

#### HYDROGENCARRIERS AND THEIR SAFETY ISSUES IN THE ENERGYTRANSITION

#### Antea Group

Understanding today. Improving tomorrow.

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#### Introductie





Strategic consultant SAVE Antea Group Energie enOndergrond E: monique.berrevoets@anteagroup.nl M: 06-53 72 62 01 Clients:

- Central and local authorities
- Infrastructure Managers
- Seveso companies







#### Vestigingen in

Nederland

Frankrijk

België

Spanje + Latijns-Amerika

Polen

UK

USA

India

Brazilië

Verdeeld over 90 kantoren





#### Need for energy transition: IPCC AR6 Synthesis Report: Climate Change 2023

0.9-2.0°C



<sup>5</sup>Projected regional impacts reflect fisheries and marine ecosystem responses to ocean physical and biogeochemical conditions such as temperature, oxygen level and net primary production. Models do not represent changes in fishing activities and some extreme climatic conditions. Projected changes in thea Arctic regions have low confidence due to uncertainties associated with modelling multiple interacting drivers and ecosystem responses.

3.4-5.2°C

#### **Energy sources**

- Until recently: fossil fuels (and nuclear power)
- Transition: fossil fuels = > green energy: solar, wind
- Future: will this fulfill all our energy needs?







### In search of green energy

- Energy from sun and wind
- Nuclear power stations:
  - Pro: No CO2 emissions
  - Con: Pass on nuclear waste to future generations; realization period>>years;
- Need for more green energy: where to find it?

### Example: solar energy





### How do we transport this overseas?



- As H<sub>2</sub>: not efficient (expensive and technical difficult)
- Looking for H<sub>2</sub> carrier
- Options:
  - NH<sub>3</sub>, LOHC's; LH<sub>2</sub>; methanol; Natrium*Boor*hydride, Dibenzyltolueen; ...
  - (Source: Presentation Stakeholder meeting H<sub>2</sub> carriers)
- What is the best available option on a short term?

### Factor: storage e.g. 2.670 ton H<sub>2</sub>



- NH<sub>3</sub>: 20.000 m<sup>3</sup>
- LOHC: 55.900 m<sup>3</sup>
- H<sub>2</sub> (cooled) : 38.000 m<sup>3</sup>
- H<sub>2</sub> (under pressure): 188.000 m<sup>3</sup>

Available space?

### Factor: How to transport inland



#### • LOHC

- Most LOHCs also require transport back to the source.
- Experience available at Dutch pipeline operators with hydrocarbon-based substances.
- Many LOHCs can be transported via pipeline
- Less toxic than Ammonia

#### • Ammonia

- Promising because of (boiling point, flash point and energy density)
- Limited experience available at Dutch pipeline operators
- Toxic hazard plays a major role
- Resistance if transport via rail

### **NH3 Market Expectations**



#### **AMMONIA MARKET STATUS AND PROSPECTS – DEMAND SIDE**



Expected ammonia demand up to 2050 for the 1.5°C scenario

Source: IRENA and AEA, 2022

- Green ammonia to replace current ammonia demand
- Future possible green ammonia applications as shipping fuel, hydrogen carrier and power generation
- 269 Mt under development worldwide.
- 133 Mt clean ammonia projects are under development in EMDCs (ex China)
- EMDC 112 projects (around half of all projects under development worldwide) have an average size of more than 1 Mt
- 1.4 Mt is under construction (1%)





#### **NH3 Market Expectations**



#### PRODUCTION COSTS - BY 2050 COSTS EXPECTED TO FALL TO USD 310-610/T



A THE WORLD BANK

Current and future production costs of renewable ammonia

- Ammonia spot price peaked in 2022, back to normal since
- Green ammonia production cost in good locations are lower than spot prices
- Hydrogen cost dominate renewable ammonia production cost (nearly 200 kg hydrogen/t ammonia)
- Many estimates but no public prices for green hydrogen or renewable ammonia at this moment – H2Global and European Hydrogen Bank will create some clarity through auctions





#### NH3 in the Netherlands





#### **Energy to Western Europe via ports**





#### Need to consider the whole chain





## Ammonia as a hydrogen carrier



- Characteristic of energy transfer substances: always a danger aspect:
  - Fossil = flammable
  - LPG = flammable and explosive
  - Hydrogen: explosive(!) and flammable)
  - Ammonia:





Safety at terminal is very important...but is not enough

- 1. Storage upstream also requires high safety level
- 2. Transport over sea: is current legislation fit for purpose? New companies will enter the shipping market? New fuels: ammonia, hydrogen, methanol, ...? Safety issues well known? TRL?
- 3. Storage at Dutch (European) ports: new PGS12
- 4. Transport inland: Available modalities? Public perception!

Policy of Antea Group:

to be able to help our clients we decided we need to be able to assist and give safety advice for every element of the chain



Storage upstream also requires high safety level:

- Current legislation overseas fit for purpose?
  - PGS12 implementation worldwide is already mentioned, but need to consider local situation
- Legislation differs per country, but what's needed in an early phase is always an indication of risk
  - Quick indication of risk (QRA) within a few minutes instead of weeks would be nice
- Engineering requires thorough knowledge of NH<sub>3</sub>
  - We extended our knowledge basis on NH<sub>3</sub> throughout the years and are now also able to support in the engineering phase



Transport over sea:

- is current legislation fit for purpose?
- new companies will enter the shipping market: is the level of knowledge of NH<sub>3</sub> sufficient?
- use of new energy fuels like NH<sub>3</sub>: crew not used to work with dangerous substances
- entering a port area: risks of collision with ammonia vessel



- New PGS 12 guideline
- Omgevingswet
- Aandachtsgebieden
- Participatie



#### PGS12:

- How to get your permit the right way, referring to the new PGS12
- Concept PGS12-2023 for large-scale NH<sub>3</sub> storage
- Motto: high safety requirements at the source (left side of the bow tie because: prevention is better than repression)
- In PGS12: requirements for piping, full containment tanks, no penetrations, etc.
- PGS12 for existing tanks: work in progress, but in principle customization applies (every tank is different)



Aandachtsgebieden:

- *aandachtsgebieden* in stead of societal risk calculations
- based on the effect, no matter the probability of an incident
  - but some authorities still oblige companies to perform a societal risk calculation
- 300 meters? 800 meters? 1.500 meters? More?
- effect reaches out for kilometers (depending of wind, process, diameter leakage, pressure leakage, etc)



- It's all about safety: but other environmental topics need attention (NOX, ecology, energy, ...)
- Especially Environmental Risk Analyses (MRA) needs attention: required model not suitable for NH<sub>3</sub>
- E.g. incident Kansas, West of Kingman, Kansas (2004)

#### Accident 2004, west of Kingman, Kansas

- 8-inch-diameter pipeline (68 bar)
- released approximately (204,000 gallons) ammonia
- Nobody was killed or injured
- Spilled into a creek killed > 25,000 fish (some threatened species).
- accident cost \$680,715, including \$459,415 for environmental remediation.



Figure 2. Ammonia vapor cloud moving northwest from pipeline rupture.



Transport inland/hinterland:

- In an early stage consider your options: which modalities are available
- Preferred options from a safety point of view



- Road: small quantity per transport (only applicable for 'provisioning')
- Inland shipping not always possible (low water level), and less 'fine-meshed' (accessibility)
- Rail is the 'easiest' and already available, but through towns and villages
- Ammonia pipeline to Germany does not yet exist
- In the Netherlands: Basic network (max risk levels, but under construction)

### Safety aspects and Participatie: because



Menu = # Recest Zrevaart Wegvervoer Haveas Binnenwaart Lucht Spoor 1 Grote zorgen DCMR over risico's grootschalige inzet ammoniak Milieudienst DCMR heeft grote zorgen over de grote risieo's van de groeiende op- en overslag van het zeer gevaartijke ammoniak in de Rotterdamse en Zeeuwse havens. 000 ROB MACKOR = 21 februari 2023 11:56 De opstag van ammonitak gebeurt onder andere is Shirokir. © Yara

#### CDA Rotterdam wil debat over 'schadelijke' ammoniakopslag

Het CDA in de Rotterdamse gemeenteraad vraagt opheldering over de uitbreiding van de ammoniakopslag in de Europoort. De partij wil daarover donderdag in debat met milieuwethouder Zeegers. Gert Onnink 31-10-23, 11-11



Zorgen over ammoniakopslag bij bewoners: 'Moetr ENERGIETRANSITIE

voor onze veiligh 'Komt er een gifwolk over Ondanks de zorgen van bewoners kans klein det er aanvullend milier kans klein det er aanvullend milier Schiedam heen, dan ben je je utbreiding van de ammoniakopsi wethouder Zeegers houdt die deu draagvlak natuurlijk helemaal kwijt. En je energie'

Bij opslag en transport van waterstof wordt veel ammoniak gebruikt. DCMR is bezorgd over de veiligheidsrisico's voor de havens in Rotterdam en Zeeland. "Bij grootschalige ammoniakopslag heb je het zo over 100.000 treinwagons per jaar."

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# Transport (safety doesn't end at the gate) anteagroup



Serbia, 25 December 2022 2 killed, 62 hospitalized



JW.

### The road to startup a terminal



- Pre feasibility: critical points on the (permit) path, e.g. quick indication of risk contour
- Engineering advice
- Nautical advice
- Participation neighbours: safety is an/the most important topic
- Application for an environmental permit:
  - EIA/MER; Water, Nature, NOX, Air Quality, Soil, Noise, ...
- All necessary Seveso requirements:
  - VR, QRA,, MRA, PGS12 check, incident control advice, Fire safety, ..
- Advice on setting up a terminal in the field of safety: where are the largest risks, how to manage
- Advice on transport from a risk/safety perspective
- Advice on setting up terminal operations: VMS, VBS, Pbzo

#### Concluding



- Energy transition is a necessity
- Knowledge gap among many parties
- As Antea Group, we want to share knowledge, make knowledge easy to find: <u>Ammoniak Expertisecentrum van Antea Group</u>
- Additional:
  - Workshop new energy carriers: Workshop Ammoniak en waterstof in de energietransitie | Antea Group
  - Cooperation with ammonia engineer/maintenance/management
  - Expertise nautical safety





### Thank you for your attention!

### **Questions?**