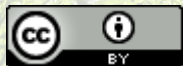


# Decarbonization scenarios for the European energy system

*Open ENTRANCE final conference, 02.06.2023*

Dr. Konstantin Löffler, EUF / TU Berlin / NTNU



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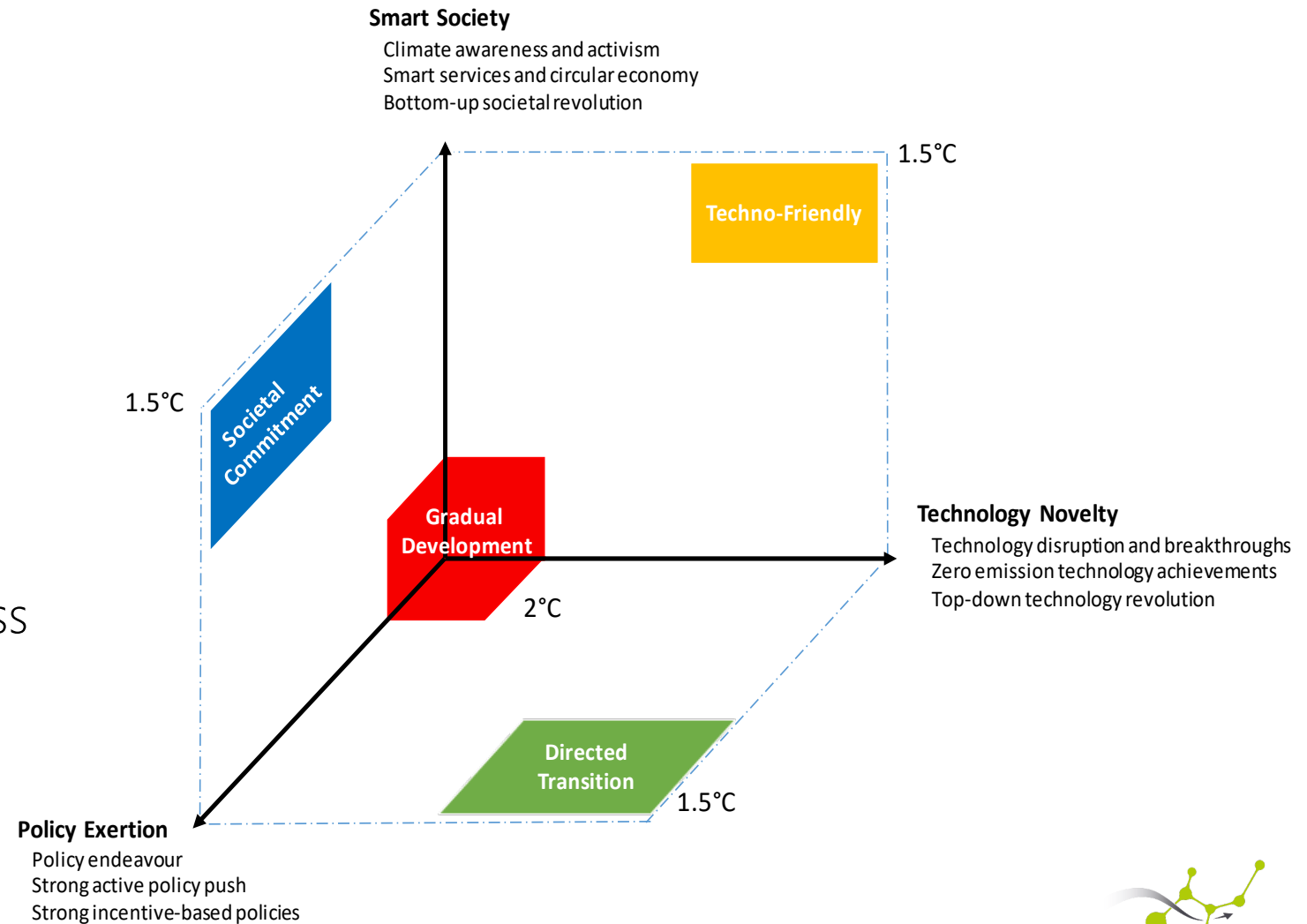
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 835896



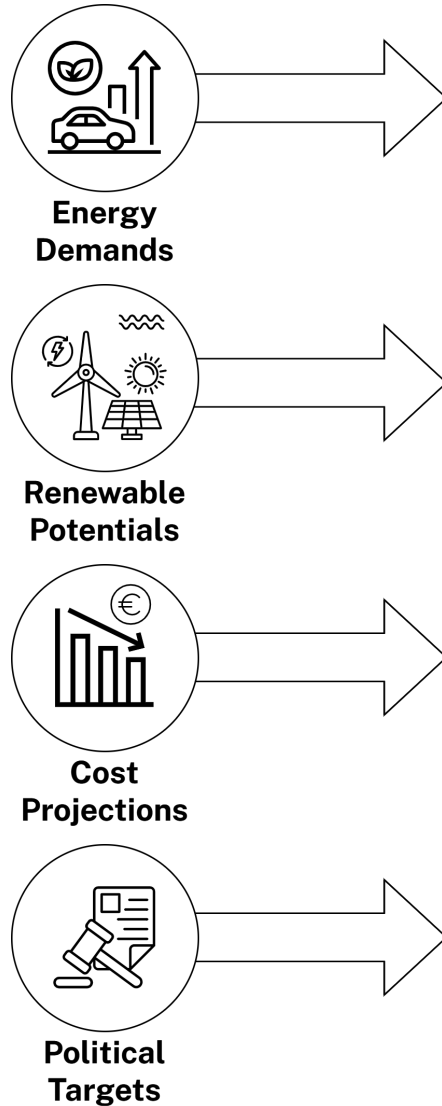


# The Open ENTRANCE scenarios

- **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

GENeSYS-MOD > GENeSYS-MOD public > Releases > GENeSYS-MOD v3.0 - Public release

## GENeSYS-MOD v3.0 - Public release

### Assets 4

- Source code (zip)
- Source code (tar.gz)
- Source code (tar.bz2)
- Source code (tar)

### Evidence collection

- genesysmod3.0-evidences-1.json 2F4c9c71
- Collected 2 months ago

## GENeSYS-MOD - The Global Energy System Model

### Version 3.0

Including source code, documentation, and Middle-Earth sample data set.

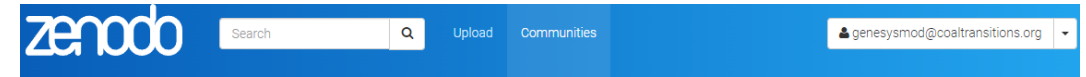


### Documentation (also included in release files):



GENeSYS-MOD v3.0 [Global Energy System Model] ~ December 2020

Based on OSEMOSYS 2011.07.07 conversion to GAMS by Ken Noble, Noble-Soft Systems - August 2012



## GENeSYS-MOD Community

### Recent uploads

Search GENeSYS-MOD Community

July 28, 2022 (v1) Preprint Open Access

View

#### Identifying policy areas for the transition of the transportation sector

Hainsch, Karlo;

Abstract: Being the only energy sector where emissions are still at 1990 levels, the German transportation sector requires rapid decarbonization to achieve ambitious climate targets. Policy makers need to put the framework in place which enables and supports this transition. This work analyzes which

Uploaded on July 28, 2022

July 28, 2022 (v1) Dataset Open Access

View

#### GENeSYS-MOD Transport Sensitivities: Data and model code for Hainsch (preprint): Identifying policy areas for the transition of the transportation sector

Hainsch, Karlo;

This dataset contains all GENeSYS-MOD input data for Hainsch (preprint): Identifying policy areas for the transition of the transportation sector. doi: 10.5281/zenodo.6919452. With the input data files and the GAMS files, the model results presented in the preprint can be replicated. Furthermore,

Uploaded on July 28, 2022

August 31, 2021 (1.0) Dataset Open Access

View

#### GENeSYS-MOD Germany: Technology, demand, and renewable data

Löffler, Konstantin; Burandt, Thorsten; Hainsch, Karlo;

This dataset contains renewable potentials, timeseries, technology data, and additional data tables for the current implementation of GENeSYS-MOD Germany.

Uploaded on September 2, 2021

New upload

Community



### GENeSYS-MOD Community

The Global Energy System Model (GENeSYS-MOD) is a cost-optimizing linear program based on the Open Source Energy Modelling System (OSEMOSYS).

Curated by: genesysmod-admin

Curation policy: Not specified

Created: December 9, 2020

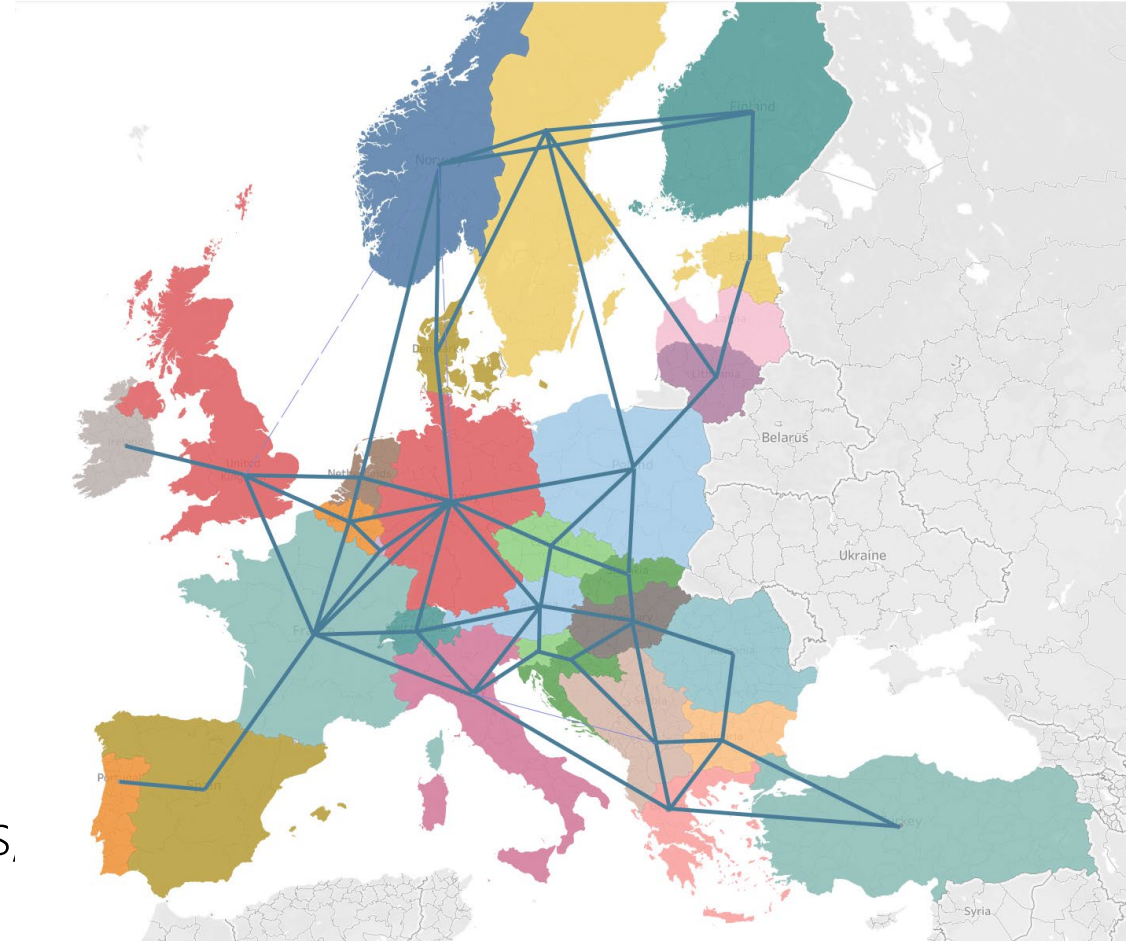
Harvesting API: OAI-PMH Interface

Want your upload to appear in this

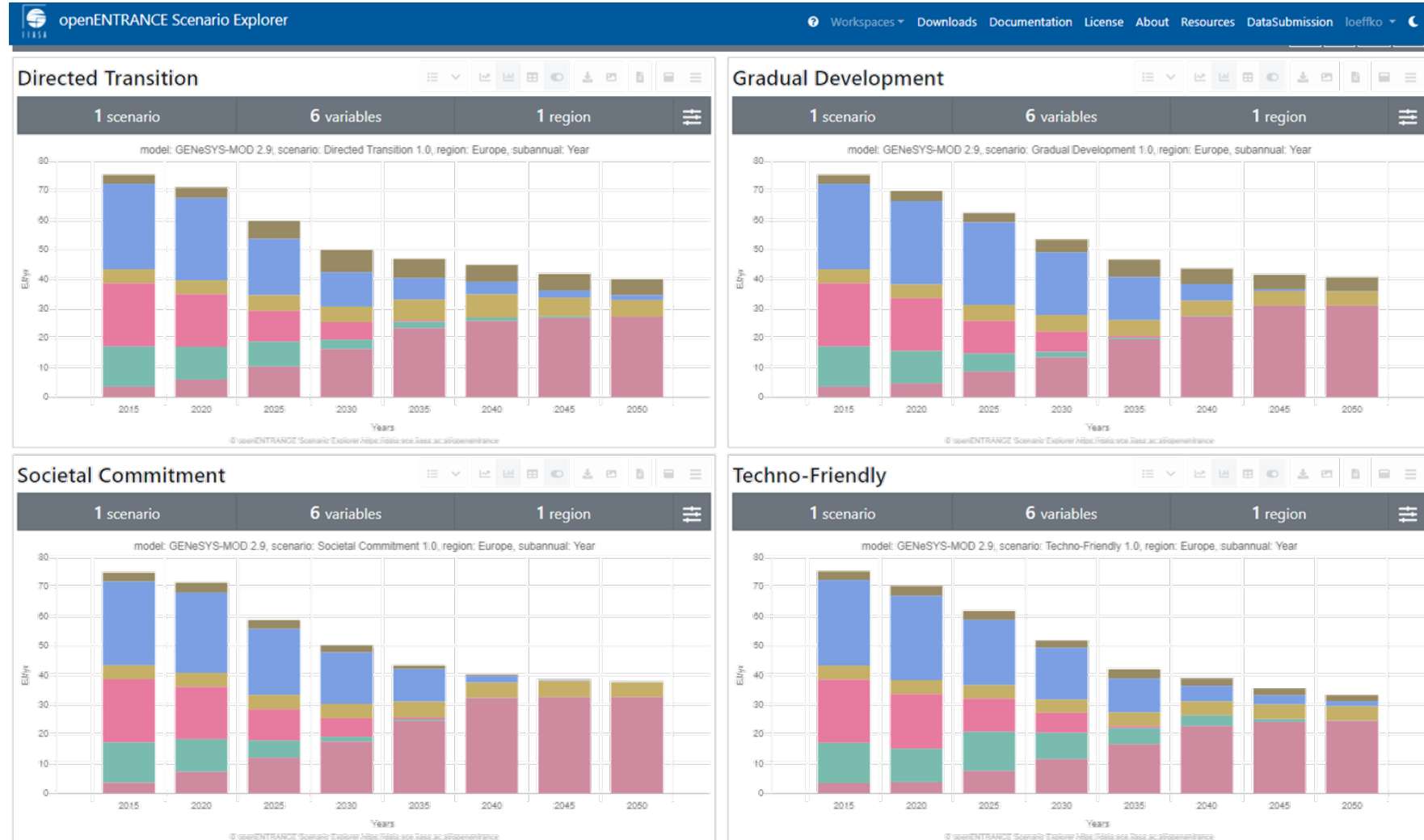


# Outline of the model set-up

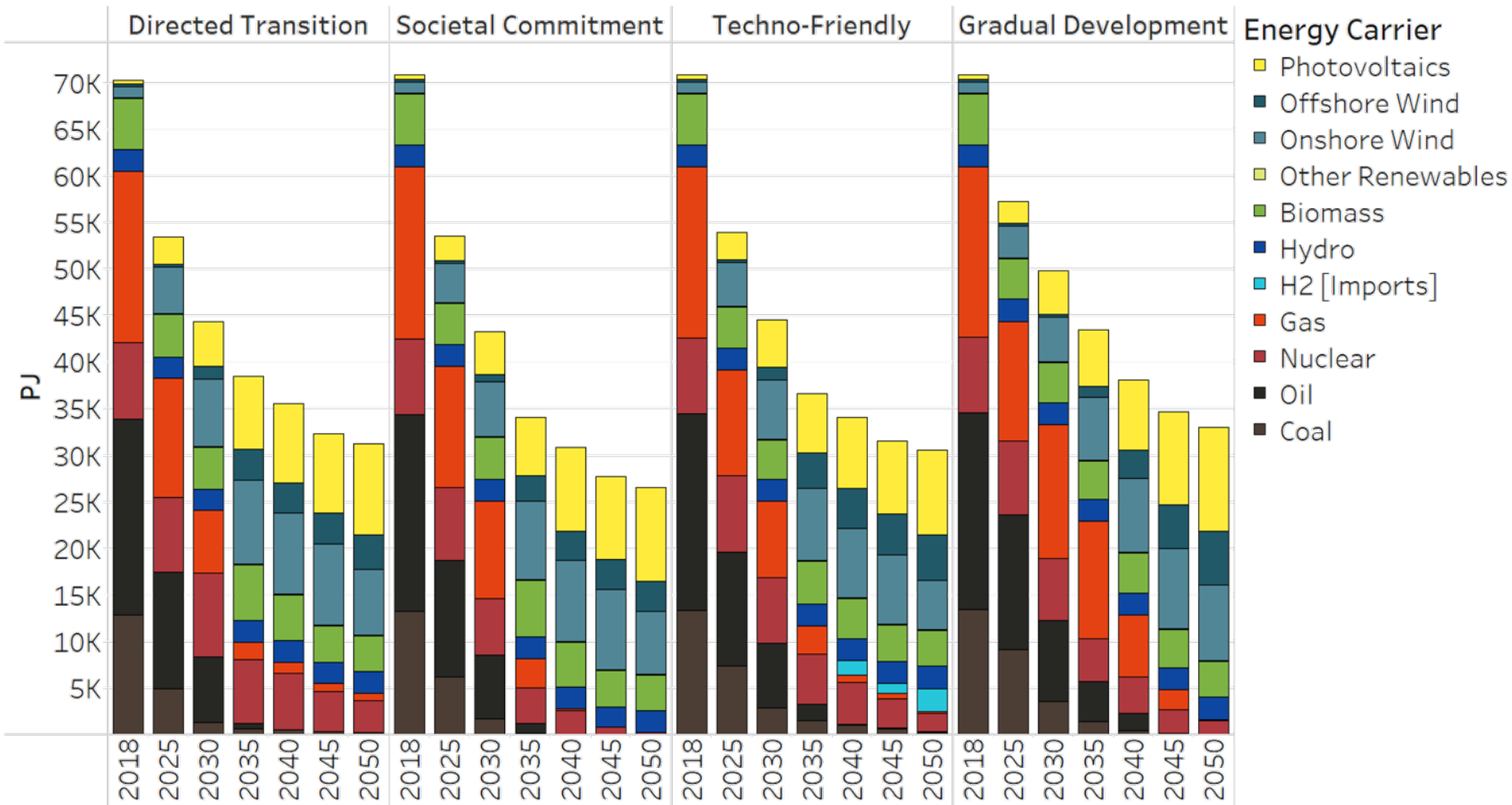
- 30 Regions (Mainland-EU, UK, Switzerland, Norway, Turkey, and the Balkan region)
- Modeled timeframe: 2018-2050
- Reduced hourly timeseries, via a reduction algorithm
- Covers the sectors: Electricity, Buildings, Industry and Transportation
- Pathway dependent features (like potential of demand shifting,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



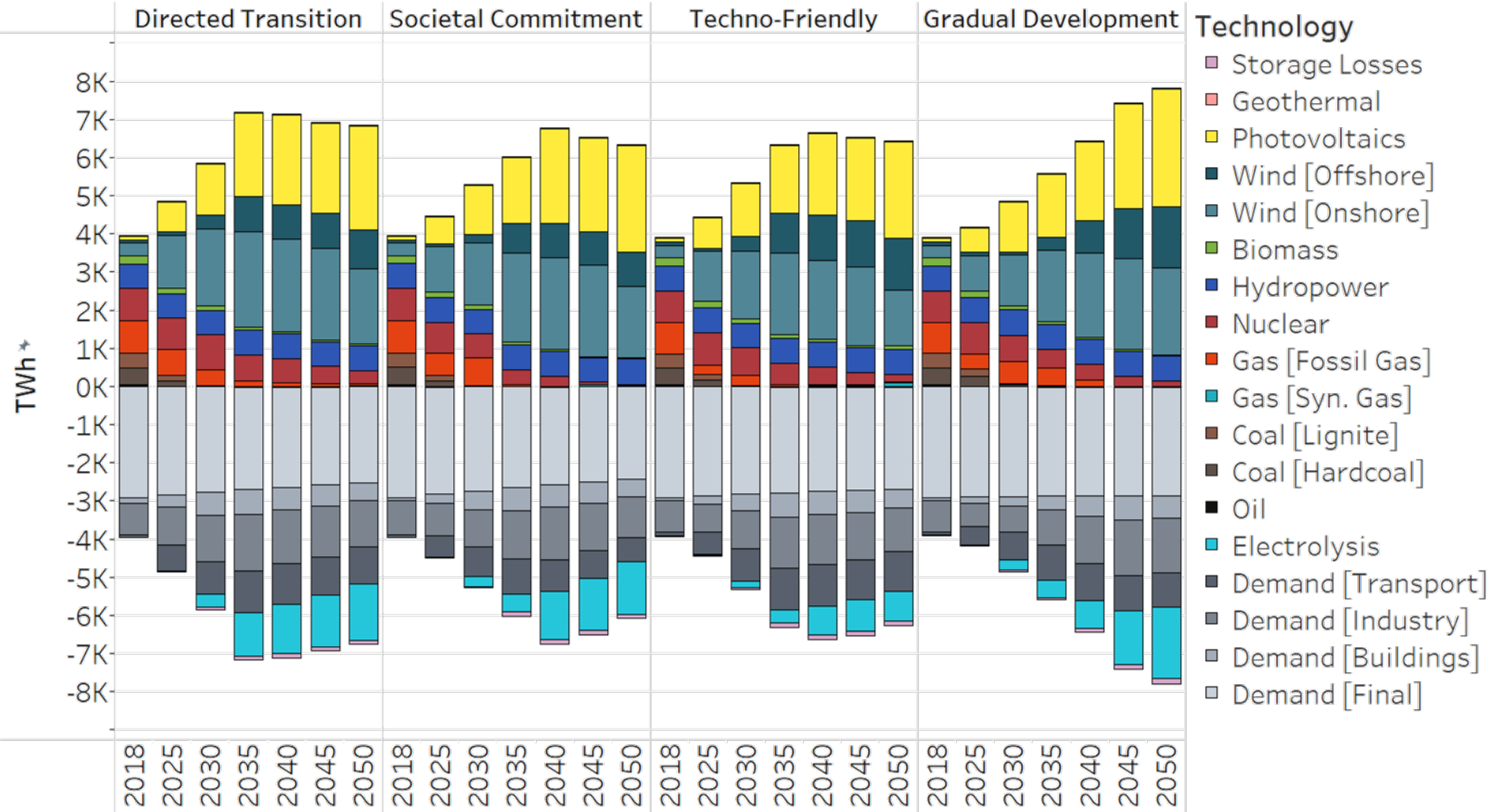
# Results on the Open ENTRANCE scenario explorer



# Results: Primary Energy

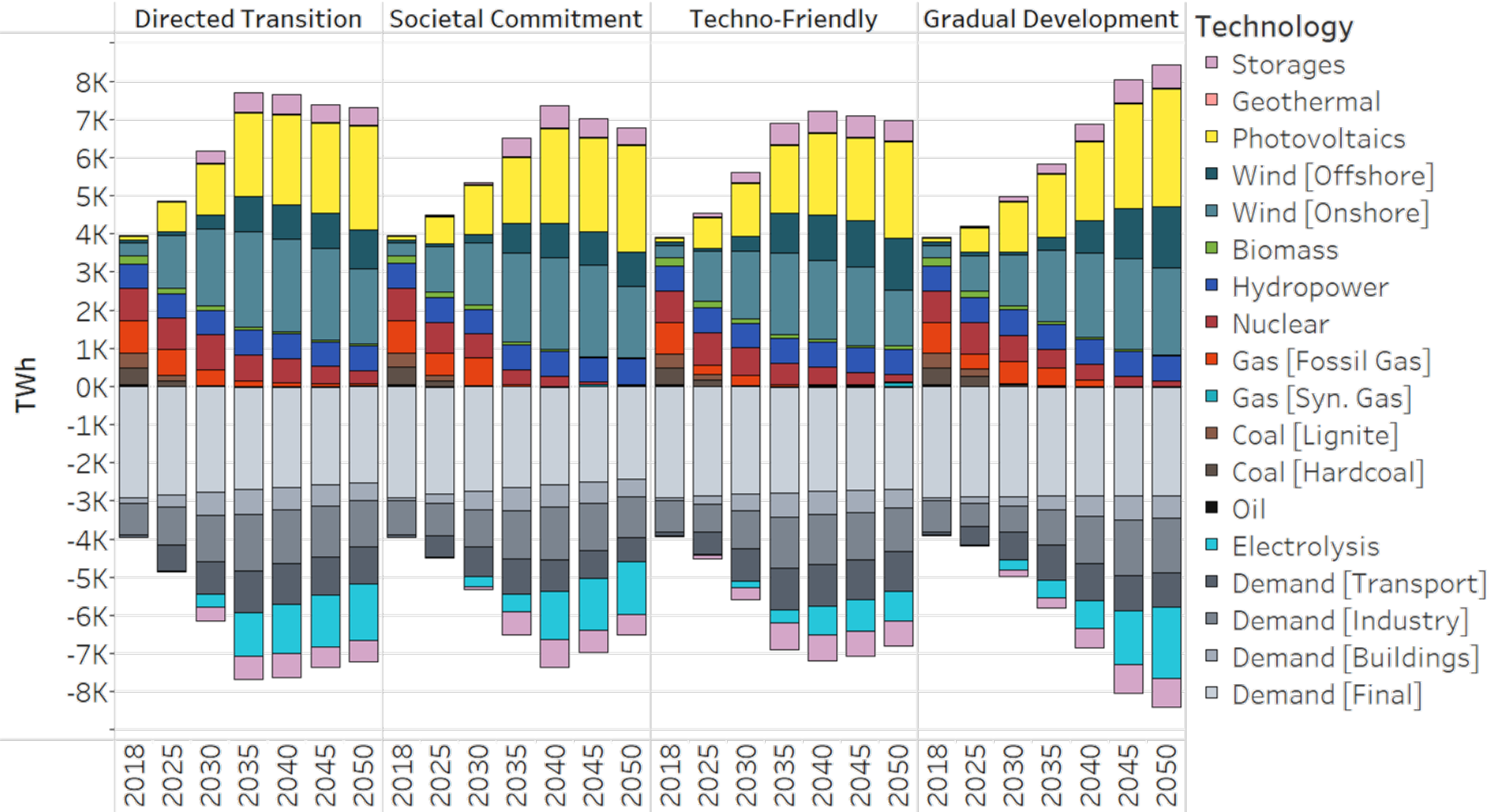


# Pathway results - Electricity

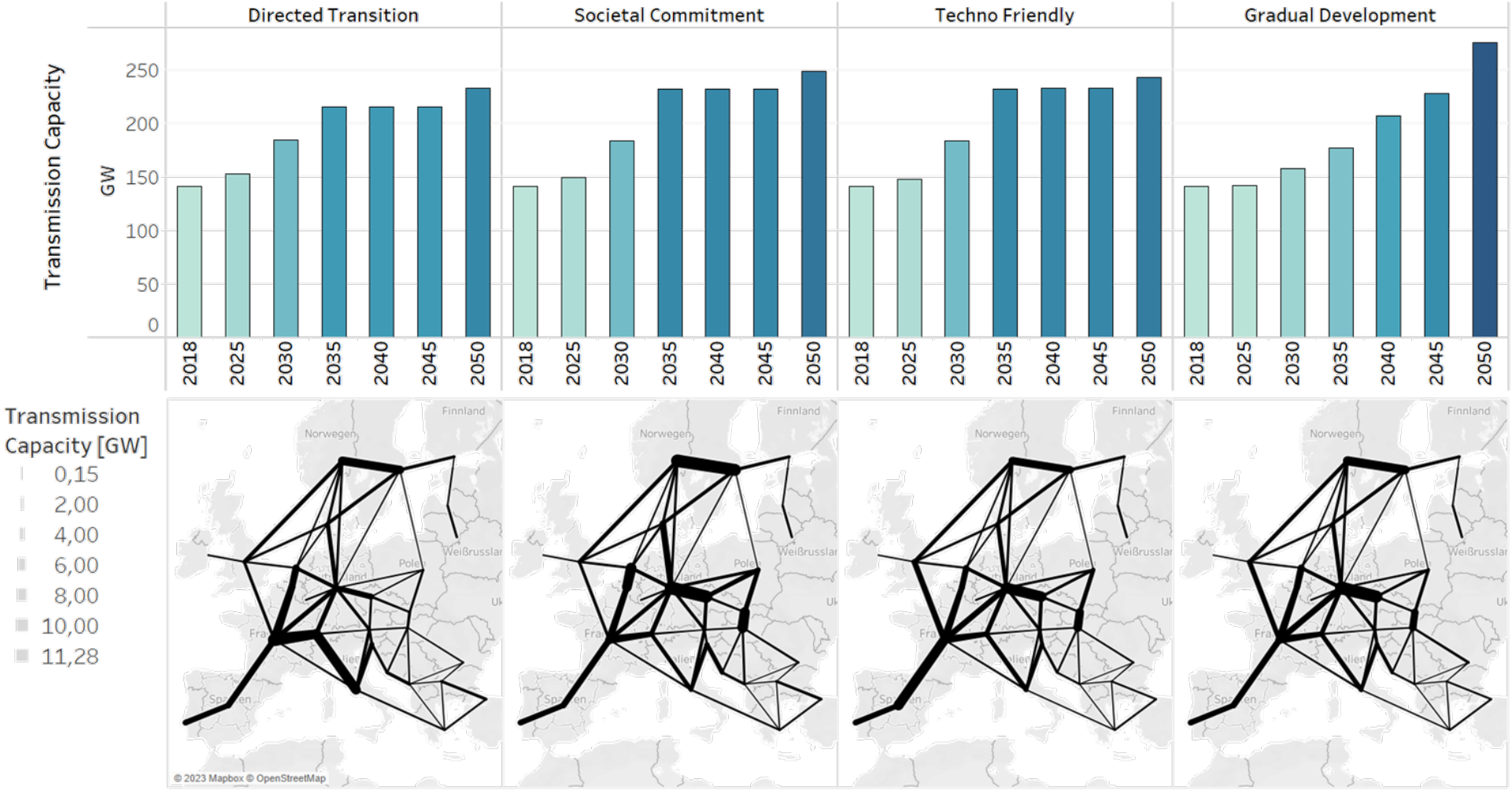




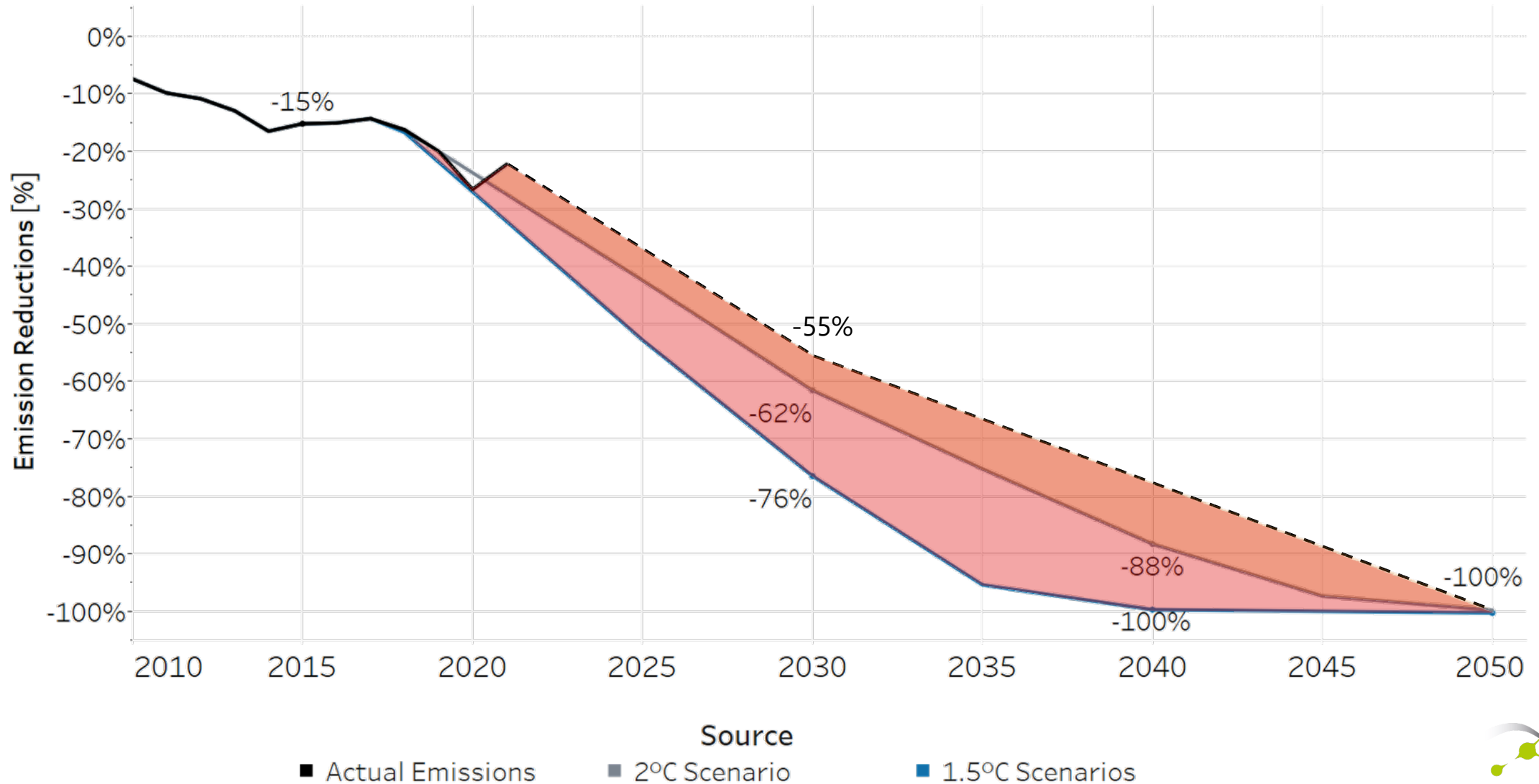
# Pathway results - Electricity



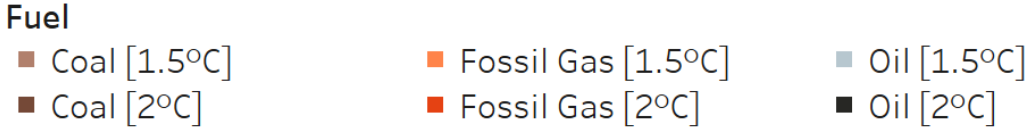
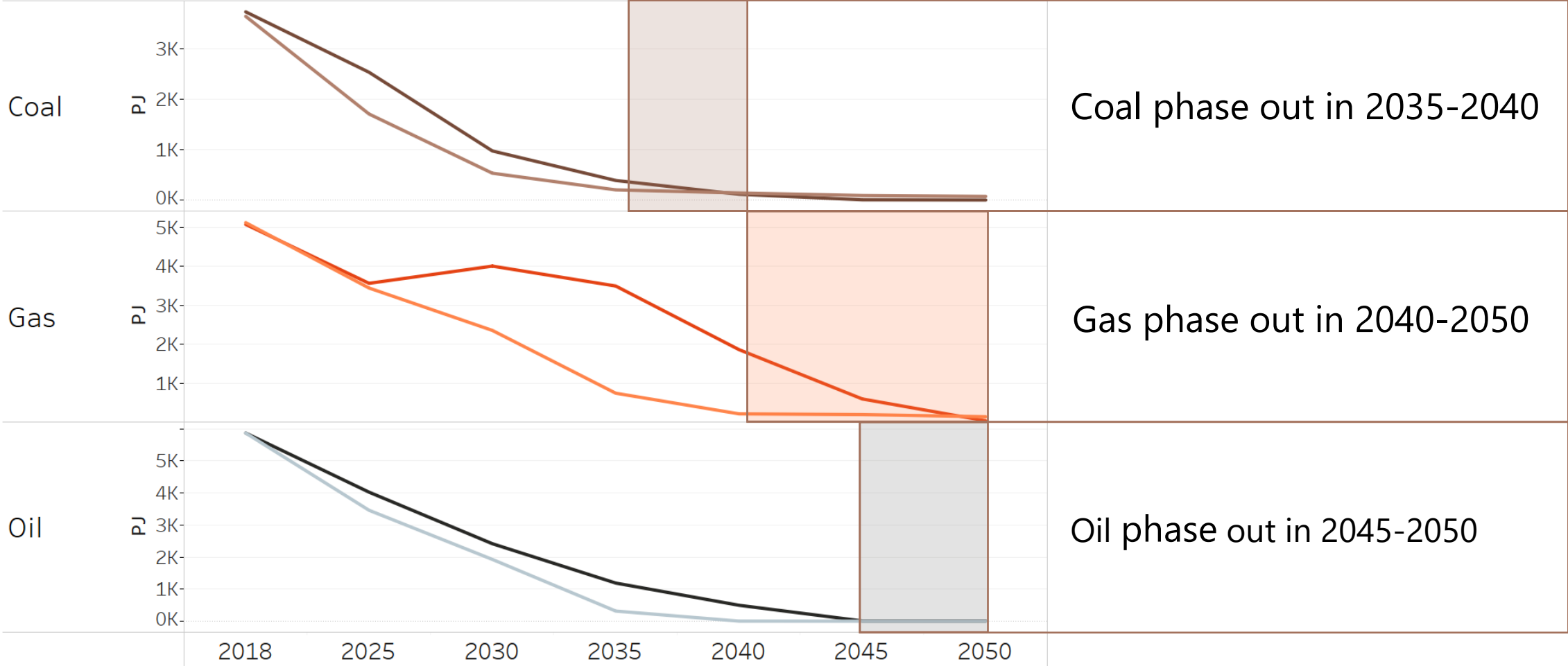
# Results: Transmission capacity



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

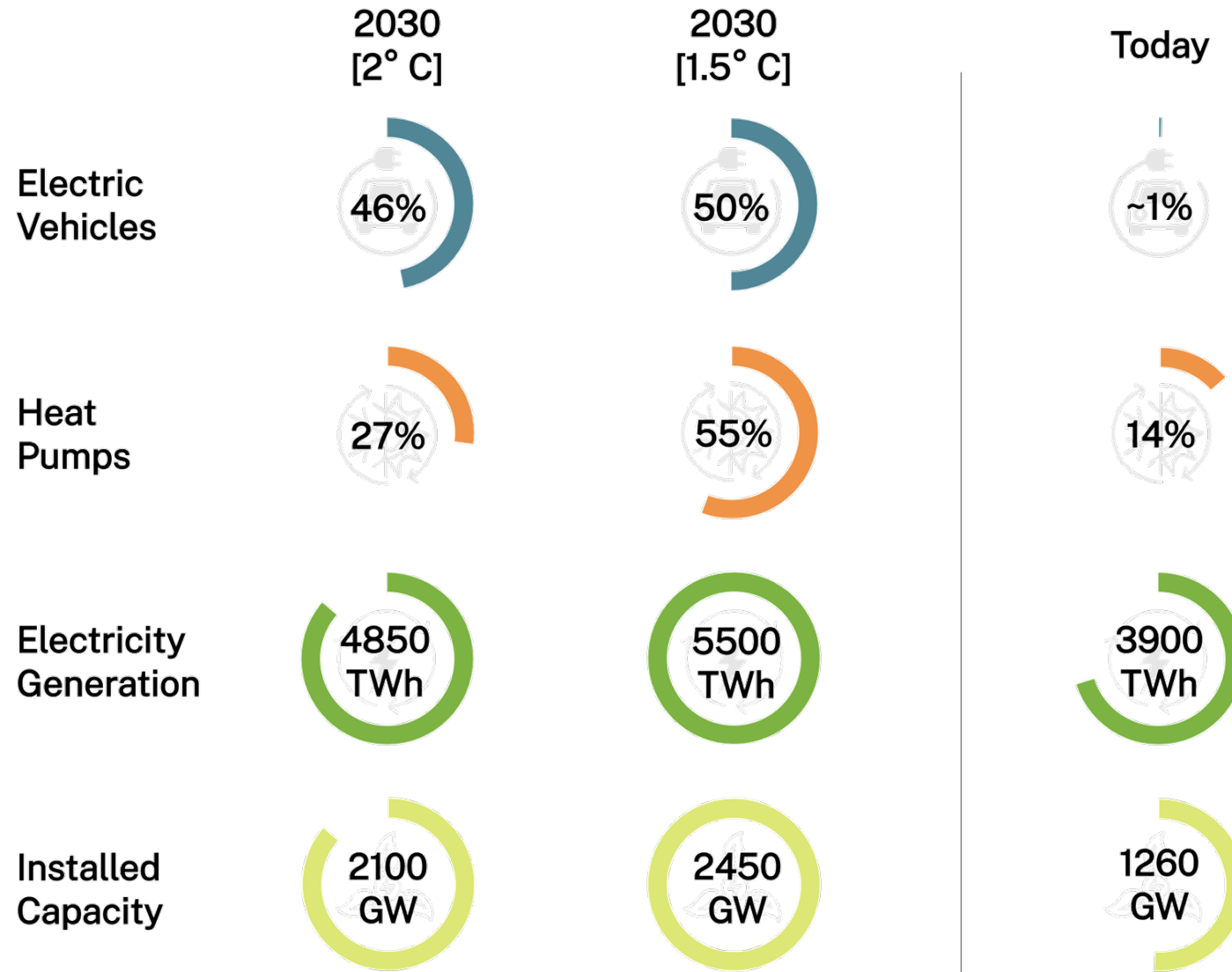


# Fossil fuel consumption needs to be reduced to zero



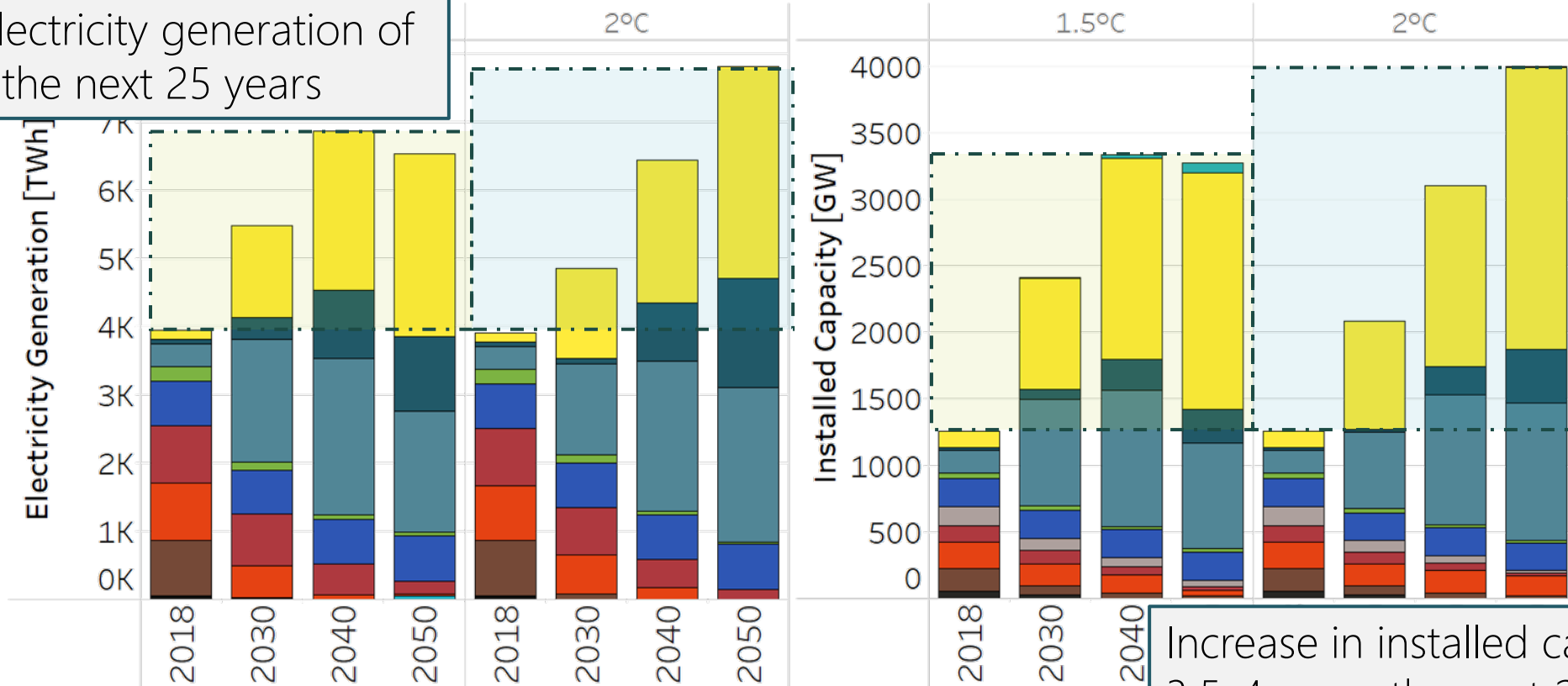


# Milestones needed for the fulfillment of climate targets



# 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

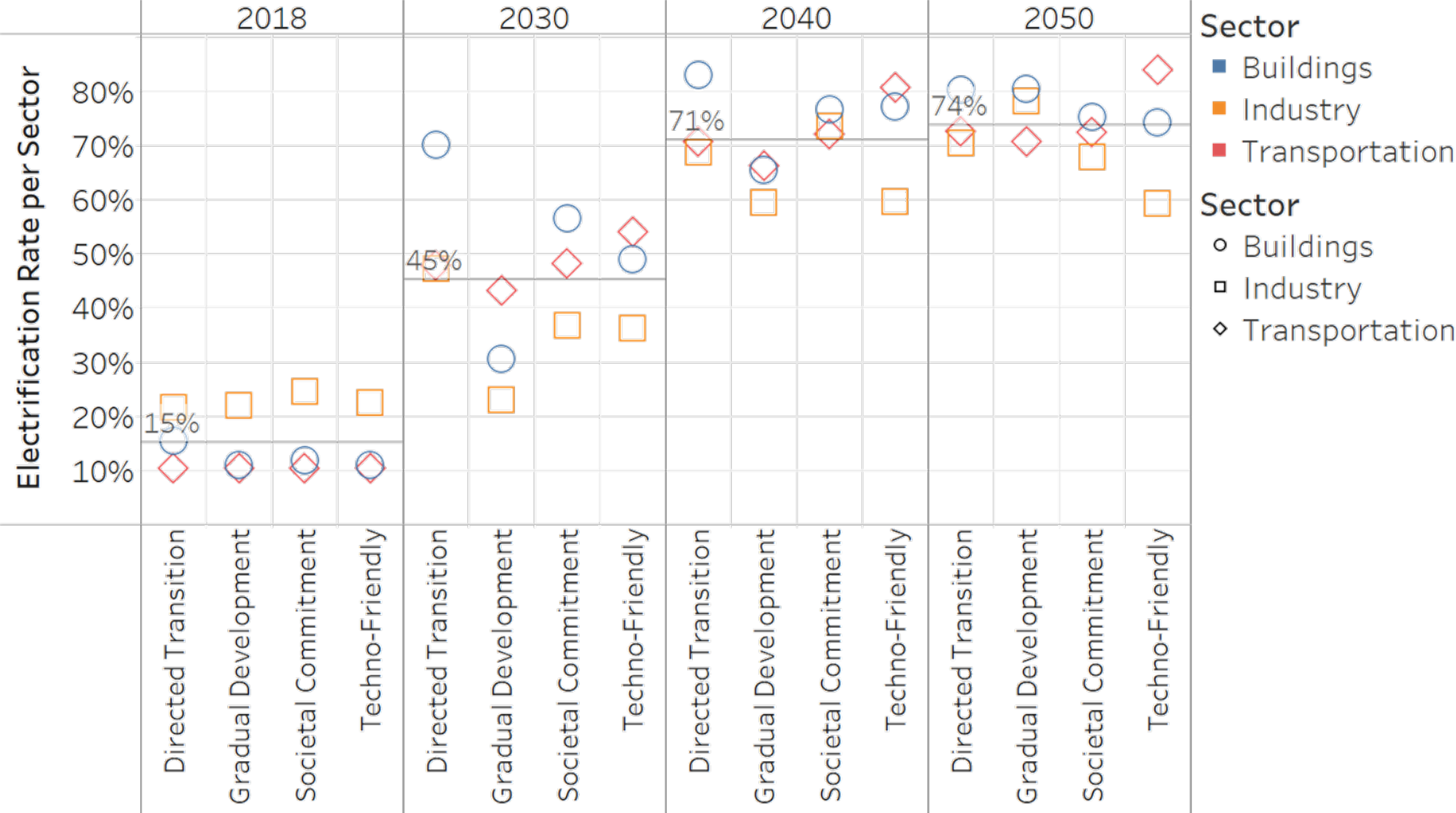
- Hydrogen
- Solar
- Wind Offshore
- Wind Onshore
- Biomass
- Hydro
- CHPs
- Nuclear
- Gas
- Coal
- Oil

## 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<sub>2</sub>**
  - Accounting for environmental and social costs of carbon<sup>1</sup>, 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

Source: [https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2019-02-11\\_methodenkonvention-3-0\\_en\\_kostensaetze\\_korr.pdf](https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2019-02-11_methodenkonvention-3-0_en_kostensaetze_korr.pdf)

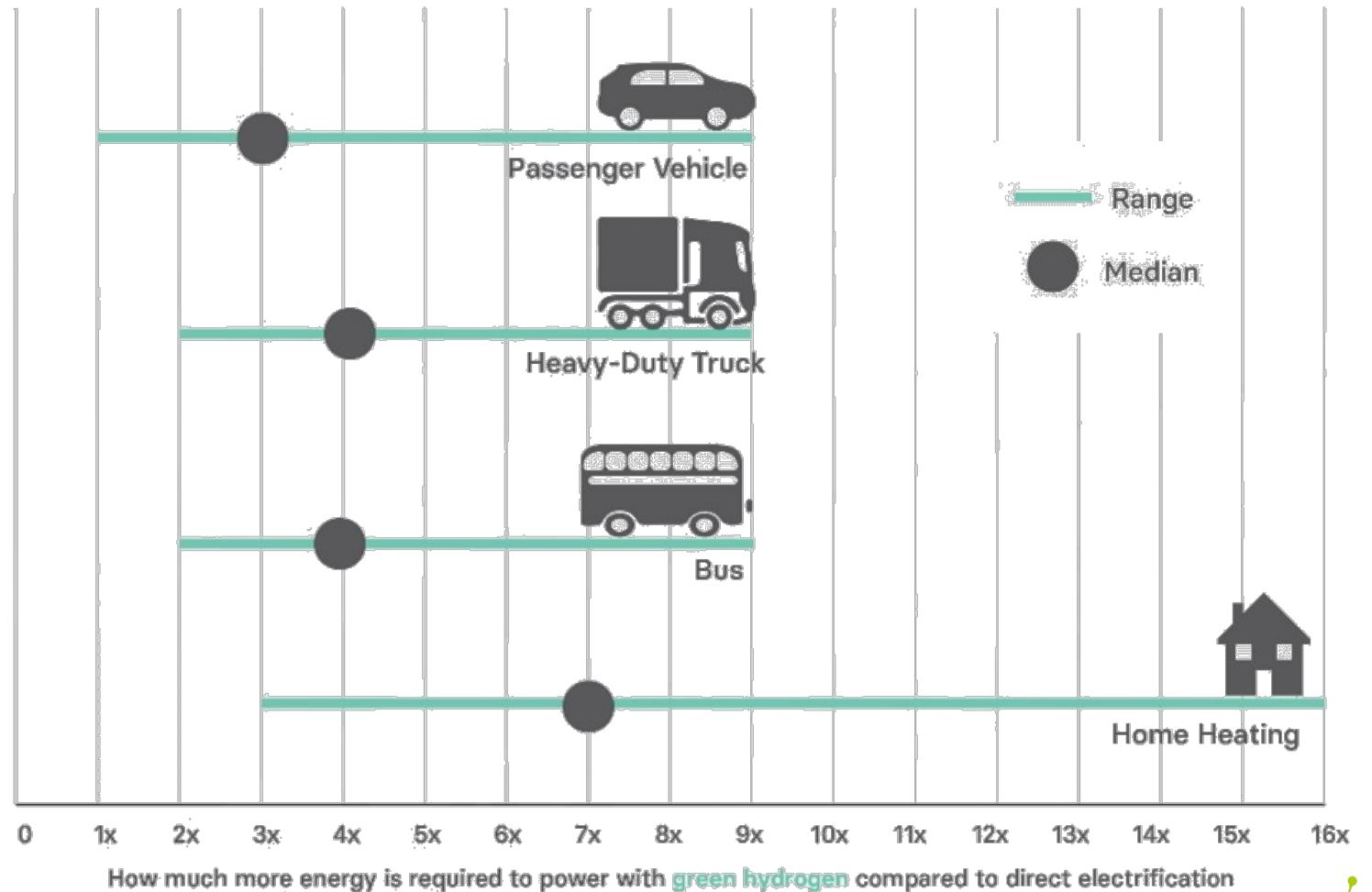
# Results: Electrification Rate





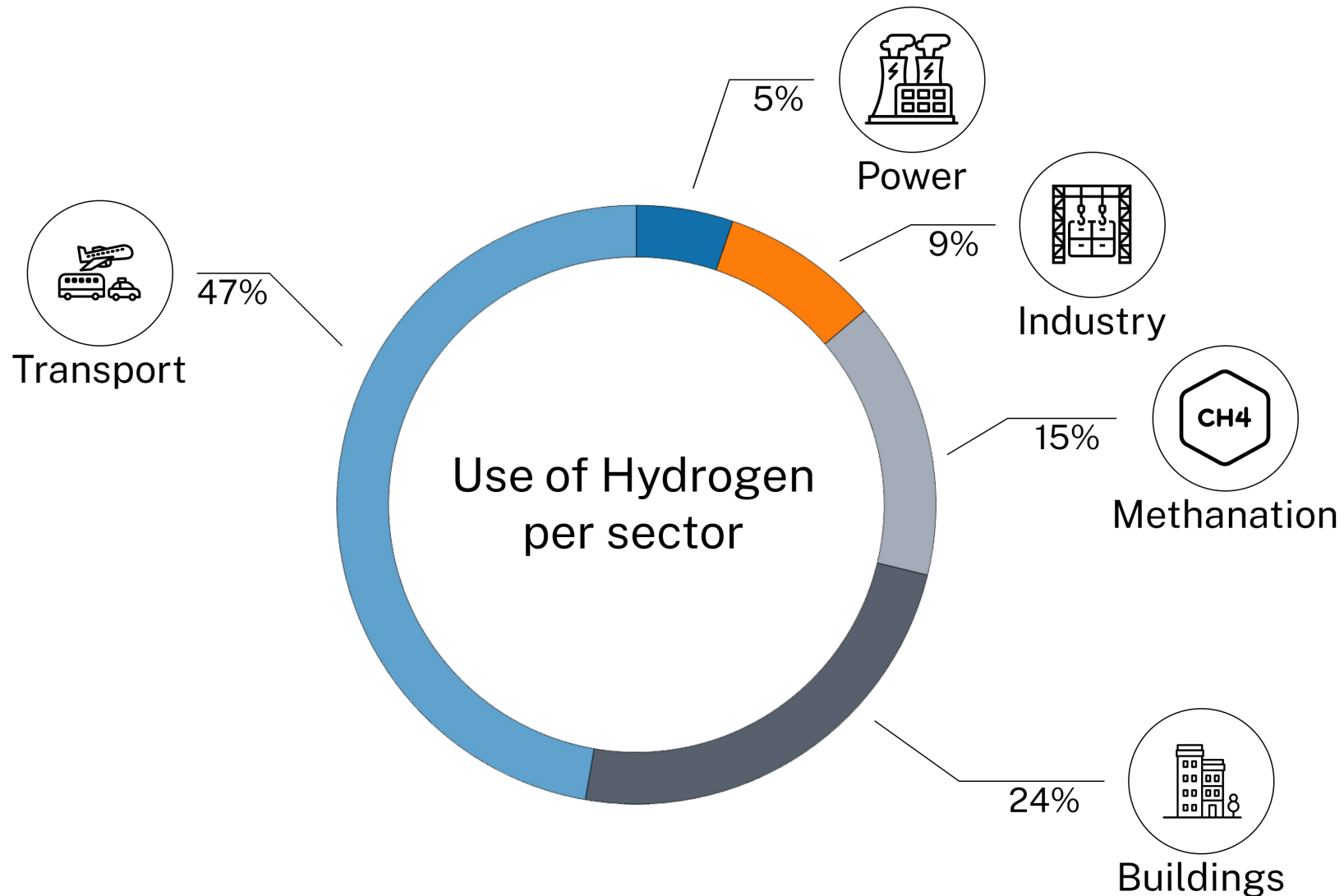
# Hydrogen as the solution for an independent European energy system?

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

### Hydrogen Generation



Hydrogen [TWh]



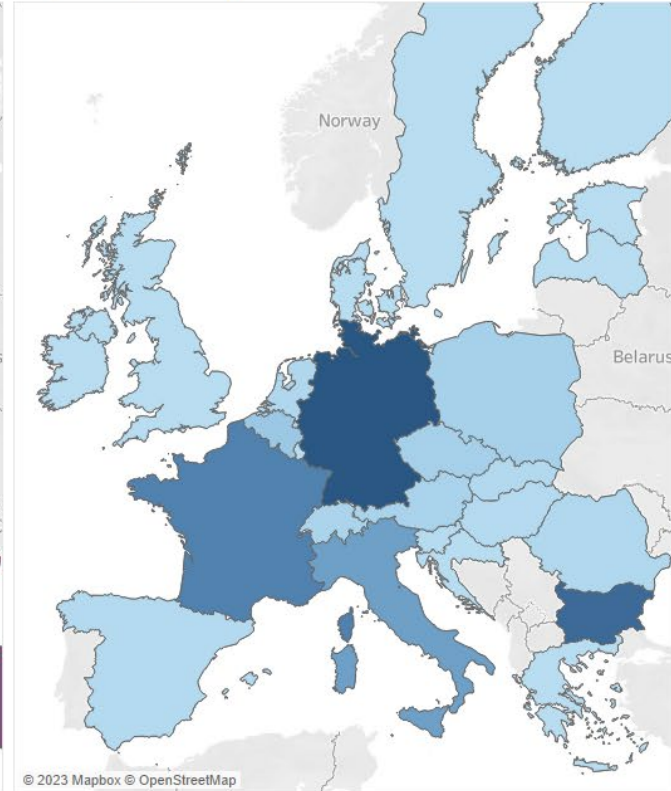
### Hydrogen Exports



Exports [TWh]



### Hydrogen Imports



Imports [TWh]



# 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

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 [@loeffko](https://twitter.com/loeffko)

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

