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# **Aligning Decarbonization of Energy Systems and Sustainable Development in India: Synergies and Tradeoffs**

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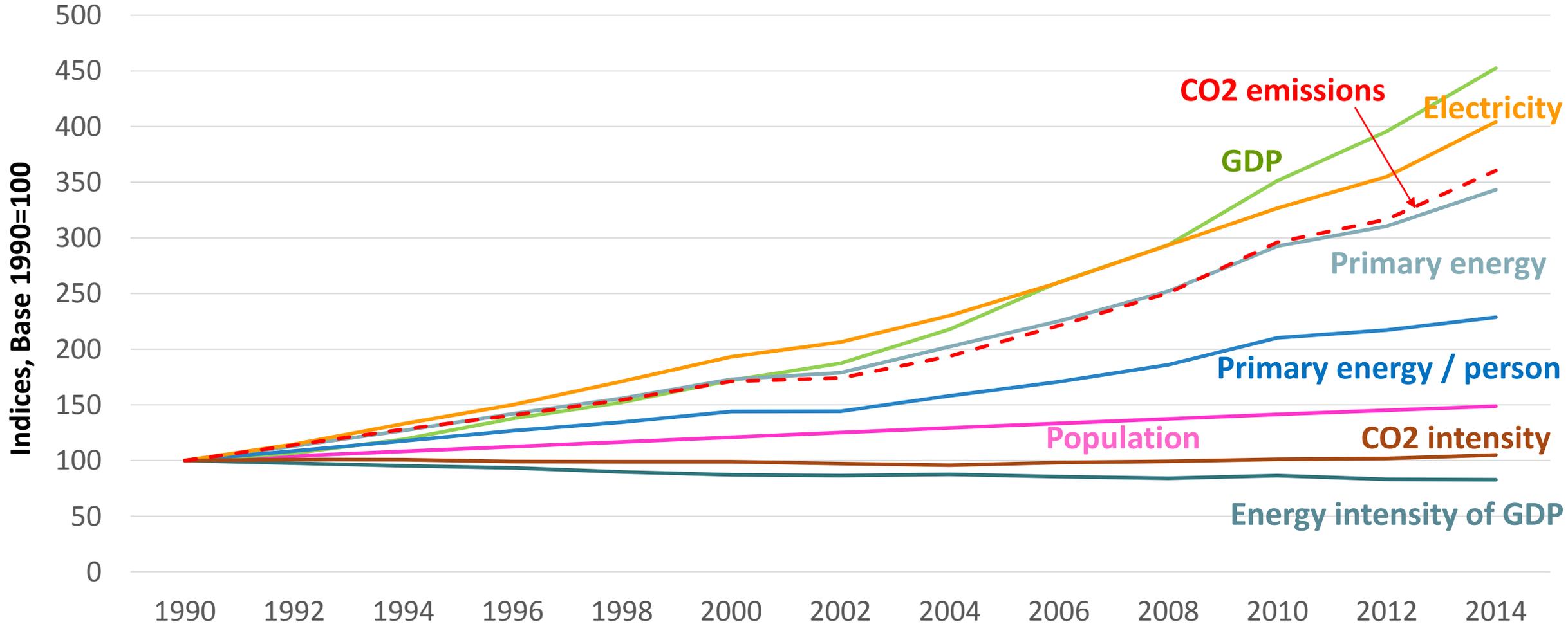
# Outline

- Context
- Research Gaps
- Research Questions
- Research Framework
- Methodology
- Intended Contributions

# Context

- **Paris Agreement on climate change (2015)**
  - Commitment: Limit the global average temperature increase to well below 2°C and pursue efforts for 1.5°C
  - INDCs: Domestic decarbonization targets
  - India's INDCs: Limits on emission intensity, focus on renewables
  - Context: **Sustainable development** and poverty alleviation
- **2030 Agenda for sustainable development (2015)**
  - 17 sustainable development goals, 169 targets
  - SDG 1, SDG 8 & SDG 9: Removal of poverty, economic growth, full employment, infrastructure
  - India: Niti Aayog is the co-ordinating agency
  - SDG 7 & SDG 13: Emphasis on **decarbonization** of energy systems

# Development Transitions for India



Source: World Bank, US EIA historical statistics, Indiatat, CMIE, The shift project data portal

# Research Gaps

Themes	Literature	Research Gap
Aspects of energy systems	Levefre (2016), Gherzi (2015), Combet et al. (2014), Hourcade et al. (2006), Gherzi et al. (2006)	<ul style="list-style-type: none"><li>• Reconciling the energy balance of India with national accounts using energy prices</li><li>• Treatment of issues related to energy systems in India like captive coal mining, non-marketable biomass and natural gas trading</li></ul>

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Renewable energy	Renewables Global Status Report (2015), Dong (2012), Schmid (2012), Hass et al. (2011)	<ul style="list-style-type: none"><li>• Global analysis of changes in renewable policies over time</li></ul>

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Decarbonization of energy systems and sustainable development	Shukla et al. (2015), IPCC AR5 WGIII report (2014), Weitzel et al. (2014), Shukla et al. (2008)	<ul style="list-style-type: none"><li>• Capturing aspects of energy systems</li><li>• Analysis with constraints such as market imperfections, structural inertia and myopic investment behavior</li><li>• Combining top-down and bottom-up approaches</li></ul>

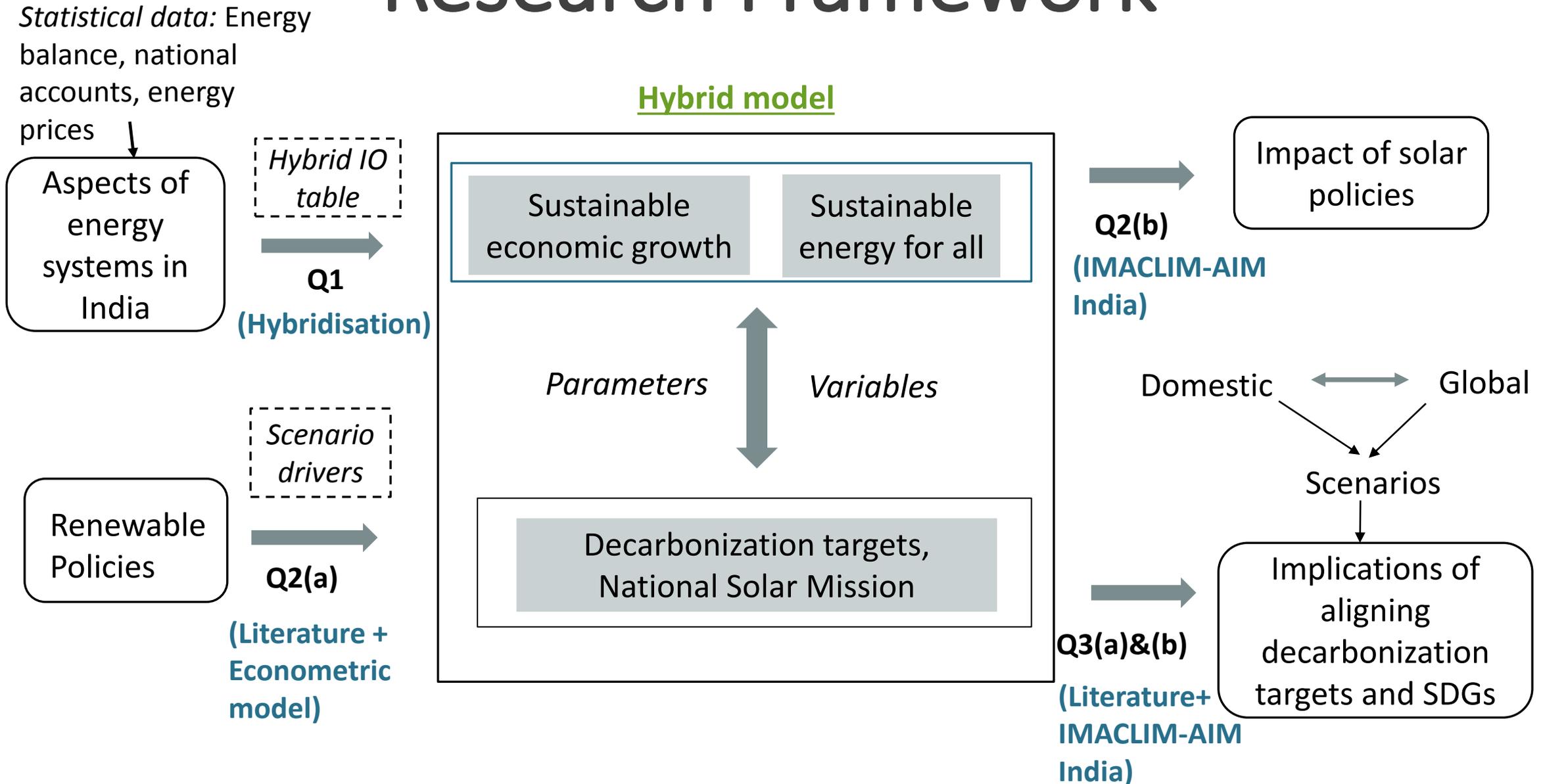
# Research Questions

1. How can decarbonization of energy systems and sustainable development goals be aligned for India, especially using the energy balance, national accounts and energy prices?
2. a) How have policy instruments evolved for promoting deployment of renewable electricity generating technologies across the world, and what policy lessons could be drawn for India?  
b) What are the macroeconomic implications of promoting deployment of solar energy in short-, medium- and long-terms in India?

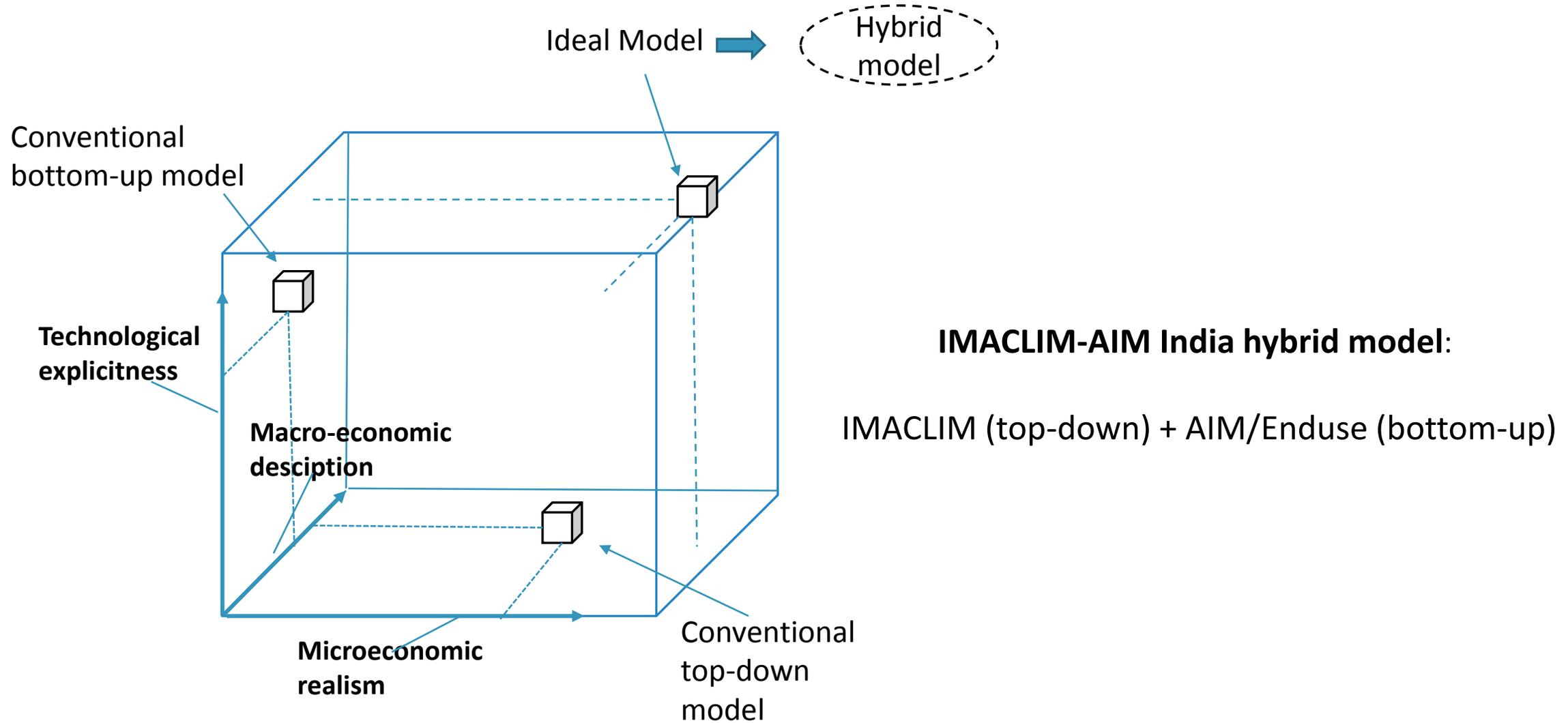
# Research Questions

3. a) What would be the implications of aligning decarbonization targets and sustainable development goals in future for India under alternate scenarios, such as, i) domestic policy scenarios – solar push, INDC, advanced INDC; ii) global decarbonization targets – 2°C, well below 2°C?
- b) What policies would be required to synchronize the domestic scenarios and the global overarching targets?

# Research Framework



# Hybrid Model



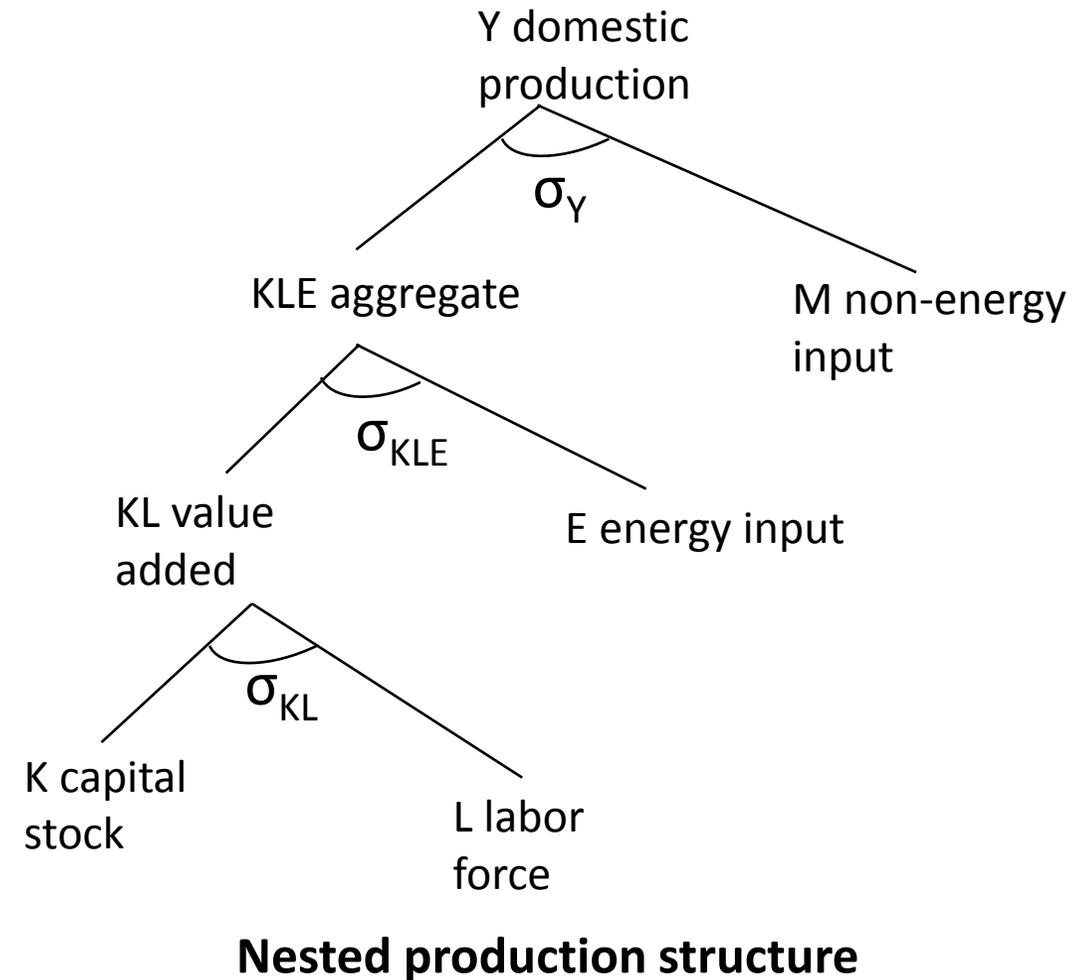
Source: Adapted from Hourcade et al., 2006

# RESEARCH METHODOLOGY

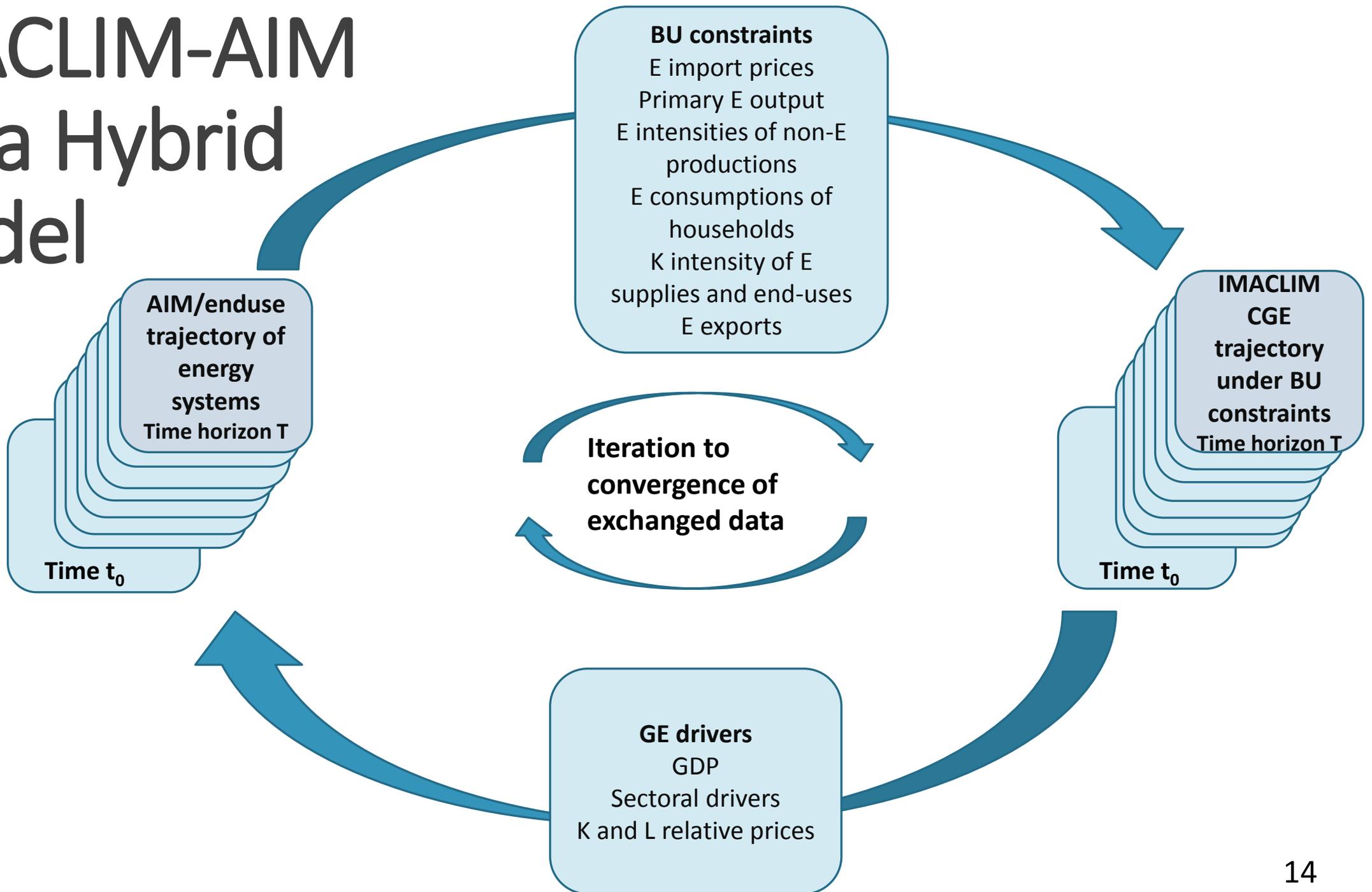
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# 2-Sector Model Overview

- 2-Sector is based on standard CGE model of 'KLEM' nature.
- Two primary factors of production capital (K) and labour (L) and two goods that is energy aggregate (E) and non-energy good (M).
- Production of both goods is represented as a nested structure of primary and secondary factor consumptions that combine following CES functions.
- Caution: Inadequacy of CES functions (Gherzi & Hourcade, 2006).



# IMACLIM-AIM India Hybrid Model



# Methodology - Q1

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1. How can decarbonization of energy systems and sustainable development goals be aligned for India, especially using the energy balance, national accounts and energy prices?

# Methodology - Q1

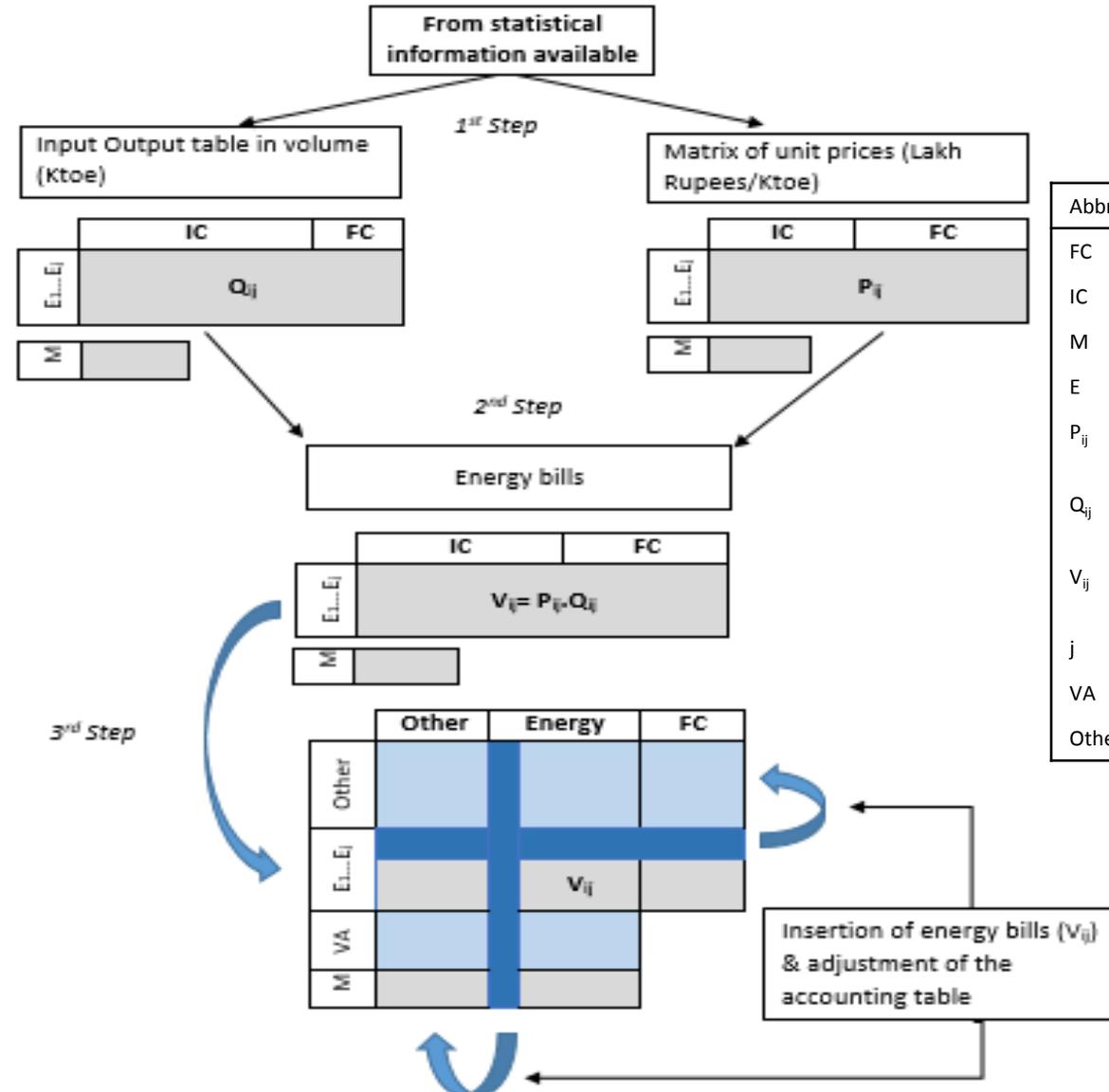
(Base Year 2012)

## Energy Sectors (8)

Coal  
Coke  
Crude oil and non-transport fuels  
Transport fuels  
Biomass  
Natural gas  
Electricity  
Renewable Energy

## Non-energy sectors (14)

Iron & Steel  
Chemical  
Aluminium  
Cement  
Construction  
Textile  
Residual industries  
Agriculture  
Air transport  
Water transport  
Road transport  
Rail transport  
Housing  
Other services



Abbreviation and description	
FC	Final Consumption
IC	Intermediate Consumption
M	Imports
E	Energy sector
P <sub>ij</sub>	Unit prices of energy sector i for sector j
Q <sub>ij</sub>	Volume of energy sector i by sector j
V <sub>ij</sub>	Purchases of energy sector i by sector j
j	Number of energy sector
VA	Value added
Other	Other sectors than energy

# Methodology – Q2(b), Q3

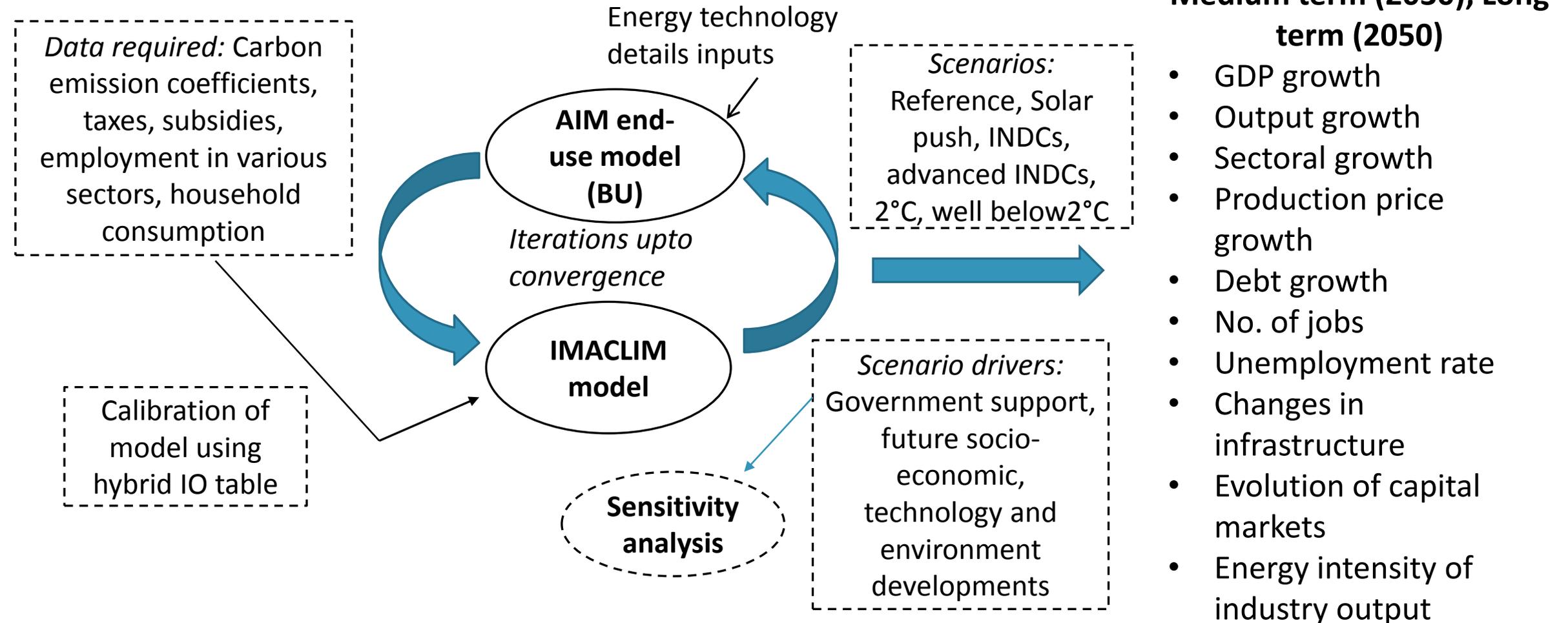
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2. (b) What are the macroeconomic implications of promoting deployment of solar energy in short-, medium- and long-terms in India?

3. a) What would be the implications of aligning decarbonization targets and sustainable development goals in future for India under alternate scenarios, such as, i) domestic policy scenarios – solar push, INDC, advanced INDC; ii) global decarbonization targets – 2°C, well below 2°C?

b) What policies would be required to synchronize the domestic scenarios and the global overarching targets?

# Methodology – Q2(b), Q3

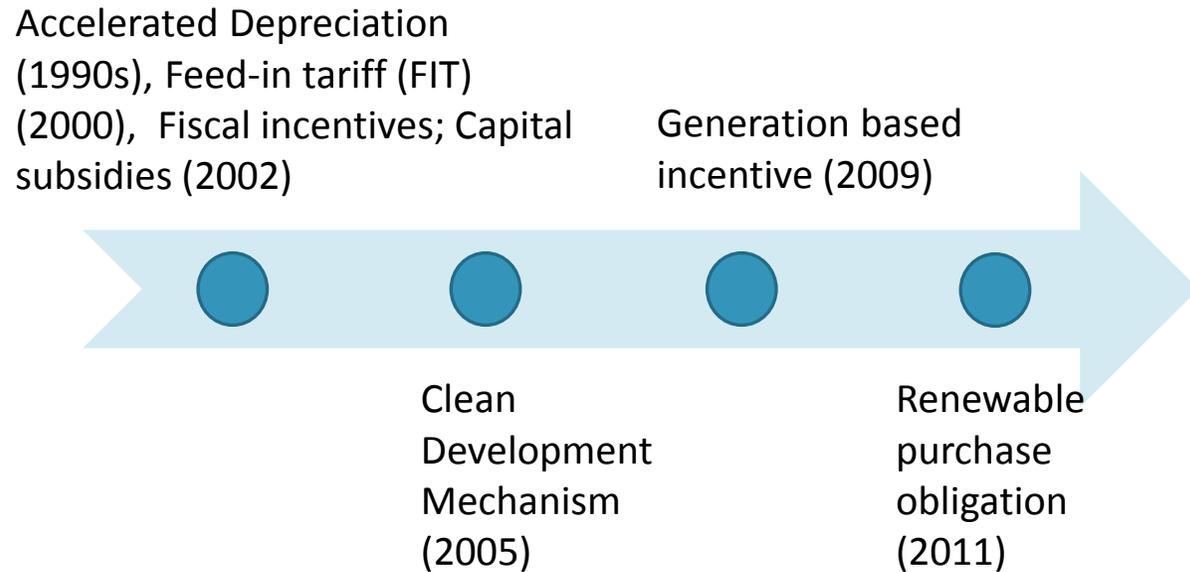


# Methodology – Q2(a)

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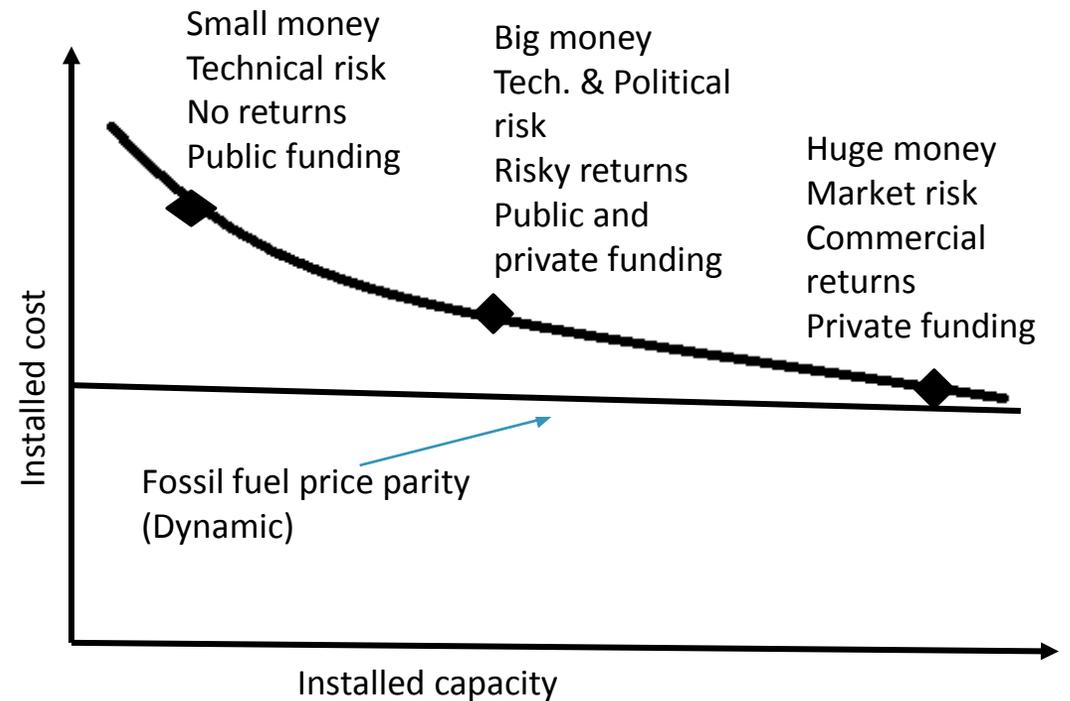
2. a) How have policy instruments evolved for promoting deployment of renewable electricity generating technologies across the world, and what policy lessons could be drawn for India?

# Renewables - Q2(a)



## Renewable policies in India

Source: Government documents



## Stages of government support

Source: Adapted from Grubb et al., 2004

# Change in Feed-in tariffs - Q2(a)

Econometric panel data analysis of feed-in tariffs across 16 countries and 10 US states from 2009-2014.

$$FIT_{it} = \beta_0 + \theta_t + \alpha_i + \beta_1 * SGEN + \beta_2 * WTP + \beta_3 * PERC + \beta_4 * SGEN^2 + Z'_{it} \delta + U_{it}$$

i = Country index

t = Year index

FIT= Feed-in tariff rate

$\beta_0$ = Intercept

$\theta_t$  = Year dummies

SGEN = Share of wind generation

WTP = Wind turbine price

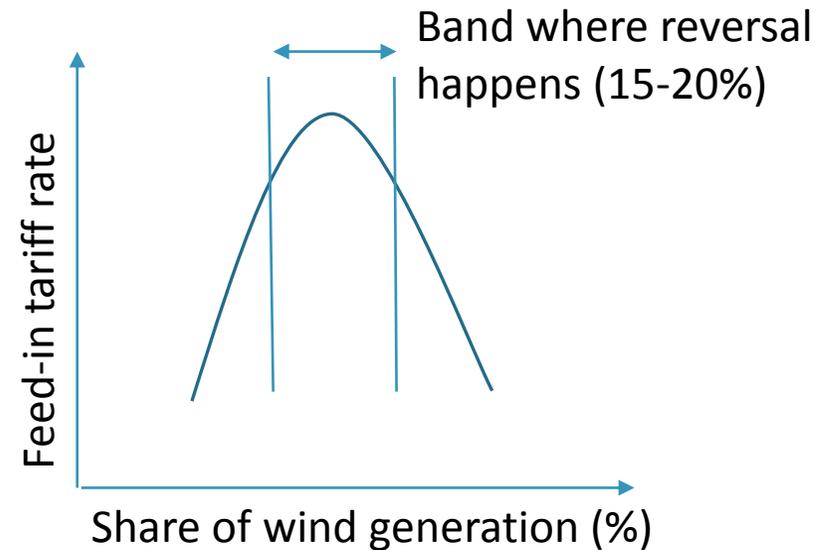
PERC = Ratio of feed-in tariff and electricity price

Z = Other covariates like share of wind capacity, absolute wind capacity and absolute wind generation

U = Error term

$\alpha_i$  = Country specific unobservable effects

**Change in feed-in tariffs with increasing share of wind energy**



# Intended Contributions

- Inputs to policymakers for aligning the decarbonization of energy systems and sustainable development in India
- Policy implications for increasing the share of solar capacity in total installed power capacity
- Development of IMACLIM-India model with hybrid IO table for India
- Contribution to the literature for achieving mitigation targets at global level

# Thank You

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# Sustainable Development Goals

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17 SDGs

## **Sustainable energy for all**

**7.1** By 2030, ensure **universal access** to affordable, reliable and modern energy services

**7.2** By 2030, **increase substantially the share of renewable energy** in the global energy mix

**7.3** By 2030, double the global rate of **improvement in energy efficiency**

**7.a** By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and **promote investment in energy infrastructure and clean energy technology**

**7.b** By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support

# Sustainable Development Goals

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## Sustainable economic growth

**8.1** Sustain **per capita economic growth** in accordance with national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the least developed countries

**8.2** Achieve **higher levels of economic productivity** through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors

**8.3** Promote **development-oriented policies** that support productive activities, **decent job creation**, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services

**8.4** Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to **decouple economic growth from environmental degradation**, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead

# Climate Policies and Sustainable Development

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## 1. Choice of development path

- Meeting both goals is no longer 'aspiration'

- Behavioral/ institutional lock-ins sustain technology/infrastructure lock-ins (Shukla, 2015)

## 2. Integrated assessment for policy assessment still lacking

## 3. Weak alignment with 2°C pathway

## 4. Long term policies should involve developing market for low carbon industry and services, unlocking old lock-ins, preventing new lock-ins and capacity building for adaptation.

# Ambitious Decarbonization Objectives

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India's INDCs: To reduce the emissions intensity of its gross domestic product (GDP) by 33-35 per cent by 2030, compared to 2005 levels, and to achieve 40 percent cumulative installed grid power capacity from non-fossil fuel-based energy resources by 2030

Climate policy: 8 missions (3 to be added later) currently being implemented under NAPCC for decarbonizing the energy systems.

## **National solar mission**

- Solar power capacity target under the mission is to achieve 100 GW by 2022 from the present capacity of 7.44 GW (6.7 GW installed power, 1 GW rooftop) (CEA, 2016; Bridge to India report, 2016). This includes 40 GW rooftop and 60 GW large and medium scale grid connected solar power projects (Gol, 2015).

- Policies and schemes to support the mission include solar park scheme, CPSU scheme, defence scheme, VGF scheme, canal bank scheme, capital subsidy, bundling scheme, Renewable Purchase Obligation (RPO), fiscal incentives (MNRE, 2016).

## **National enhanced energy efficiency mission**

- Overall size of energy efficiency market is estimated to be Rs 74,000 crores of which only 5% has been tapped mainly in the area of lighting (BEE, Ministry of Power).

- EESL (joint venture of NTPC, PFC, REC and POWERGRID) created to facilitate the implementation of energy efficiency projects.

- 4 initiatives: Perform Achieve Trade (PAT), Market Transformation for Energy Efficiency (MTEE), Energy Efficiency Financing Platform (EEFP), Framework for Energy Efficient Economic Development (FEEED)

# India's Energy-Economy-Environment

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## **Energy sector**

- 75% of the demand for energy in India is met by fossil fuels with coal forming the backbone of Indian power sector accounting for 70% of power generation (India energy outlook report (IEA, 2015).
- India's growing population and urbanization will lead to an increase of energy demand by one-third by 2022 in INDC scenario (IEA, 2015) which will be met by fossil fuels to a large extent.

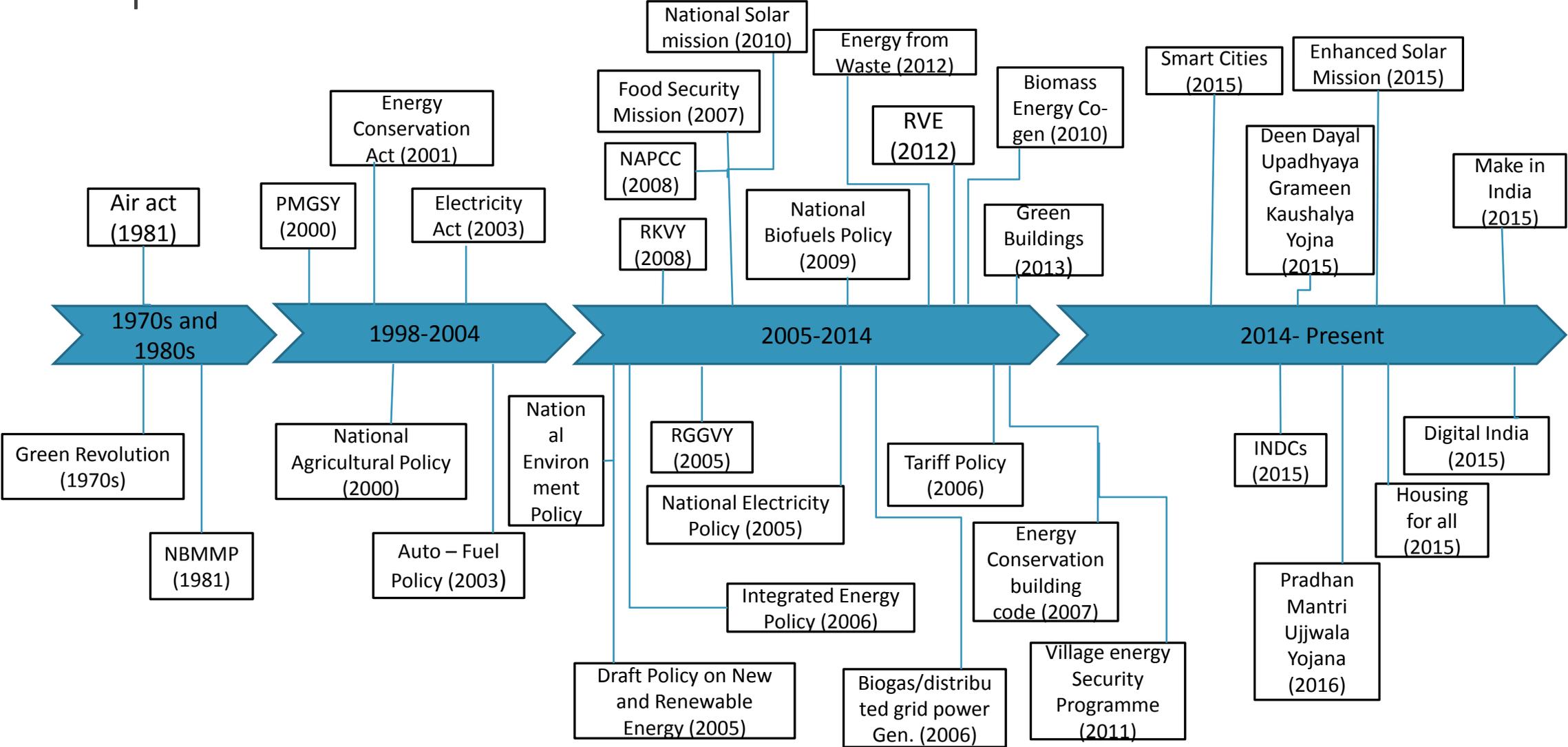
## **Economy**

- India is a developing economy with a growth rate of 7.6% in 2015-16 and per capita income of Rs 77,435 in 2015-16 at constant 2011-12 prices (MoS&PI, GoI, 2016). 21.9% of the total population lives in poverty (NSSO, 68<sup>th</sup> round). 19% of the population does not have access to electricity (WEO, 2016)
- Half of rural India lacks basic socio-economic services and is categorized as 'deprived' (SECC survey, 2011)
- "The exodus of rural Indians into the cities over the coming decades will pose tremendous challenges..." (Economic Survey, 2016-17)

## **GHG emissions profile for India**

- India has fourth largest emissions in the world, though per capita emissions at 1.5 tonnes of CO<sub>2</sub> (2013) are just one third of global average.
- Estimates from IEA indicate that with the rapid growth in energy demand, CO<sub>2</sub> emissions are expected to increase by 65% by 2030.
- Move to carbon tax regime, India is now de facto imposing a carbon tax of US\$150 per ton on petroleum products which is about 6 times above the level recommended by the Stern Review on Climate Change (Economic Survey, 2016-17).

# Timeline of development policies having interface with energy & climate policies



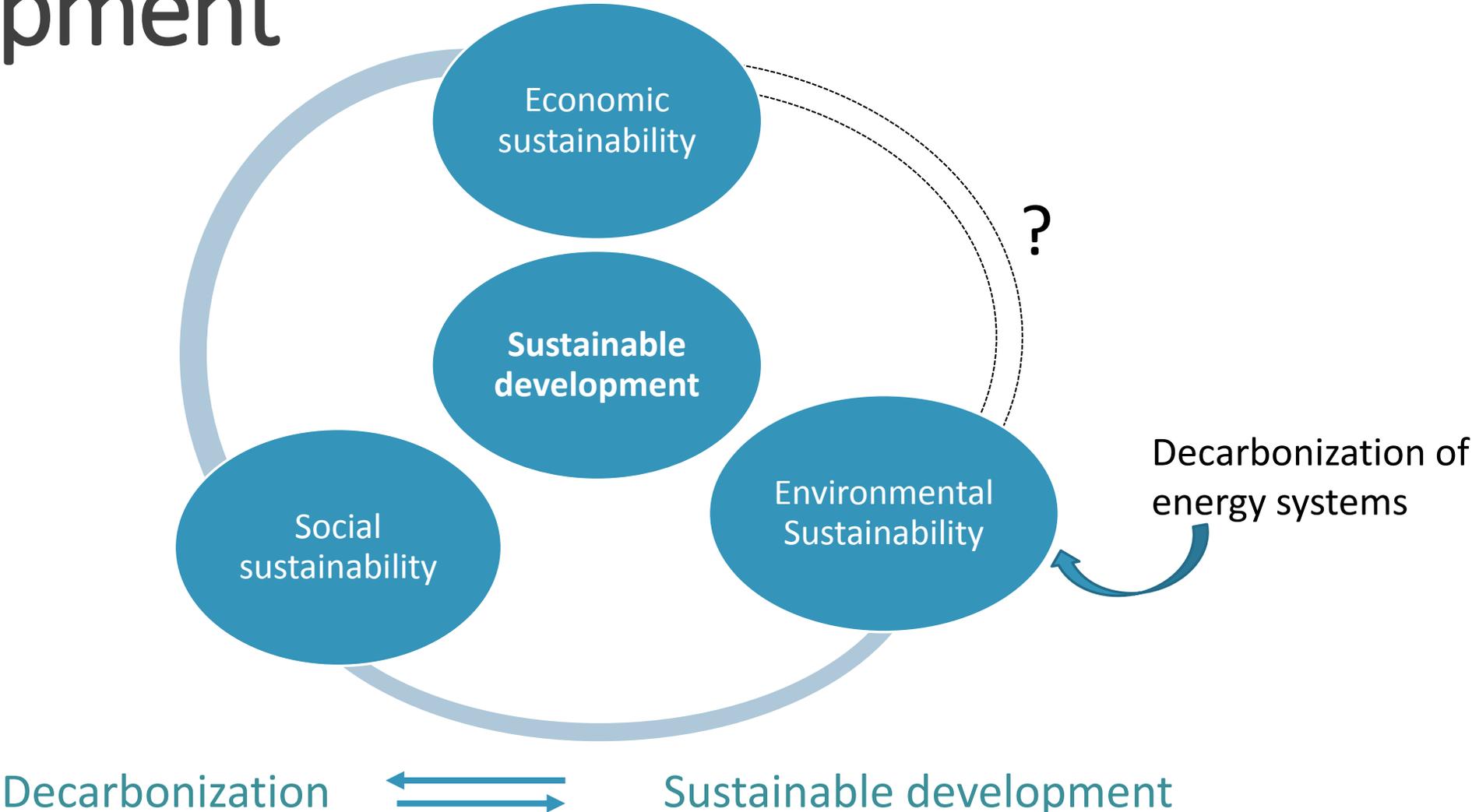
NBMMP: National Biomass and Manure Management Programme; RKVY: Rashtriya Krishi Vikas Yojana; RGGVY: Rajiv Gandhi Grameen Viduytikaran Yojana; RVE: Remote Village Electrification Programme

Source: MoP&NG (GoI), MoEF, MNRE, Ministry of Power, Ministry of Coal, Shukla et al., 2015

# Context

- “...holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change” - Historic Paris agreement which was adopted by 175 countries on 12<sup>th</sup> December, 2015 and came into force on 4<sup>th</sup> November, 2016.
  - To reduce the emissions intensity of its gross domestic product (GDP) by 33-35 per cent by 2030, compared to 2005 levels, and to increase the renewable capacity from 35 GW to 175 GW by 2022 – India’s INDC to UNFCCC
  - “Protecting the poor and vulnerable sections of society through an inclusive and sustainable development strategy, sensitive to climate change” - National Action Plan on Climate Change (NAPCC), MoEF, GoI. Currently, National Missions like National Solar Mission (NSM) and National Mission for Enhancing Energy Efficiency (NMEEE) form the core of National action plan.
- Adoption of 17 Sustainable Development Goals (SDGs) under 2030 agenda in Sept, 2015 by 193 countries
  - By 2030, ensure universal access to affordable, reliable and modern energy services –SDG7
  - Sustain per capita economic growth in accordance with national circumstances- SDG8

# Decarbonization and Sustainable Development



Source: Milanovic, 2011; Fay, M. (2012)

# How can Decarbonization impact Sustainable Development?

