

# Power Sector for the Developing Asian Regions by 2050: Modelling the strategic vision

**Joyashree Roy, Distinguished Professor**

**SMARTS Center**

**Asian Institute of Technology, Thailand**

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**SMARTS**  
Center for South and Southeast Asia Multidisciplinary Applied  
Research Network on Transforming Societies of Global South  
SMARTS@AIT

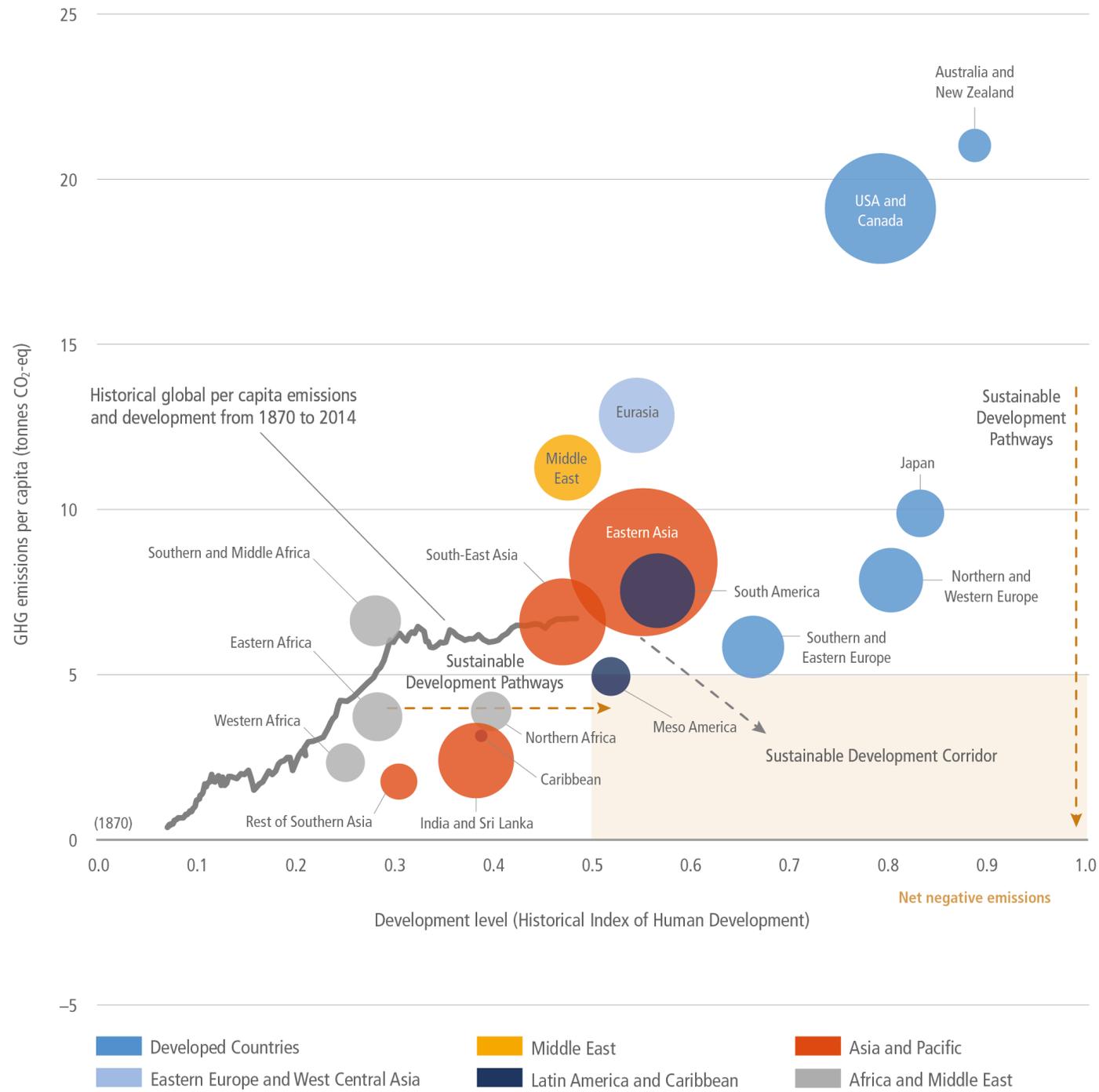
## **Some science driven hard facts**

***Climate Change: Unprecedented Challenge to Global Common Asset***

***The state of the climate system determines economic outcomes***

***In the economic development model, each country makes a choice that determines the state of the climate system***

***Time to back cast to determine the development pathway***



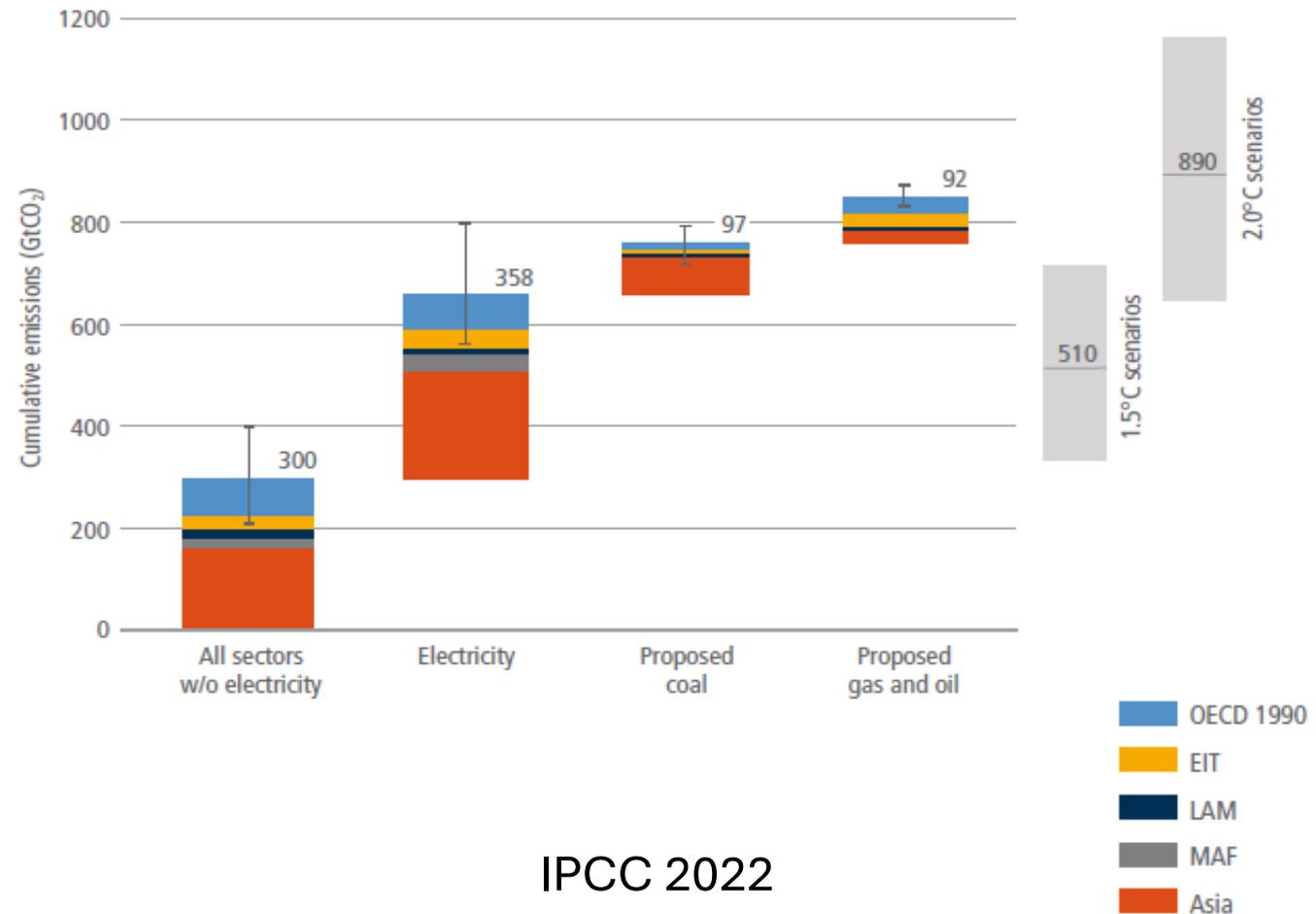
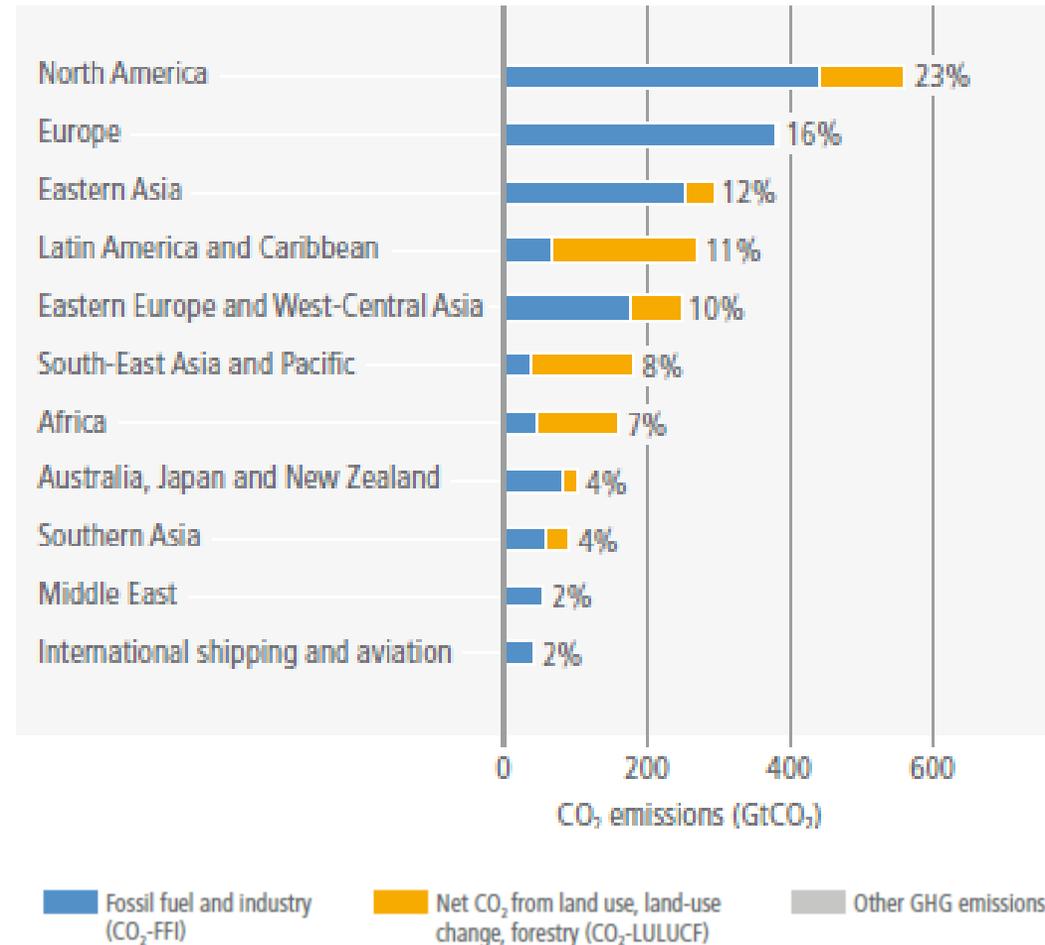
The emphasis of pathways into the sustainable development zone differ (dashed brown arrows), but in each case transformations are needed in how human development is attained while limiting GHG emissions.

**In developing Asia  
How to innovatively expand  
the sustainable energy system**

# Regional diversity in challenges

Future CO<sub>2</sub> emissions from existing and currently planned fossil fuel infrastructure in the context of the Paris Agreement carbon budgets in GtCO<sub>2</sub>

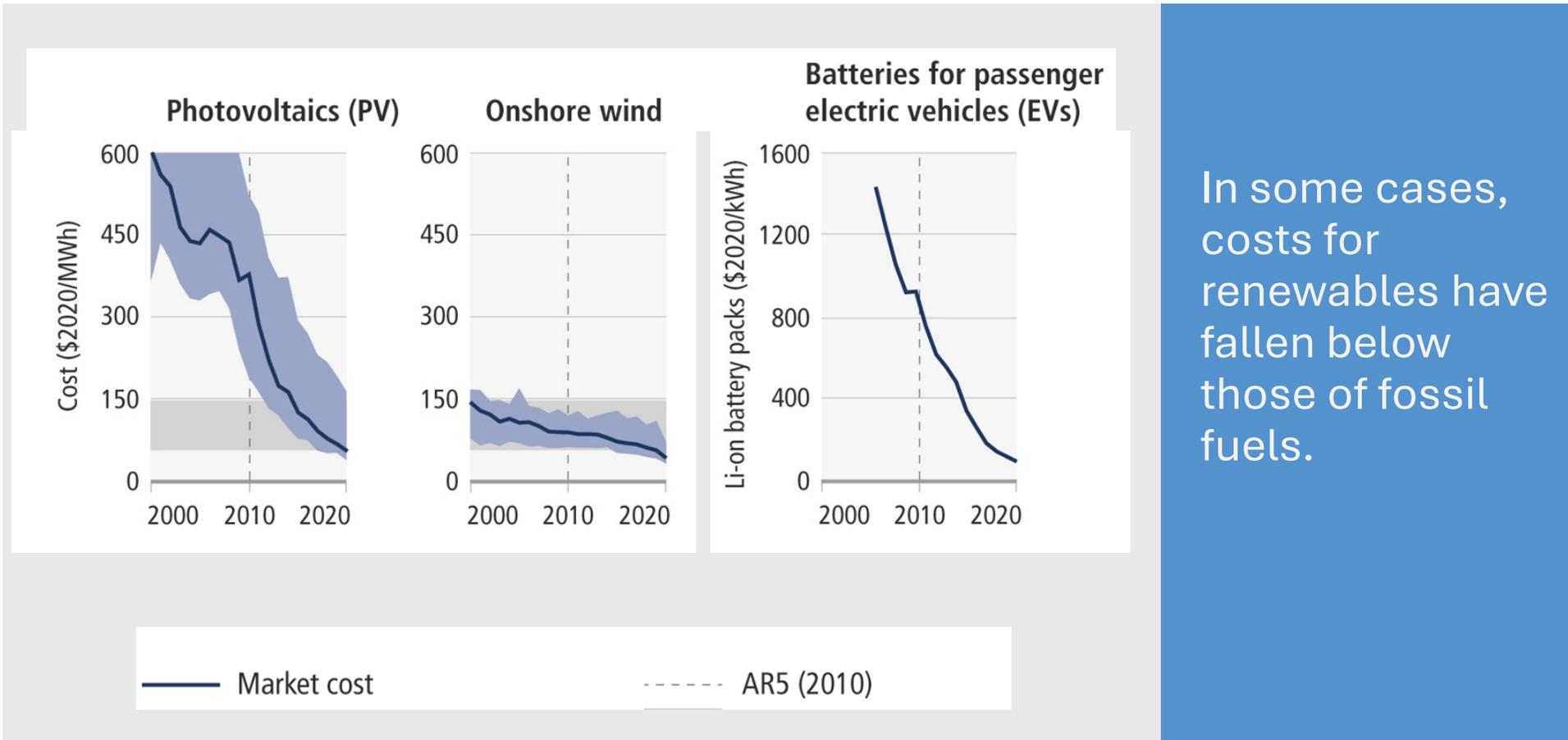
(a) Historical cumulative net anthropogenic CO<sub>2</sub> emissions per region (1850–2019)



IPCC 2022

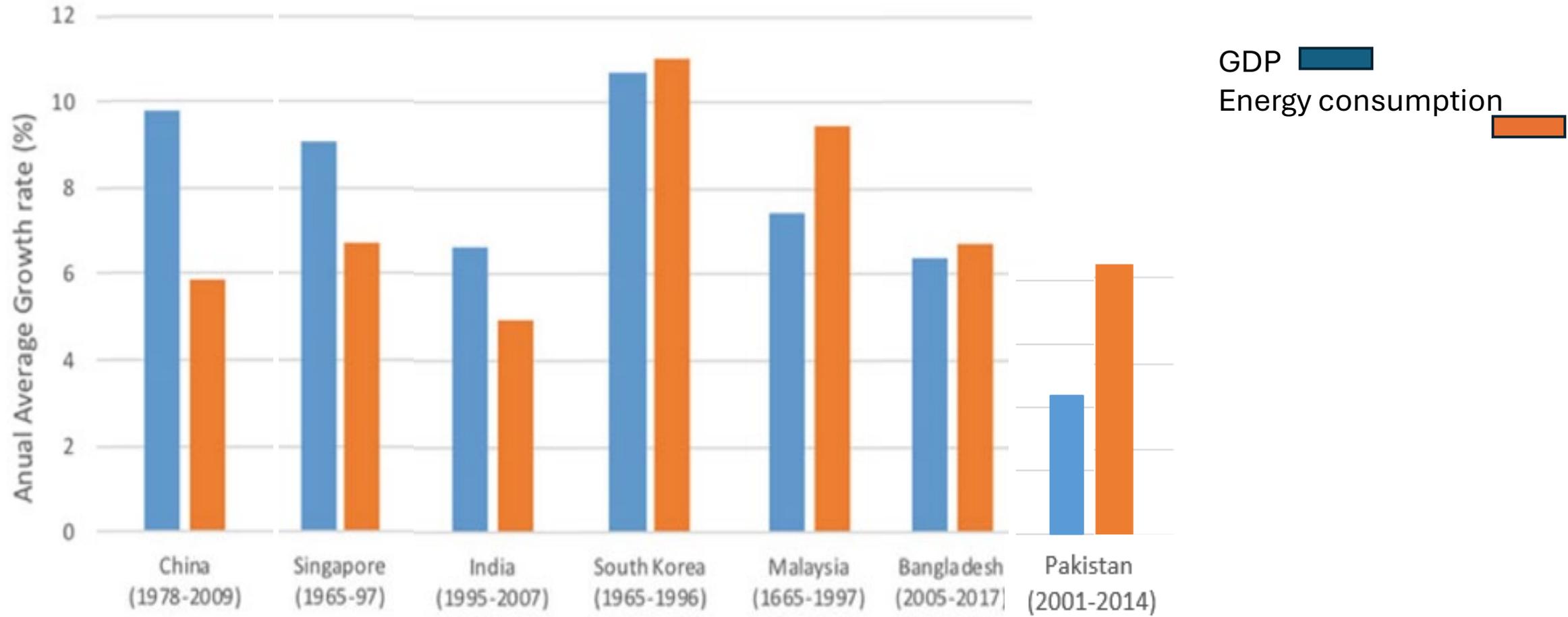
# Competitive Market Price for Renewable Energy

IPCC 2022



In some cases, costs for renewables have fallen below those of fossil fuels.

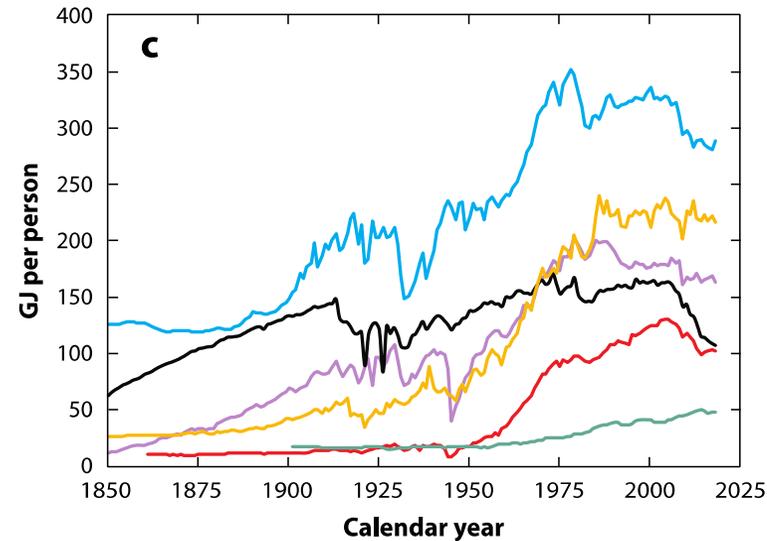
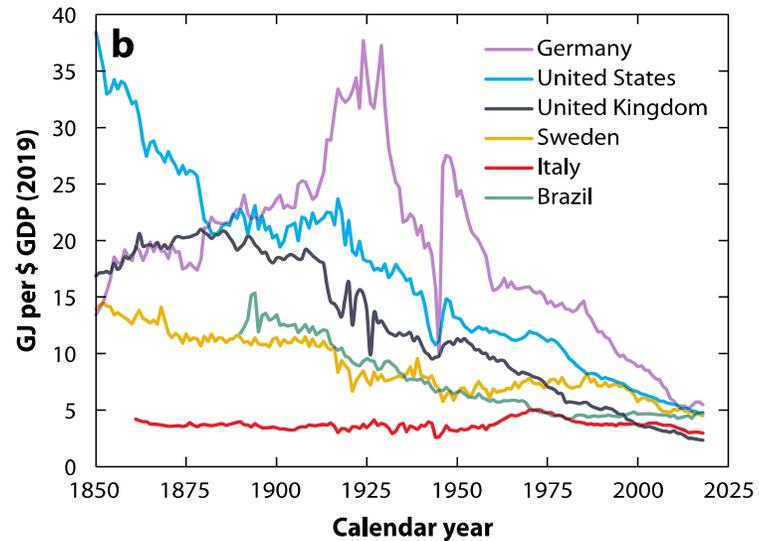
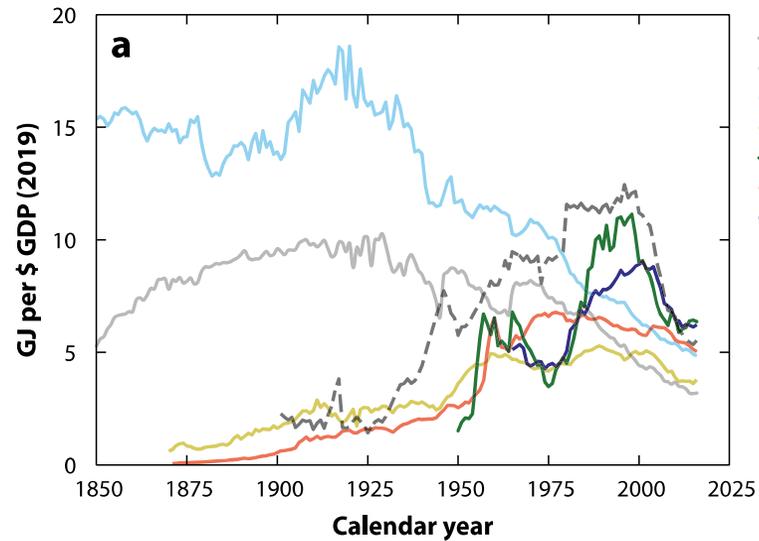
# Asian countries: fast growing phases and energy consumption growth



Energy and GDP growth rates in fast-growing phase of selected Asian countries.

Source: Adapted from Mahmud and Roy (2020)

# Energy Efficiency/Intensity of world regions



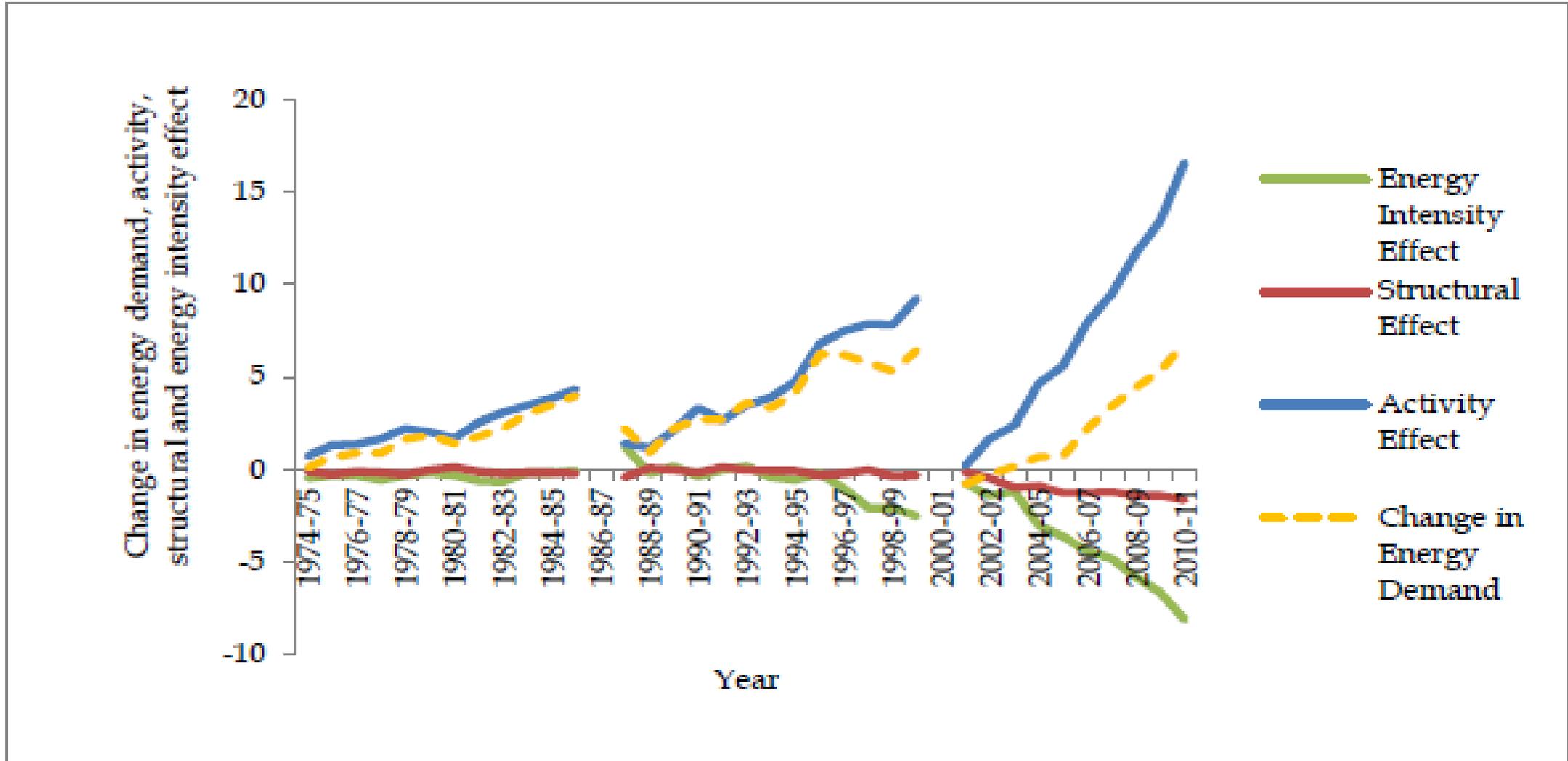
Saunders, Roy et al 2021

Annu. Rev. Environ. Resour. 2021. 46:15.1–15.31

The *Annual Review of Environment and Resources* is online at [environ.annualreviews.org](http://environ.annualreviews.org)

<https://doi.org/10.1146/annurev-environ-012320-084937>

### Manufacturing Energy efficiency in India



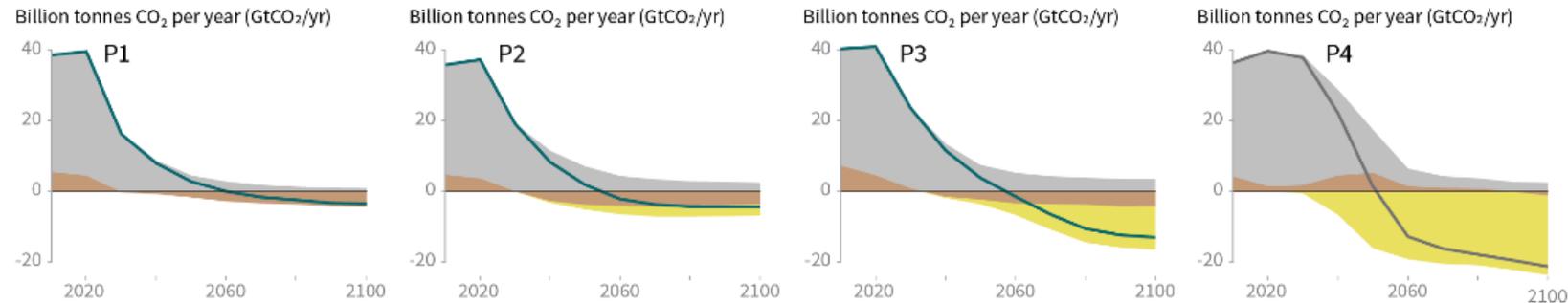


## SPM3b|

### Characteristics of four illustrative model pathways

#### Breakdown of contributions to global net CO<sub>2</sub> emissions in four illustrative model pathways

● Fossil fuel and industry ● AFOLU ● BECCS

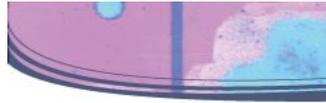


**P1:** A scenario in which social, business and technological innovations result in lower energy demand up to 2050 while living standards rise, especially in the global South. A downsized energy system enables rapid decarbonization of energy supply. Afforestation is the only CDR option considered; neither fossil fuels with CCS nor BECCS are used.

**P2:** A scenario with a broad focus on sustainability including energy intensity, human development, economic convergence and international cooperation, as well as shifts towards sustainable and healthy consumption patterns, low-carbon technology innovation, and well-managed land systems with limited societal acceptability for BECCS.

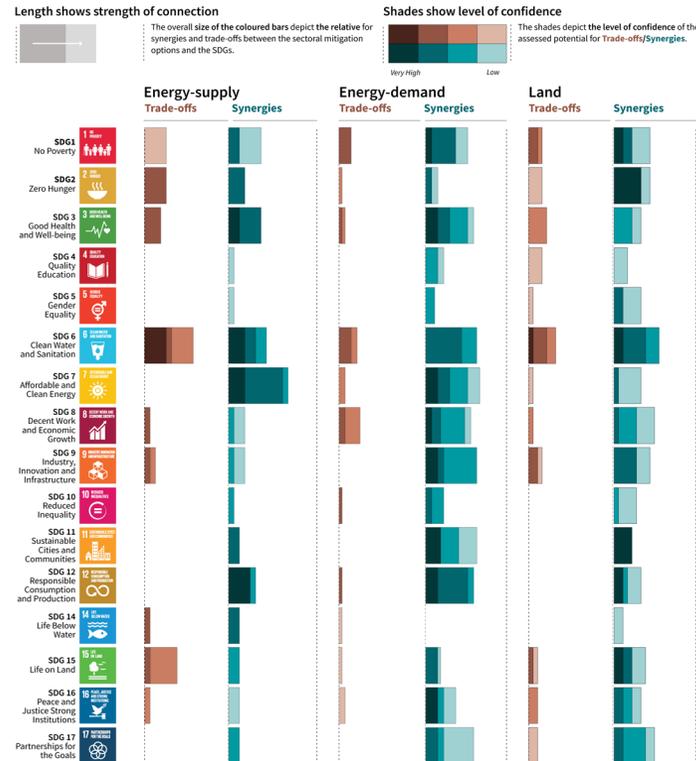
**P3:** A middle-of-the-road scenario in which societal as well as technological development follows historical patterns. Emissions reductions are mainly achieved by changing the way in which energy and products are produced, and to a lesser degree by reductions in demand.

**P4:** A resource- and energy-intensive scenario in which economic growth and globalization lead to widespread adoption of greenhouse-gas-intensive lifestyles, including high demand for transportation fuels and livestock products. Emissions reductions are mainly achieved through technological means, making strong use of CDR through the deployment of BECCS.

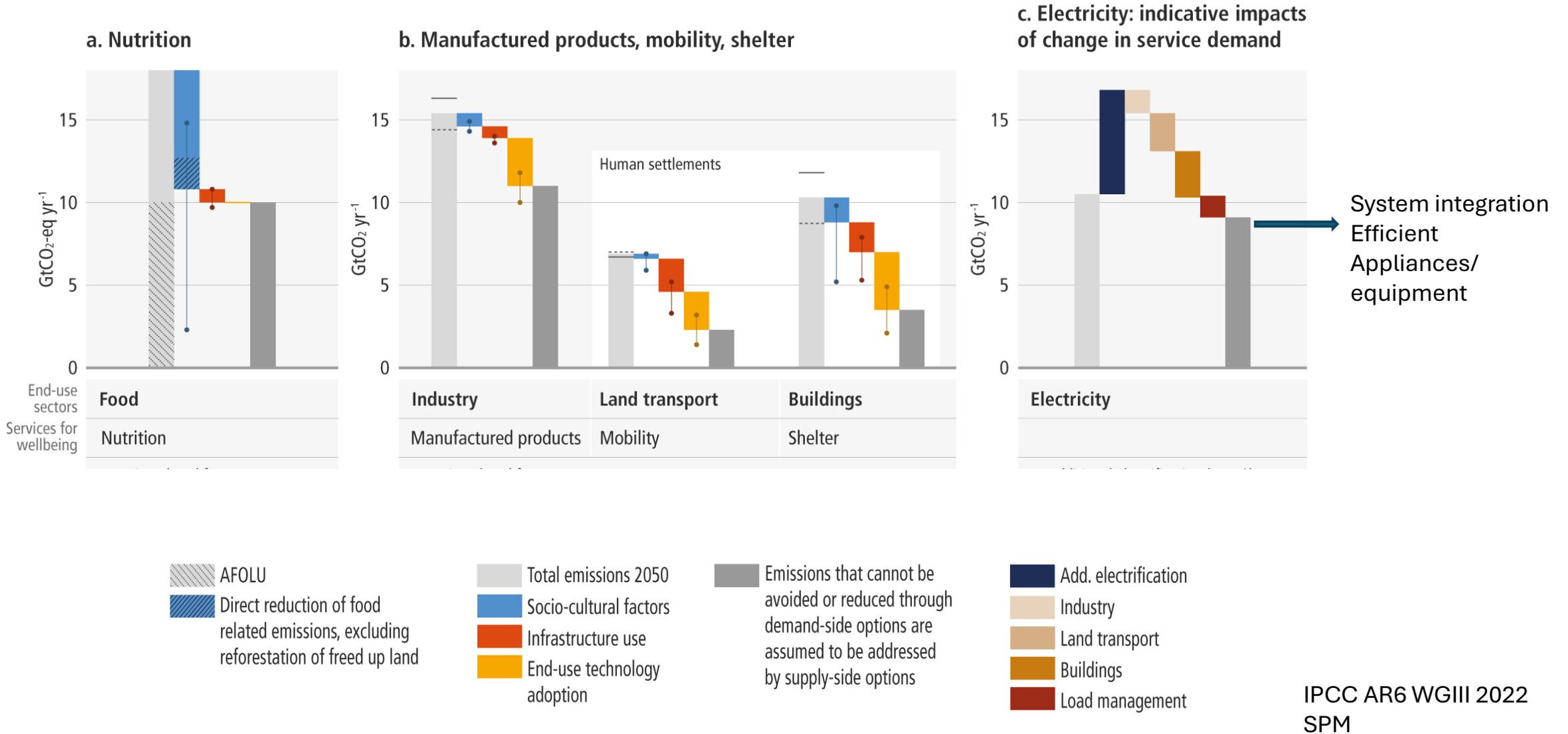


### Indicative linkages between mitigation options and sustainable development using SDGs (The linkages do not show costs and benefits)

Mitigation options deployed in each sector can be associated with potential positive effects (synergies) or negative effects (trade-offs) with the Sustainable Development Goals (SDGs). The degree to which this potential is realized will depend on the selected portfolio of mitigation options, mitigation policy design, and local circumstances and context. Particularly in the energy-demand sector, the potential for synergies is larger than for trade-offs. The bars group individually assessed options by level of confidence and take into account the relative strength of the assessed mitigation-SDG connections.



# Demand-side mitigation can be achieved through changes in socio-cultural factors, infrastructure design and use, and end-use technology adoption by 2050.



# Research Questions and Contributions

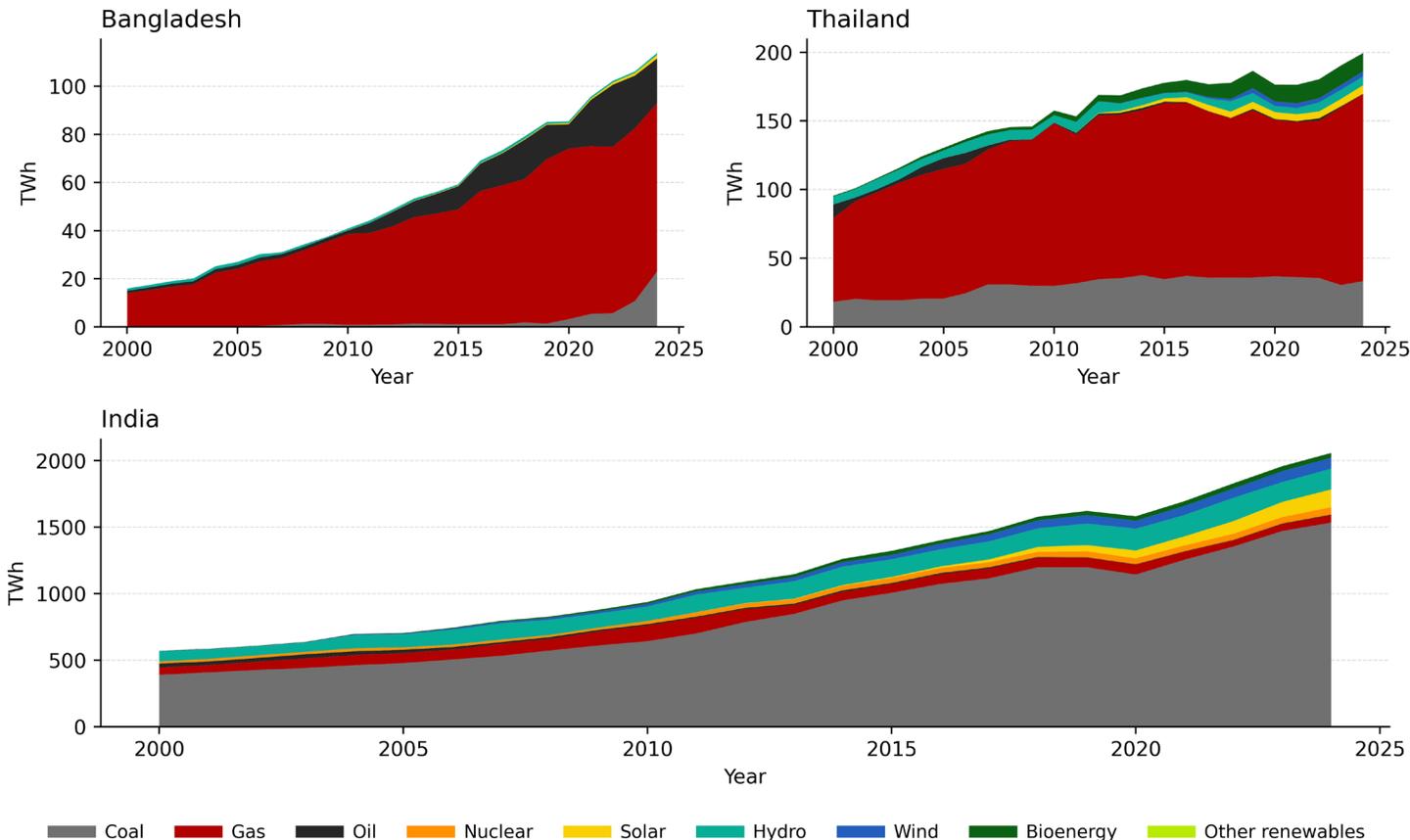
## Research Questions

- i. How can we model power sector expansion integrating demand and supply side planning?
- ii. Alternative scenarios, pathways?
- iii. Implications for investment need, land footprint, affordability, and jobs

## Contributions

- i. Developed PyPSA-BD/TH-IDS, IDEEA open-source planning models that integrate both demand and supply-side interventions to develop short-, medium-, and long-term scenarios towards a 100% clean electricity pathway.
- ii. Co-optimizes capacity investment and dispatch under operational and policy constraints
- iii. Uses national publicly accessible data.

# Background: Power Generation Mix



**Data Source:** Electricity Mix | Our World in Data  
<https://ourworldindata.org/electricity-mix>

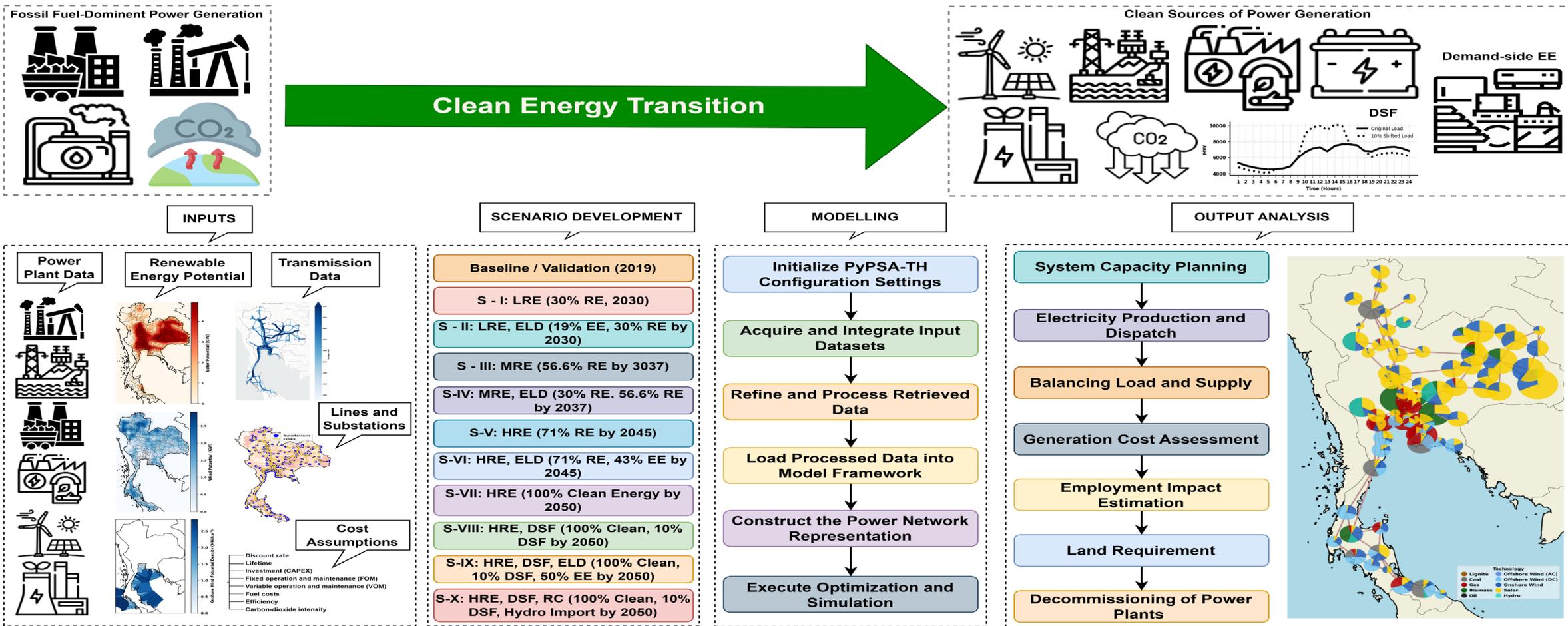
**Power generation from low-carbon sources**

Global Average: 40.88%

- Bangladesh: 2.03%
- Thailand: 14.86%
- India: 19.80%

All these countries plan to diversify their power generation mix by increasing the RE Share

# Methodology



Note: DSF - Demand-side Flexibility, EE - Energy Efficiency, HRE - High Renewable Energy, ELD - Efficient Low Demand, LRE - Low Renewable Energy, MRE - Moderate Renewable Energy, RC - Regional Cooperation

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## Data Sources (Bangladesh)

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<b>Geographic Data</b>	Open Street Map (OSM)
	BPDB Annual Report 2023, PGCB Annual Report 2023
<b>Power Plant and Demand Data</b>	Open Street Map (OSM), BPDB Annual Report 2023 , PGCB Annual Report 2023
	IEPMP 2023, BPDB Annual Report 2023 , PGCB Annual Report 2023
<b>Economic Data</b>	IEPMP 2023, IEEFA 2023
<b>Technical Data</b>	BPDB Annual Report 2023, PGCB Annual Report 2023, Open Street Map (OSM)
<b>Policy and Regulatory Data</b>	IEPMP 2023, NDC Report 2021, MCPP, EECMP
<b>Scenario Data</b>	IEPMP 2023, EECMP

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**The PyPSA-TH model's data are also from different official sources of Thailand.**

# Pledged and Higher Action Ambitious Scenario Design

## Bangladesh

Scenario name	Year	Narrative and Assumptions	Scenario Acronyms/Cluster
<b>Reference</b>	2030, 2041, and 2050	2019 Policy Frozen	Reference
<b>Scenario – I</b>	2030	30% renewable energy	LRE (S)
<b>Scenario – II</b>	2030	Scenario I + 20% energy efficiency	LRE (S), ELD (D)
<b>Scenario – III</b>	2041	40% renewable energy	MRE (S)
<b>Scenario - IV</b>	2041	33% energy efficiency, 40% renewable mix	MRE (S), ELD (D)
<b>Scenario - V</b>	2050	100% clean energy	HRE (S)
<b>Scenario - VI</b>	2050	100% clean energy, 44% energy efficiency	HRE (S), ELD (D)
<b>Scenario - VII</b>	2050	100% clean energy, 10% demand-side shift	HRE (S), DSF (D)
<b>Scenario - VIII</b>	2050	100% clean energy, 44% EE, 10% demand shift	HRE (S), DSF(D), ELD (D)

PAS

PAS,  
HAAS

HAAS

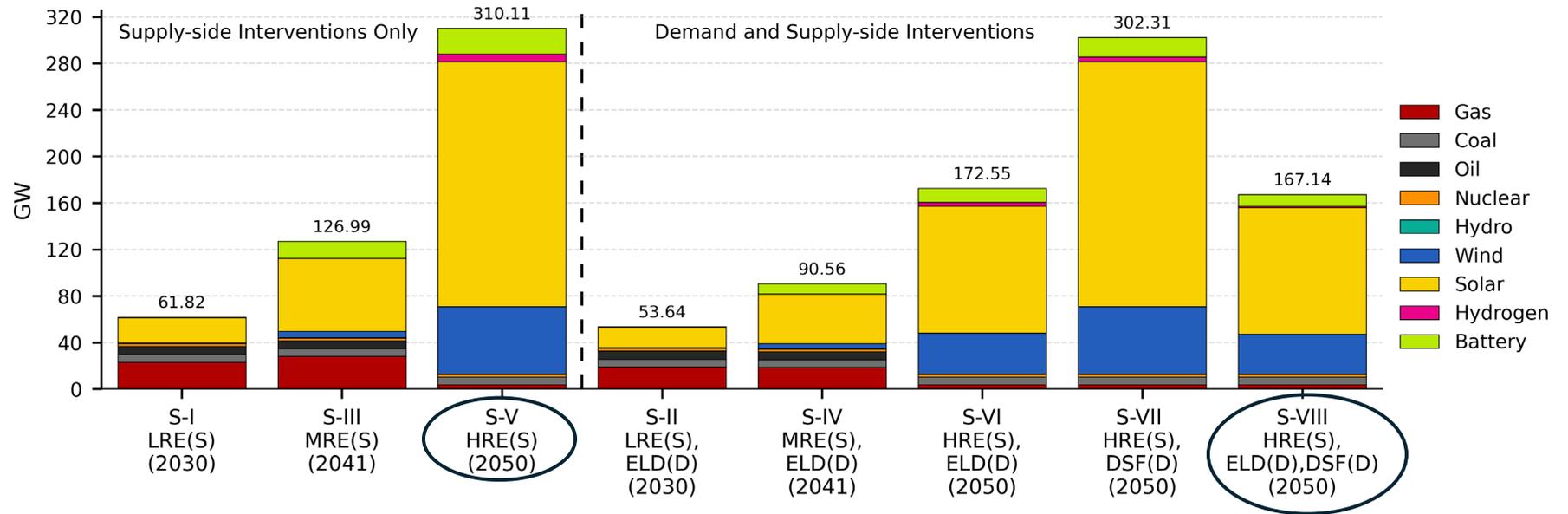


## Thailand

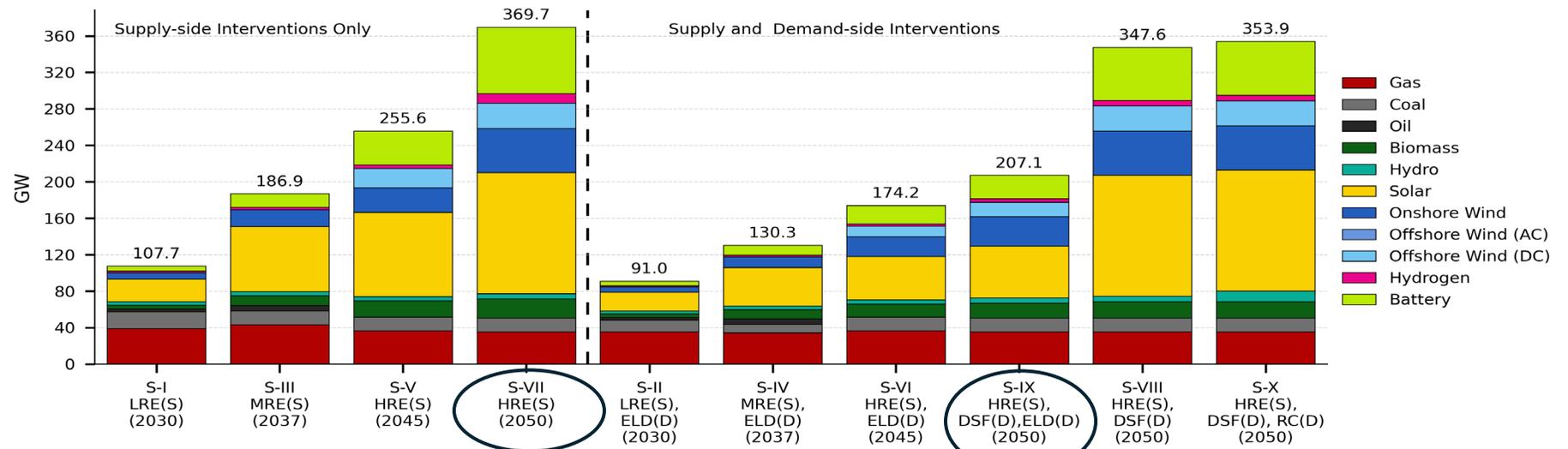
Scenario Name	Year	Narrative and Assumptions	Scenario Acronyms/Cluster	
<b>Reference Scenario</b>	2030, 2037, 2045, and 2050	2019 Policy Frozen	Reference	
<b>Scenario-I</b>	2030	30% RE	LRE (S)	PAS
<b>Scenario-II</b>	2030	19% EE and 30% RE	LRE (S), ELD (D)	
<b>Scenario-III</b>	2037	50% RE	MRE (S)	
<b>Scenario - IV</b>	2037	30% EE and 50% RE	MRE (S), ELD (D)	
<b>Scenario - V</b>	2045	71% RE	HRE (S)	PAS, HAAS
<b>Scenario - VI</b>	2045	43% EE and 71% RE	HRE (S), ELD (D)	
<b>Scenario - VII</b>	2050	100% Clean Energy	HRE (S)	HAAS
<b>Scenario - VIII</b>	2050	100% Clean Energy With A 10% Demand-side Load Shift (DSF)	HRE (S), DSF (D)	HAAS
<b>Scenario - IX</b>	2050	100% Clean Energy With 50% EE and 10% DSF	HRE (S), DSF(D), ELD (D)	HAAS
<b>Scenario - X</b>	2050	100% Clean Energy with 10% DSF and Imported hydro from Lao PDR and Malaysia	HRE (S), DSF (D), RC (D)	HAAS

# Modelled installed capacities over time

## Bangladesh

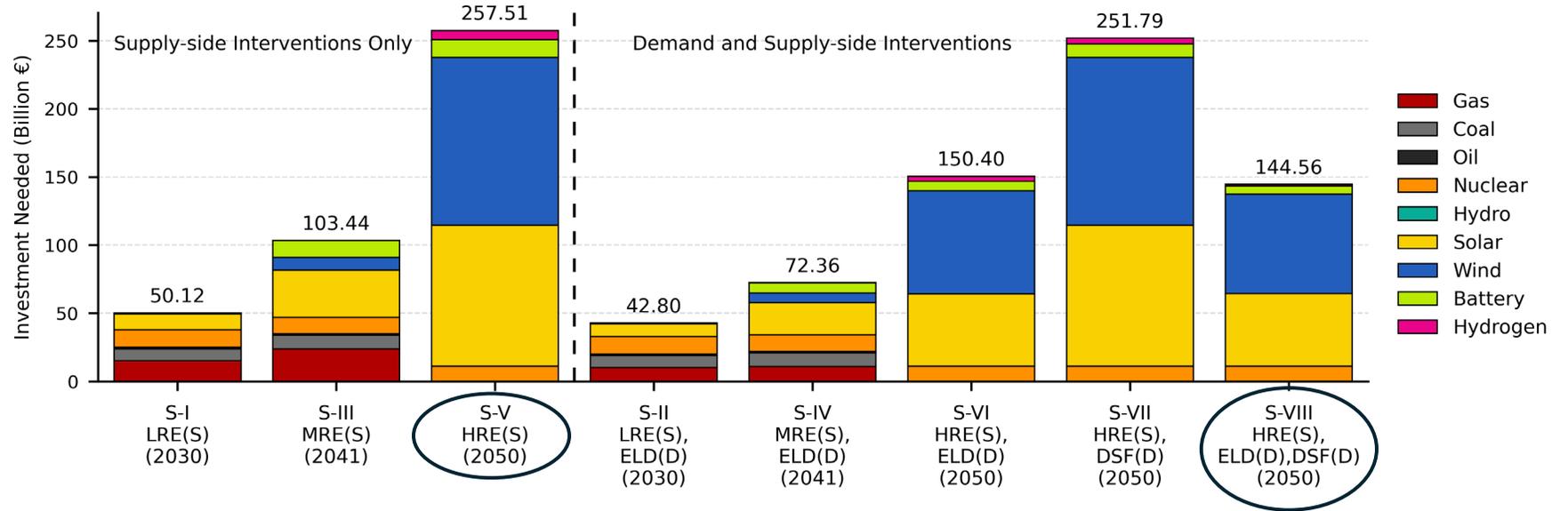


## Thailand

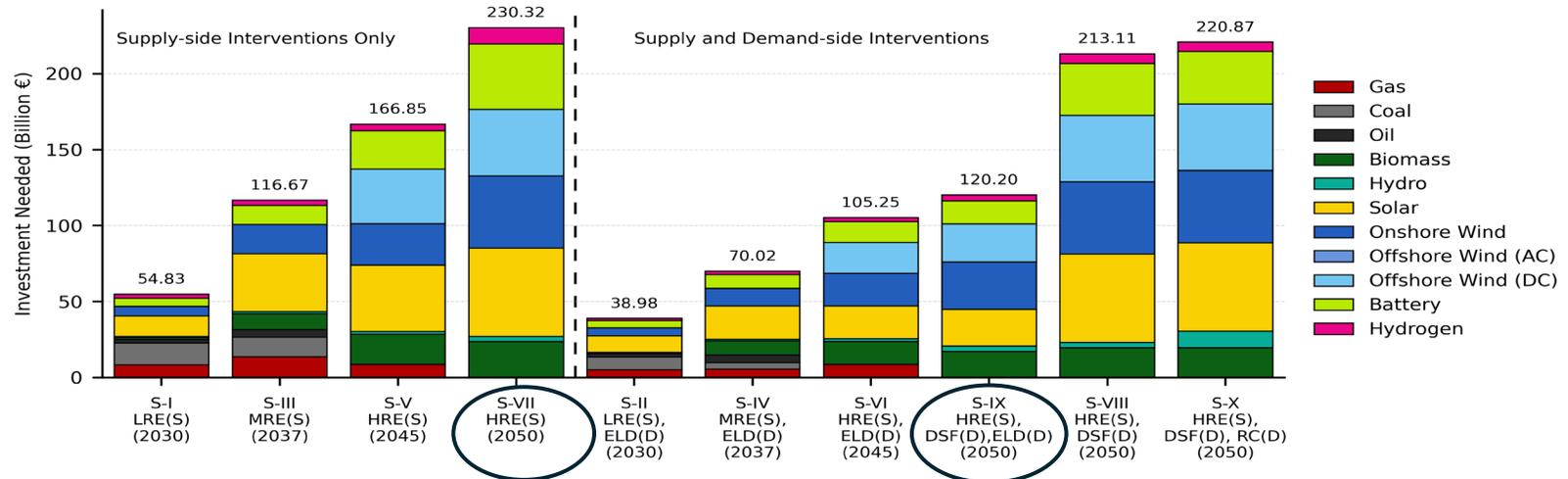


# Investment requirement: Model Results

## Bangladesh

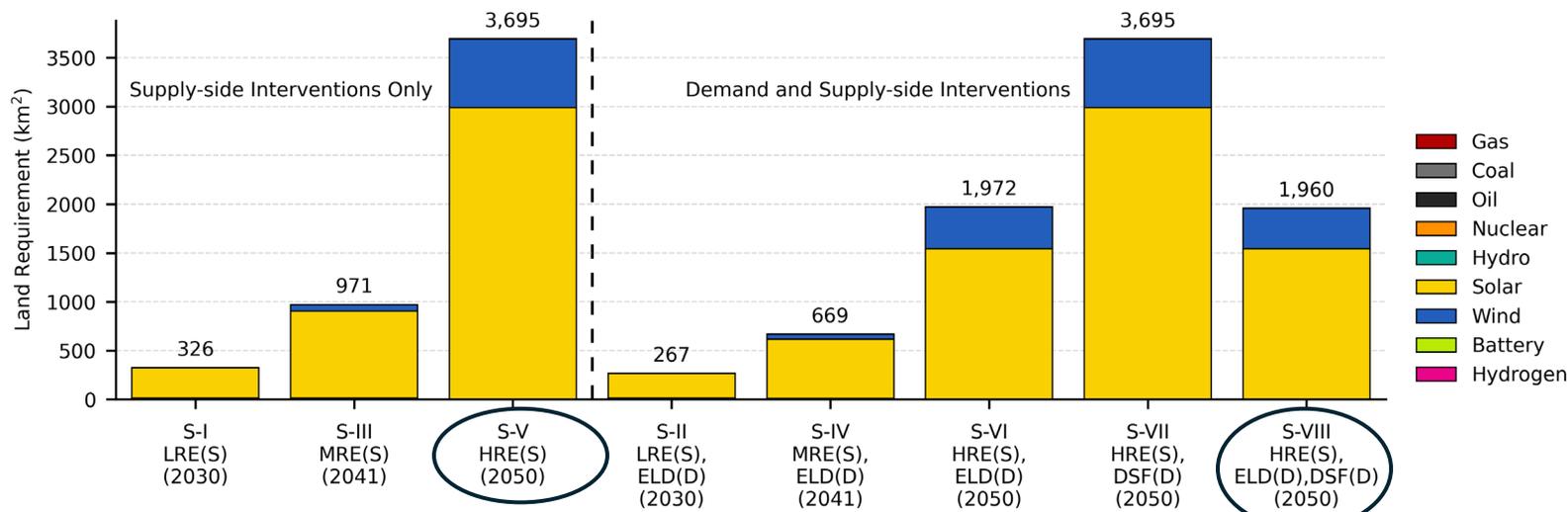


## Thailand

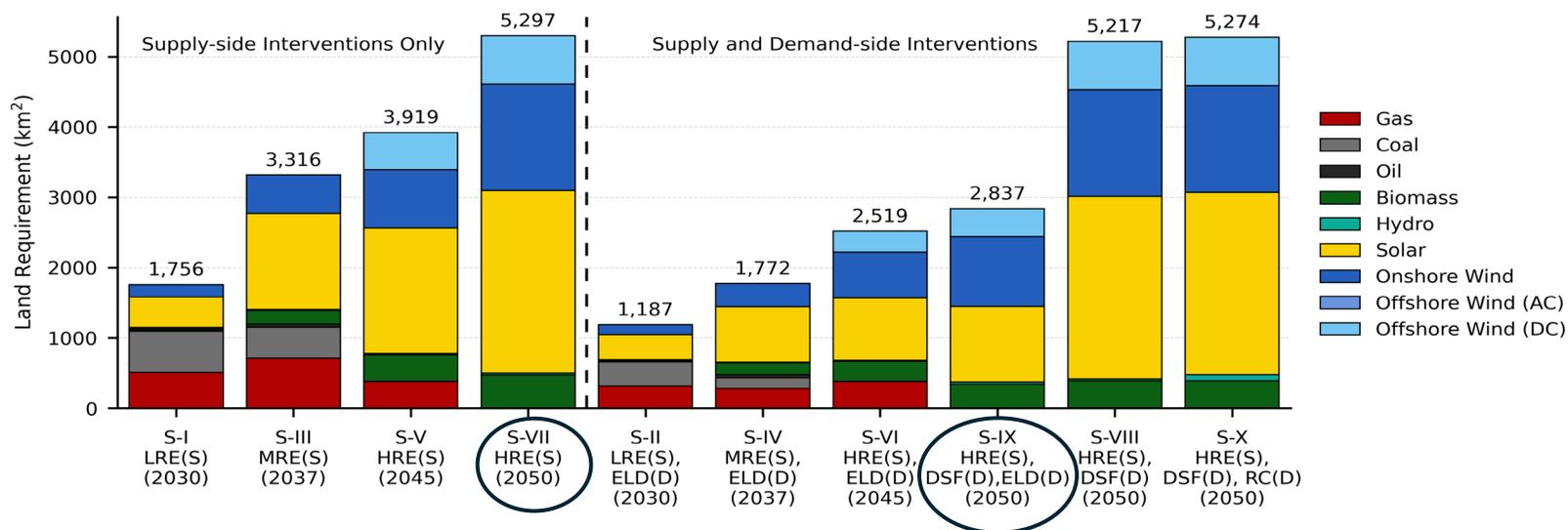


# Land Footprint: Model Results

## Bangladesh

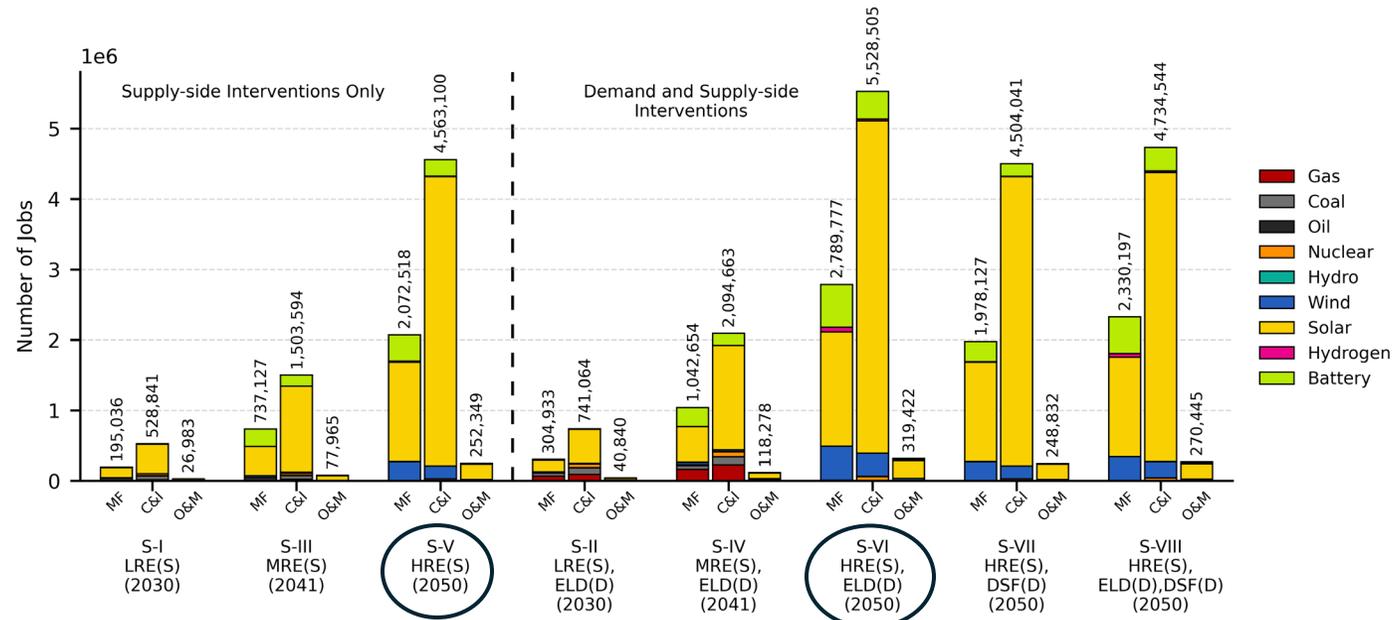


## Thailand

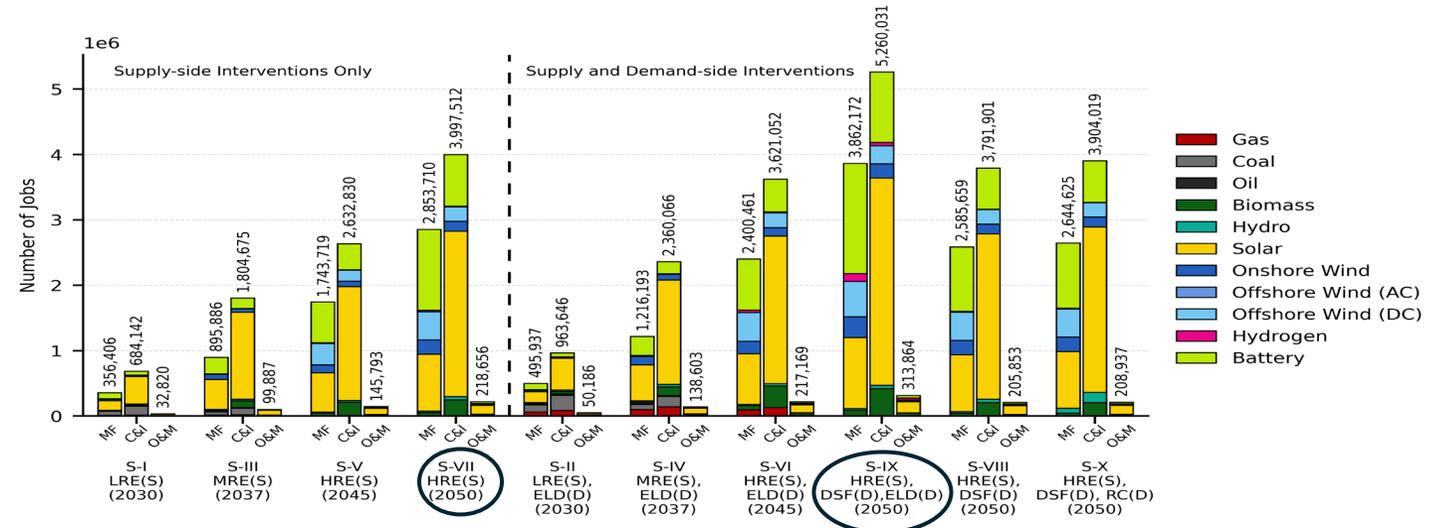


# Job Creation Potential: Model Results

## Bangladesh

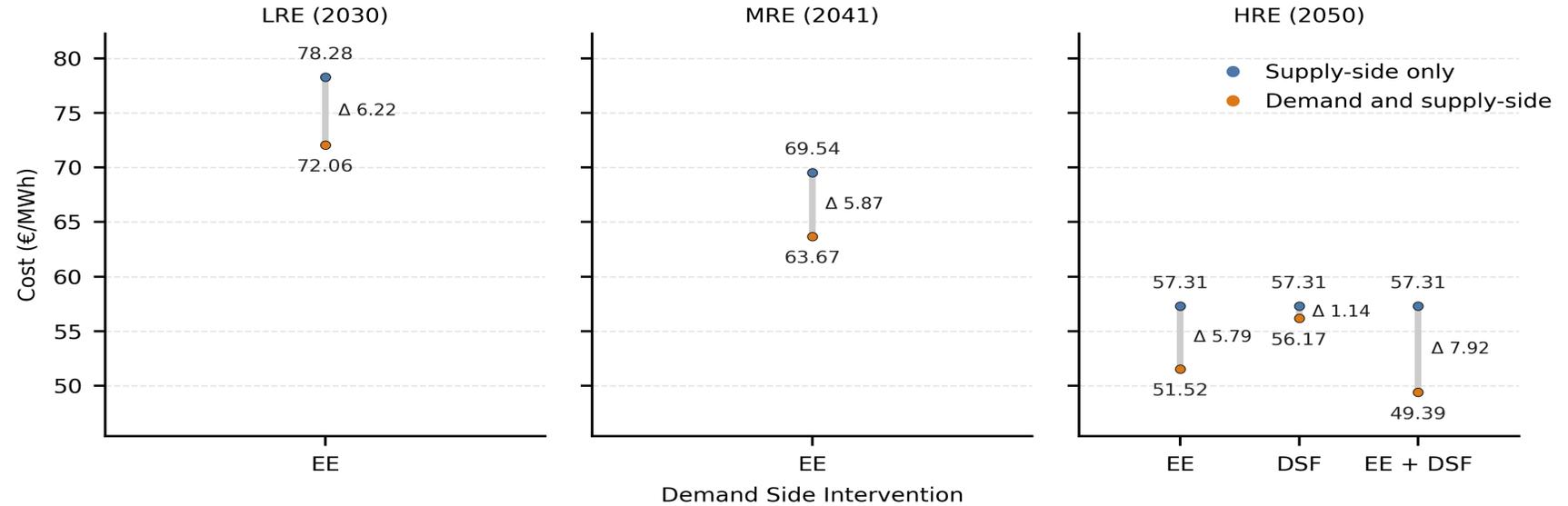


## Thailand

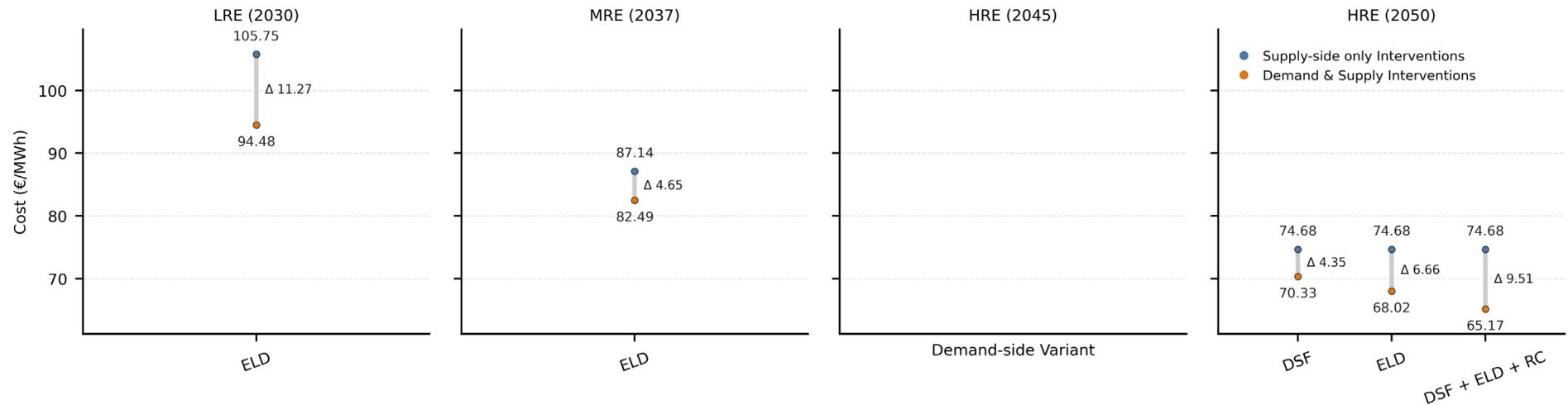


# Power Generation Cost: Model Results

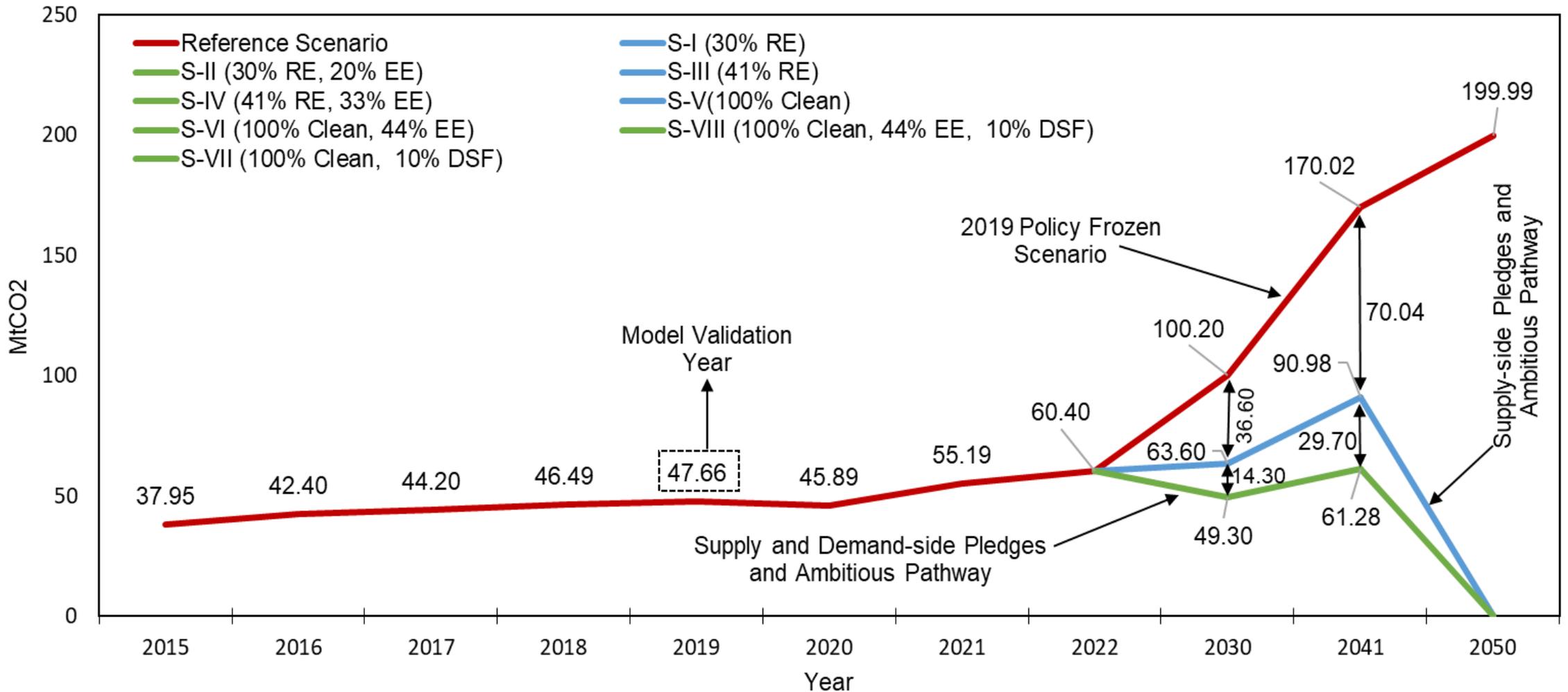
## Bangladesh



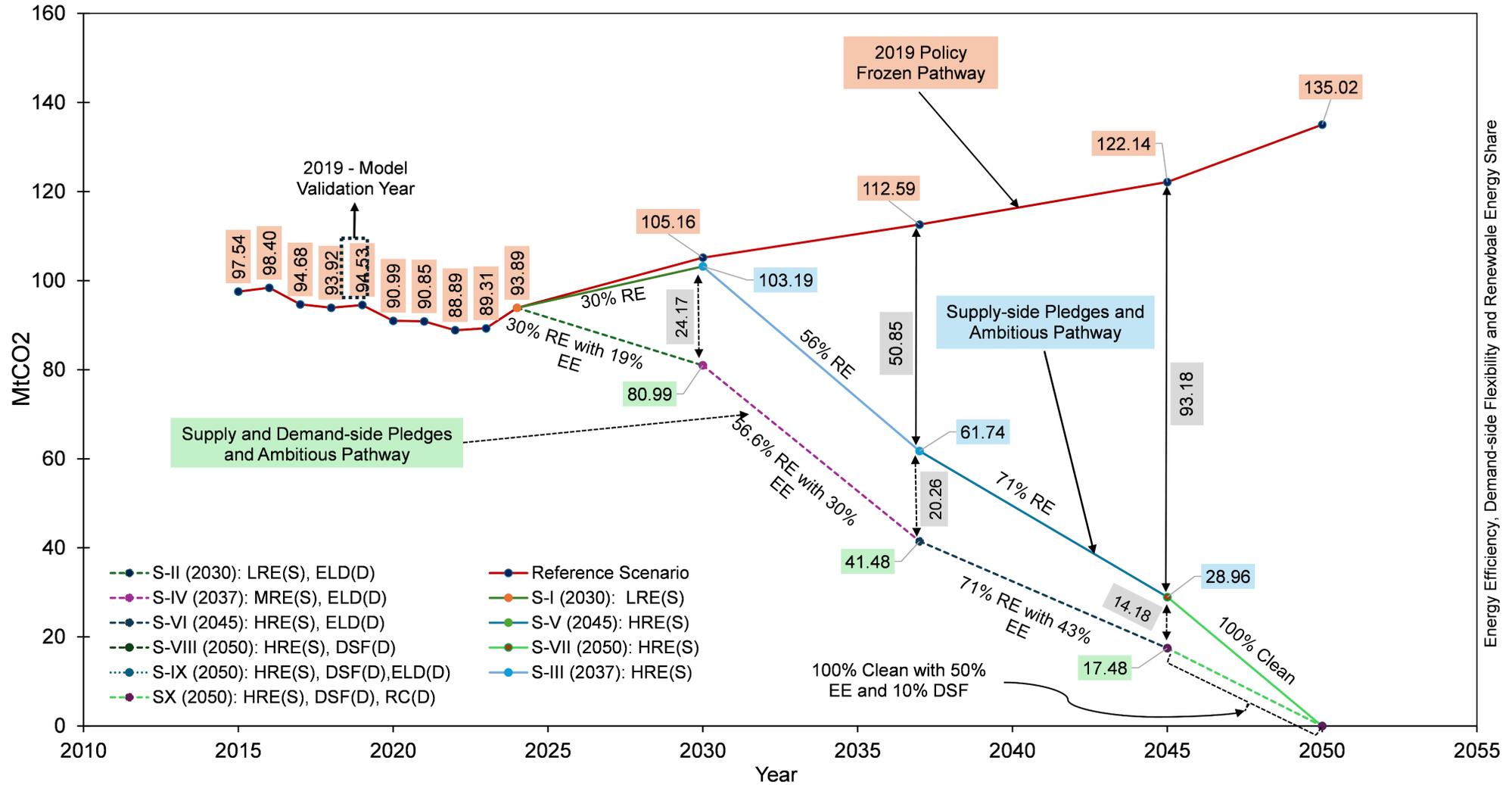
## Thailand



# Emission Pathway: Model Results (Bangladesh)



# Emission Pathway: Model Results (Thailand)



# **India: National and Subnational**

# InDian zEro carbon Energy pAthways

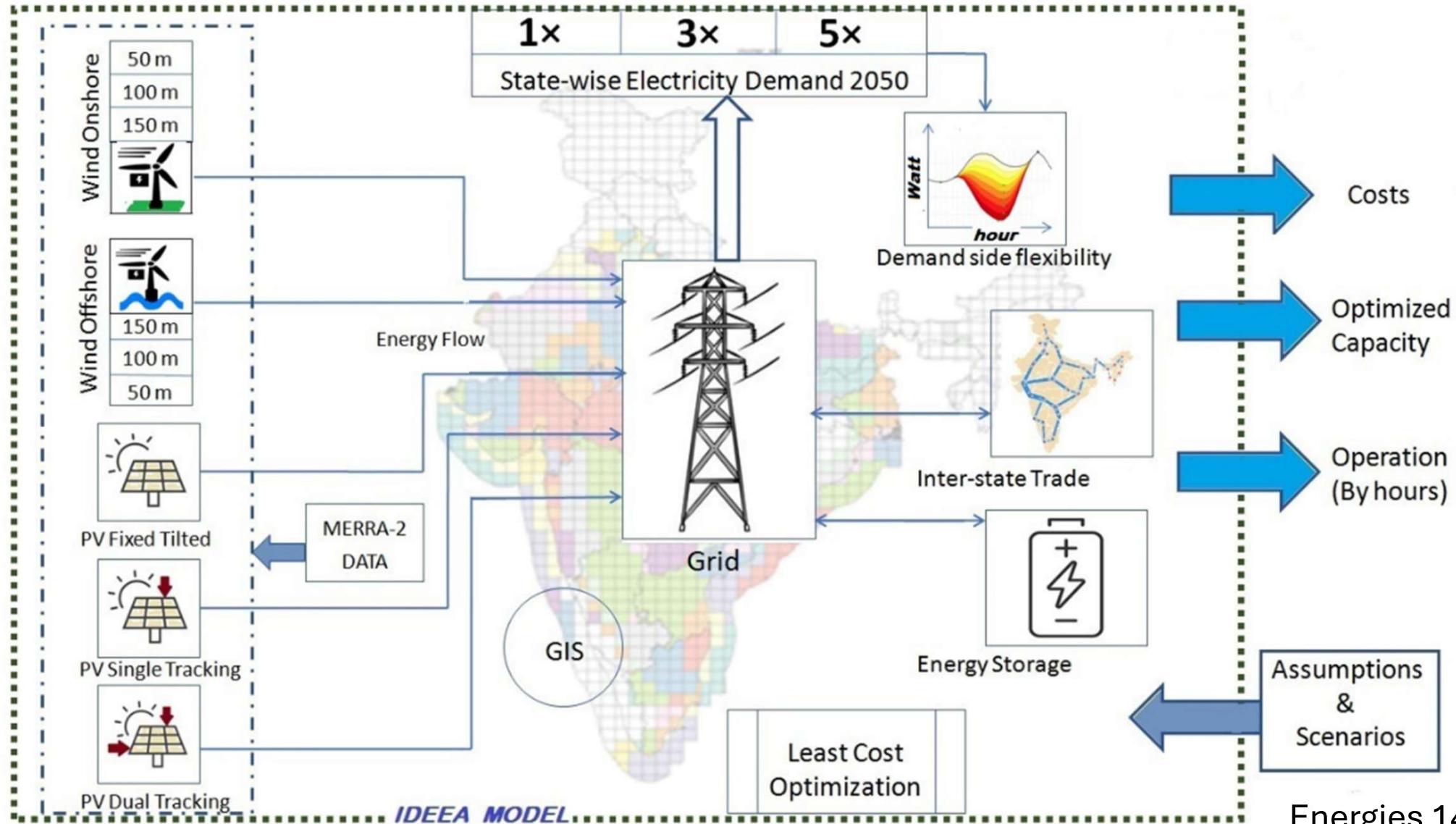
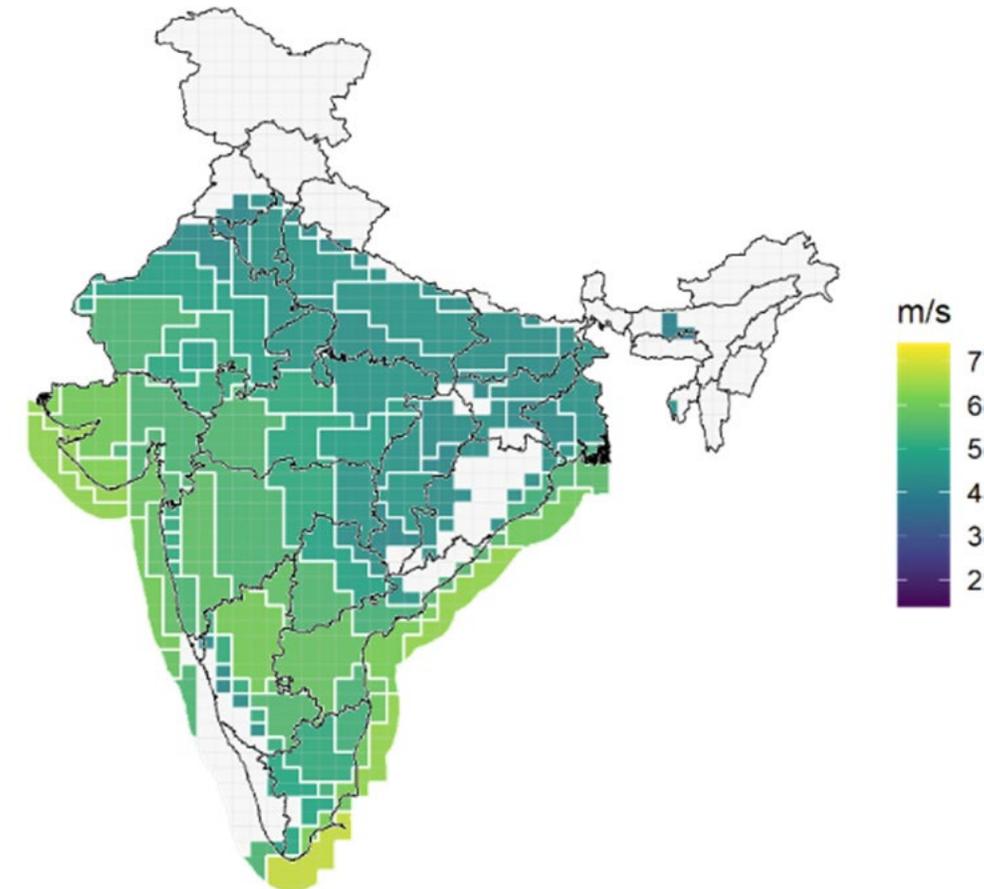
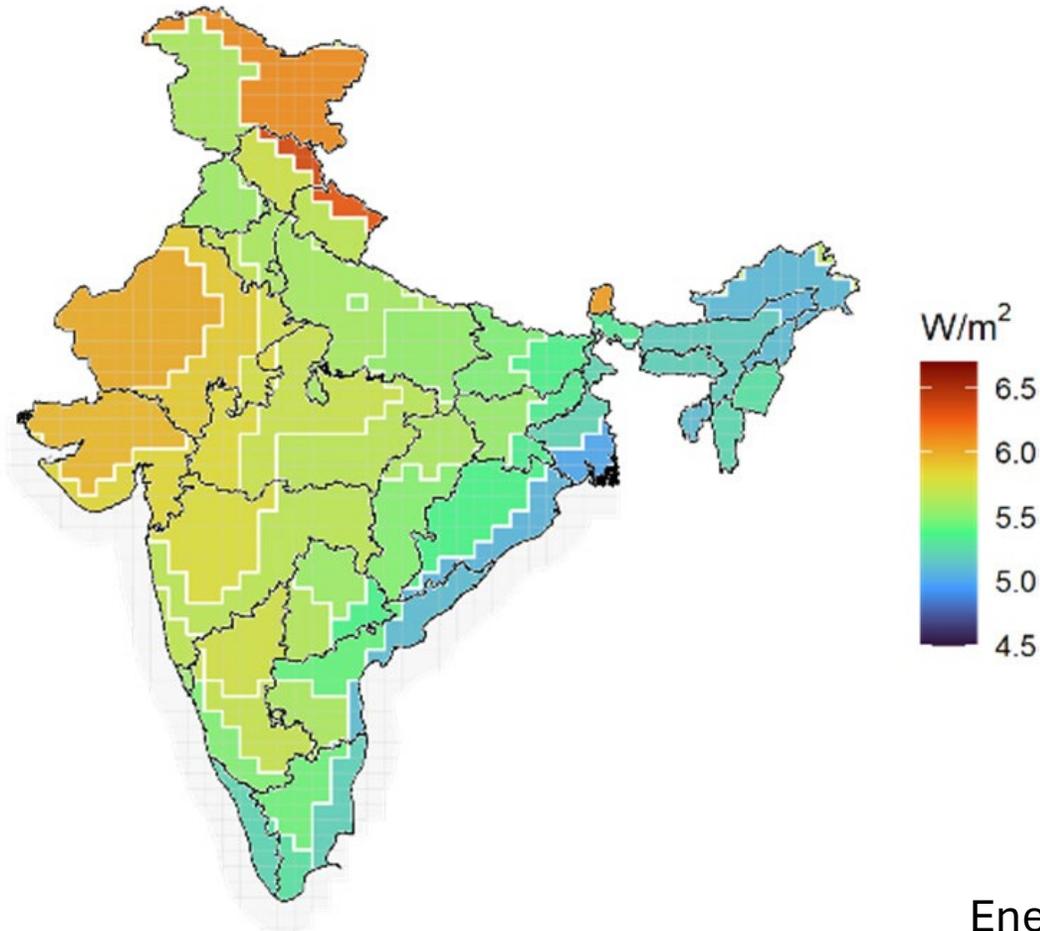
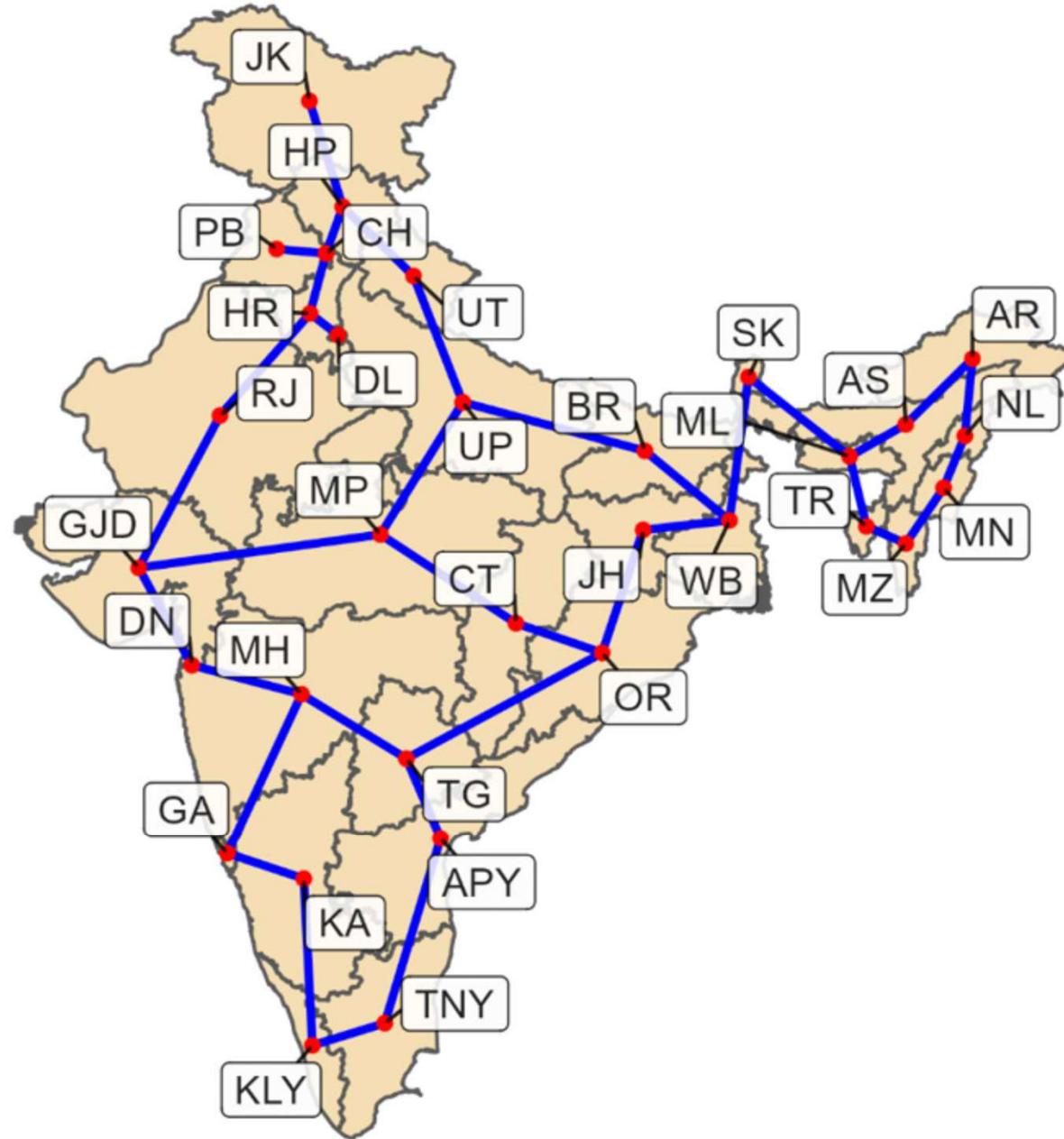


Figure 1. Schematic representation of IDEEA model structure and main functions.

Energies 14, no. 21: 7063.  
<https://doi.org/10.3390/en14217063>

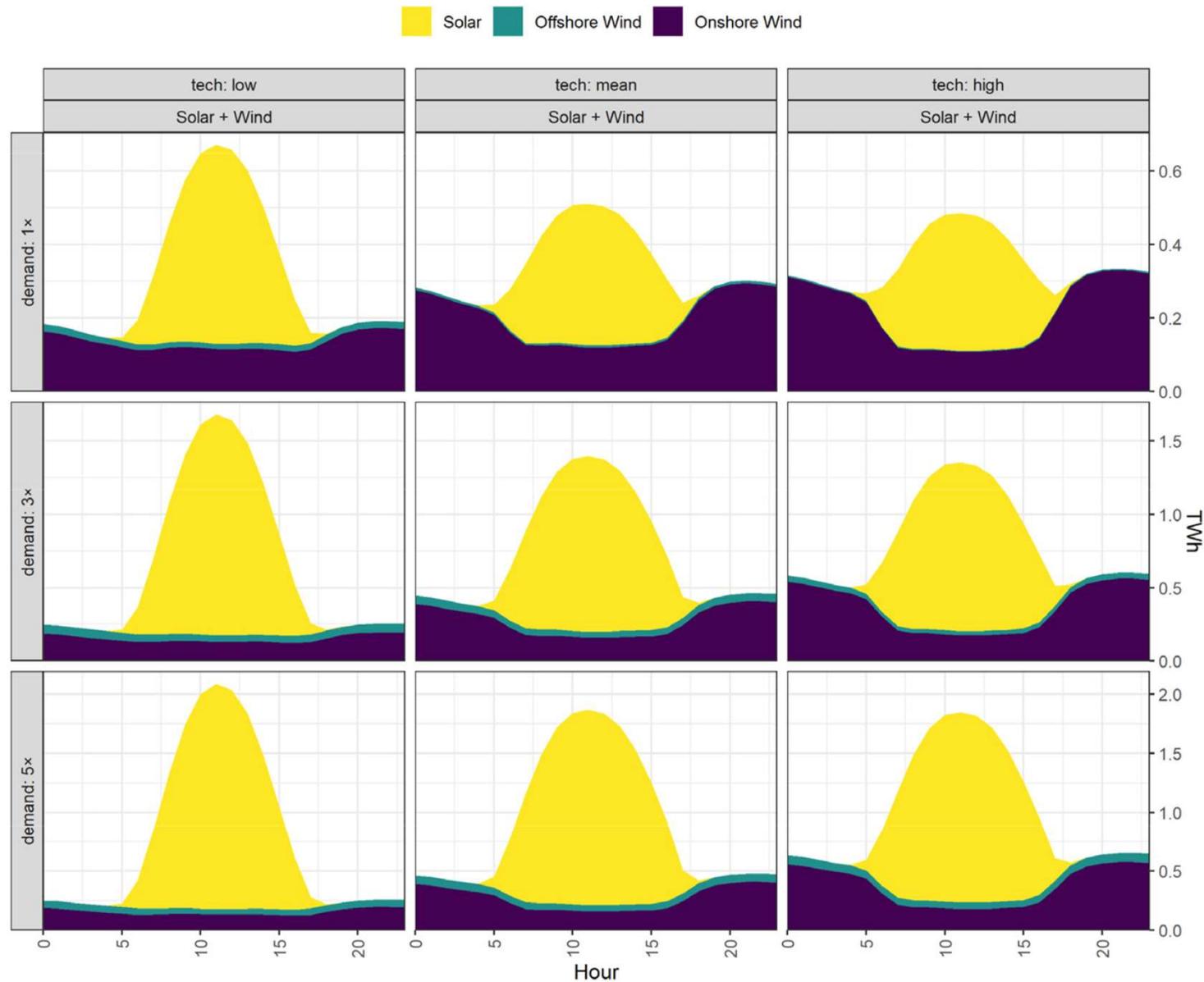
# Solar and wind resource clusters





Energies 14, no. 21: 7063.  
<https://doi.org/10.3390/en14217063>

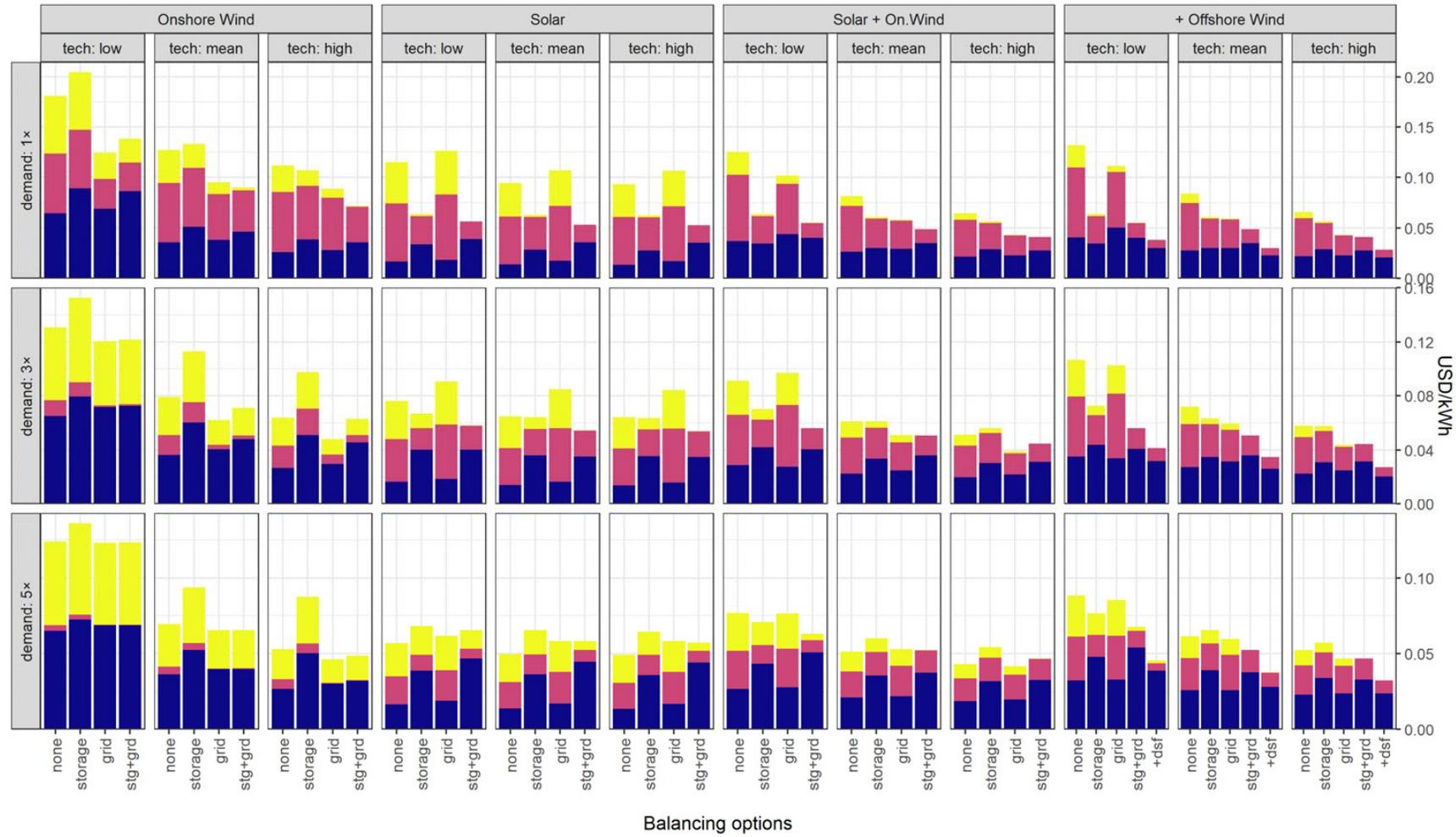
**Figure 3.** Simplified representation of inter-region power grid network with 36 power lines and 32 nodes.



**Figure A25.** Intraday complementarity of wind and solar energy, national aggregate, scenarios without balancing technologies ('none'), weather year 2020.

# Levelized cost of Electricity 153 scenarios

Costs structure: ■ Unserved load ■ Curtailed supply ■ Generation



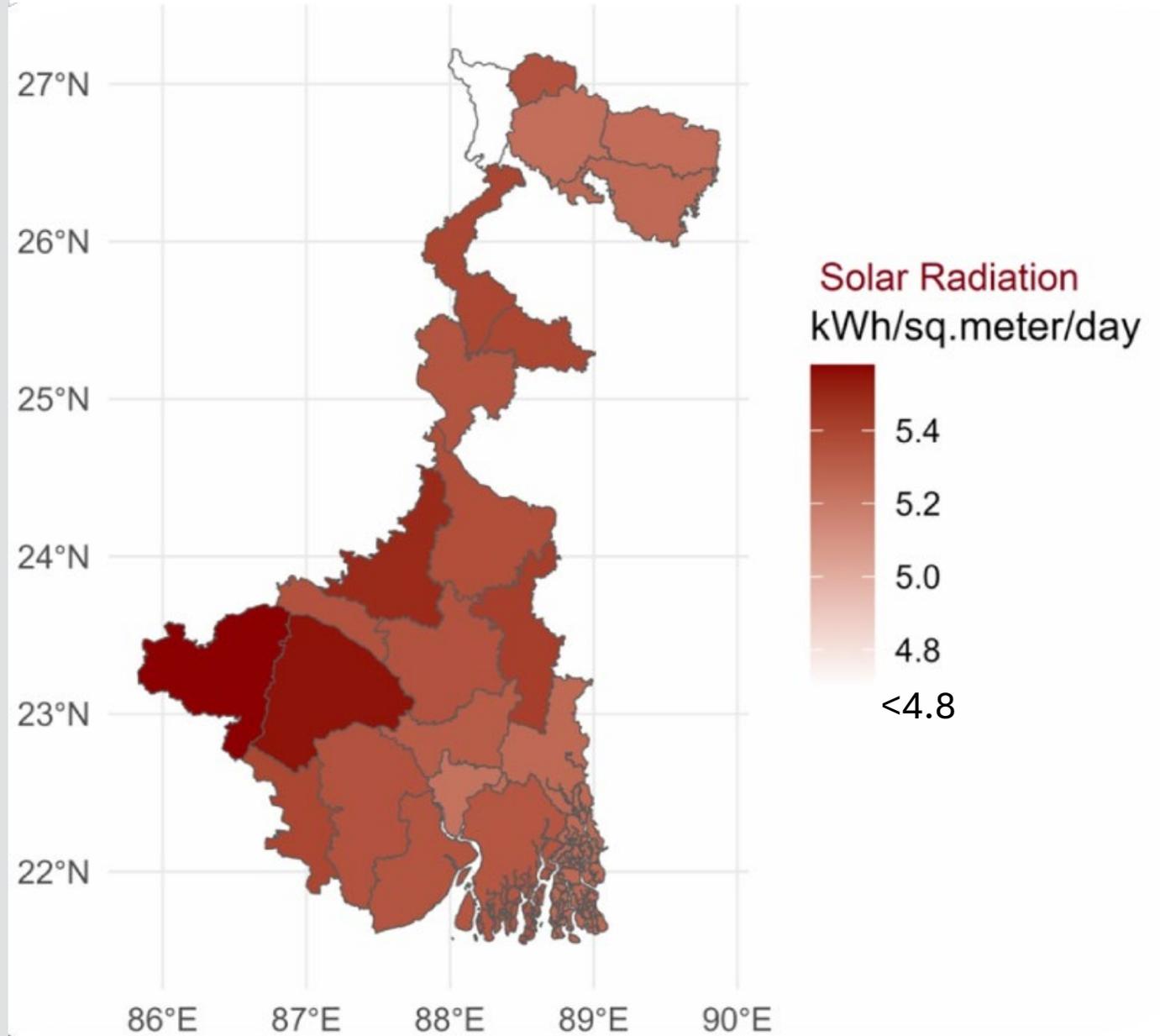
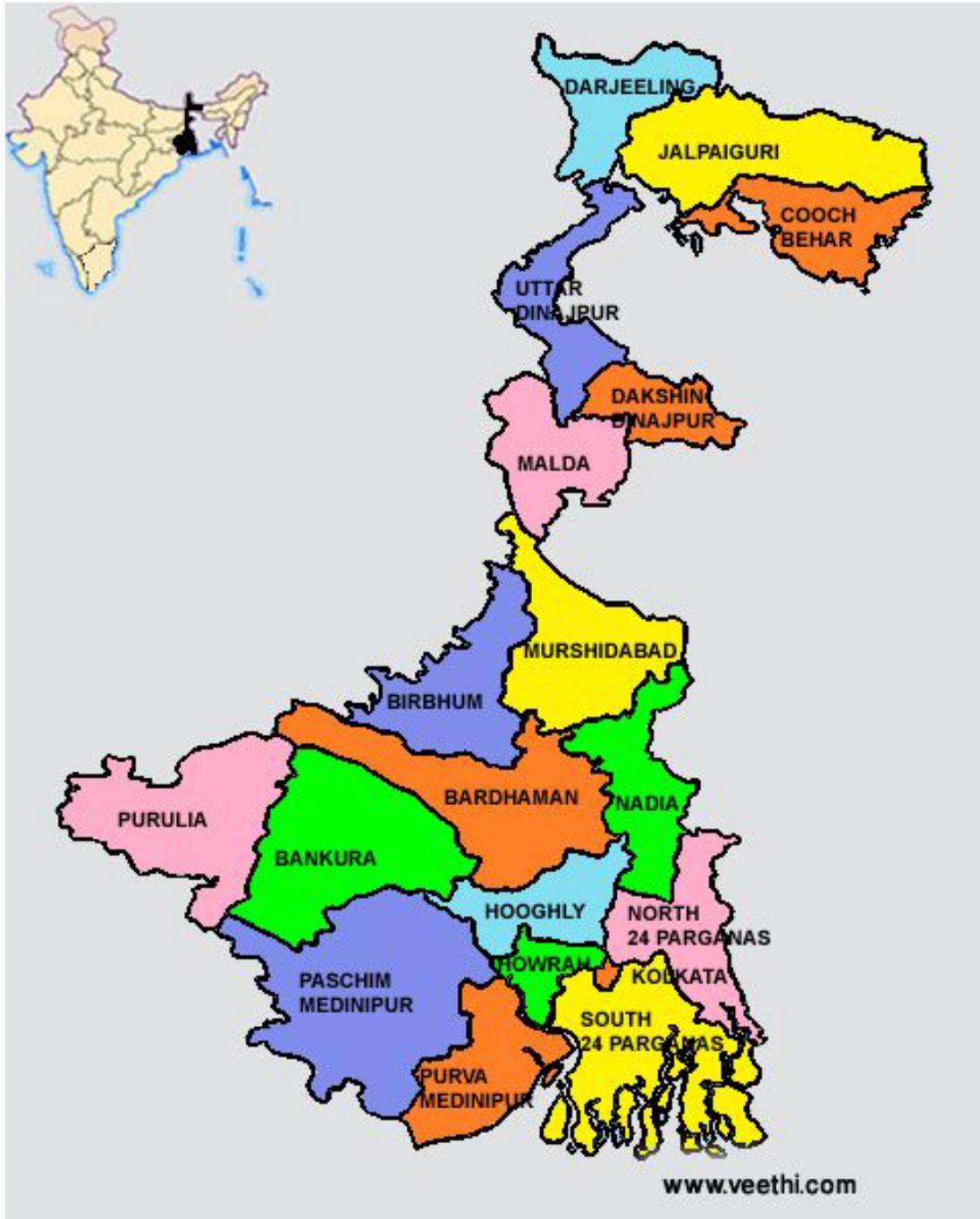
Demand in 2019 (3800 TWh) x3x5

Long term reliable solar-wind based system (optimised over 40 years hourly data)

Demand-side flexibility (+dsf) show the lowest supply costs: 3–4 cents/kWh ( $\geq 5$  cents/kwh)

More technological options on the generation or demand side reduce system inefficiency and lower the cost of electricity.

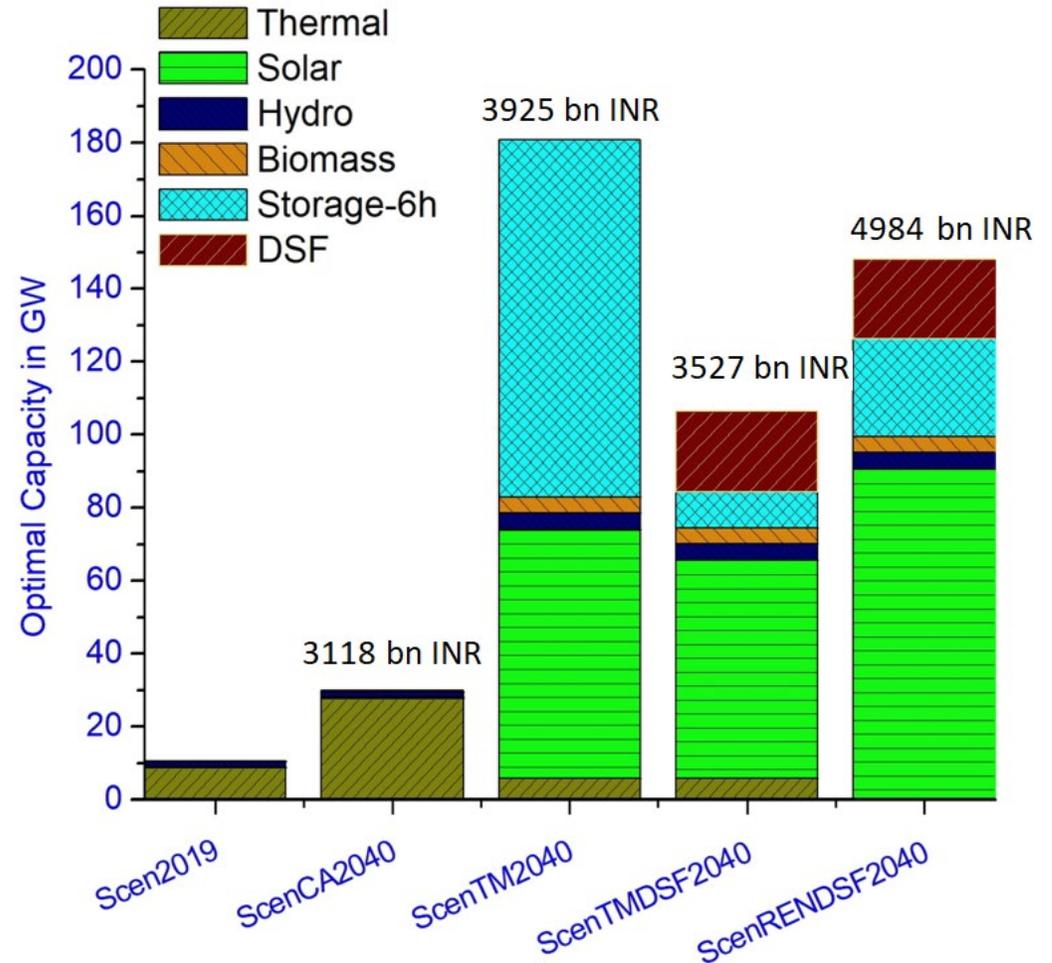
# District level solar potential can drive decisions



<https://doi.org/10.1016/j.esd.2024.101560>

# Alternative Transition plan for WB looking ahead till 2040

- Non fossil fuel-based plan if feasible with storage technology w/wo DSF
- How much thermal generation with DSF
- Investment can be spread over time in various phases (~1.03% of 2021-2022 GDP annual for 20 years)



# Justice in Transition: what narrative will work?

- Competitive market price for RE
- Stranded Assets
- Stake in claims on the remaining global carbon budget
  
- National needs of growth, employment
- Need for redirecting finance
- Development finance agencies to focus on infrastructure and technology access for sustainable transformation

## **Justice in Transition**

To achieve net-zero would mean shifting employment from high- to low-carbon sectors, globally and even locally in carbon-intensive regions

Regional cooperation, new business, new infrastructure

# Thank you for your attention

## Acknowledgement

<https://smartscenter.ait.ac.th/>

### Contact

[joyashree@ait.asia](mailto:joyashree@ait.asia)

[joyashreeju@gmail.com](mailto:joyashreeju@gmail.com)