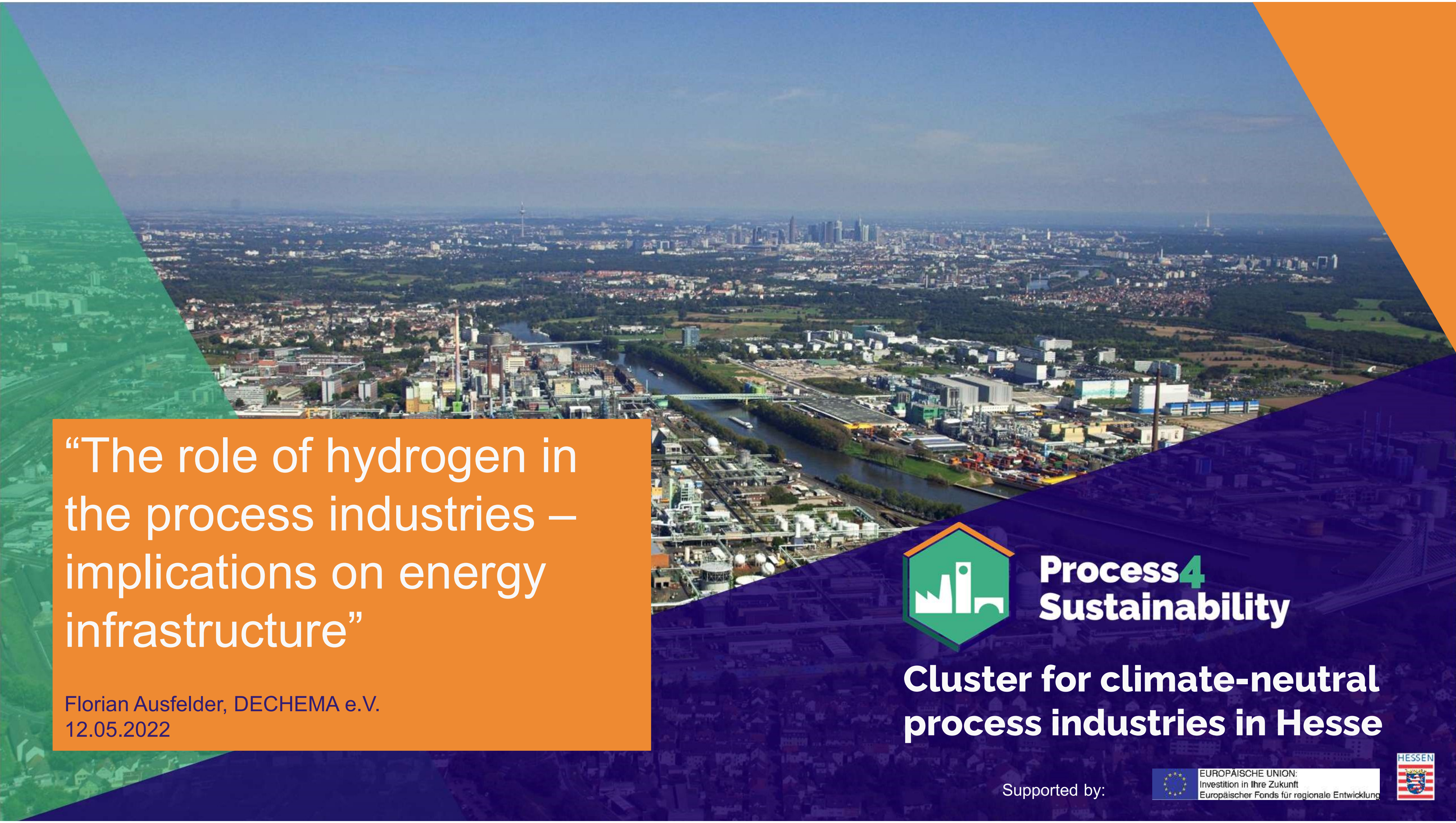


“The role of hydrogen in the process industries – implications on energy infrastructure”

Florian Ausfelder, DECHEMA e.V.
12.05.2022

Process4 Sustainability

Cluster for climate-neutral process industries in Hesse

Supported by:
EUROPÄISCHE UNION:
Investition in Ihre Zukunft
Europäischer Fonds für regionale Entwicklung
HESSEN

Perspective Europe 2030

- NH_3 is globally the largest volume chemical (180 Mio. t/a)
- Responsible for 1-2% of global CO_2-emissions
- Subsequent production of chemical fertilizers (urea, nitrates, …)
- Chemical fertilizers feed half of the world‘s population
- In Europe based on natural gas (SMR)
- **What is the CO_2-abatement potential of the European ammonia production up to 2030?**
- Study commissioned by Fertilizers Europe

https://dechema.de/dechema_media/Downloads/Positionspapiere/Studie+Ammoniak.pdf

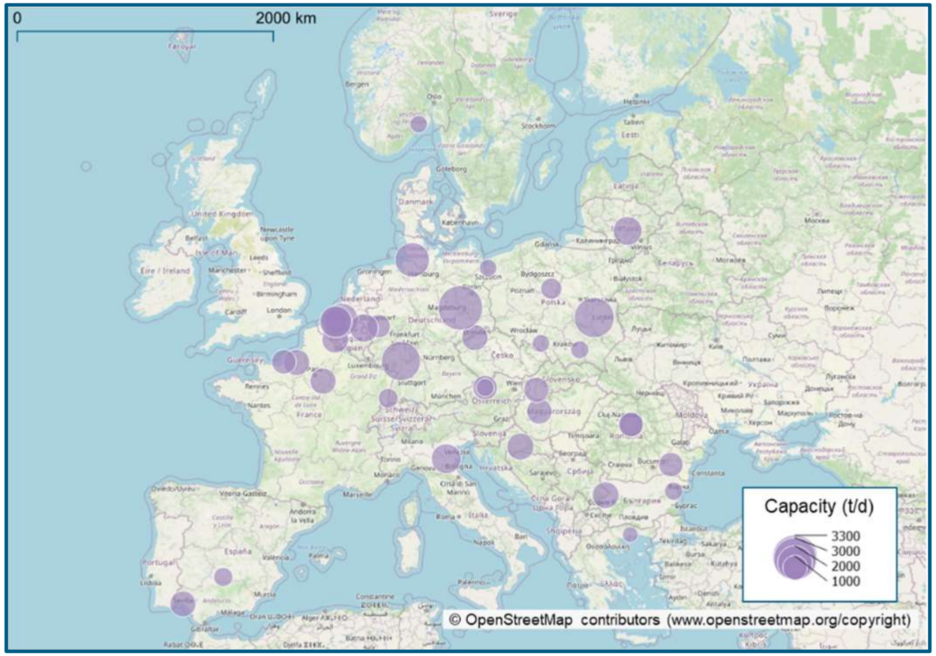
General aspects of the study

- Comparison of different technological options for ammonia production
- Timeframe: 2020 – 2050 ► Focus on 2030
- Boundaries: hydrogen and ammonia production processes
- Plant's characteristics: "Average European Ammonia Plant"
- Evaluated aspects:
  - Energy consumption
  - Specific production costs
  - CO_2 emissions and avoidance costs

Scope 1	Direct, from production process
Scope 2	Indirect, from electricity consumption
Scope 3	All other indirect emissions

Outside study boundaries

  - Abatement potential for two scenarios
- Regions: Southern, Northern, Western and central Europe



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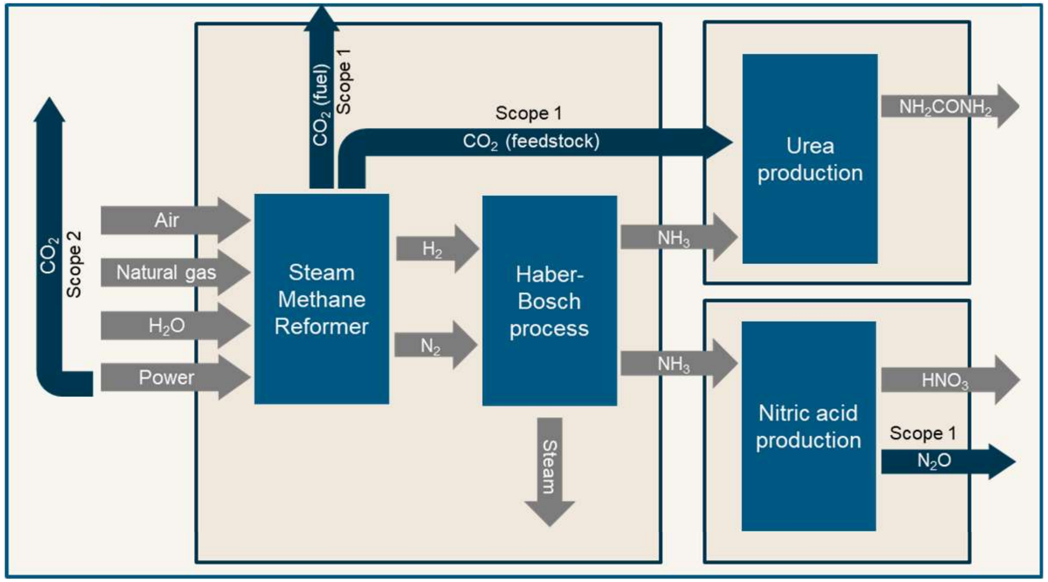
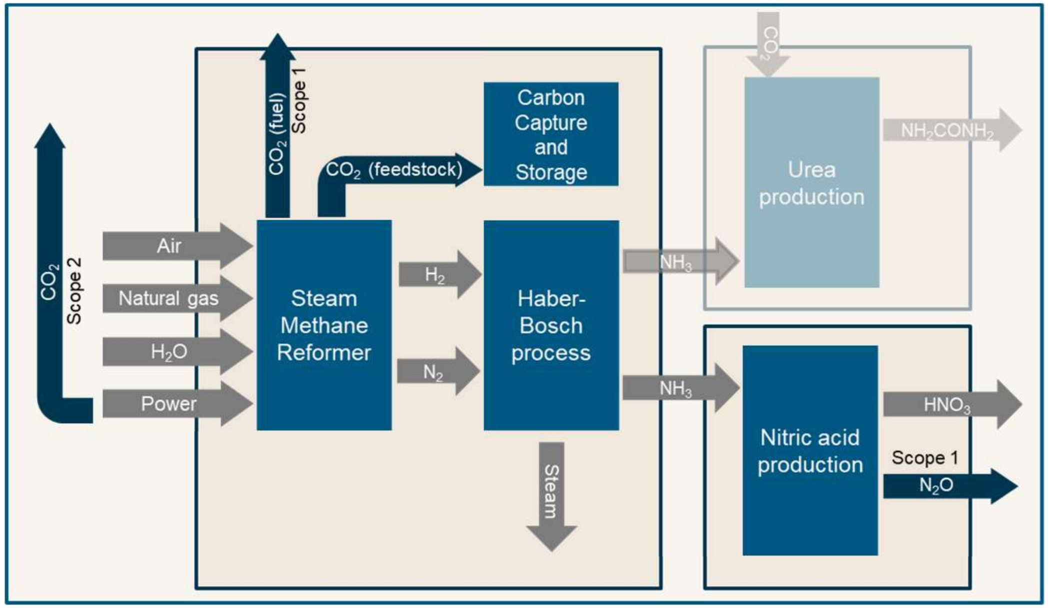
Grey

From conventional production process (SMR) using natural gas

Blue

From conventional production process (SMR) using natural gas combined with Carbon Capture and Storage (CCS).





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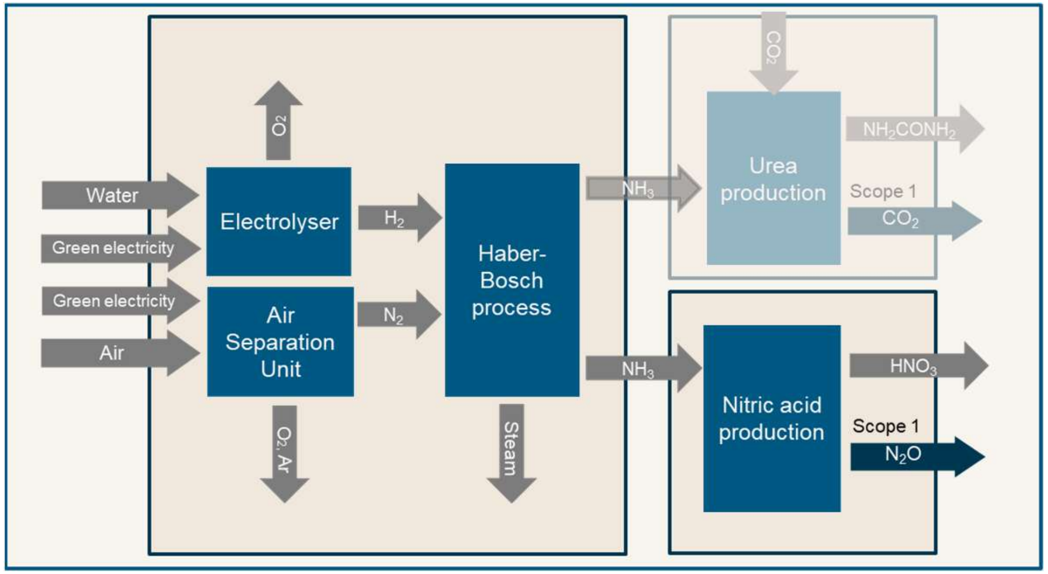
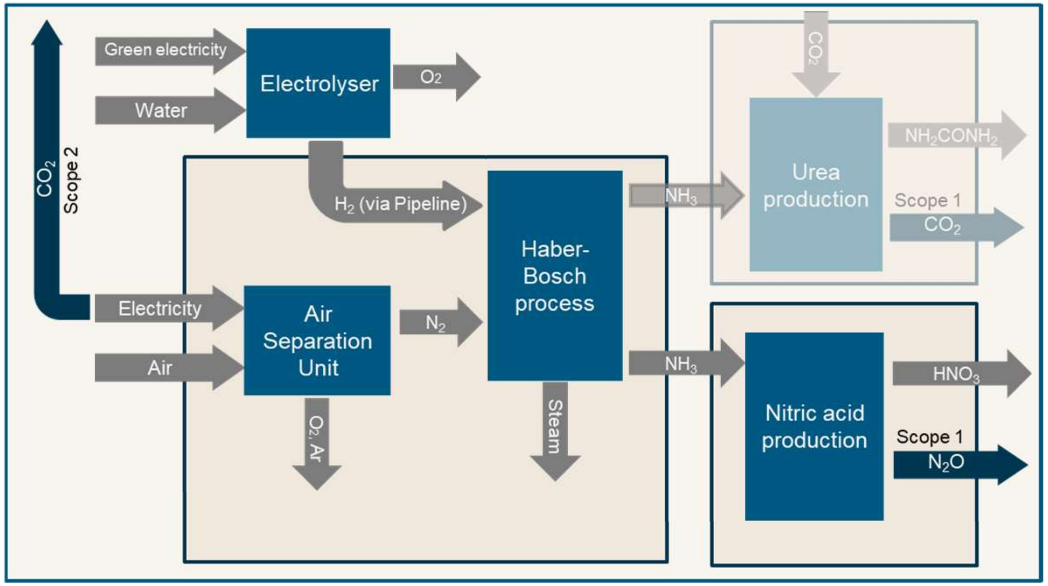
Green

From electrolysis using exclusively renewable electricity for its production.

On-site



Off-site



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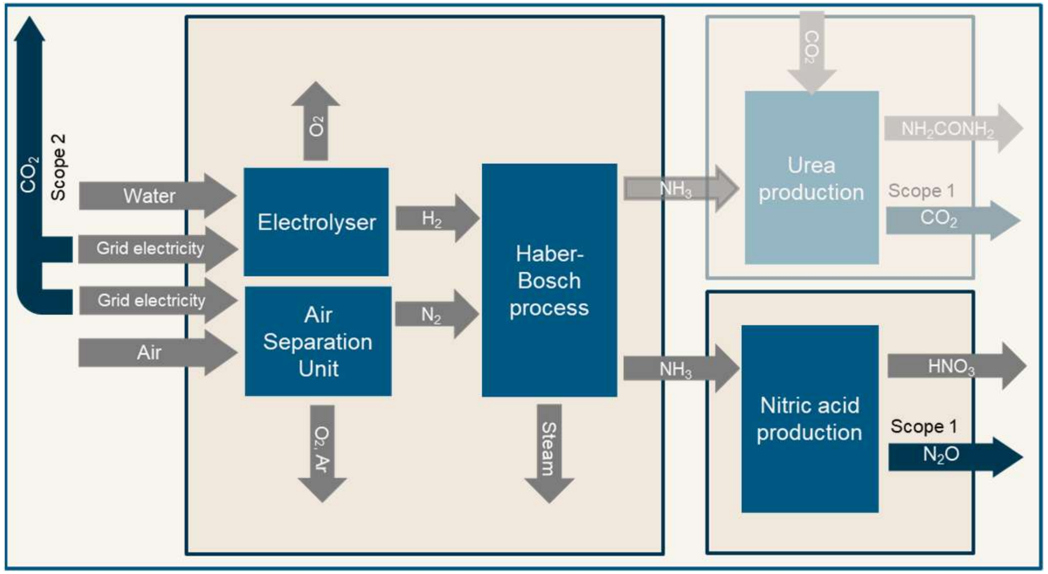
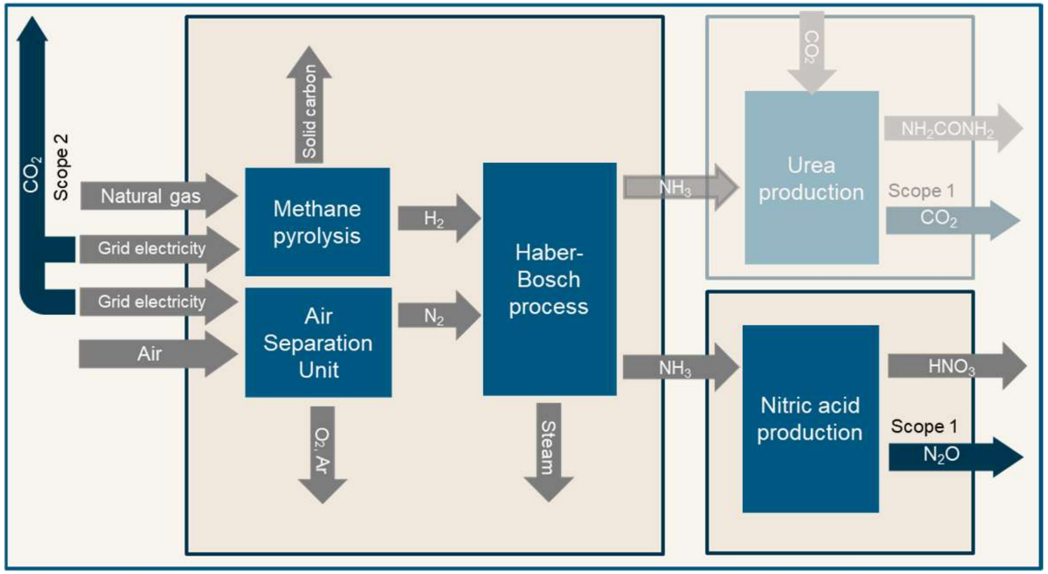
Yellow

From electrolysis using the current available electricity mix of the grid.

Turquoise

From methane pyrolysis.





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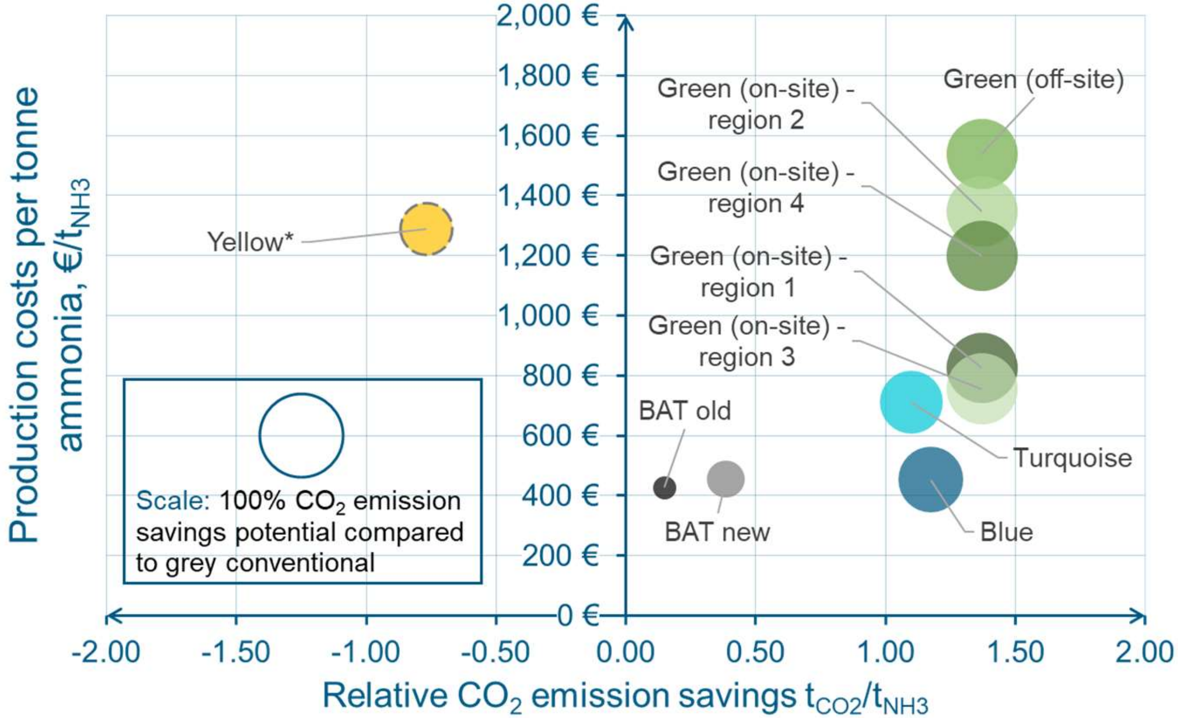
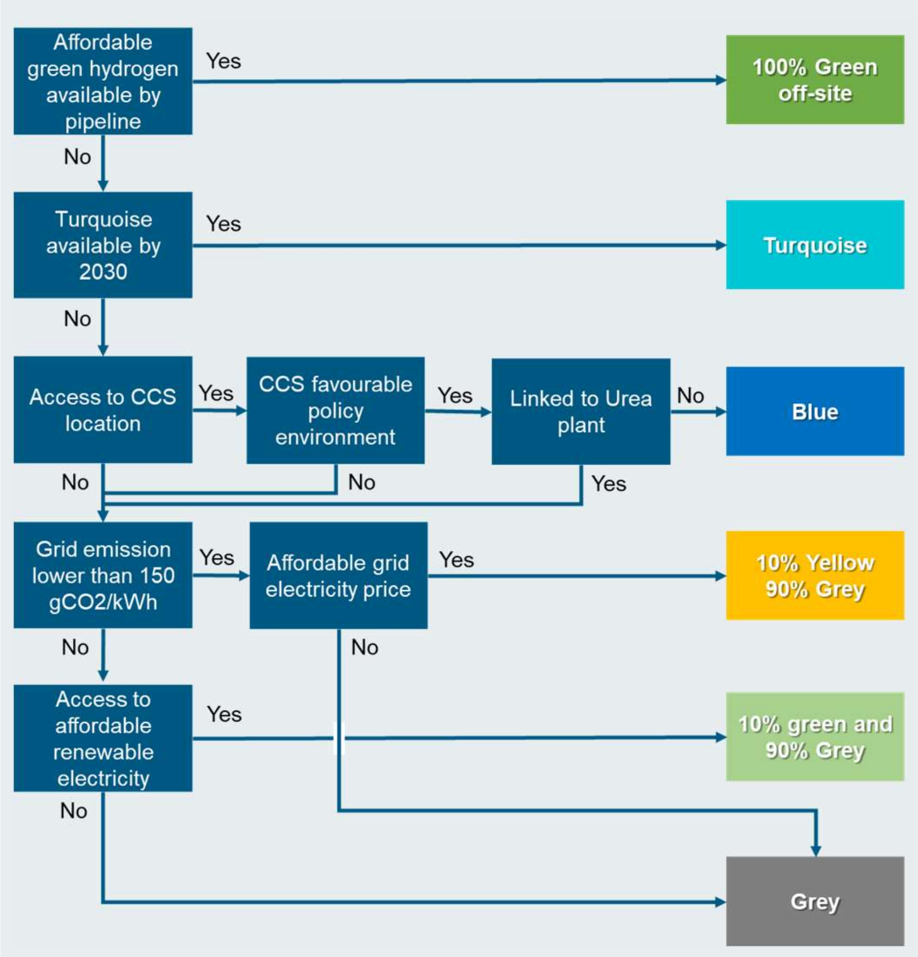
Emissions | Energy consumption | Production costs | **Saving potential**

- Largest reduction potential is achieved with green ammonia (70%)
- Blue and turquoise are also good options (60% and 56% reduction potential) with lower production costs
- BAT old and new plants present 8% and 20% reduction potential
- Yellow ► only in locations with low grid emission factors



General approach to calculations of abatement potential



Nitrate plants

Technology	Requirements	% Base case	% Best case
Blue	Access to CCS	22%	29%
Turquoise	Rapid technological development required	0%	3%
Yellow	Not considered for 2030	0%	0%
90% grey, 10% yellow	Low grid emission factor	28%	28%
Green	Low specific price of green hydrogen	0%	4%
90% grey, 10% green	Low specific price + availability of green electricity	37%	33%
Grey conventional	All remaining plants	13%	3%

Urea plants

Technology	Requirements	% Base case	% Best case
90% grey, 10% green	Low specific price + availability of green electricity	59%	81%
Grey conventional	All remaining plants	41%	19%

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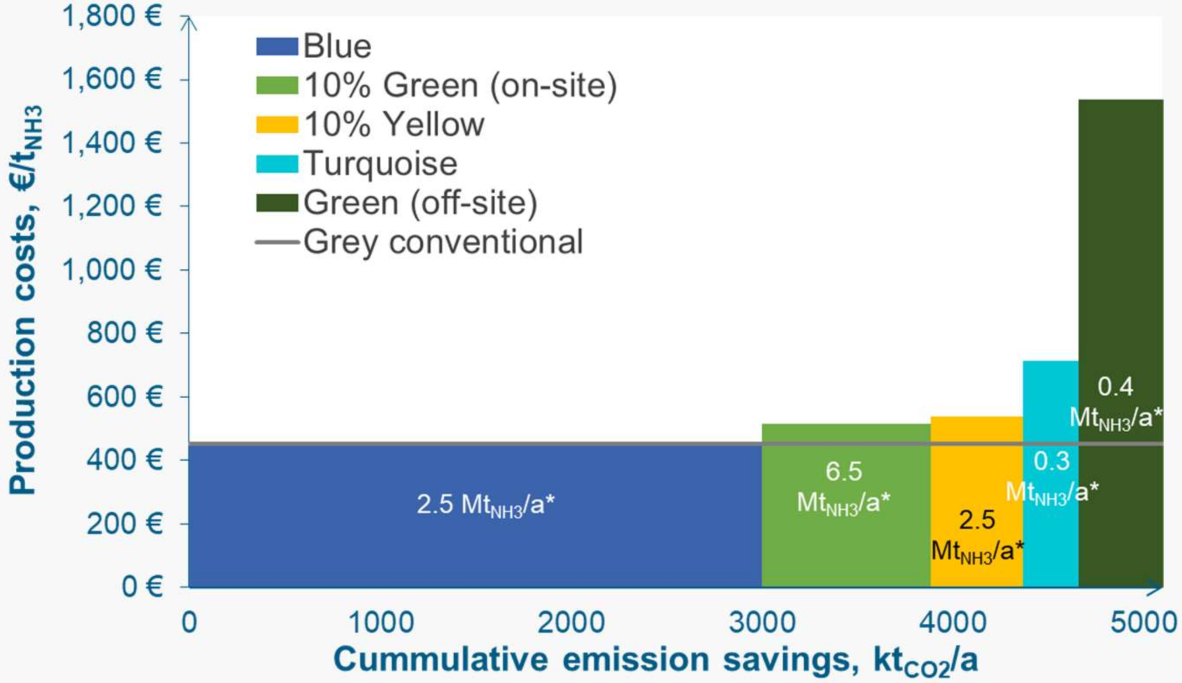
Total abatement potential – best case scenario

- Total production of 13.2 Mt_{NH3}/a
- Largest contribution of blue ammonia
- Application of 10% green brings benefits
- Yellow contribution depends on production site
- Turquoise contribution depends on availability
- Costs of green ammonia should be reduced

Total abatement potential	
Base case scenario	14%
Best case scenario	20%



*applicable production capacity

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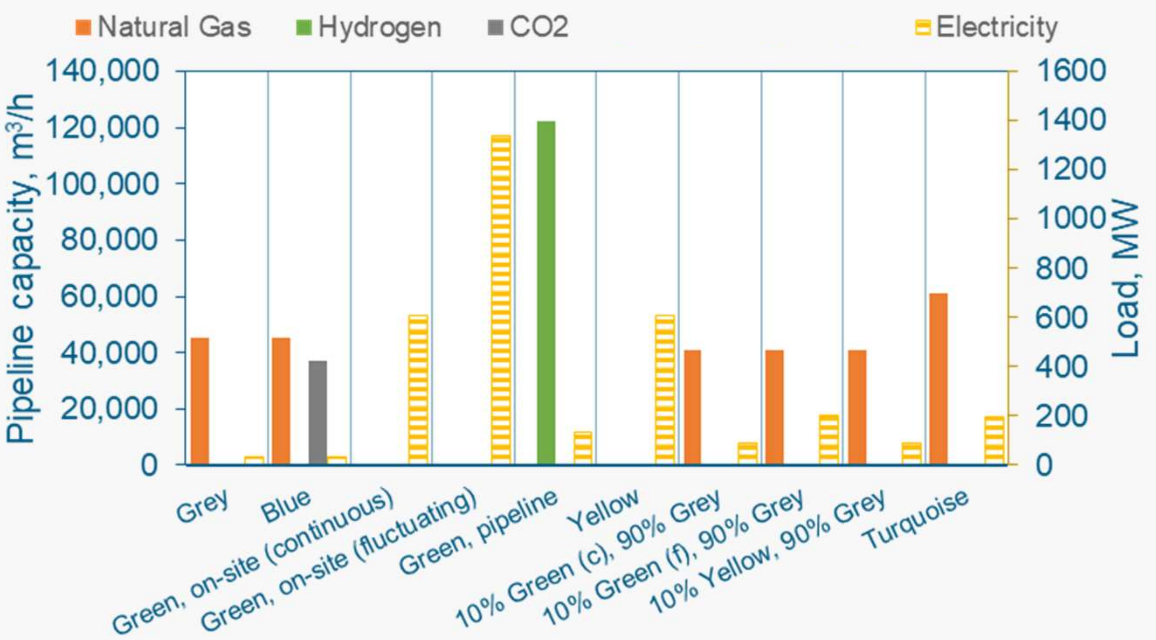
Infrastructure

Values for an "average European ammonia plant" – Capacity of 500,000 t_{NH3}/y
Comparation of technology options with conventional process:

- Blue: CO_2 pipeline needed (0.8 times of NG pipeline)
- Green on-site and Yellow: electric power 18 to 39 times higher
- Green off-site: H_2 pipeline 2.7 times larger than pipeline for NG
- Turquoise: NG pipeline 1.3 times larger and electric power 6 times higher



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Bundesministerium für Bildung und Forschung

TransHyDE – Transport options for green hydrogen
TransHyDE-Sys: System analysis for green hydrogen transport options

Dr. Florian Ausfelder I Höchst I 12.05.2022

Wasserstoff Leitprojekte Grün. Groß. Global.

DECHEMA Gesellschaft für Chemische Technik und Biotechnologie e.V.

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Hydrogen Republic Germany: „Leitprojekte“ (04/21-03/25)

- H2Giga: Mass manufacturing technologies for electrolyzers
  - Funding: 480 Mio. €, 130 Partners
- H2Mare: Offshore water electrolysis and PtX-processes
  - Funding: 100 Mio. €, 29 Partners
- **TransHyDE: Transport options for green hydrogen**
  - **Funding: 140 Mio. €, 85 Partners**
- Fundamental research projects
  - Currently 16 projects and ongoing

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Introduction

- Green hydrogen is a universal and versatile energy carrier
- It is an essential component in the energy transition towards greenhouse gas neutrality
- It will be applied in various sectors, differing widely in volumes and specifications

- The „Leitprojekt“ TransHyDE develops and evaluates various technology options for hydrogen transport

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Project Structure: Demonstration Projects

- (A) MUKRAN – New spherical H_2-storage vessel
- (B) GET-H_2 – Experimental H_2-Pipeline
- (C) CAMPFIRE – Ammonia as H_2 transport option
- (D) HELGOLAND – Logistics and supply chain for LOHC (liquid organic hydrogen carrier)

Project Structure: Research Projects

- **RESEARCH PROJECT (1) SYSTEM ANALYSIS**
- Research Project (2) Safe and secure Infrastructure: Materials testing, sensors, safety and security
- Research Project (3) H_2-Transport with ammonia
- Research Project (4) Transport and use of liquid hydrogen
- Research Project (5) Standardisation, technical norms and certification

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TransHyDE-Sys
System Analysis of transport option for green hydrogen

Shutterstock: 94931578

- Spatial and temporal development of ttransport infrastructure for hydrogen
  - Stakeholder perspective (energy-intensive industries)
  - System perspective (Optimization of macro-economic cost)
- Let us compare methodologies (stakeholder - vs. system perspective)
- Consistent system boundaries and parameters for ecological evaluation of transport technologies
- Communication and stakeholder integration
- Roadmapping: reflecting technological developments within the overall energy system

TransHyDE-Sys: System Analysis

- Coordinators:
  - Florian Ausfelder (DECHEMA)
  - Mario Ragwitz (FhG IEG)
- 22 Funded Partners:
  - 7 Industry sector technical associations
  - 8 Research institutes
  - 5 Universities
  - 2 Companies
- 9 Associated Partners
- Funding: 17 Mio. €

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AP 2/3 Development of infrastructure
AP 4 Let us compare methodologies

Spatial and temporal development of ttransport infrastructure for hydrogen

- **AP 2 Stakeholder perspective**
  - Development of hydrogen infrastructure and interaction with existing and future energy and feedstock infrastructures within the transformation of heavy industry
- **AP 3 System perspective**
  - Minimal macro-economic cost for optimal hydrogen infrastructure development to supply green hydrogen
- **AP 4 Let us compare methodologies**

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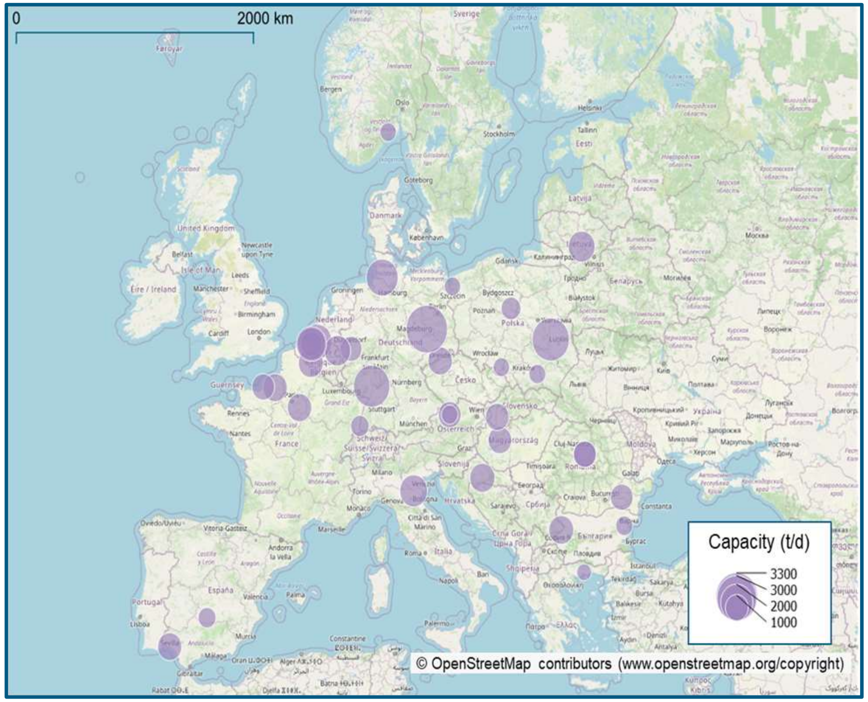
Leitprojekt TransHyDE

What will the results look like?



Quelle: © KPMG
https://klardenker.kpmg.de/
h2-zukunftsbarometer-auf-dem-weg-zum-europaeischen-wasserstoffnetz/

Quelle:
Perspective Europe 2030 - Technology options for CO_2- emission reduction of hydrogen feedstock in ammonia production

Leitprojekt TransHyDE

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Thank you for your attention

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