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Transition pathways scenarios and integration of climate risks

Background analysis and approach

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Introduction

Background & Motivation

Different visions and pathways for the decarbonization of the energy system.

Exposure to climate hazards more likely in the future under climate change

Energy system modelling aid to quantify impacts and potential system designs;
However, these are limited by modelling resolution, scope, and computational capacity

Gap in understanding impacts of climate hazards and vulnerability in the system in future low-carbon sector coupled energy system scenarios and models

Research Question

How can new knowledge about climate risks of a future renewable energy system be implemented in current energy models used in energy policy decision-making?

What are the system preconditions?

How can new knowledge on climate risks be integrated into energy system models?

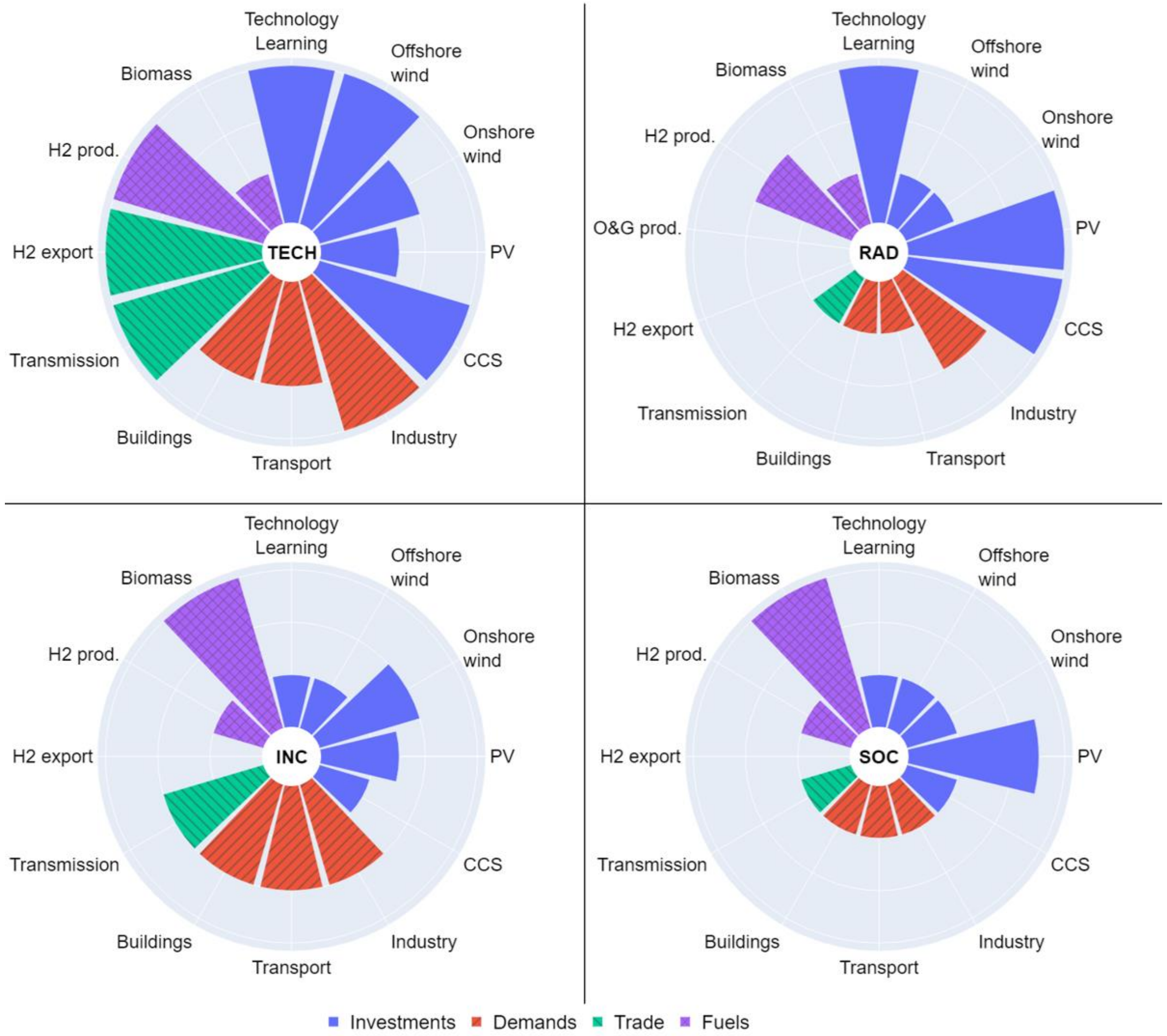
Scenario selection

NTRANS Socio-technical transition pathways for Norway

Different assumptions for the 4 scenarios:

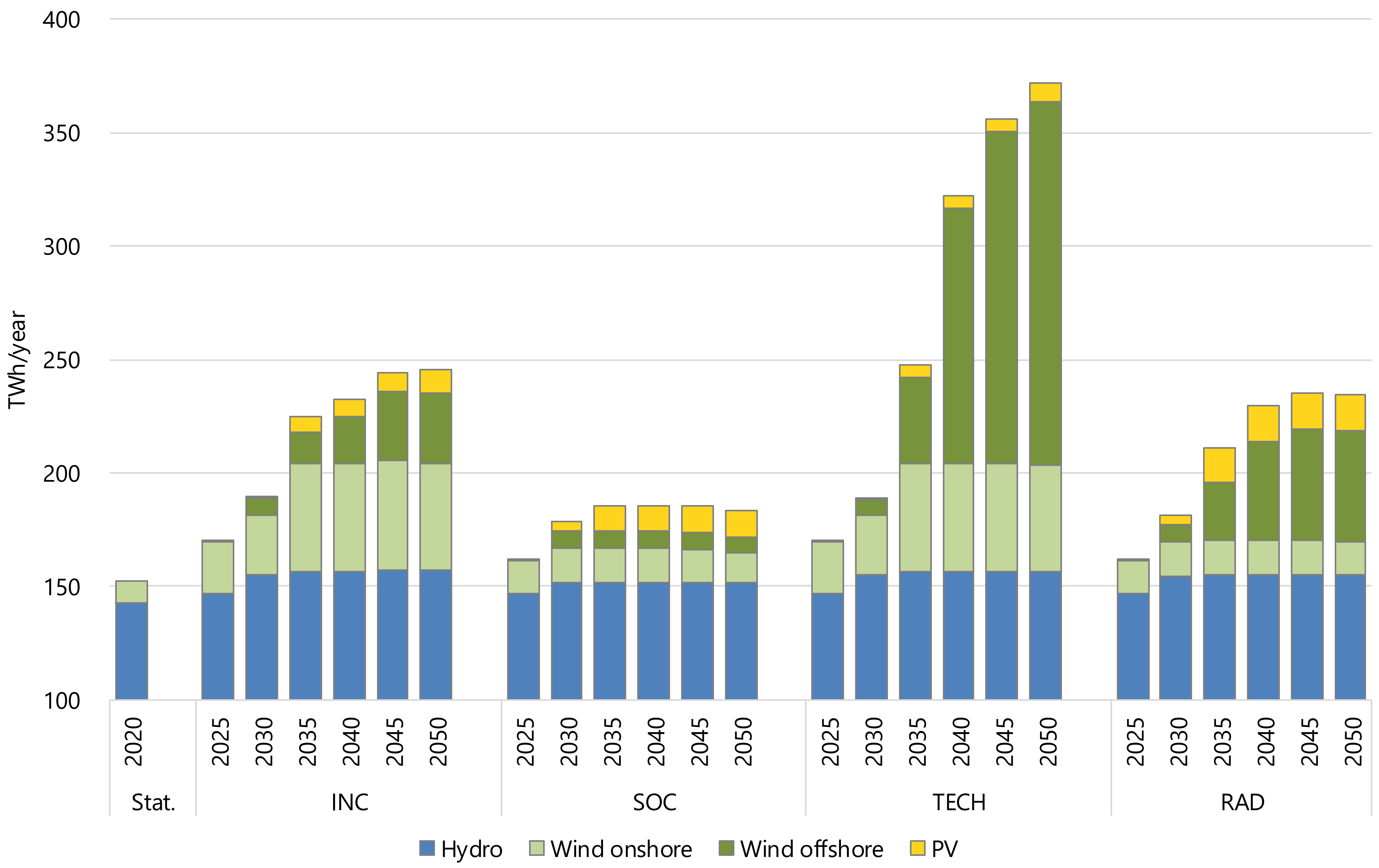
- Activity levels in transport, industry and buildings
- Activity in the petroleum industry
- Energy and power transmission
- Costs and availability of bioenergy
- Technology learning
- Potentials for new power generation
- CCS

Define the system conditions that might be affected by climate hazards.

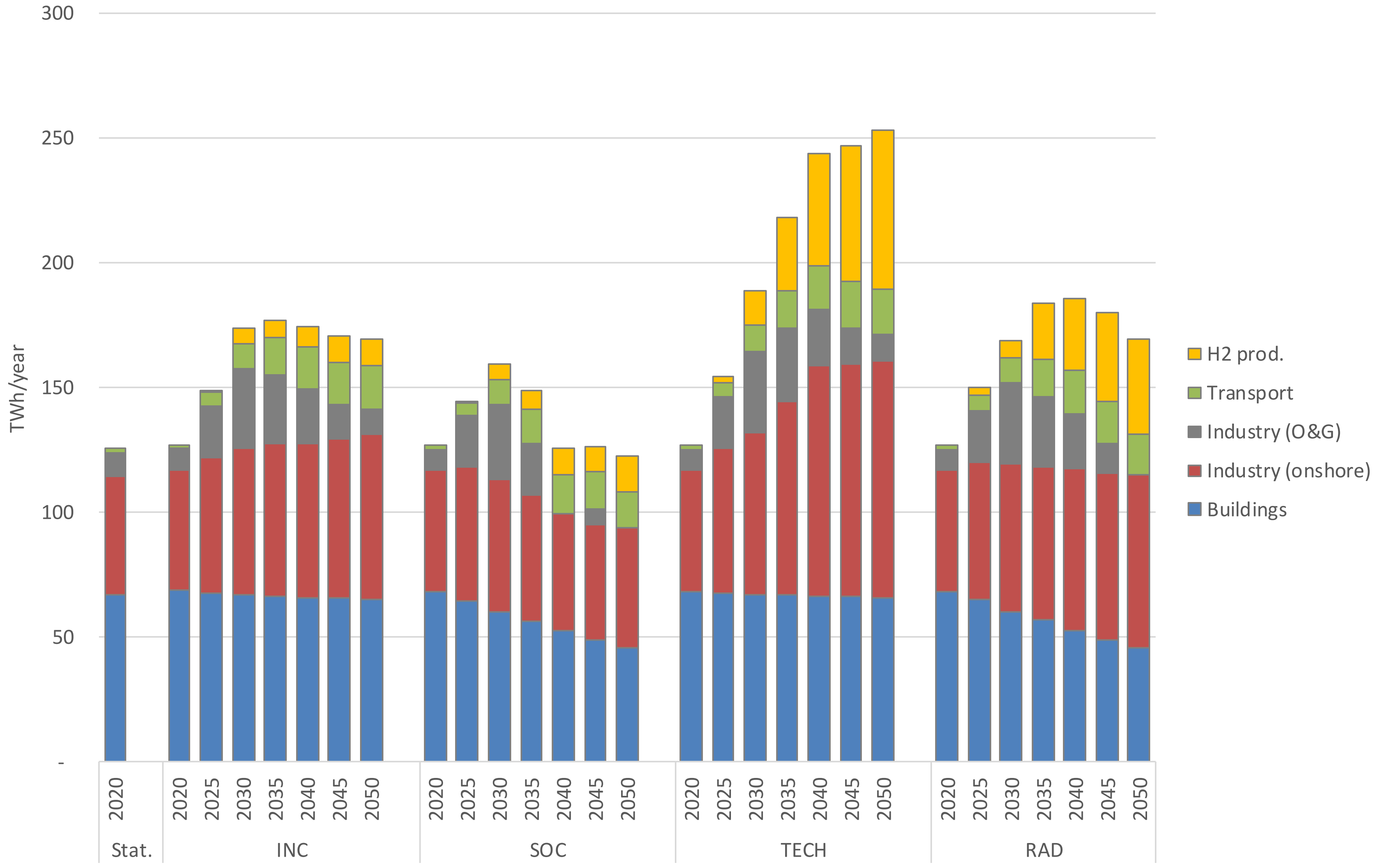


Espegren et al (2023) NTRANS Socio-technical pathways and scenario analysis (ntnu.no)

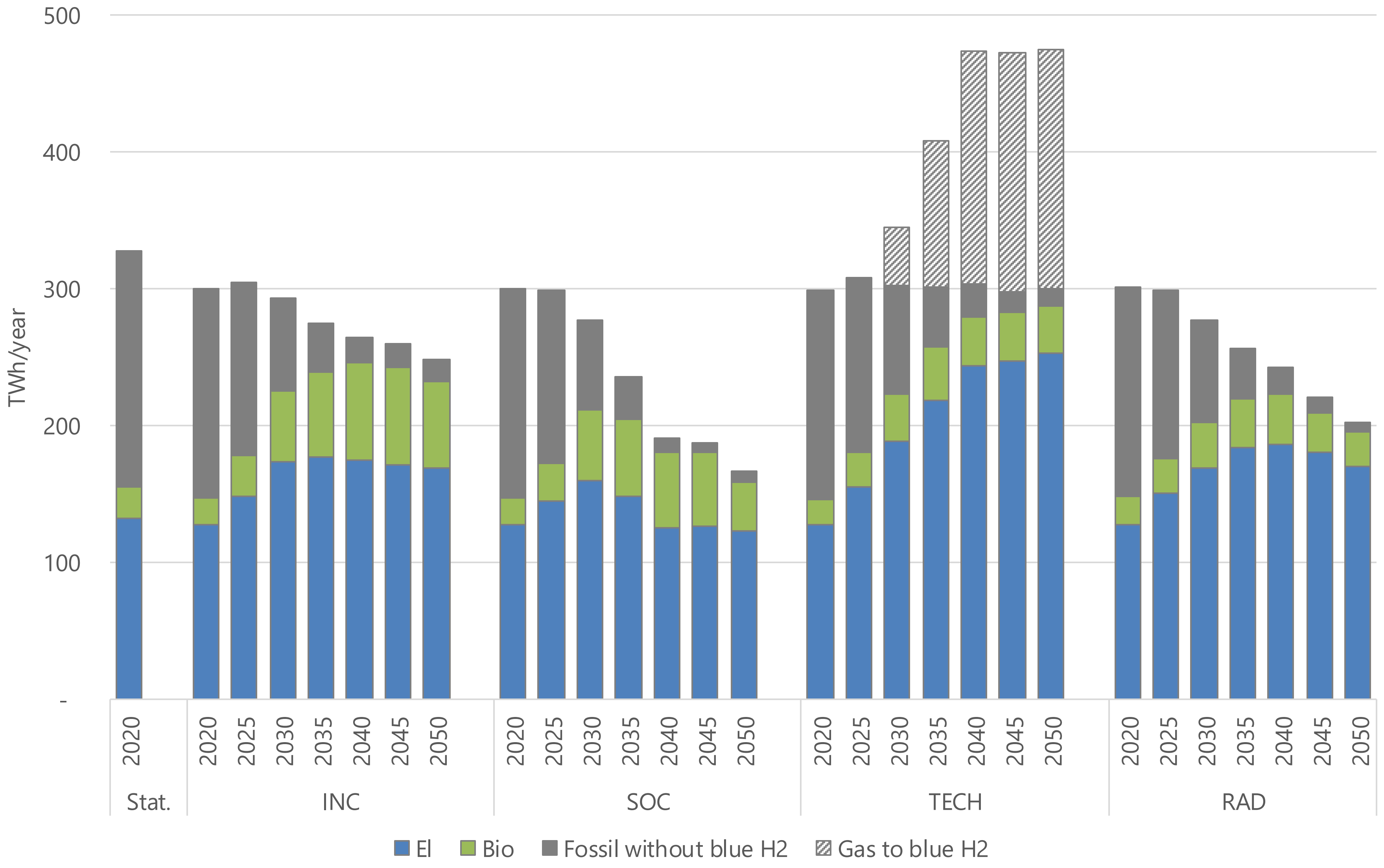
Electricity generation



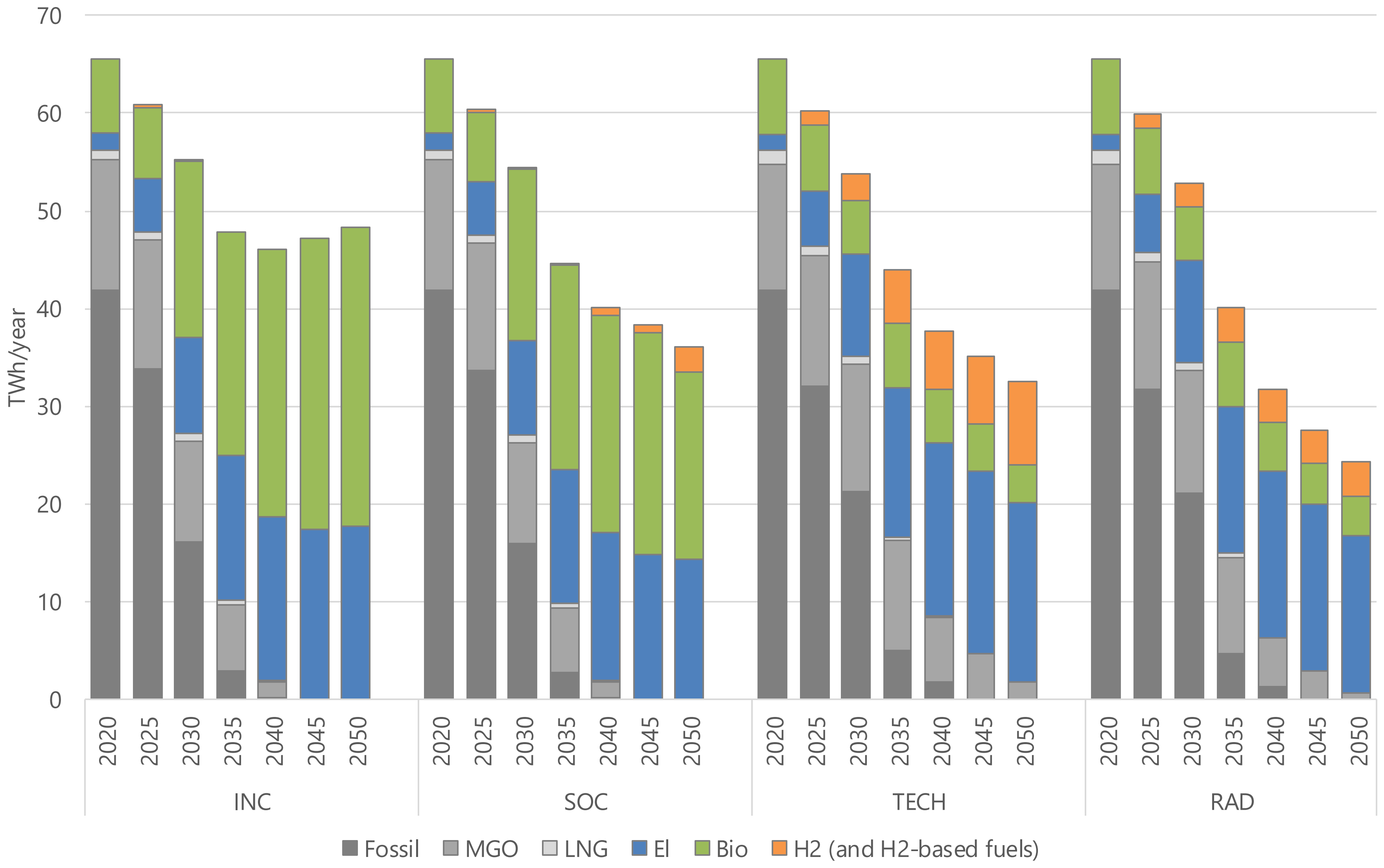
Electricity use



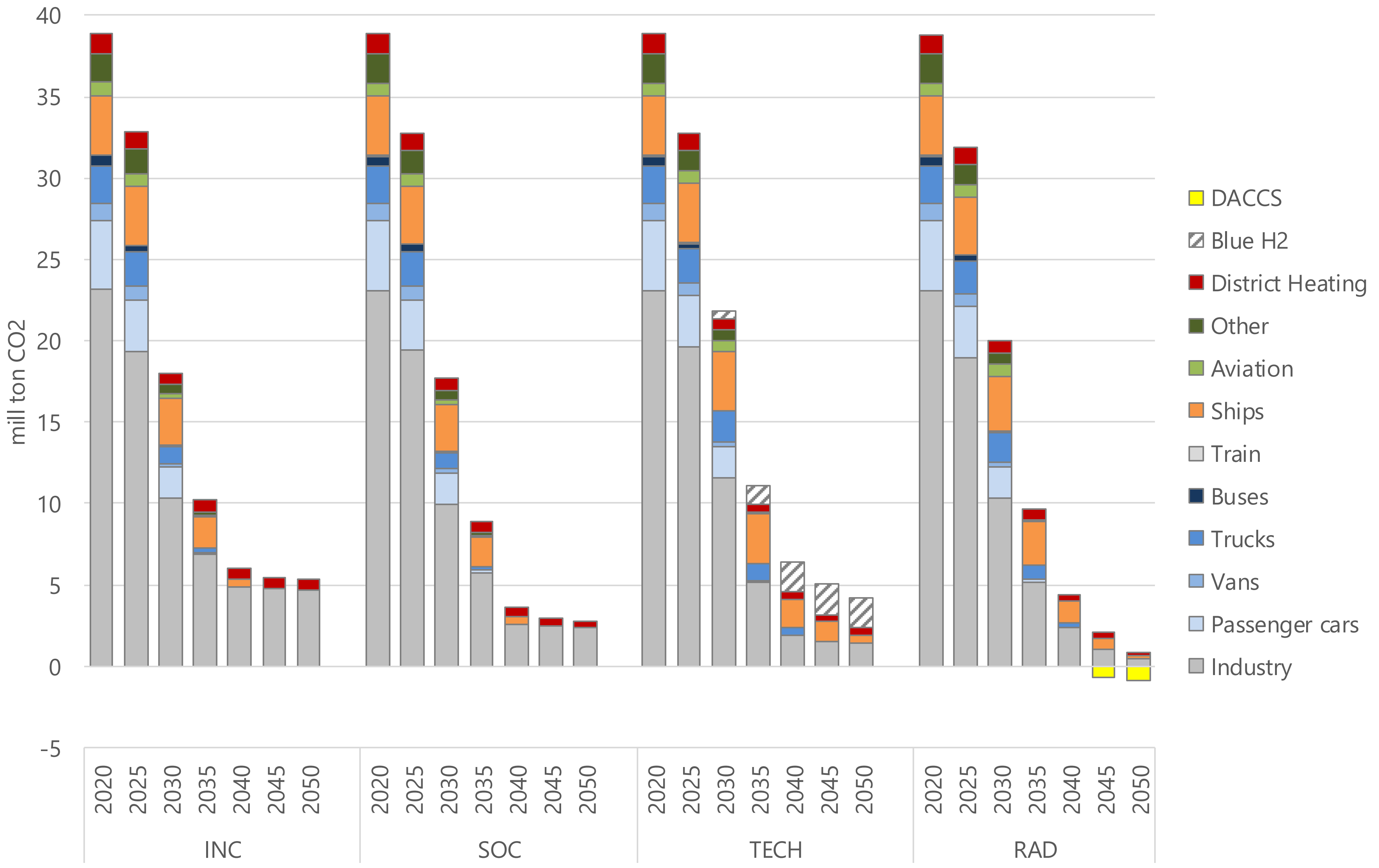
Energy use by source



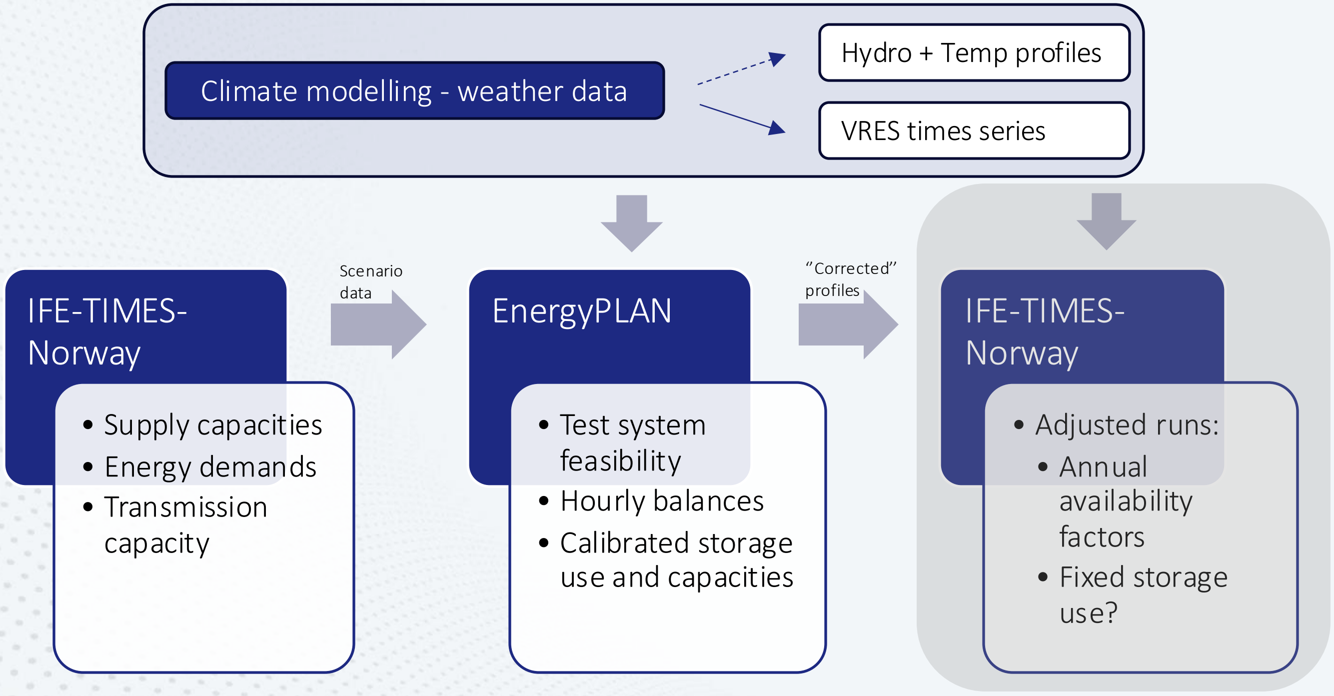
Energy use in transport



CO2 emissions by sector



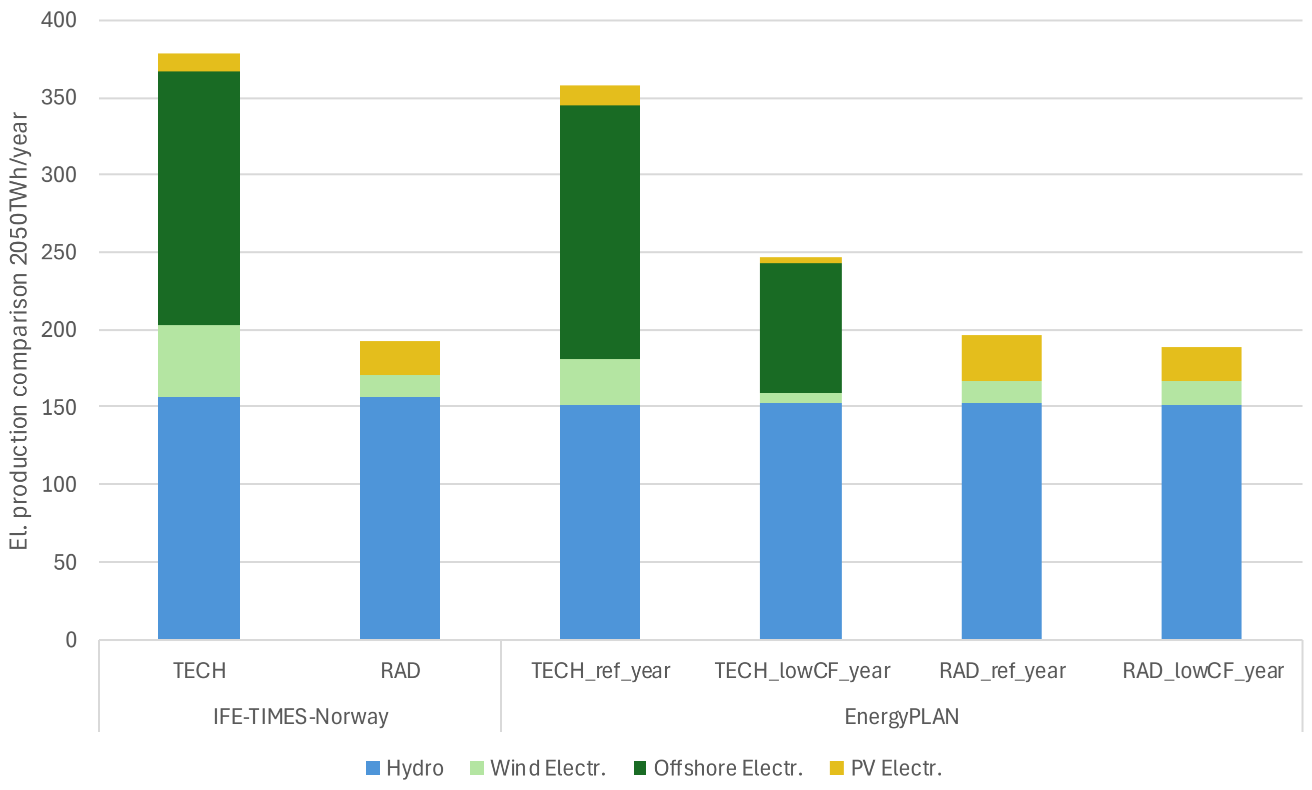
Proposed Approach & Modelling Framework



- Representation of climate hazards as input to energy system
  - Incl. time-series from climate modelling
- Scenario selection
  - Use contrasting transition pathways scenarios to test climate risks under different energy system designs
  - Provide scenario data from IFE-TIMES-Norway as inputs to simulation model (EnergyPLAN)
- Stress test system feasibility during hourly operations
  - Eg with two years: 1972, 2010
- Integrate new knowledge about climate risk in existing energy models:
  - Implement time series data for climate risk cases in energy system models
  - Coupling models' complementary perspectives
- Assess likelihood of climate hazards and vulnerability of resulting system designs.

Preliminary model setup – Comparison of temporal resolution

- Relatively similar power production trends
- Hourly VRES profiles show slightly lower production values
- Testing compounded physical climate hazards assumed in "lowCF_year" (1972):
  - -Long-period of unavailable VRES ("*dunkelflaute*").
  - -Spreadout low VRES availability
    - -> limited import/export potential

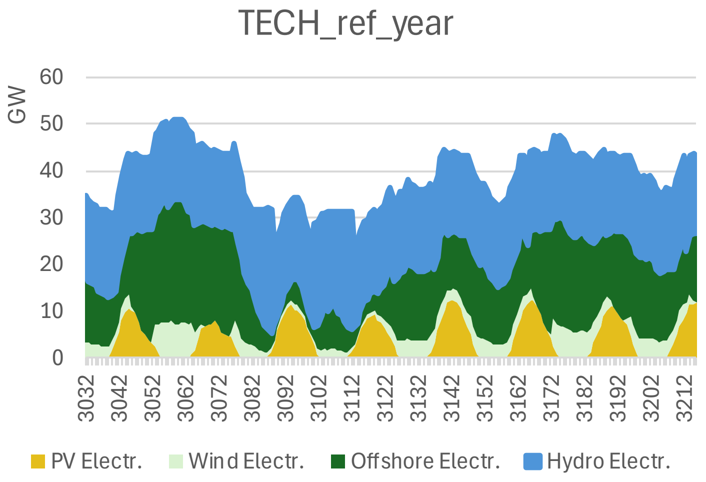


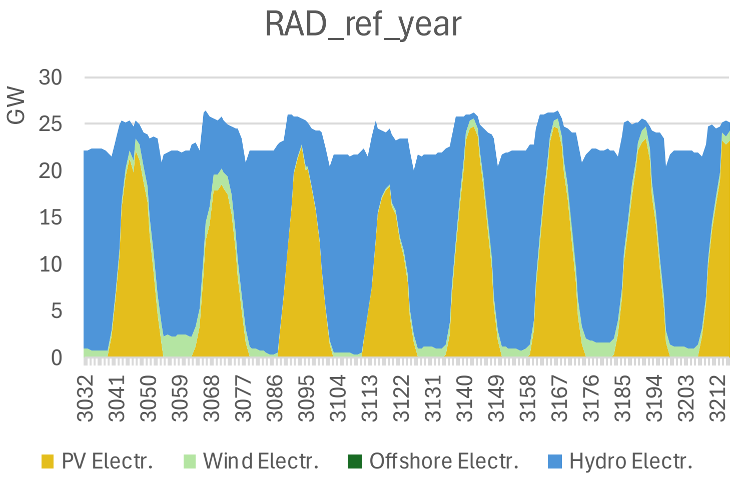
Preliminary model setup – Test comparison of weather years & conditions

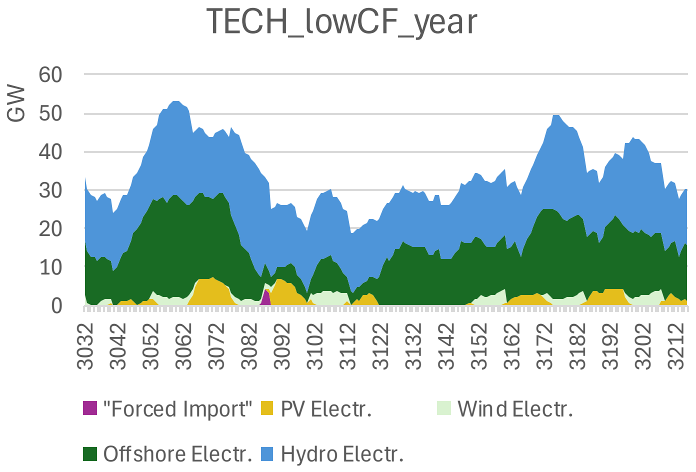
- Stress test of scenarios with hourly profiles for a average weather year and low VRES availability year

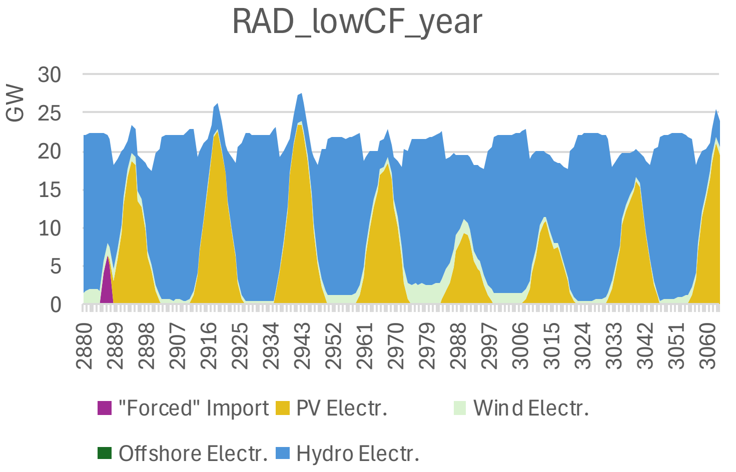
- Compounded physical climate hazards:
  -Long-period of unavailable VRES ("*dunkelflaute*").
  -Spreadout low VRES availability
  -> limited import potential

- "Forced imports" denote need for additional capacity in year with lower VRES availability









Next steps

- Map and incorporate additional climate hazards, and related time-series data in modelling framework
  - Consider additional effects of hazards for different weather years in available resources, and effects on hourly demand profiles
  - Map likelihood of hazards and system impacts
- Develop links and feedback loop from hourly simulations of the system back into long-term modelling
- Benchmark performance of long-term capacity expansion model running operationally with higher temporal resolution (i.e. hourly) against proposed linked modelling framework
- Expand analysis with higher spatial resolution and for additional transition scenarios

Thank you for your interest