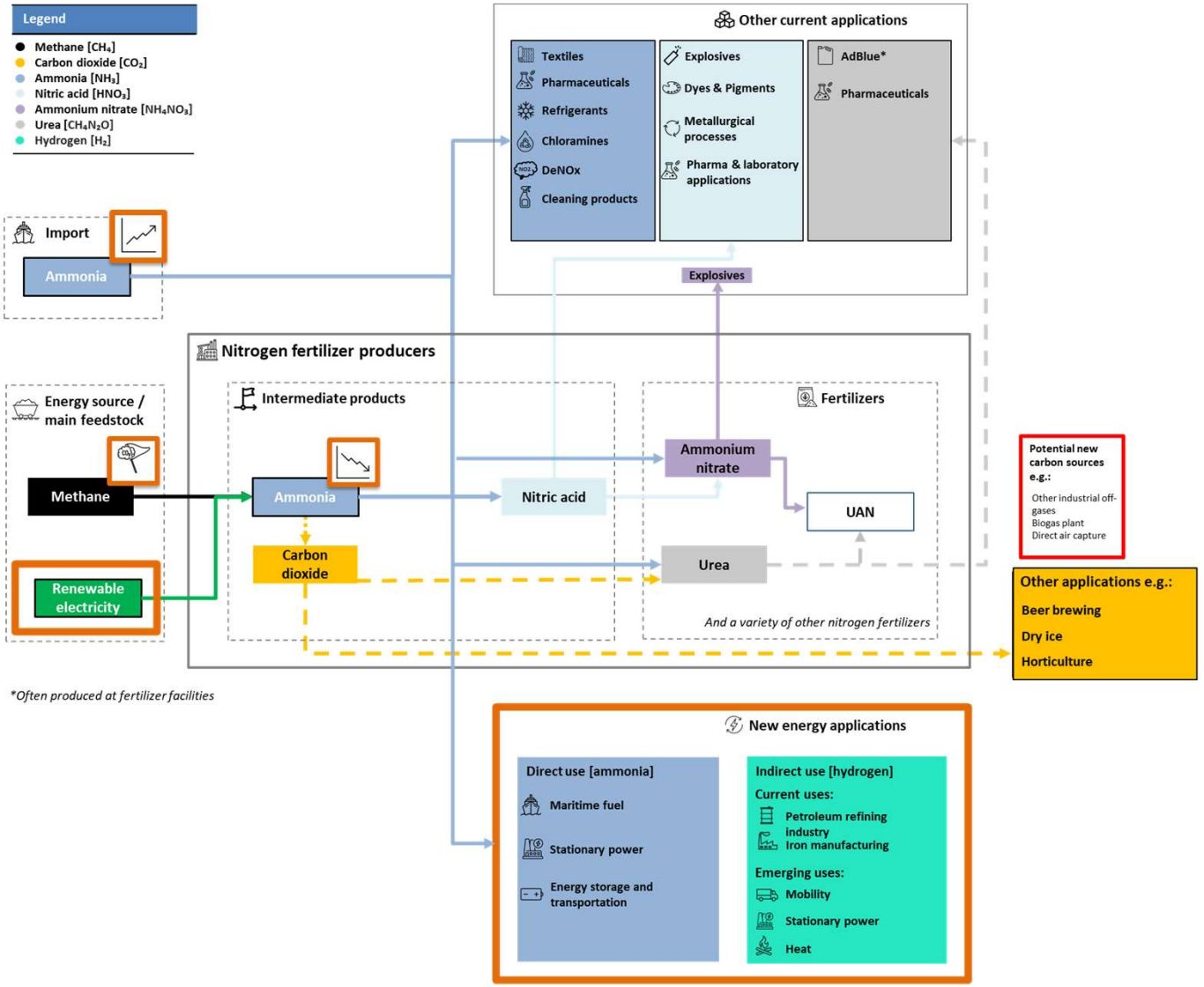

Thank you for your attention

Volgende kennissessie

- Volgende sessie woensdag 20 maart a.s.:
  - 14.30-15.00 Ontvangst
  - 15.00-15.30 Tour de table
  - 15.30-16.00 Diverse onderwerpen, o.a. WHS
  - 16.00-17.00 Varen op duurzame waterstofdragers | PoR & TNO
  - 17.00-18.00 Borrel

Datum	
Woe 20 maart	F2F
Woe 17 April	Online
Woe **22** mei	F2F
Woe 19 juni	Online
Woe 10 juli	F2F
Woe 18 september	F2F
Woe 16 oktober	Online
Woe 20 November	F2F
Woe 18 december	Online

SHIP>NL Sessie II 21 februari 2024

Hartelijk dank voor uw aandacht

Vragen? Neem gerust contact met mij op:

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Monique.Rijkers@tno.nl
+31 6 23 34 65 16

De slides van alle sessies zijn te vinden op:
SHIPNL: Sustainable Hydrogen Import Program Netherlands | Nationaal Waterstof Programma