Stikstof terugwinning

Maar waarom dan?...

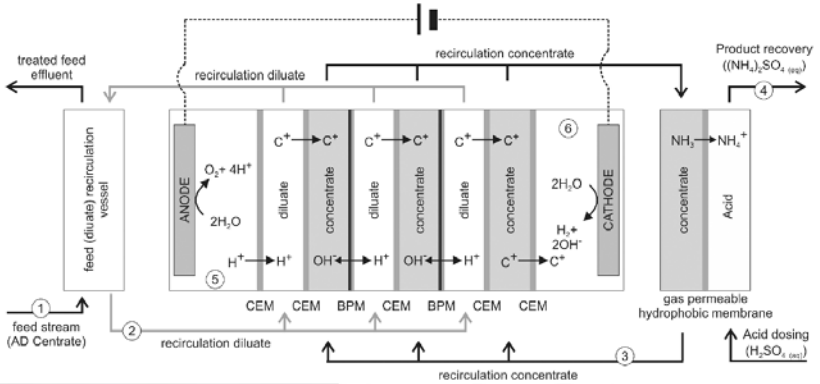
XXXX-RHD-XX-XX-PP-X-0001
Confidential
Marco Kerstholt
12 March 2024

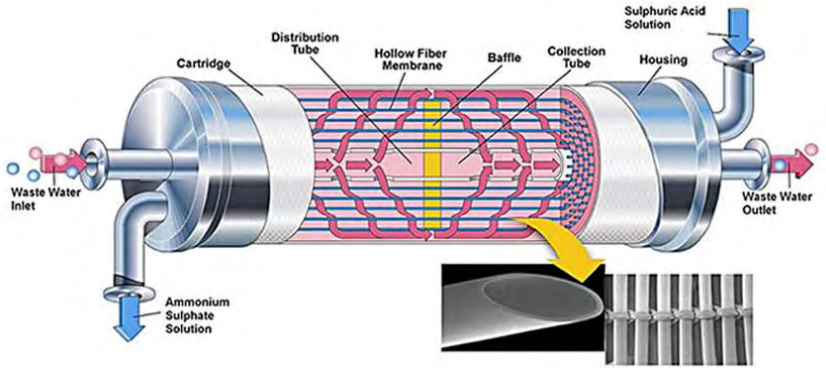
Introduction

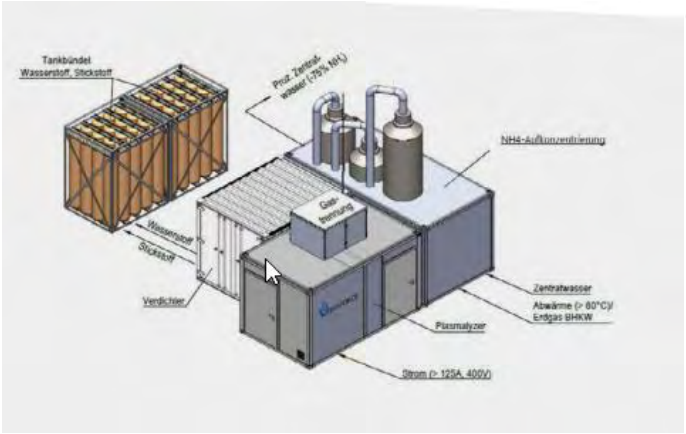
- Marco Kerstholt
- Senior process Engineer

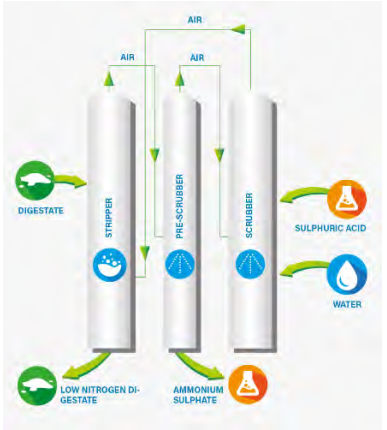
- 2008 started at (Royal Haskoning)DHV
  - Water for industry
  - 4 years South Africa, 2015 - 2019
  - Since 2022 member of the R&D team

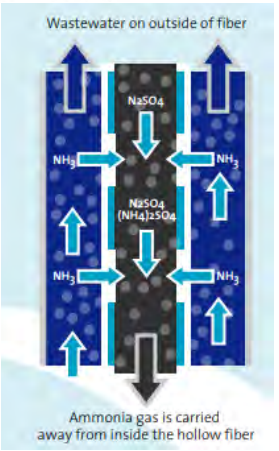
Search of new technologies for nitrogen recovery











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Drivers for nitrogen recovery

Let's dive deeper into this matter

- Why recover nitrogen?
  - Driving force for a circular economy
  - Ammonia production causes a significant CO_2 emission globally
    - Haber-Bosch process is responsible for 99% of ammonia production
    - Ammonia production emits 1.8% of the global CO_2 emission
  - Biological treatment of return liquors are becoming less popular
    - Infection with legionaries (health risk)
    - N_2O emission (significant contribution to global warming)

Why would we want to recover nitrogen?

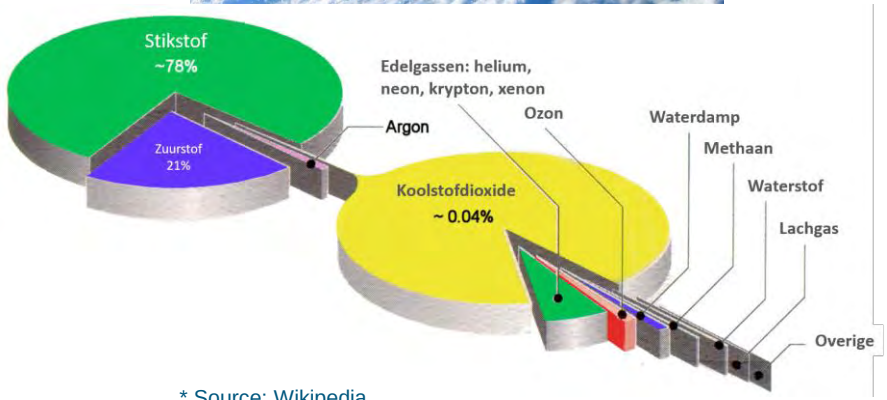
1. Scarcity

2. Sustainabillity (SMART: CO_2 footprint)

Why would we want to recover nitrogen?

Scarcity

- Nitrogen stored in atmosphere 5.15 * 10^9 Mton-N/year*
- Yearly production of ammonia 2021 – 150 million metric tons of ammonia (123 Mton-N/year)



* Source: Wikipedia

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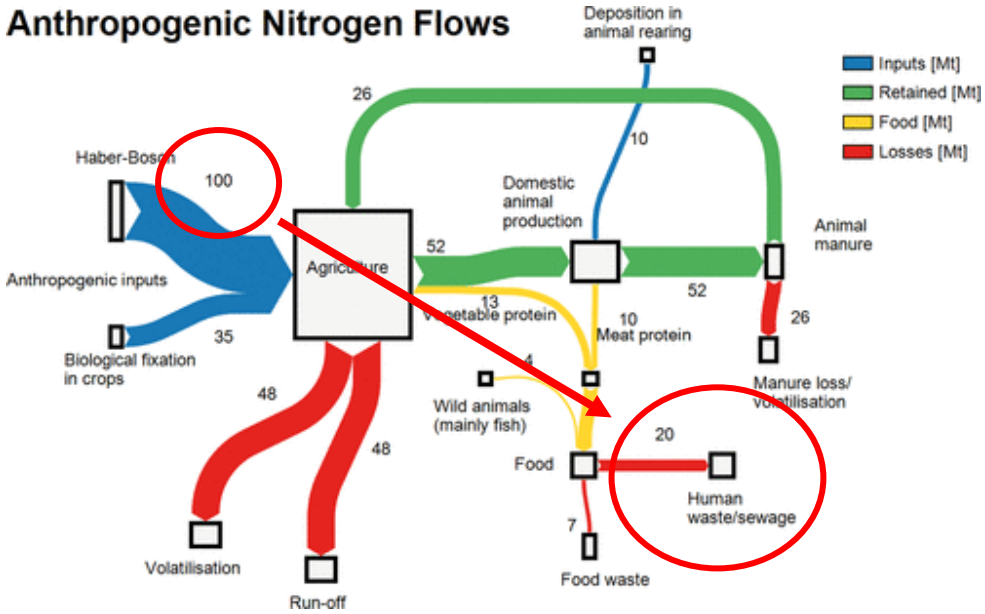
Global nitrogen balance

- Yearly production of ammonia 2021 – 150 million metric tons of ammonia (123 Mton-N/year)
  - 80%* used for fertilizers
  - Only 17%* ends up in crops, dairy and meat products (63% is lost in agriculture/food production!)
- Yearly excretion by humans - 20 Mton-N/d (approx. 16% of the total production)
- Nitrogen released in digestion – 3.5 Mton-N/d (approx. 17.5% of nitrogen to WWTP or 3% of total production)
  - 600 mg COD/l, 60 mg-N/l, Yield 0.4, 8%N and 50% ODS reduction
  - Assumed all wastewater is treated globally (which is not the case)
  - Assumed all wastewater treatment plants have a digester (which is not the case)



Bron: Silvio Matassa; Can Direct Conversion of Used Nitrogen to New Feed and Protein Help Feed the World? 2015

* Bron: Ammonia: zero-carbon fertiliser, fuel and energy store 2020, The royal society

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Nitrogen production in NL

- Yara Sluiskill produces 1.8 Mton ammonia/year (0.7% of global production)
  - 50% of global nitrogen recovery potential from return liquors
  - Nitrogen recovery potential in NL 170 ton ammonia/year (0.01% of production @ Sluiskill)

Impact of Hydrogen economy on Ammonia production

- Compared to hydrogen, ammonia is:
  - Easier to transport (higher energy density)
  - Lower risk during storage and transport (lower ignition energy)

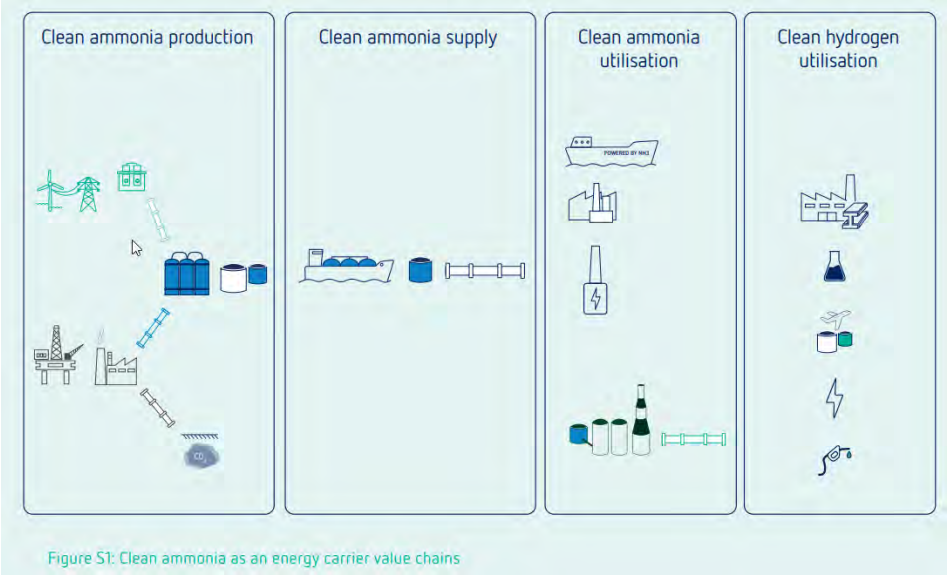

Figure S1: Clean ammonia as an energy carrier value chains

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Impact of Hydrogen economy on Ammonia production

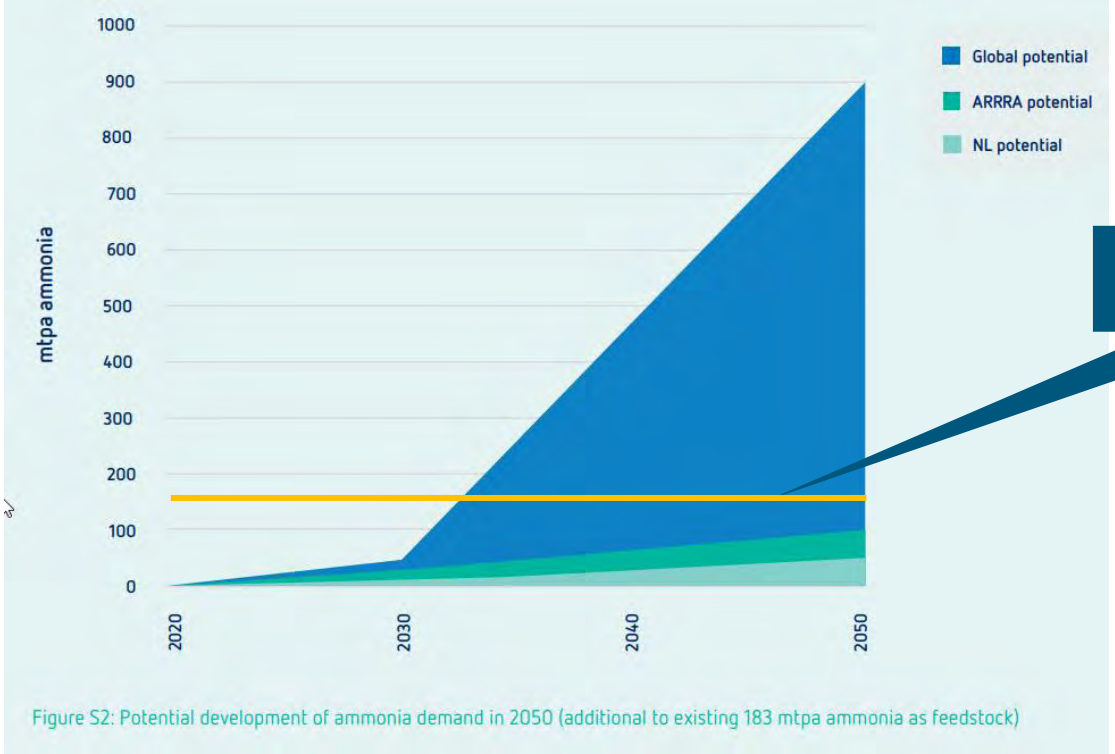

Figure S2: Potential development of ammonia demand in 2050 (additional to existing 183 mtpa ammonia as feedstock)

- Source: Clean ammonia roadmap 2024, ISPT (institute for sustainable process technology

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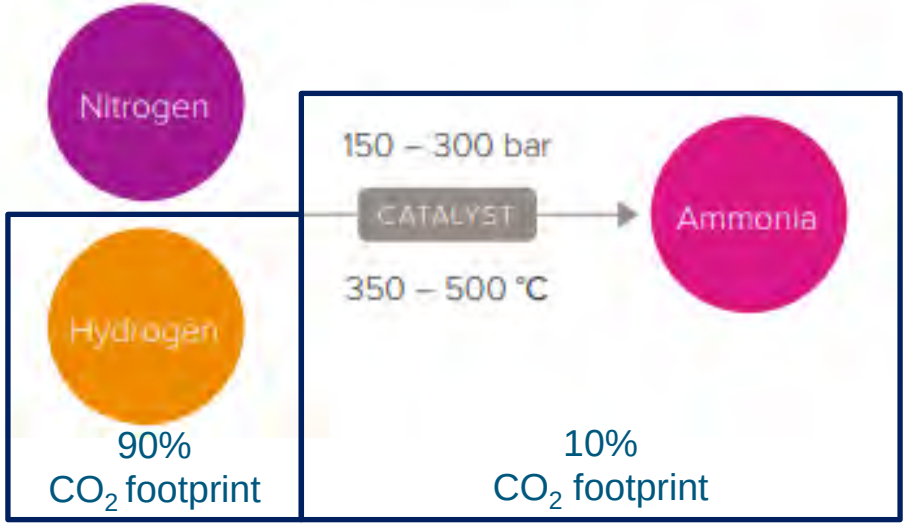
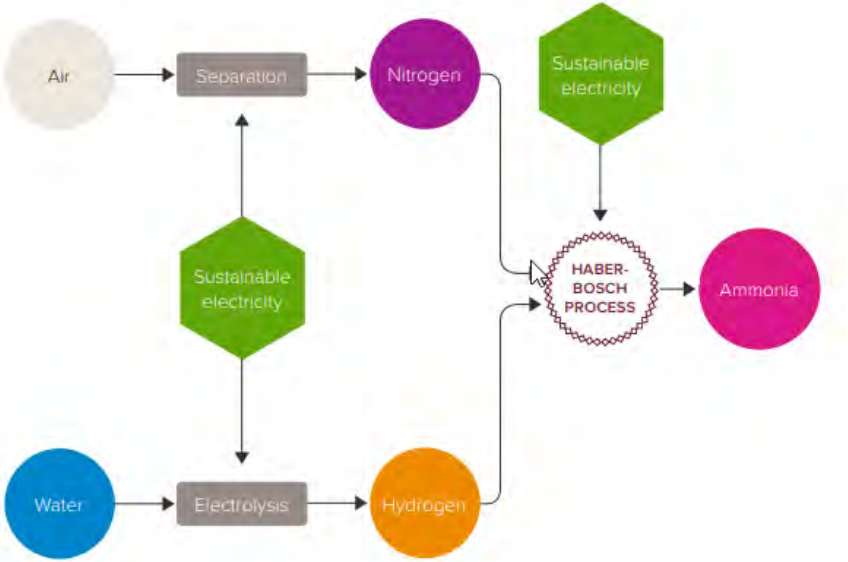
Haber-Bosch process (current)

Schematic of the Haber Bosch ammonia synthesis reaction.



Haber-Bosch process (future)

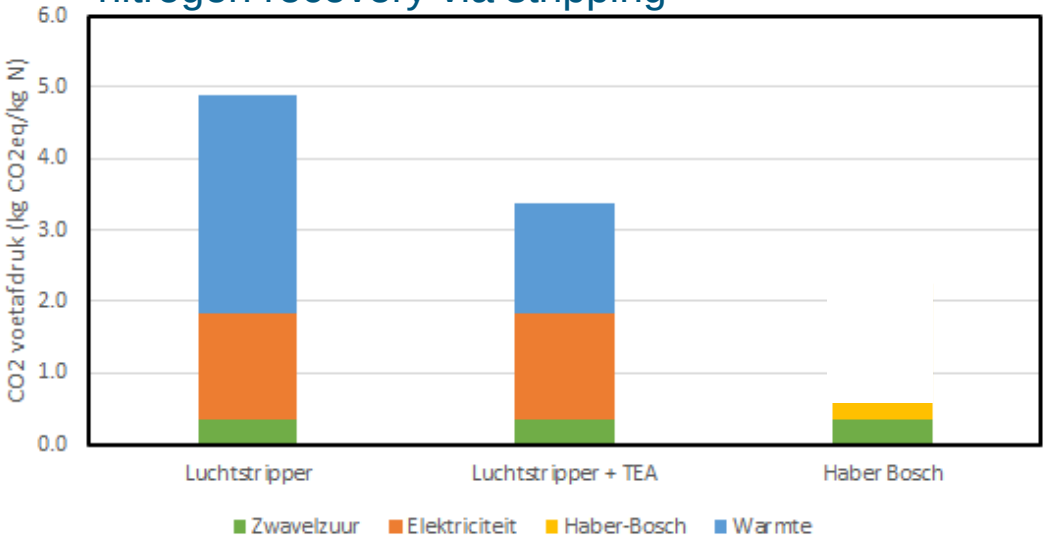
Schematic of green ammonia production based upon hydrogen production from water electrolysis and the full decarbonisation of the Haber-Bosch process.



Detailed evaluation – sustainability nitrogen recovery

CO_2 footprint

- Direct comparison between ammonium sulphate with nitrogen from Haber-Bosch and nitrogen recovery via stripping*



Haber-Bosch has a significantly lower footprint than recovery from wastewater

Treatment efficiency might improve but so does ammonia production! If green hydrogen would be applied the CO_2 footprint drops by 90%!

* Based on a system selection study for nitrogen removal on return liquors

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Why would we want to recover nitrogen?

Conclusions

- Nitrogen is not scarce → No necessity for reuse

- Nitrogen recovery doesn't make an impact on the world nitrogen production
  - In the future this impact will be even less with the upcoming hydrogen/(ammonia) economy

- CO_2 footprint of nitrogen recovery higher than of the Haber-Bosch process

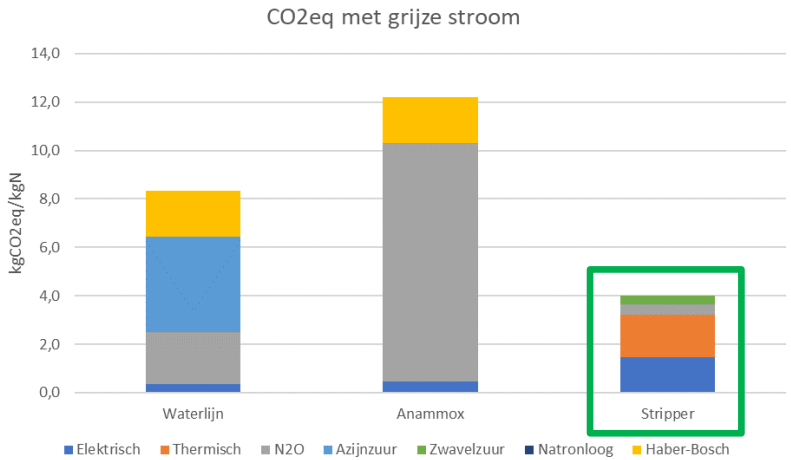
Should nitrogen recovery then even be considered at WWTPs?

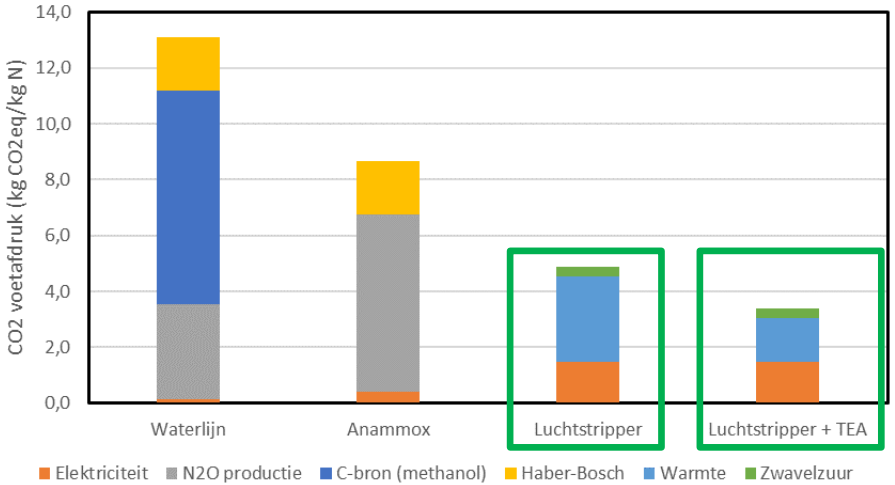
Change of viewpoint: WWTP

CO_2 footprint

Nitrogen recovery, however, can reduce the CO_2 footprint of the complete value chain of treatment

(Do note your starting points have an impact on the outcome: (in)sufficient COD for DN, N_2O emission factor, availability of excess heat, nitrogen concentration in return liquors, etc.)





System selection nitrogen removal on return liquors

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Change of viewpoint: WWTP

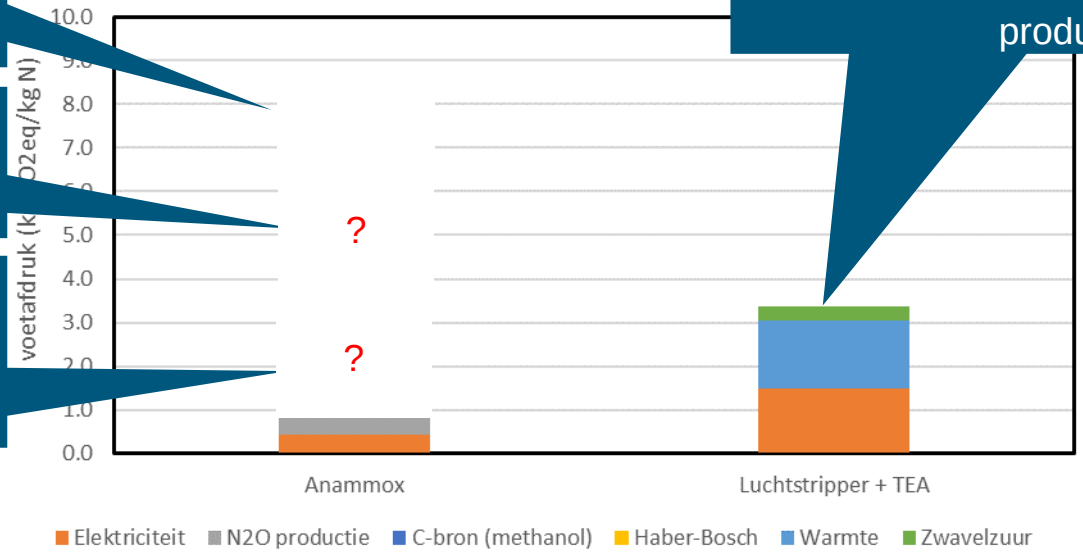
Biology vs nitrogen recovery

Impact of ammonia production will diminish over time

Knowledge about N_2O production is increasing!

N_2O can also be dealt with by post gas treatment (DeNOX, LOTOX)

Opportunities to strengthen its position:
- Use of waste heat (nearby industries?)
- Use of recovered ammonia for energy production



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Nitrogen recovery isn’t a goal

It’s just another alternative for nitrogen removal