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The energy transition in India: quantifying effects of the low-carbon transition on the Indian energy system

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Agenda

1) Motivation: The transformation of the Indian energy sector

2) Research Design: Global Energy System Model (GENeSYS-MOD)

3) Key findings: Development of the Indian energy system under varying CO2 constraints and implications for the Indian energy sector

The transformation of the Indian energy sector

- **India´s role in reducing global emissions**
  - Continual rise in CO2 emissions (power generation one of key contributors), rising population and economic performance, and growing energy demand

- **Key challenge for India =** meeting rising energy demand while ensuring energy security and reducing energy poverty

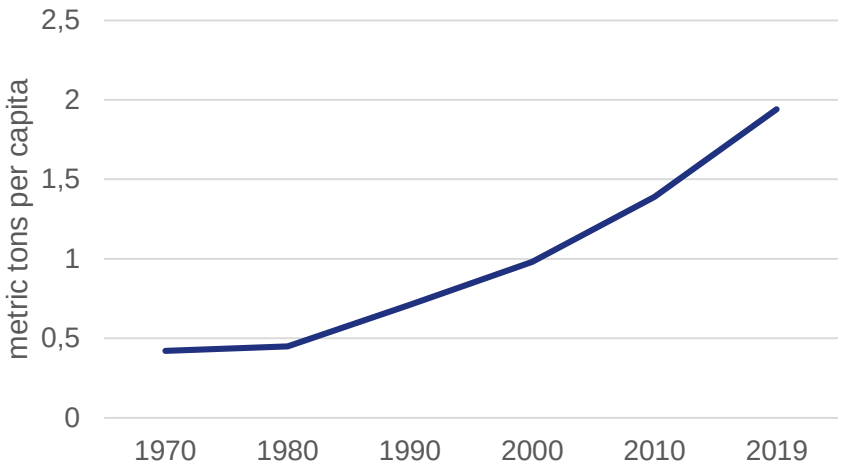

Figure 1: Emissions per capta India.
source: Worldbank (2020)

The distribution of energy sources in India

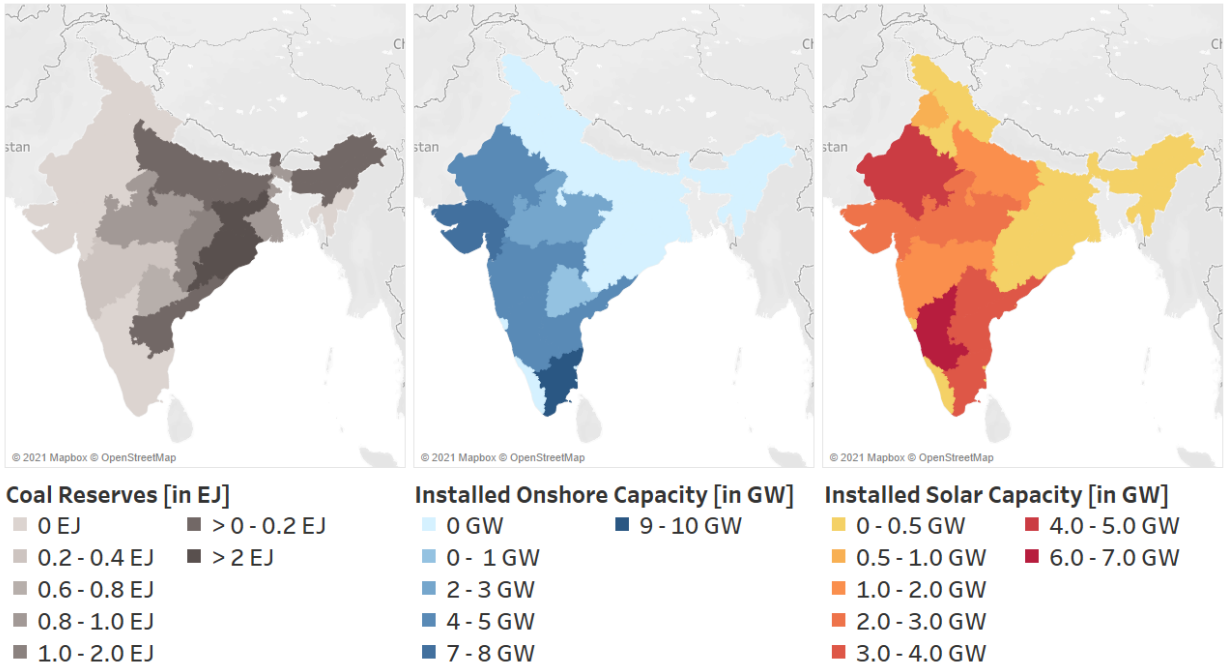

Figure 2: Overview of available coal reserves and installed capacities of onshore wind and solar power.

We look at a sector-coupled energy system including the sectors power, heating, transportation, and industry at a state-level for India, using the open-source energy system model GENeSYS-MOD

Research Design – Global Energy System Model (GENeSYS-MOD)

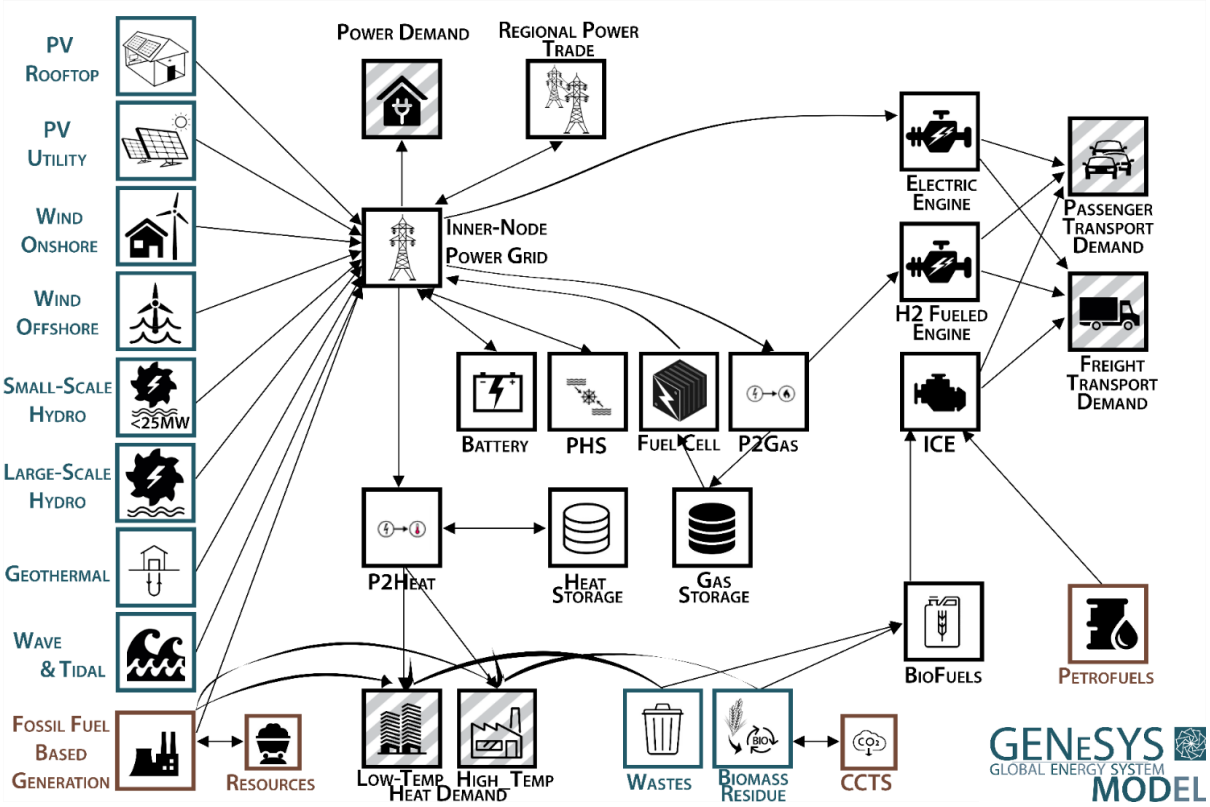

Figure 3: Model design and technologies.

Additions:

- Flexlibe computation of years
- Introduction of axis-tracking PV modules

Research Design – Global Energy System Model (GENeSYS-MOD)

Scenarios

- **Delayed Action**
  - serves as a base to compare the impact of a CO2 budget on the Indian energy sector development
- **Limited Emissions**
  - focusing on the fulfilment of climate targets
  - Budget for India that is compatible with limiting global warming to 2°C

Key Data

- 31 regions are considered (mostly state-level)
- Residual capacities for supply technologies are taken from Farfan and Breyer (2017)
- Demand development and fossil fuel prices are fixed and based on the IEA 450ppm scenario datasets (World Energy Outlook 2017)

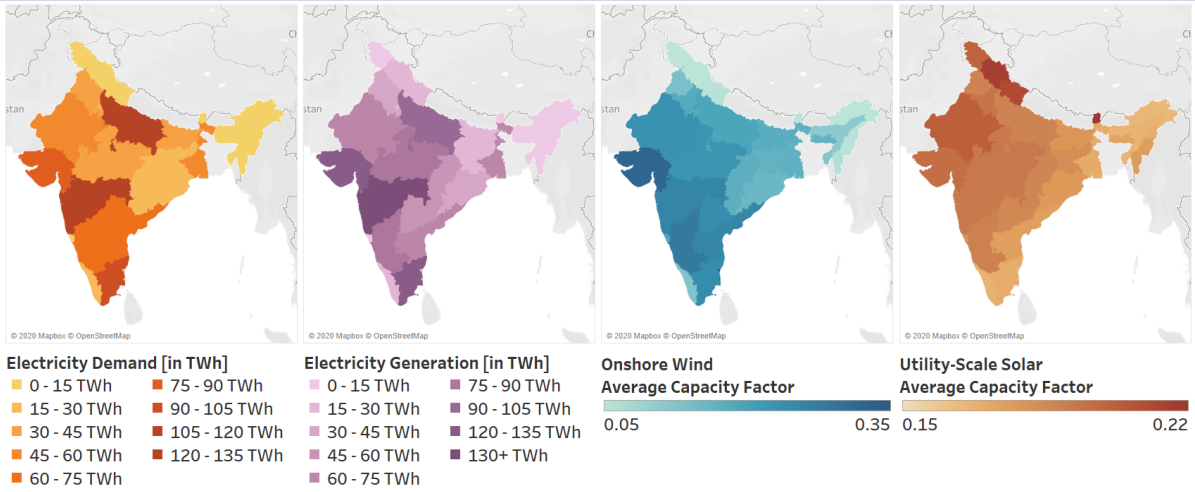

Figure 4: Overview of electricity demand in 2015, electricity generation in 2015, and onshore wind and utility-scale solar average capacity factors.

Results - Development of the Indian energy system under varying CO2 constraints

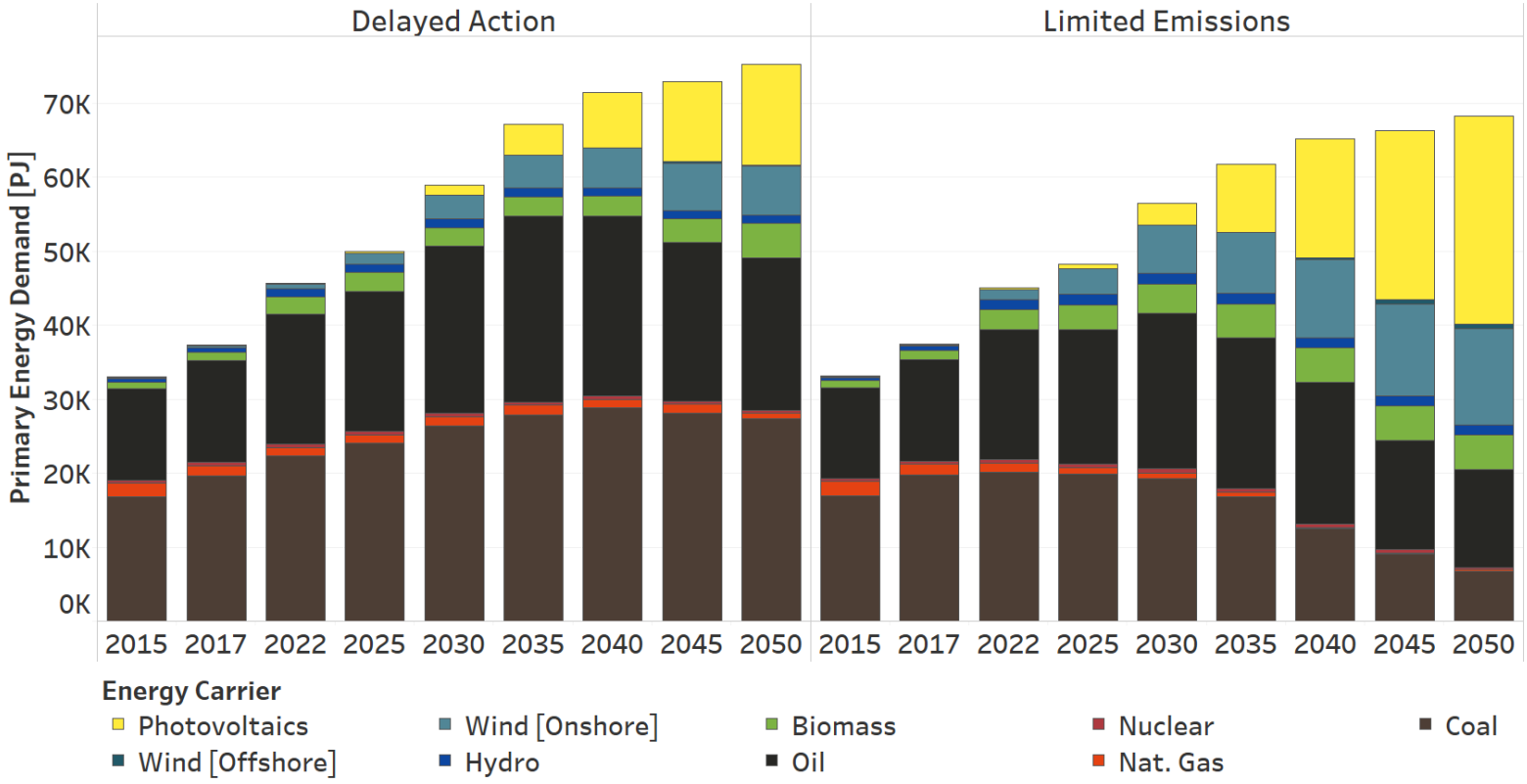

Figure 5: Primary energy in India.

Results – Cross-sectoral analysis and sector-coupling

- Renewable energy sources increase in all sectors
- Increase of sector-coupling

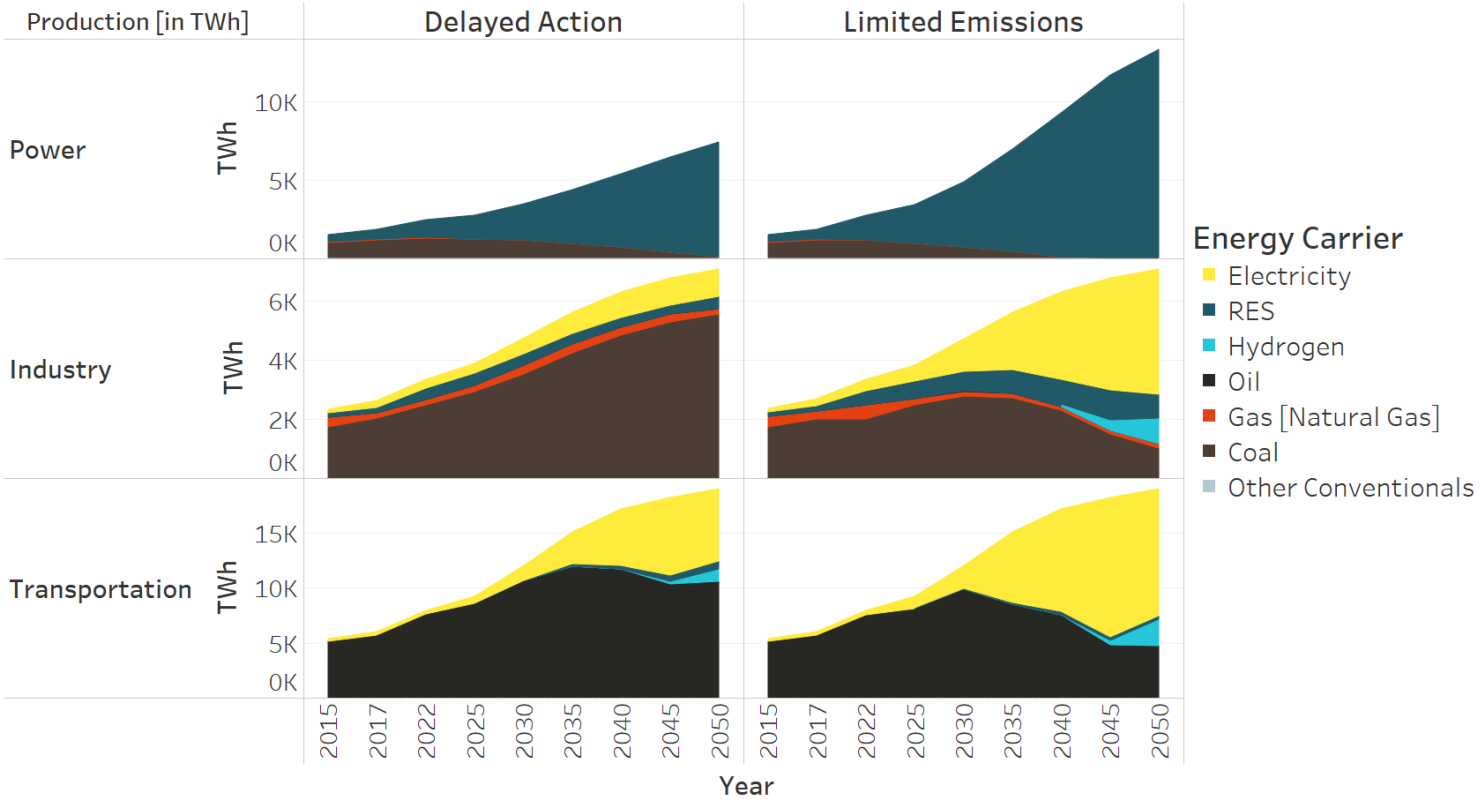

Figure 6: Sector comparison.

Results – Effects on the electricity sector

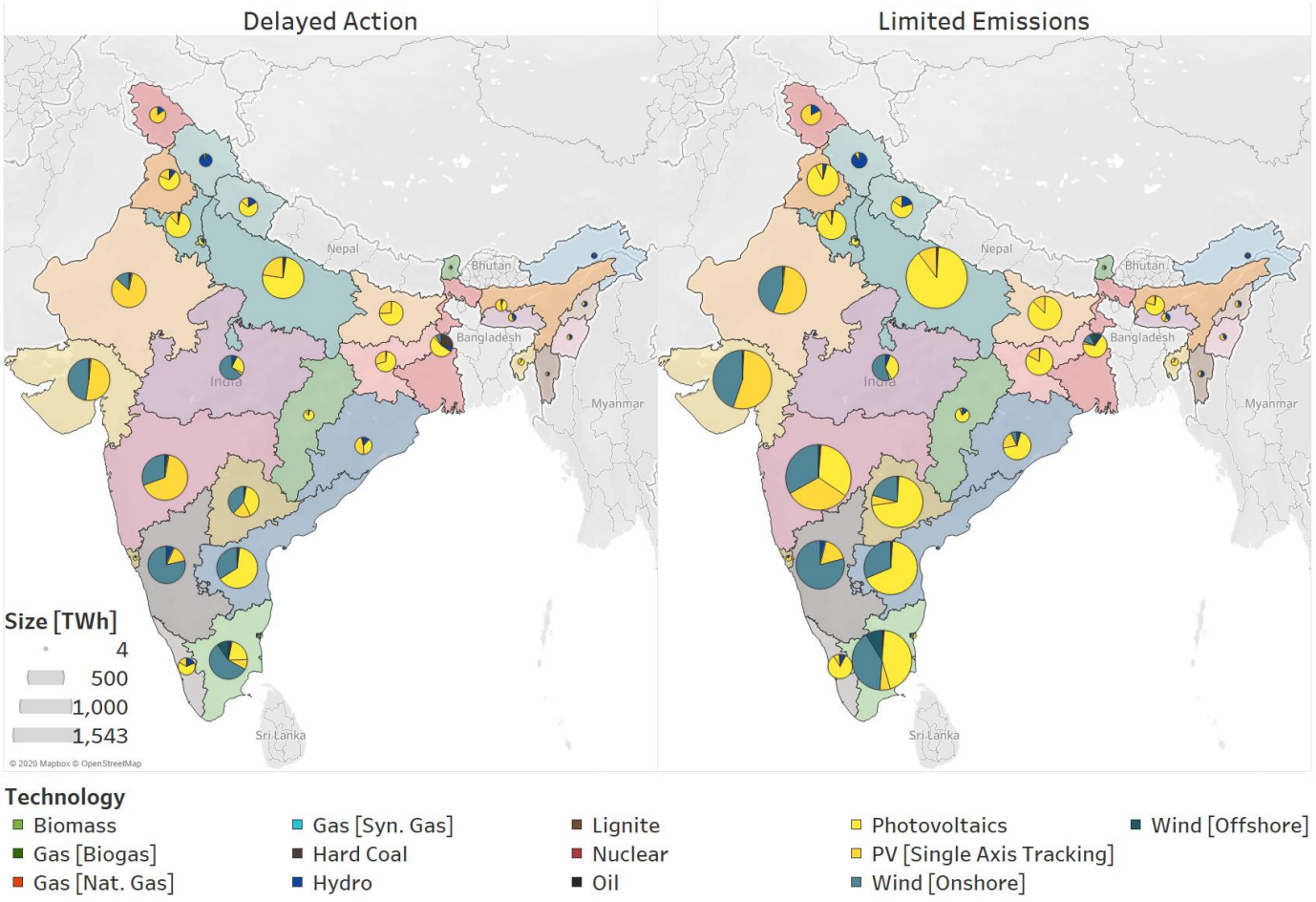

Figure 7: Power generation – regions (2050).

Results – India´s climate ambitions in context

- Government plans for 2030 are not sufficient to stay within below 2°C global warming
- Political targets can fill the gap until renewables are not only cost-competitive, but actually cheaper than their fossil counterparts

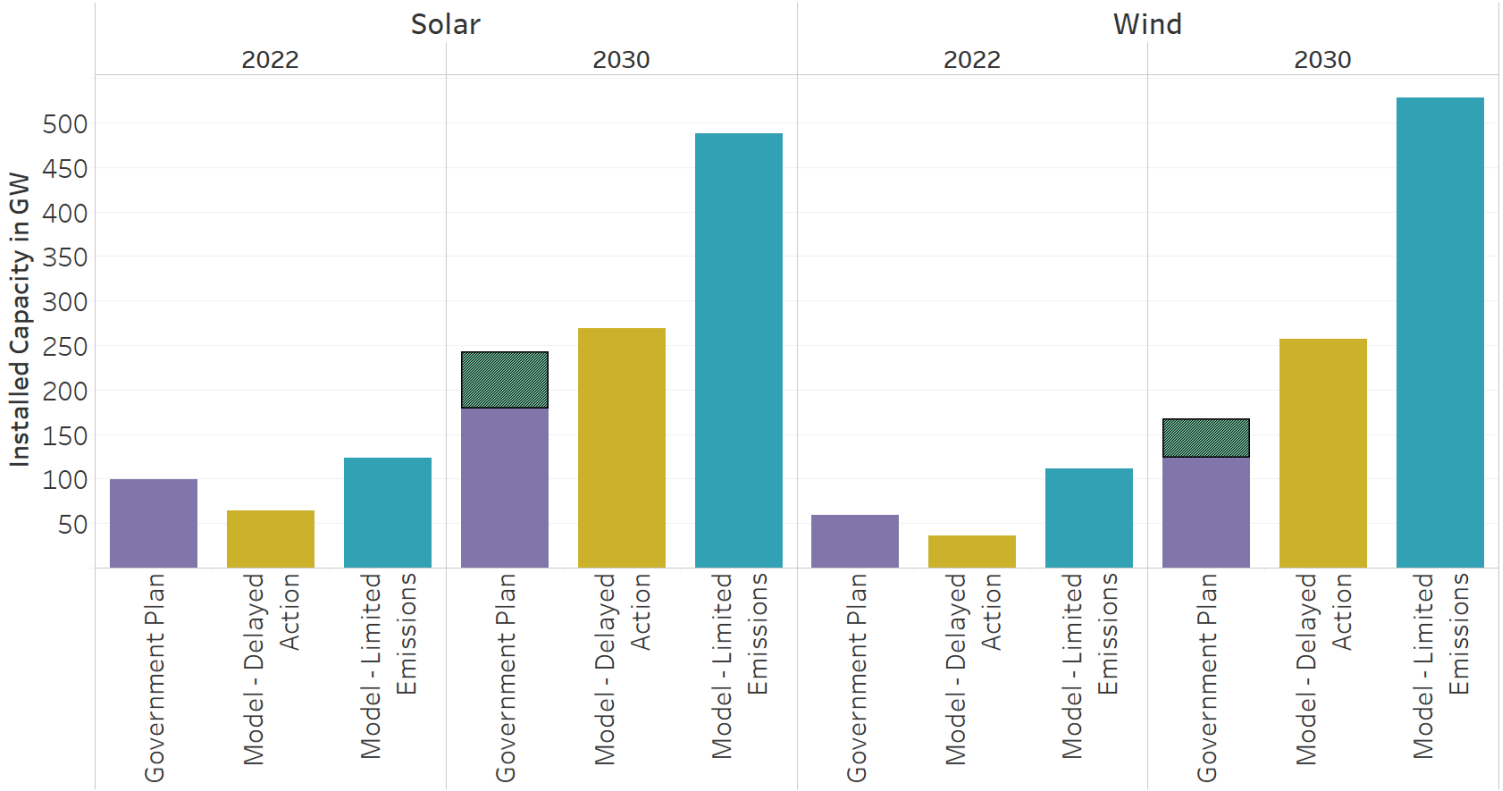

Figure 8: Climate targets.

Implications for the Indian energy sector

- Immense and fast expansion of renewable energy sources is necessary
- The ambitious efforts to expand renewable energies must be accompanied by an equally ambitious coal phase-out
- It is necessary for policy-makers to act and enforce policies to push forward the energy transition
- Alternative and innovative concepts are necessary to limit global warming to well below 2°

Thank you for your interest. We highly appreciate your feedback.

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Back-up

Primary Energy Changes compared to 2015					
2030			2050		
Input Demand	Limited Emissions	Delayed Action	Input Demand	Limited Emissions	Delayed Action
207%	170%	179%	323%	206%	228%

Table A-1: Changes in input demand assumptions and primary energy demand per scenario, relative to 2015 values. While demand growth is the same across both scenarios, clear efficiency improvements via sector coupling can be observed in the Limited emission scenario.

Back-up

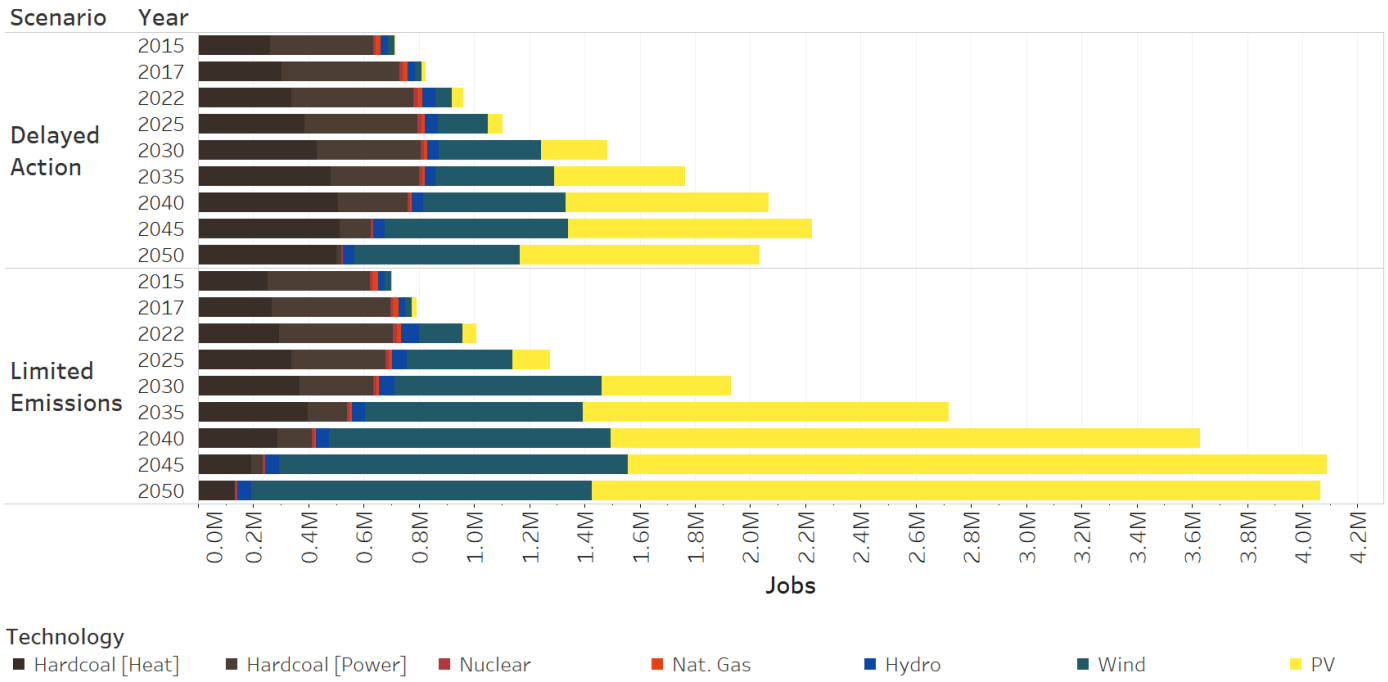

Figure A-1: Employment per energy carrier in million jobs.

Back-up

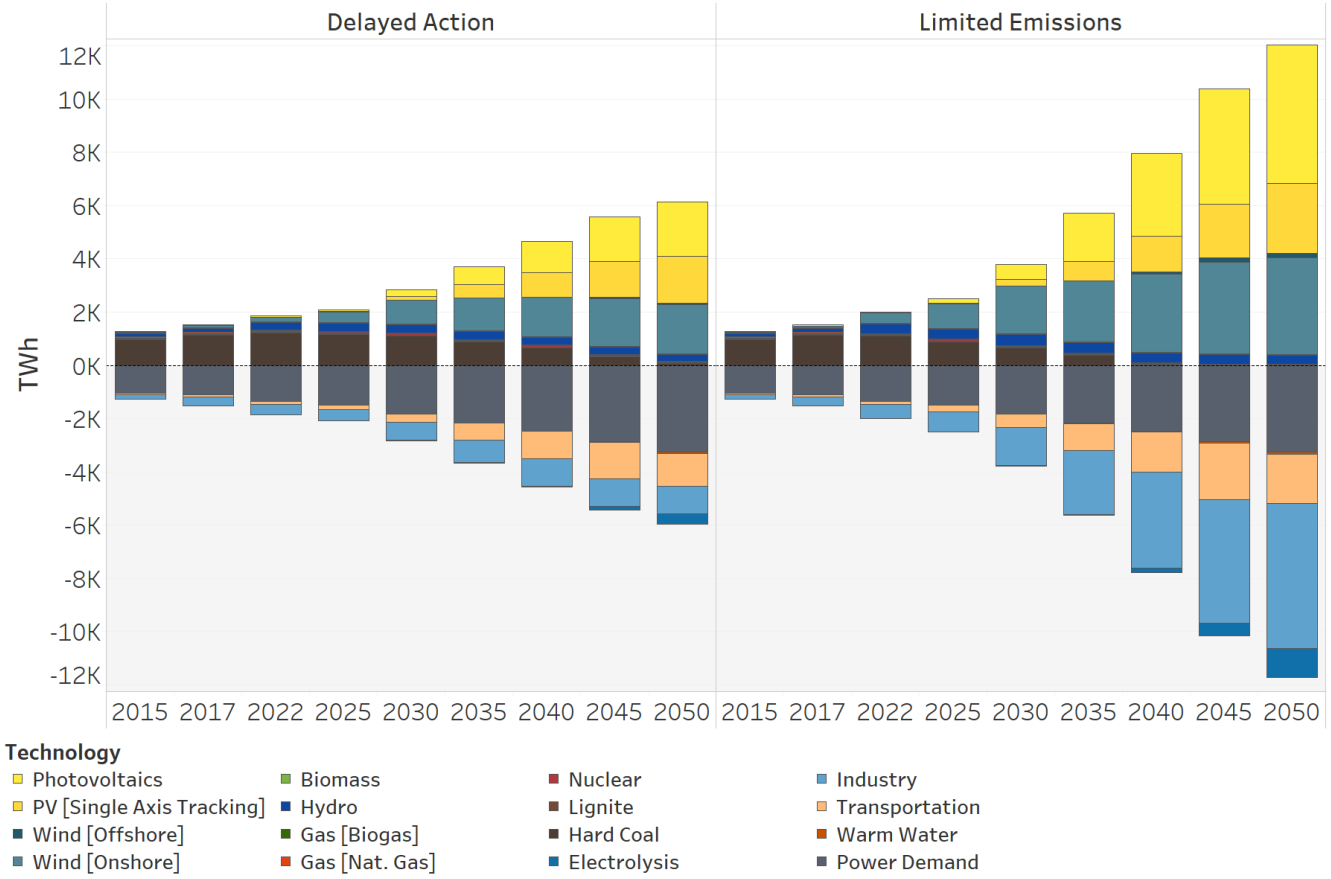

Figure A-2: Power generation (positive values) and use per sector (negative values).in TWh.

Back-up

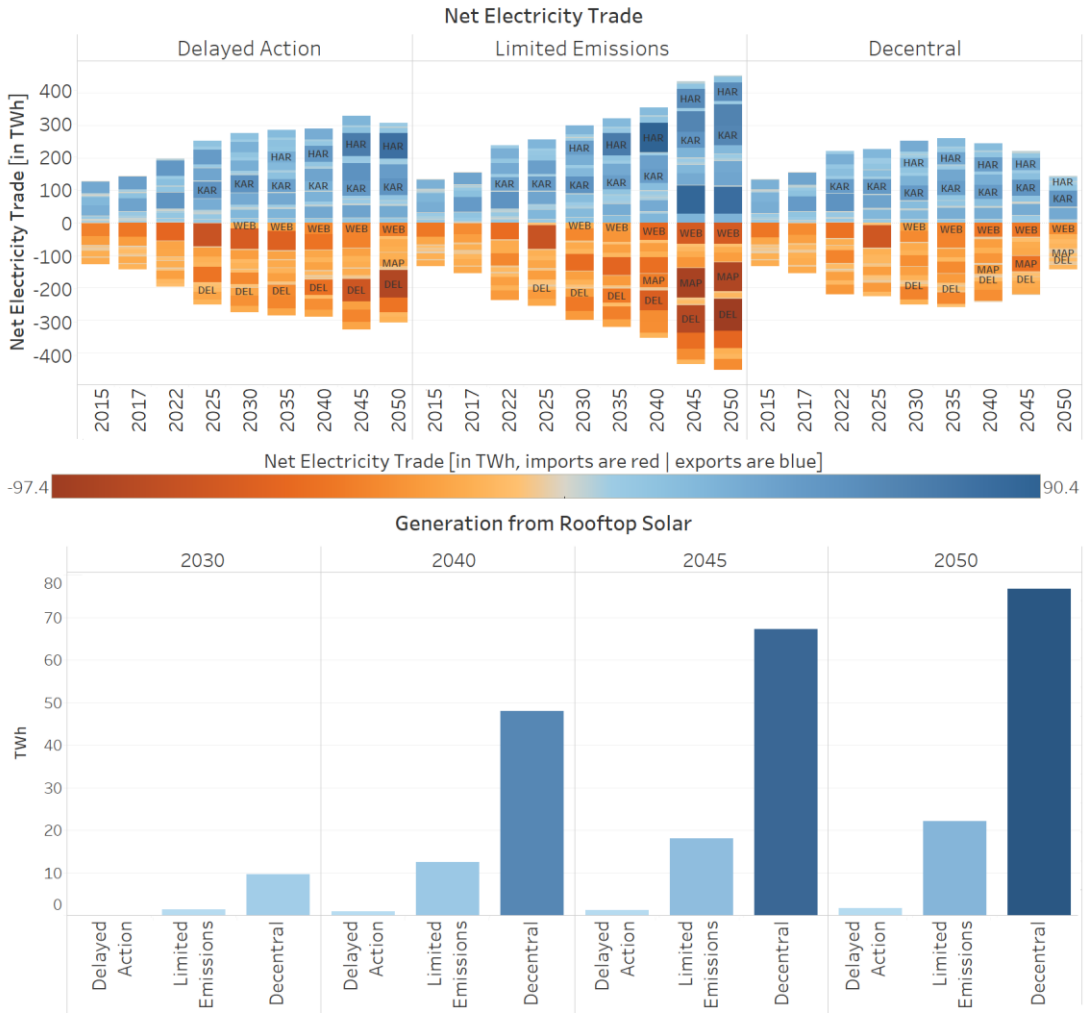

Figure A-3: Net electricity trade per region and rooftop solar installations in comparison.