Exploring Energy Pathways for the Low-Carbon Transformation in India

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Agenda

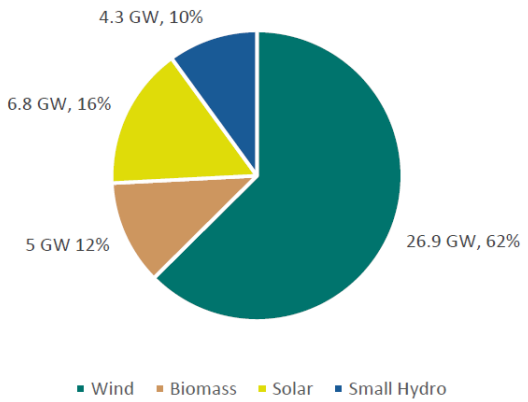
1) Overview
2) Conventional and renewable energy in India
3) Approach and model description
4) Model results
5) Barriers
6) Conclusion

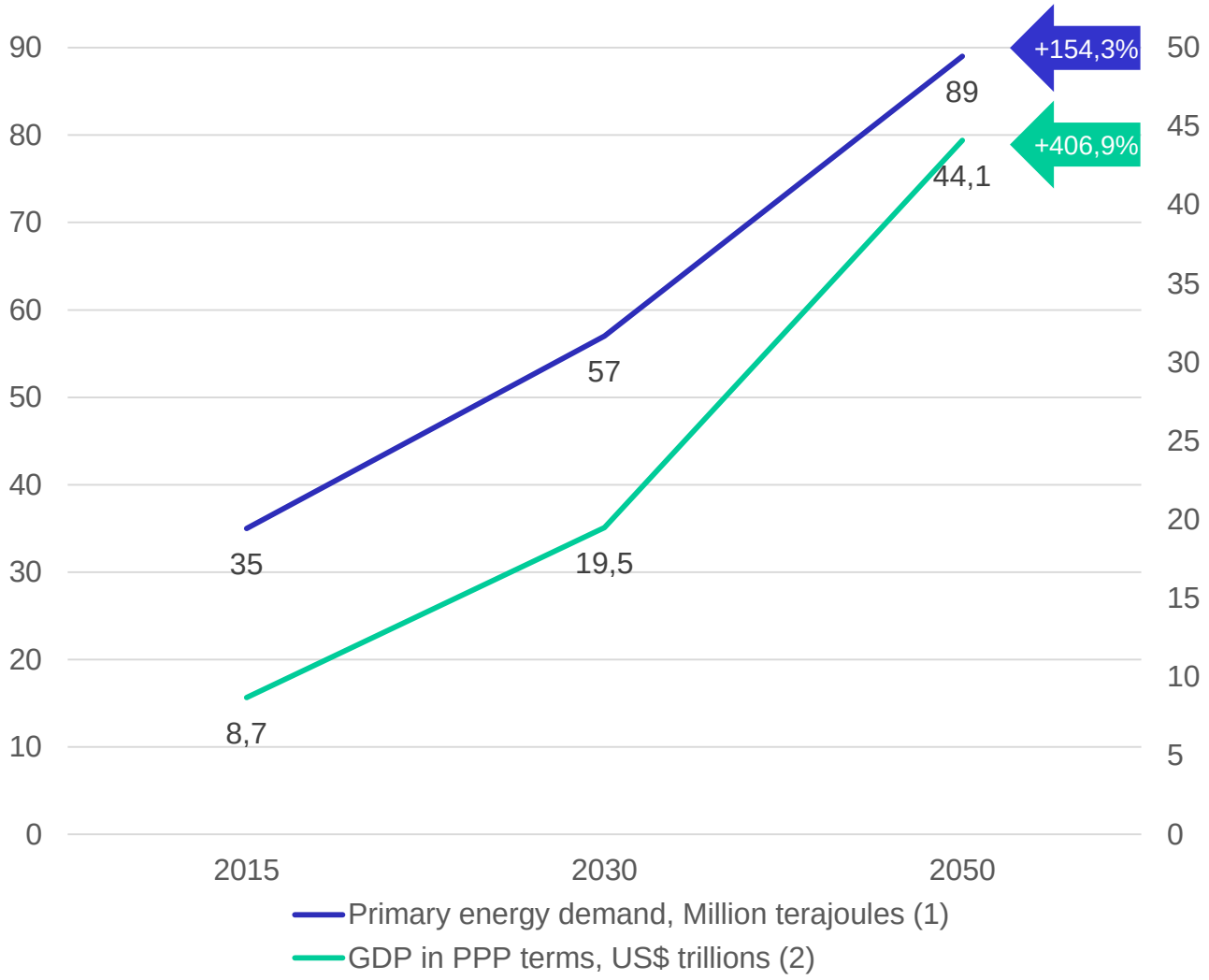
India – Political overview

Key data

Population	1.33 billion[1)]
GDP p.c.	US$ 1,852[1)]
Poverty rate	17 % (< $ 1,9 /day) [2)]
CO_2 emissions p.c.	1.73 metric tons[2)] *Germany: 8.89 metric tons*
Electrific-ation	99.25 %[3)]

Share of RES IC





[1)] World Economic Outlook Database 2017; [2)] World Bank Group 2016 ; [3)] Progress Report of Village Electrification 2017, GoI

(1) McKinsey Energy Insights' Global Energy Perspective, December 2017, (2) The Long View How will the global economic order change by 2050?, PwC February 2017

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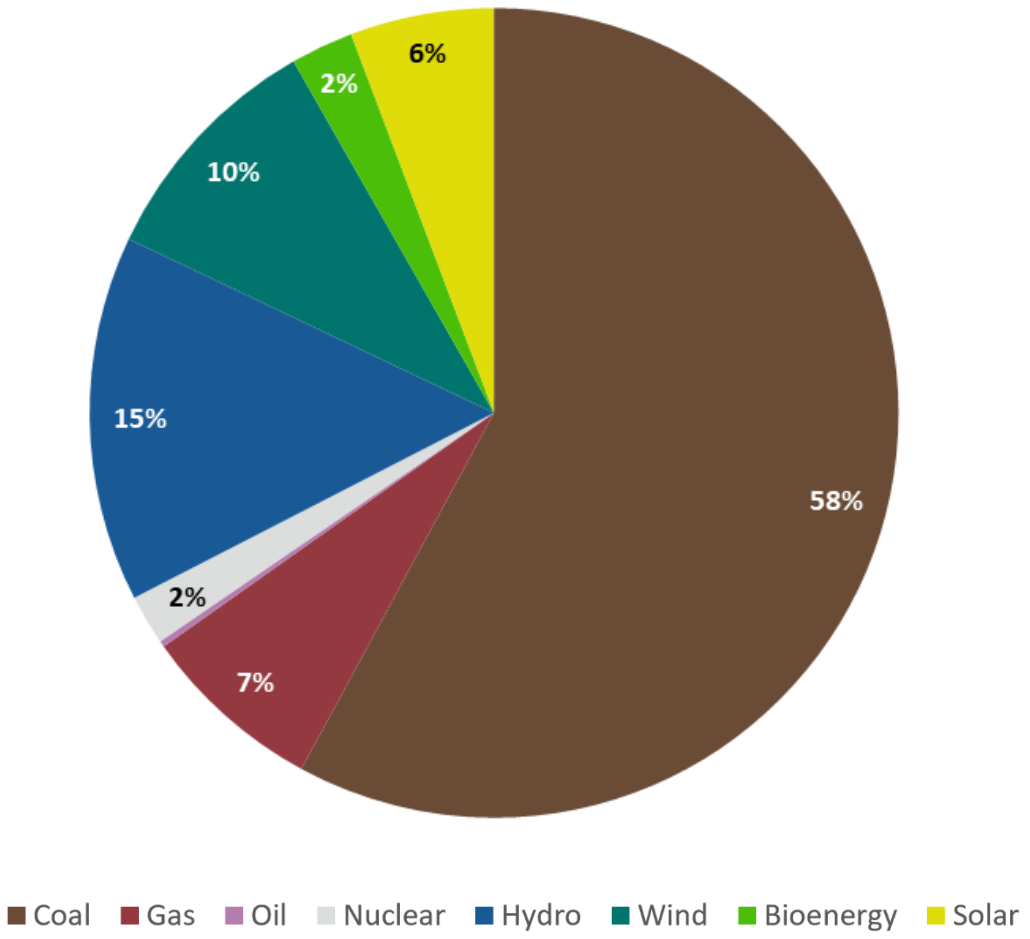
Conventional and renewable energy in India



Installed power capacity mix 2017

Source: CEA (2018)

Conventional energy

- India is the third largest producer of coal (IBEF 2017)
- Disproportionate part on economies relies on fossil fuels and energy intensive industries
- No coal based capacity addition will be required after 2022 (50 GW of coal based power projects are currently under construction)

Renewable energy

- Installed capacities for renewables vary greatly between regions

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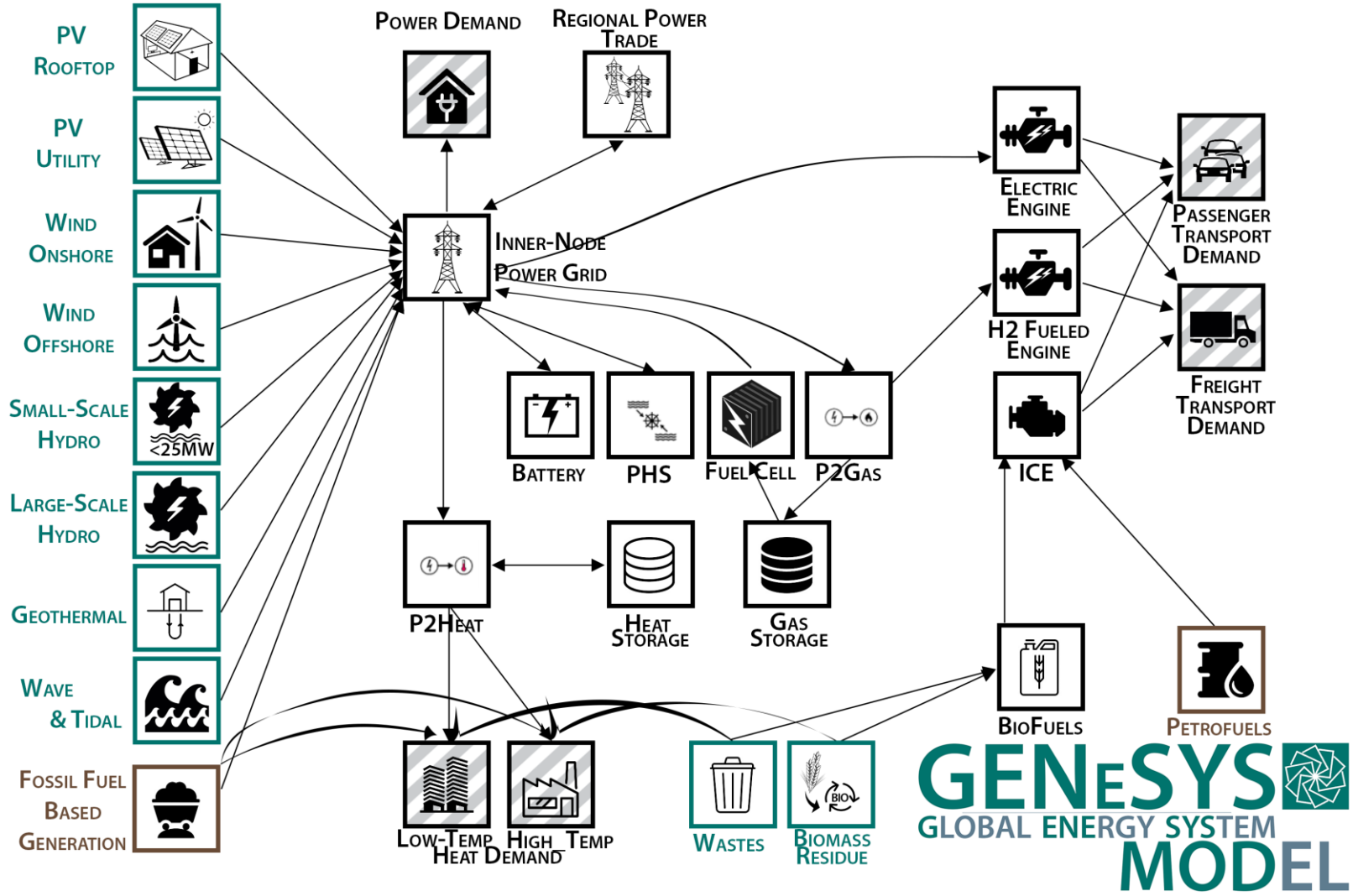
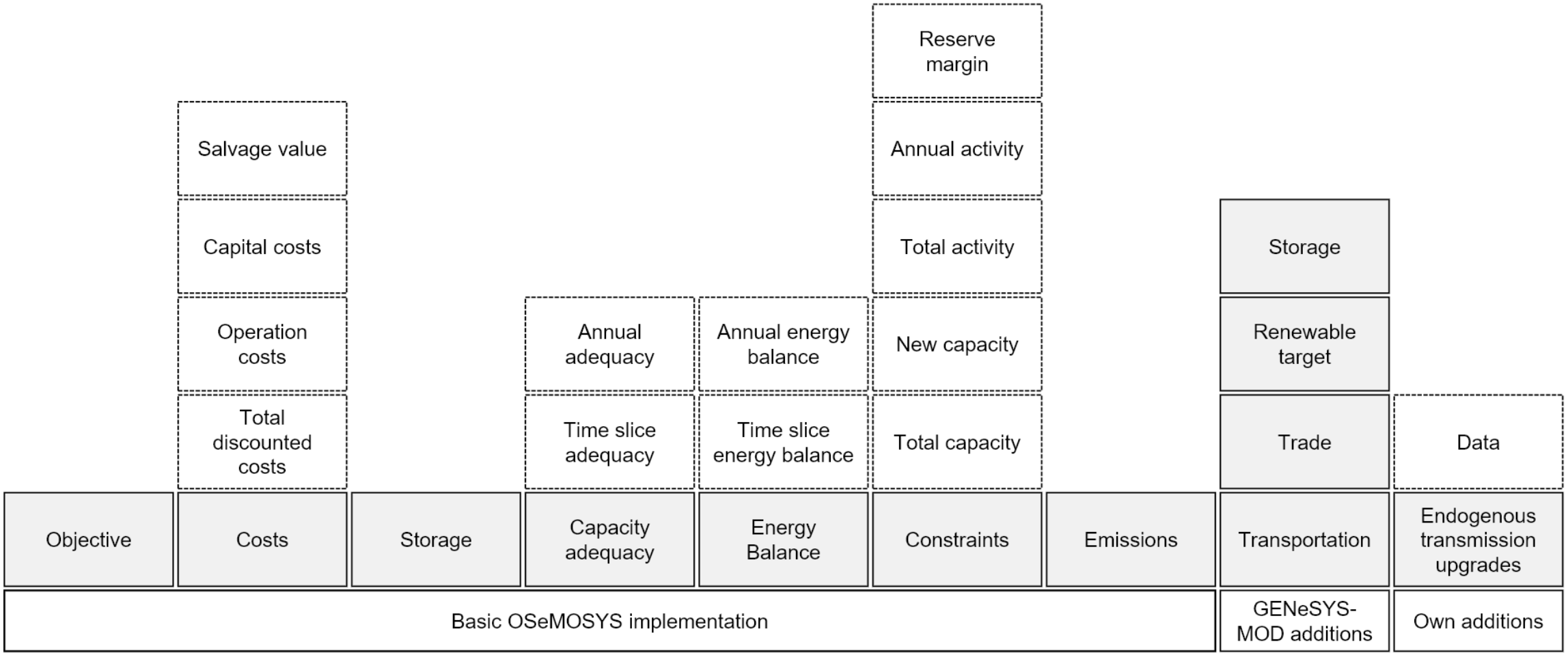
Design & Features of the Global Energy System Model (GENeSYS-MOD)

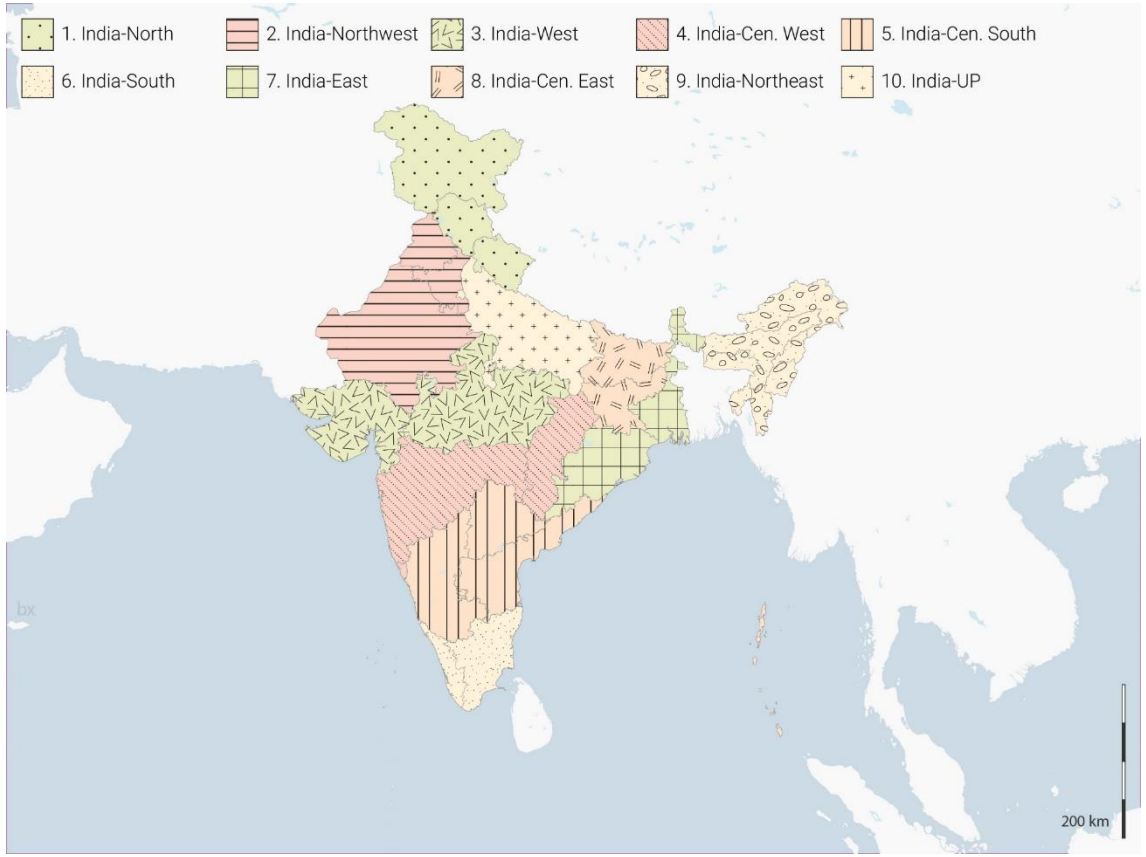


Layout of GENeSYS-Mod with own additions



India – Nodesplit for GENeSYS-MOD

India‘s different subregions



Source: Own illustration based Gulagi et al. (2017).

1. India-North
   Jammu and Kashmir, Himachal Pradesh, Uttarakhand
2. India-Northwest
   Punjab, Haryana, Dehli, Rajasthan, Chandigarh
3. India-West
   Gujarat, Madhya Pradesh, Dadra and Nagar Haveli, Daman and Diu
4. India-Central West
   Maharashtra, Chhattisgarh, Goa
5. India-Central South
   Karnataka, Andhra Pradesh, Telangana
6. India-South
   Tamil Nadu, Kerala, Pondicherry
7. India-East
   Odisha, West Bengal, Sikkim
8. India-Central East
   Jharkhand, Bihar
9. India-Northeast
   Assam, Nagaland, Manipur, Meghalaya, Arunachal Paradesh, Tripura, Mizoram
10. India-UP
    Uttar Pradesh

Scenarios

Benchmark Scenario:

LEO Scenario

Specifications and goal

= Limited Emissions Only

- Goal: To see how the cost optimal path until 2050 looks by keeping the CO_2 emissions within fixed national budgets of the respective countries

Restrictions

- Limited CO_2 budget, based on 2 degree goal
- Losses within the transmission grid decrease down to 5% in 2050

Compared scenarios

BAU Scenario

= Business As Usual

Restrictions:

- IEA's projected capacities for renewable energies are upper limits
- No limiting CO_2 budget

100 % RES Scenario

=100% Renewable Energy Sources

Restrictions:

- In 2050 only renewable energy sources (RES) are allowed
- Limited CO_2 budget, based on 2 degree goal

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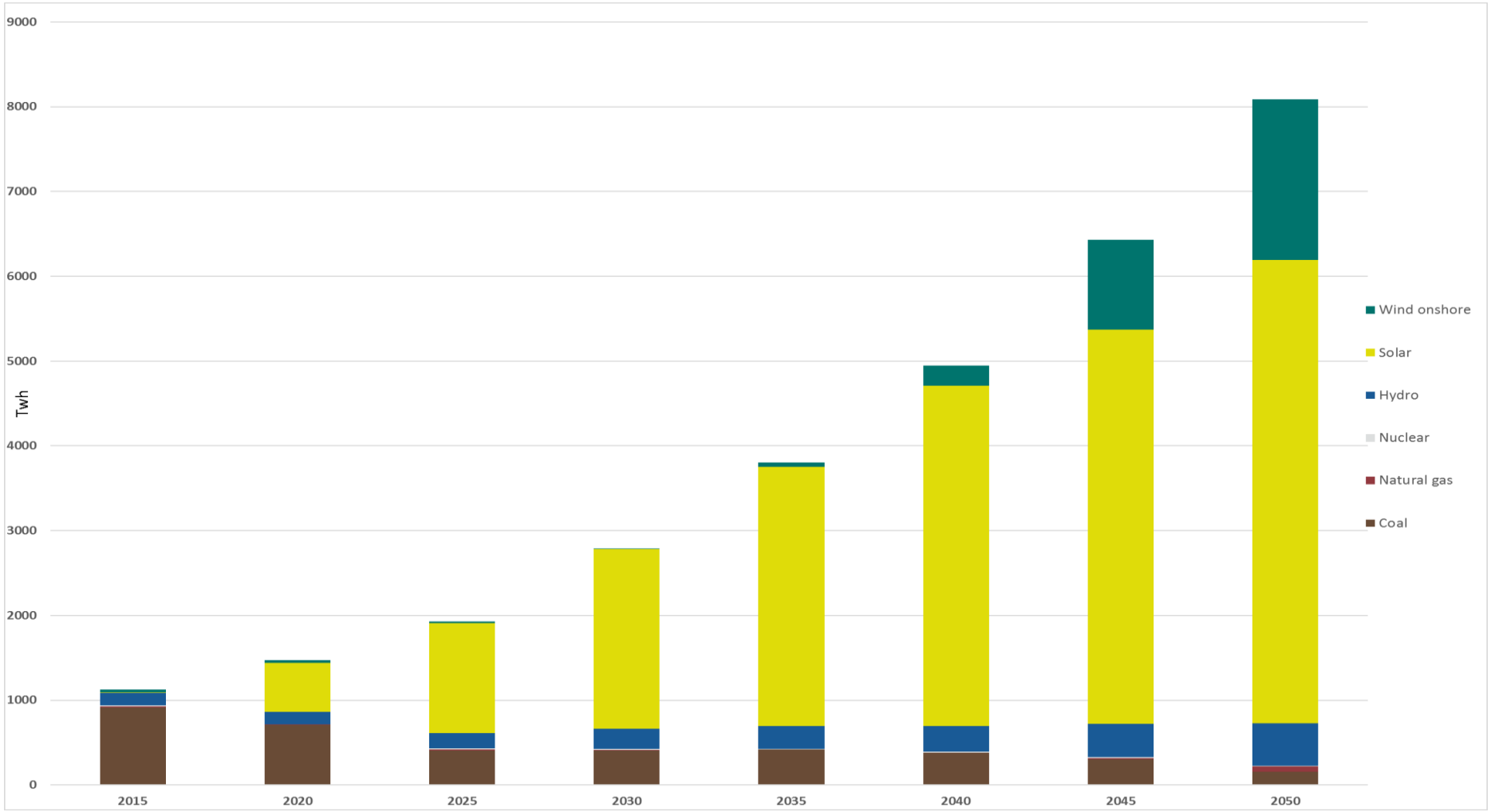
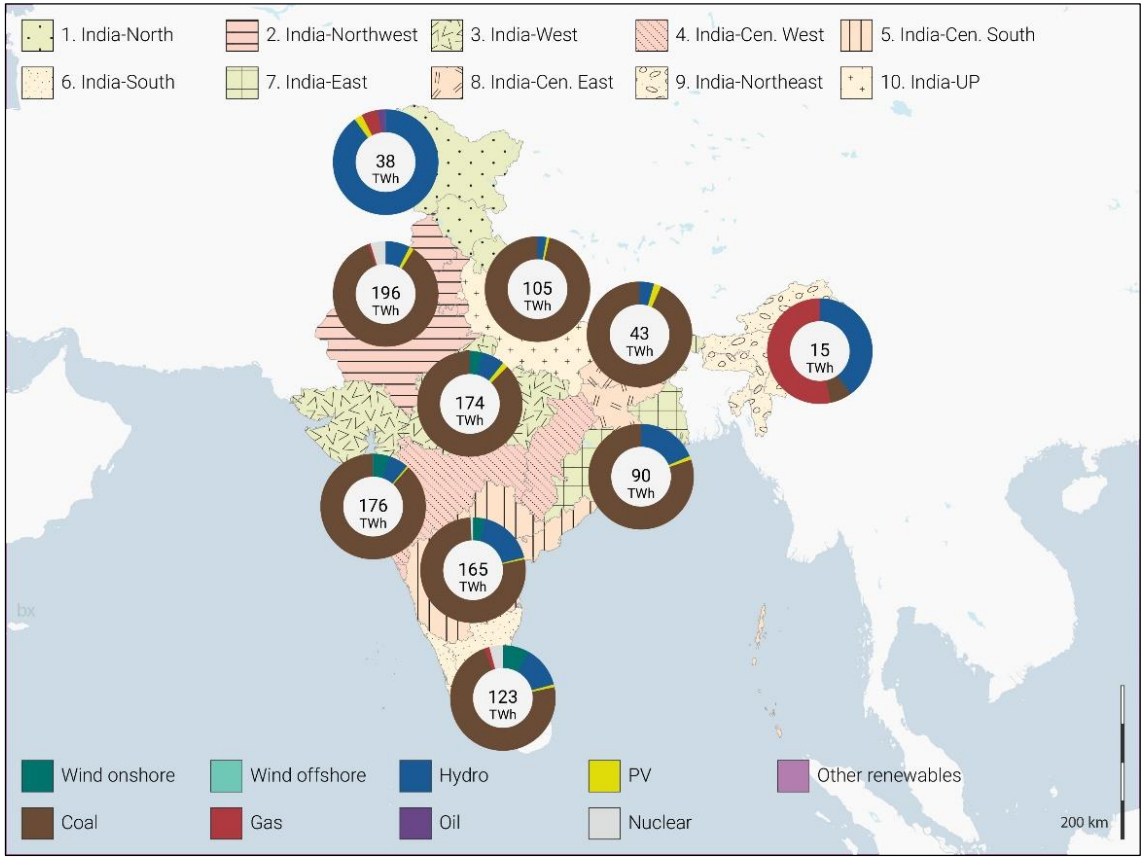
Development of India‘s power generation in the LEO Scenario

India’s power pathway – LEO Scenario

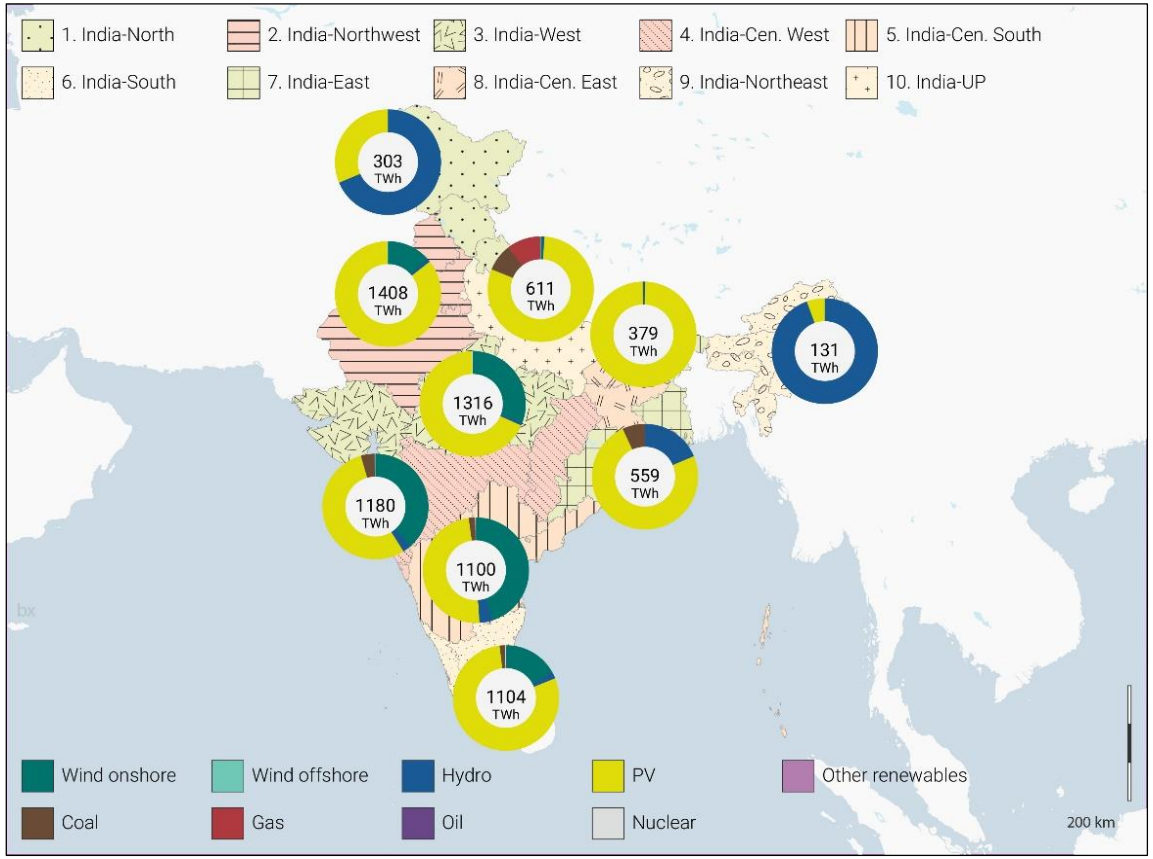


India‘s regional power generation in the LEO Scenario

India’s electricity production (2015)



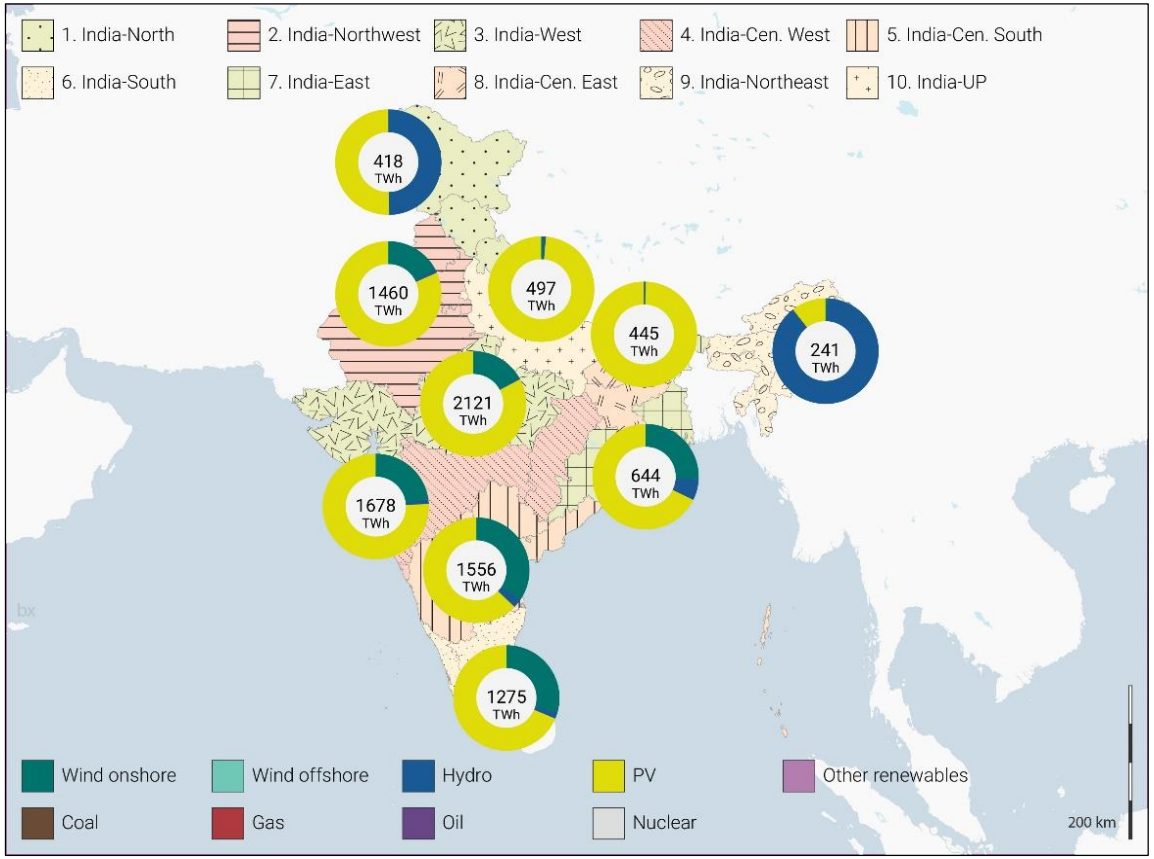
India’s electricity production (2050)



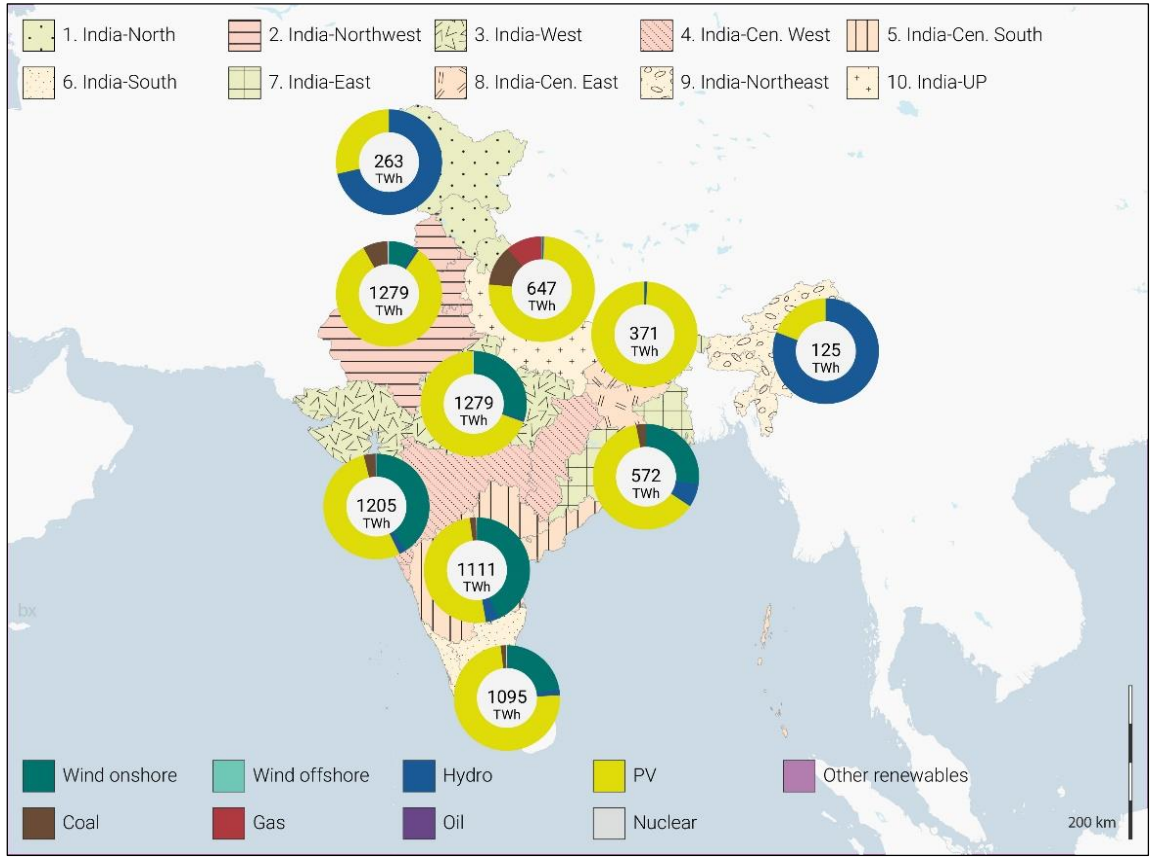
Source: Own illustration.

India‘s regional power generation in the 100% RES and BAU Scenario

India’s electricity production (2050) – 100%RES Sc.



India’s electricity production (2050) – BAU Sc.



Source: Own illustration.

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Key barriers for the Low-Carbon Transformation in India

Social Barriers

- Lack of awareness of climate change and the need for an energy transformation
- Perception of environmental standards as barriers to economic growth

Political Barriers

- India, as a developing country is highly unlikely to prioritize the mitigation of climate change
- Lobbying of the conventional energy sector, especially coal industry

Economic Barriers

- Private investment hesitations into renewable energies due to economic and political uncertainties
- One of the highest transmission and distribution losses worldwide

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Conclusion

Model results

- The Model results show that alternative pathways for India to a low-carbon energy transformation are both technically achievable and economically feasible
- On the pathway to decarbonization, solar power will play an essential role, contributing around 67% of the generation mix in 2050 (LEO)

Challenges

- The biggest challenge for the renewable roadmap will be the lacking potential for renewable energies in the metropolitan areas
- Private investment hesitations into renewable energies due to economic and political uncertainties
- Losses within the transmission grid need to be reduced

Further research

- Due to limited time, capacities, and lack of specific data, not every technology was implemented on the same level of detail, i.e. geothermal
- More projections for the freight and passenger transportation sector are required, as they play a key role in India's energy demand
- To enhance the stability the power system, more realistic features and behavior of different storage systems need to be included

Next steps

- Refining the research for publication
- 41st IAEE International Conference Groningen 2018

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Thank you for your attention!

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Thank you for your attention!

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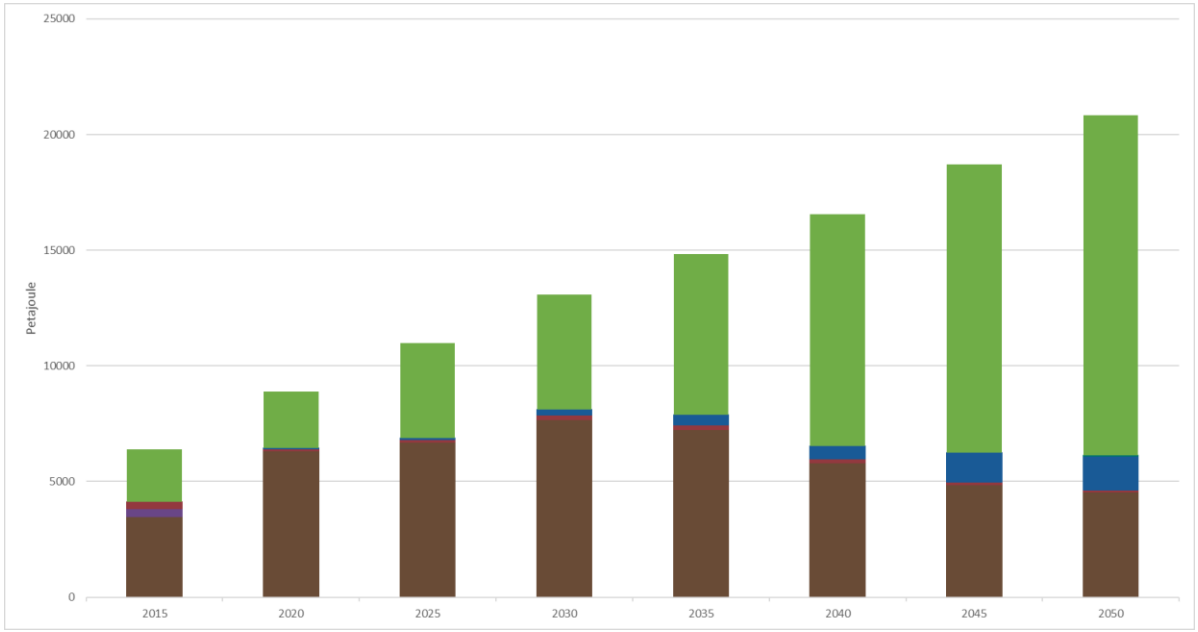
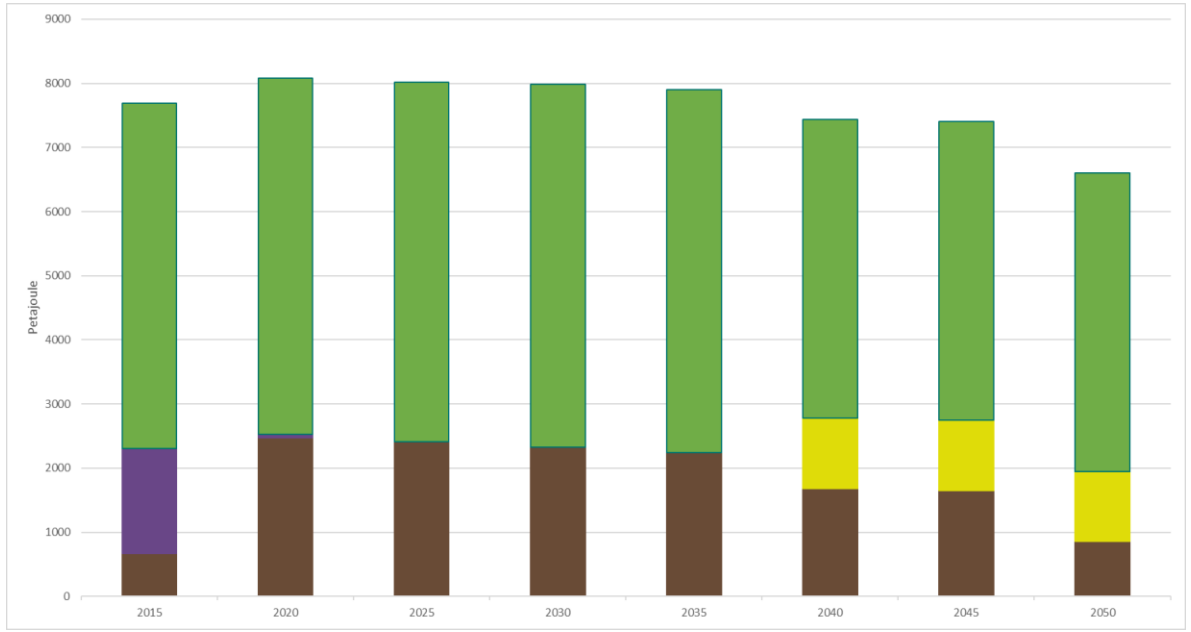
Development of high and low heat in LEO Scenario

India's high heat pathway – LEO Scenario



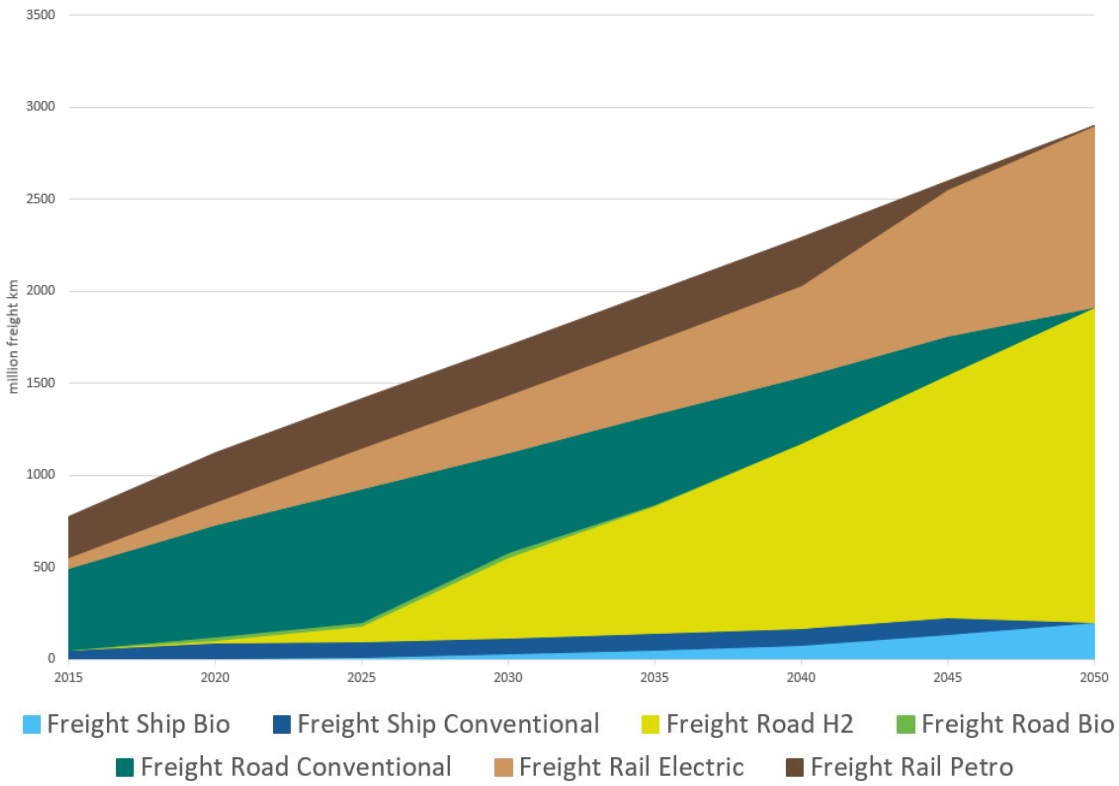
India's low heat pathway – LEO Scenario



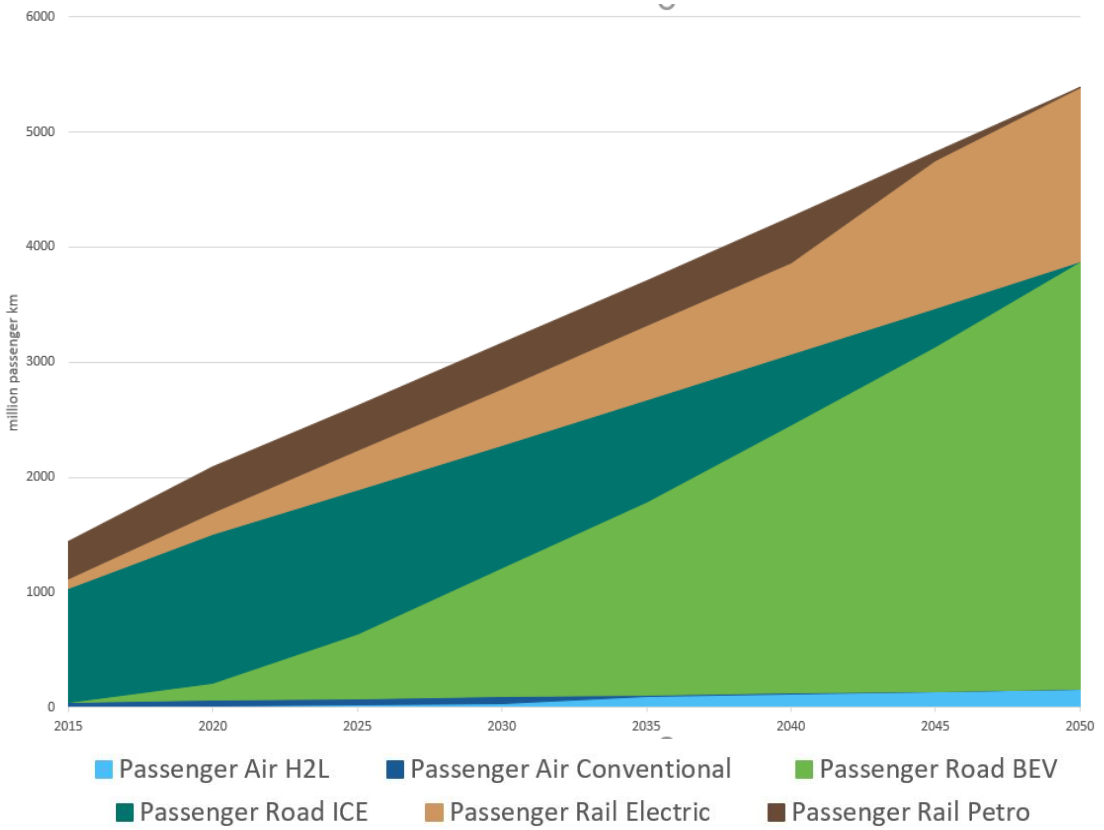
Coal Oil Gas Electric Furnace Renewable Gas Biomass Heat Pump Solar Thermal

Development of freight and passenger Transportation in LEO Scenario

India's freight transport pathway – LEO Sc.

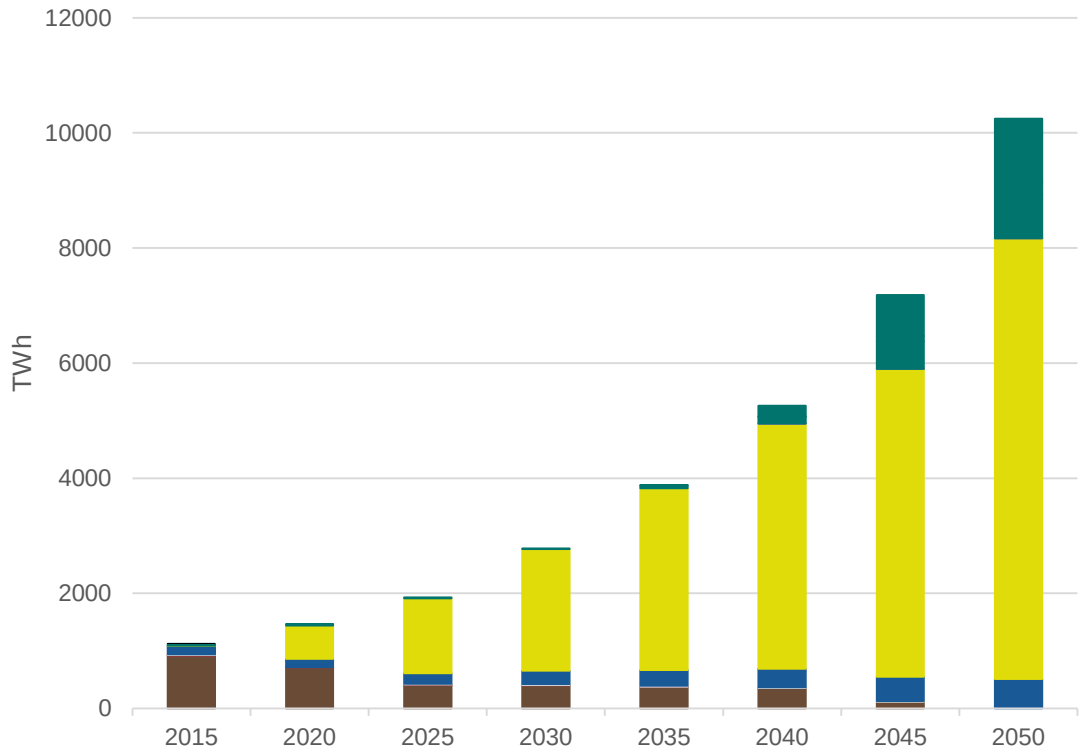


India's passenger transport pathway – LEO Sc.



Comparison of India‘s 100% RES and BAU power pathways

India’s power pathway – 100% RES Scenario



India’s power pathway – BAU Scenario