PTKA Projektträger Karlsruhe
Karlsruher Institut für Technologie

Baden-Württemberg
MINISTERIUM FÜR UMWELT, KLIMA UND ENERGIEWIRTSCHAFT

Plattform H2BW

Projekt H2 Chemie 2050

Ohne Umwege zu grünem Wasserstoff in der chemischen und pharmazeutischen Industrie

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H2-Kolloquium Baden-Württemberg | 04.–05. Juni 2024, Baden-Baden

EVONIK Leading Beyond Chemistry

INEC INSTITUTE FOR INDUSTRIAL ECOLOGY

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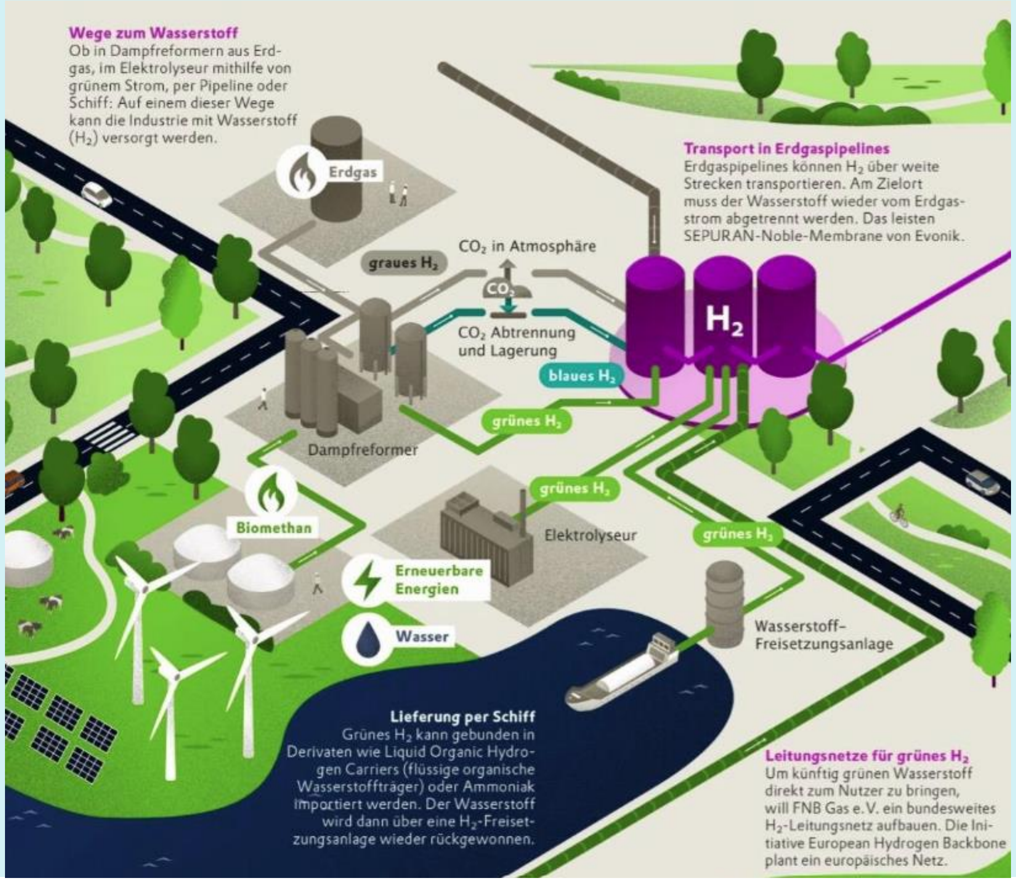
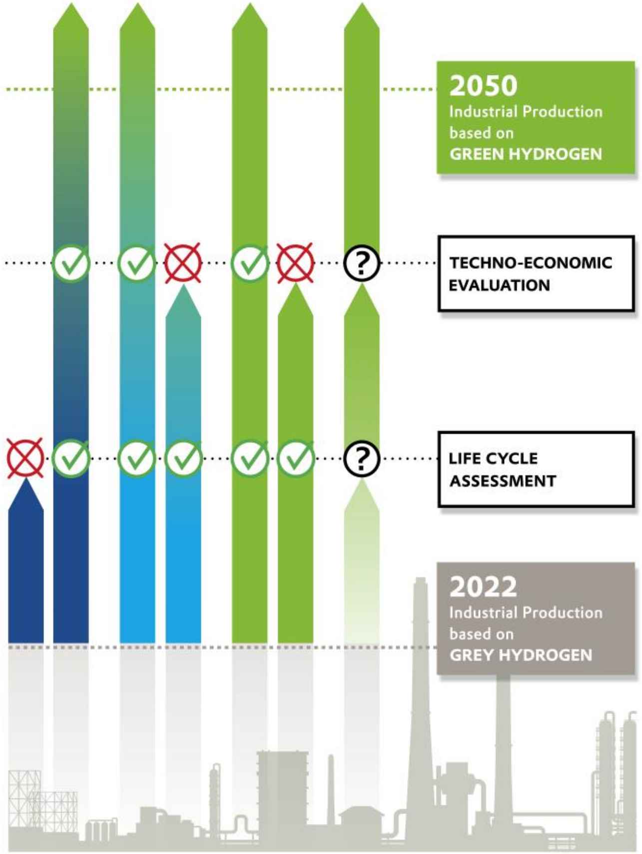
Agenda



Wege zum Wasserstoff
Ob in Dampfreformern aus Erdgas, im Elektrolyseur mithilfe von grünem Strom, per Pipeline oder Schiff: Auf einem dieser Wege kann die Industrie mit Wasserstoff (H_2) versorgt werden.
Erdgas
graues H_2
CO_2 in Atmosphäre
CO_2
CO_2 Abtrennung und Lagerung
blaues H_2
grünes H_2
Dampfreformer
grünes H_2
Biomethan
Elektrolyseur
grünes H_2
Erneuerbare Energien
Wasser
H_2
Transport in Erdgaspipelines
Erdgaspipelines können H_2 über weite Strecken transportieren. Am Zielort muss der Wasserstoff wieder vom Erdgasstrom abgetrennt werden. Das leisten SEPURAN-Noble-Membrane von Evonik.
Wasserstoff-Freisetzungsanlage
Lieferung per Schiff
Grünes H_2 kann gebunden in Derivaten wie Liquid Organic Hydrogen Carriers (flüssige organische Wasserstoffträger) oder Ammoniak importiert werden. Der Wasserstoff wird dann über eine H_2-Freisetzungsanlage wieder rückgewonnen.
Leitungsnetze für grünes H_2
Um künftig grünen Wasserstoff direkt zum Nutzer zu bringen, will FNB Gas e.V. ein bundesweites H_2-Leitungsnetz aufbauen. Die Initiative European Hydrogen Backbone plant ein europäisches Netz.

Project overview



Background

- To reduce CO_2 emissions and to enhance the **transformation to climate neutrality**, hydrogen plays a major role for the chemical and pharmaceutical industry
- Project aims for scientific consideration of different transformation paths for hydrogen production in industrial use, where the **Evonik Rheinfelden site** is to serve as a nucleus
- The optimal and most efficient way from "grey" to "green" hydrogen must be identified based on
  - techno-economic analysis
  - life cycle assessment
  - system modelling
- The goal is to create a **basis for decision-making** from an economic and ecological perspective for the chemical and pharmaceutical industry towards green hydrogen
- It is a joint publicly funded project of Evonik and INEC

Funding

Baden-Württemberg
MINISTERIUM FÜR UMWELT, KLIMA UND ENERGIEWIRTSCHAFT

The project partners gratefully acknowledge funding by the Ministery of Environment Baden-Württemberg

Project duration

01/2022 – 07/2024

Simplification of the overall system under consideration

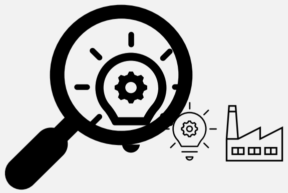
Raw materials & feedstocks → **Technology & Processes** → **On-site demand**

Raw materials & feedstocks

Natural gas
Biogas
Electricity
Ammonia
LOHC
H_2 pipeline
...

On-site demand

Hydrogen
Heat
Steam
Methanol
CO_2
...



Which **technologies & processes** can we use on a **needs-based scale** in order to link the feedstocks and demand of an industrial site as **sustainably & cost-efficiently** as possible?

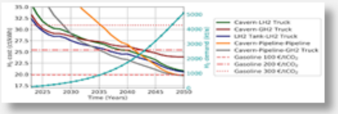
Where will the hydrogen of the future come from?

Hydrogen production on-site	Supply by hydrogen carrier	Connection trans-regional infrastructure
		
1. Gas-based technologies …based on natural gas SMR, SMR + CC, Plasma pyrolysis …based on biogas/biomethane Sepuran + SMR, ATR, ATR + CC **2. Electrochemical water splitting** …using renewable energy sources PEM, AEL, SOEC, AEM	**3. Chemical hydrogen carriers** …based on the import of (green)… LOHC, ammonia, methanol	**4. Pipeline** European Hydrogen Backbone, Pipeline from Northern Germany

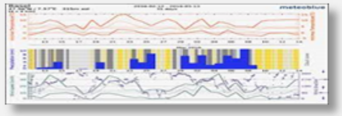
The basis for modelling future transformation paths is a comprehensive database on technologies and site-specific boundary conditions

Demand development
- Hydrogen
- Electricity, heat & Steam
- Others (CO_2, MeOH,...)
- **System boundaries**

Procurement
- Raw materials
- Energy carriers



Weather data
- Insolation
- Wind speed distr.



Network partner
- Industry
- Municipalities & Cities
- Politics
- Associations

Site-specific & regional data

Technology toolbox

Technology data
- Technology Readiness Level
- Mass- and energy balance
- Capacity data

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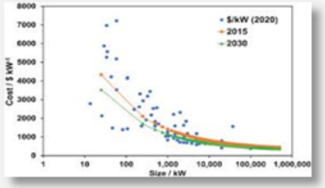
Economic data
- CAPEX
- OPEX
- Lifetime



Ecologic data
- LCA
- Emissions

Info & network
- Expert contact
- Supplier contact
- Literature review

Input for modelling

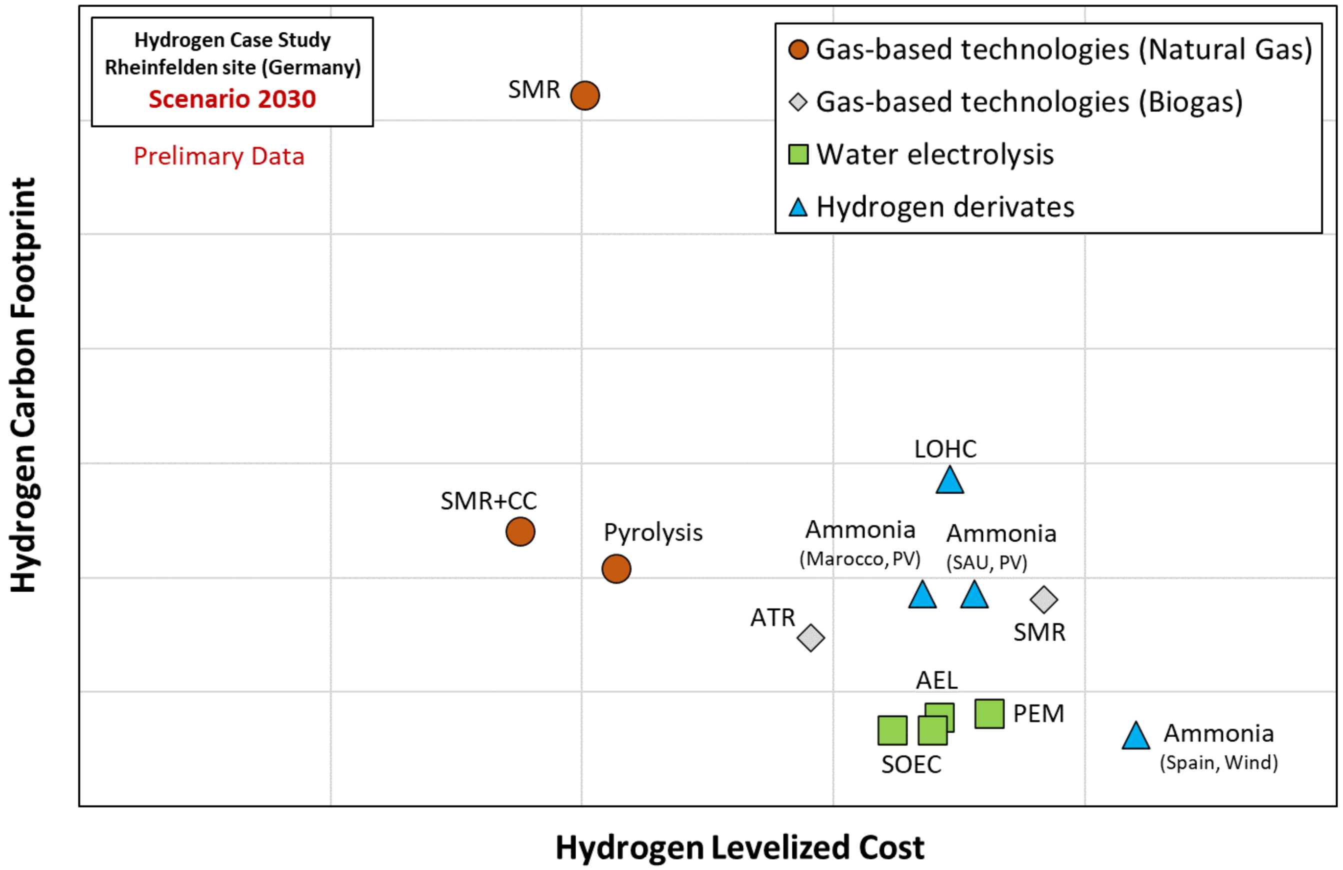
Hydrogen supply for Rheinfelden in 2030 (5000 t H2 per year)

Evonik Rheinfelden site

What will the industrial hydrogen hub Rheinfelden look like in 2030?

- What are the expected Hydrogen Levelized Cost?
- What are required invest cost (indication)?
- What are the mass and energy flows and their corresponding costs?
- What are the expected Hydrogen Carbon Footprint?
- By what percentage can the CO_2 emissions of the existing hub be reduced?

Hydrogen supply for Rheinfelden in 2030 (5000 t H2 per year)



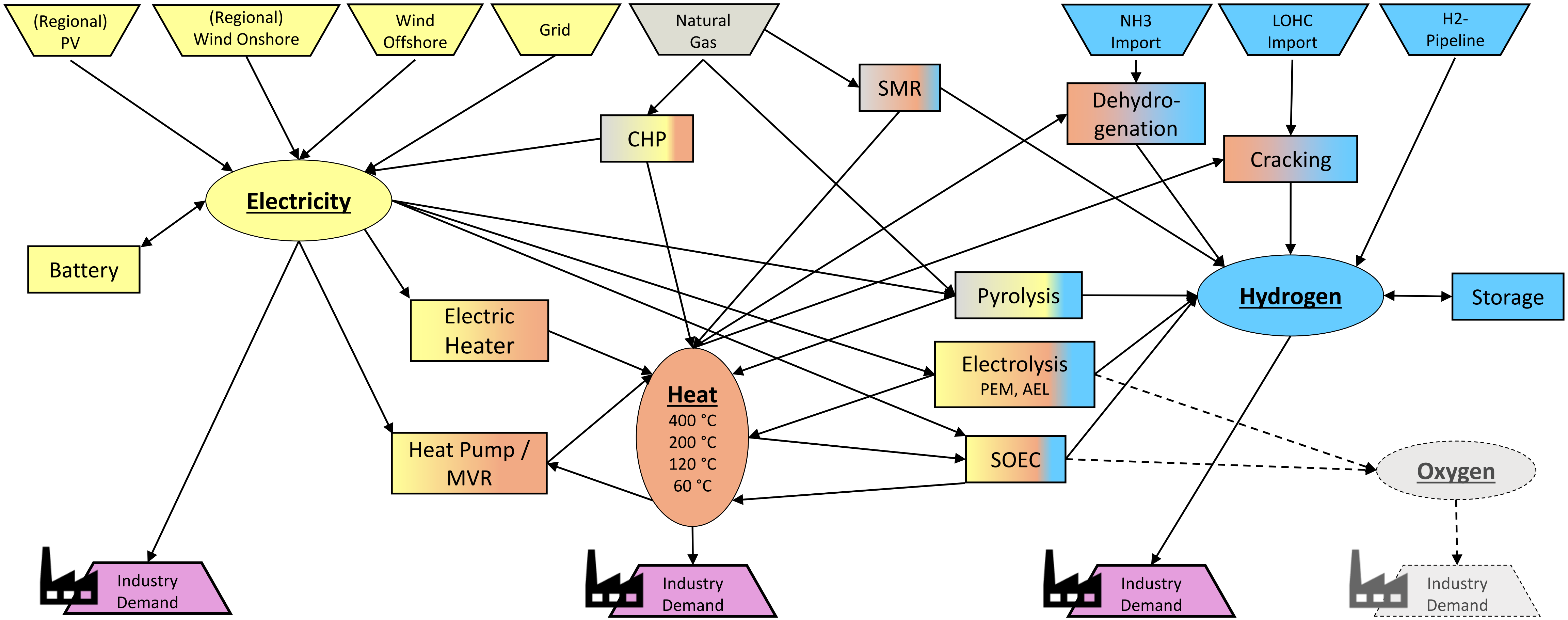
We get insights into…

- Hydrogen Levelized Cost
- Hydrogen Carbon Footprint
- CO_2 Abatement Cost
- Cost structure
- Mass- and energy flows
- among others…

*Pyrolysis and ATR are not expected to be TRL 9 in 2030

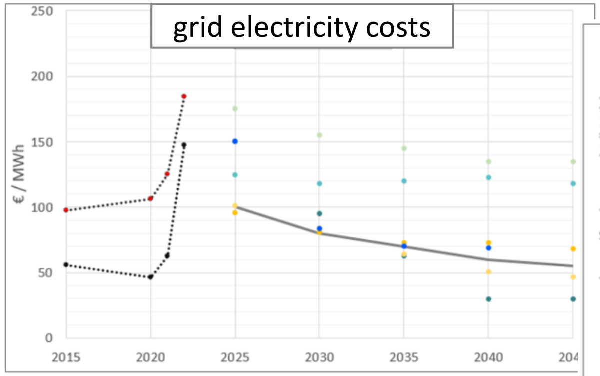
DISCLAIMER
Please don't distribute this data. The results are highly depended on corresponding assumptions and cannot be used generally.

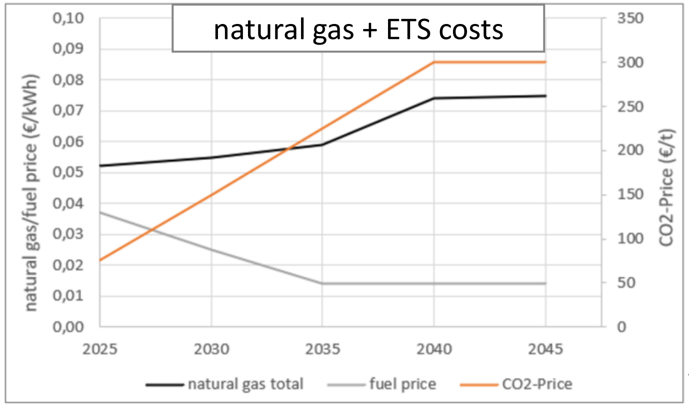
Technology Options within regional H_2 System

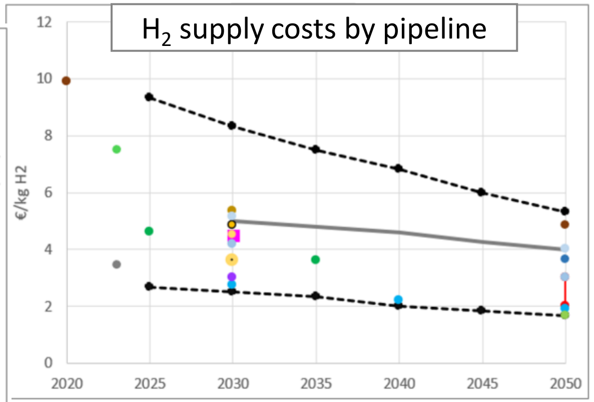


Optimization Scenarios

	Reference	Standard	No Fossil Invests	Lowest GHG
Description	continuation of current technologies (SMR & CHP)	free choice between fossil and non-fossil technology investments	no fossil-based investments allowed	least possible GHG emissions; „no matter the cost“
Objective	minimal total costs			minimal total emissions
Assumptions	forecasted energy and technology costs 2025-2050			







Preliminary Results

	Reference	Standard	No Fossil Invests	Lowest GHG
Total Costs (2025-2050)	100 %	91 % ↓	118 % ↑	336 % ↑↑
GHG Emissions in 2050	100 %	43 % ↓	<5 % ↓↓	<5% ↓↓
Total GHG Emissions (2025-2050)	100 %	76 % ↓	41 % ↓	12 % ↓↓

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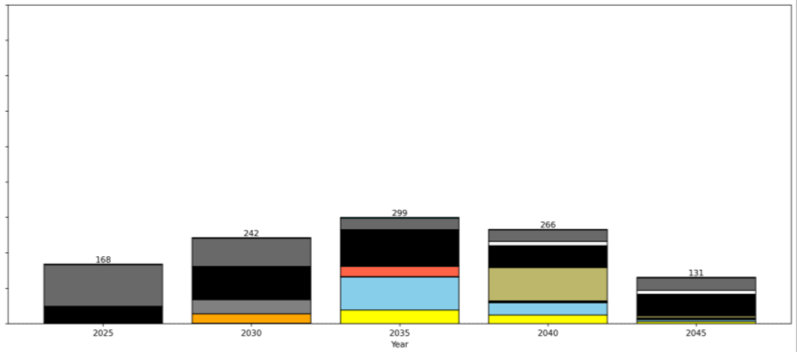
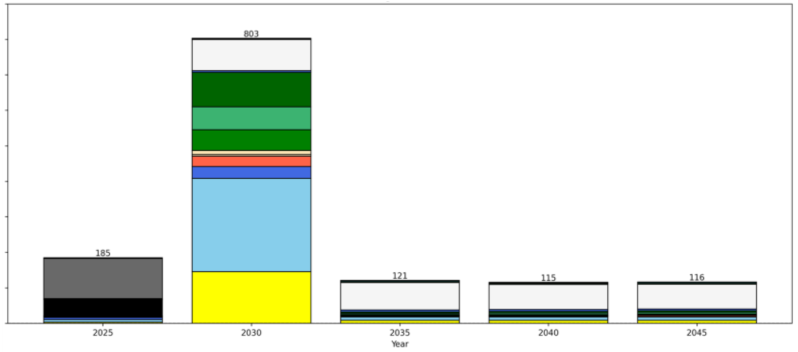
Cost Forecast

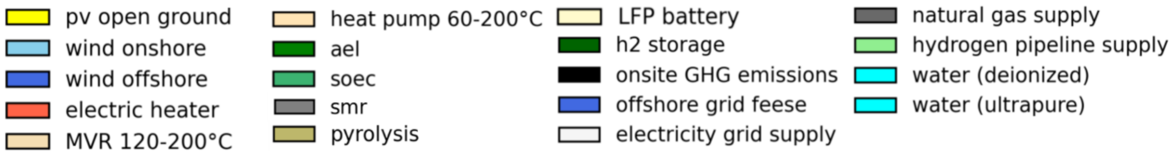
- Standard: threat of stranded assets in 2050
- No Fossil Invests: enormous invest amount necessary at once, mainly due to RE

Standard



No Fossil Invests





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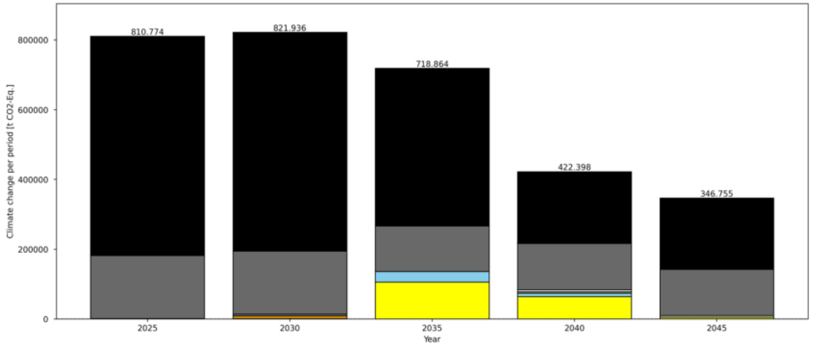
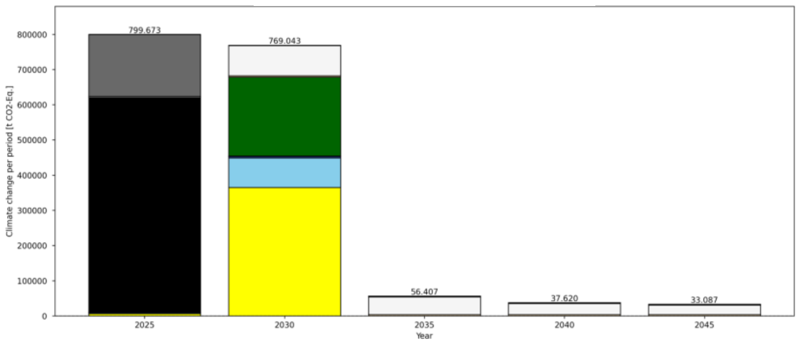
Emission Forecast

- Standard: no ‚climate neutrality‘ in 2045
- No Fossil Invests: ‘climate neutrality’ is achieved; high emissions during construction

Standard



No Fossil Invests



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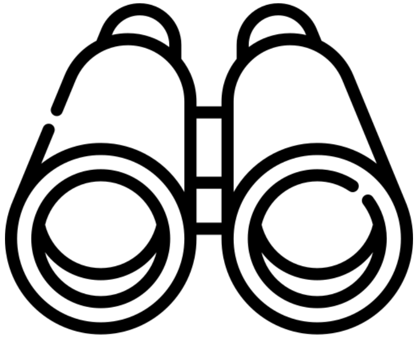
Preliminary Conclusions

- Future low-emission **hydrogen costs** will be **above today's costs**
- Through **sector coupling**, extra **costs can be limited**
- Prerequisite: **sufficient Renewable Energies**
  → **Industry as „Multiplier"** for regional RE expansion, activation of civic capital, in return reduction of grid fees

- Limitation: Conclusion is just valid for „decentral", comparably low H_2 demands – for more regionally concentrated demands, hydrogen import is essential

- Outlook:
    - Scenarios under consideration of **pre-defined decarbonization pathway**
    - Scenarios under consideration of **different funding instruments**



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Für den Inhalt sind ausschließlich die Autor:innen verantwortlich.

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