EXPERIENCES FROM MODELLING HYDROGEN FOR GERMANY AND EUROPE

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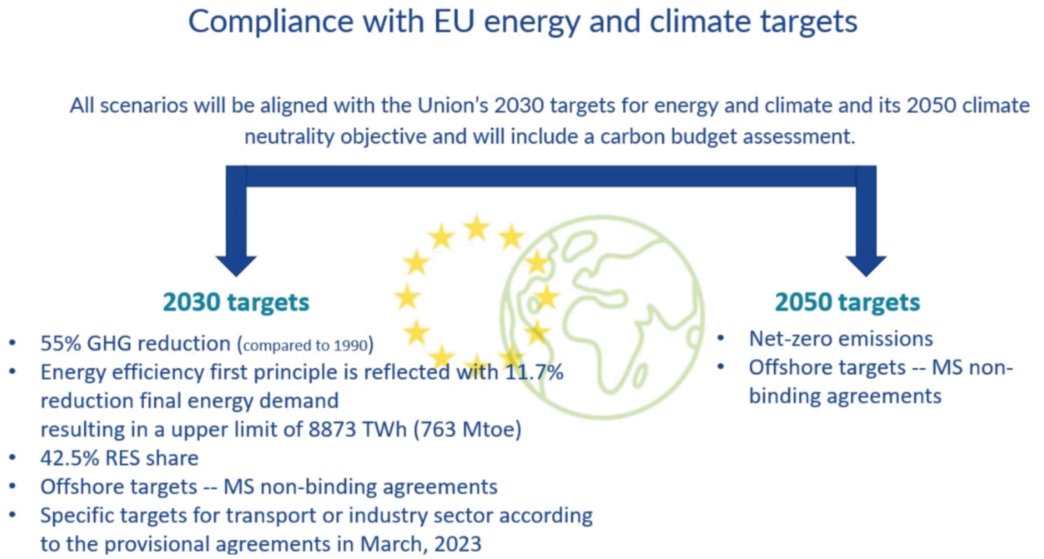
Challenges in European energy strategy

Climate risk and geopolitical crises drive the urgency for transformation:

- Decarbonizing the energy supply systems across sectors
- Providing security of energy supply

How can the system be transformed to reach these goals?

- What it the optimal timing for switching to hydrogen and green energy carriers?
- How can electrolyzers be ramped up efficiently for increasing demand of hydrogen?
- What are the implications for power grids and pipeline networks and their respective topology?



TYNDP2024 stakeholder consultation

Tab. 1 – Strategic choices in the European clean hydrogen value chain

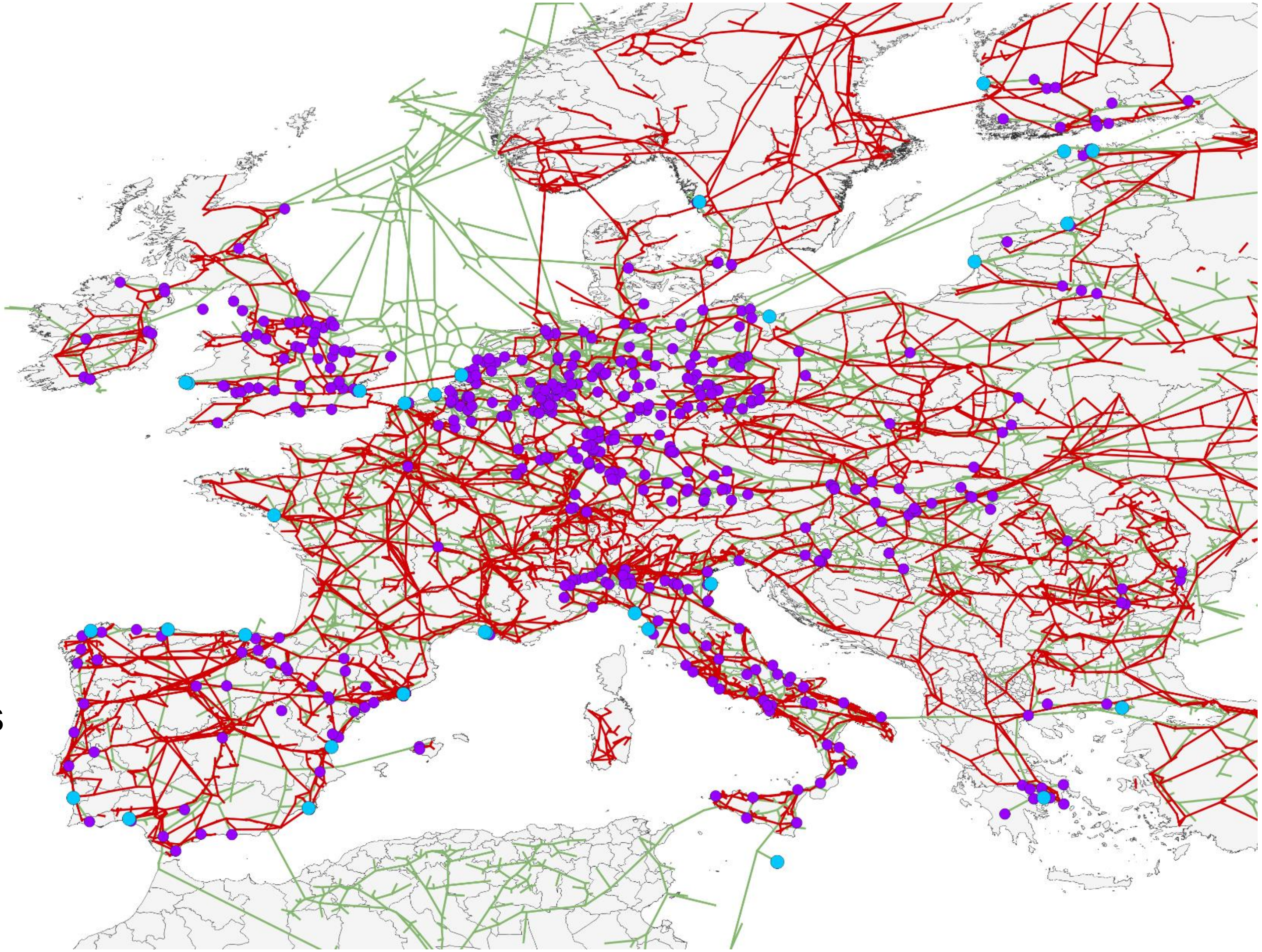
European Union	**40 GW** **10 MtH$_2$**	• Push for renewables • Promotes a "Hydrogen Valley" approach to facilitate local integration and growth • By 2024: **6 GW** electrolyzers, **1 MtH$_2$** • By 2030: **40 GW** electrolyzers, **10 MtH$_2$** • 2030-2050: large-scale deployment across all hard-to-abate sectors
Germany	**10 GW** **3 MtH$_2$**	• Push for renewables • Emphasis on imports of hydrogen (low-carbon hydrogen not excluded) • €8bn of public budget has already been allocated to 62 pre-selected projects • Up to €3.4bn to build refuelling stations

Deloitte 2022 The European hydrogen economy

European power and gas infrastructure

- One model region per country
- Increased spatial resolution
- Integration of high res power grid
- Integration of high res gas network
- Integration of LNG terminals
- Power and gas network with LNG terminals and gas power plants

→ European infrastructure modelling requires high spatial and temporal resolution



Own depiction based on ENTSO-E GridKit and SciGrid_gas IGGIELGN

Modelling toolchain

SciGRID Gas

bdw/GridKit

GridKit is an power grid extraction toolkit

eGo^n

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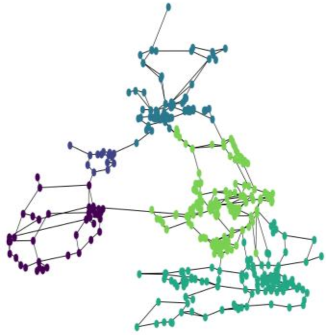
Topology reduction for networks



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Calculation of EEZs

- Area allocation based on coastlines or points

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Renewable energy potentials and feed-in

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REMix
Renewable Energy Mix

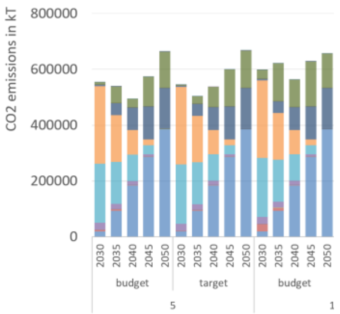
Open source publication
- Source code release
- Python API and PyPI release

Model development
- Infrastructure repurposing
- Improved model formulation
- PIPS-IPM++ for pathways

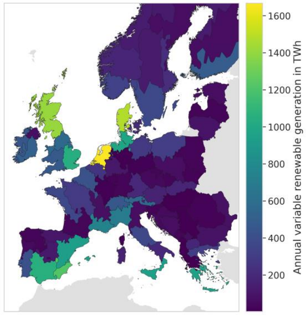
→

Results from the REMix model

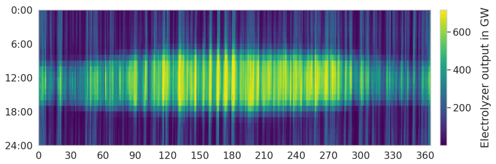
- Annual energy balances



- Spatial allocation of technologies

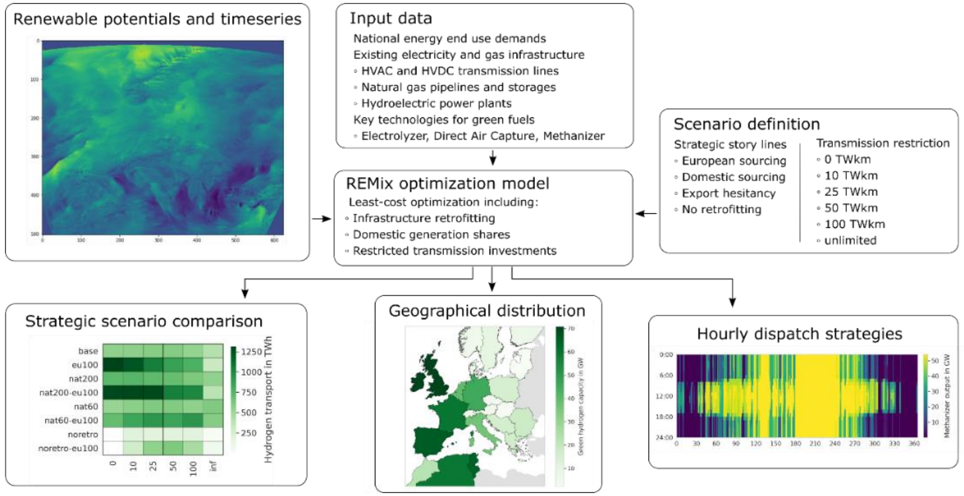


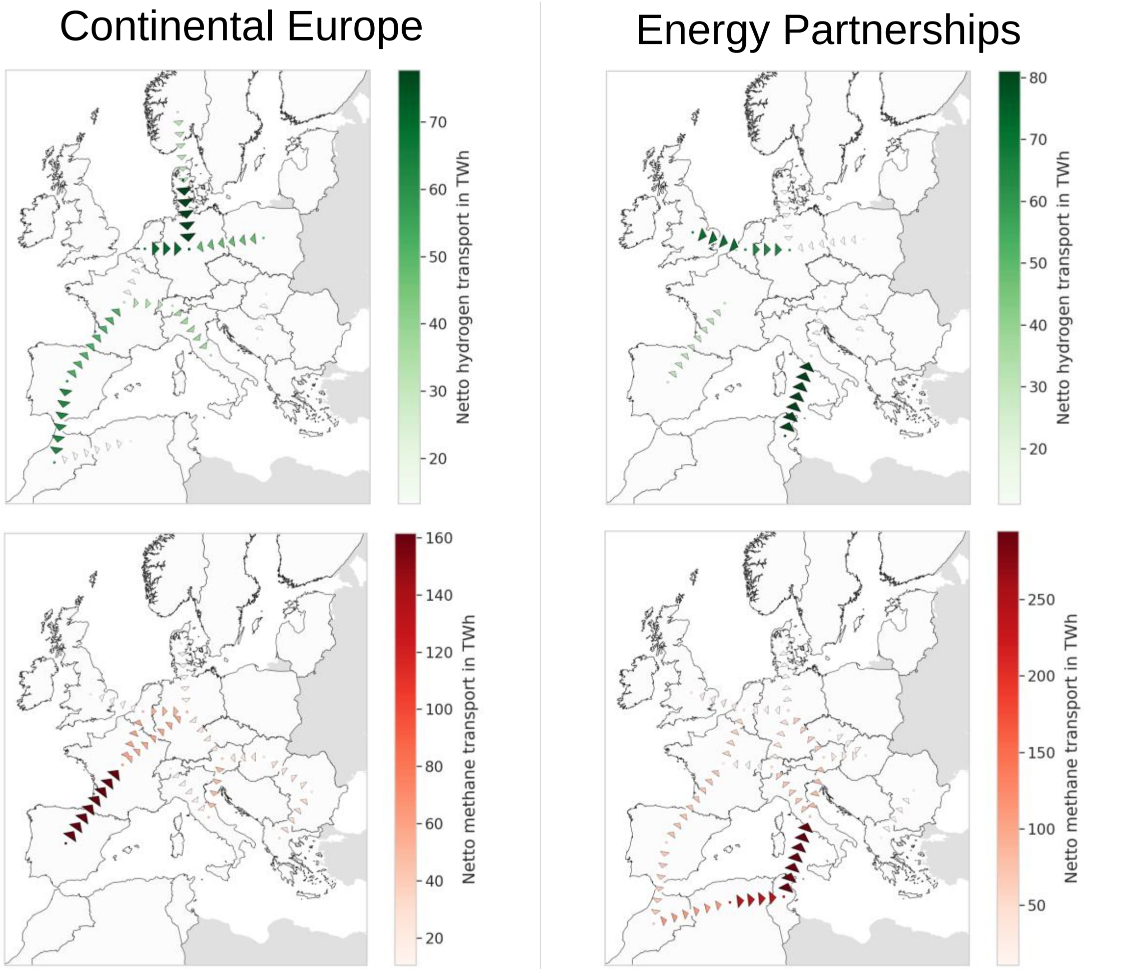
- Hourly interactions between technologies



The role of green hydrogen and methane

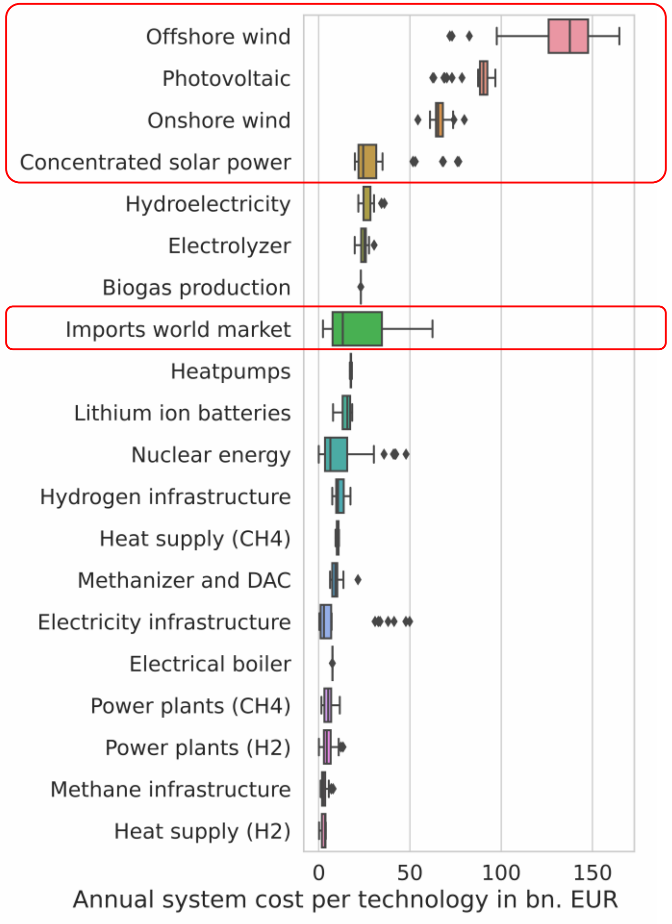
- Climate neutral energy system in 2050
- Scenarios on energy partnerships, domestic sourcing, network expansion limits





Wetzel, M., Gils, H.C., Bertsch, V., 2023, Green energy carriers and energy sovereignty in a climate neutral European energy system, Renewable Energy

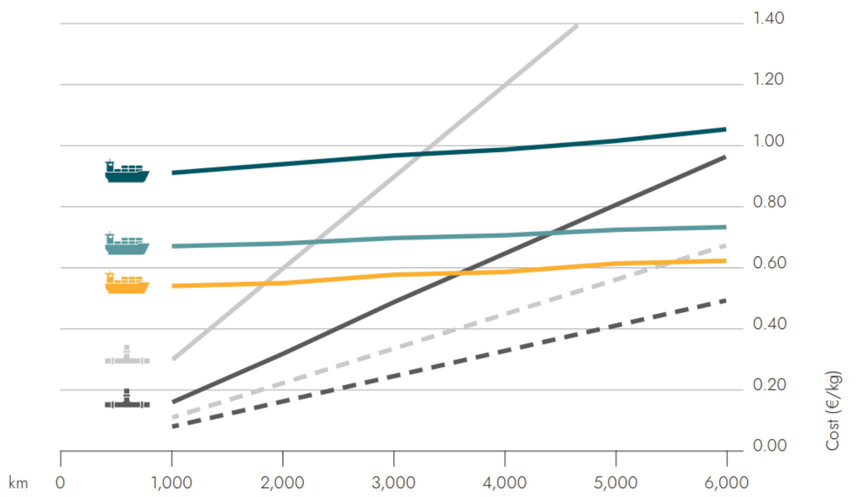
The uncertainty of future energy imports



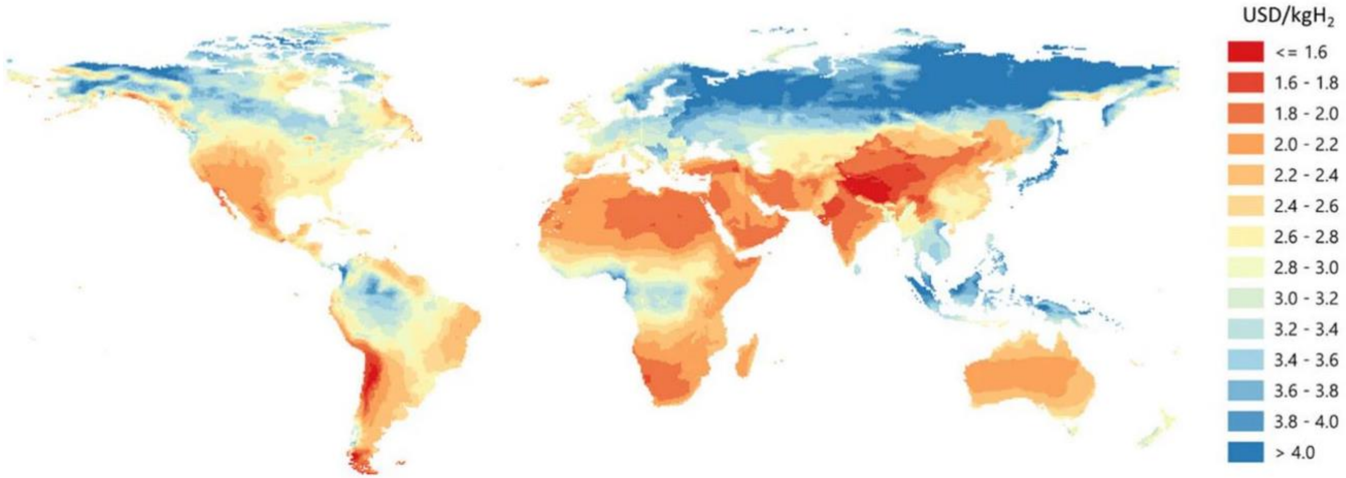
Wetzel, M., Gils, H.C., Bertsch, V., 2023, Green energy carriers and energy sovereignty in a climate neutral European energy system, Renewable Energy

Investments into renewable energy becomes main driver of system costs

Large uncertainty about imports from global energy markets



Guidehouse 2021, Future demand, supply and transport of hydrogen



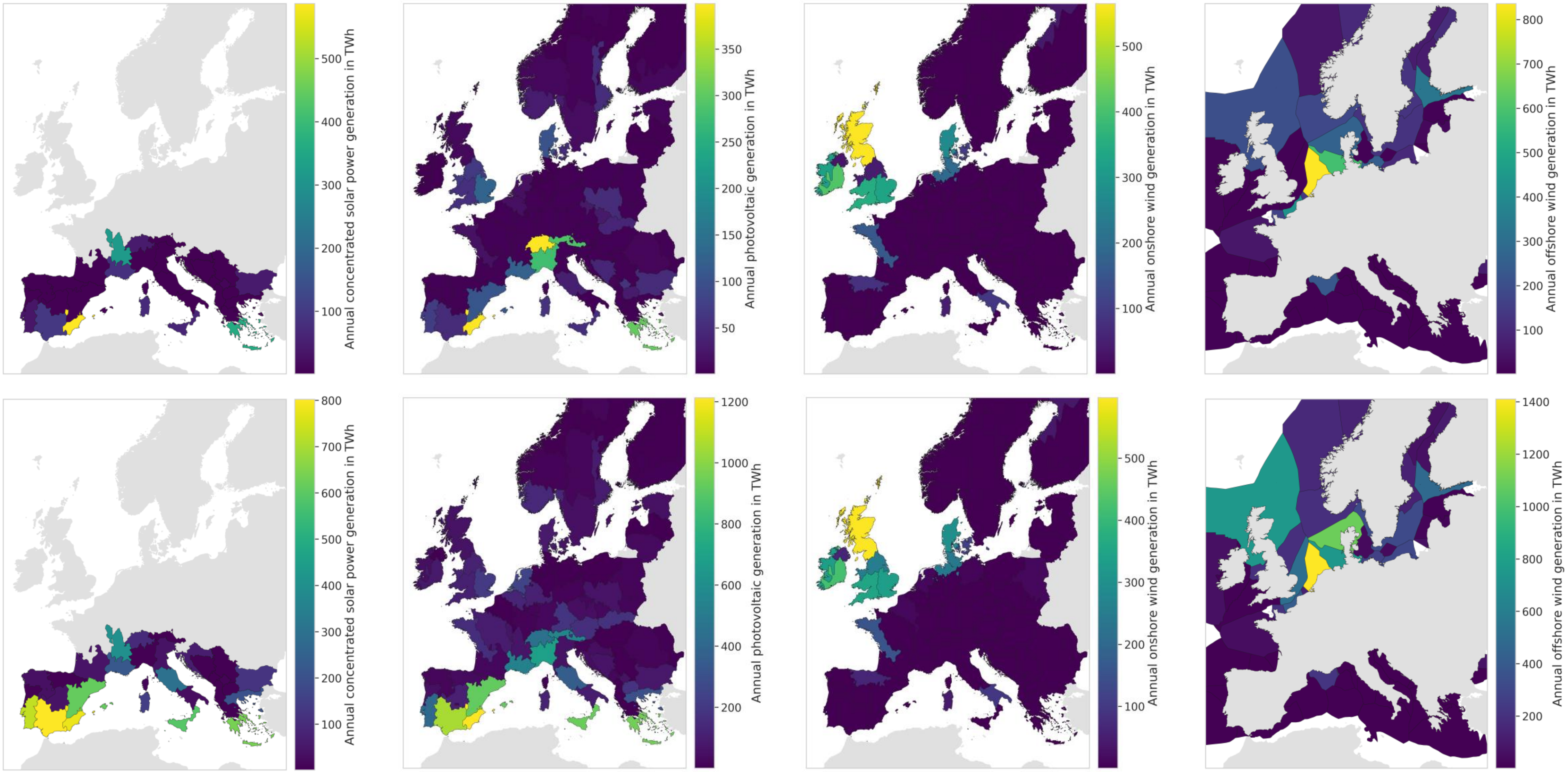
IEA 2020, The Future of Hydrogen

REMix results – Electricity production sites (H2 scenario)

Concentrated solar | Photovoltaics | Onshore wind | Offshore wind

2035

2050

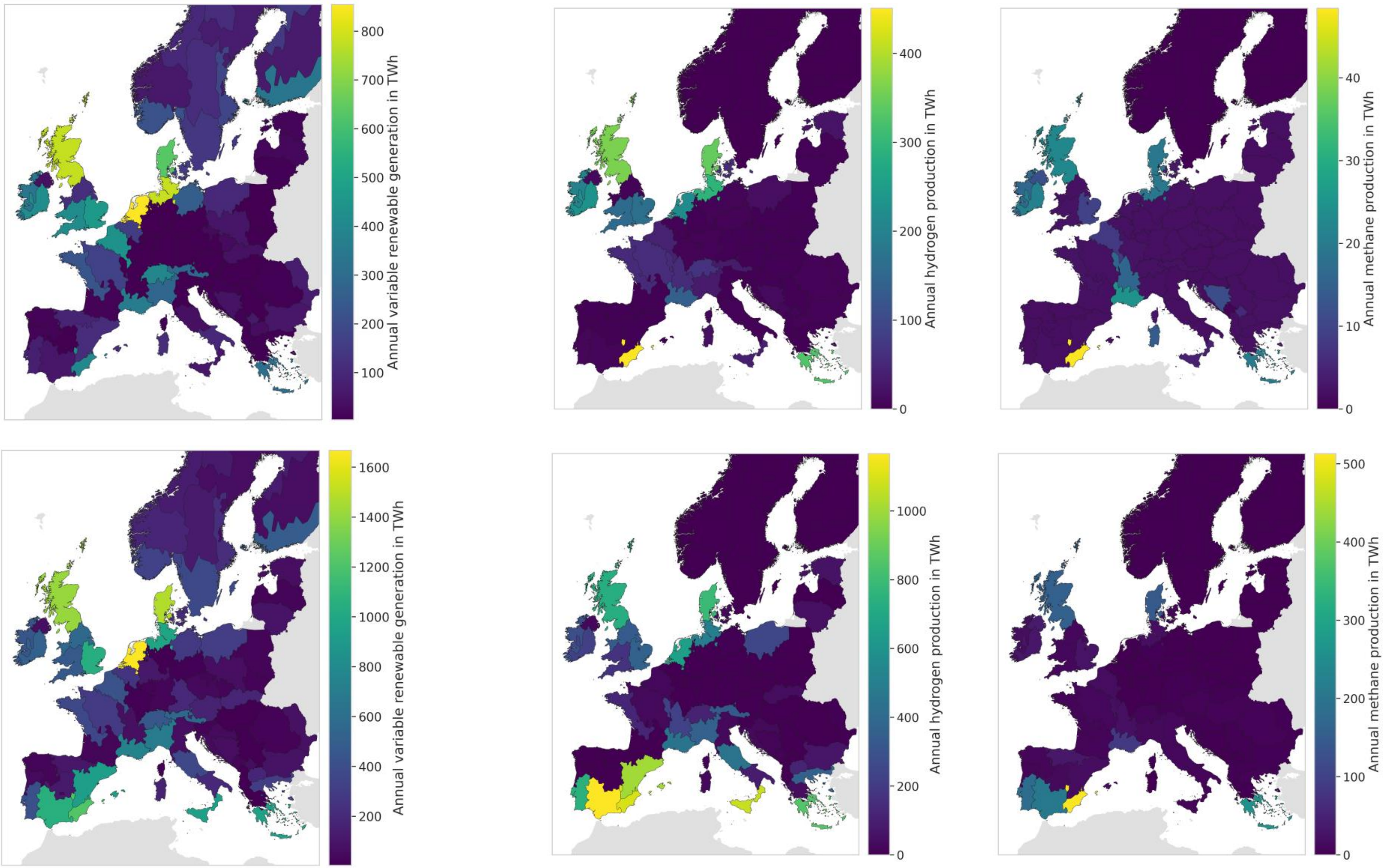


REMix results – Hydrogen and methane sites (H2 scenario)

Variable renewable energy | Hydrogen production | Methane production

2035

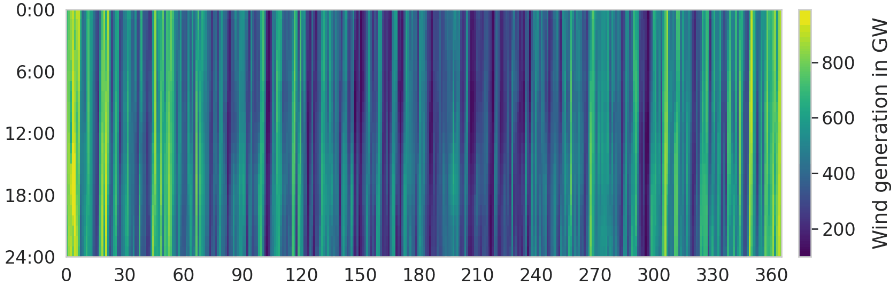
2050



Temporal technology correlations

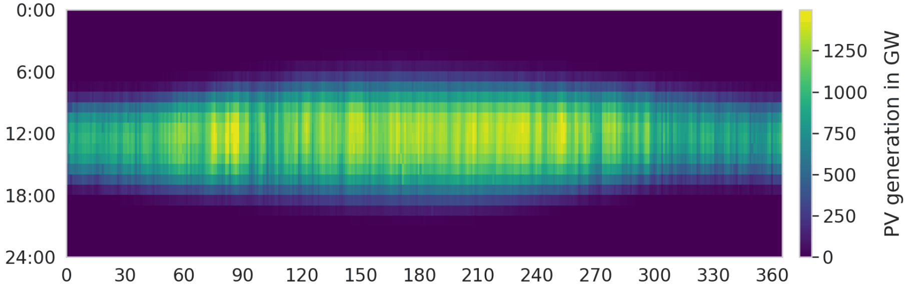
Onshore and offshore wind


pexels



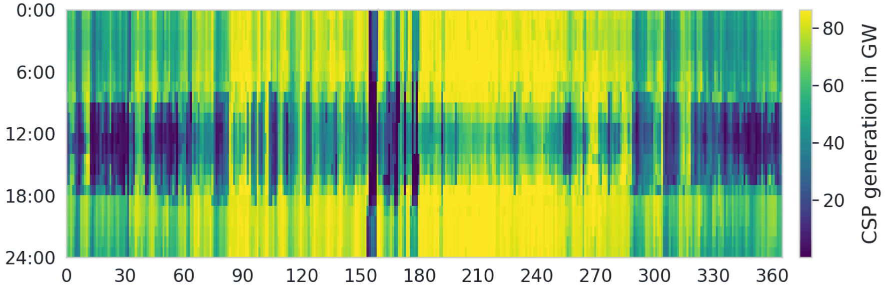
Photovoltaics


pexels

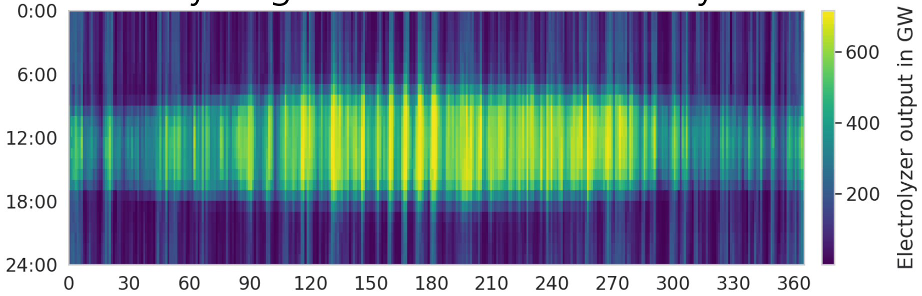


Concentrated solar power

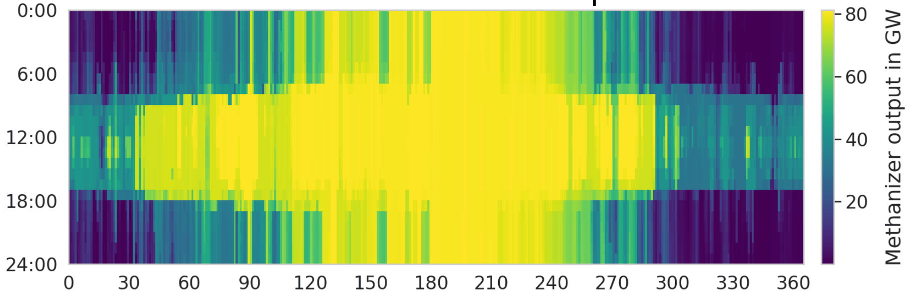

SENER



Hydrogen from water electrolysis



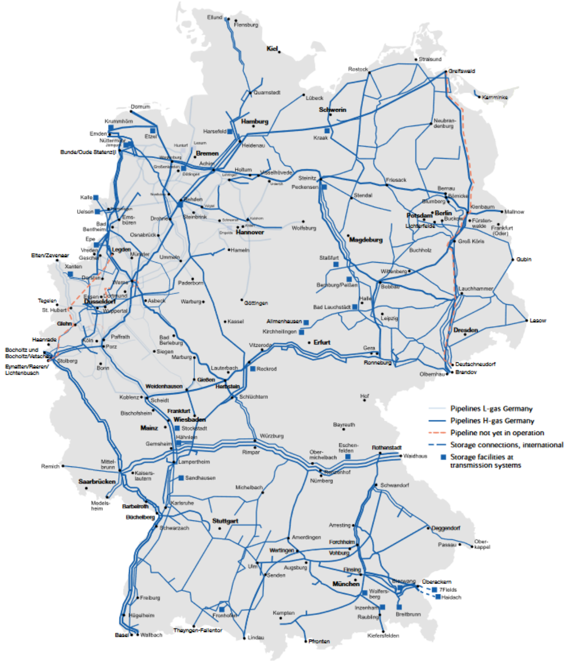
Methane from Sabatier processes



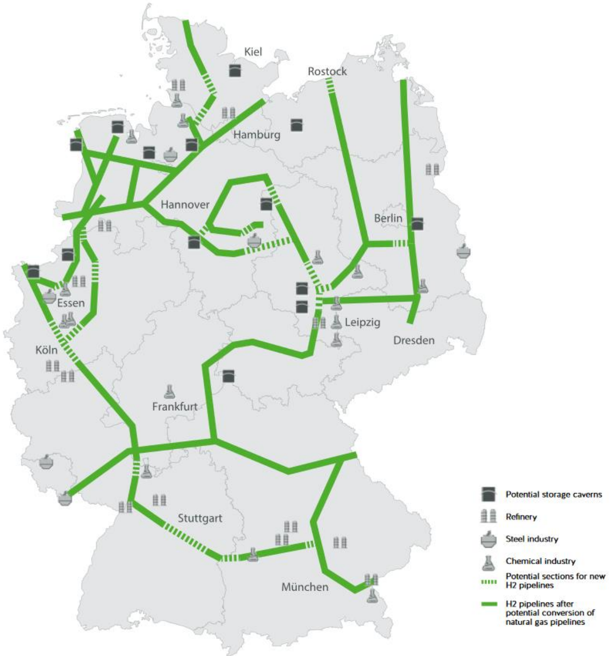
- Electrolyzers offer demand side flexibility
- Green methane requires seasonal storage

Infrastructure repurposing

Current H-gas network



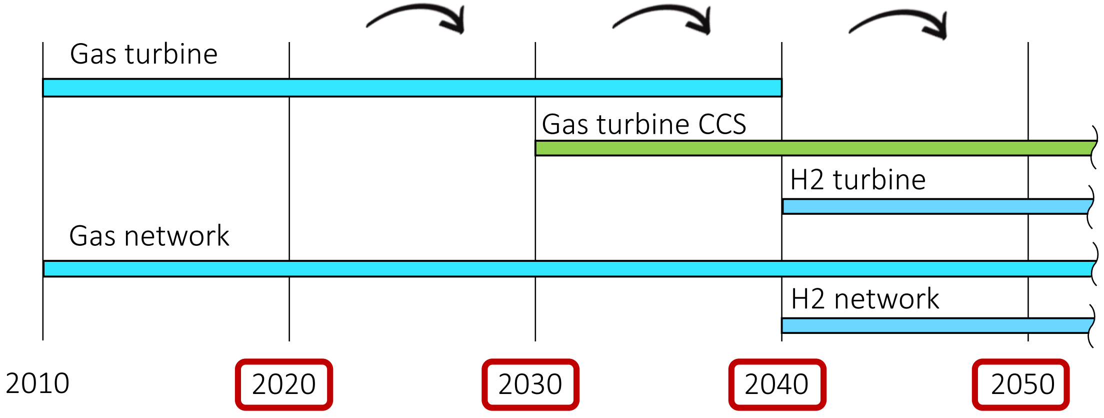
Envisioned hydrogen network



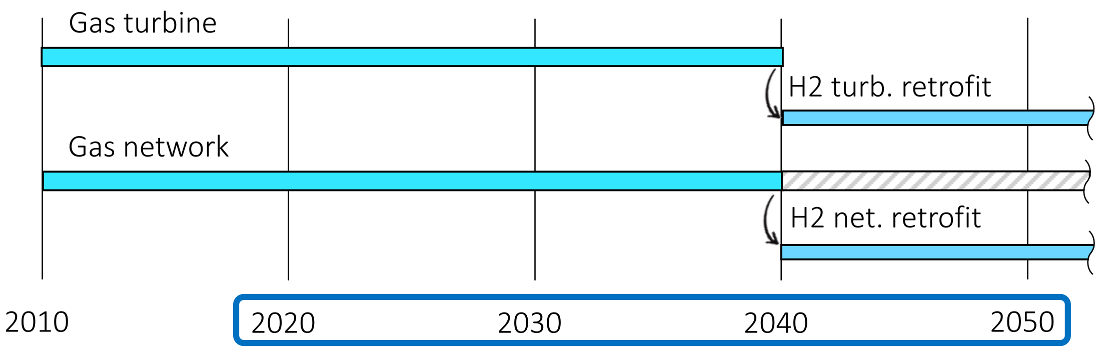
Gas Network Development Plan 2020 - 2030

- Foresight of the model has impact on the transformation pathway and timing of infrastructure repurposing

Myopic foresight

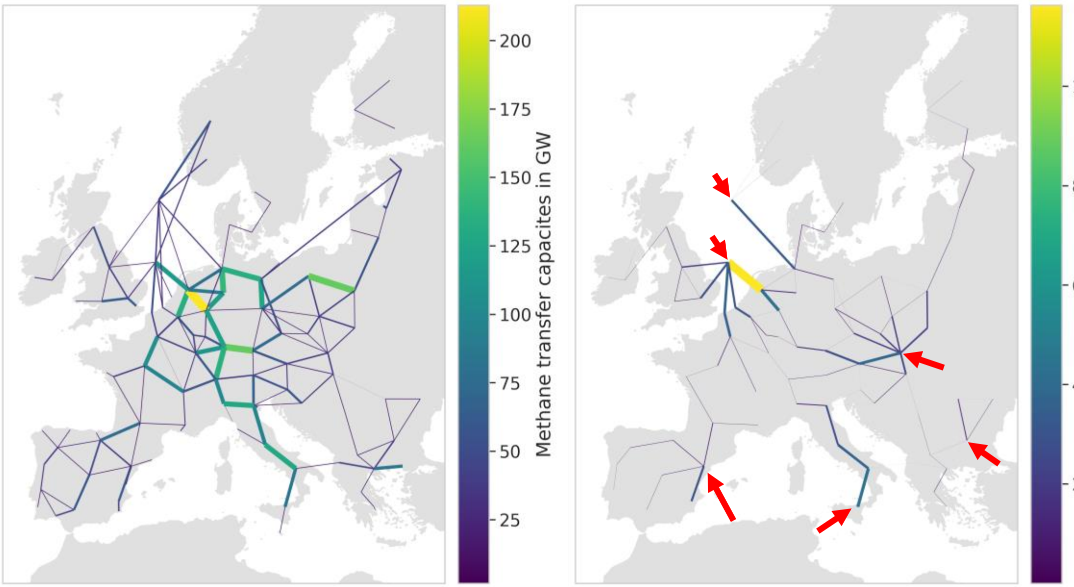


Perfect foresight



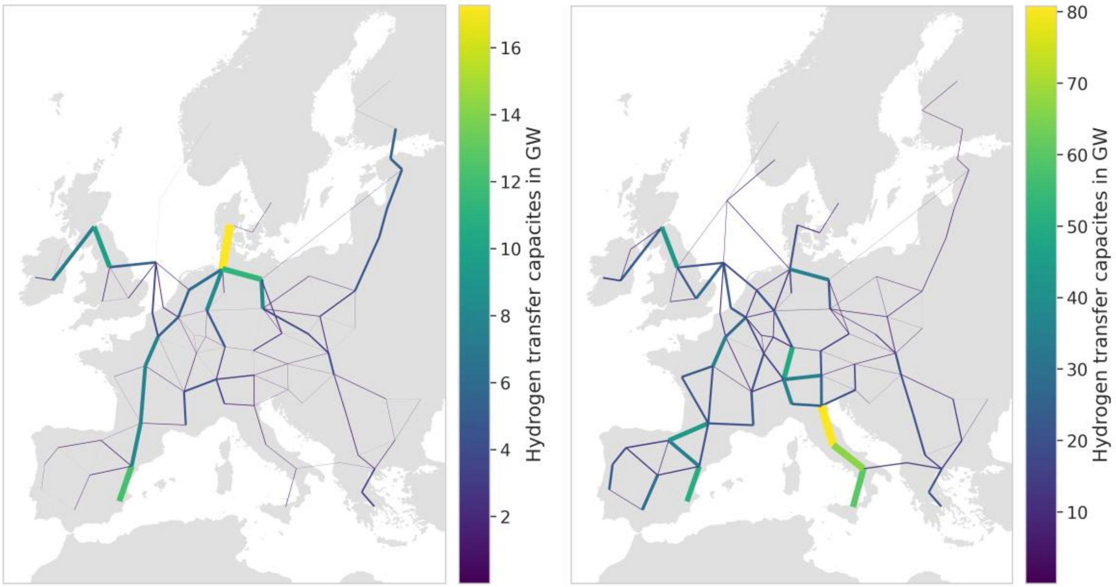
REMix results – Network topology (H2 scenario)

Methane network capacities 2025 - 2035



- Remaining gas network mainly focused on pipeline corridors for imports and gas rigs

Hydrogen network capacities 2030 - 2050



- Initial hydrogen network focused on the North Sea area and Southern Europe
- Evolutionary development towards a highly meshed grid

Acknowledgements

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