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Delivering on the Paris Agreement in a fragmenting world

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**Bottlenecks to sectoral decarbonisation in Europe:
national insights**

Jakob Wachsmuth, Khaled Al-Dabbas, Andrea Herbst, Philine Warnke
(Fraunhofer ISI)



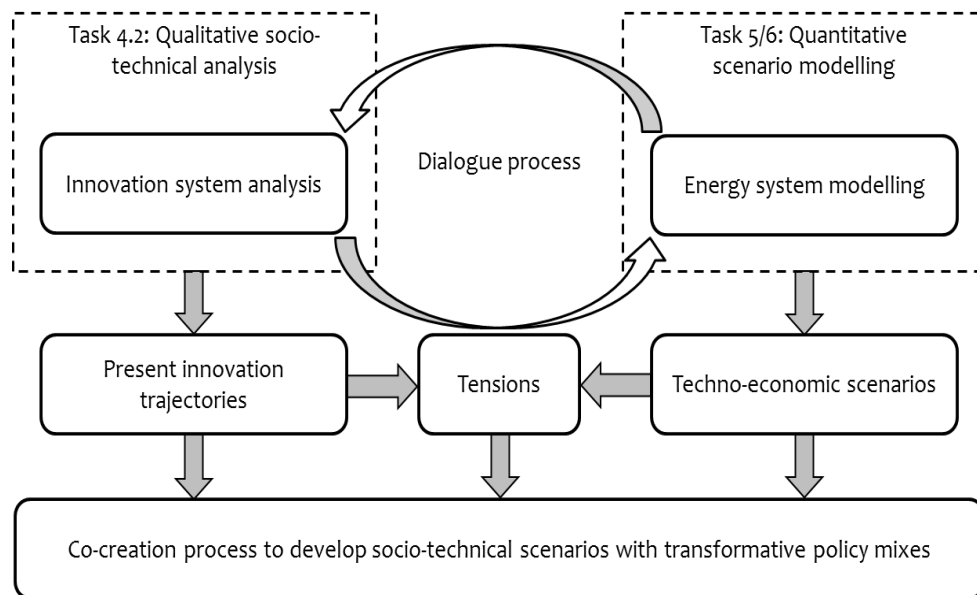
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- **Techno-economic models** commonly used to inform climate policy
- **High relevance** of model-based techno-economic scenarios is uncontested
- Limited coverage of **transitions beyond diffusion** of innovations
- **Depicting only parts** of the complex empirical reality **of the manifestation of innovations**
- Ineffective **inclusion of policymakers** in the heart of modelling activities



One objective within PARIS REINFORCE:

Extend quantitative techno-economic scenarios in line with the Paris targets to socio-technical narratives **based on innovation system analyses.**



Source: own representation of Fraunhofer ISI

Approach: Identify transition bottlenecks and co-create transformative policy mixes

- Bottlenecks are derived from tensions between modeled scenarios and present innovation trajectories.
- Scientists and stakeholders co-create narratives by describing transformative policy mix to overcome these over time

5 case studies

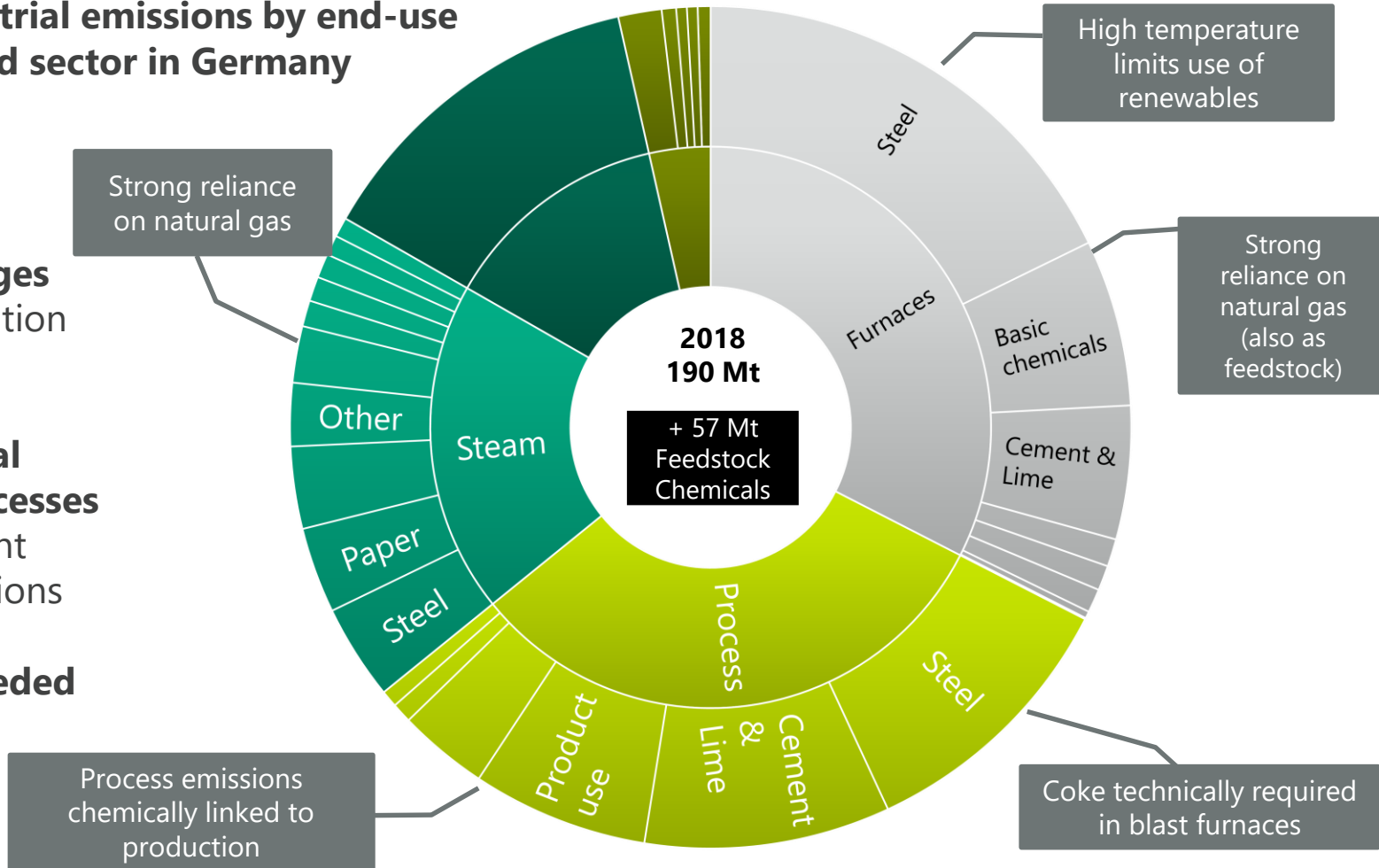
- Energy sector transformation in Greece
- Energy-intensive industries (steel, cement, chemicals) in Germany and the UK
- Transport sector in Brazil and Canada



Net-zero emissions in the industry sector requires profound change

Direct industrial emissions by end-use category and sector in Germany

- **Diverse challenges** across all application areas
- **New CO₂-neutral production processes** address important sources of emissions
- But **action is needed in all areas**



Source: own representation of Fraunhofer ISI



The PARIS REINFORCE project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No 820846.

Characteristics of net-zero pathways for energy-intensive industries in Germany and the EU

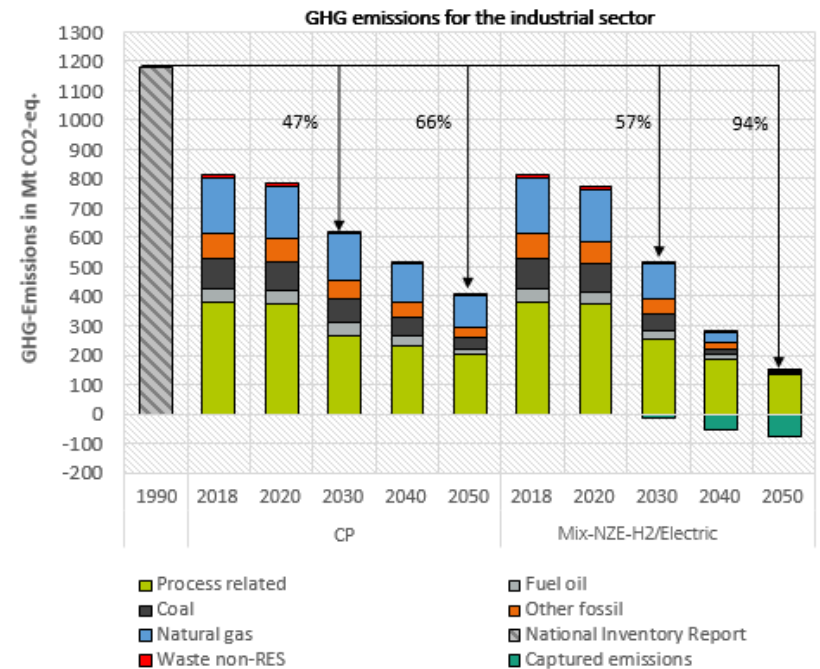
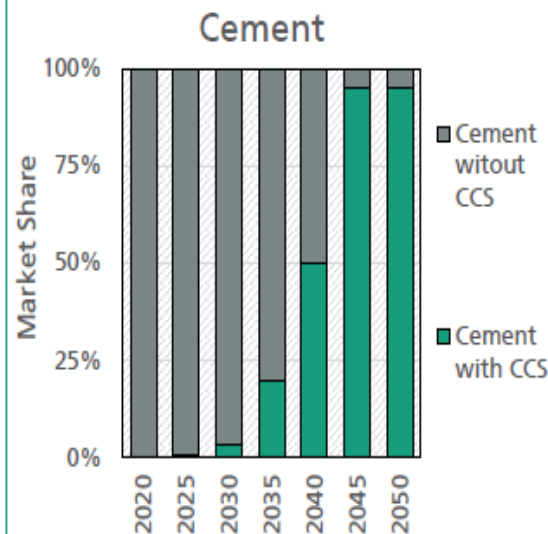
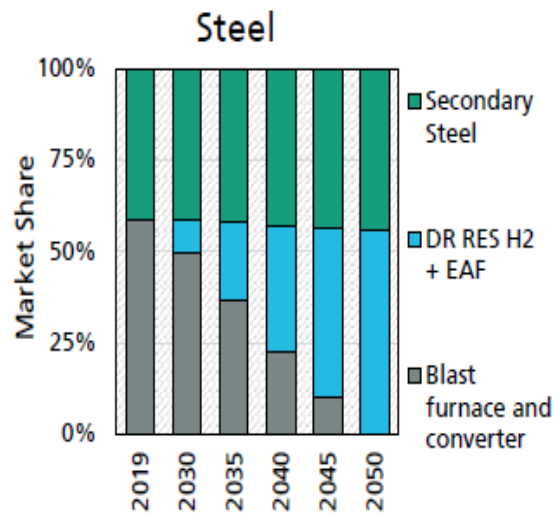
Reference pathways for energy-intensive industries in the EU

Key characteristics

- Ambitious energy efficiency measures
- Electricity for low-temperature heat
- Fuel switch to biomass to a certain extent

Net-zero pathways for energy-intensive industries in the EU

- **Ambitious material efficiency + circular economy measures**
- Electricity for low- and mid-temperature heat
- **Hydrogen + renewable gases as energy carriers** and feedstocks
- **Carbon capture + storage (CCS)** for unavoidable process emissions



Source: : Al-Dabbas et al. (2022)

FORECAST
 FORecasting Energy Consumption Analysis and Simulation Tool

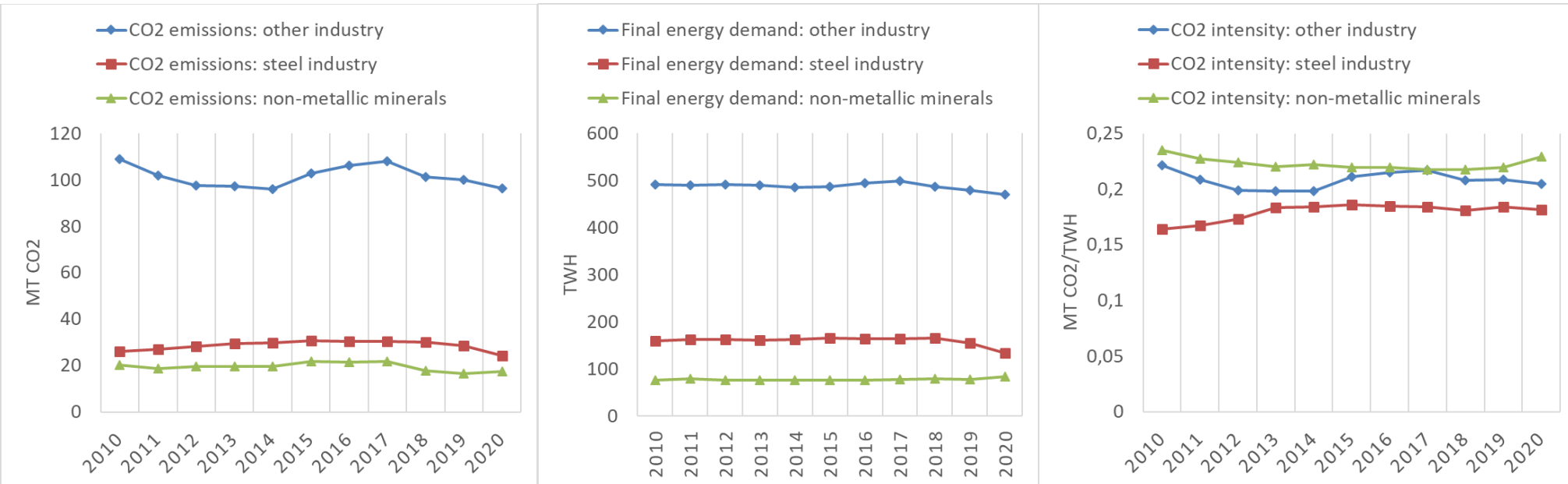


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Recent emission reductions in German industry very limited



- The CO₂ emission intensity of energy-intensive industries has been almost constant since 2010.
- Reduction of absolute CO₂ emissions have been driven mainly by reductions in economic output.



Source: ENERDATA based on official public statistics



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Recycling

- High-quality steel with increased scrap usage (TRL 4-9)

Hydrogen

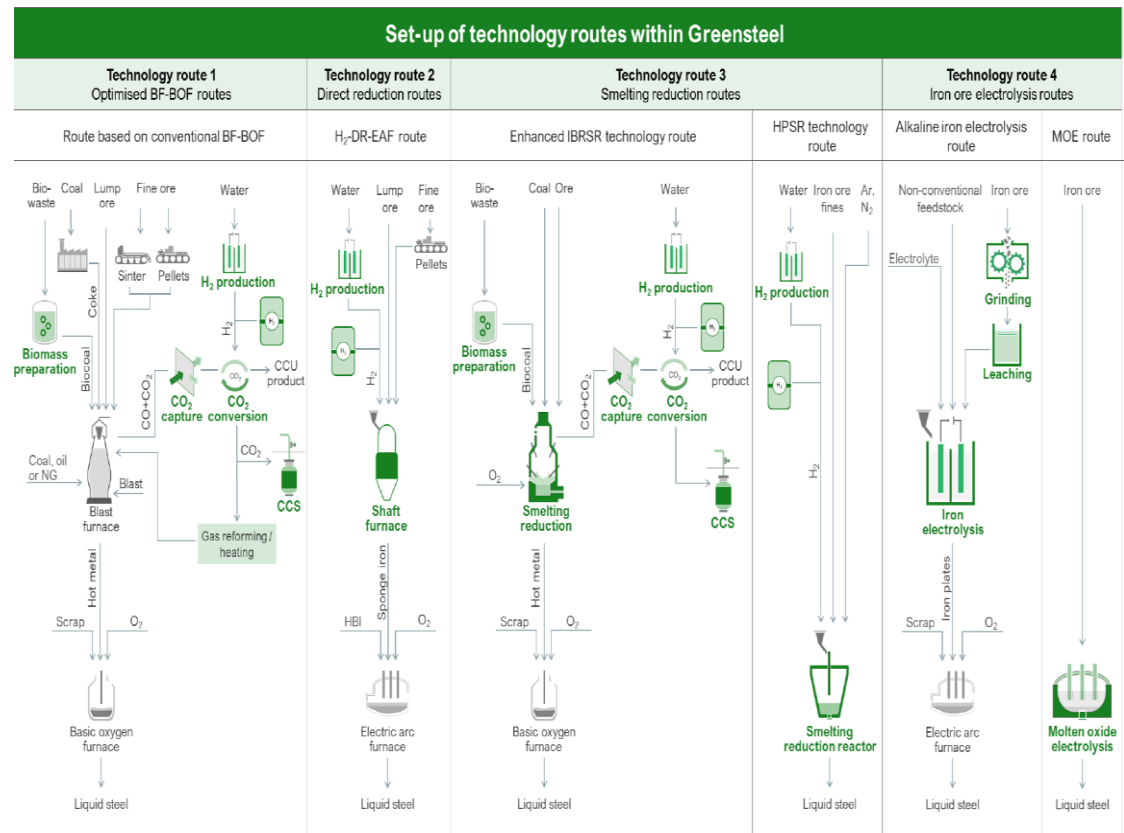
- H₂-based direct reduction (TRL 6-8)
- H₂ plasma smelting reduction (TRL 5)

Electricity

- alkaline iron electrolysis (TRL 5-6)
- molten oxide electrolysis (TRL 2)

Carbon based

- Iron based smelting reduction (TRL 6) using „Substitution of fossil energy by biomass (TRL 2-7), carriers by Carbon oxide conversion (TRL 8)
- Optimised BF using „Substitution of fossil energy by biomass (TRL 2-7), carriers by Carbon oxide conversion (TRL 8), gas injection into the blast furnace (TRL 8)



Source: <https://www.estep.eu/green-steel-for-europe/publications/>



Conceptual approach to co-creating transformative policy mixes

Pre-workshop processes

Model-based transformation pathways

- Where we are heading
- Paris-compatible pathways (optional: several variants)

Innovation system analysis and policy mix delineation

- Stage of transformation
- Actor constellations and power structures
- Infrastructures: physical, knowledge, financial
- Role of regulation and socio-cultural factors

Workshop preparation

Workshop inputs

- Geographically and sectorally focused overview of modelled pathways
- Input on innovation system, including an indicative list of potential bottlenecks
- Input on present policy mix and its delineation

Stakeholder involvement

- Stakeholder mapping
- Stakeholder selection for workshop

Workshop implementation

1st block: bottlenecks

Tensions between model-based pathways & current trajectories:

- social + political feasibility
- techno-economic feasibility
- socio-ecological and socio-economic impacts

2nd block: transformative policy mix elements

1. Agree on a policy strategy
2. Combine policy instruments
3. Reflect on actor & governance structure

Wrap up: policy mix signposts

Workshop evaluation

Result: STEEP narrative

- Comparison of **current and desired transformation** pathway
- Social, technical, economic, ecological, political **bottlenecks** along the way
- **Signposts for a transformative policy mix:** how to
 - ... overcome bottlenecks
 - ... destabilize non-sustainable practices
 - ... foster the realization of sustainable pathways
- **Implications for implementation** of policy mix

Source: Wachsmuth, J.; Jackwerth-Rice, T.; Seus, S.; Warnke, P. (2021): A Methodology for Co-Creating Transformative Policy Mixes as an Approach to Generalise Diffusion-Based Transition Pathways. Submitted to TFSC (based on full paper at the IST 2021 conference)



Transition bottlenecks for the German industry sector

Bottlenecks energy-intensive industries in Germany

Social feasibility	<ul style="list-style-type: none"> Fossil industry seen as guarantor for economic growth + labor Low acceptance of CCUS and no established framework yet
Political feasibility	<ul style="list-style-type: none"> International and EU state aid regulations limit subsidies Strong networks btw. industry and policy makers Uncertainty political framework conditions Certification green steel/cement
Technological feasibility	<ul style="list-style-type: none"> CCS + hydrogen technologies are not fully mature yet upscaling of technologies in an unprecedented way Potential lack of high-quality resources
Economic feasibility	<ul style="list-style-type: none"> Price impacts and value chain disruptions due to Covid and Russia-related sanctions Investment cycle requiring invest in process not yet competitive No infrastructures for transport of hydrogen (H₂) + CO₂ No established markets for green H₂ + cement yet
Socio-economic impacts	<ul style="list-style-type: none"> Uncertainty about CBAM impacts Price impacts for downstream industries Risk of carbon leakage and associated job losses
Socio-ecological impacts	<ul style="list-style-type: none"> Land use conflicts related to infrastructure + RES expansion



Source: own representation based on Koasidis, K. et al. (2020b) and Wachsmuth, J.; Aydemir, A.; Döscher, H.; Eckstein, J.; Poganietz, W.-R.; François, D.-E. et al. (2021): The potential of hydrogen for decarbonising EU industry. Brussels: European Parliament.



Transition bottlenecks for the German industry sector

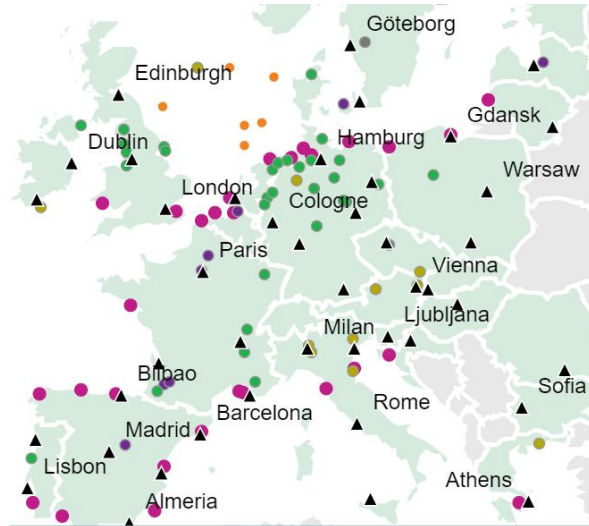
Bottlenecks energy-intensive industries in Germany	
Social feasibility	<ul style="list-style-type: none"> Fossil industry seen as guarantor for economic growth + labor Low acceptance of CCUS and no established framework yet Low acceptance of new infrastructures
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Socio-economic impacts	<ul style="list-style-type: none"> Uncertainty about CBAM impacts Price impacts for downstream industries Risk of carbon leakage and associated job losses Customer-related barriers (norms, competences)
Socio-ecological impacts	<ul style="list-style-type: none"> Land use conflicts related to infrastructure + RES expansion



Source: own representation based on Koasidis, K. et al. (2020b) and Wachsmuth, J.; Aydemir, A.; Döscher, H.; Eckstein, J.; Poganietz, W.-R.; François, D.-E. et al. (2021): The potential of hydrogen for decarbonising EU industry. Brussels: European Parliament.



Narrative: How major bottlenecks to the industry decarbonisation in Germany will have been overcome



2020s



Demand for CO₂-neutral hydrogen increases substantially

- 2030: 68-144 TWh
- 2050: 825 – 1289 TWh

If not imported, hydrogen production would **increase the electricity demand by up to 1700 TWh.**

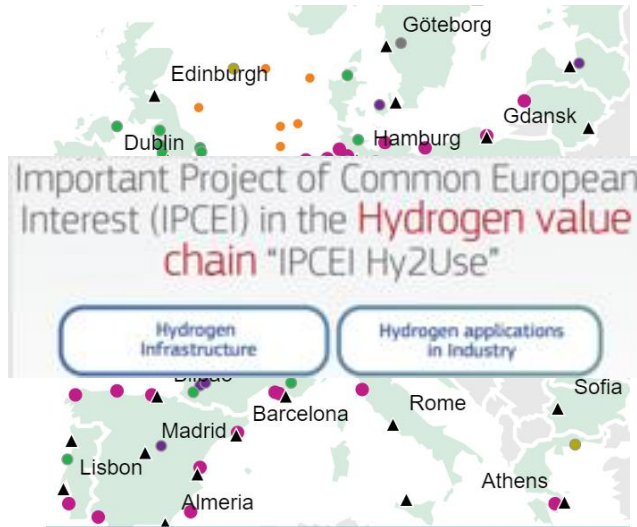


2040s

Sources: European Hydrogen Backbone (2022), A-Dabbas et al. (2022)



Narrative: How major bottlenecks to the industry decarbonisation in Germany will have been overcome



2020s

- Developing an **overarching system development strategy**
- **Certification of green and blue H2** based on RED III and Gas Package
- **Support schemes for infrastructure and electrolyser build up**
- Carbon **contracts for difference**



2030s

- **Green public procurement initiative** in the building sector
- Establishing **labels and green lead markets**



Sources: European Hydrogen Backbone (2022), A-Dabbas et al. (2022)



Sectoral bottlenecks considered most relevant by stakeholders

Country	Sector	Bottlenecks considered most relevant by the stakeholders
Germany	Energy-intensive industries	<ul style="list-style-type: none"> (1) Infrastructure-related bottlenecks: Uncertainty around availability of hydrogen and renewable electricity & political framework conditions (2) Demand-side-related bottlenecks: Certification & markets for green steel/cement, customer related barriers (norms, competences)
UK	Energy-intensive industries	<ul style="list-style-type: none"> (1) Financing, investment cycles, and energy prices (2) Unprecedented upscaling of technologies and required skilling (3) Infrastructure expansion
Brazil	Transportation	<ul style="list-style-type: none"> (1) Issues around resistance of powerful actors (2) price of batteries, access to credits and (3) cost of mobility, Diesel sensitivity.
Canada	Transportation	<ul style="list-style-type: none"> (1) uncertainties around CCS technologies (2) decarbonisation of freight transport (3) urban planning not suitable for mobility shift <p>Crosscutting: governance issues resulting from multi-scalar structures</p>
Greece	Electricity sector	<ul style="list-style-type: none"> (1) High costs of grid adaption to RES requirements & Access to finance (2) Issues with RES (esp. wind power) expansion: opposition, ecosystem impact & land use constraints (3) Potential lock-in due to high investment into (L)NG infrastructure (4) Storage maturity

Source: Wachsmuth, J.; Warnke, P.; Gambhir, A.; Giarola, S.; Koasidis, K.; Nikas, A.; Pied, M.; Vaillancourt, K. (2022): D4.7 – Transformative Policy Mixes: Comparing National Case Studies. To be published on the PARIS REINFORCE website soon



Conclusions

- The workshops made clear that substantial **tensions exist btw. modeled pathways and the real world**
→ **Realisibility of the narratives remains open!**
- **Some challenges and solutions stand out in all countries** in spite of the strong diversity of contexts:
 - **Allocation of capital** towards massive investments into low-carbon solutions
 - **Infrastructure development** for hydrogen, capture and use of CO₂ and electricity grids and storage adapted to renewable energy solutions
 - **Stakeholder and citizen dialogues** where agreement is reached on cornerstones of long-term decarbonisation trajectories
 - **Demand-side measures** complementing investments into low-carbon processes

Outlook

- In order to facilitate change in the respective countries, **the narratives need to be validated, enriched and amended by the stakeholders** themselves.
- This process reaches beyond PARIS REINFORCE but can and **should be initiated by the project partners** in their respective countries or in further cooperations.





Thank you!

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