Hydrogen – GENeSYS-MOD modelling results from the openENTRANCE project (including results for Japan)

31.03.2023

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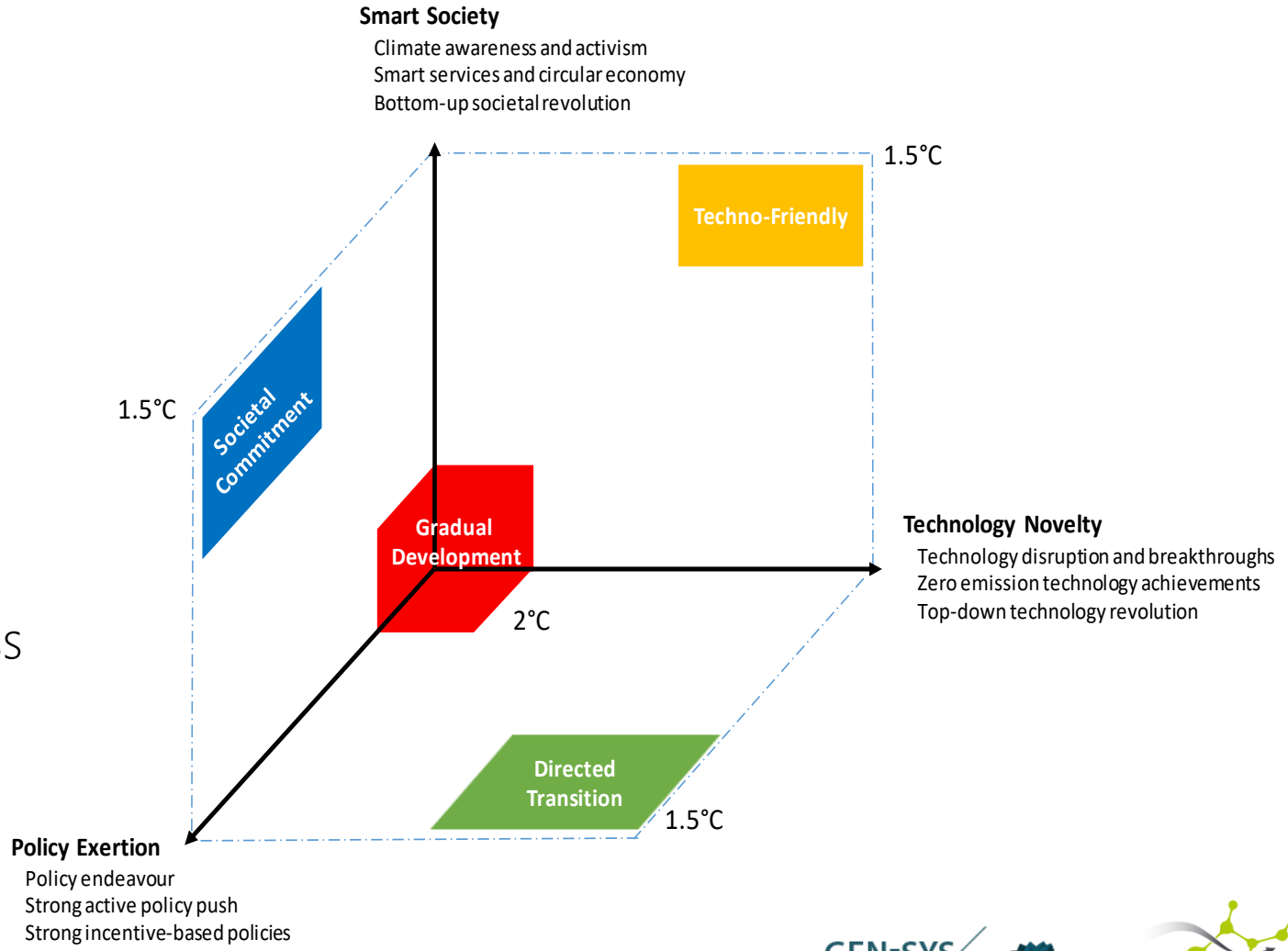
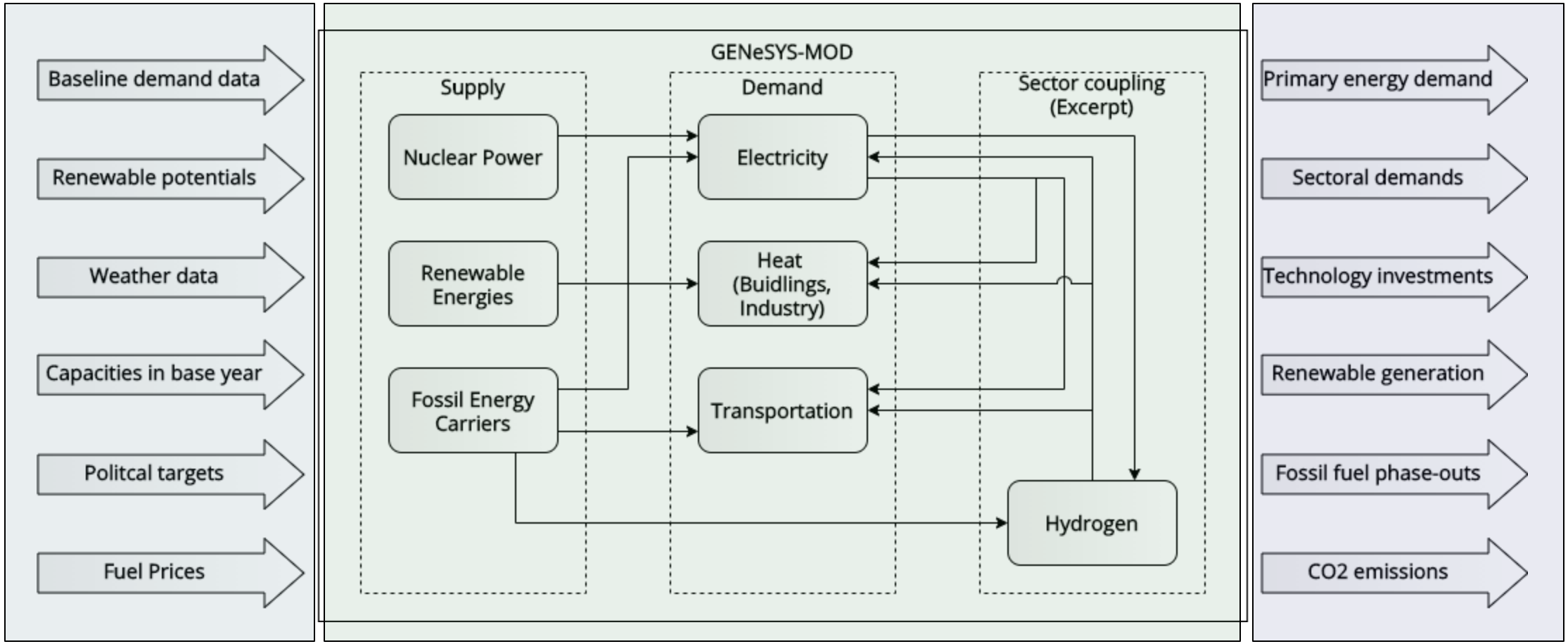
The openENTRANCE storylines

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

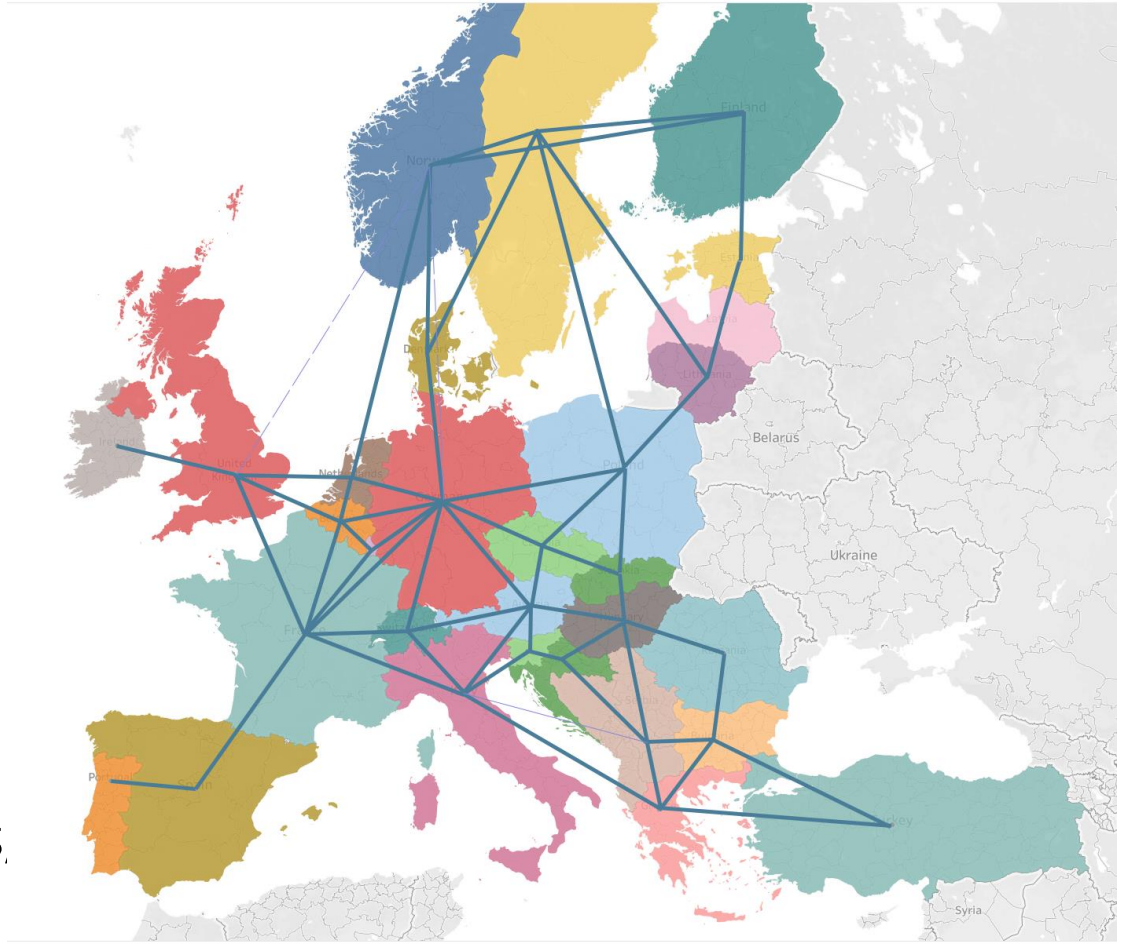


The Global Energy System – GENeSYS-MOD

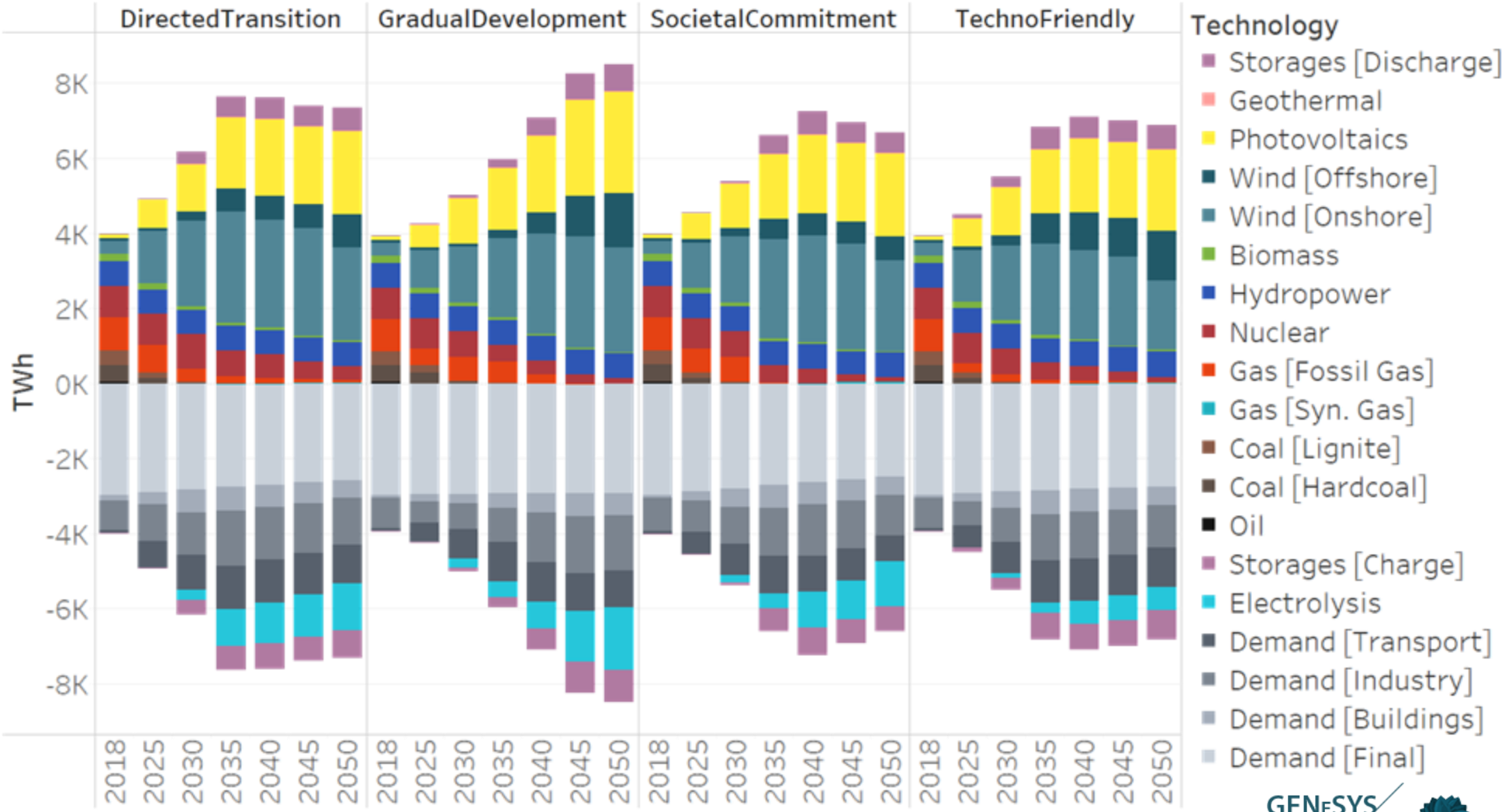


Outline of the model set-up

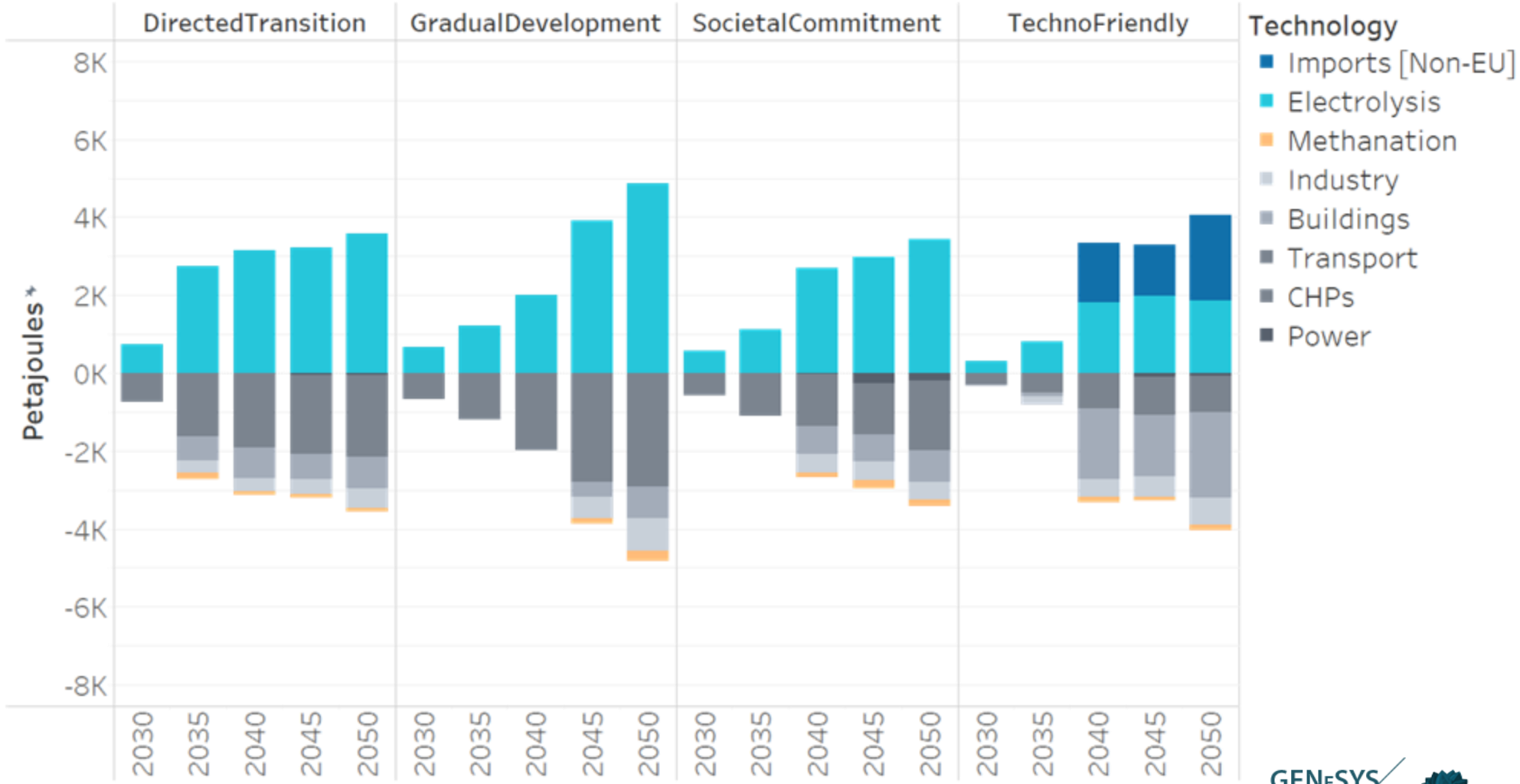
- 30 Regions (Mainland-EU, UK, Switzerland, Norway, Turkey, and the Balkan region)
- Modeled timeframe: 2018-2050
- Reduced hourly timeseries, via a reduction algorithm
- Covers the sectors: Electricity, Buildings, Industry and Transportation
- Pathway dependent features (like potential of demand shifting,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



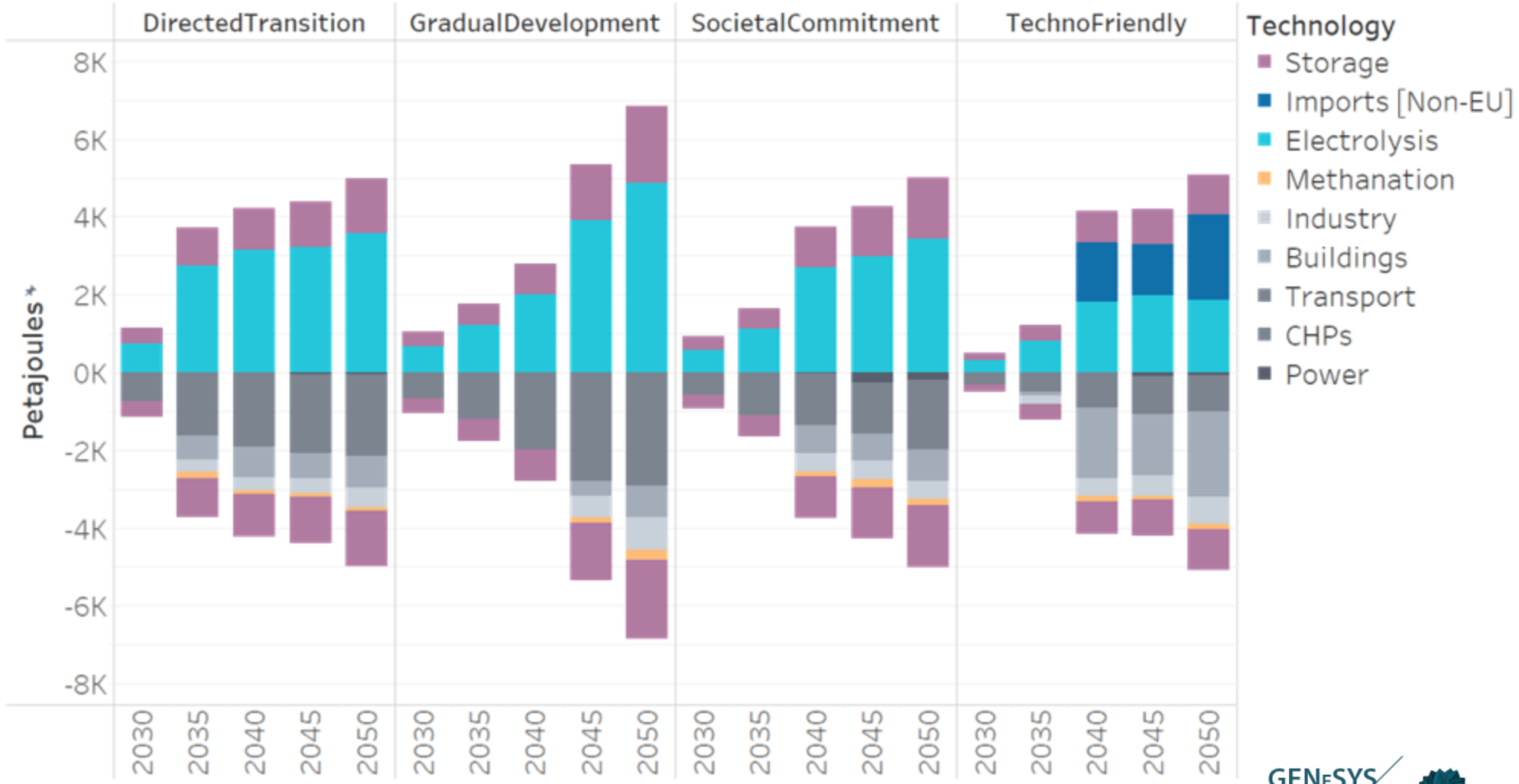
Pathway results - Electricity



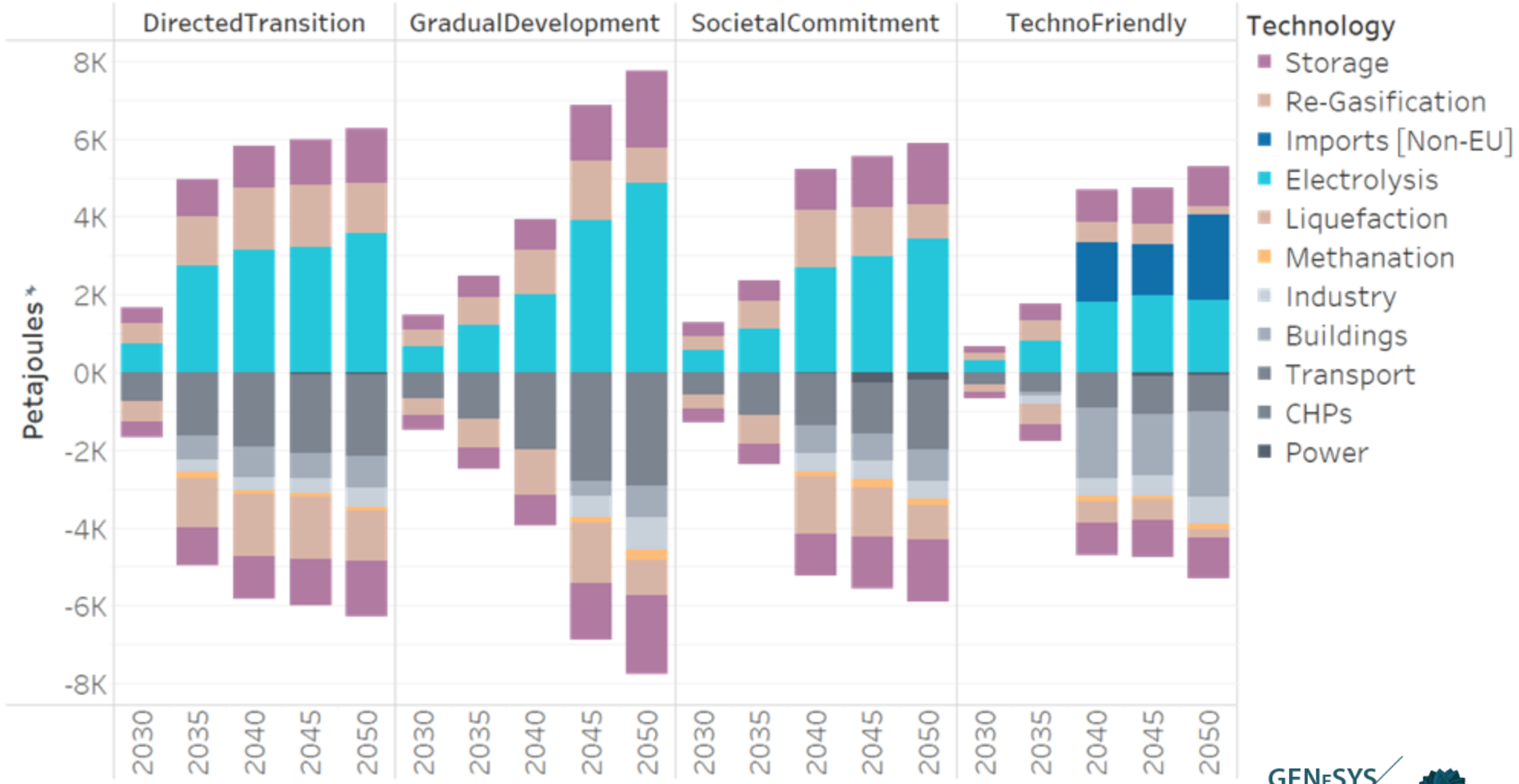
Pathway results – Hydrogen [excl. Storage & Liquefaction]



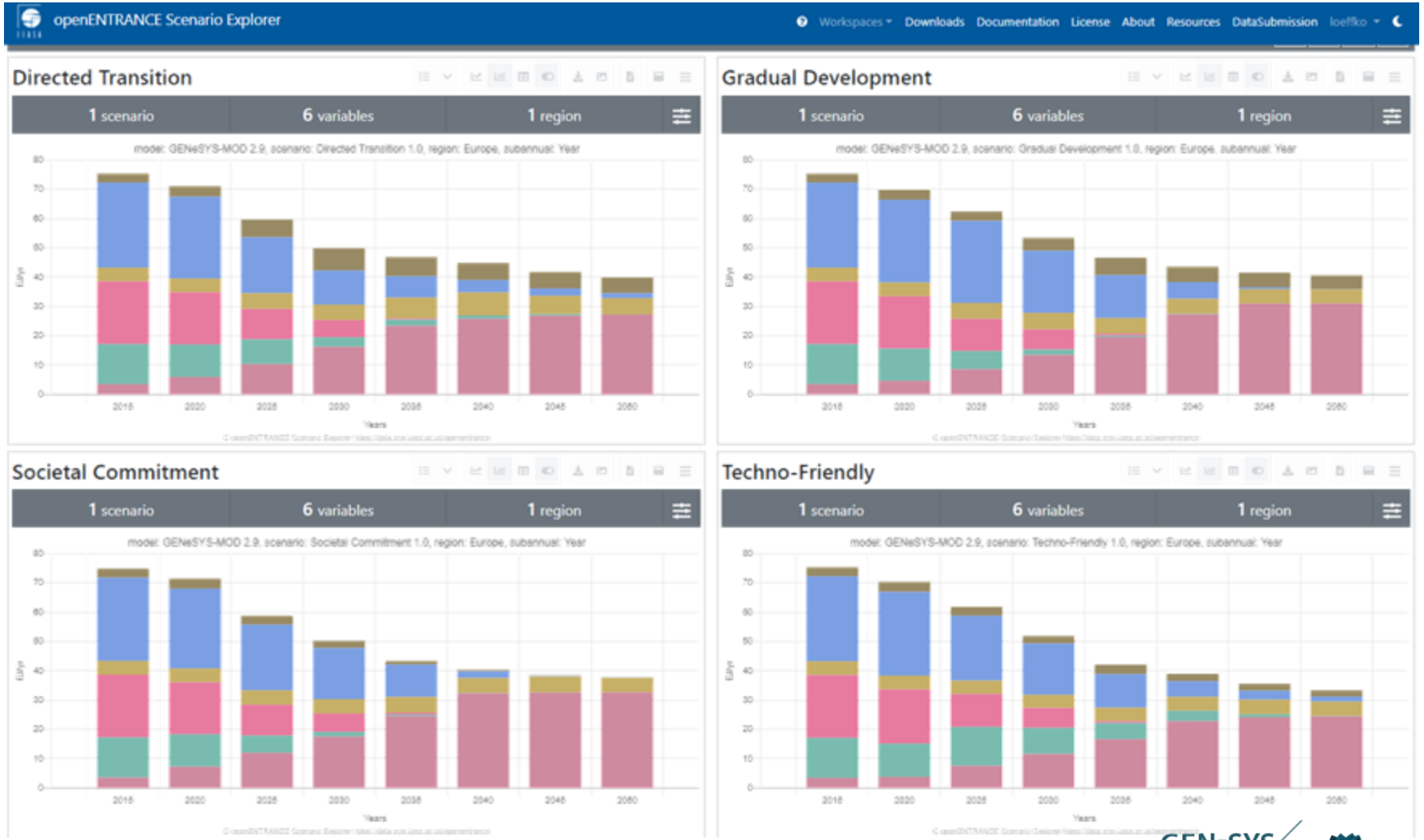
Pathway results – Hydrogen [incl. Storage]



Pathway results – Hydrogen [incl. Storage & Liquefaction]

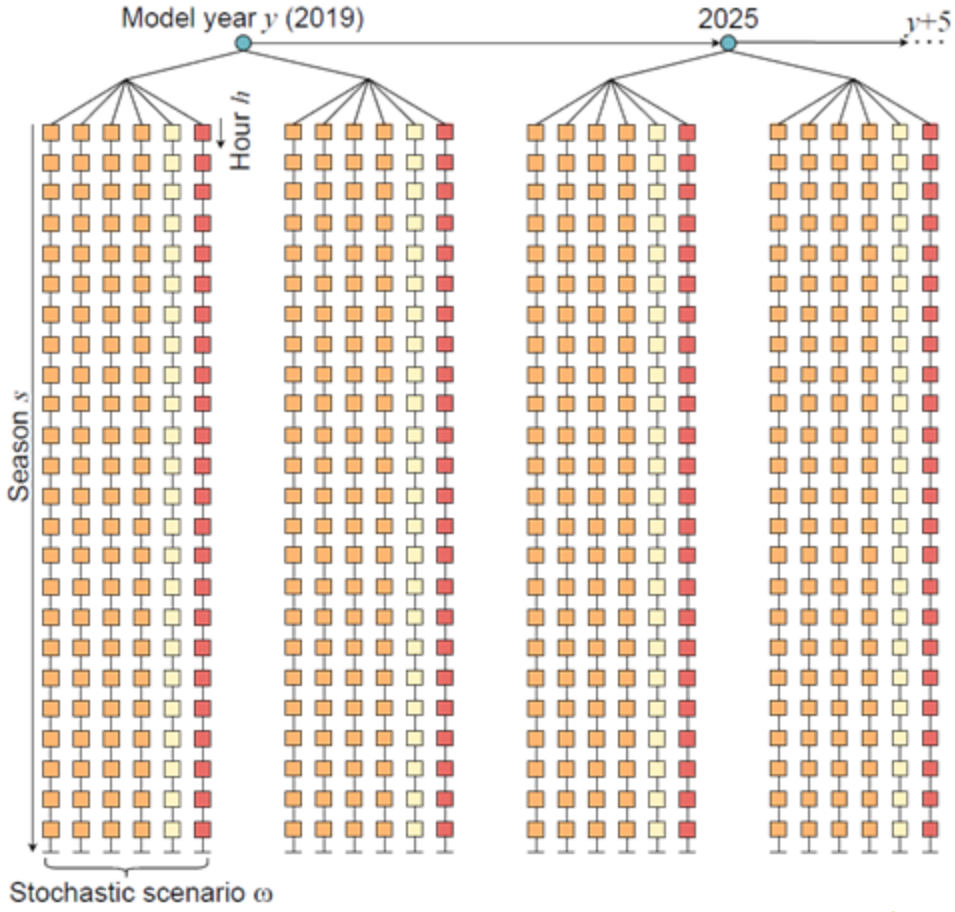


Results on the openENTRANCE scenario explorer



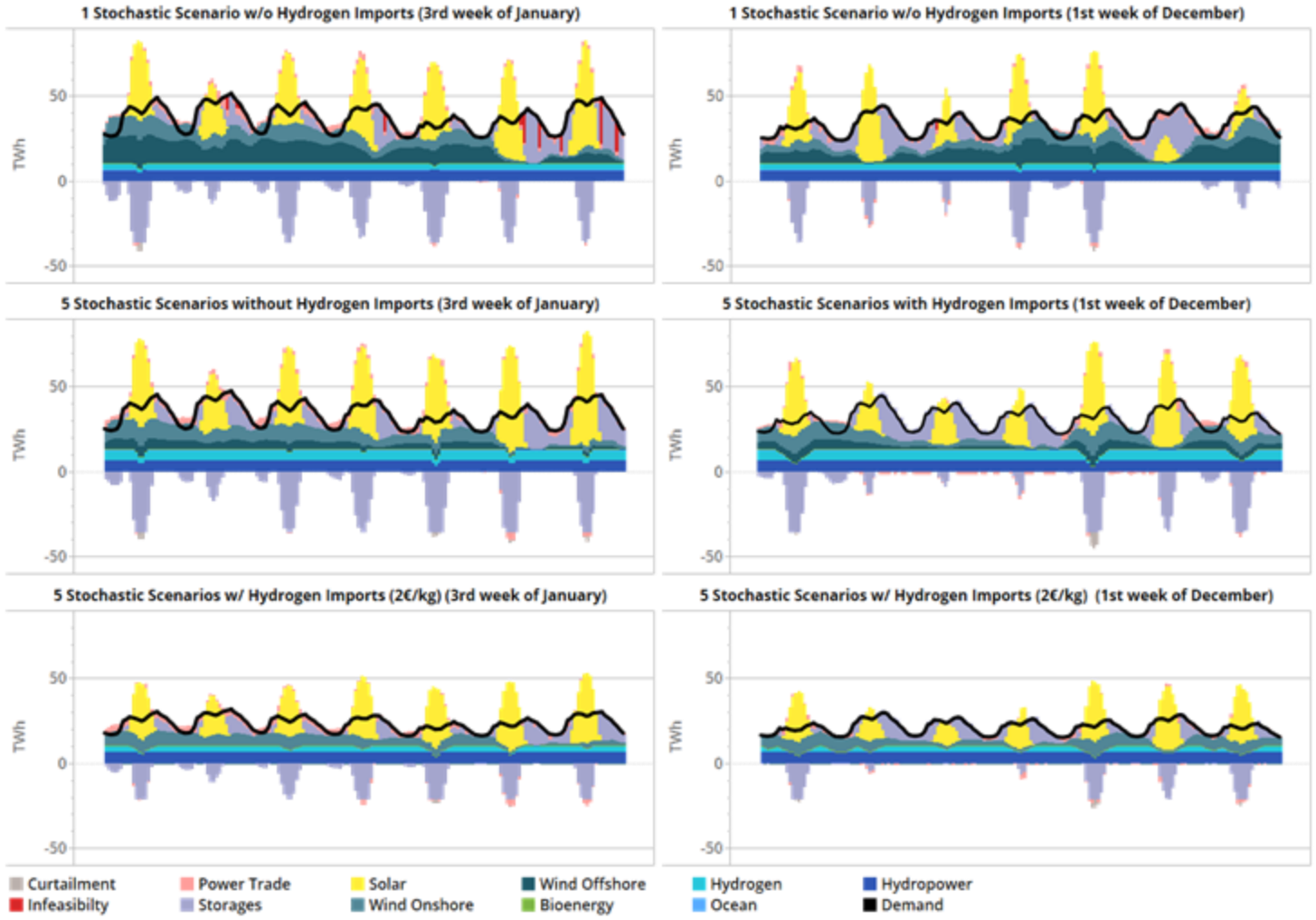
GENeSYS-MOD & stochasticity: A case study for Japan

- Model reformulated as two-stage stochastic program with recourse (Birge and Louveaux 2011)
- Stochastic operational decisions based on uncertain hourly demand for electricity, heating, and transportation and uncertain hourly renewable production
- Stochastic scenarios based on random sampling from historical data
- Up to five stochastic scenarios with 6 seasons and 24 hours each have been able to be solved
- Ex-post dispatch model to assess the quality of resulting pathways for Japan's energy system



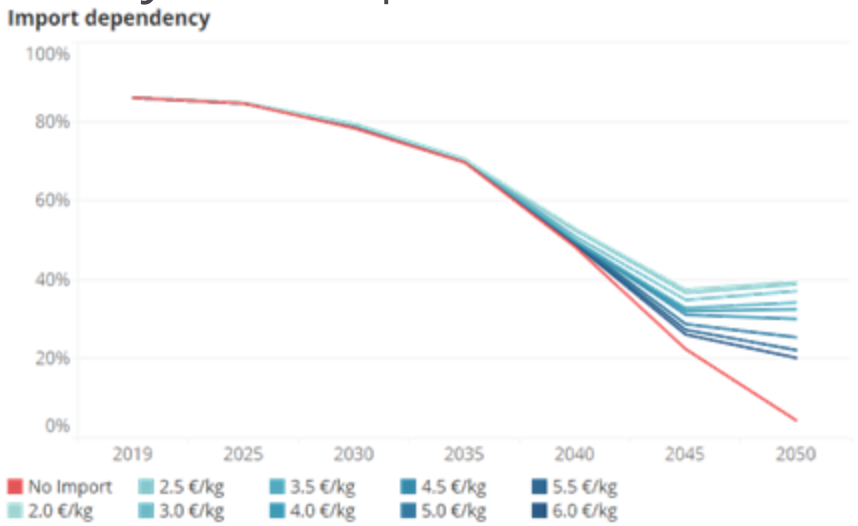
Burandt (2021): https://doi.org/10.1016/j.apenergy.2021.117265

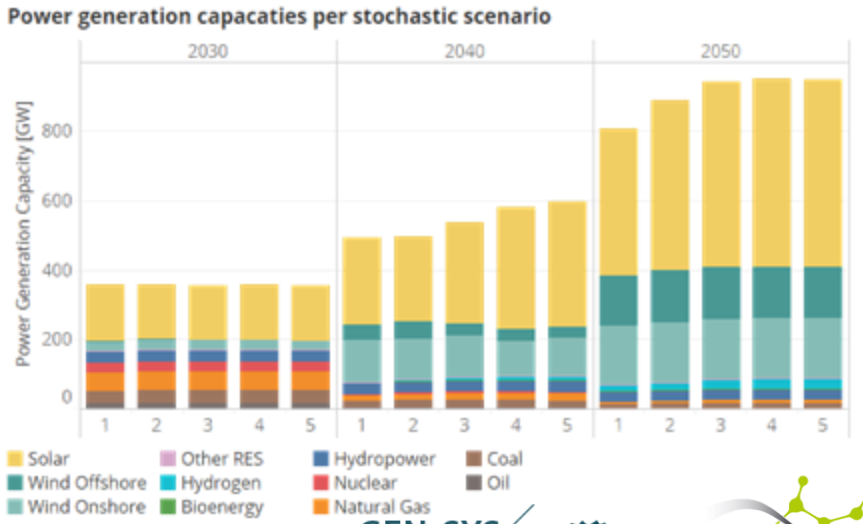
GENeSYS-MOD & stochasticity: A case study for Japan



GENeSYS-MOD & stochasticity: A case study for Japan

- Impact of stochasticity
  - Generation of more robust results regarding power system planning
  - Usage of multiple historic years reduces data bias when using data for one year instead
  - Substantial increase in matrix size and calculation time compared to a deterministic version of the model
- Key insights
  - Renewable energy source are the primary energy provider in all cases, regardless of hydrogen import prices
  - Electrification and expansion of variable renewable energy sources proves the most cost-efficient way of decarbonizing the energy system
  - Cheaply available imported hydrogen is mainly used in the industry and freight transportation sector as well as for residential heating in urban areas





Thank you for your attention!

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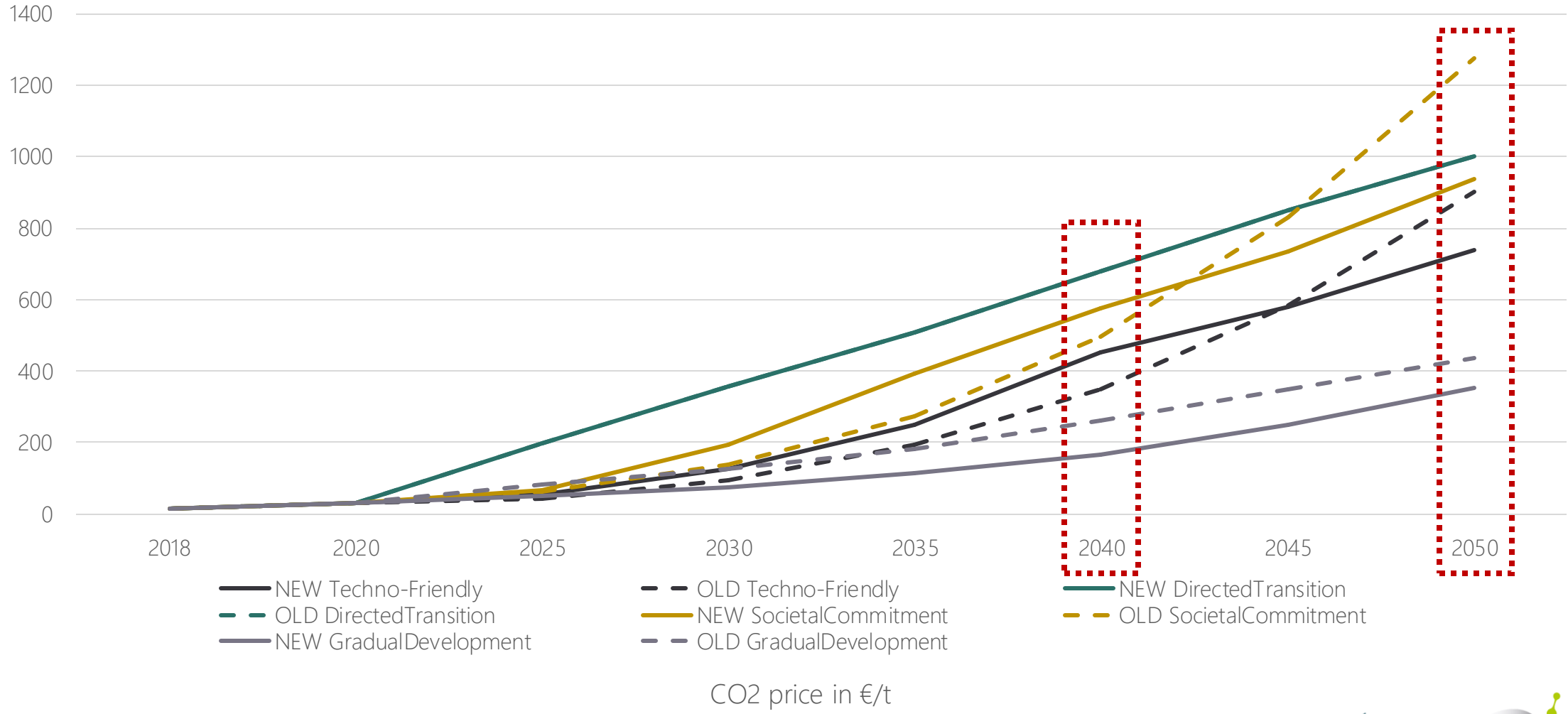
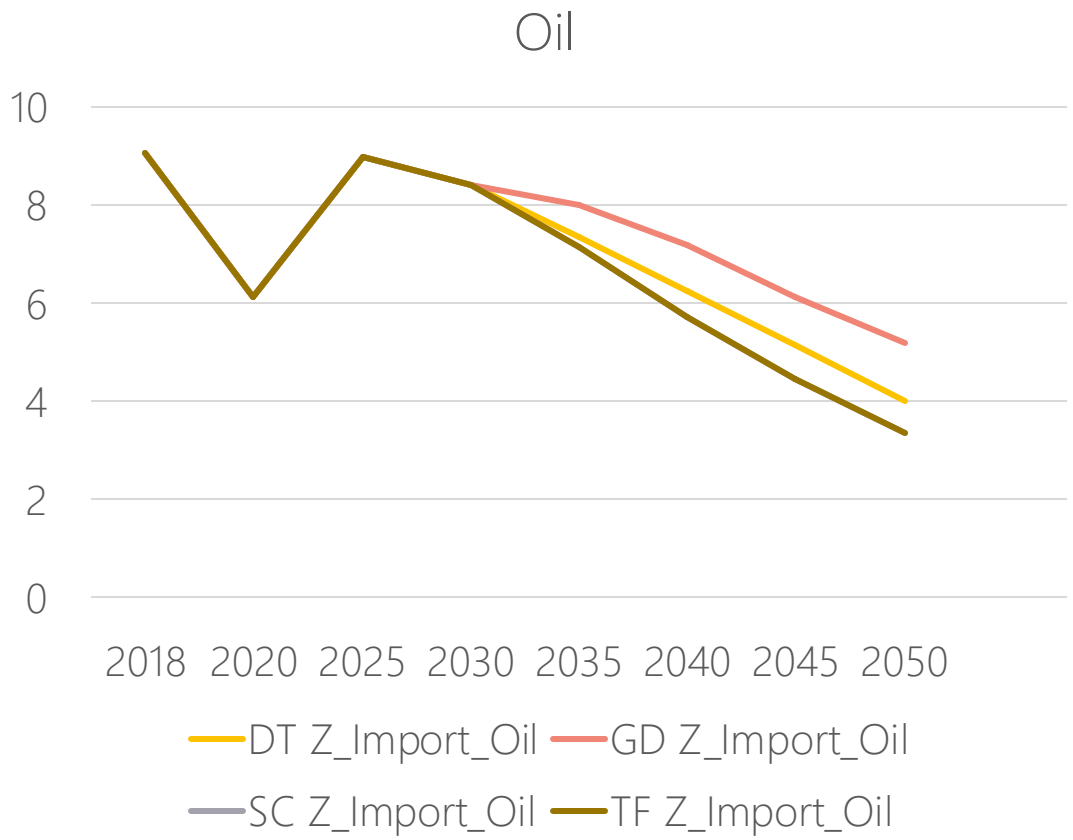
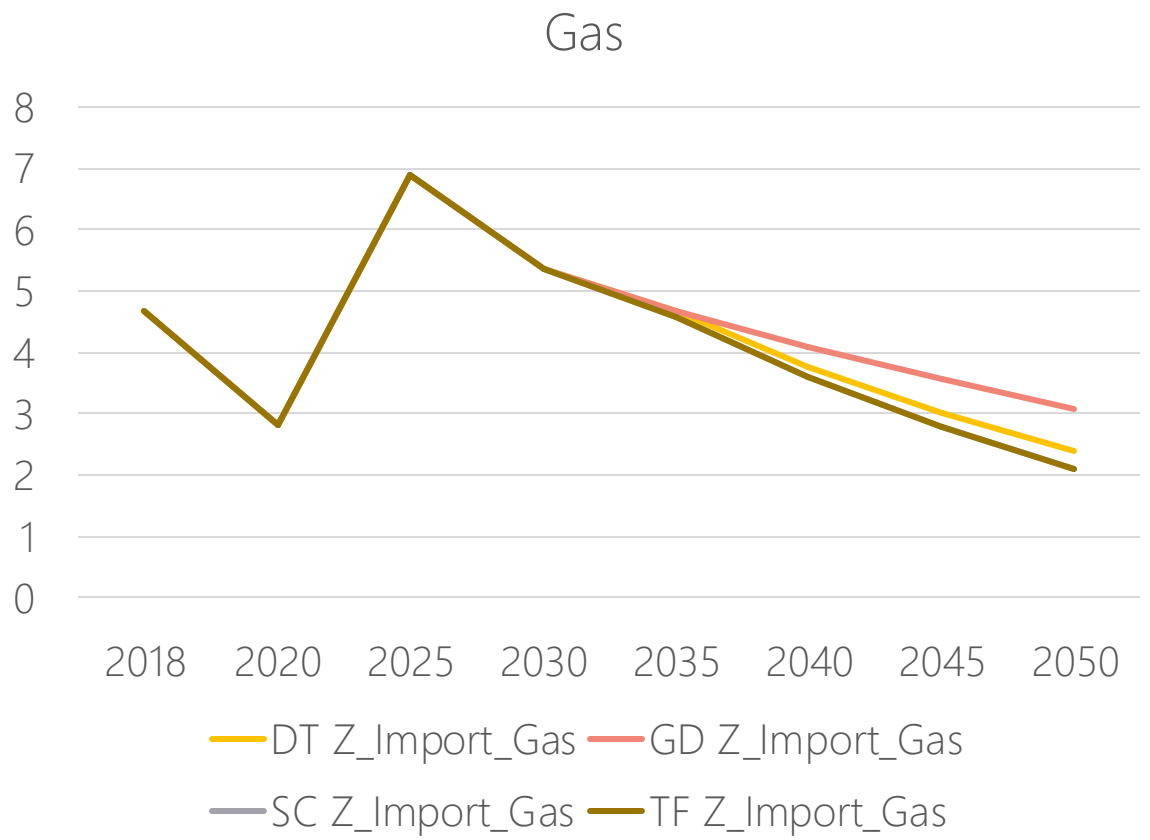
Additional Slides: openENTRANCE pathway results

Additional Slides – New CO_2 prices for 2022 pathways



Additional Slides – Fossil fuel prices [in M€/PJ]





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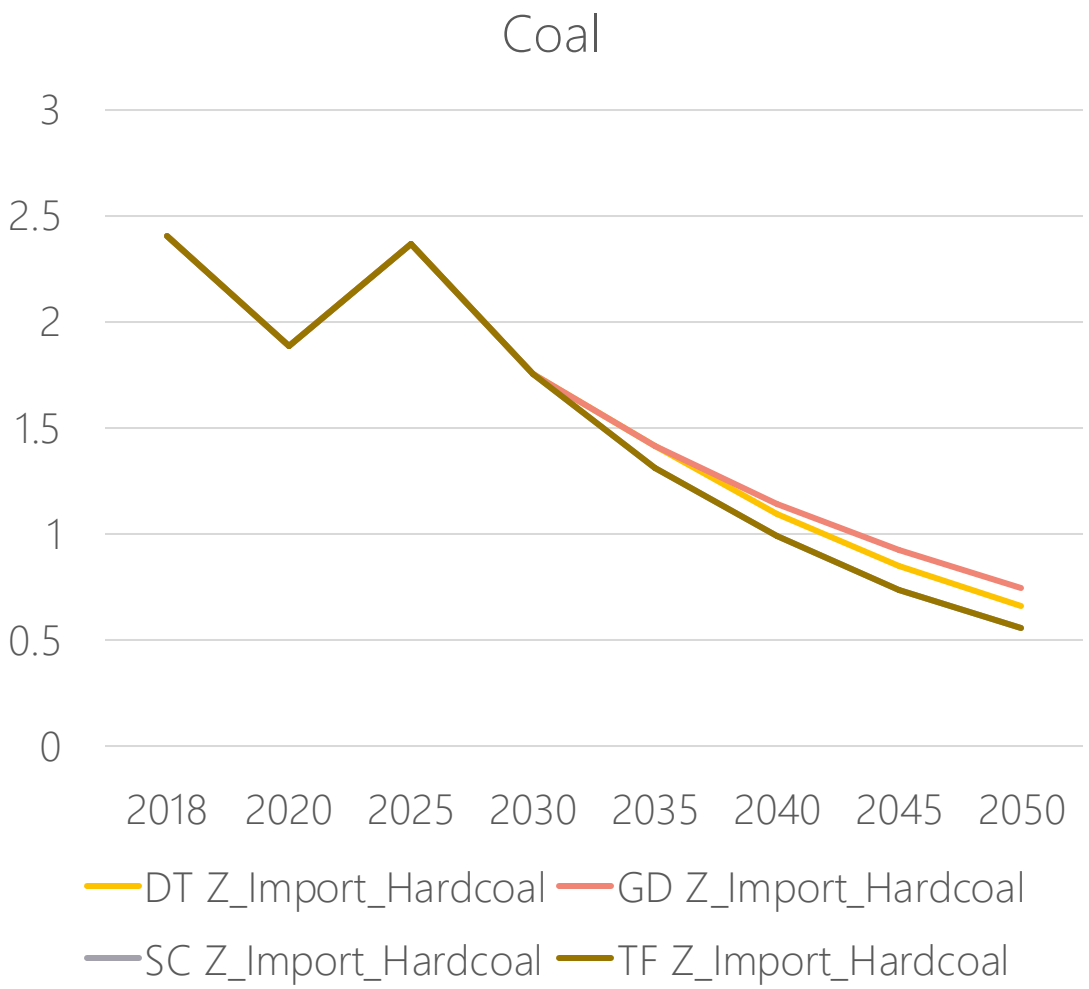
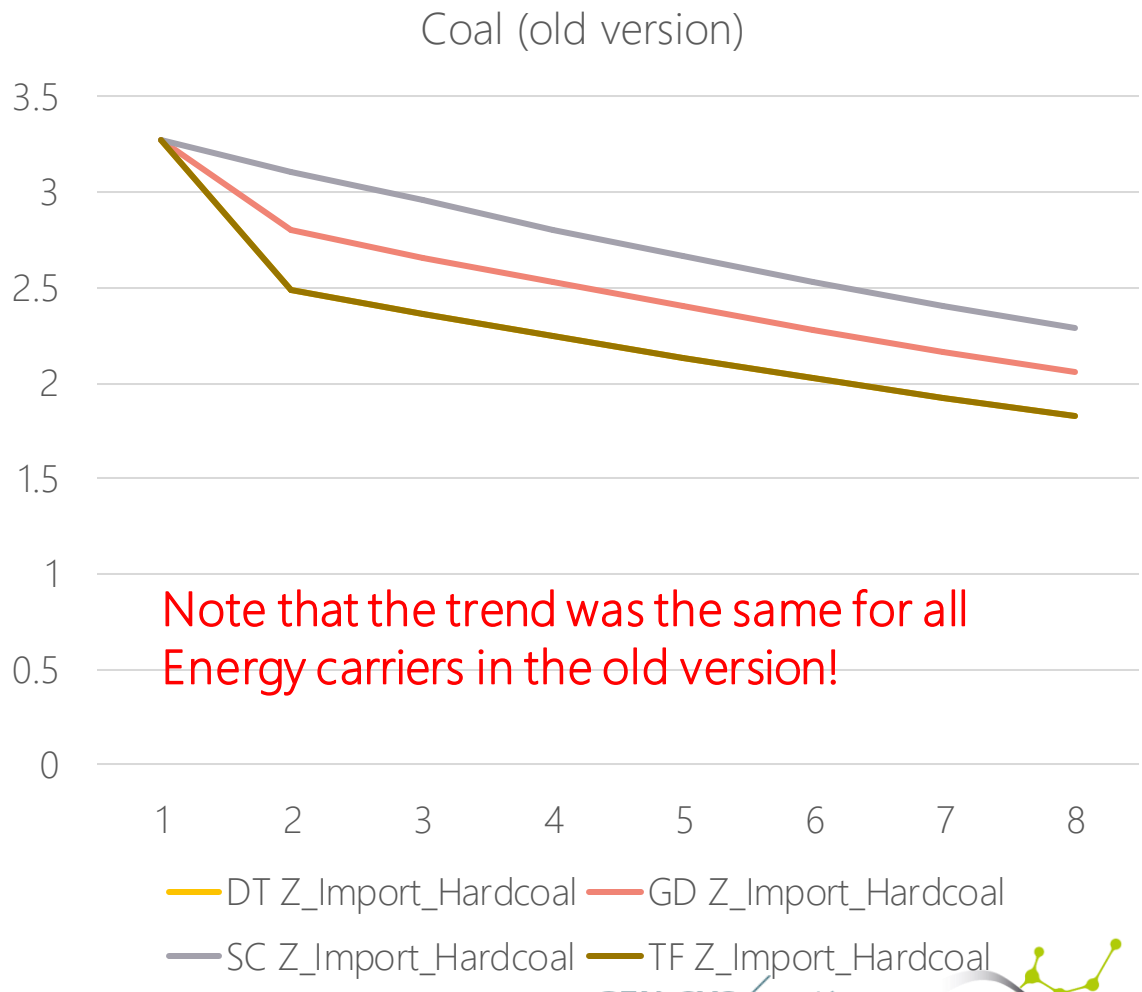
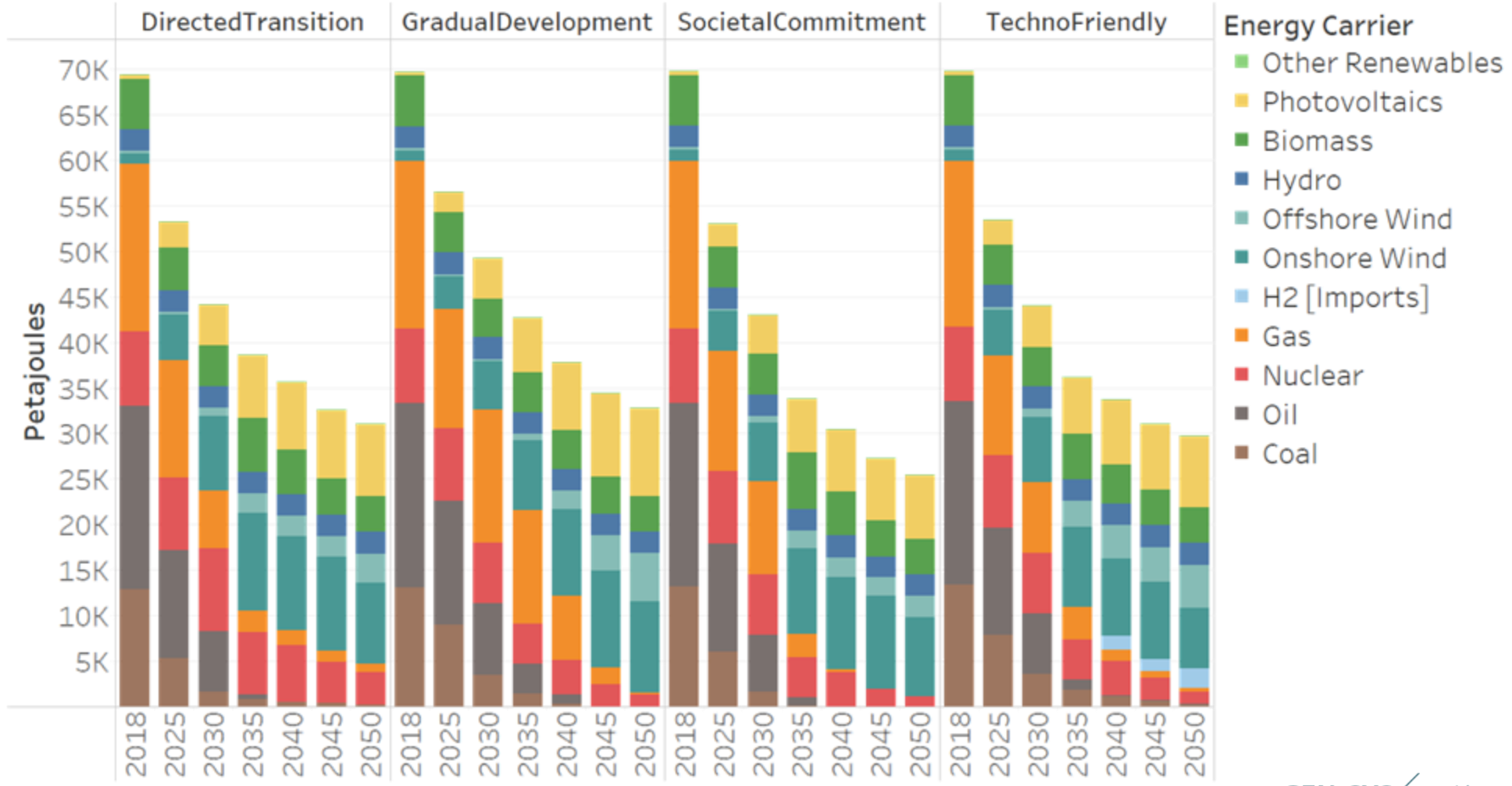


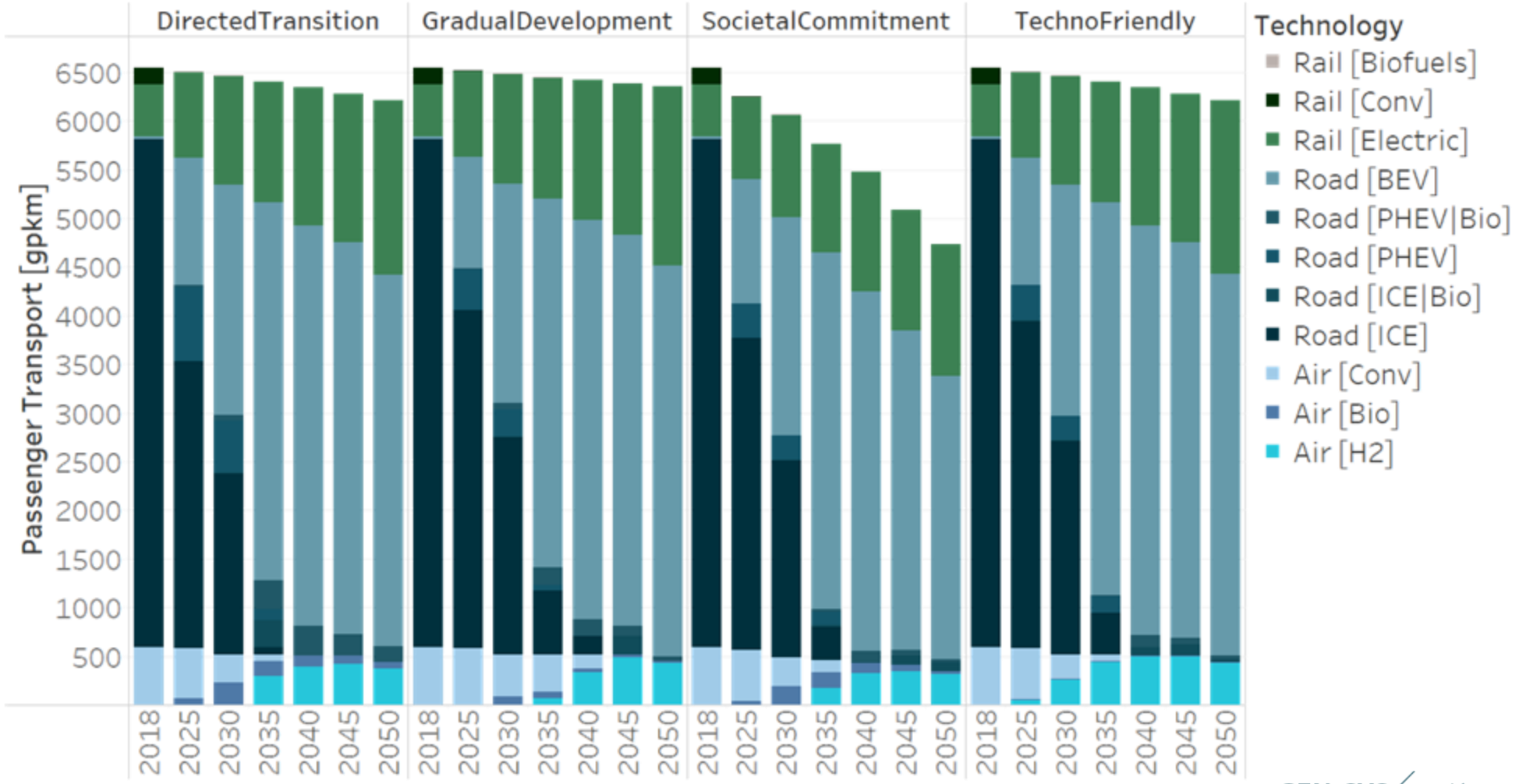


Note that the trend was the same for all Energy carriers in the old version!

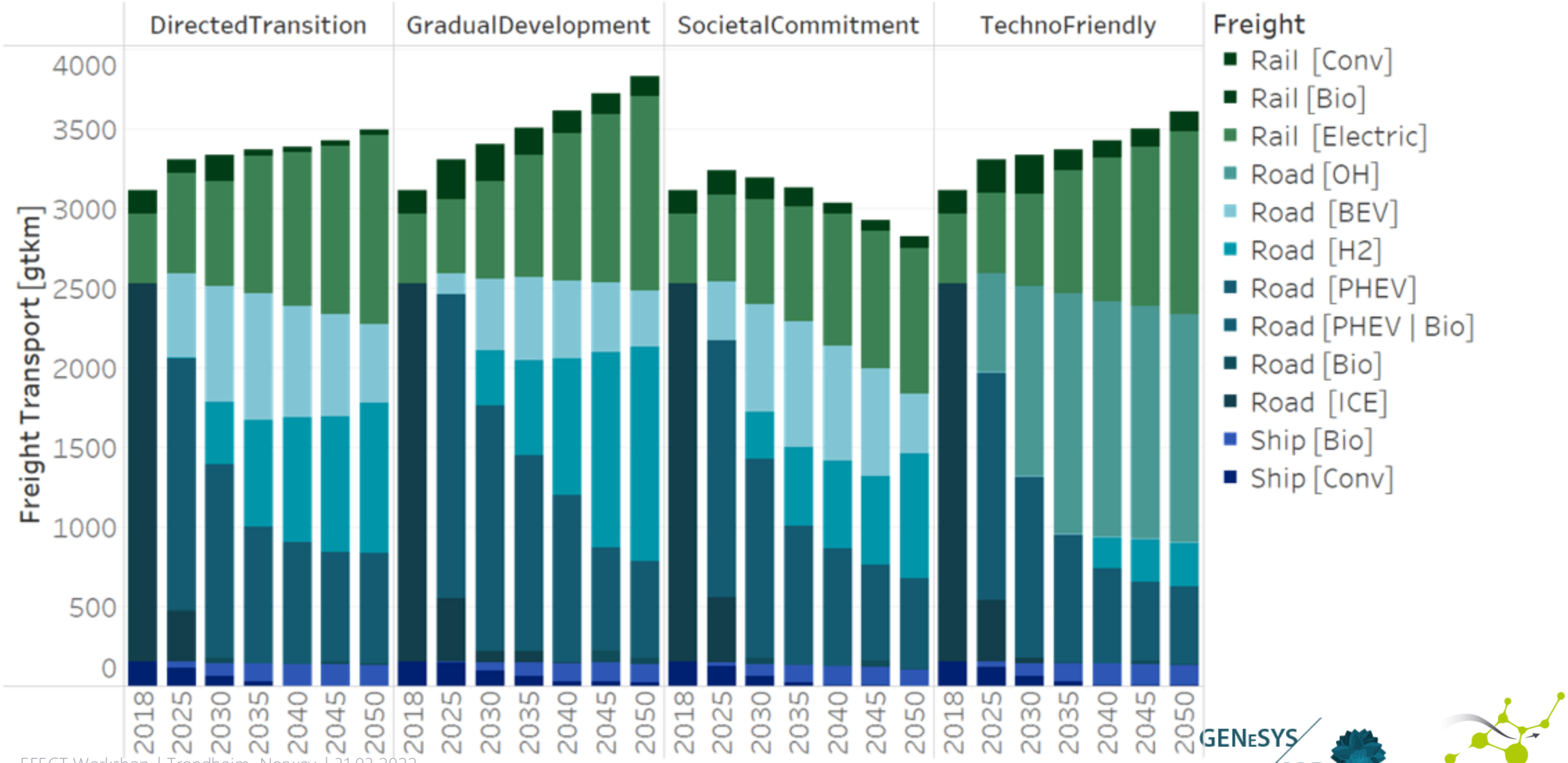
Additional Slides – Primary Energy



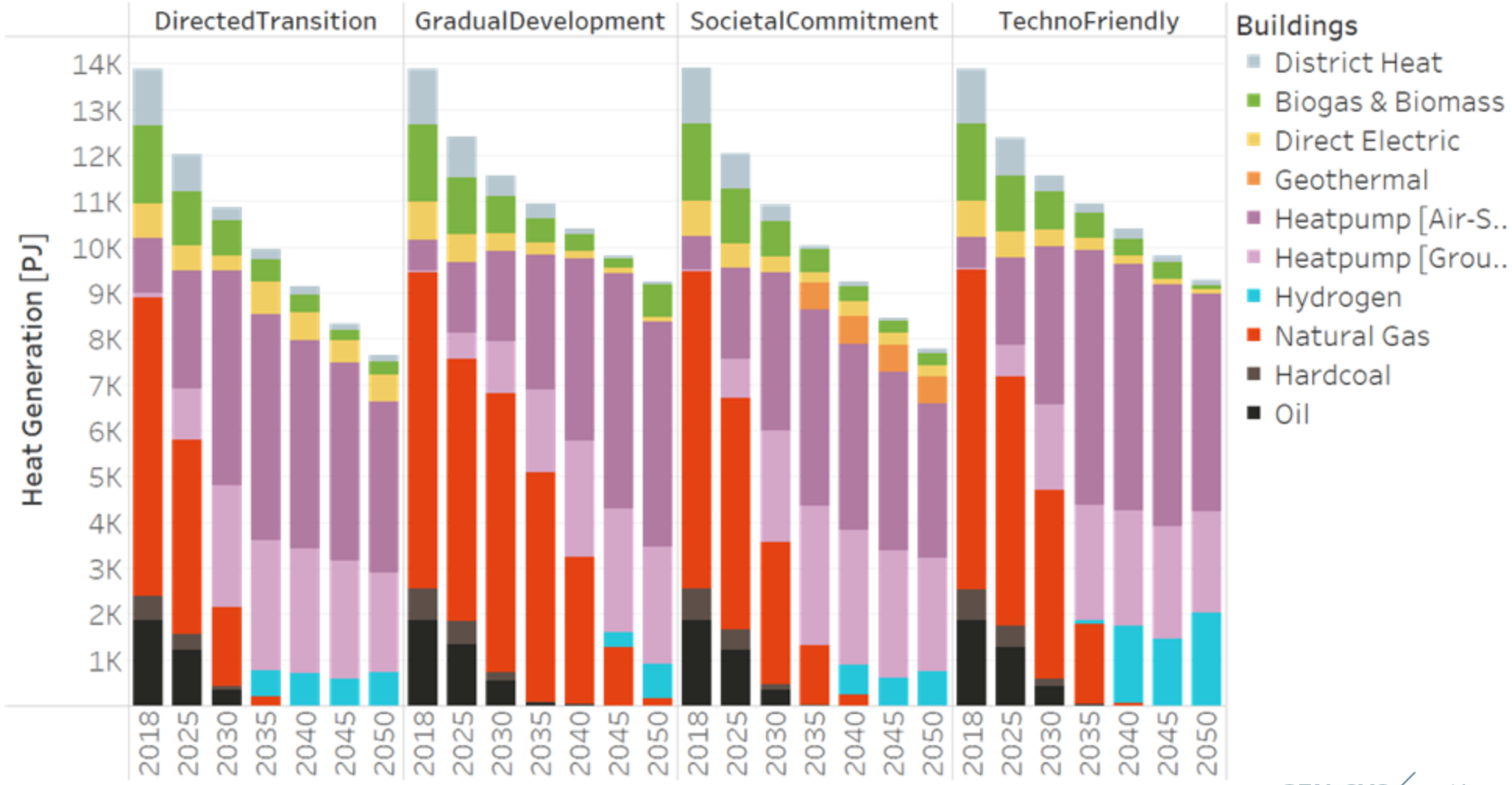
Additional Slides – Passenger transport



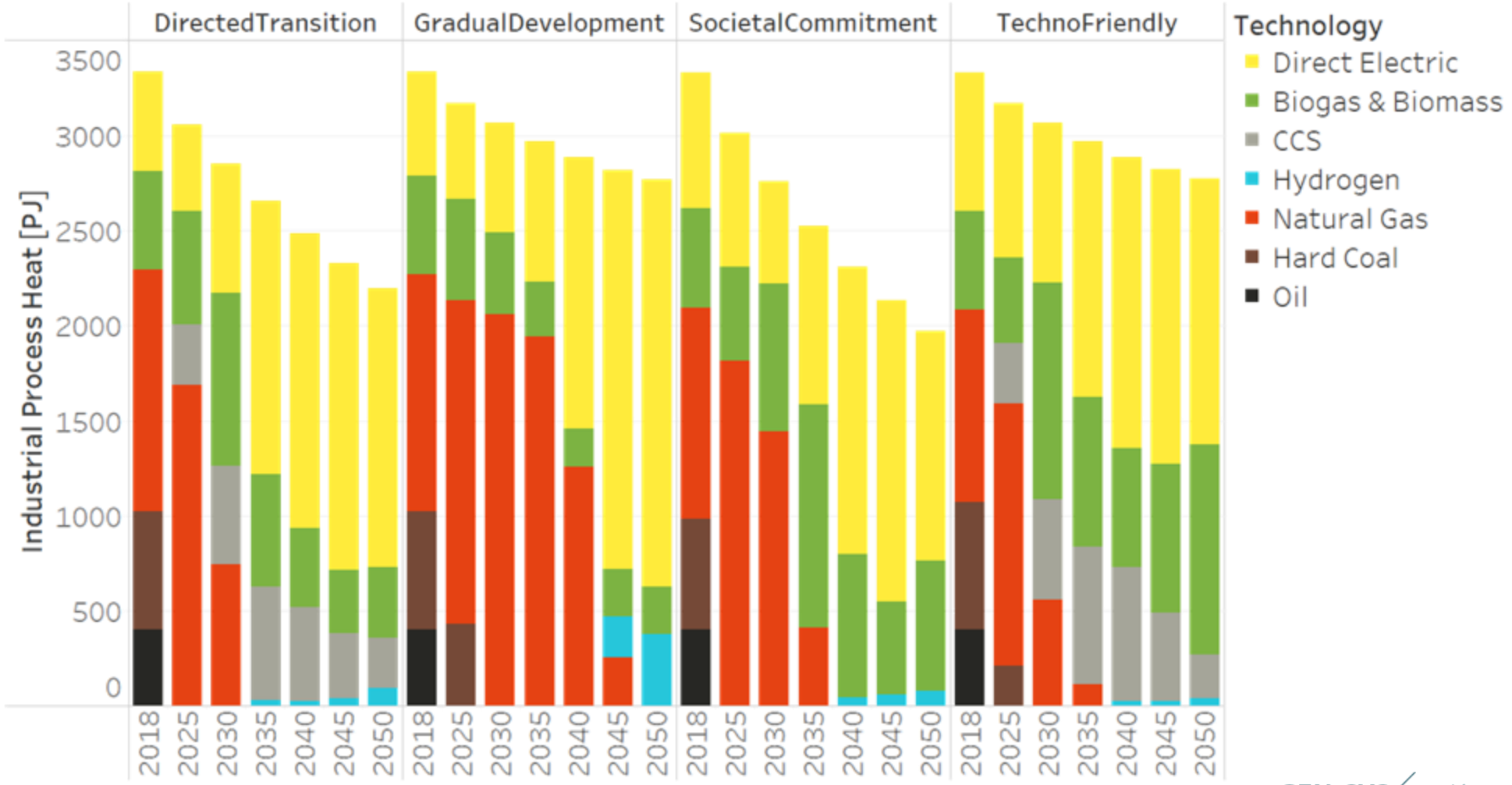
Additional Slides – Freight transport



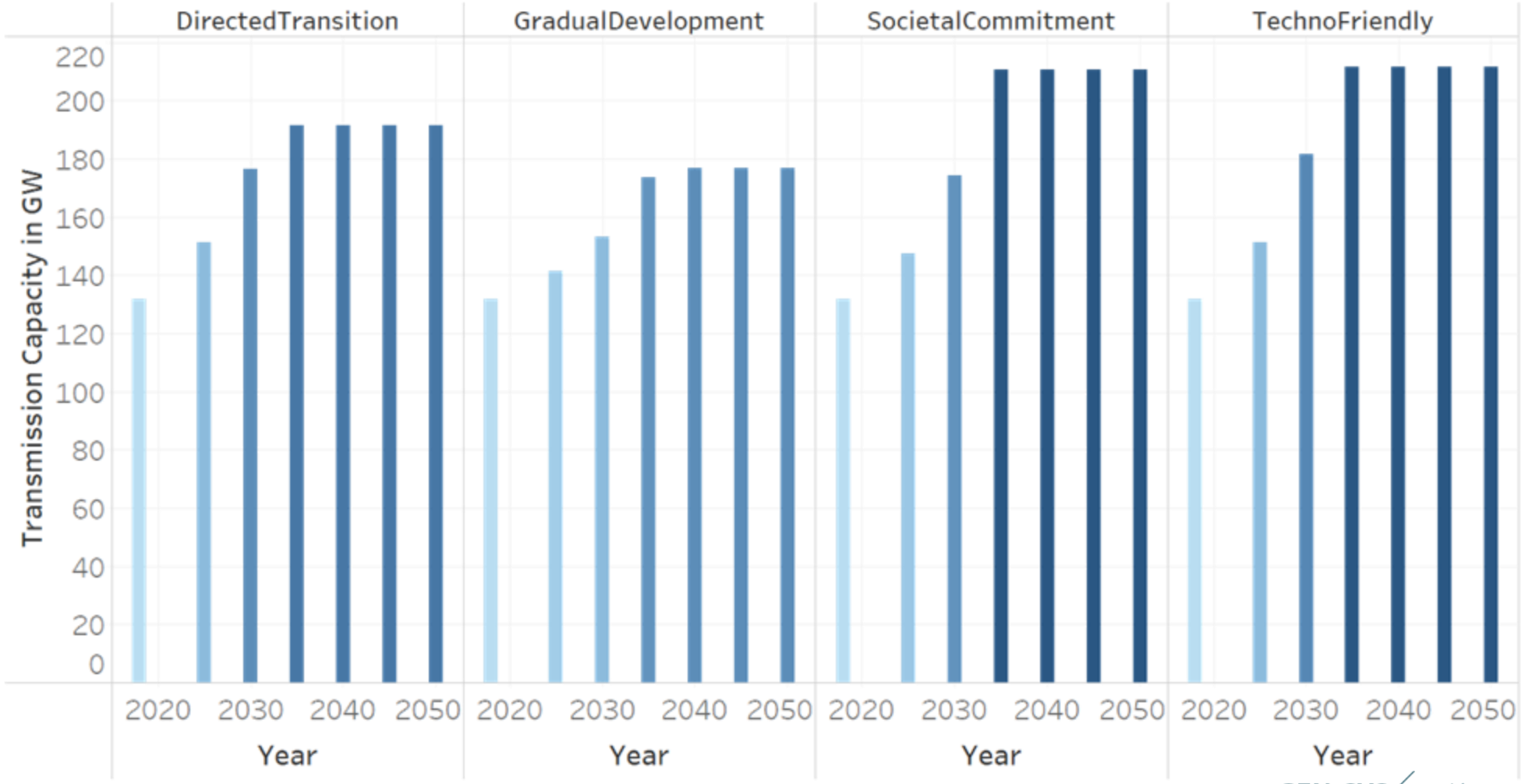
Additional Slides – Building heat



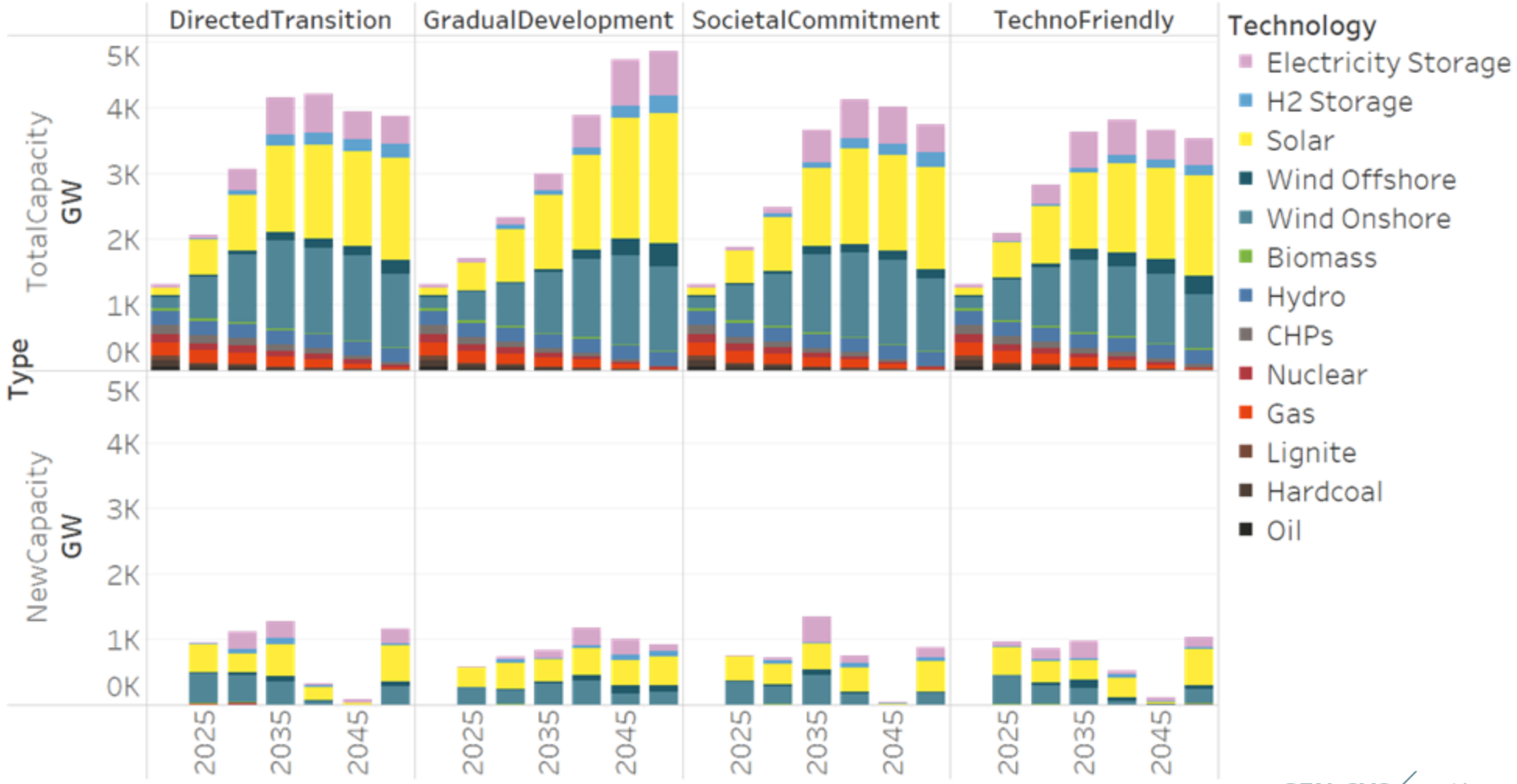
Additional Slides – Industrial process heat



Additional Slides – Transmission capacity

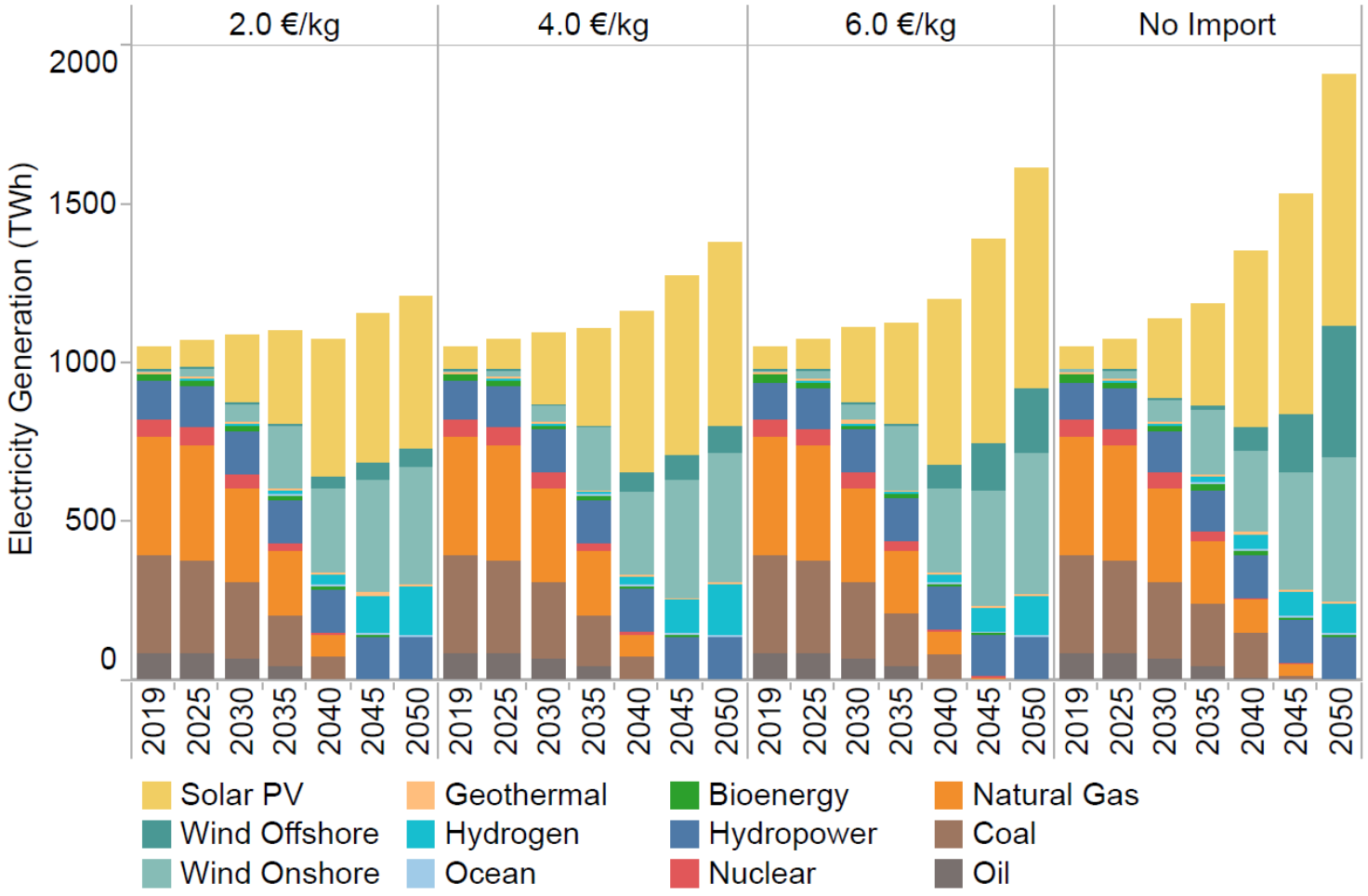


Additional Slides – Installed (power) capacity

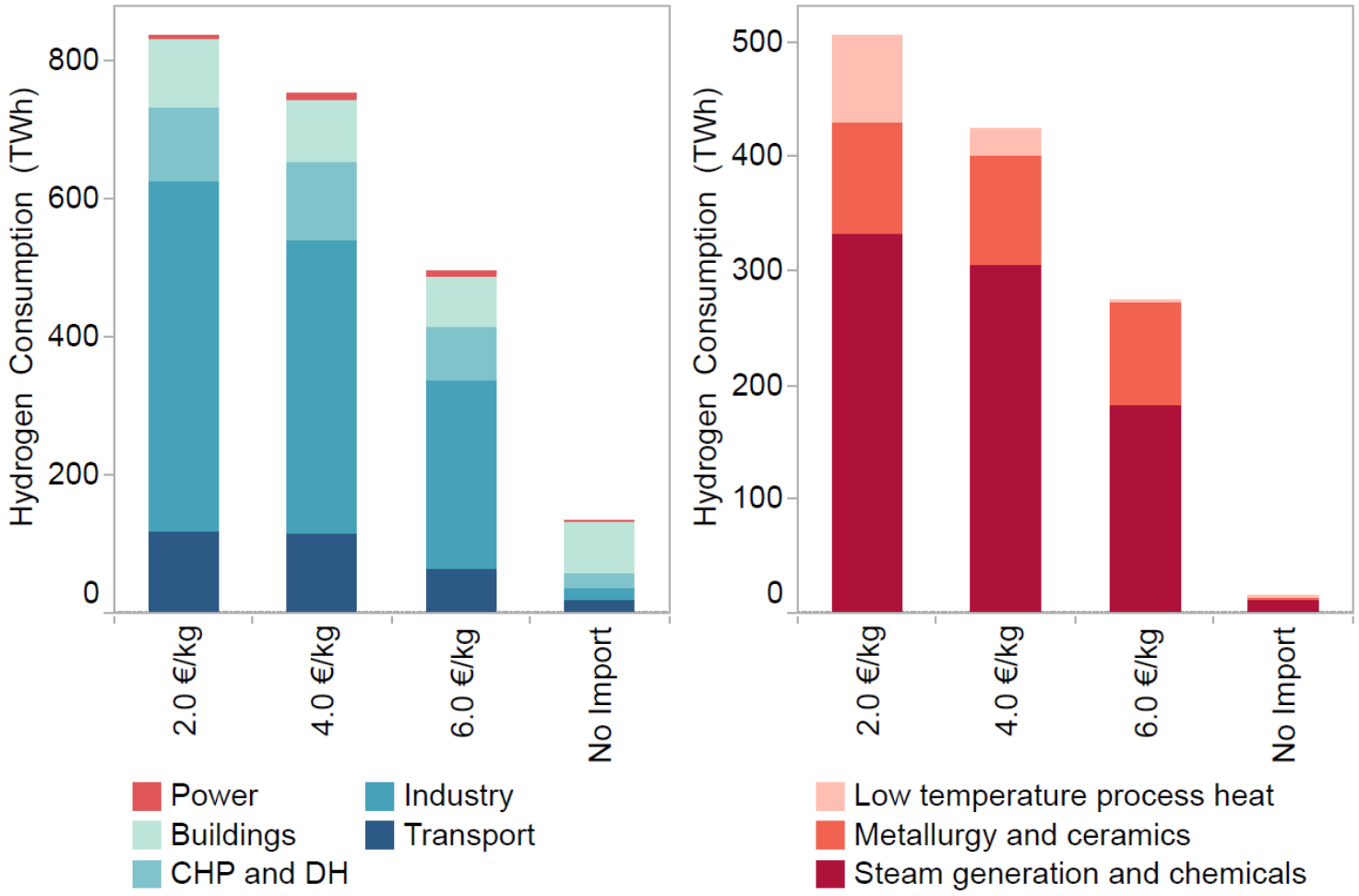


Additional Slides: Japan case study

Additional Slides – Power production for Japan



Additional Slides – Hydrogen use per sector for Japan



Additional Slides – Hydrogen production for Japan