HYDROGEN TECHNOLOGIES FOR A CO_2-NEUTRAL CHEMICAL INDUSTRY

A PLANT-SPECIFIC BOTTOM-UP ASSESSMENT OF PATHWAYS TO DECARBONISE THE GERMAN CHEMICAL INDUSTRY

ECEEE Industrial Efficiency – Panel 6: Deep decarbonisation of industry
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AGENDA

- Motivation
- Methodology
- Results
- Summary

MOTIVATION

Paris Climate Convention

Limiting the rise in the global average temperature to a maximum of 2°C

German Climate Protection Law

1) Reduction of greenhouse gas emissions by 55% by 2030 compared to 1990
2) Goal of reaching climate neutrality by 2050

Chemical industry as an energy- & emission-intensive sector

Huge energy demand for hydrogen as Feedstock:

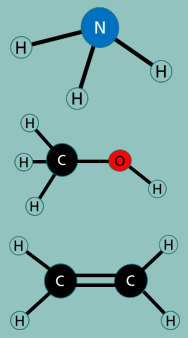
Switch to alternative climate-neutral technologies unavoidable

METHODOLOGY

Technology evaluation

Extensive overview over conventional and alternative (hydrogen-based) production routes for:

- Ammonia
- Methanol
- Ethylene



Site-specific age structure

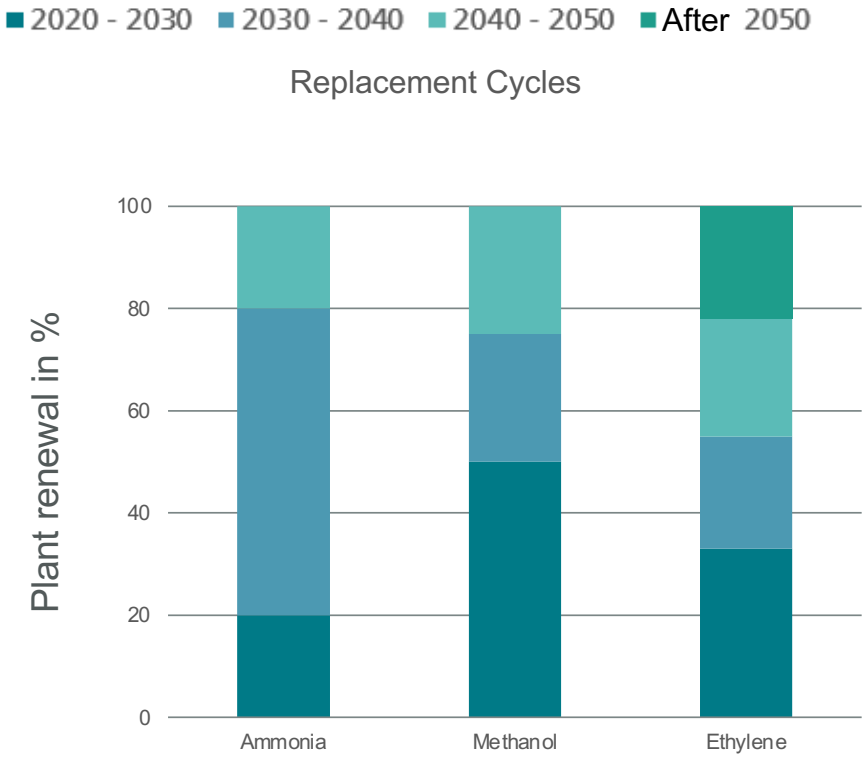
1) Determination of the status quo of the plant stock in Germany (incl. age structure)
2) Transformation through diffusion of hydrogen-based production routes

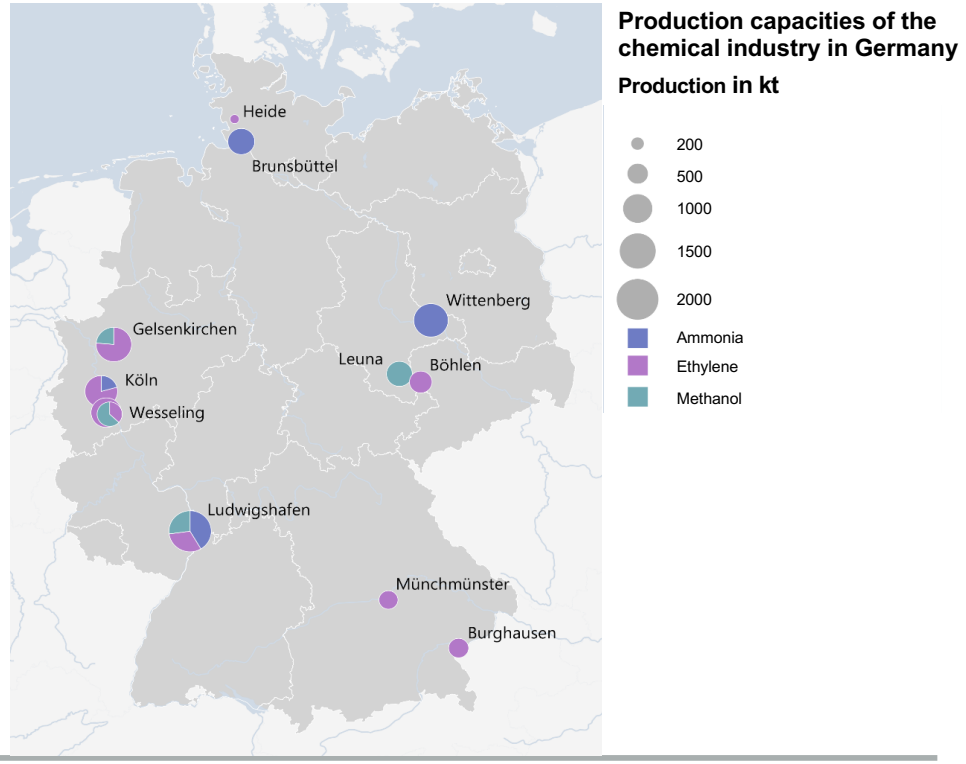
Calculation of the possible Transformation pathway

Benchmarking 4bMix95

1) Consistency of the scenario with the political framework
2) Energy demand prognosis with the modeling platform FORECAST
3) No consideration of plant stock
4) Modernisation cycles are considered by statistical curves

RESULTS
AGE STRUCTURE OF THE PLANT STOCK (1/2)

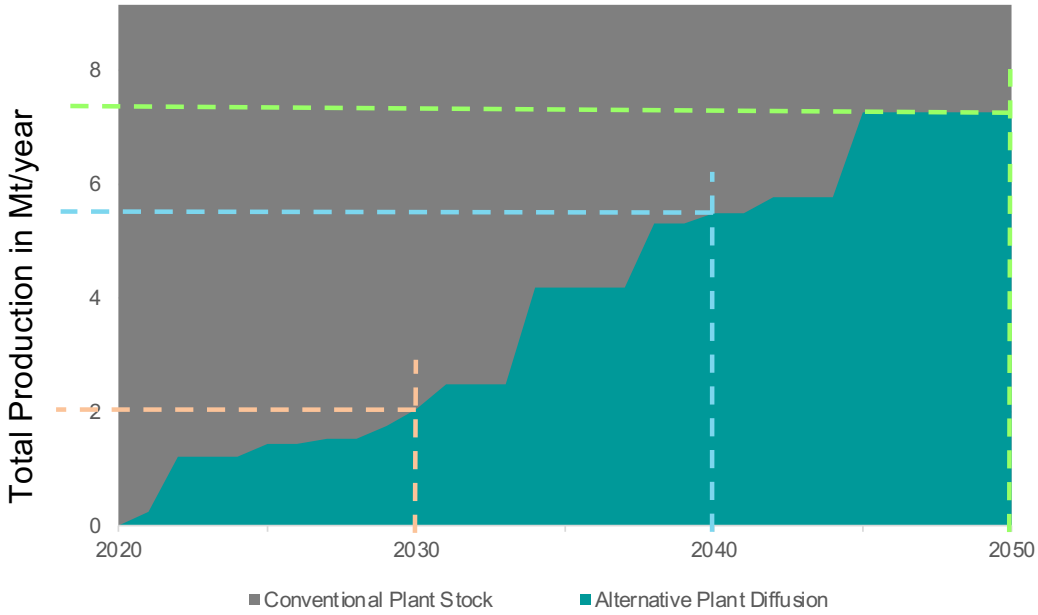




RESULTS
AGE STRUCTURE OF THE PLANT STOCK (2/2)

Possible plant replacement by means of the age of the plant stock

- 2 Mt/year replaceable until 2030
  - 20% of Ammonia,
  - 50% of Methanol,
  - 33% of Ethylene
- About 5.5 Mt/year replaceable until 2040
  - 80% of Ammonia,
  - 75% of Methanol,
  - 55% of Ethylene
- About 7.2 Mt/year replaceable until 2050
  - 100% of Ammonia,
  - 100% of Methanol,
  - 78% of Ethylene



➡ 22% of Ethylene plants have to be renewed after 2050

RESULTS
TRANSFORMATION PATHWAY (1/2)

Capital Investments in decades

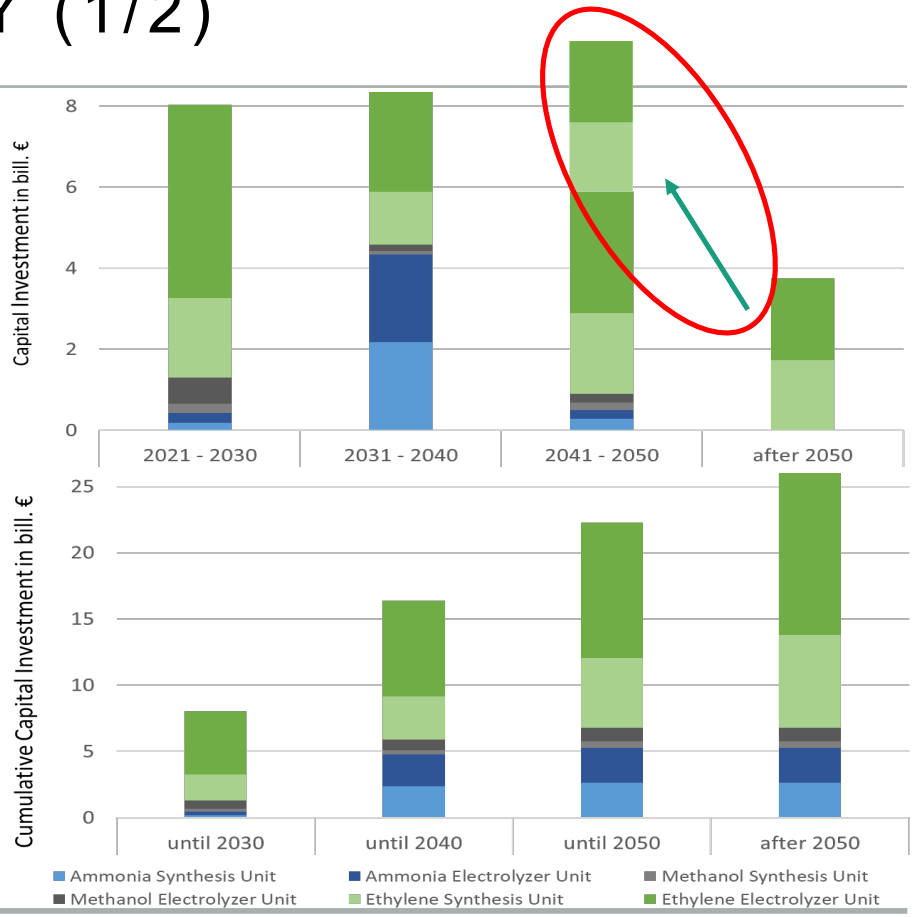
2021-2030
~8 bill.€

2031-2040
~8.2 bill.€

2041-2050
~9.5 bill.€

Cumulative Capital Investments: ~26 bill.€

- 3.7 bill.€ left after 2050 considering theoretical lifetime
- No major investments in only one decade
- 55% for hydrogen production for ethylene via MtO



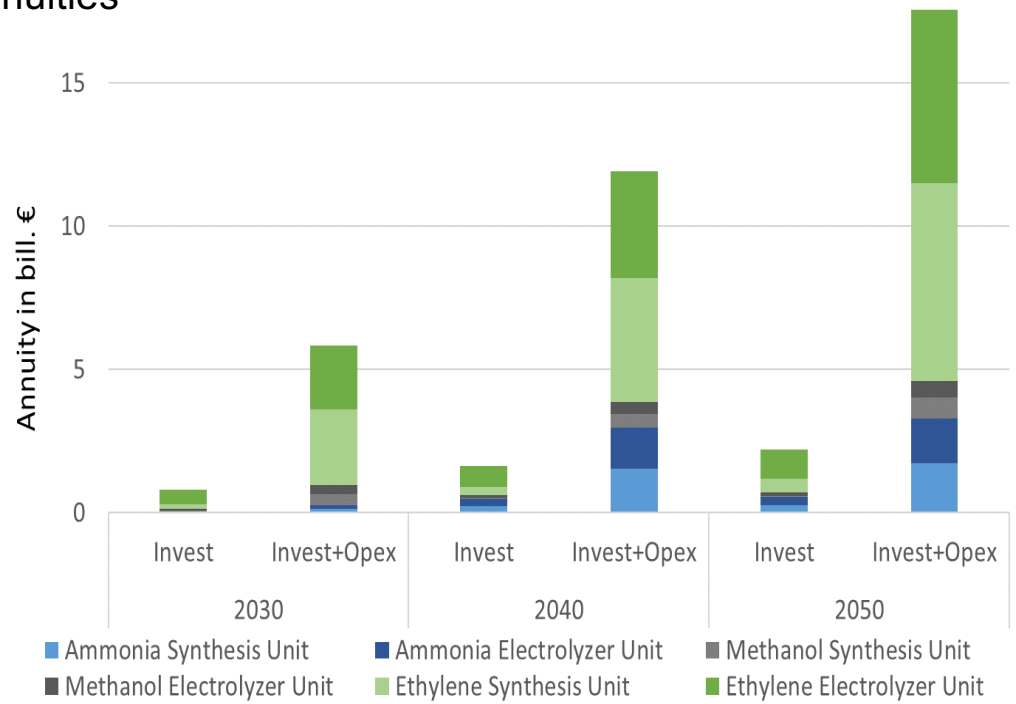
RESULTS
TRANSFORMATION PATHWAY (2/2)

Operating costs and annuity for plant replacement by means of their age structure

- low influence of investments on total costs of annuities
- much more impact of operating costs (OPEX)
  - biggest share of OPEX: energy (el.) costs

Results for 2050

- Total Hydrogen Demand in 2050:
  - 3450 kt/year
- Total Energy Demand
  - 180 TWh/year
- Avoidable Emissions in 2050
  - 16 Mt/year



SUMMARY & BENCHMARKING & CONCLUSIONS

Summary

Nearly 100%

- renewable electricity essential for CO_2-savings with alternative technologies
- of the plants are at the end of their (theoretical) lifetime until 2050

Benchmarking

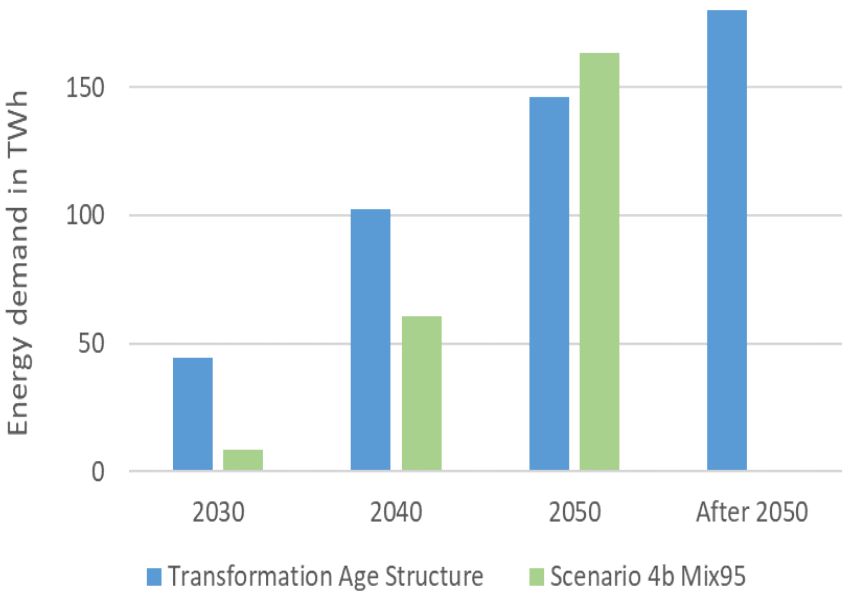
4bMix95

- Technology diffusion starts around 2030
- Energy Demand is underrated until 2040
- 100% implementation of alternative technologies until 2050

Conclusions

Key findings

- Production costs as most interesting parameter for subsequent considerations
- Prognoses and life cycles difficult to realize due to possible partial renewals
- Good fit of the two scenarios for 2050



QUESTIONS, REMARKS, DISCUSSION

Thank you very much for your Attention!

Contact

FORECAST FORecasting Energy Consumption Analysis and Simulation Tool | eLOAD energy LOad curve ADjustment tool

http://www.forecast-model.eu

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