Decarbonization scenarios for the European energy system

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Dr. Konstantin Löffler, EUF / TU Berlin / NTNU

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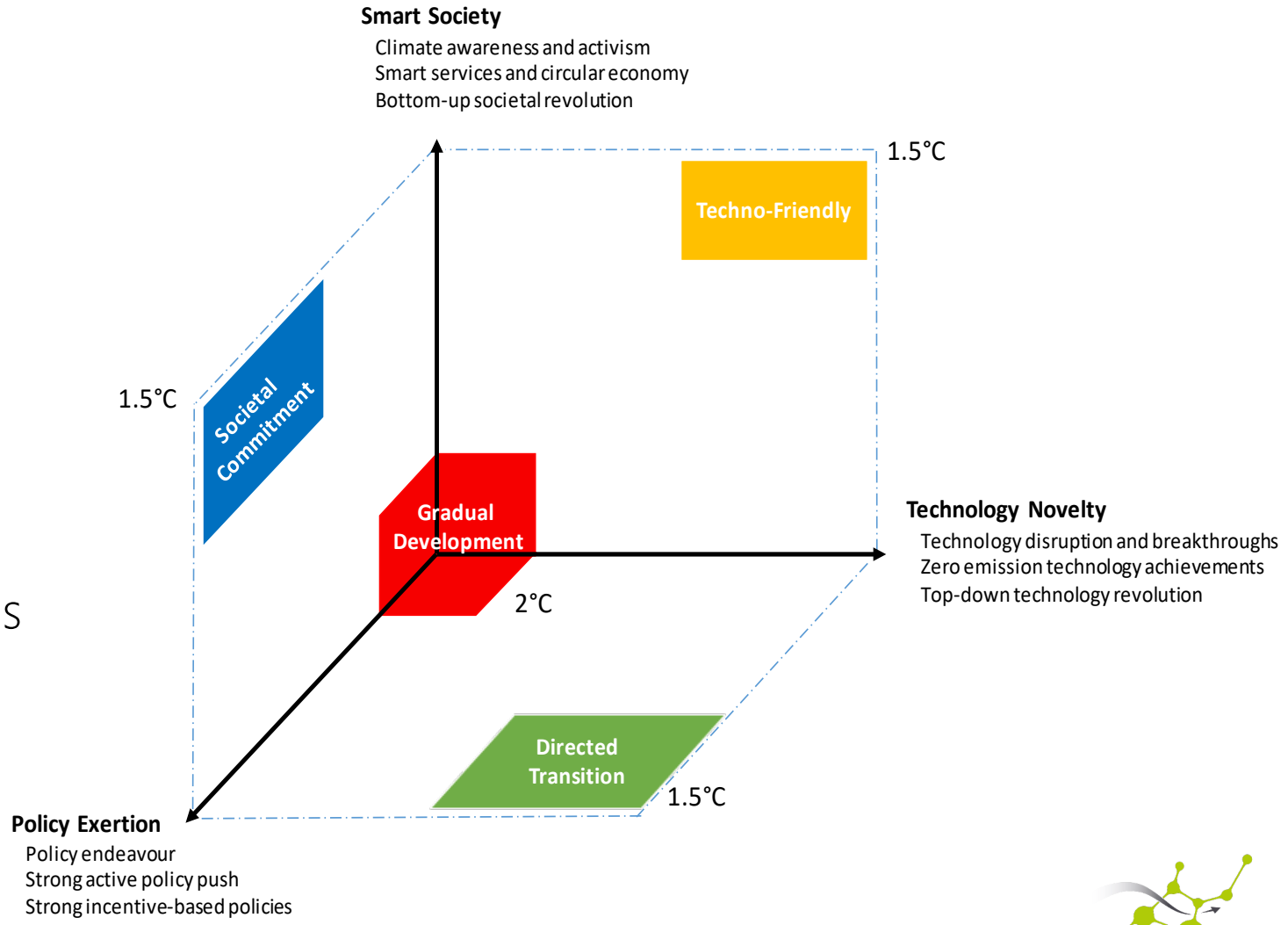
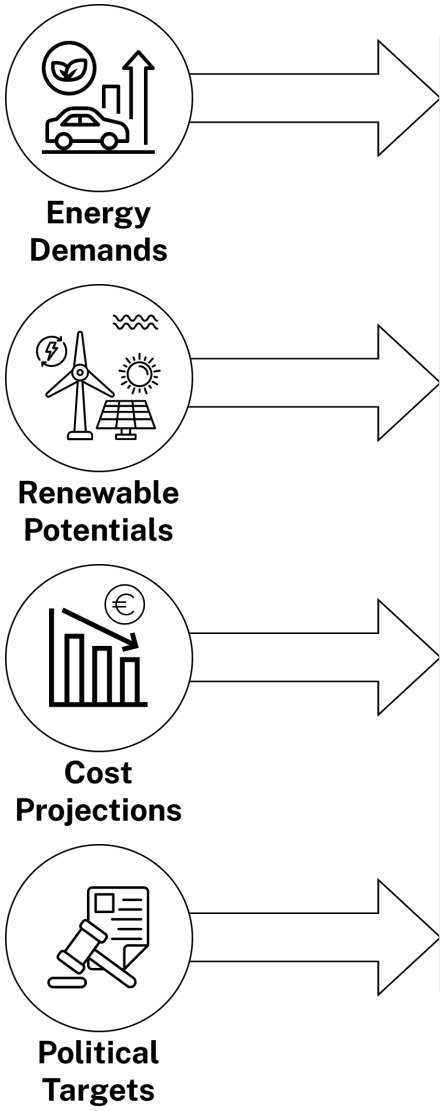
The Open ENTRANCE scenarios

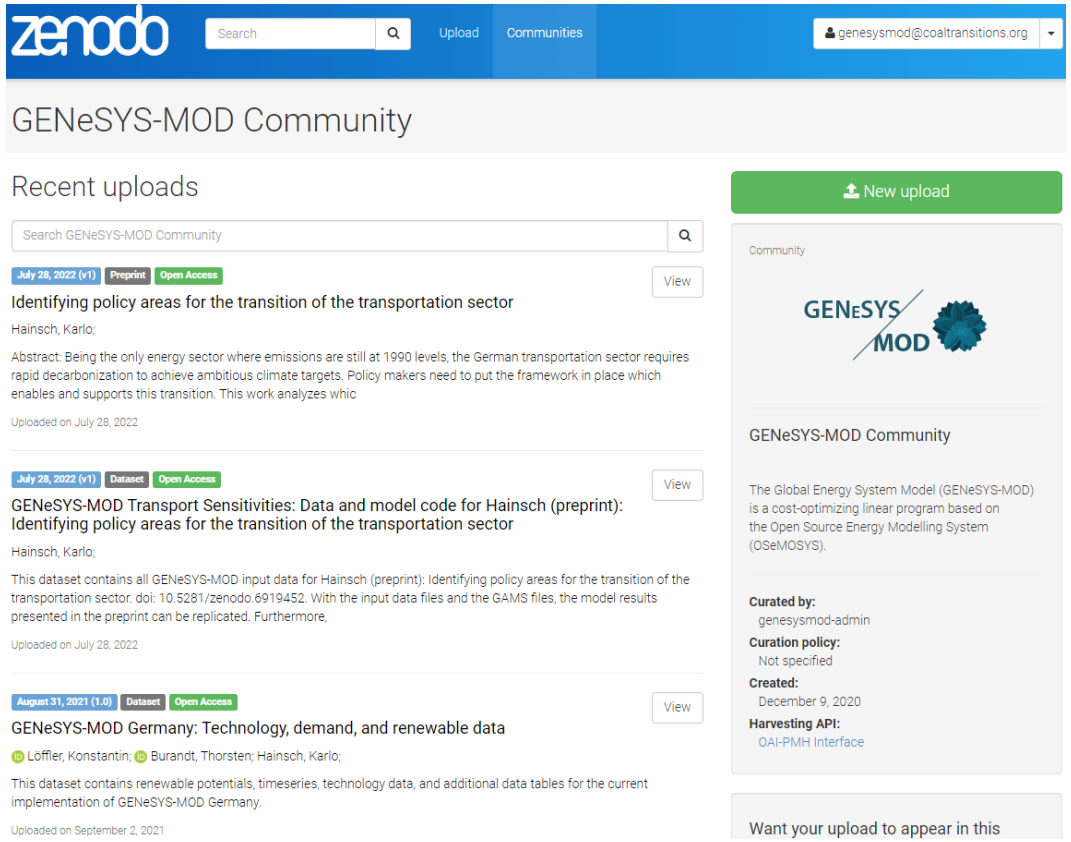
- Directed Transition
  - Strong policy push
- Societal Commitment
  - Willingness of society
- Techno-Friendly
  - High technological progress
- Gradual Development
  - Little of everything



Using energy system analysis to gain insights in long-term effects



The Global Energy System – GENeSYS-MOD



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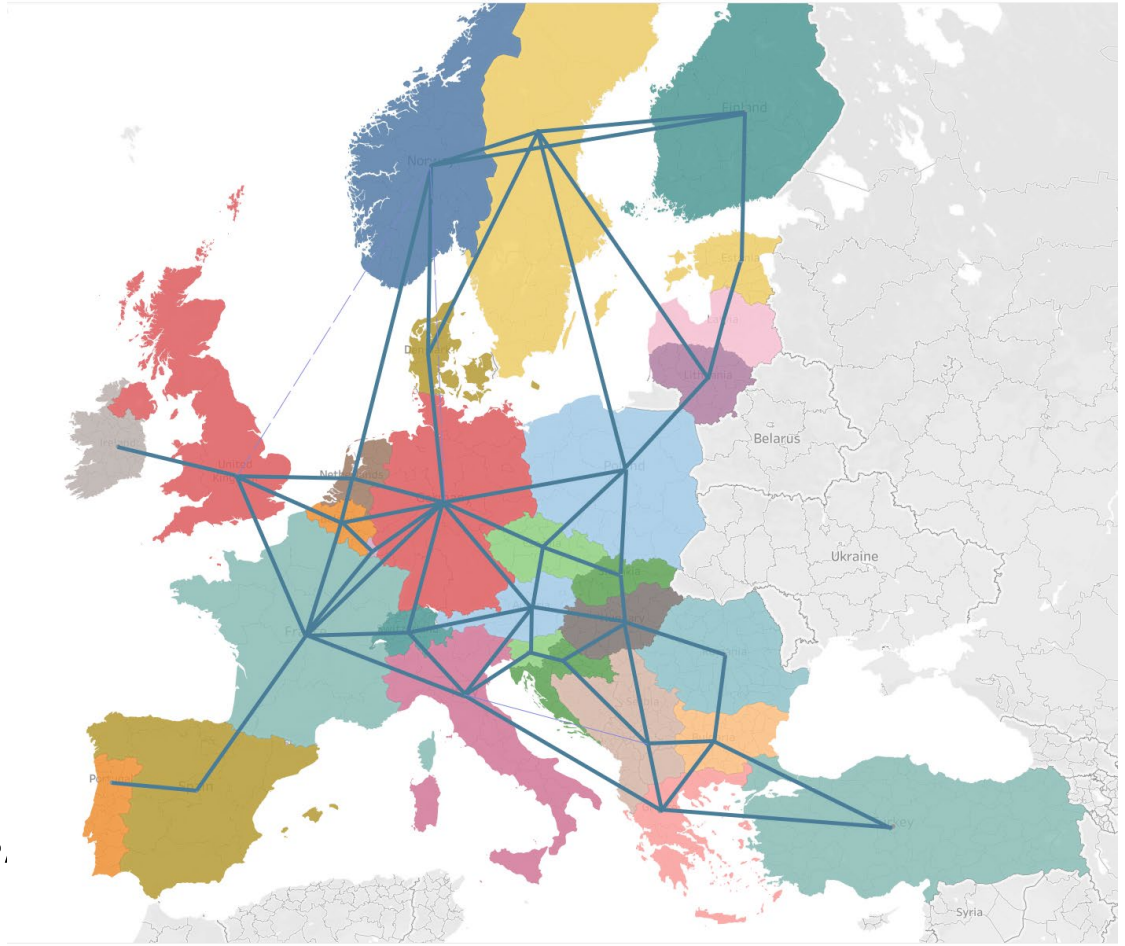
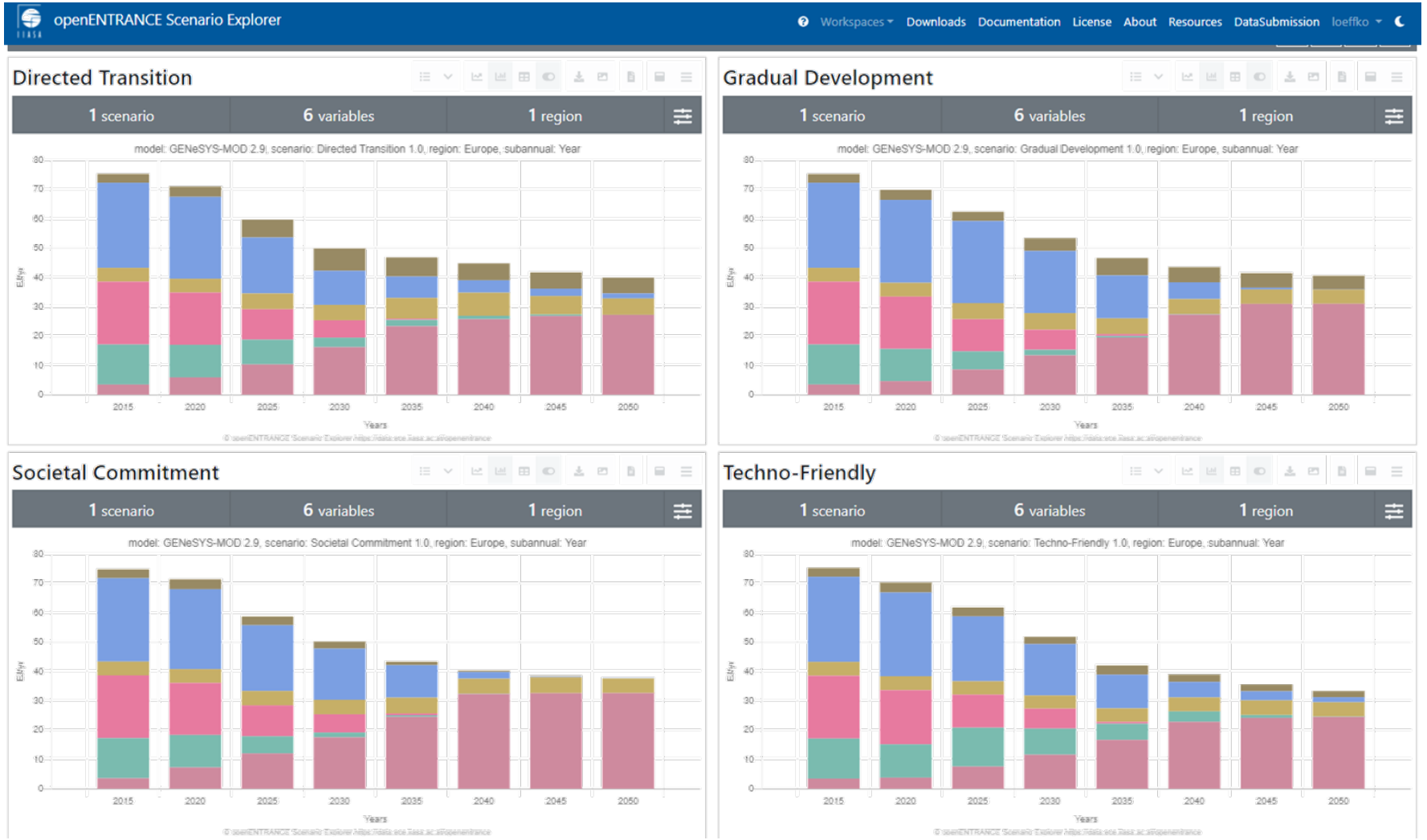
Outline of the model set-up

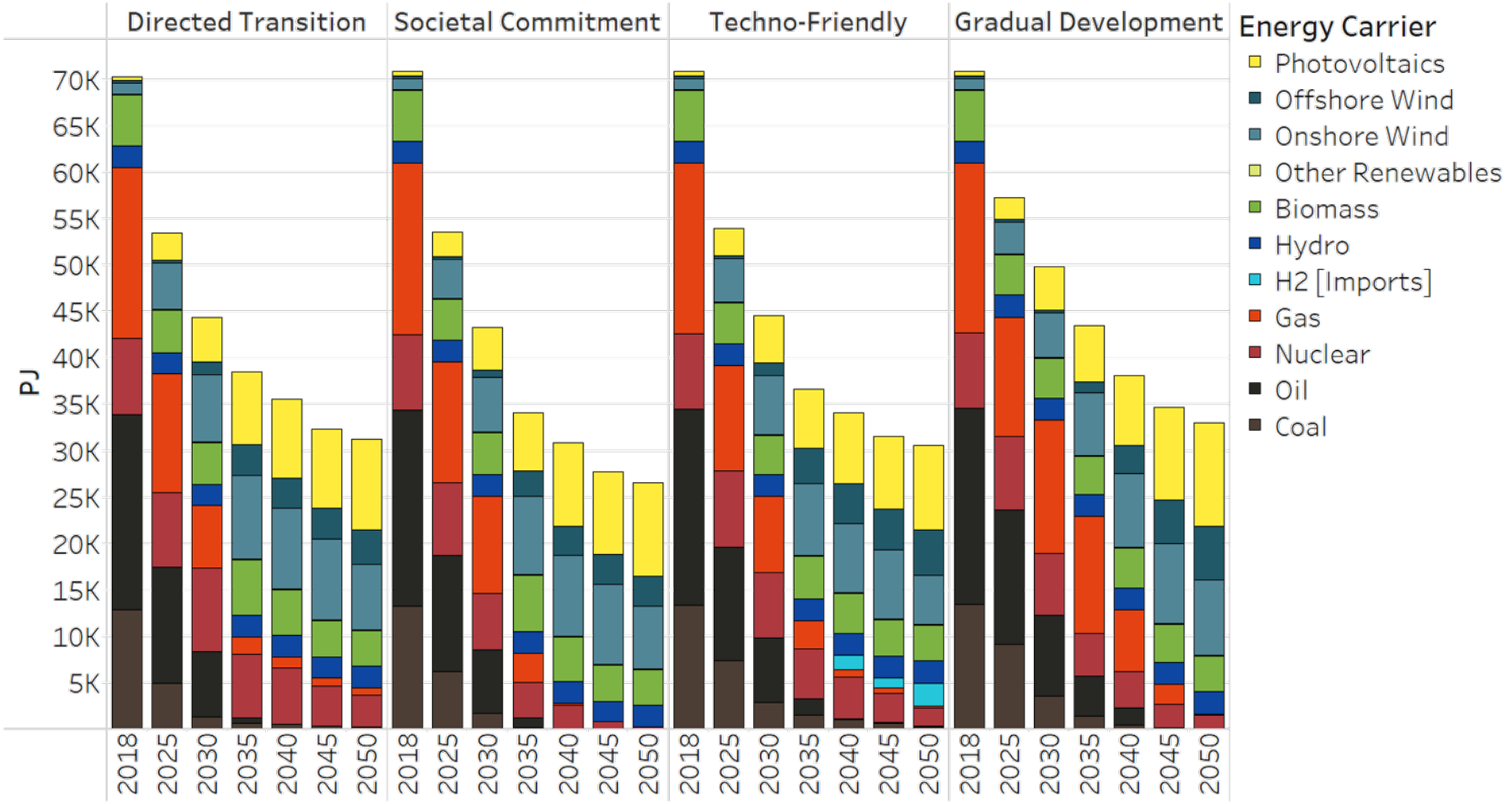
- 30 Regions (Mainland-EU, UK, Switzerland, Norway, Turkey, and the Balkan region)
- Modeled timeframe: 2018-2050
- Reduced hourly timeseries, via a reduction algorithm
- Covers the sectors: Electricity, Buildings, Industry and Transportation
- Pathway dependent features (like potential of demand shifting, political climate-targets, or breakthrough of certain technologies)



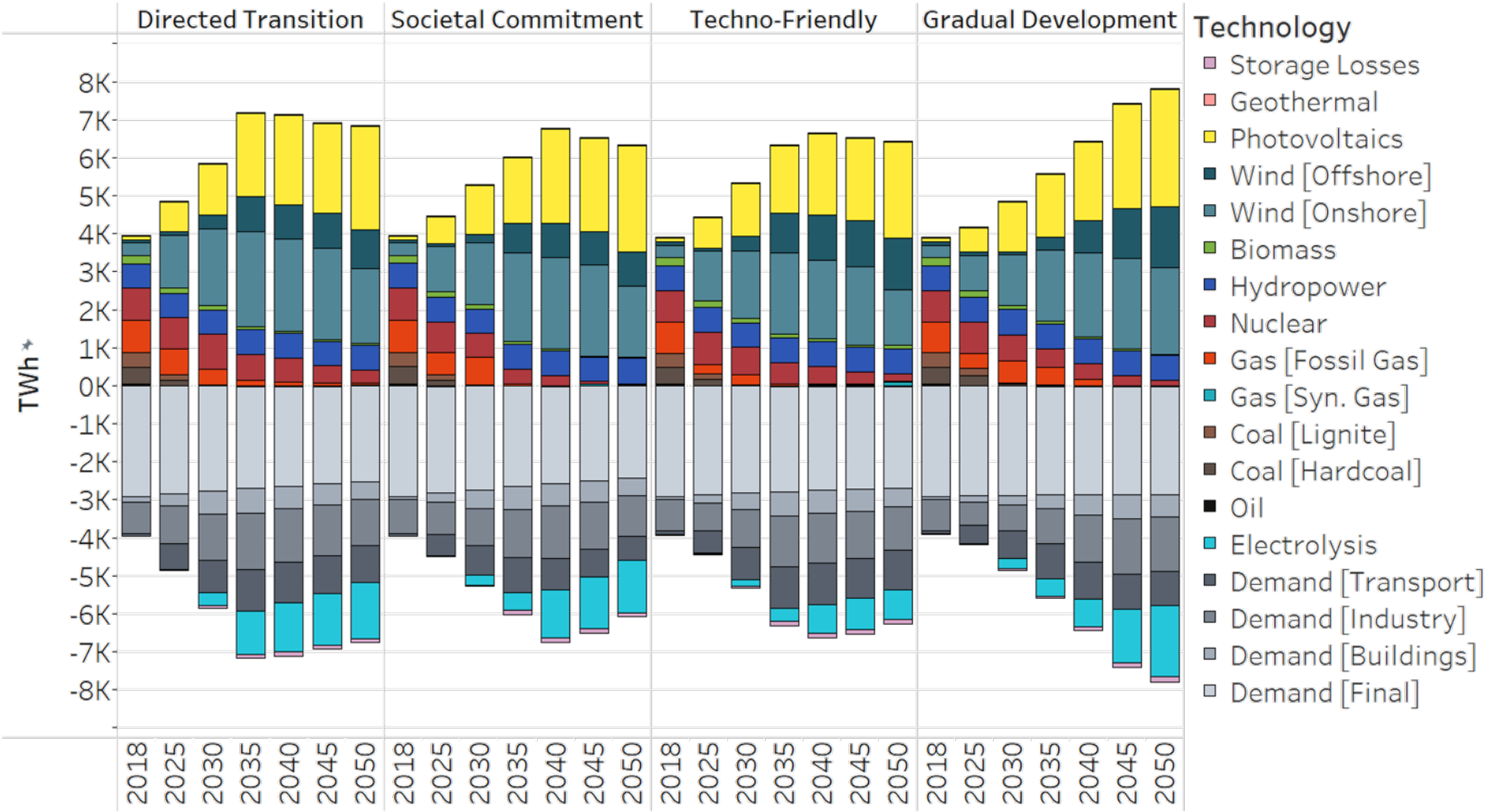
Results on the Open ENTRANCE scenario explorer



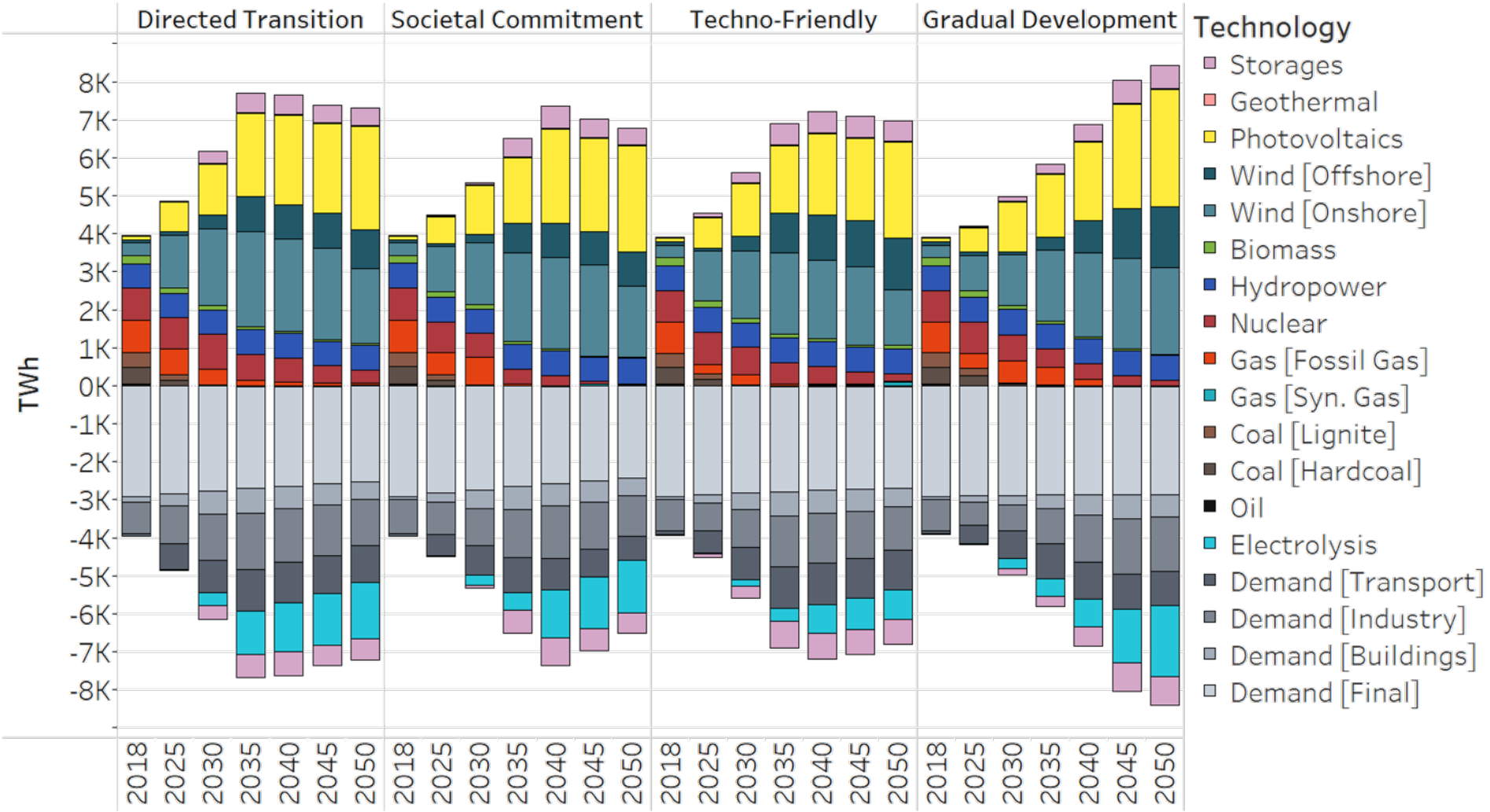
Results: Primary Energy



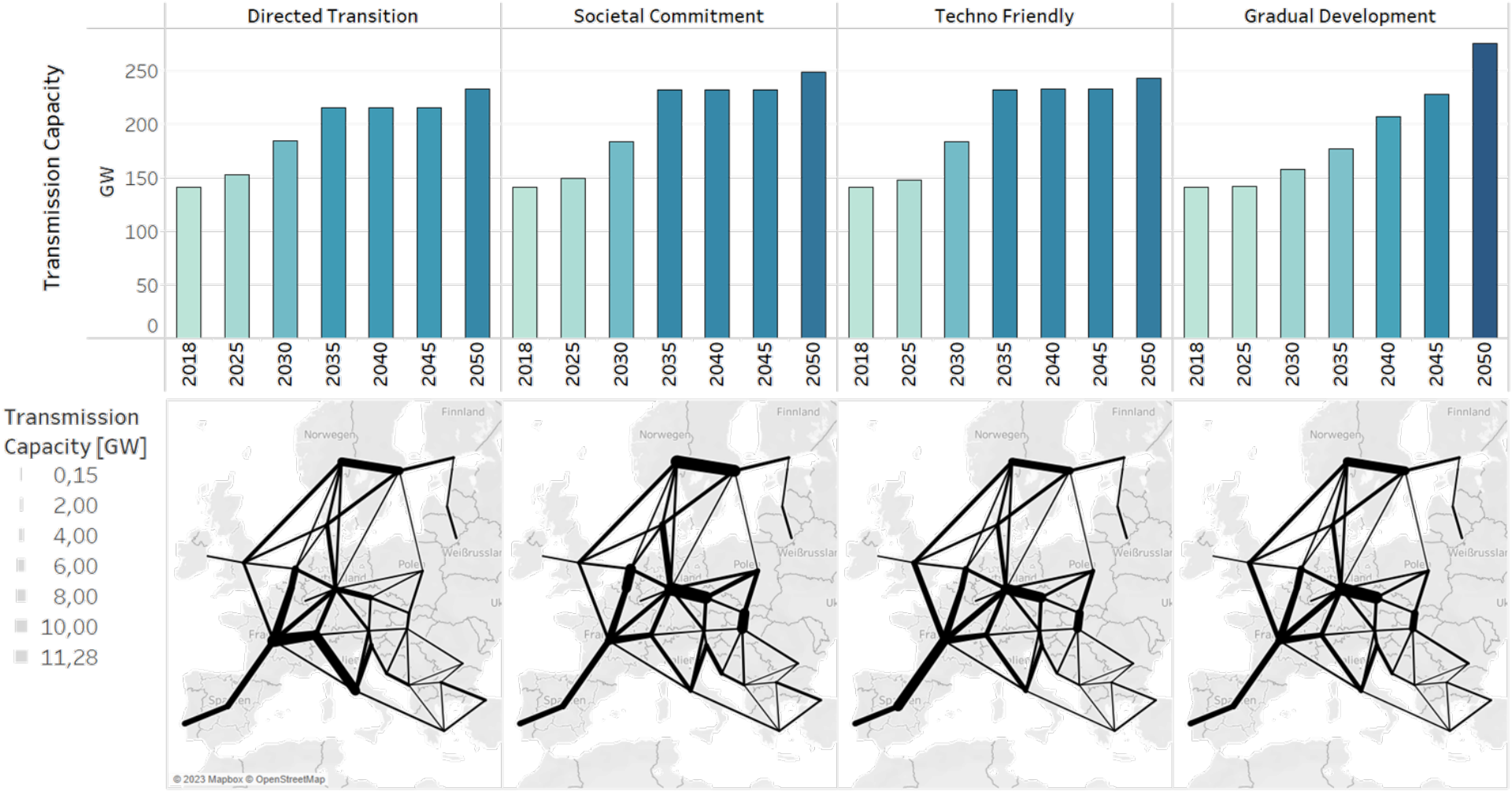
Pathway results - Electricity



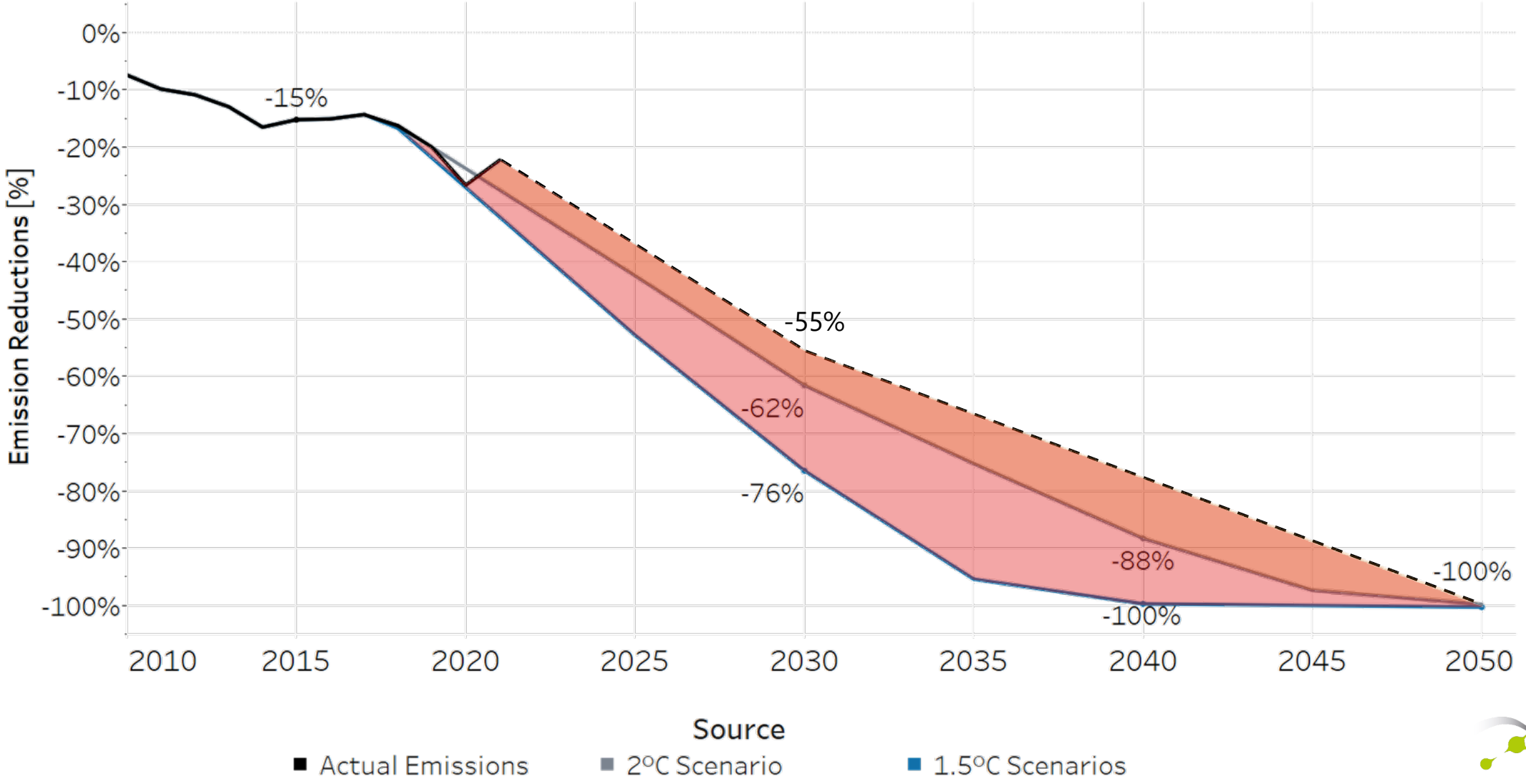
Pathway results - Electricity



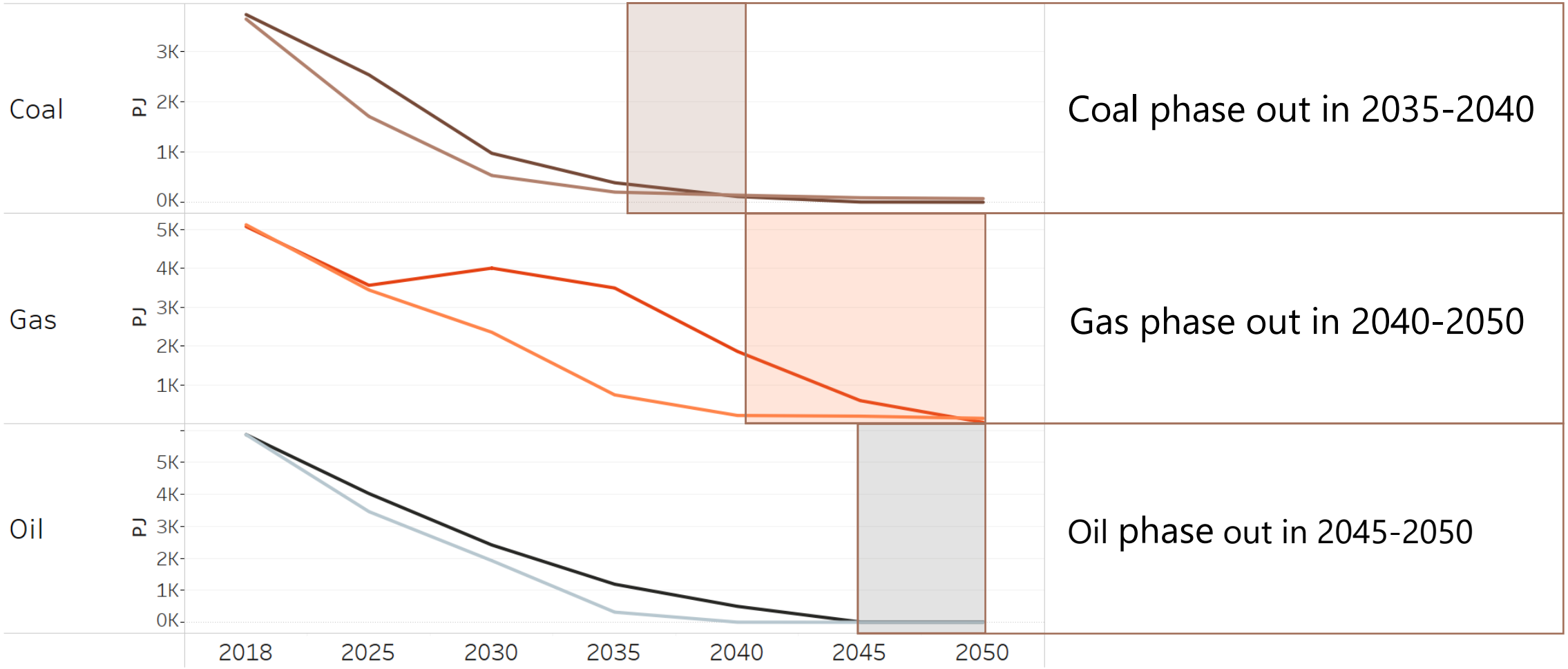
Results: Transmission capacity



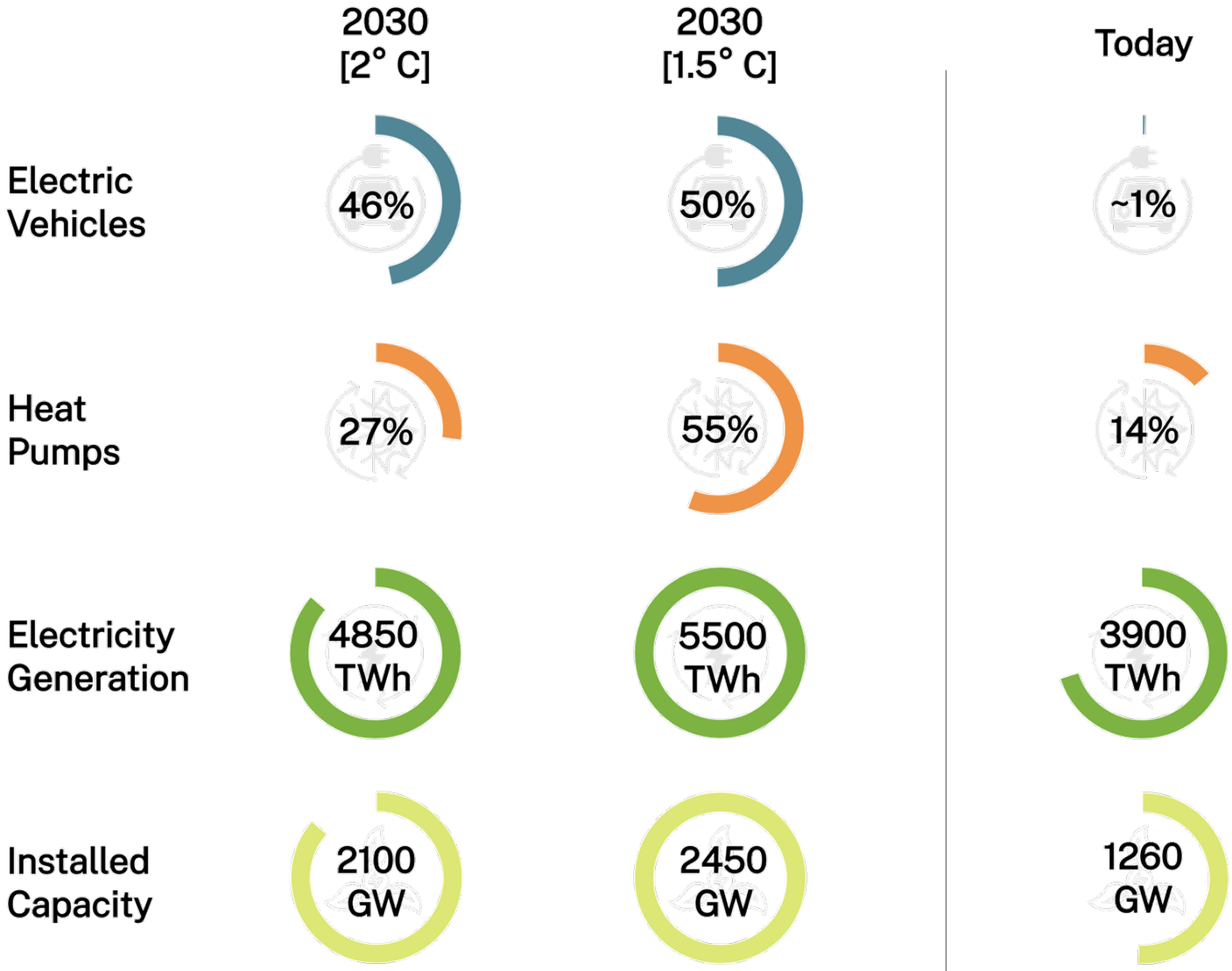
Current EU climate ambitions are not in line with a 1.5°C target



Fossil fuel consumption needs to be reduced to zero



Milestones needed for the fulfillment of climate targets



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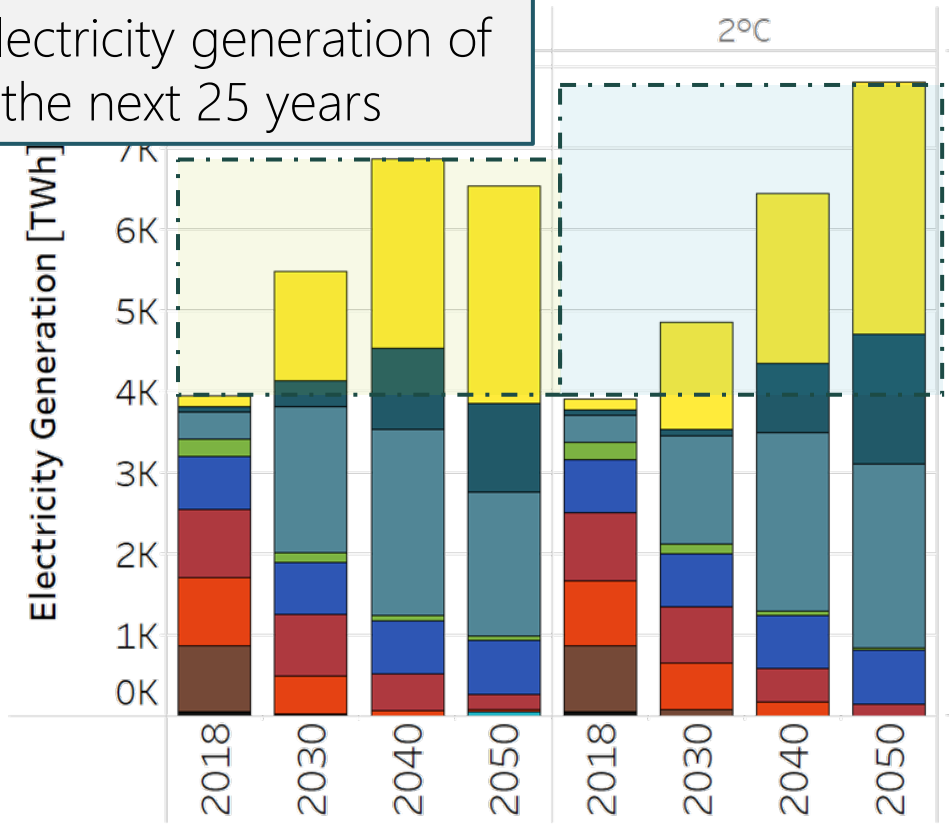
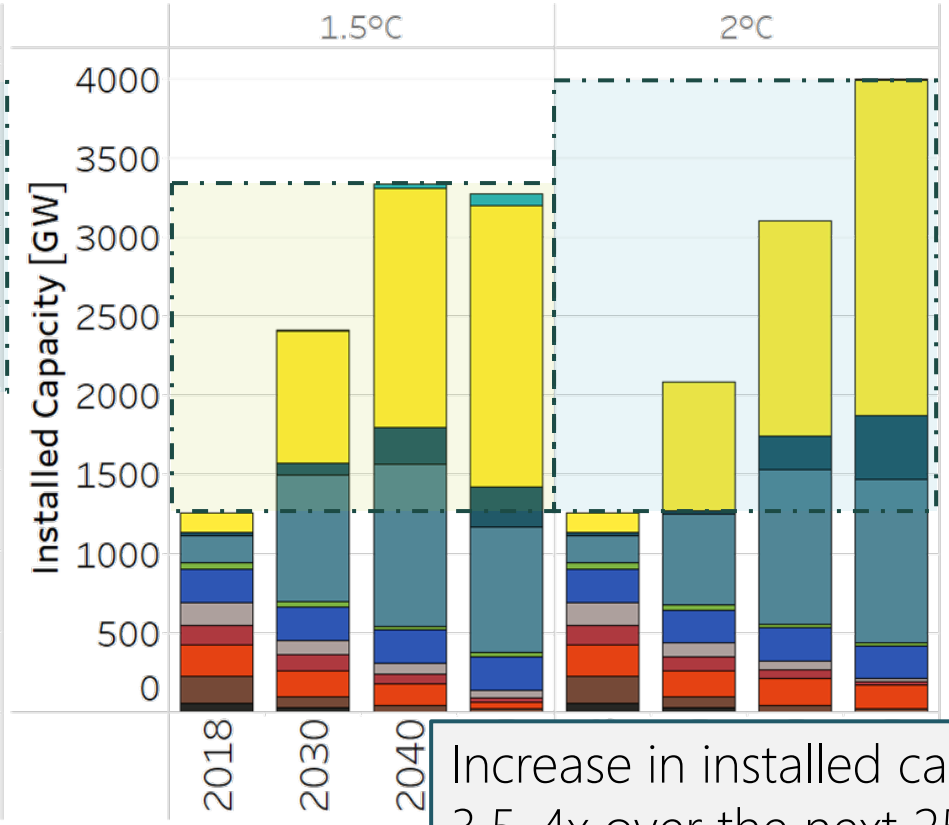
Drastic capacity increases are required – starting today

Increase in electricity generation of 1.75-2x over the next 25 years





Increase in installed capacity of 3.5-4x over the next 25 years

Technology

- Photovoltaics
- Wind [Offshore]
- Wind [Onshore]
- Biomass
- Hydropower
- Nuclear
- Gas [Fossil Gas]
- Gas [Syn. Gas]
- Coal
- Oil

Technology

- Hydrogen
- Solar
- Wind Offshore
- Wind Onshore
- Biomass
- Hydro
- CHPs
- Nuclear
- Gas
- Coal
- Oil

Delayed action will be increasingly expensive

- On average, the **1.5°C scenarios** are **5% more expensive** than the 2°C one

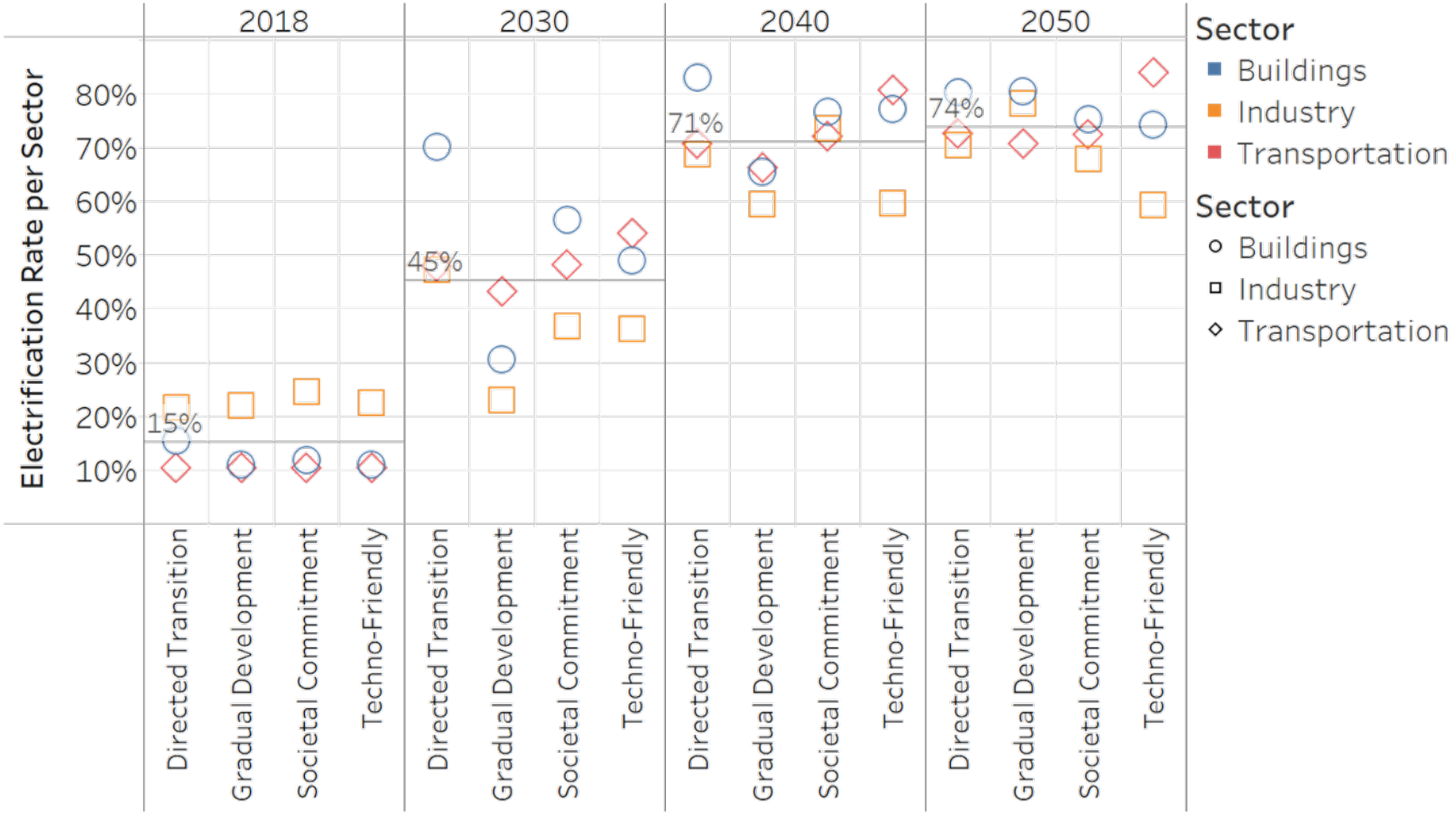
  -> Cost increase of ~**580 billion €**

- However, **emissions saved** are roughly **30%**, or **14.5 Gt CO_2**
- Accounting for environmental and social costs of carbon[1], this would mean an avoided welfare loss of over **2.5 trillion €**

-> This means that every Euro spent leads to 5 Euros of avoided damages

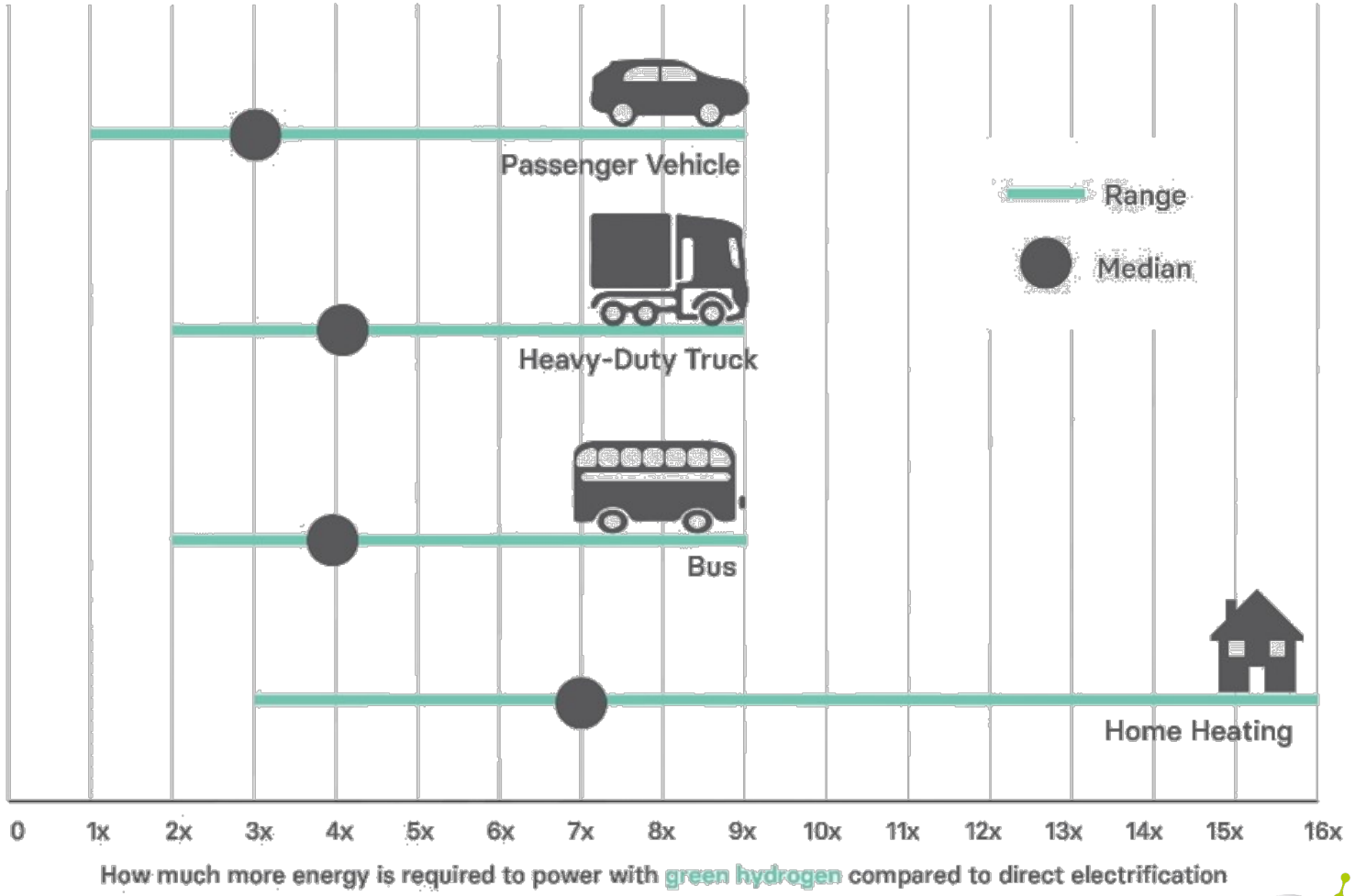
[1] Source: https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2019-02-11_methodenkonvention-3-0_en_kostensaetze_korr.pdf

Results: Electrification Rate



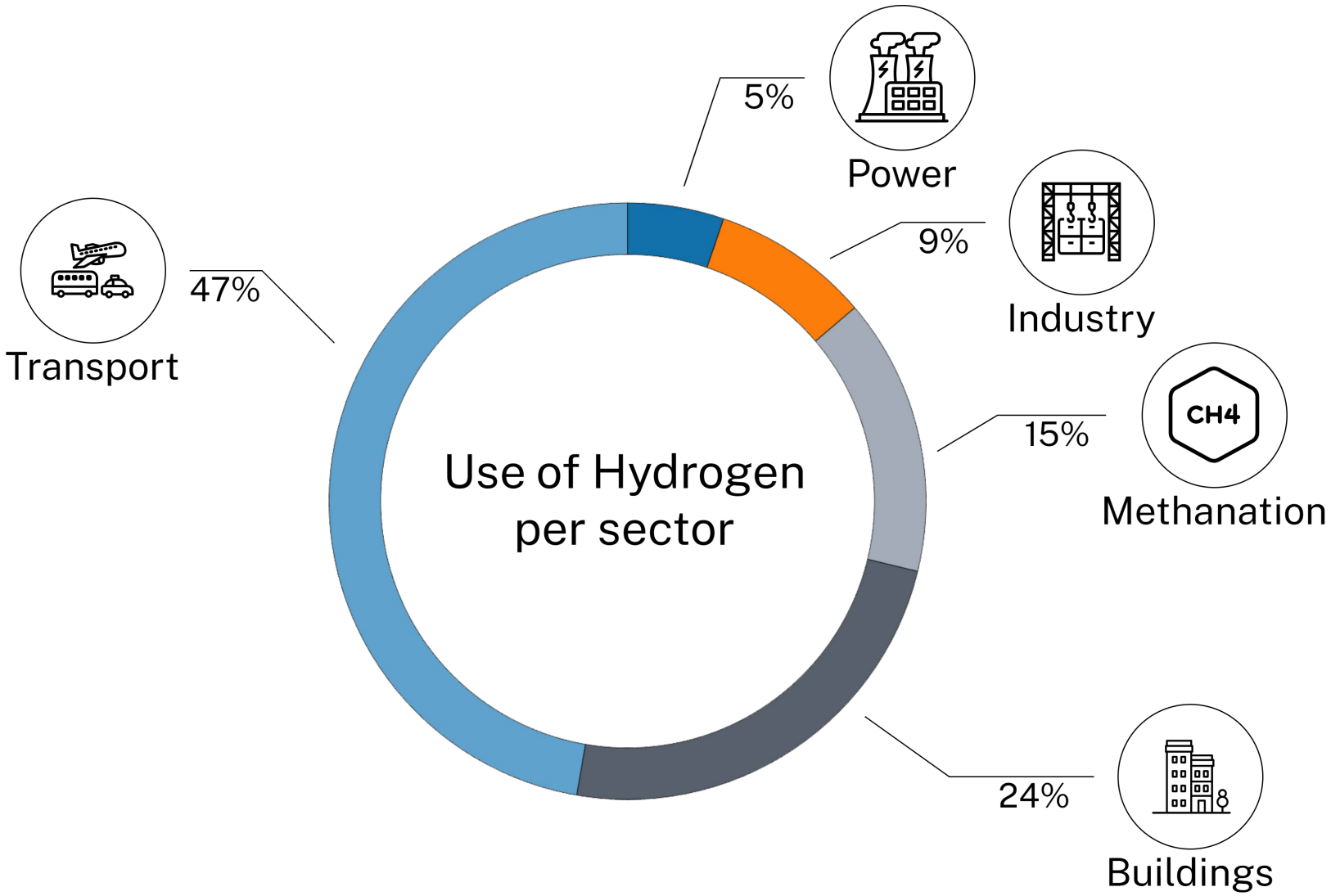
Hydrogen as the solution for an independent European energy system?

Using green hydrogen for heat and transportation requires much more energy than direct electrification.

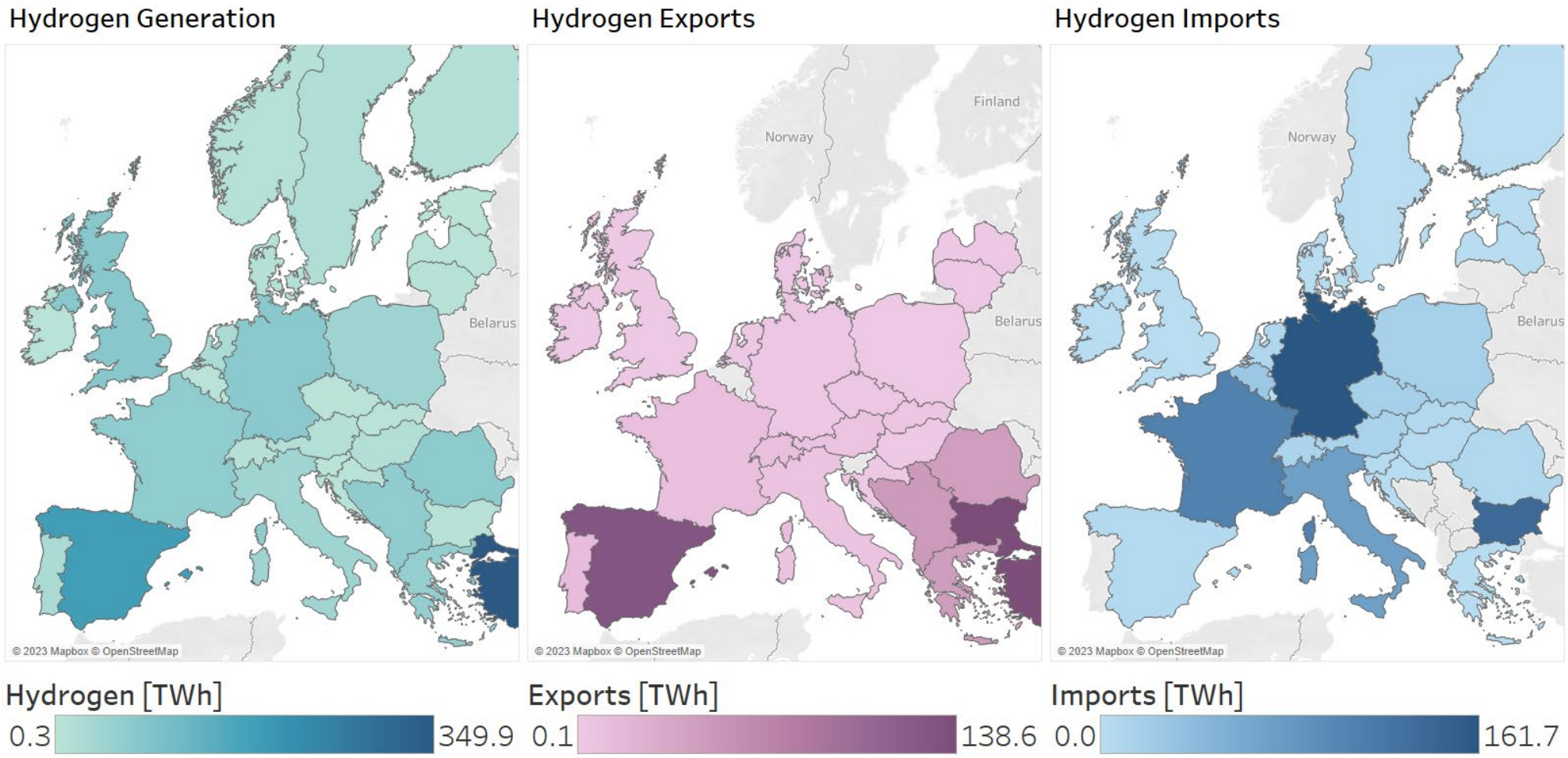


Source: https://blogs.edf.org/energyexchange/2023/01/30/rule-1-of-deploying-hydrogen-electrify-first/

So where is hydrogen used in the future energy system?



Sourcing of hydrogen in the Open ENTRANCE scenarios



Conclusions

- To **reach the ambitious climate target of 1.5°C**, the energy system needs to be **fully decarbonized by 2040**
- **Current emission trajectories** and **EU climate laws lag behind** this and would **fail to uphold** the **Paris Agreement**
- **Massive action** is **required immediately** to enable the necessary **expansion of renewable capacities** and **low-carbon technologies**
- Any **delays will incur massive additional costs** in the medium-term future

Conclusions (II)

- With a strong focus on **electrification** as a sector-coupling option, we foresee a **significant increase in variable renewable electricity generation**
- To balance these variabilities, different **flexibility options**, both **short- and long-term**, are required
- We **cannot** rely only on **one type of flexibility**, instead, the optimal mix of flexibility options includes a **sharp increase of all available options**, including **storages**, **hydrogen**, **transmission** expansion, and **demand side management**

Thank you for your attention

Dr. Konstantin Löffler

kl@wip.tu-berlin.de

@loeffko

https://git.tu-berlin.de/genesysmod

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