A PATHWAY FOR THE GERMAN ENERGY SECTOR COMPATIBLE WITH A 1.5°C CARBON BUDGET

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HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

DLR

Structure

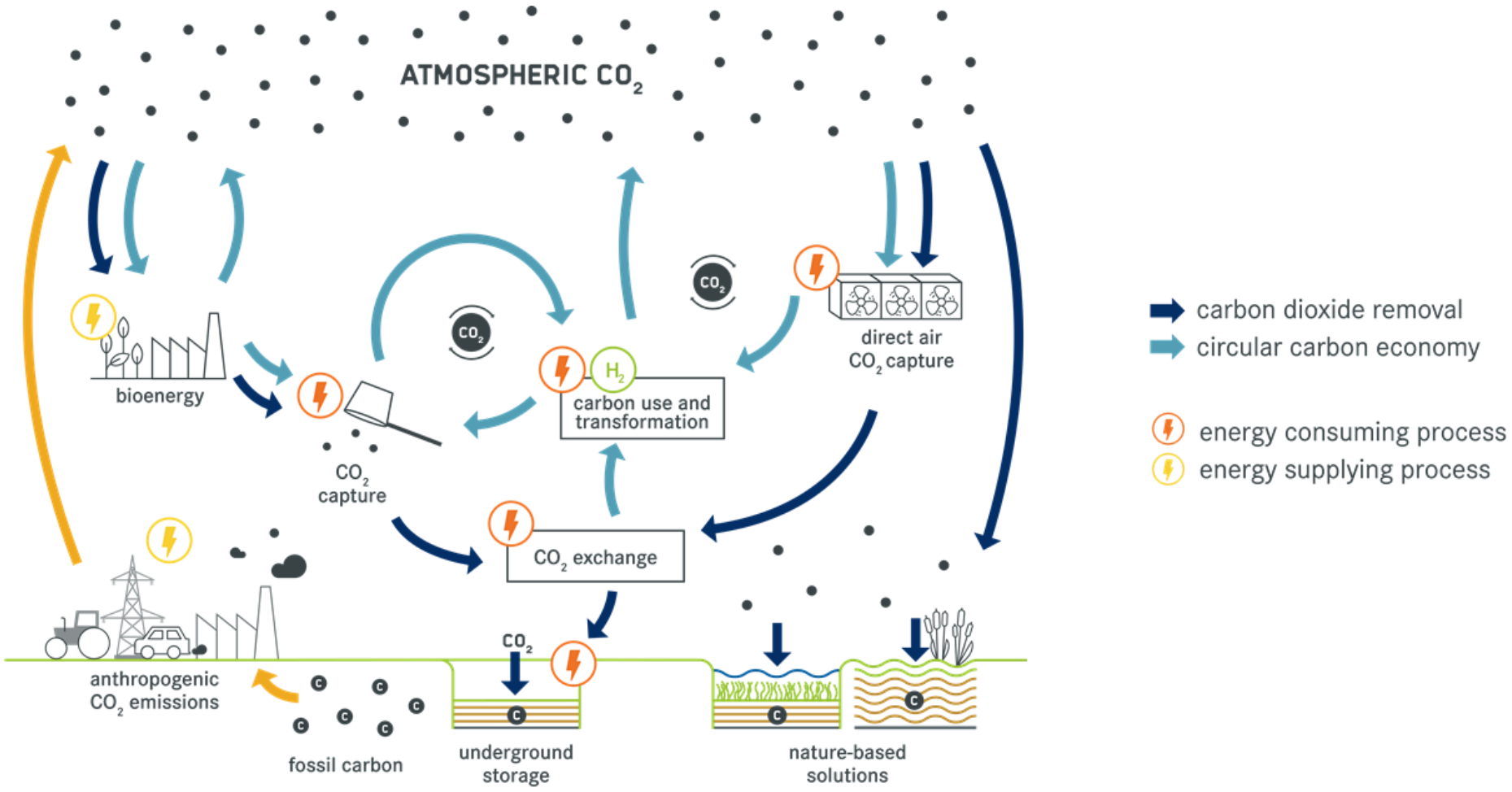
- Setting the scene: the Helmholtz Initiative Climate Adaptation and Mitigation
  - HI-CAM Cluster I
  - Carbon budget approach
- Methods and Storyline for the Energy scenario
  - System & Models
- Basic results of the Energy scenario
- Conclusion and Outlook

HI-CAM: THE NET ZERO PROJECT

Bildquelle hier angeben

Sonja Simon, DLR 13.6.23

NET-ZERO
Pathways to Carbon Neutrality 2050

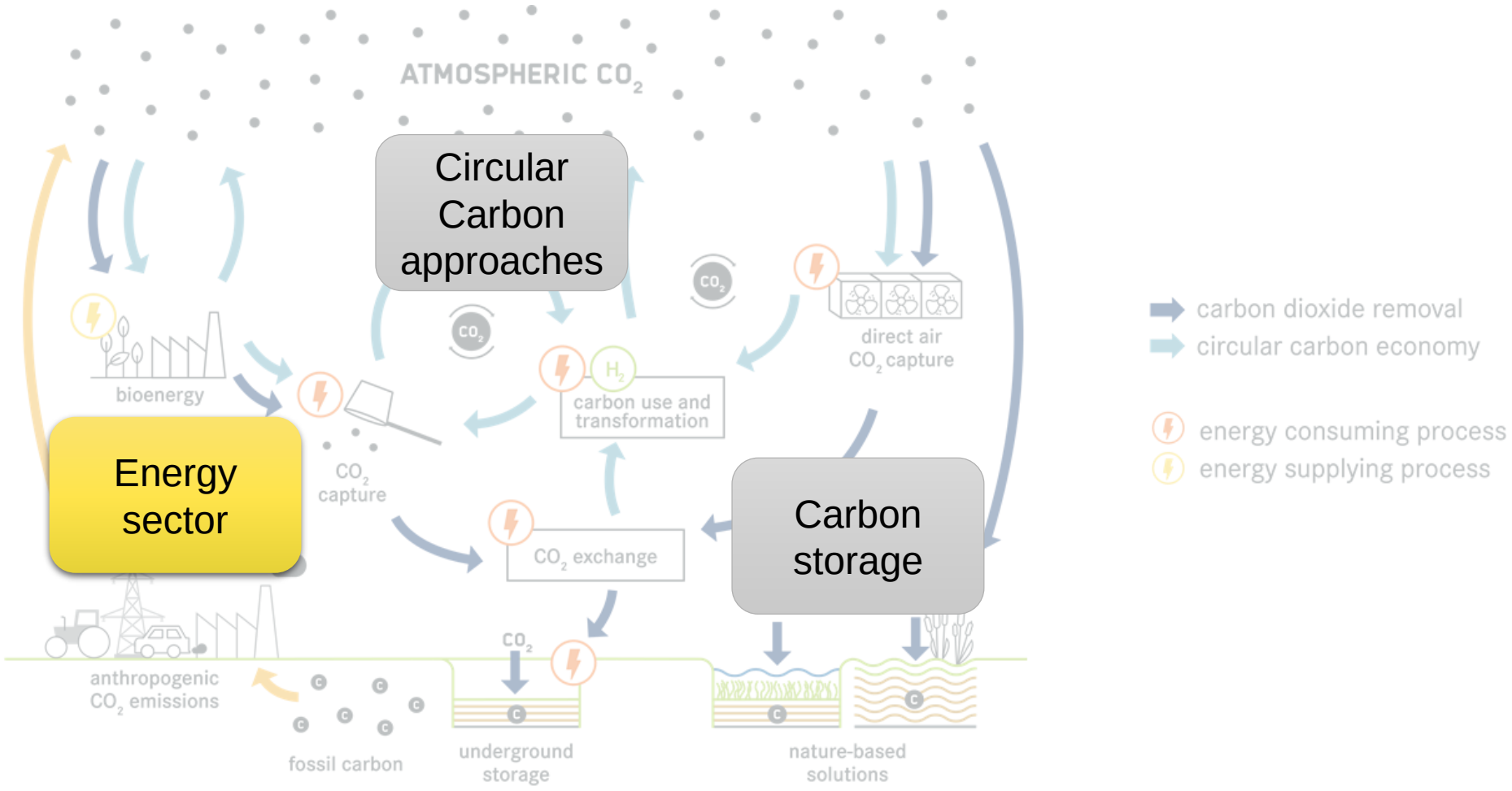


Source: Net- zero CO_2 Germany - A retrospect from the year 2050, Mengis, Kalhori et al., 2022, https://doi. org/10.1029/2021EF002324

HELMHOLTZ CLIMATE INITIATIVE

NET-ZERO
Pathways to Carbon Neutrality 2050

DLR



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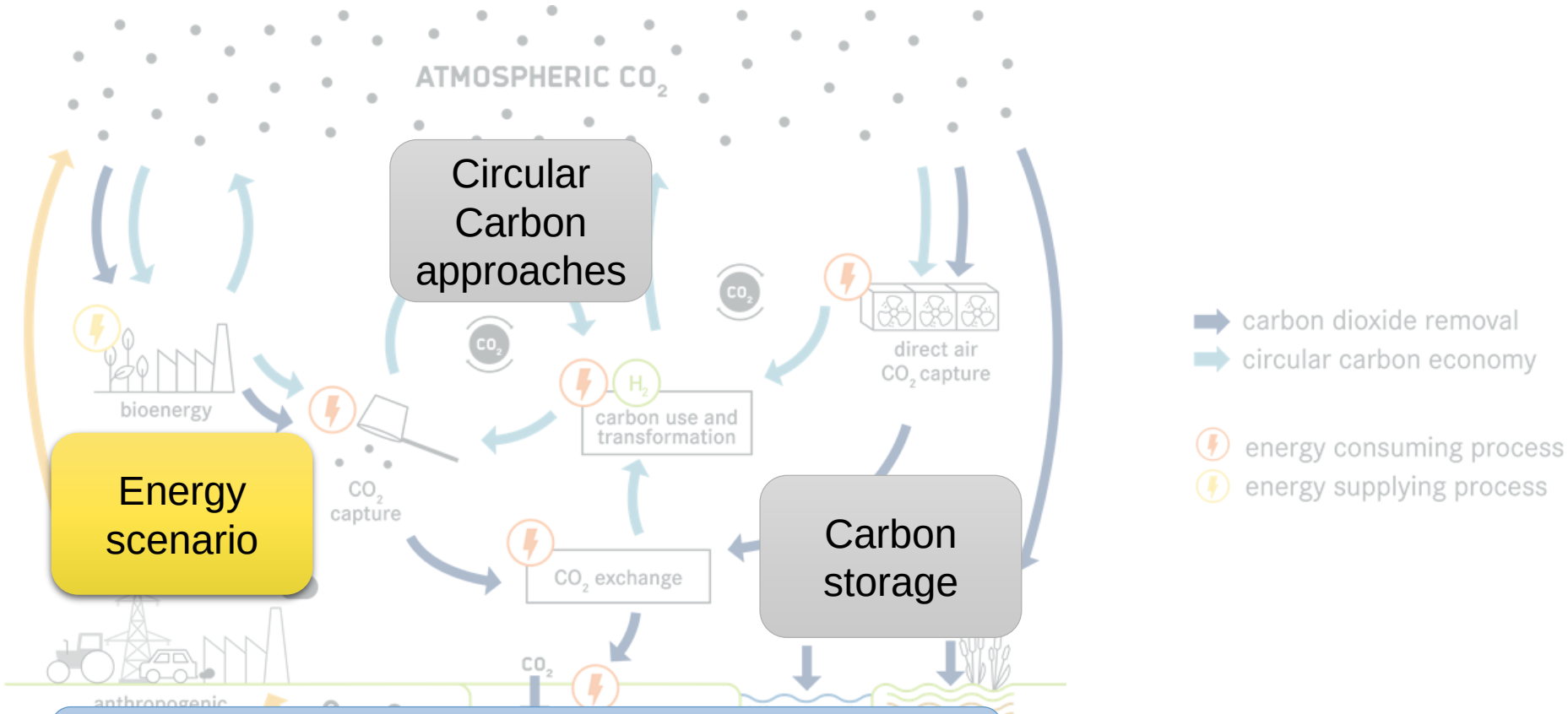

Integrated under a joint carbon budget for Germany

Source: Net- zero CO_2 Germany - A retrospect from the year 2050, Mengis, Kalhori et al., 2022, https://doi. org/10.1029/2021EF002324

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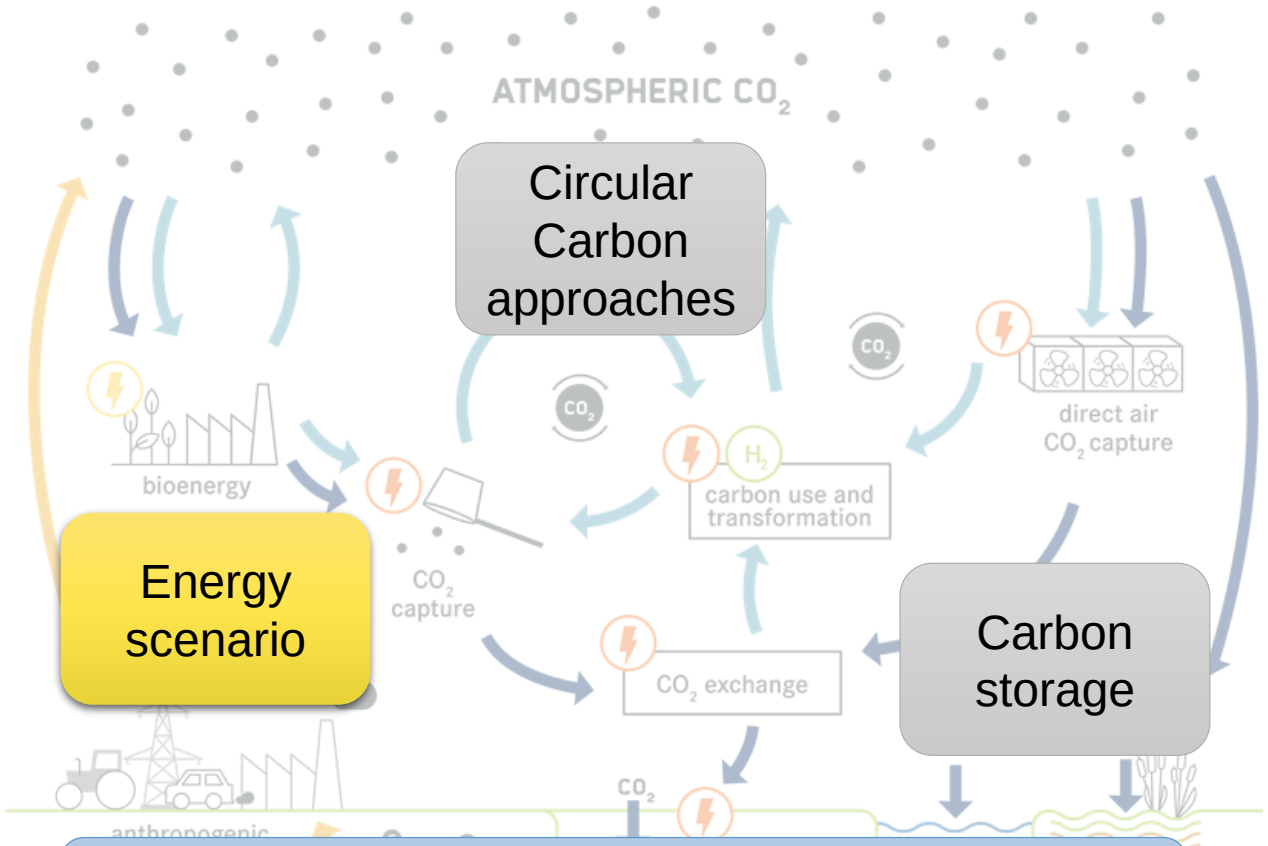
DLR



Integrated under a joint carbon budget

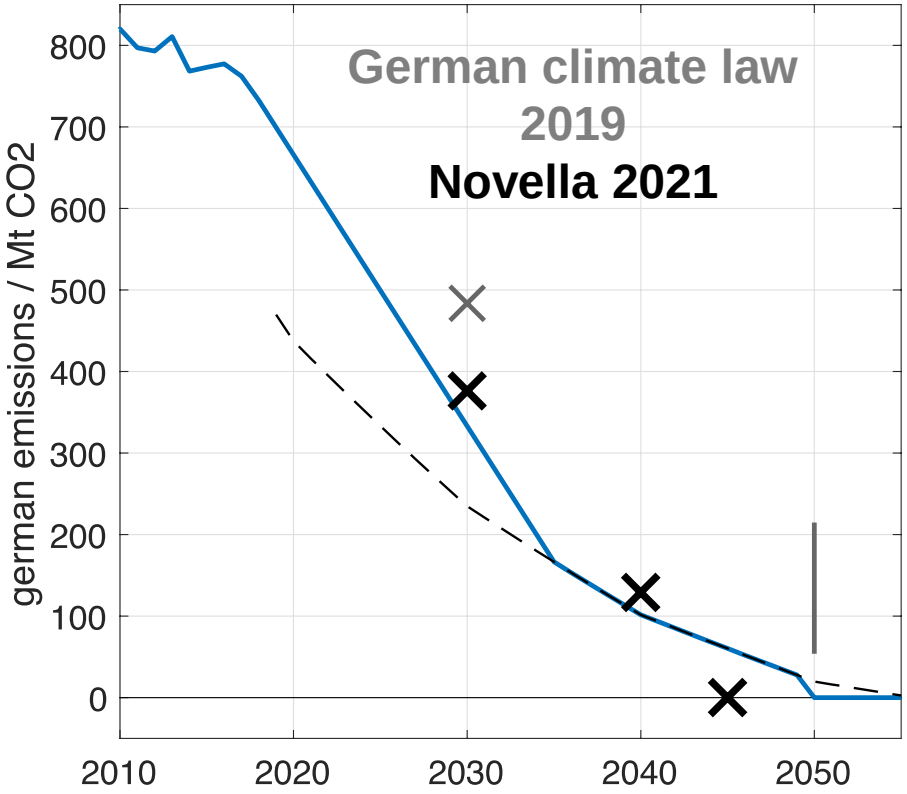
Partners

and many more

Source: Net- zero CO_2 Germany - A retrospect from the year 2050, Mengis, Kalhori et al., 2022, https://doi. org/10.1029/2021EF002324

HELMHOLTZ CLIMATE INITIATIVE

Target: Defining the carbon budget for Germany



- Net Zero Emissions in 2050
- Defined by Geomar based on IPCC Contraction & Convergence
- Overall budget for Germany: 8 Gt CO_2

Sources:
Meyer, A. (2000) Contraction and Convergence: The Global Solution to Climate Change, see also https://de.wikipedia.org/wiki/Kontraktion_und_Konvergenz
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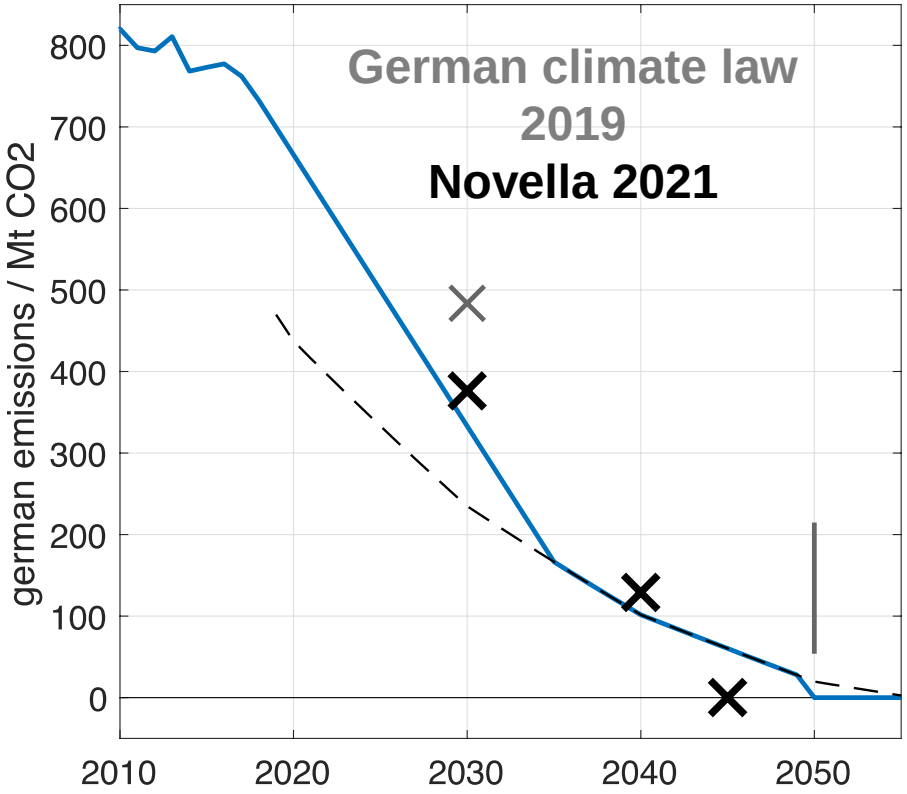

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- Net Zero Emissions in 2050
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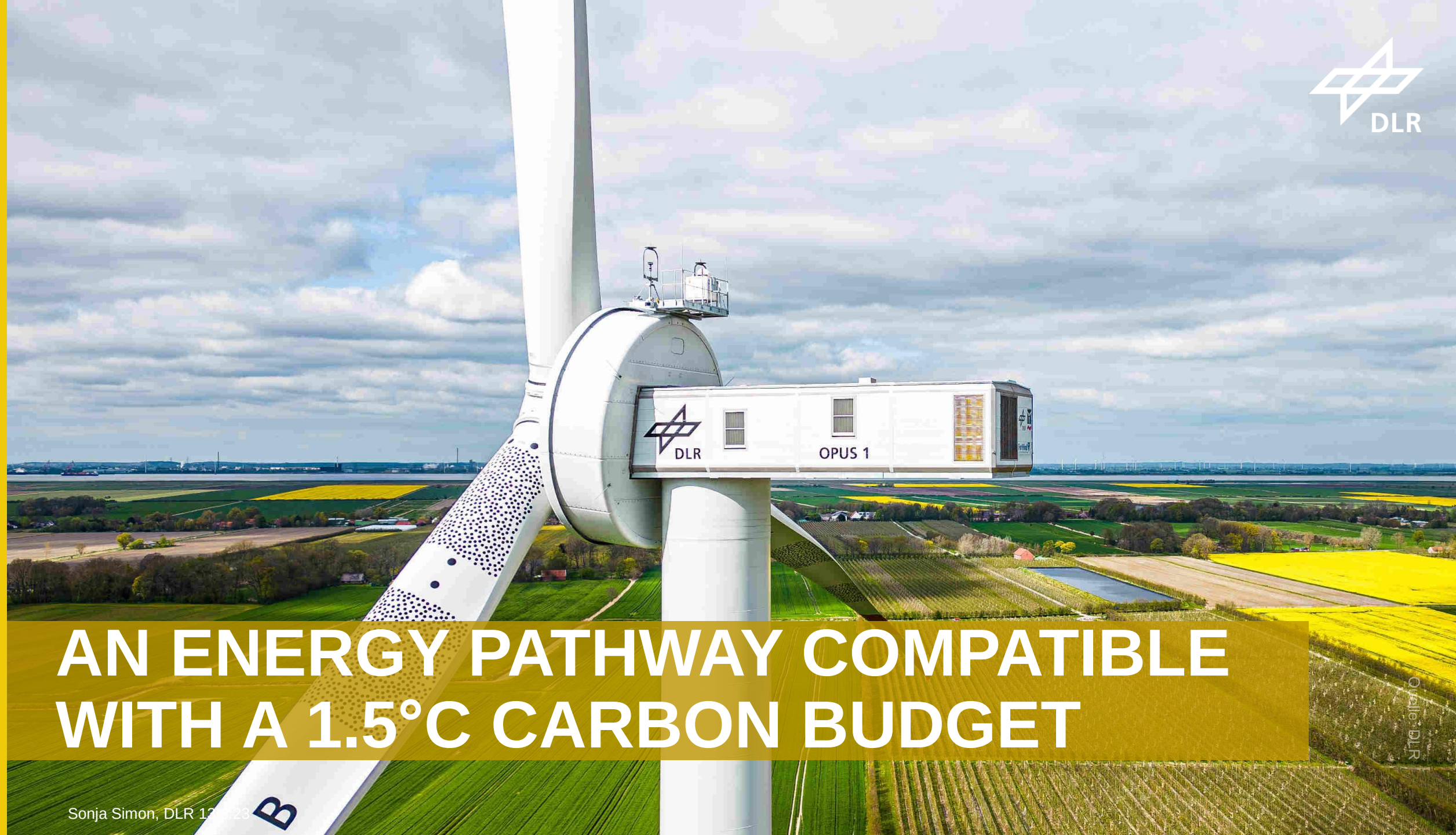
- Overall budget for Germany: 8 Gt CO_2
- **Sectoral carbon budget is „grandfathered“:**

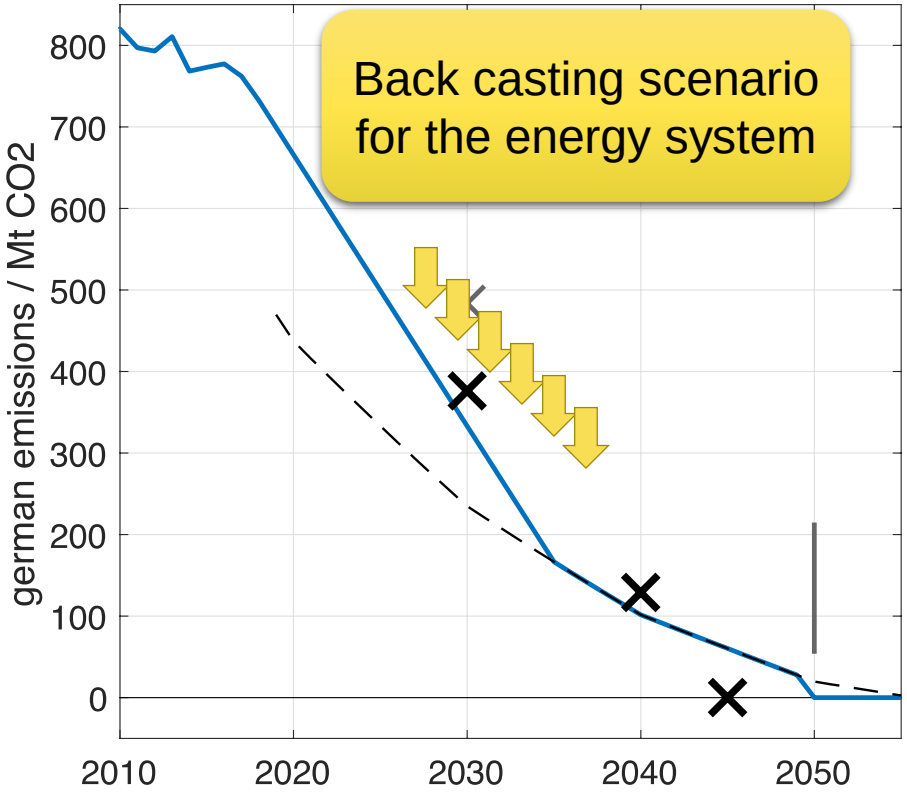
7 Gt CO_2 for the energy sector



AN ENERGY PATHWAY COMPATIBLE WITH A 1.5°C CARBON BUDGET

Quelle: DLR

Scenario approach



Normative Scenario approach – NO PROGNOSIS

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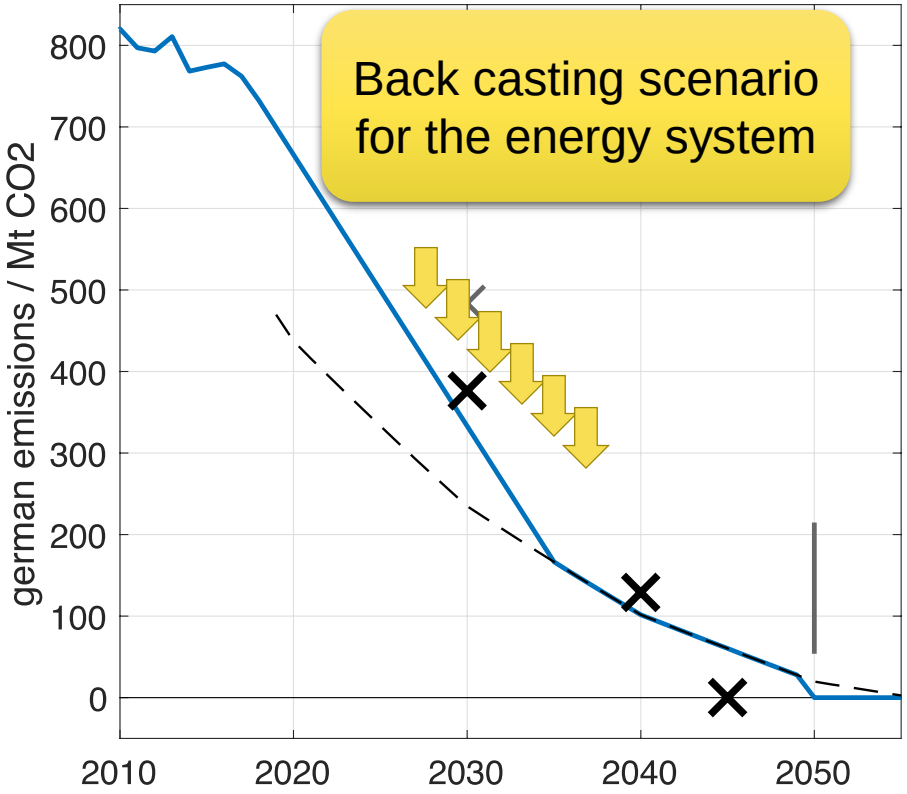

Normative Scenario approach – NO PROGNOSIS

Identifying the **necessary** deployment of Renewable Energy & Efficiency technologies

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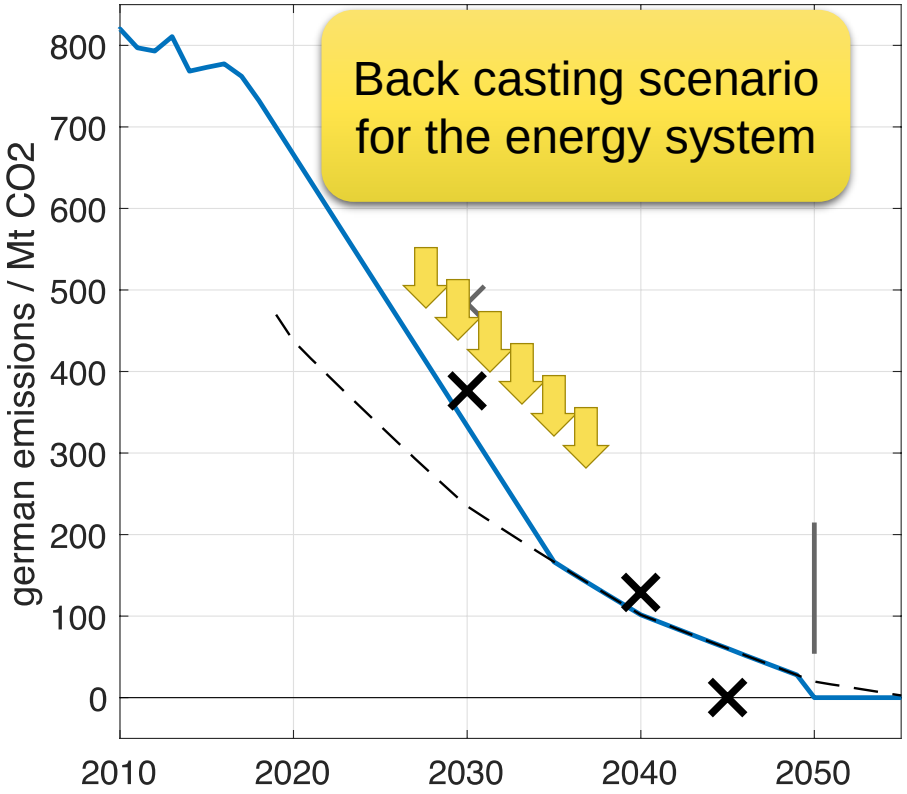

Identifying the necessary deployment of RE technologies

Targets

- Cutting emissions by half by 2030 to stay below 7 Gt CO_2
- Efficiency gains and demand reduction
- Expansion of renewable energy supply
- Providing the necessary infrastructure

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Energy system model approach

Joint model input and technology representation

Input data: energy statistics, population, GDP, …

Technologies: power, heat & transport technologies (RE & fossil)

REMix-EnDAT

RE potentials

Hourly demand profiles

ESM

Simulation & Backcasting

Model coupling

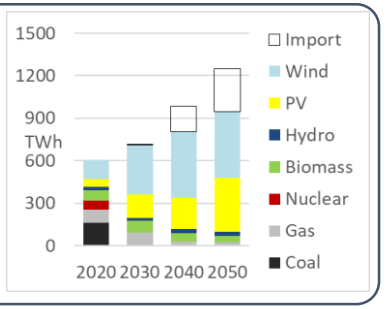
Energy demand development

System configuration at final stage

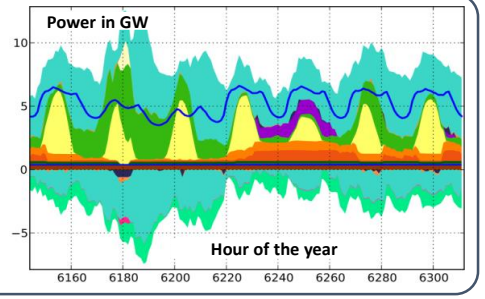
REMix-OptiMo

Least cost optimization of supply
Temporally and spatially resolved

System transformation pathways

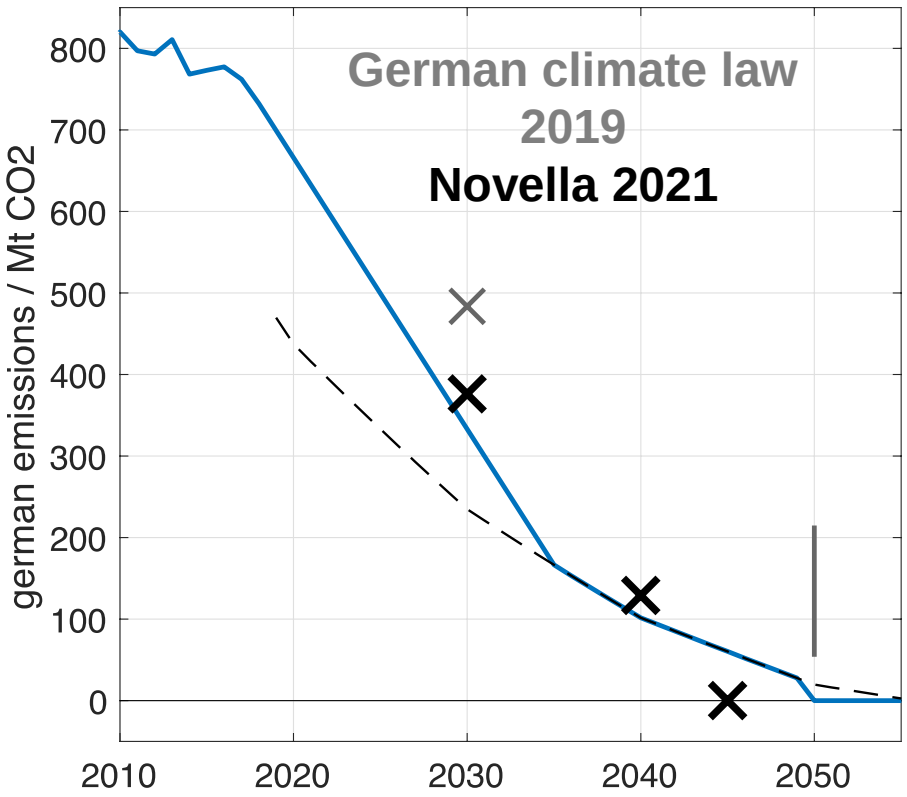


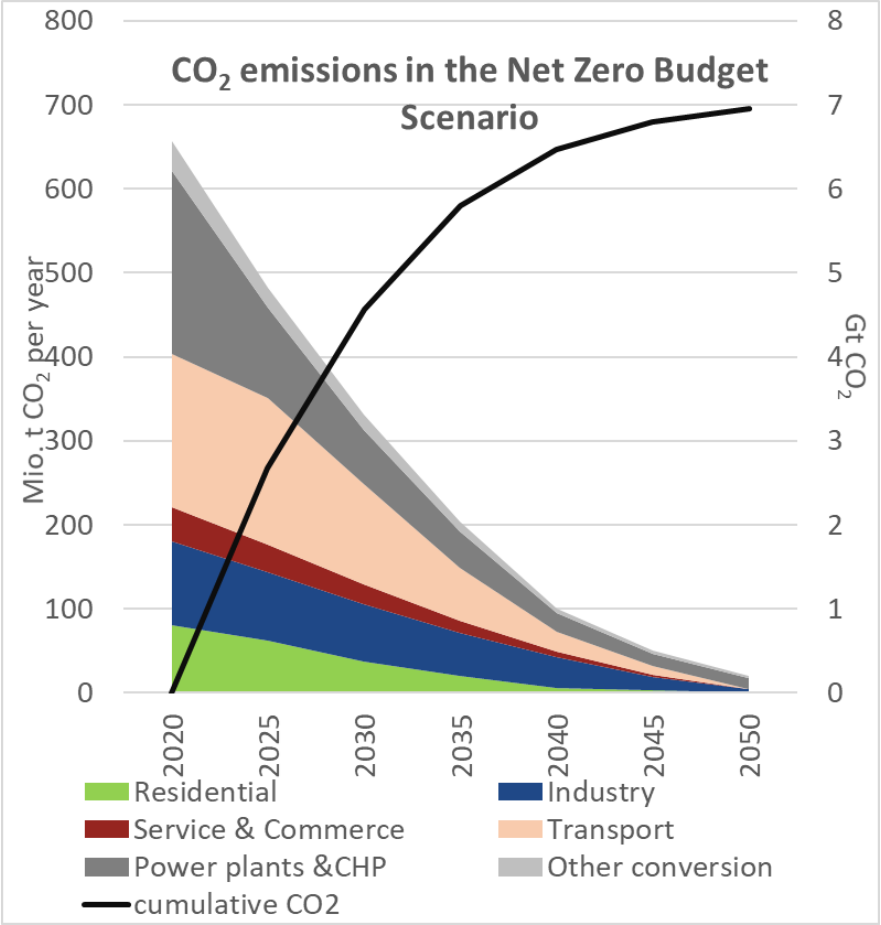
Hourly generation, transmission and balancing



Source: Simon, S. et al. "A Pathway for the German Energy Sector Compatible with a 1.5°C Carbon Budget." *Sustainability* (2022). https://doi.org/https://doi.org/10.3390/su14021025.

Reaching the target





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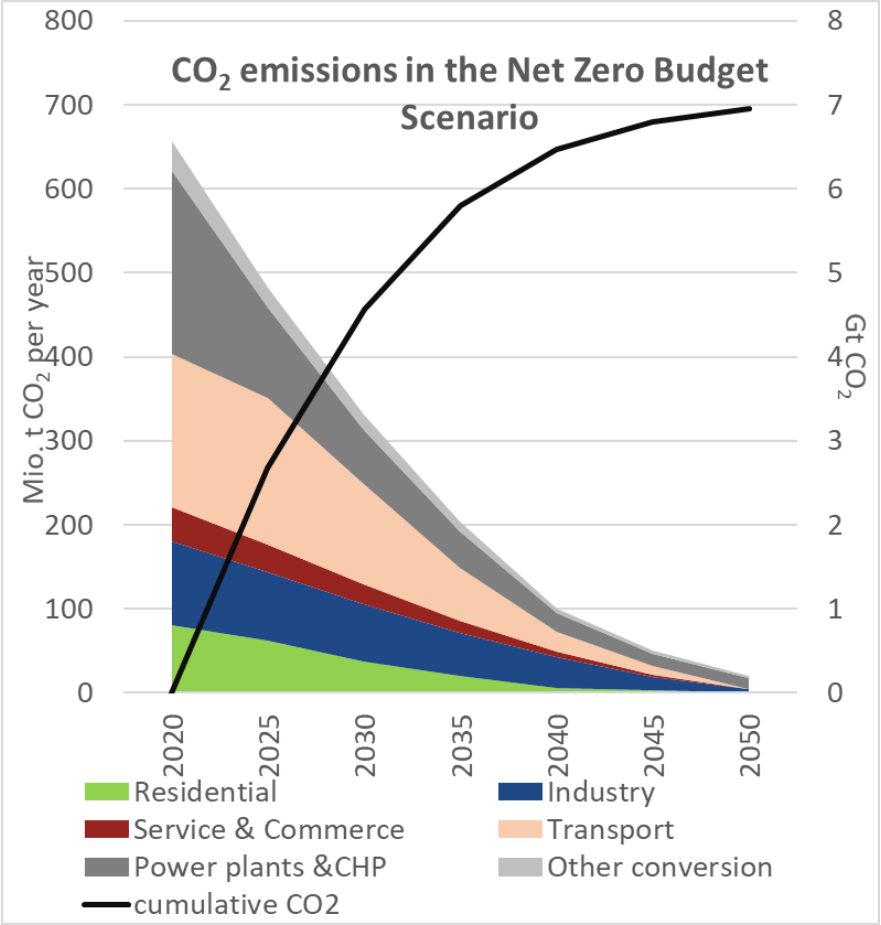
Demand Sectors: Examples of necessary steps

Heat sector

- Buildings:
- Industry:

Transport sector

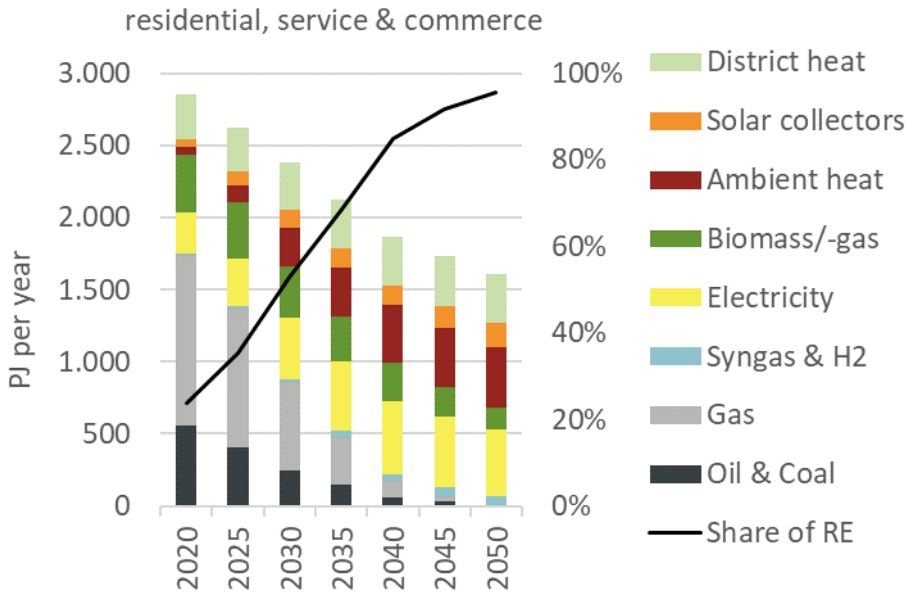
- Road transport:
- Synfuels:



Demand Sectors: Examples of necessary steps

Heat sector

- Buildings:
  - 5 Mio. heat pumps by 2030 (~ 500.000 per year)
    Electrification in 2050: 29% (+26% ambient heat)
  - Significant expansion of district heat connections
    →distribution of similar energy to more buildings
- Industry:



Transport sector

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- Industry:
  - Electrification 2050: 35% (+20% H2)
  - Example Steel: switch to H2 direct-reduction from 2025, electro winning from 2040

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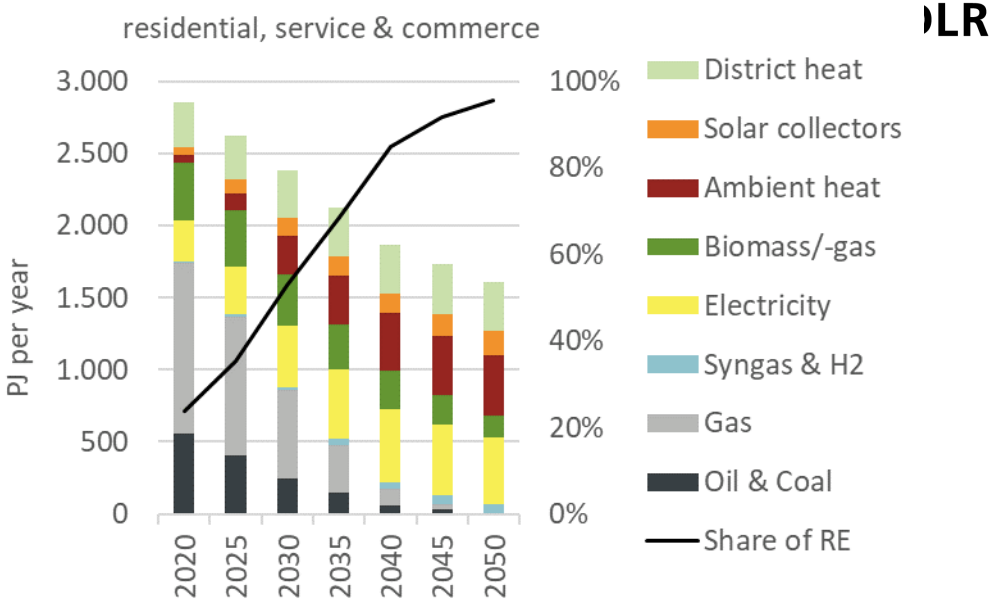

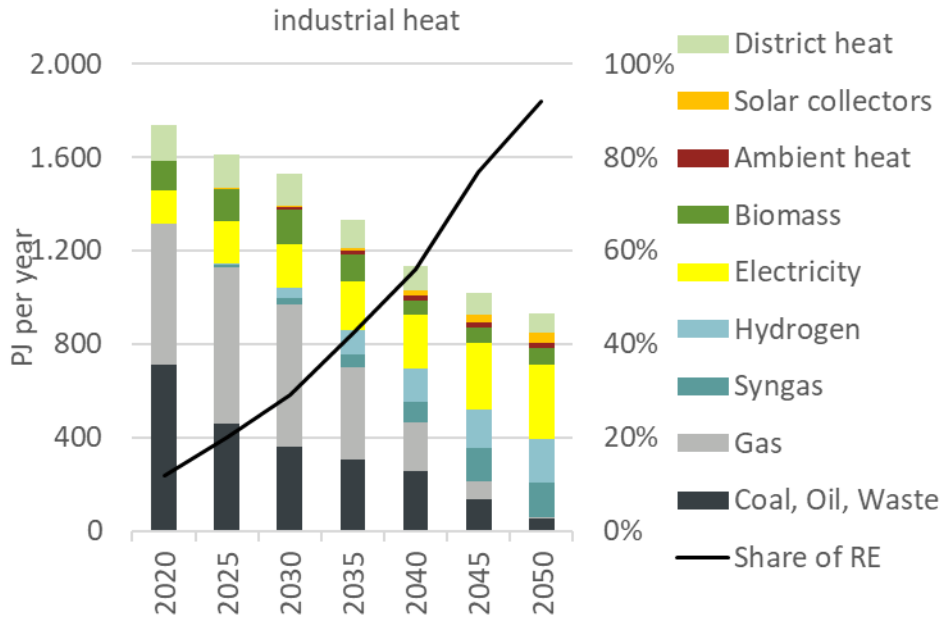

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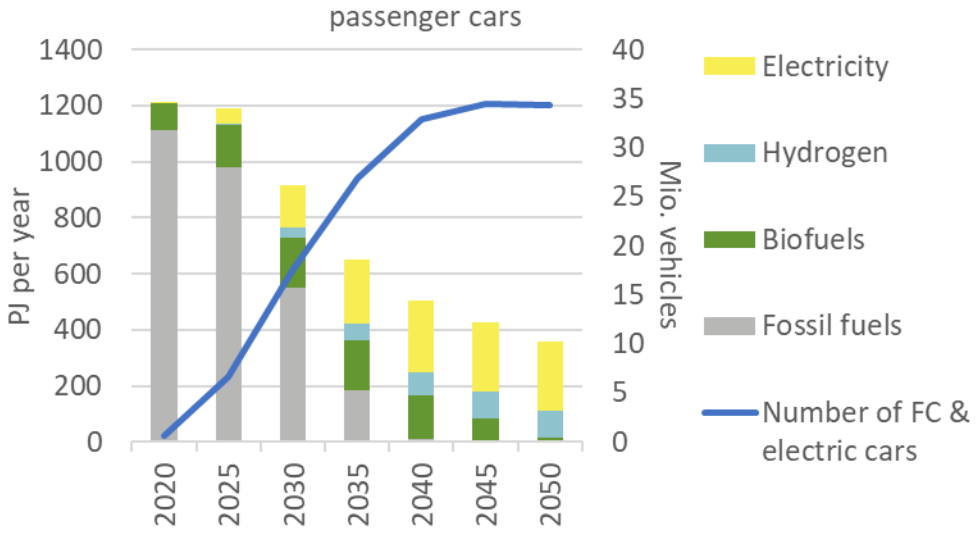
Transport sector

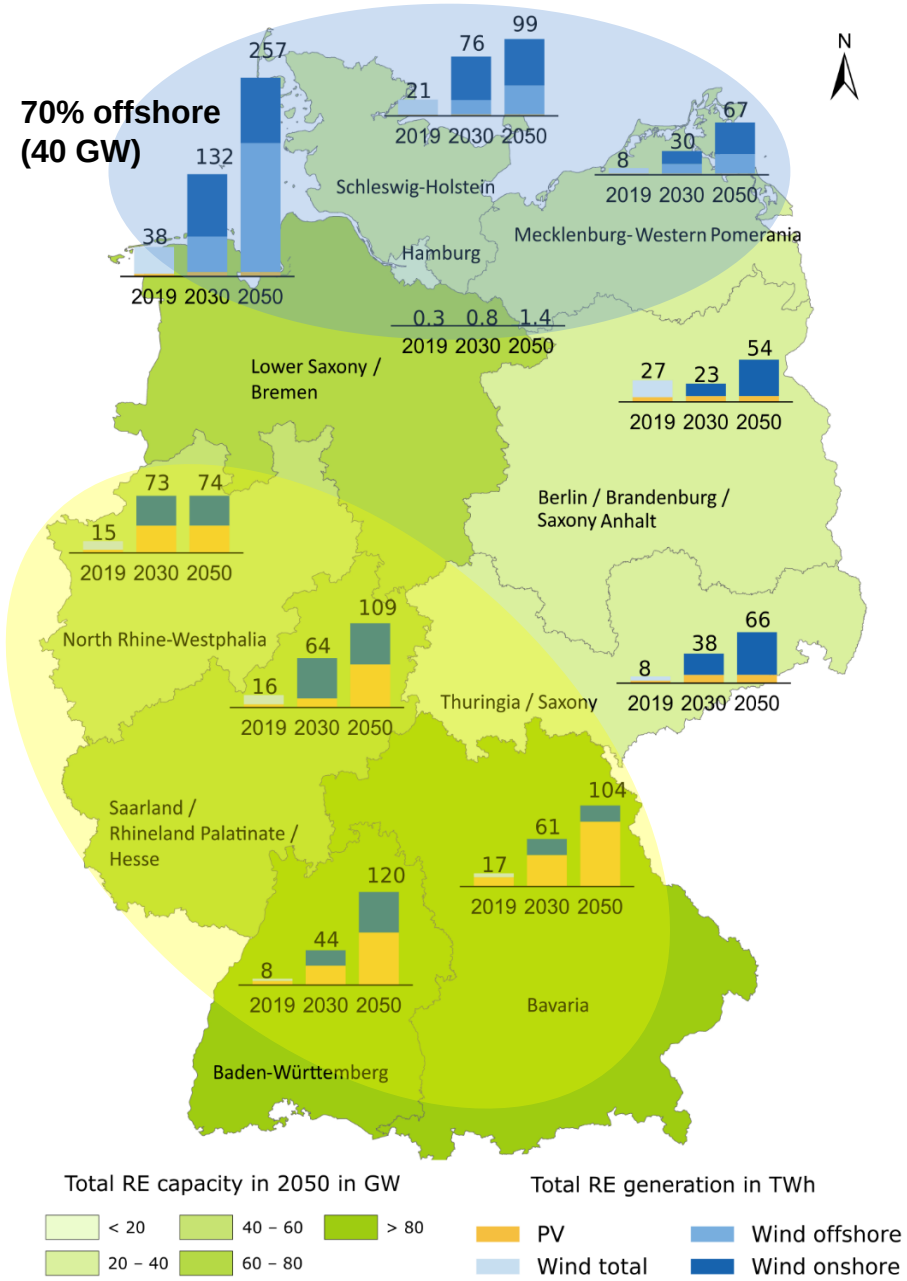
- Road transport: largest reduction necessary!
  - Passenger cars: 17.5 Mio. Electric vehicles by 2030 (+1.5-2 Mio. per year)
  - Electrification in 2050: 69% (+27% hydrogen)
- Synfuels:
  - Midterm → Trucks
  - Longterm → Aviation, Ships
- Total transport electrification 2050: 32% (+38% H2)



Energy supply sector: Power production

Installed renewable capacities & generation

- 70% offshore: Lower Saxony (40 GW)
- Major role of wind except for Bavaria
- Highest RE power capacities (~ 90 GW) Bavaria; Baden-Württemberg



Expansion of renewable power capacities by 2050 for a CO_2-neutral Ger
Net-Zero-2050 Web Atlas, 2021. https://atlas.netto-null.org/contribution/12.

* 2019 statistic data

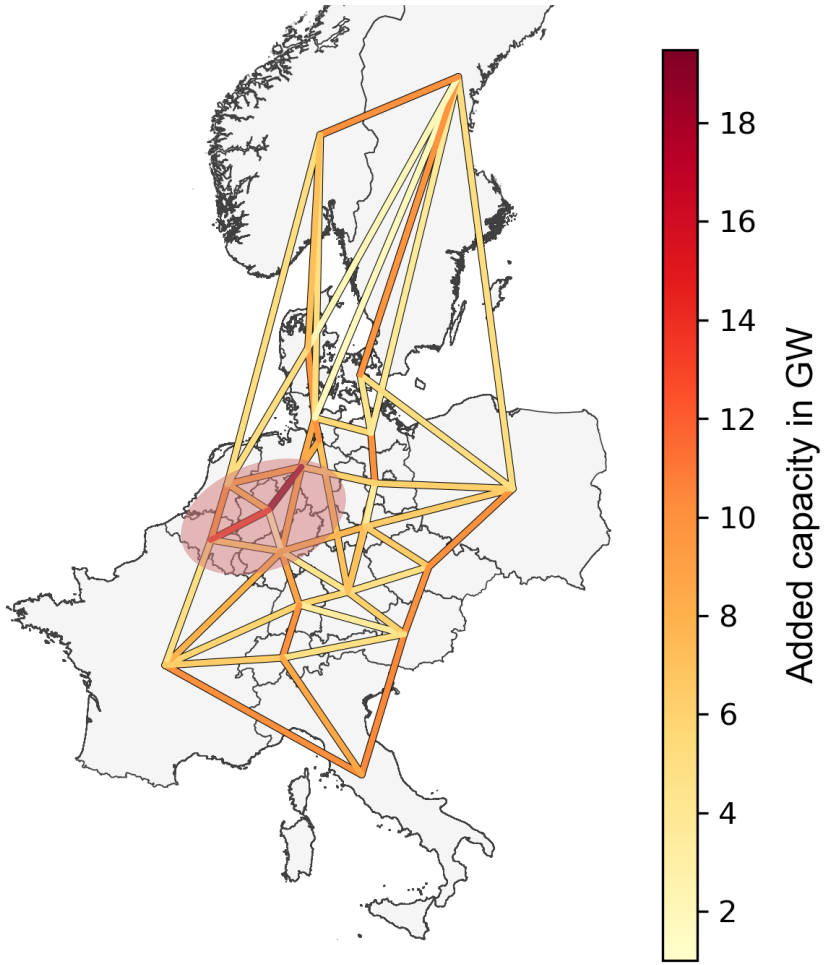
Grid expansion and Hydrogen Infrastructure

Transmission power grid expansion

- Triple capacity within Germany:
  61 GW (2020) → 189 GW (2050)

- Expand to neigbours by factor 5:
  29 GW (2020) → 153 GW (2050)

- Focus North-Rhine Westfalia/Benelux



- 2020 to 2050
- NEP 2030 included

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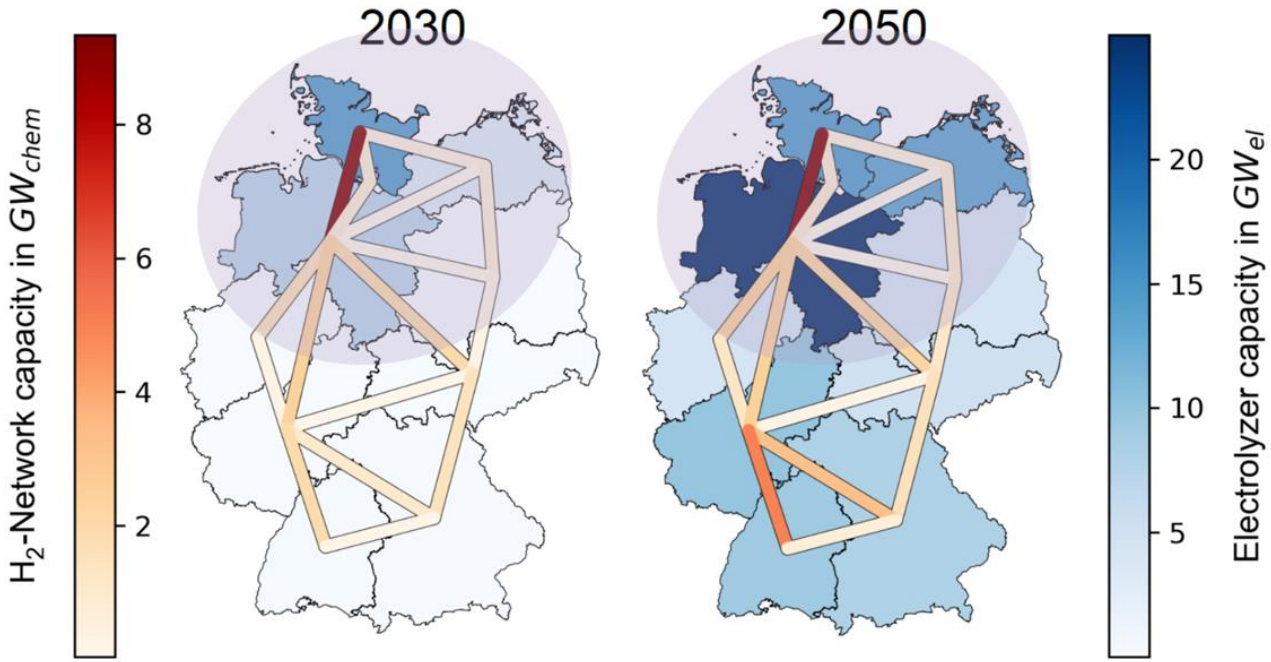
Grid expansion and Hydrogen Infrastructure

Hydrogen infrastructure expansion

- Early construction of hydrogen transport network: 23 GW in 2030
- Connect the electrolyzer capacities & cavern storage (N) to the demand centers (S & W)
- Massive deployment of electrolyzer capacity:
  26 GW (2030) → 96 GW (2050)



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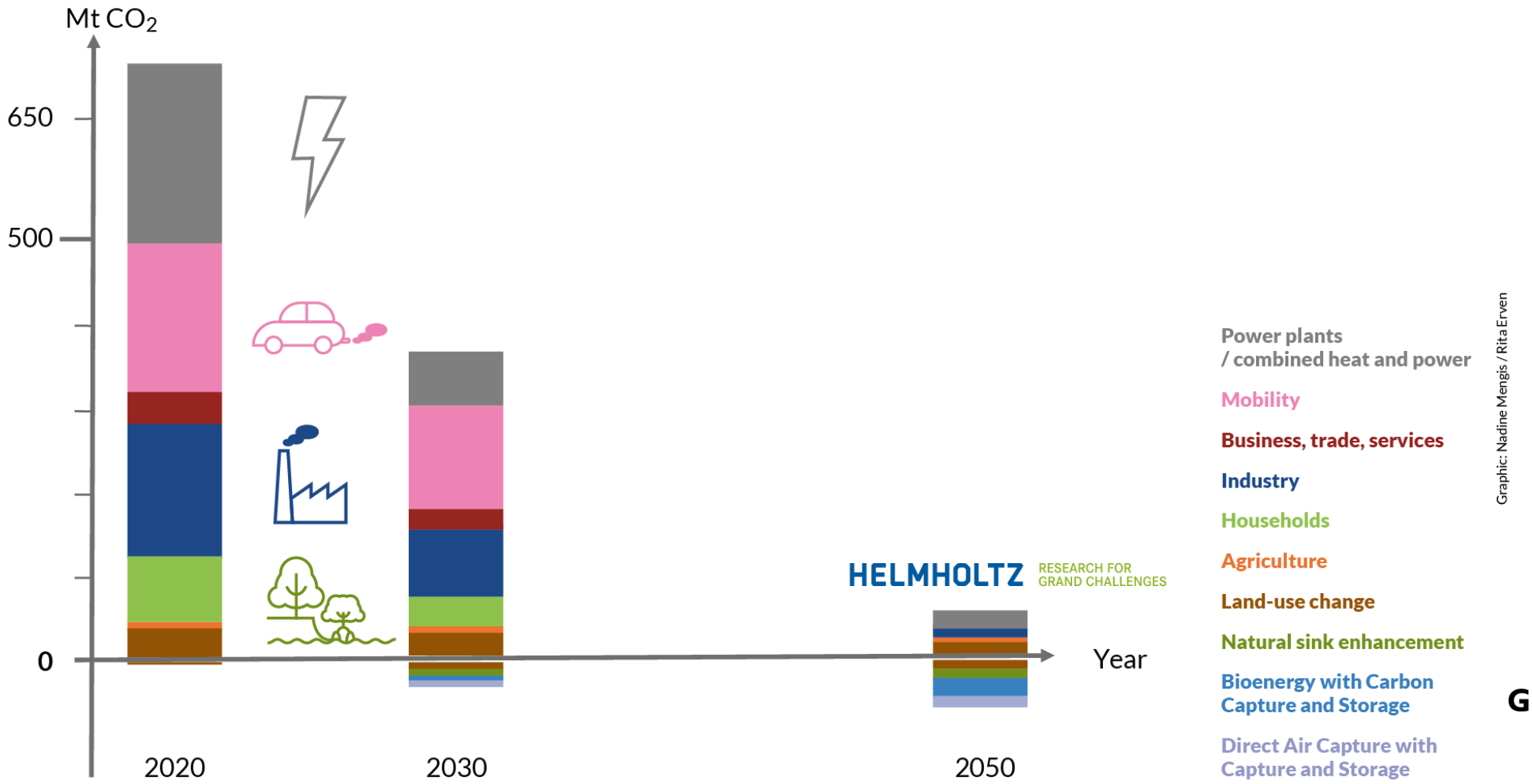
Net-Zero CO2 Germany - A Retrospect From the Year 2050



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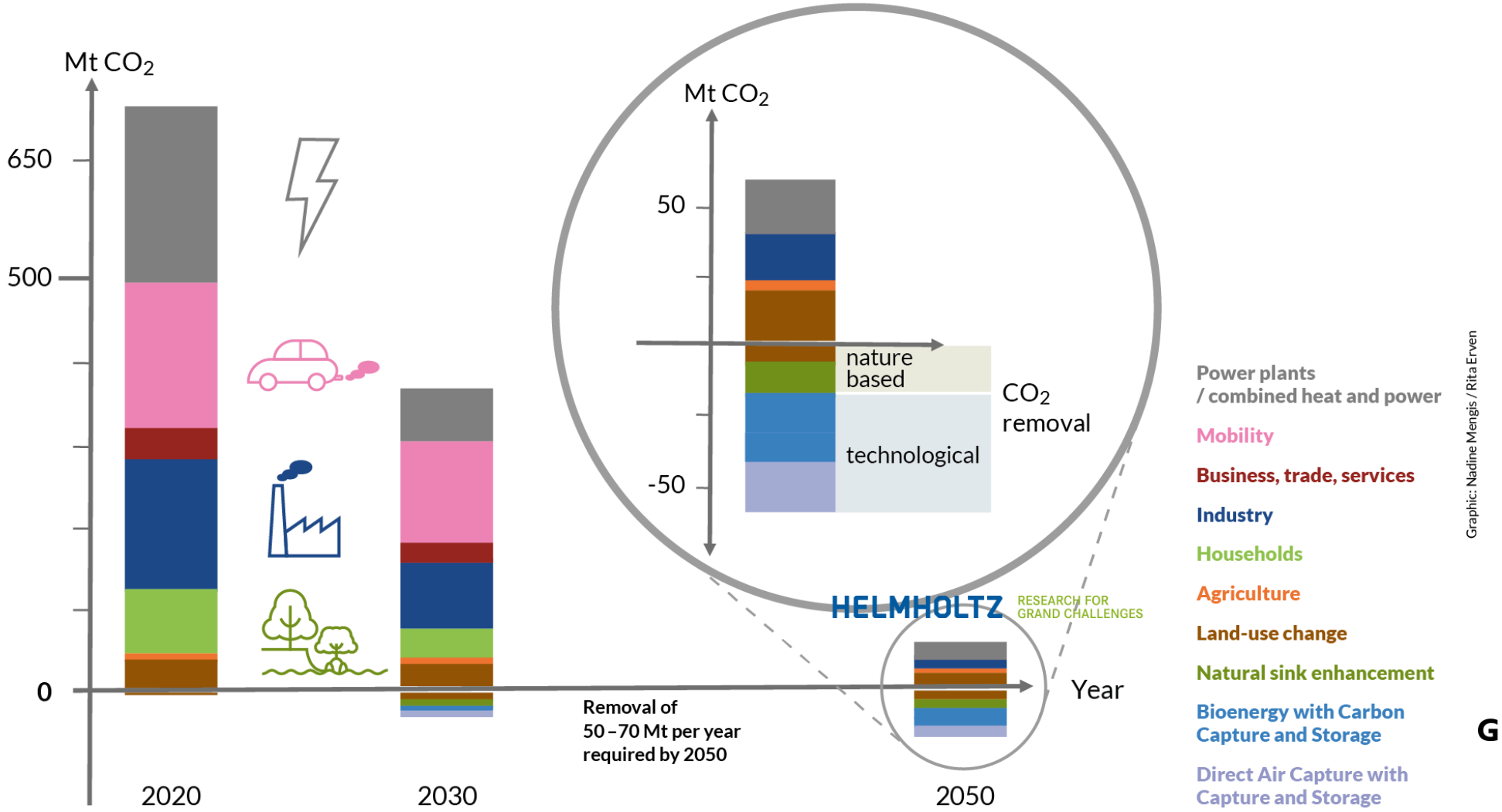

Graphic: Nadine Mengis / Rita Erven

Data source: Net- zero CO_2 Germany - A retrospect from the year 2050, Mengis, Kalhori et al., 2022, https://doi. org/10.1029/2021EF002324

Conclusions

- Cutting emissions by half by 2030
  - Apply all existing technologies in heat, transport and power production
  - Expansion of PV & Wind (10 GW/a), EV (2 Mio./a) and heat pumps (0.5 Mio/a) inevitable
  - Hydrogen infrastructure necessary by 2030
- Technology neutrality?
  - Plenty of opportunities for new technologies in the long term
  - Investments in large grid infrastructures already needed now
- Carbon sinks:
  - Limited capacity in Germany → For residual CO2 only (e.g. waste, industrial processes)
  - No option for extending the budget significantly in/for Germany

If Germany is seriously committed to the Paris climate agreement we need all available technologies NOW

Outlook: Knowledge Transfer

- Identify effective measures to enhance expansion of presented RE and Efficiency technologies
- Support local implementation: Break down results to local level and match with local boundary conditions (of energy providers, small and large communities, regions etc…)
- Enhance knowledge transfer:
  - Enable scientists in communication with the public
  - Develop formats for knowledge transfer to society and decision makers

Break down results of energy scenarios into digestible chunks for implementers

Publications

- https://www.dlr.de/de/forschung-und-transfer/energie
- Netto Null Atlas https://atlas.netto-null.org/
- Budget Scenario paper https://www.mdpi.com/2071-1050/14/2/1025
- Abschlusskonferenz https://www.youtube.com/watch?v=taGCoTi3lUc&t=14s

Thank you for your attention!