Just Energy Transition in India: Policy Modelling and Implementation

Keshab Bhattarai
University of Hull, Business School, HU6 7RX, UK
Phone 44 (0)1482463207 mobile 447932854651
Email: K.R.Bhattarai@hull.ac.uk

Debesh Patra
Visiting faculty, St. Xavier's Autonomous College, Mumbai
Former Executive Director, Bharat Petroleum Corporation Ltd.
Telephone – 022-35095771; Mobile - 9820132213
E-mail: drdcpatra@gmail.com,

Asha Prasuna
Department of Economics, K J Somaiya Institute of Management
Somaiya Vidyavihar University (SVU), Vidyavihar (E) Mumbai 400077, India
Telephone – 022-67283056 Mobile 9819533266
Email Address: ashasivakumar@somaiya.edu

S.N.V. Siva Kumar
Department of Economics, K J Somaiya Institute of Management
Somaiya Vidyavihar University (SVU), Vidyavihar (E) Mumbai 400077, India
Telephone – 022-67283052 Mobile 9833914459
Email Address: sivakumar@somaiya.edu

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Abstract

The process of a Just Energy Transition (JET) seeks to address the dual challenges of mitigating climate change and ensuring social equity. For India, a country with significant development needs and a vast reliance on fossil fuels now, transitioning to a low-carbon economy while safeguarding the livelihoods of vulnerable communities presents both a critical opportunity and a formidable challenge.

India's energy sector is characterized by heavy dependence on coal, which accounts for over 62% of the electricity generated. While renewable energy targets, such as achieving 500 GW of non-fossil fuel capacity by 2030, reflect the country's commitment to a low-carbon future, the socio-economic implications of transitioning from fossil fuels have not been adequately addressed. The coal sector directly and indirectly employs millions of workers and supports several coal-dependent regions. Any abrupt shift risks exacerbating unemployment, economic disparities, and social tensions. Consequently, a just transition in India must prioritize inclusive growth, retraining programs, and the creation of alternative livelihoods for affected populations.

Policy frameworks form the cornerstone of India's energy transition efforts. The paper reviews national-level policies, including the National Electricity Plan, Renewable Energy Policy, and coal sector reforms, assessing their alignment with principles of justice and equity. Additionally, state-level initiatives in coal-rich regions such as Jharkhand, Chhattisgarh, and Odisha are analyzed to understand localized challenges and best practices. However, the analysis identifies gaps in integrating labor rights, social welfare measures, and community engagement into these policies. The absence of a centralized just transition framework further complicates the implementation process.

Just energy transition theory revolves around five themes: (1) just transition as a labour-oriented concept, (2) just transition as an integrated framework for justice, (3) just transition as a theory of socio-technical transition, (4) just transition as a governance strategy, and (5) just transition as public perception. This research aims to show Just Energy Transition from socio-economic perspectives with an illustration of Just Energy Transition path, phases and impact models.

After examining energy trends and quantitative data simple numerical example of energy transition dynamics, CGE model for analysis of sectoral and institutional foundations of the relative price system of the Indian economy and ultimatum game analysis can provide empirical frameworks required by policies on just energy transition. These results provide insights into the trade-offs between economic growth, emissions reduction, and energy affordability, transition for all stakeholders.

Theoretical models existing in the literature in this domain are multisectoral, prominently such as the Neo-classical Economic Theory, Energy-Economy Modelling, Integrated Assessment Models (IAMs), Resource Economics Theory, Behavioural Economics framework, Energy Transition Theory, Energy Justice Framework, Complex Systems and Network Theory, Institutional and Political Economy Theories, Energy Demand-Side Management Frameworks.

Keywords: Just energy transition, sustainable development, green energy, green finance

Introduction

India is growing very fast – this requires a massive amount of energy. The growth of electricity generation shows that non-renewable fossil fuels, such as coal, are the major sources of electricity and contribute to over 60 per cent of electricity generation in India. Despite very active government programs to promote renewable energy, only 30 per cent of electricity is generated by renewable sources such as hydro, solar, nuclear and biofuel. Figures 1, 2, 3 and 4 clearly illustrate the heavily carbon-intensive composition of electricity in India (2030 Global Renewable Target Tracker | Ember).

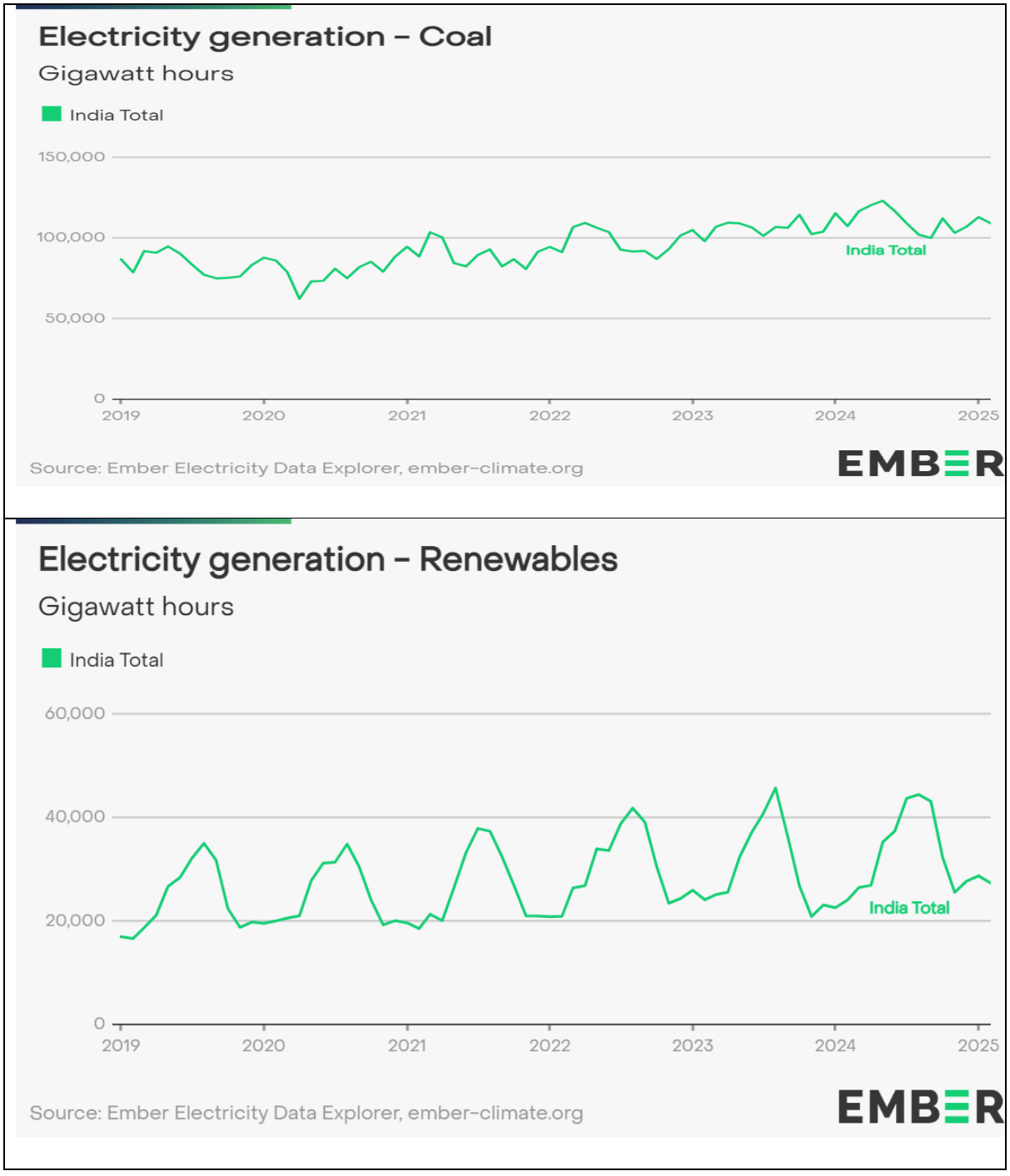

Figure 1: Energy composition in GW

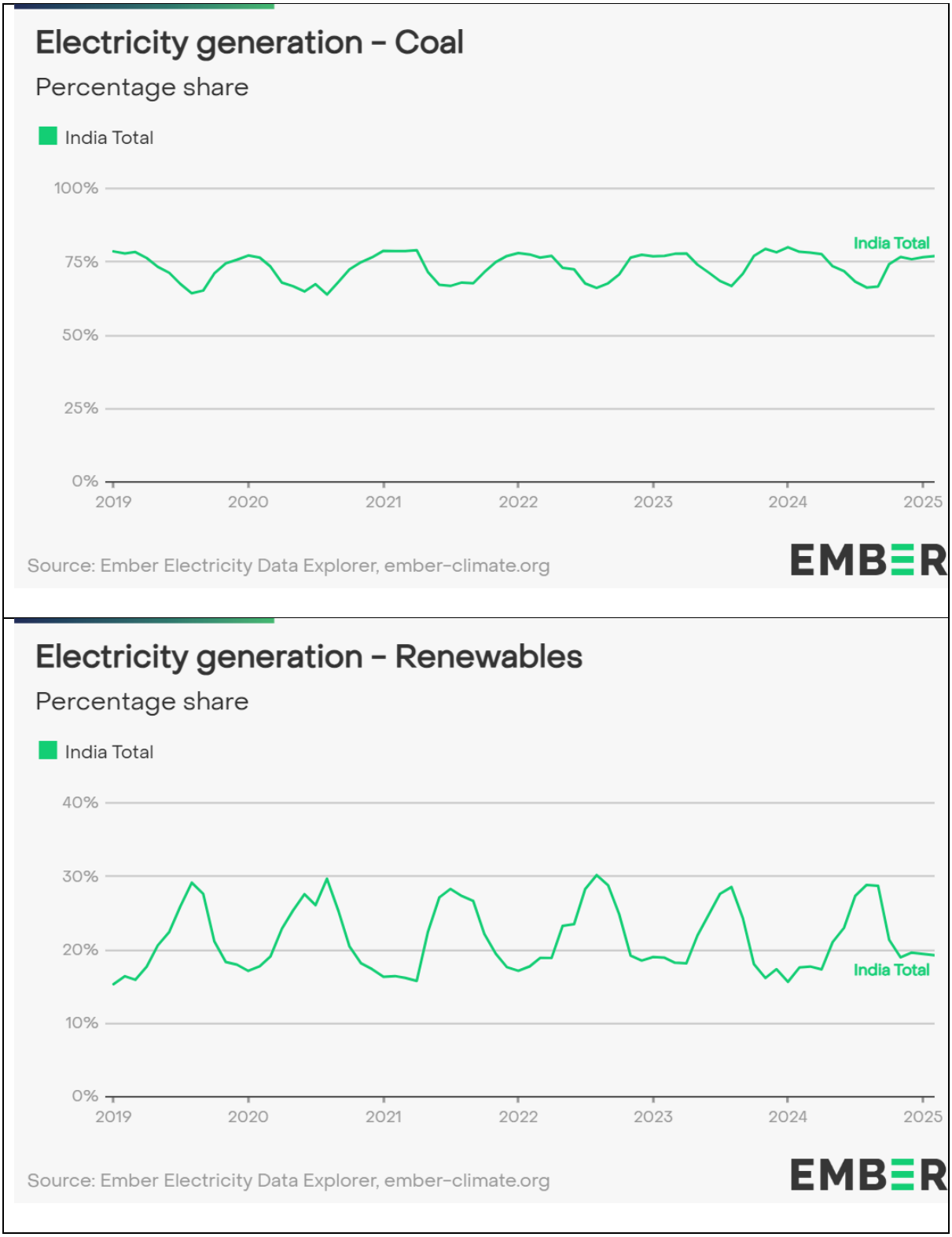

Figure 2: Energy composition share

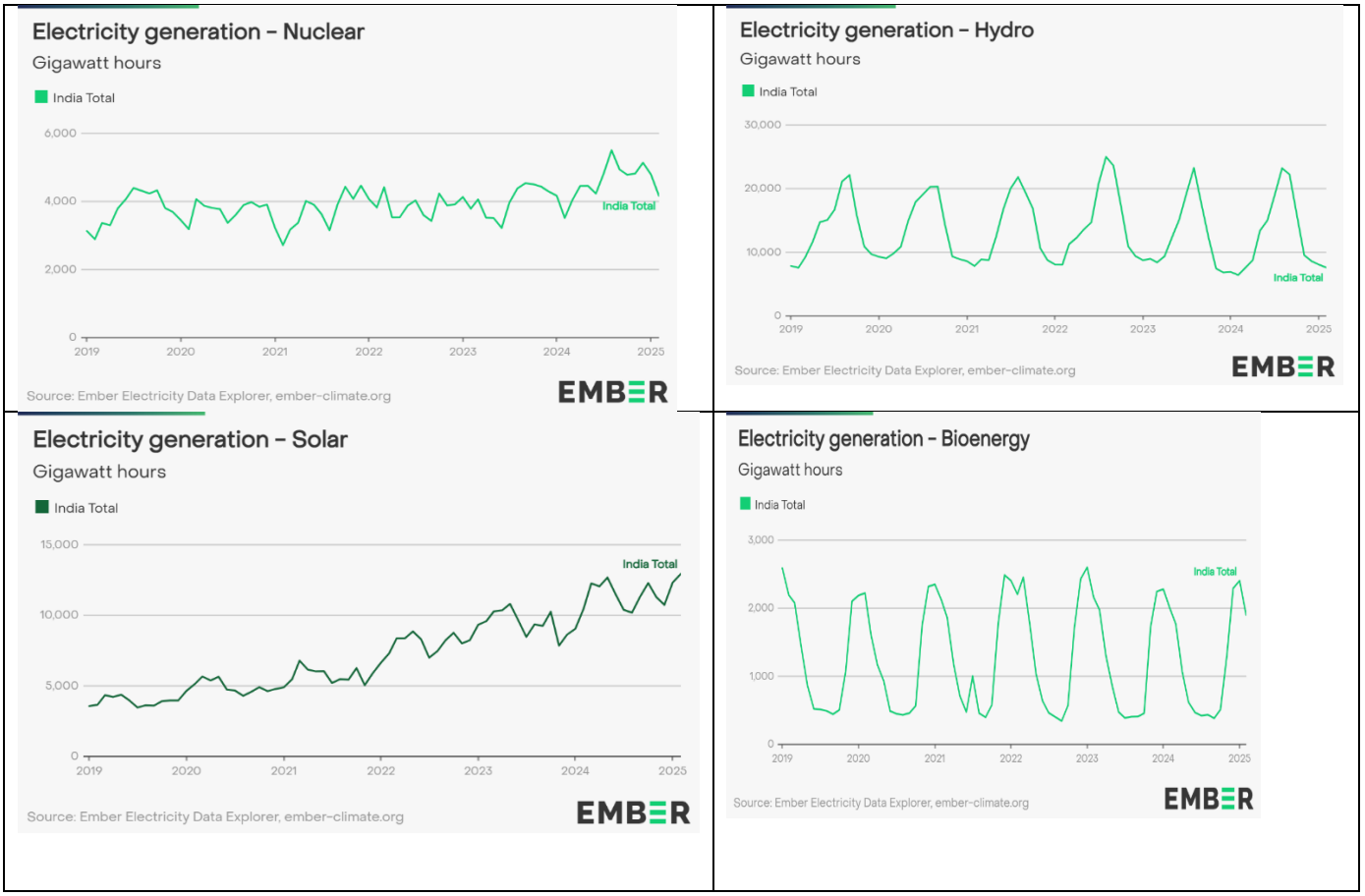

Figure 3: Energy composition of renewables in GW

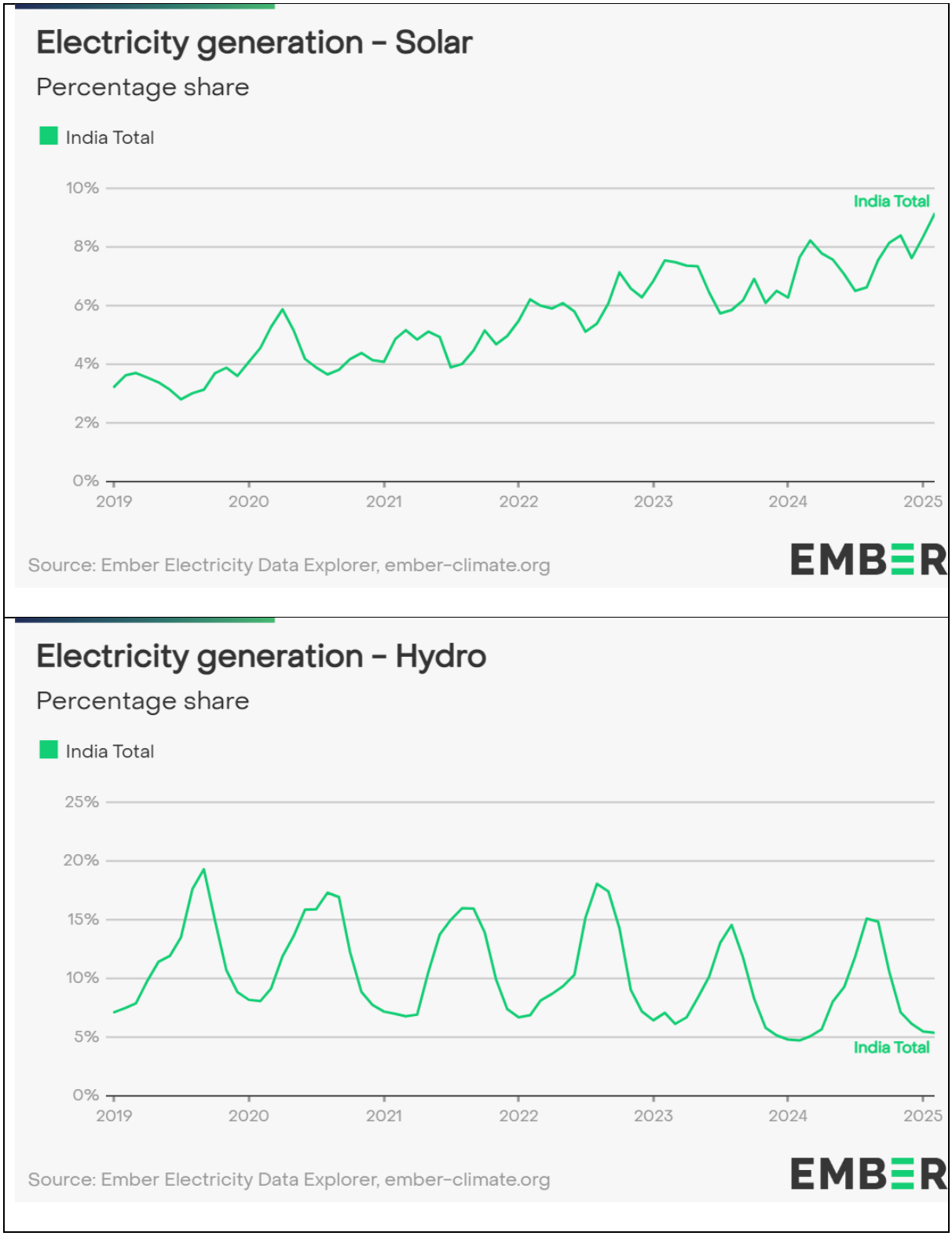

Figure 4: Energy composition of renewables share (India | Ember)

Right composition of energy matters a lot (see Niti Ayog India Climate & Energy Dashboard). Along with countries of global south, India is confronted with triple challenges: a) environment crisis requiring low carbon energy regime, b) poverty and inequality requiring inclusive growth in energy consumption, and c) non-availability of efficient technology and concessional finance.

The complexity of the transition to low carbon energy requires action on multiple fronts. Principal amongst those are: a) major areas of consumption of energy, namely industries, have to switch over to

low carbon energy technology, b) large composition of energy consumption has to shift to renewable power and power transmission has to be smart to take in large component of renewable power, c) cost effective and competitive generation, storage and transportation of clean energy carriers like nuclear and hydrogen. Summarily, it involves expediting movement towards low low-carbon and climate-resilient economy, while minimizing hardship for workers and their communities in the transformation. The process of energy transition, involving technology innovation, dislocation of incumbent energy systems and industrial order, trade in rare earth minerals, all of mega scale, is both time-consuming and cost intensive.

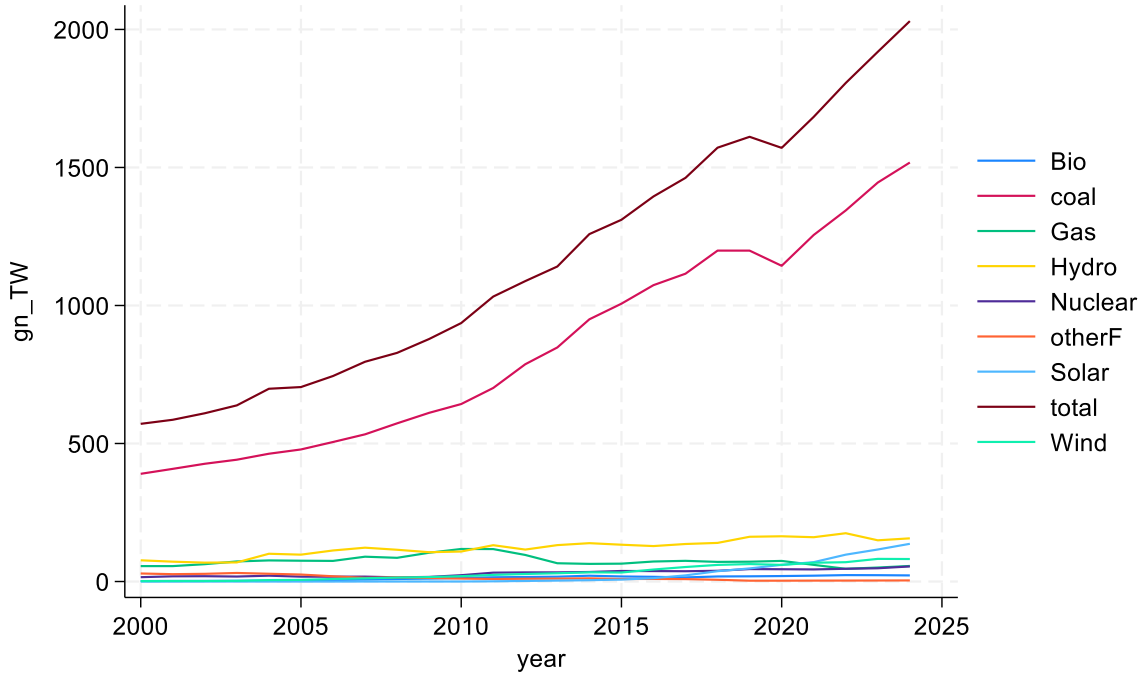

Figure 5: Trends of energy composition in India (Data source: Ember)

People-centred clean energy transition is classified into four categories: (1) jobs and skills; (2) social and economic development; (3) equity, social inclusion, and fairness; and (4) people as active participants in change. This paper is an attempt to visualize just energy transition challenges, constraints and contours for India. The paper is structured around the following sections: (i) Theories of just energy transition; (ii) Challenges of just transition; (iii) Financial implications of just transition; (iv) SWOT analysis of just transition in India (v) Transition trajectory for India (vi) Investment for just transition in India; and (vii) Road ahead for just transition in India.

Research Gap

Emerging Asian economies need to analyse the urgency of energy transition and take appropriate policy measures to address it. Most of the energy sector models primarily pertain to the context of developed nations, where population and socio-economic challenges have been relatively less important in the energy transition process. India needs to emphasise the just energy transition by balancing equity and the displacement of labour from traditional energy sources.

Research Objectives:

- To specify the Just Energy Transition path and phases
- To draw lessons based on the relative fuel price from a Computable General Equilibrium Model
- To estimate the ultimatum game model and draw inferences through simulations and impact analysis.

The hypothesis being tested is that the process of energy transition in India will be just and equitable to be in synch with the global urgency of climate action. The policy approach being advocated is essentially incremental and will be able to break the status quo bias. Further, it is also hypothesised that there are gaps in policy level and inadequate financing options that need to be addressed to achieve net zero transition.

A Numerical Example for Energy Transition

Below is a simple framework for an energy transition model, specifically focusing on the energy mix in India as it transitions from fossil fuels to renewable energy sources. This simplified model simulates the energy demand, the share of renewable versus non-renewable energy sources, and a basic projection over time and consistent with recent studies such as Ahluwalia and Patel (2025). Model Assumptions:

- Total energy demand increases linearly over time.
- The share of renewable energy in the total mix increases at a fixed rate (e.g., 2% per year).
- Non-renewable energy decreases correspondingly as renewable energy increases.

This numerical example is based on the following assumptions and targets

1. **Initial Energy Demand**: 1000 TWh
2. **Annual Growth in Demand**: 2% of 1000 TWh = 20 TWh added each year.
3. **Renewable Energy Share**: Starts at 10% and increases by 2% per year.
4. After 30 years, if all assumptions hold, the model will simulate:
    - **Total Energy Demand** = Increases linearly to 1000 * (1.02^30) ≈ 1812 TWh
    - **Renewable Energy Share** = 100% (capped)
    - Initial years see a mix where renewable energy gradually increases, and non-renewable energy decreases.

Code Explanation:

- **Parameters**: The model parameters define the initial energy demand, growth rates for demand and renewable energy share.
- **Simulation:** The loop simulates each year, updating total energy demand, the share of renewable energy, and subsequently calculating the actual amounts of renewable and non-renewable energy.
- **Plotting**: The results are plotted in three subplots that show total energy demand, the mix of energy sources (renewable vs. non-renewable), and their respective shares over time.
- Figure 6 provides energy demand, the mix of energy sources (renewable vs. non-renewable), and their respective shares over next 30 years (up to 2055).

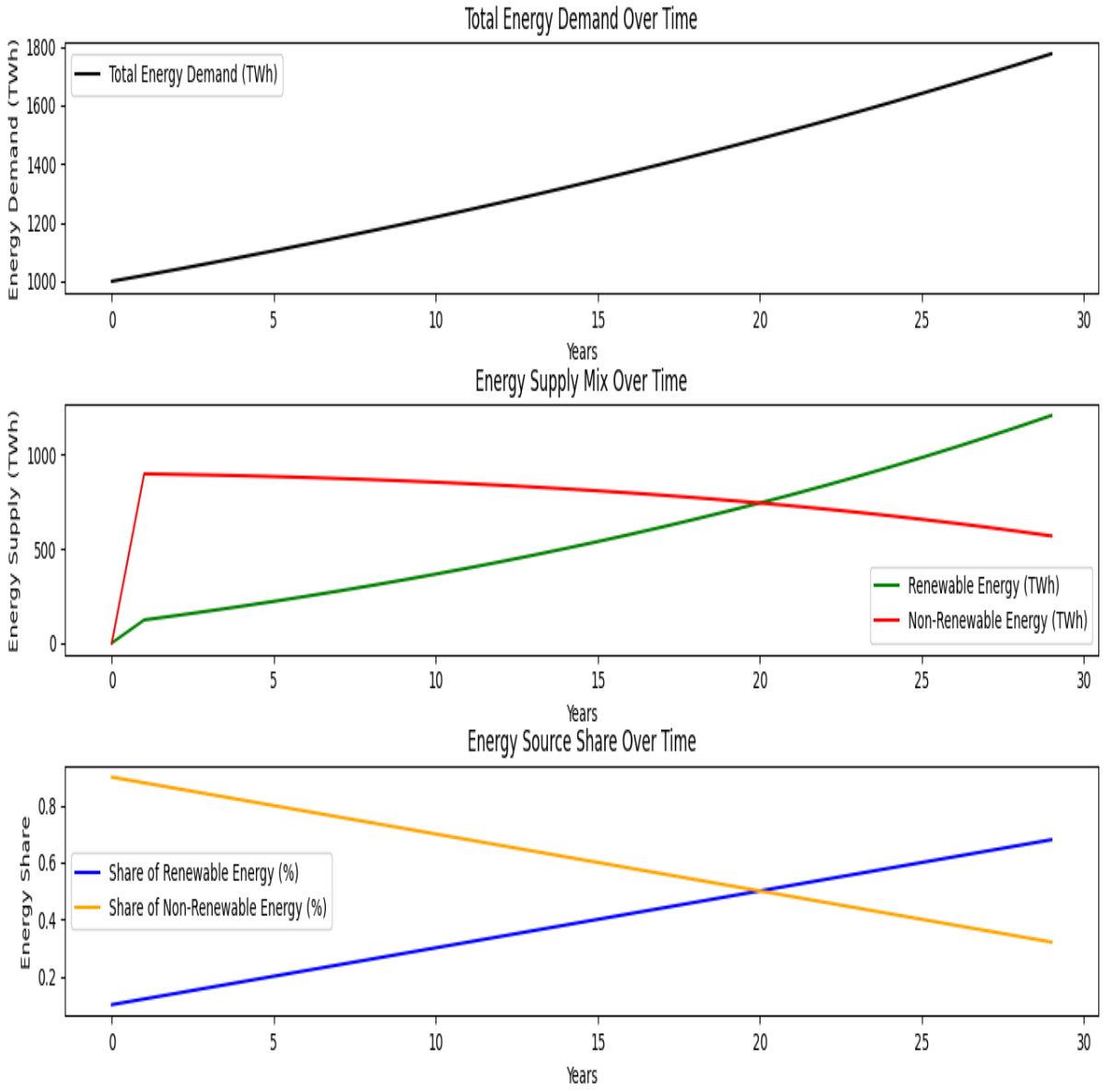

Figure 6: Energy transition model

This code can be further sophisticated by incorporating policy impacts, costs, technology advancements, or demand shocks, but the provided example serves as a straightforward entry into modelling energy transitions in India. The parameters could be adjusted according to real data or more complex relationships to conduct a deeper analysis.

Energy Transition Model

Initial state and transition probabilities show the dynamics of energy aggregates in the coming years. Here:

$$S = \{S_0 \quad S_1 \quad S_2\} \qquad (1)$$

S0: Current pollution state (Baseline/High Emissions).
S1: Intermediate hybrid state (Partial Emission Reduction, e.g., 50% target achieved).
S2: Net-Zero emission state (The Absorbing Target)

A numerical example of a transition probability for low transition can be:

$$\Pi = \begin{bmatrix} \pi_{0,0} & \pi_{0,1} & \pi_{0,2} \\ \pi_{1,0} & \pi_{1,1} & \pi_{1,2} \\ \pi_{2,0} & \pi_{2,1} & \pi_{2,2} \end{bmatrix} = \begin{bmatrix} 0.5 & 0.4 & 0.1 \\ 0.2 & 0.6 & 0.2 \\ 0 & 0 & 1 \end{bmatrix} \quad (2)$$

Or for a high transition:

$$\Pi = \begin{bmatrix} \pi_{0,0} & \pi_{0,1} & \pi_{0,2} \\ \pi_{1,0} & \pi_{1,1} & \pi_{1,2} \\ \pi_{2,0} & \pi_{2,1} & \pi_{2,2} \end{bmatrix} = \begin{bmatrix} 0.2 & 0.5 & 0.3 \\ 0.3 & 0.6 & 0.1 \\ 0 & 0 & 1 \end{bmatrix} \quad (2')$$

$$S = \{S_0 \quad S_1 \quad S_2\}$$

$$\pi^0 = \{1 \quad 0 \quad 0\}$$

$$\pi^t = \{\pi_0^t \quad \pi_1^t \quad \pi_{02}^t\} \quad (3)$$

The state distribution after *T* time steps is given by:

$$\pi^T = \pi^0 \Pi^T \quad (4)$$

This gives the probability of reaching Net-Zero (*S*2) after *T* time. This process is illustrated in Figure 7, which is computed from 2025 to 2073. Fossil fuels are likely to remain foundational to the energy mix from 2030 to 2050, even as renewables rise. Running alongside the energy transition pathway will be the need to keep the lights on in an aspirational, growing economy in which India's energy security and affordability will reign supreme.

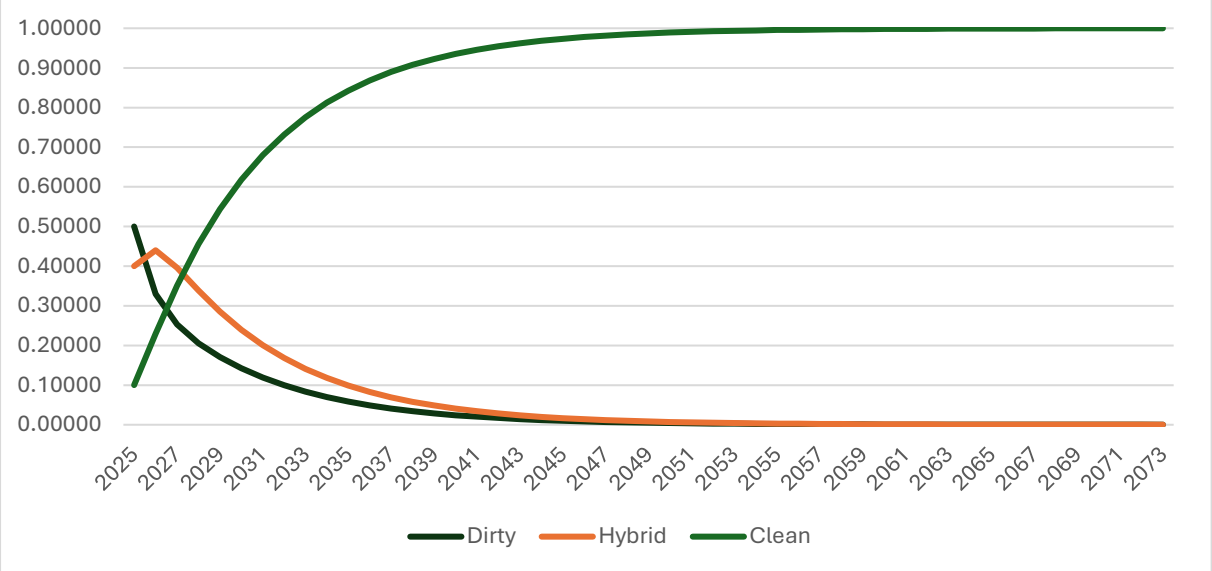

Figure 7: **Transition process to the renewable source of energy in India**

India's power sector faces the hurdle of heavy reliance on coal now, which makes up above 62% of total generation. Continued power demand growth, the intermittent and variable nature of power supply from renewables, high storage costs and infrastructure constraints suggest the coal bias will continue in India's power mix in the near term. To address these challenges and scale up renewables, India is pursuing a multipronged strategy that includes diversifying energy sources, reducing costs through competitive tenders and economies of scale, strengthening grid infrastructure, and achieving self-

reliance in supply chains. India is targeting to more than triple its current renewable capacity to reach about 500 GW by 2030. This ambitious goal provides long-term visibility for renewables demand, which will be tender-driven by federal and state-level agencies. Further, India is prioritising low-emission technologies such as green hydrogen, green ammonia, small nuclear reactors and CCUS to achieve its transition objectives.

After this motivation on the need for energy transition, this paper is structured in three parts. Part A deals with the theoretical aspects of just energy transition and the challenges of achieving that, including the finance mobilization that will be required. Part B presents the background and status of the energy transition process underway in India. Part C critically examines and analyses the just energy transition, finds gaps and deficiencies and also lays out measures to improve the process. This concluding part also tests the hypothesis that states that the process in practice is getting delayed for making it just. Annexure contains the details of the action plan and lays out a roadmap for the just energy transition in India.

PART A

Review of Literature

The concept of a 'just energy transition' (JET) has gained prominence as a critical framework for addressing the dual challenges of climate change and social equity. It emphasises transitioning from fossil fuels to renewable energy sources while ensuring that vulnerable communities are not left behind. Scholars and policymakers argue that this approach is essential for creating sustainable and inclusive energy systems (Jha and Leslie (2025).

The just energy transition draws from the principles of climate justice, energy justice, and the broader notion of a just transition, first articulated by labor movements in the 1970s (Heffron & McCauley, 2018). It seeks to balance three key dimensions: environmental sustainability, economic viability, and social equity.

It is important to prioritize marginalized groups, such as low-income communities and workers in carbon-intensive industries, to avoid exacerbating inequalities during the energy transition. Effective strategies include workforce retraining, community engagement, and equitable distribution of energy resources. Sovacool et al. (2021) utilise a mixed-methods research design based on 64 semi-structured research interviews with experts across all four transitions, five public focus groups, and the collection of 58 comments from twelve public internet forums to answer this question. Drawing inductively from these data, the paper identifies and analyses 44 injustices spread across three spatial scales.

Governments and international organisations have increasingly adopted policies to promote a just energy transition. For example, the European Green Deal includes mechanisms to support regions heavily reliant on coal and other fossil fuels (European Commission, 2020). Critics argue that existing frameworks often lack actionable steps to achieve justice in practice. Newell and Mulvaney (2013) caution that without clear mechanisms for accountability, the transition could perpetuate existing power imbalances.

Empirical studies provide valuable insights into real-world applications. For instance, studies in South Africa highlight how coal phase-out policies must align with local socio-economic realities to avoid large-scale job losses (Baker et al., 2020).

The IEA's World Energy Outlook 2023 highlights a significant shift towards clean energy, projecting that renewables will account for 80% of the global electricity demand growth by 2030 (IEA, 2023). Solar energy, in particular, is expected to lead this expansion, consistently outperforming new coal or

gas-fired power plants in cost-effectiveness. The report also indicates that global energy demand is set to rebound to pre-crisis levels by early 2023, with emerging markets, especially India, driving this growth.

IRENA's World Energy Transitions Outlook 2023 emphasises the necessity for enhanced international cooperation to facilitate a successful energy transition. The report calls for a re-evaluation of the roles of national and regional entities, international organizations, and financial institutions to ensure effective contribution to the energy shift. It also highlights the critical need for increased funding directed towards large-scale energy transition projects, particularly in the Global South.

Mitra et al. (2025) has analyzed the economic implications of technological decoupling, estimating that such a divide could reduce global GDP by 1.2%, with Asia potentially facing a 1.5% decrease. This underscores the importance of international cooperation in leveraging technological advancements to build more productive, inclusive, and sustainable economies. The IMF also stresses the need for substantial investments, approximately $5 trillion annually, to drive the energy transition and address climate change effectively.

Collectively, these reports underscore a global consensus on the critical role of renewable energy in achieving a sustainable and secure energy future. They highlight the economic viability of renewables, the necessity for international collaboration, and the importance of strategic investments to facilitate the global energy transition.

Summary observation is that a just energy transition is essential for achieving sustainable development while addressing inequalities. However, its success depends on holistic approaches that integrate social, economic, and environmental dimensions into policy and practice.

Theories and Context of Just Energy Transition

Theories of just transition revolves around five themes: (1) just transition as a labor-oriented concept, (2) just transition as an integrated framework for justice, (3) just transition as a theory of socio-technical transition, (4) just transition as a governance strategy, and (5) just transition as public perception (Wang, X and Lo (2021).

Decisions about climate change and its impacts have justice implications across many different dimensions. A decision made today on mitigating climate change and investing in adaptation and resilience will have a major impact on the ability of people to enjoy a clean, healthy and sustainable environment in future. However, without proactive and inclusive transition planning, a decision today to phase out fossil fuels and transition to a climate-resilient society may also disproportionately affect the interests of certain workers, communities and other vulnerable groups. Those who are already acutely affected by climate change impacts are also likely to experience greater negative impacts from policy interventions that are targeted at combating climate change.

The idea behind just transition is to make the living conditions of people better, while pursuing the path of development, equity, and decarbonisation. The idea is to act boldly but also pragmatically (Avelino, Wijsman, van Steenbergen et al.(2024). Climate policy will only be successful if it combines people's desire for a good life, inclusive better future for generations to come and limits to global warming, including solutions to halt pollution and biodiversity loss.

The agenda of a just transition first emerged out of the trade union movement and is now mainstreamed in multilateral climate negotiations, most recently culminating in the UNFCCC Work Programme on Just Transition Pathways. The 2015 Paris Agreement and 2015 ILO Just Transition Guidelines have underscored the concept's significance at a high level (Stark, Gale, & Murphy-Gregory, 2023). The Paris Agreement acknowledges the 'imperatives of a just transition of the workforce and the creation of decent work and quality jobs in accordance with nationally defined development priorities. The 2021

Glasgow Pact expanded the definition to include ‘promoting sustainable development and eradication of poverty’ (Yang et al., 2024).

Challenges of Just Energy Transition

Just transition means the importance of investing in social equity to empower vulnerable communities, protect workers’ rights, enhance community resilience, promote diversity, maintain cultural heritage, and advance gender equality.

Industrial production is responsible for approximately 25% of global energy-related CO_2 emissions. Despite its substantial impact, decarbonising industry remains a formidable challenge due to underdeveloped low-carbon technologies, high costs and the longevity of existing industrial assets. While progress has been made, it remains insufficient on a global scale. The developing and emerging economies need more of industrial growth in coming years and decades to escape the middle-income trap. The industrial sector offers significant opportunities for employment, economic growth and the production of green technologies. This underscores the importance of transforming the sector, especially in hard-to-abate industries like steel and cement, which are essential yet highly emission-intensive. What is required is to identify verifiable, comparable and interoperable standards for emission intensities and CO_2 footprints, as the actions are to be taken by multiple countries in collaboration. The goal and the actionable points lie at the strategic interface of climate, trade and industrial policy of multiple countries (Krawchenko & Gordon (2021).

Sufficient availability of carbon-free energy requires massive investment in research, development, demonstration and deployment of green technology. Secondly, the green energies must be competitive with the incumbent and substitute fuels, which these aim to replace. Thirdly, this requires collaboration at global scale.

Many green hydrogen projects have been proposed, and some are in operation, like green hydrogen trains and ferries. But these projects are still insufficient in size for a just transition. Strong governance is needed. A just transition must avoid creating a resource curse. This is the paradox where countries, particularly in the developing world, offer their abundant natural resources to a global market but do not experience commensurate benefits. For example, South Africa and Namibia and Morocco are offering land and sun and wind for renewable resources to make green hydrogen, but those countries need to ensure that their citizens will benefit. A resilient just transition require that governments, investors, innovators, and local stakeholders work together.

It is to be appreciated that each country at any point in time is conditioned by its own energy-related conditions, and transition has to factor energy system conditions and economic aspirations. Coal is India’s largest source of greenhouse gas emissions, contributing to climate change and air pollution. Mining activities cause significant environmental degradation, further complicating efforts to align economic activities with sustainable practices. The coal sector's dominance in India's energy system presents significant challenges to achieving just energy transition. While coal has been central to India’s economic development and energy security, it creates structural, economic, social, and environmental challenges that can slow down or complicate the transition to cleaner and more inclusive energy systems.

Coal accounts for over 62% of India’s electricity generation and supports energy-intensive industries like steel, cement, and aluminium. India is the second-largest producer and consumer of coal globally. Rapidly phasing out coal risks disrupting power supply and economic stability, especially given India’s growing energy demand. Coal provides significant revenue for state governments (e.g., Jharkhand, Odisha, and Chhattisgarh) through royalties, taxes, and levies. A sudden reduction in coal production could lead to revenue deficits, limiting funds for social and infrastructure programs. India's coal sector

includes substantial investments in power plants, mining infrastructure, and transport networks, many of which risk becoming stranded as global markets shift away from fossil fuels.

The coal sector employs millions directly and indirectly, particularly in regions where alternative livelihoods are scarce (Muinzer, 2023). A premature phase-out without adequate reskilling and alternative opportunities could lead to mass unemployment and social unrest (Anderson & Johnson 2024). Many communities depend on coal mining for subsistence, making a just transition a complex social issue.

Coal production and consumption are heavily subsidized, creating a financial and institutional lock-in that disincentivises clean energy adoption. Established interests in coal-heavy industries and political systems can resist rapid transitions due to economic and political risks. Continued investments in coal power plants divert resources from renewable energy projects. Long term coal power purchase agreements create financial commitments that hinder the growth of decentralized renewables.

Coal's dominance undermines the effectiveness of carbon pricing and trading mechanisms by keeping coal artificially cheap. Coal is often positioned as a critical resource for energy security, particularly during periods of high-power demand, making the case for reducing its role politically contentious.

Energy Transition in India: A Dynamic CGE Model-Based Analysis

Energy transition, especially in emerging economies like India, is a critical component of sustainable development. This essay examines the economic implications of promoting renewable energy and discouraging fossil fuels through subsidies and taxes, using a Computable General Equilibrium (CGE) model. The model incorporates a Constant Elasticity of Substitution (CES) production and demand function as in Bhattarai (2020) to simulate the impact of different policy scenarios on energy use, output, and overall welfare.

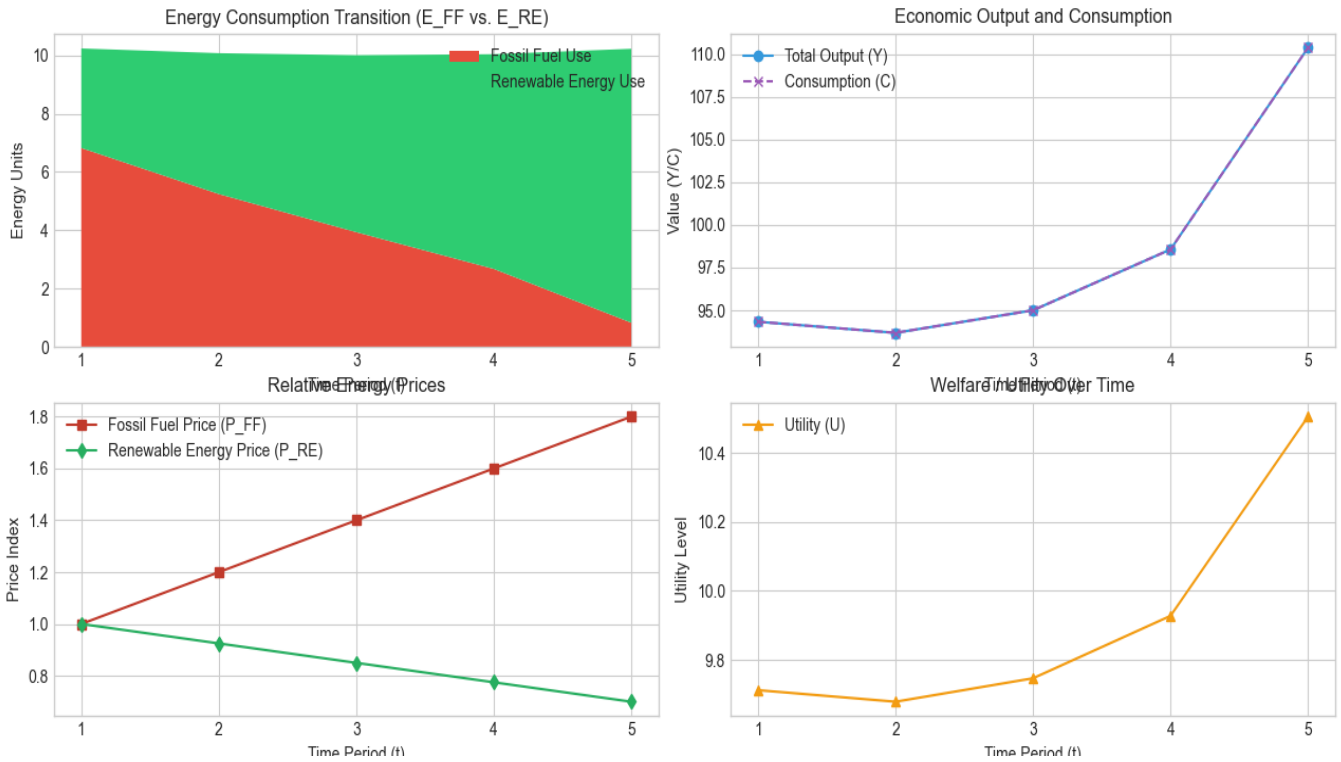

Figure 8: **CGE scenario for transition to renewable energy**

Subsidies to renewable energy producers and reduction in the cost of renewables due to technical advancement lower the relative prices of renewables and raise demand for renewables. Fossil fuel becomes more expensive and gradually get eliminated from the system.

The CGE model highlights the effectiveness of targeted subsidies and taxes in influencing energy use and supporting India's transition to a sustainable energy future. Subsidies for renewable energy are more effective than fossil fuel taxes in shifting the energy mix while maintaining economic output. However, a combined policy approach may yield the most balanced outcomes, addressing both environmental and economic objectives.

Ultimatum GAM for Just Energy Transition

The JET process involves a conflict between the government, which desires a swift transition to secure environmental and economic benefits, and fossil fuel workers, who fear job displacement and demand fair compensation or retraining. This scenario is aptly modelled as an Ultimatum Game, a framework used to study strategic bargaining and the role of fairness or reservation utilities in negotiations (Akiln 2025). The game involves two players and a fixed resource> Let there be:

- Resource (R): The total benefit of the successfully executed J.E.T., normalized to R = 1.
- Player 1 (Proposer): The Government (G), which proposes a share x ∈ [0, 1] of R for the workers.
- Player 2 (Responder): The Fossil Fuel Workers (W), who decide to Accept (A) or Reject (R) the offer x.

Acceptance (A): Workers cooperate; the transition succeeds with pay-offs $\pi G(x) = 1 - x$; $\pi W(x) = x$. Rejection (R): Workers protest/strike, disrupting the transition. The total benefit R is lost, and both incur conflict costs (CG, CW). $\pi G(\text{Reject}) = -CG$; $\pi W(\text{Reject}) = -CW$. Workers accept offer if $x \geq T$; reject if $x < T$. $T \in [0, 1]$ reflects the threshold for bargaining power and job loss severity. Using backward induction, the subgame perfect Nash equilibrium implies the government offers $x^* = T$ to maximize its payoff while ensuring acceptance. Consider three scenarios: T = 0.2 (Weak Workers), T = 0.5 (Fair Split), T = 0.8 (Strong Workers).

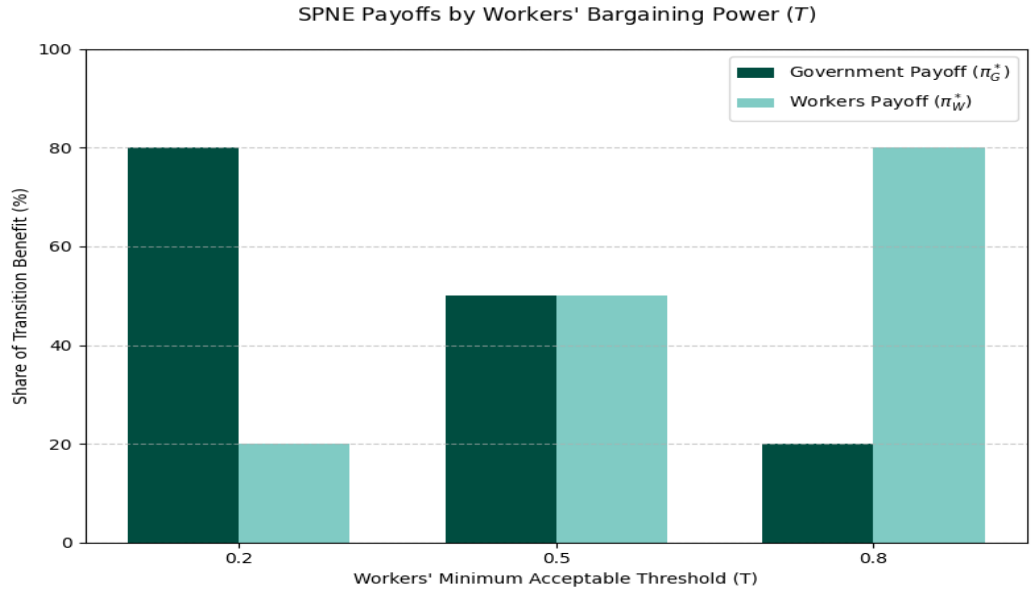

Figure 9: **Outcome of the ultimatum game by the strength of the workers in decommissioned energy sectors**

Table 1: SPNE Results for the J.E.T. Ultimatum Game on distribution of gains from transition

Scenario	T (Threshold)	Government Payoff (%)	Workers Payoff (%)
Weak Workers	0.2	80.0	20.0
Fair Split	0.5	50.0	50.0
Strong Workers	0.8	20.0	80.0

Global Financial Implications of Just Energy Transition

Various estimates have been made for arriving at the cost of carbon neutrality by 2050. An Independent high level expert group of the United Nations Convention for Climate Change (UNFCCC) reported in November 2024 that emerging market and developing countries other than China require $2.3-2.5 trillion per year of investment in climate action by 2030. Out of this $2.4 trillion per year, approximately $1.6 trillion will be required for the clean energy transition, $0.25 trillion for adaptation and resilience, $0.25 trillion for loss and damage, $0.3 trillion for natural capital and sustainable agriculture, and $0.04 trillion for a just transition. The challenge for developing countries, including India, is that this order of financing is beyond their reach. Here comes the role of innovative financial instruments. Deloitte has estimated that this presents a financing potential of US 5.5 trillion per year till 2050. (UNFCCC, 2024; Deloitte, 2024; Agbaitoro and Ekhator (2025))

To induce change, financial institutions not only need to set their own ambitious plans for transition, but they also require interventions from governments on policy and legal frameworks to support them to redirect existing financial flows and generate new financing towards green technologies and innovations, climate change adaptation solutions, social protection mechanisms and community benefit schemes, as appropriate.

PART - B

Assessment of National-Level Policies: Justice and Equity in Focus

National Electricity Plan

The National Electricity Plan 2024 serves as a comprehensive roadmap for the development of the power sector, with a focus on enhancing energy access, reliability, and sustainability. The plan prioritizes renewable energy, targets coal dependency reduction, and incorporates energy efficiency measures. While the NEP's objectives align with sustainable development goals, a justice and equity analysis reveals both strengths and areas for improvement. The positive impacts of National Electricity Plan are that it helped to expand electricity access to underserved regions which aligns with distributive justice, ensuring marginalized communities gain from infrastructure investments. National Electricity Plan also helps to integrate decentralized renewable energy systems, such as mini-grids and solar home systems and also addresses energy poverty in remote areas (GOI, 2024). However, affordability concerns remain, particularly for lower-income households. While the plan encourages renewable energy, the initial costs of adoption could burden disadvantaged groups. The transition away from coal risks socioeconomic disruptions for workers and communities reliant on the coal sector, raising procedural justice issues related to inadequate participation in decision-making and planning for alternative livelihoods.

It is therefore recommended to target subsidies or financing mechanisms to support low-income households in adopting renewable energy. This can be done in short-term, within 1-3 years. It is also recommended to ensure a just transition framework with reskilling programs, financial support, and community consultations for coal-dependent regions within time frame of medium-term: 3-5 years.

Renewable Energy Policies

The Renewable Energy Policies emphasize scaling up solar, wind, and biomass energy production to achieve ambitious renewable capacity targets of 500 GW by 2030 and reduce greenhouse gas emissions. While commendable for its environmental benefits, its equity dimensions warrant closer examination. Its positive impacts are: a) promotion of decentralized renewable systems empowers local communities and improves resilience; and b) creation of green jobs in renewable energy sectors provides new employment opportunities.

There are however changes such as land acquisition for large-scale solar and wind farms, which occasionally led to displacement and conflicts, disproportionately affecting indigenous and rural populations. The benefits of renewable energy projects, such as job creation and revenue generation, are not always equitably distributed among local stakeholders.

It is therefore recommended to strengthen safeguards to prevent displacement and ensure fair compensation for affected communities. This ought to be done in short-term: 1-2 years. Further, it is required to promote community owned renewable energy projects to enhance local benefits and participation within timeframe of medium-term: 3-5 years. It is recommended to establish mechanisms to monitor and address gender inequities in access to renewable energy resources and employment opportunities. This is to be put in place in medium-term that is 3-5 years.

Coal Sector Reforms

Recent coal sector reforms aim to boost domestic production, attract private investment, and reduce reliance on imports. These reforms are framed around economic growth but raise critical justice and equity considerations. However, the positive impact of the reforms is increased when domestic production reduces energy costs, potentially benefiting consumers. Revenue from coal mining can support national and regional development programs.

Environmental degradation and health issues associated with coal mining disproportionately impact vulnerable communities living near mining sites. Privatization and reduced regulatory oversight risk exacerbating existing inequities by prioritizing profits over local well-being. Limited engagement with affected communities undermines procedural justice.

It is therefore recommended to introduce stronger environmental and social impact assessment protocols for coal mining projects in short-term that is 1-2 years. This includes mandating corporate social responsibility (CSR) initiatives to support community development in mining areas in medium-term that is 3-4 years and developing comprehensive plans to transition of coal-dependent regions towards sustainable economic activities in long-term that spans 5-10 years.

State-Level Initiatives in Coal-Rich Regions

States such as Jharkhand, Chhattisgarh, and Odisha, being rich in coal reserves, face unique challenges in navigating a just energy transition. Their initiatives offer critical insights into localized strategies such as: a) heavy reliance on coal mining for state revenues and employment creates resistance to transitioning away from coal; and b) limited diversification of local economies exacerbates vulnerabilities when coal demand declines.

These states suffer social and environmental costs by way of displacement, land degradation, and air and water pollution, which disproportionately affect indigenous and rural populations. Due to weak enforcement of environmental regulations, people in these states face health and livelihood challenges.

Following best practices have been adopted in these states: a) Odisha’s participatory governance frameworks, such as engaging Gram Sabhas in mining approvals, improve procedural justice; b)

Jharkhand's focus on skill development programs for displaced workers facilitates economic diversification.

On the sustainable development front: a) Chhattisgarh has piloted community-based afforestation and watershed management projects to rehabilitate mining-affected regions; and b) Odisha's solar energy initiatives in mining regions aim to create alternative livelihoods while reducing environmental impacts.

Establishment of District Mineral Foundations (DMFs) in all three states has channelled mining revenues into local development, including health care, education, and infrastructure.

These states can extend their initiatives further. They can: a) scale up investments in renewable energy projects tailored to local needs, such as decentralized solar and biomass (short-term: 2-3 years); b) strengthen DMF governance to ensure funds reach the most affected communities (short-term: 1-2 years); c) promote public-private partnerships for green job creation and skill development in non-coal sectors (medium-term: 3-5 years); d) enhance monitoring and enforcement of environmental and social safeguards in mining regions (short-term: 1-2 years).

The National Electricity Plan, Renewable Energy Policies, coal sector reforms, and state-level initiatives in coal-rich regions each contribute to India's energy development objectives. However, their alignment with justice and equity principles is mixed. A more inclusive and participatory approach is essential to ensure these policies do not exacerbate existing inequalities but instead contribute to a just energy transition. Integrating targeted support mechanisms, enhancing community engagement, and prioritizing marginalized populations can help bridge the gap between policy intentions and equitable outcomes.

SWOT Analysis of Energy Transition in India

India's energy transition is set to be a multidimensional engineered process, with a multipronged focus. The challenge for India is that the process must support economic growth, elevating the quality of life of 1.4 billion people, while transforming itself on such fronts as agriculture, industry, services and technology. The SWOT analysis helps explain how India can take the global imperative of decarbonisation and net zero as an opportunity.

Strength

India is poised to be the third-largest economy in the world by 2030. Its economy has been growing at 7 to 8 per cent per annum in recent years. It contributed 16 per cent to the global growth in 2023. It is the third-largest energy consumer. Its size and strength attract collaborative stance from key global players in the areas of trade, technology, investment, manufacturing, and lending.

India's emphasis on a rule-based international order, advocacy for collaboration to solve common issues, and commitment to uphold democratic values make it a stabilising force in an increasingly complex global geopolitical landscape. Importantly, India also helped herald a new dawn of multilateralism where developing countries take their rightful place in shaping the global narrative by mainstreaming the Global South's concerns in international discourse.

India has a large and deep manufacturing base, scientific establishment and is trying to expand more, including the latest initiative of mobile phone and semiconductor manufacturing. Its digital density is very high, complex, and includes globally recognised digital public infrastructure, known as India Stack. These provide strength and resilience that would enable India to negotiate energy transition and face disruptions.

India's public representatives, policy makers and technocrats have acquired experience and confidence in managing its energy system well for the past seven and a half decades, despite being handicapped with indigenous resource endowments. This is particularly so for renewable energy capacity, which

crossed 200 GW in October 2024. India's policy makers have realised the need for getting into hydrogen and nuclear energy at scale with urgency.

Weakness

India's energy insecurity concern is of epic proportions. It is import dependent for crude oil by 89%, for gas by 43%, for LPG by 50% and for coal by 20%. These fossil fuel deficits are largely geological and resource endowment weakness. These would be partly relieved by transitioning to alternate fuels like renewables, biofuels, and hydrogen.

India's population density and scant water availability in large parts of the country are detrimental to the generation of renewables and hydrogen.

Though India has a very active and deep capital market, financing of renewables remains a concern. Moreover, with the global phenomena of inflation and high interest costs, the viability of investment in risky areas like hydrogen remains a question for investors.

India's power sector is riddled with challenges which have proved to be insurmountable, despite various measures taken by Governments. State Governments' contributory participation in the exercise to make power sector profitable is very much warranted.

Though large corporates like Reliance, Adani, L&T, Greenco have taken steps to get into the hydrogen value chain, they are waiting for Government incentives, which as of now are not coming forth in a significant way. There certainly is a public policy gap.

Threats

India's manufacturing sector in emerging technological area are mostly dependent on foreign vendors. So is the case for renewable equipment. In the prevailing scenario of global supply chain realignment, these constitute risk areas.

Other countries like the USA, UA, Australia, Chile and a few more have gone far ahead in the research, development and deployment of green hydrogen. These countries are trying for a breakthrough in technology innovation to be in a leadership position in hydrogen. Saudi Arabia and Australia have already piloted exporting green Ammonia to countries of the Far East. India may lose the export market to early starters.

India needs to depend upon imports for the rare earth minerals, which are critical ingredients for renewable power generation.

Opportunity

India, by far, is the least cost renewable market. India is making good progress on the renewable capacity front, and those are expected to make the transition to electricity quick and reliable.

India is emerging to be attractive shore for foreign investment. This would facilitate technology collaboration required for the energy transition. Investment and technology of a huge proportion are required for the next 2 decades in India for the total revamping of industries to make them zero carbon compliant.

Substitution of fossil fuels by renewable energy in household and commercial buildings brings into use distributed energy resources, which converts consumers into prosumers. Besides demand management, renewables would provide the scopes like energy cloud, shared energy economy and virtual power plant. India's IT talent, mixed with the start-up ecosystem provide fertile ground for breakthrough technology in renewables, storage and adoption of transition energy.

The Energy Transition Trajectory for India – Status and Approach

A just energy transition pathway for India must balance the imperatives of economic development, energy access, and climate action while ensuring that vulnerable communities and workers are not left behind (Pollin, 2023). Figure A1 in the Appendix presents a framework with timelines for achieving a sustainable, inclusive, and equitable energy transition for India.

Areas of Strategic Action for Just Energy Transition in India

1) Make the radical choice of gas in power mix: Gas, a key growth fuel and bridge for the full energy transition, remains underrepresented in the Indian energy mix, being stuck at approximately 6%. To achieve the government's ambition of 15%, India must deploy sufficient gas in power to support flexibility, alongside the growth of renewables and sustainability, to transition away from coal.

2) Advance critical mineral security: India, the only developing nation in the Minerals Security Partnership, has identified 30 critical minerals necessary for its energy transition. The country has also established Khanij Bidesh India Ltd., a joint-venture company under the aegis of the Ministry of Mines, to secure access to critical minerals overseas. While the number of projects on critical minerals more than double to 127 in 2023 from 59 in 2020, more focus on domestic exploration is required.

3) Accelerate power sector reforms: India must prioritise market reforms to address legacy issues such as high losses, inefficient operations and financial distress in the distribution sector. It should foster a competitive market environment by promoting private participation and ensuring fair market practices. It should also develop and implement innovative market-based solutions to improve grid reliability, including demand response programs, advanced AI-linked grid technologies and real-time pricing. Additionally, India needs to focus on grid modernisation and expansion to accommodate increasing renewable energy integration and enhance grid resilience.

4) Boost energy efficiency and productivity: India should focus on energy-intensive industries for significant efficiency improvements. It must promote energy-efficient cooling solutions, expand public transportation and leverage energy service companies for environmentally friendly building projects. A concerted effort to reduce energy consumption in these areas is vital for improving energy productivity.

5) Build strong clean energy supply chains: Securing domestic raw material supplies, developing a skilled workforce and promoting local component manufacturing are essential for building robust battery, electrolyser and photovoltaic manufacturing ecosystems. Leveraging government procurement to create a domestic market is crucial for supporting local industries.

6) Mobilise green finance: India should create a conducive environment for green bond issuances, explore innovative financing models and strengthen financial institutions' capacity to manage green projects. Attracting private capital through a climate taxonomy and impact investment funds is necessary to scale up clean energy investments.

7) Drive innovation and technology development: India must focus on decentralised renewable energy solutions, promote domestic innovation and foster public-private partnerships for technology development. Supporting research and development in off-grid and mini-grid technologies will be crucial for addressing energy access challenges in rural areas.

8) Deal with the coal sector with sensitivity: The coal sector's dominance is undoubtedly a drag on India's just energy transition due to structural, economic, and social dependencies. However, with proactive policymaking, strategic investments, and multi-stakeholder collaboration, India can transform this challenge into an opportunity to drive equitable and sustainable growth. The key lies in balancing environmental goals with economic and social considerations to ensure no one is left behind in the transition.

It is important to develop a clear, time-bound roadmap to reduce coal dependency in line with India's net-zero 2070 target, identifying priority areas where coal plants can be retired based on age, inefficiency, and environmental impact (Foley eta al, 2024). This requires investing in economic diversification programs for coal-dependent regions to create alternative sources of income and employment focusing on sectors like agriculture, forestry, renewable energy, and sustainable tourism.

Additionally, it requires launching large-scale reskilling programs for coal sector workers, enabling them to transition to jobs in renewable energy, manufacturing, and services providing social protection measures, including unemployment benefits and community development funds, to mitigate disruptions. Accelerating investments in solar, wind, and hydroelectric projects, particularly in regions with high coal dependency by enhanced grid infrastructure to support higher shares of intermittent renewable energy.

Gradually phasing out subsidies for coal production and consumption is possible by redirecting financial support toward renewable energy, battery storage, and energy efficiency initiatives.

Encouraging private sector participation in clean energy projects through incentives and risk-sharing mechanisms requires leveraging coal company expertise to explore opportunities in renewable energy and sustainable mining practices.

Establishing legal and institutional frameworks to guide a fair transition for workers, communities, and industries should include affected stakeholders, including coal-dependent states, in transition planning.

For essential industrial uses of coal, it is essential to invest in carbon capture, utilization, and storage technologies to mitigate emissions.

PART - C

Analysis on the Process of Just Energy Transition in India

Knowing that India’s energy consumption is inexorably dependent on fossil fuel to the extent of 62 per cent now, it will be naïve to claim that India will easily migrate from fossil fuel to clean fuel by any significant measure. Secondly, disruption in the fossil fuel value chain will disrupt the economy. Thirdly, the fossil fuel ecosystem is fragile. Policymakers often face political and economic pressure to maintain coal production and employment, leading to slower regulatory changes favouring renewables. In this context, it appears reasonable to hypothesise that a just energy transition framework for India would, by implication, mean a slow transition in practice.

Perspective observation of India’s energy system says that the just energy transition (JET) framework for India does not inherently mean a slow transition; rather, it emphasises a fair and inclusive transition that considers the social, economic, and developmental realities of the country. However, certain aspects of JET may appear to slow down the process compared to a purely aggressive decarbonization strategy. Here's a breakdown of why it might seem slower and whether this is justified:

A just transition requires ensuring that workers in fossil fuel sectors, like coal mining, are not left jobless or impoverished. Time is needed to design and implement reskilling programs and create alternative livelihoods. India’s coal sector is concentrated in regions like Jharkhand, Chhattisgarh, and Odisha, where economies are heavily reliant on coal mining. Transitioning these regions to new industries requires careful planning, which takes time.

Nearly one billion Indians depend on affordable energy for basic needs. Transitioning without ensuring reliable and affordable renewable energy could exacerbate energy poverty, especially in rural areas.

The transition requires significant investment in renewable infrastructure, grid modernization, and social protections. India's limited fiscal space may necessitate a gradual approach to avoid economic disruptions.

India has argued for the principle of common but differentiated responsibilities in climate action, emphasizing that its per capita emissions are far below global averages and that it has the right to development. This stance justifies a measured approach.

Keeping the above developments in perspective, it may be said that the process of energy transition that India is undergoing in practice, even if slow, is justified. A transition that prioritizes justice and equity is essential for long-term sustainability. Rushing the transition could lead to negative outcomes, including: (a) social unrest due to loss of jobs in coal-dependent regions; (b) unequal development, with some communities left behind in the renewable energy transition; and (c) overburdening of already strained economic resources.

A well-implemented just energy transition framework can balance speed and equity by addressing key challenges in the following manner:

a) **Strategic Phasing**: Begin with low-hanging fruits. That would mean phasing out inefficient coal plants and scaling up decentralized renewable energy. Further, use revenues from carbon pricing or coal cess to fund green jobs and social programs.

b) **Leveraging Technology and Finance**: International climate finance and technology transfer can help India deploy renewables more rapidly without sacrificing social protections.

c) **Regional Strategies**: Tailor transition plans to the needs of coal-dependent states. For example, focus on solar parks in arid regions and wind energy in coastal states.

d) **Integrated Planning**: Align renewable energy deployment with economic development goals to ensure that new industries, infrastructure, and jobs emerge alongside clean energy expansion.

e) **Global Collaboration**: Engage in initiatives like the Just Energy Transition Partnership (JETP) to access funding and expertise for a faster, more equitable transition.

Policy Gap in the Just Energy Transition Process Being Followed

Notwithstanding the appropriate action taken in India for just energy transition, glaring gaps remain at policy level which appear to hinder smooth and inclusive transition as shown in Table 2.

Challenge	Gap	Solution
Lack of comprehensive just energy transition framework	India lacks a national-level policy explicitly focused on a just energy transition that integrates energy, social, and economic objectives.	Develop a national JET roadmap, outlining targets, milestones, and roles for stakeholders, aligned with India's development goals and net-zero commitments.
Limited support for coal-dependent communities	Policies fail to adequately address the socio-economic impacts of coal phase-outs on communities dependent on coal mining and related industries.	Establish a Just Transition Fund to finance reskilling, alternative livelihoods, and community development in coal-reliant regions. Introduce regional economic diversification policies tailored to coal-producing states like Jharkhand, Chhattisgarh, and Odisha.

Insufficient reskilling and workforce transition plans	There is no comprehensive strategy for reskilling coal sector workers or creating jobs in renewable energy, green hydrogen, or energy efficiency sectors.	Launch large-scale, industry-specific reskilling programs in partnership with private companies and educational institutions. Provide financial incentives to renewable energy firms to prioritize hiring and training workers transitioning from fossil fuel sectors.
Inequitable renewable energy deployment	Renewable energy expansion has largely benefited industrialized and urban areas, neglecting energy access and employment generation in rural and marginalized regions.	Promote decentralized renewable energy projects like solar micro-grids and rooftop solar in rural areas. Implement policies to ensure equitable distribution of benefits, including subsidies for rural households and MSMEs to adopt clean energy solutions.
Weak social protection mechanisms	There are inadequate measures to provide social safety nets for displaced workers and communities affected by energy transitions.	Enhance social security schemes, including unemployment benefits, pension plans, and healthcare for workers in transitioning sectors. Foster community-driven energy projects to create localized benefits and ownership.
Financing gaps	India's renewable energy targets require massive investment, but financing mechanisms for just energy transition, especially for social dimensions, are underdeveloped.	Establish public-private partnerships to attract private capital for just transition projects. Mobilize international climate finance through mechanisms like the Green Climate Fund and Just Energy Transition Partnerships.
Lack of localized transition plans	National energy policies often fail to consider regional disparities in energy needs, economic structures, and social contexts.	Develop state-level just energy transition plans tailored to local contexts, supported by regional data on energy demand, employment, and social vulnerabilities. Encourage state governments to align their policies with the national framework while addressing localized challenges.
Weak stakeholder engagement	Limited involvement of local communities, civil society organizations, and workers in decision-making processes.	Create inclusive governance mechanisms that include affected workers, local leaders, and civil society in planning and monitoring just energy transition projects. Foster public awareness campaigns to build support and understanding of the transition process.
Inefficient energy market structures	Limited involvement of local communities, civil society organizations, and workers in decision-making processes.	Create inclusive governance mechanisms that include affected workers, local leaders, and civil society in planning and monitoring just energy transition projects. Foster public awareness campaigns to build support and understanding of the transition process.

Table 2 – Challenges, Gaps and Solutions in Just Energy Transition Actions in India

To align a just energy transition with inclusive economic growth, it is important that energy transition process be integrated with country's development goals. It is to be ensured that

energy transition policies are aligned with broader economic development priorities like poverty alleviation, rural development, and industrial growth. Renewable energy projects are to be used as vehicle to create jobs, improve energy access, and reduce energy costs for MSMEs. A Just energy transition authority at the national level may be set up to coordinate efforts across sectors and regions, ensuring alignment with economic and social priorities.

Green jobs are to be created in renewable energy, electric mobility, and sustainable agriculture, ensuring opportunities for all demographics, including women and marginalised groups. Public works programs focused on climate resilience, such as afforestation and infrastructure upgrades, are to be developed. Renewable energy projects are to be used as anchors for rural development, linking them with agriculture (e.g., solar pumps), education (e.g., electrification of schools), and healthcare (e.g., energy for cold chains).

Collaborations should be done with international donors, financial institutions, and technology providers to access funding, expertise, and technology for just energy transition projects.

By addressing these gaps and adopting these strategies, India can ensure that a just energy transition is not only environmentally sustainable but also socially inclusive and economically beneficial.

Areas of Investment for Just Energy Transition in India

To make India just energy transition-ready, significant investments are required across multiple areas, including renewable energy infrastructure, social safeguards, skill development, and institutional capacity building (BEE (2024)). Presented below are key investment areas and strategies for mobilising the necessary finances:

1. Renewable Energy Infrastructure

Investment is required in: a) expanding solar, wind, and green hydrogen production capacity; b) modernising the grid to integrate renewable energy sources; and enhancing energy storage systems like batteries and pumped hydro. The objective is to achieve India's renewable energy targets (500 GW by 2030) while ensuring equitable access.

2. Decentralised Energy Systems

Investment is required in establishing microgrids, rooftop solar installations, and community-owned renewable energy projects in rural areas. The objective is to improve energy access for marginalised communities and reduce reliance on centralised fossil-fuel-based systems.

3. Green Jobs and Workforce Transition

Investment is to be made in areas like: a) large-scale reskilling and upskilling programs for workers in fossil fuel-dependent industries; and b) job creation in renewable energy, energy efficiency, sustainable agriculture, and circular economy sectors. This would ensure workers transition smoothly into emerging green sectors.

4. Regional Economic Diversification

Investment has to be directed at promoting alternative industries in coal-dependent regions, such as agroforestry, eco-tourism, or clean manufacturing and for developing infrastructure to attract new investments in these regions. These will go a long way to mitigate the socio-economic impact of coal mine closures.

5. Social Protection Programs

Money will be required for establishing safety nets, such as unemployment benefits, pensions, and healthcare for displaced workers. That will minimise the social costs of the transition and build public support (Crawford et al. (2022)).

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6. Research, Development, and Innovation

Investment is required for supporting R&D in green hydrogen, advanced battery technologies, carbon capture and storage (CCS), and smart grid solutions. The aim is to drive technological breakthroughs and reduce costs in clean energy sectors.

7. Climate Resilient Infrastructure

A good investment is required for strengthening infrastructure to withstand climate impacts (e.g., flood-resilient energy systems). This is meant to ensure energy security and system reliability in the face of climate change.

8. Capacity Building and Institutional Strengthening

Investment is required for building institutional capacity for planning, implementing, and monitoring just energy transition initiatives. It is therefore felt necessary to establish a Just Energy Transition Authority to coordinate efforts, so that governance and accountability get enhanced.

Mobilisation of Finances for Just Energy Transition in India

Financing just energy transition requires collaborative participation by governments, private business, multinational financial institutions and the governments of developed countries. Capital market, instruments and regulatory ecosystem jointly play a key role within the country.

1. Domestic Public Finance

Required policy measures under the public sector domain are: a) reallocate public funds from fossil fuel subsidies (e.g., coal cess) to renewable energy and social protection programs; and b) introduce carbon pricing or increase taxes on fossil fuels to generate funds for just energy transition initiatives. It is necessary to establish a Just Transition Fund to pool public resources for targeted programs, especially in coal-reliant regions.

2. Private Sector Participation

Policy measures required under the private sector are: a) to provide fiscal incentives like tax breaks, low-interest loans, and subsidies for private investments in renewable energy and green technologies; and to simplify regulatory frameworks to attract private capital in decentralised energy and storage projects. The capital market has to offer suitable instruments to mobilise private investment in infrastructure development, such as renewable energy parks or grid modernisation.

3. International Climate Finance

India has to leverage multilateral and bilateral funding mechanisms, such as the Green Climate Fund (GCF), Just Energy Transition Partnership (JETP), and International Solar Alliance (ISA). It also has to get access to concessional loans and grants from development banks (World Bank, ADB. This calls for strengthening India's climate diplomacy to secure greater financial commitments for JET as part of global climate action.

4. Green Bonds and Sustainable Finance

Capital market policy has to permit the issuance of green bonds through public and private entities to raise funds for renewable energy and climate-resilient infrastructure projects. It also has to encourage financial institutions to create green lending portfolios for clean energy projects. Indian players have to collaborate with global financial institutions to access international green bond markets.

5. Community and Cooperative Models

Opportunities have to be provided to mobilise resources for community-driven renewable energy projects through cooperatives and crowdfunding. Strategically local ownership is to be encouraged and ensured that benefits are equitably distributed to enhance community buy-in.

6. Carbon Markets

It is necessary to develop a robust emissions trading system to generate revenue from carbon credits. It has to be integrated with the carbon market with global mechanisms to attract international buyers for Indian carbon credits.

7. Philanthropic and Impact Investments

Just energy transition activities provide opportunities to partner with philanthropic organisations and impact investors to fund social aspects of just energy transition, such as education, healthcare, and reskilling. It is therefore important to align philanthropic goals with India's energy transition priorities through targeted campaigns.

8. Technological and Knowledge Transfers

Indian entities are required to collaborate with international partners for access to cutting-edge renewable energy technologies and expertise. That would facilitate joint ventures and partnerships with global firms in clean energy innovation.

Policy Enablers for Financial Mobilisation

The country has to develop a clear, actionable roadmap that provides confidence to investors. This has to ensure stable policies for renewable energy tariffs, grid access, and carbon pricing. This also has to establish transparent systems to track and report on financial flows and project outcomes.

Mobilising finances for a just energy transition in India requires a mix of domestic public funds**,** private investments**,** and international climate finance**,** supported by innovative financial instruments and robust policy frameworks. By targeting these investment areas and leveraging diverse financial sources, India can align its energy transition with sustainable and inclusive economic growth.

India’s capital market has made progress in supporting energy transition goals, but it still faces challenges in fully meeting the financing requirements for a Just Energy Transition. While the market shows promise due to innovations like green bonds and growing investor interest in sustainability, significant gaps need to be addressed to align the market with the scale, scope, and inclusivity required for a just energy transition.

Onus of Public-Private Participation in India’s Just Energy Transition

The responsibility for fostering public-private participation in India’s just energy transition lies with both the government and the private sector. However, their roles differ. The government bears primary responsibility for creating an enabling environment that attracts private sector participation in the just energy transition (Massari et al., 2024). This includes: a) developing long-term, transparent policies for renewable energy, decarbonisation, and social equity in just energy transition; and

b) establishing mechanisms like the national carbon market and financial incentives to make green investments attractive.

Responsibility of the Government lies in: a) de-risking investments through guarantees, subsidies, and public financing mechanisms like sovereign green bond; and b) offering stable tariffs for renewable energy and ensuring timely payments to energy producers.

The government has a primary role in capacity building exercises by: a) investing in skill development and reskilling for workers transitioning from fossil fuel industries; and b) creating specialised institutions or authorities to coordinate just energy transition activities across sectors and regions. Social safeguards have to be ensured by providing funding and policy support for social protection programs to ensure communities and workers are not left behind.

The private sector must step up to innovate, scale, and finance solutions that align with just energy transition goals. Key responsibilities include: a) mobilising capital for renewable energy projects, grid modernisation, energy storage, and green hydrogen; and b) partnering with the public sector in infrastructure projects and technology deployment.

The private sector has to ensure job creation and reskilling by: a) implementing large-scale workforce reskilling programs to help fossil fuel workers transition to clean energy sectors; and b) creating green jobs in industries such as solar manufacturing, electric vehicles, and sustainable agriculture.

The private sector has to lead in the area of technology and innovation by: a) leading the adoption of advanced technologies like AI in grid management, battery innovations, and carbon capture and storage; and b) developing scalable solutions for decentralised renewable energy systems, especially in rural areas.

All business entities have to adopt ESG principles by way of: a) integrating Environmental, Social, and Governance standards into core business strategies; and b) measuring and reporting carbon footprints and actively reducing emissions across operations and supply chains.

The private sector in India has a clear grasp of the global and environmental direction that is unfolding on the just energy transition front. India's private sector has been proactive in renewable energy development. Companies like Adani Green Energy, Tata Power Renewables, and ReNew Power are significant contributors to India's renewable energy capacity, which surpassed 125 GW in 2023. Indian firms are also making inroads into green hydrogen and battery storage technologies.

Several large Indian corporates, including Infosys, Mahindra Group, and Reliance Industries, have committed to achieving net-zero emissions. Many firms are integrating renewable energy into their operations and transitioning fleets to electric vehicles. Start-ups and corporates are driving innovation in solar energy, EV charging infrastructure, and energy efficiency technologies. Initiatives like Tata's reskilling programs and partnerships between companies and training institutions reflect early efforts in workforce transition.

There are areas of challenge for private sector initiatives for which some gaps are visible. Most private sector initiatives focus on clean energy infrastructure rather than addressing social aspects like job losses in coal-dependent regions or community impacts.

Micro, Small & Medium Enterprises (MSMEs) have been slow to adopt green technologies due to high upfront costs and limited access to credit. Many companies prioritise compliance and short-term gains over long-term investments in deep decarbonization or systemic changes. Coordination between private sector entities and public authorities is often fragmented, resulting in missed opportunities for large-scale impact.

Private sector initiatives can further be strengthened. The government must provide consistent fiscal incentives, such as tax breaks and low-interest loans, to encourage private investments in green sectors. Clear guidelines on PPP models and risk-sharing arrangements will enhance private sector confidence.

Public institutions should use sovereign green bonds or international climate finance to de-risk projects and crowd in private capital. All business entities have to introduce stronger ESG regulations to drive private sector accountability and align business strategies with national just energy transition goals.

There should be platforms for regular dialogue between governments, corporates, communities, and civil society to ensure alignment of just energy transition strategies and equitable outcomes. Private companies need to be incentivised to invest in reskilling programs, social safety nets, and economic diversification initiatives in coal-dependent regions. Public-private partnerships have to be fostered for R&D in emerging technologies such as green hydrogen, smart grids, and carbon capture.

Conclusions

Just energy transition for India demands a multi-stakeholder approach, with each entity playing a vital role in achieving the country's climate and development goals. Coordination among these actors is essential to ensure the transition is equitable, inclusive, and aligned with India's socio-economic realities. Simple numerical example of transition dynamics, the CGE model for structural analysis and the ultimatum game provide mathematical and empirical frameworks required by policies on just energy transition.

While coal’s dominance poses clear challenges, it can also be reframed as an opportunity. Coal companies can reinvest profits into renewable energy and transition projects, becoming key players in the shift to a low-carbon economy.

India can draw on international experiences in managing coal transitions, such as Germany’s Coal Commission, which combined gradual phase-outs with robust social protections. Coal-dependent communities can serve as pilot regions for innovative just energy transition programs, demonstrating how inclusive planning can succeed.

Just energy transition for India does not imply an intentionally slow transition. Instead, it reflects a pragmatic and balanced approach that ensures long-term success and social stability. While it may take more time upfront to address structural challenges, the outcome is likely to be more sustainable, equitable, and politically feasible. Technological advancement and the reduction in the cost of renewables is very promising.

The onus of driving public-private participation lies primarily with the government, which must create an enabling framework and de-risk investments. The private sector in India has shown promise in renewable energy development and corporate ESG initiatives, but needs to expand its focus to include social equity and long-term commitments to systemic transformation. A stronger alignment of public and private efforts is essential to achieve a truly just energy transition in India. Price analysis from the CGE model and workers' rights protection in lines of the ultimatum game show solutions to the transition problem.

India’s capital market has a strong foundation but requires strategic interventions to fully support the just energy transition. Scaling up green finance, creating innovative instruments like just energy transition bonds, strengthening carbon markets, and mobilising both domestic and international investments are essential steps. By addressing these gaps, India’s capital market can play a pivotal role in ensuring an equitable, inclusive, and sustainable energy transition.

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Appendices

Roadmap for Just Energy Transition in India

Phase I of 20s: 2024–2030: Laying the Foundation

Objectives:

- Ramp up renewable energy capacity to meet growing energy demand sustainably.
- Address coal dependency with a phased and worker-centric approach.
- Foster green job creation in renewable sectors.

Key Actions:

1. Renewable Energy Expansion:
    - Achieve 500 GW of non-fossil fuel capacity by 2030 (aligned with India's COP26 commitment).

- Prioritize investments in solar and wind energy, including rooftop and decentralized solutions.
- Strengthen grid infrastructure for renewable integration.

2. Coal Transition:
   - Identify and prioritize the gradual closure of inefficient coal plants.
   - Initiate coal mine reclamation projects, creating local employment opportunities in land restoration and afforestation.
3. Social Protection for Coal Workers:
   - Design reskilling programs for workers in coal-dependent regions, focusing on solar panel installation, battery storage, and electric vehicle (EV) manufacturing.
   - Establish a national Just Transition Fund to support affected communities.
4. Green Industries Development:
   - Encourage domestic manufacturing of renewable energy components.
   - Scale up EV production and associated infrastructure (e.g., charging networks).
   - Promote green hydrogen pilot projects for industrial decarbonization.
5. Policy and Finance:
   - Introduce market incentives like Renewable Energy Certificates (RECs) and feed-in tariffs.
   - Mobilize international climate finance for technology transfer and capacity building.
   - Strengthen decentralized energy access initiatives to electrify rural and underserved regions.

Phase II of 30s: 2030–2040: Scaling and Consolidation

Objectives:

- Accelerate clean energy dominance in the energy mix.
- Achieve significant emissions reductions while fostering economic growth.
- Strengthen social and economic equity in the transition.

Key Actions:

1. Renewables Dominance:
   - Expand renewable capacity to 60–70% of the energy mix by 2040.
   - Introduce advanced energy storage systems and smart grids to stabilize renewable supply.
2. Coal Phase-Out:
   - Decommission 50% of coal-fired power plants by 2040.
   - Transition coal-reliant regions to diversified economies (e.g., tourism, agroforestry, and clean manufacturing).
3. Industrial Decarbonization:
   - Scale up green hydrogen production to decarbonize steel, cement, and fertilizer industries.
   - Introduce carbon pricing mechanisms to incentivize low-carbon technologies.
4. Transport Electrification:
   - Aim for 80% EV penetration in passenger and commercial vehicle segments.
   - Upgrade public transport systems to run on electricity or biofuels.
5. Inclusive Development:
   - Ensure affordable and reliable energy access for all, especially marginalized communities.
   - Expand education and skill-building programs for the green economy.

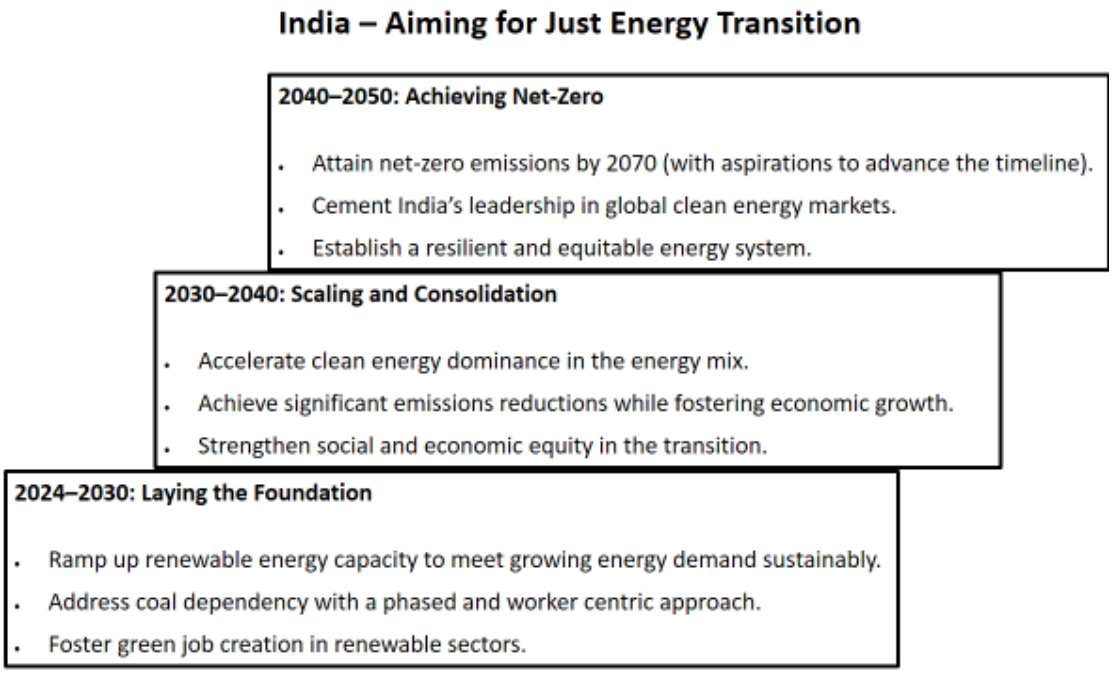

Figure A1 – Roadmap for Just Energy Transition in India; Source – Proposed by the authors

Phase III of 40s: 2040–2050: Achieving Net-Zero

Objectives:

- Attain net-zero emissions by 2070 (with aspirations to advance the timeline).
- Cement India's leadership in global clean energy markets.
- Establish a resilient and equitable energy system.

Key Actions:

1. Complete Coal Transition:
   - Achieve full coal phase-out by 2050.
   - Ensure all displaced workers are resettled in alternative livelihoods or receive adequate pensions.
2. Net-Zero Industries:
   - Transition major industries and agriculture to renewable energy or low-carbon alternatives.
   - Strengthen carbon capture and storage (CCS) technologies for residual emissions.
3. Energy Efficiency and Conservation:
   - Promote deep energy efficiency retrofits across residential, commercial, and industrial sectors.
   - Encourage behavioral shifts towards energy conservation.
4. Climate Resilience:
   - Invest in adaptive infrastructure to mitigate climate risks (e.g., heatwaves, floods).
   - Foster community-led renewable energy initiatives to enhance local resilience.
5. Global Leadership:
   - Export clean energy technologies and expertise to developing nations.
   - Advocate for equity in global climate negotiations and partnerships.

Structural Changes Required for Just Energy Transition in India

To make India energy transition-ready, several structural, institutional, financial, and societal changes are needed. These changes must address the unique challenges of balancing economic development,

social equity, and environmental sustainability as summarised in Table 3. Explicitly, here's what needs to change:

1. A Comprehensive Just Energy Transition Policy Framework

India lacks an integrated JET framework that explicitly ties together energy transition goals with social and economic justice. It is therefore required to develop a national just energy transition policy framework, which would, among other things, a) define clear goals, timelines, and pathways for transitioning to renewable energy while addressing socio-economic impacts; b) include mechanisms for stakeholder participation, including workers, industry representatives, and civil society.

It is also required to incorporate Regional Transition Plans, which would design region-specific plans for coal-heavy states like Jharkhand, Odisha, and Chhattisgarh to manage economic shifts.

2. Social Safeguards for Fossil Fuel Workers and Communities

Coal-dependent workers and communities lack adequate social protection or alternative employment opportunities in transitioning sectors. It is important to create large-scale, targeted reskilling initiatives for workers in the coal, oil, and gas sectors to prepare them for jobs in renewable energy, green manufacturing, and services. It is also required to expand unemployment benefits, pensions, and healthcare for displaced workers. A Just Transition Fund is required to be established to finance these protections and community development projects.

3. Accelerated Renewable Energy Deployment with Equity Focus

While India is making significant progress in renewable energy deployment, rural and marginalised areas often lack access to these benefits. It becomes imperative, therefore, to promote off-grid and community-owned renewable energy systems to ensure energy access in rural and underserved regions. Subsidies or financing support for SMEs and rural households to adopt renewable energy technologies are to be provided. Renewable energy investments in coal-dependent states are to be undertaken with priority that would create new economic hubs.

4. Enhanced Institutional Capacity and Governance

Fragmented governance and a lack of coordination between national, state, and local agencies slow the implementation of JET initiatives. It is therefore suggested to establish a dedicated Just Energy Transition Authority to oversee, coordinate, and monitor transition efforts across sectors and states. Local governments are to be empowered to manage decentralised renewable energy projects and reskilling initiatives.

5. Mobilising Finance for Just Transition

India faces significant financial constraints in funding renewable energy projects and social transition programs. The capital market has to gear up for the adoption of green bonds, carbon markets, and public-private partnerships (PPPs) to attract domestic and international investments. Funds like the Green Climate Fund (GCF) and Just Energy Transition Partnerships (JETP) are to be leveraged to finance the social aspects of JET. Gradually, subsidies for fossil fuels are to be phased out and redirected towards renewable energy development and social programs.

6. Accelerating Green Job Creation

India's renewable energy sector has not yet generated enough jobs to offset potential losses in the fossil fuel sector. Therefore dedicated mission to create jobs in renewable energy should be launched together with a focus on energy efficiency, electric mobility, and sustainable agriculture. SMEs are to be incentivised to adopt and produce clean energy technologies.

7. Advancing Technological Readiness

India's energy system lacks sufficient grid infrastructure and storage capacity to handle large-scale renewable energy integration. Investment in smart grids and advanced storage solutions should be encouraged to ensure a reliable and resilient energy system. Funding for research in green hydrogen, energy storage, and carbon capture technologies should be scaled up with emphasis on commercialisation.

8. Strengthening Climate and Energy Literacy

Awareness of the economic, social, and environmental benefits of JET is limited among the public and stakeholders. Therefore, educational campaigns are to be carried out to build support for JET and encourage community participation. Training and upskilling opportunities are to be provided to local government officials, industry leaders, and community organisations on JET principles and practices.

9. Reforming Energy Markets

India's energy markets are heavily skewed towards fossil fuels, with limited incentives for clean energy adoption. Carbon pricing or emissions trading systems should be put in place effectively to make fossil fuels less competitive compared to renewables. Renewable energy sources need to receive priority in grid integration and market pricing.

10. Ensuring Stakeholder Participation

Affected workers, communities, and civil society groups have limited involvement in decision-making processes. It is necessary to create platforms for dialogue between governments, workers, businesses, and communities to co-design JET policies. Policy has to encourage community-driven energy projects to build local ownership and distribute benefits equitably.

Thus, India's readiness for a just energy transition requires systemic changes in policy, finance, governance, and public awareness. By addressing these gaps and fostering inclusivity, India can achieve a sustainable energy future that aligns with its development goals while ensuring social and economic justice.

Monitoring and Evaluation

For a long term continuing exercise like just energy transition, monitoring and evaluation present a challenging exercise. It is necessary to establish independent agencies to monitor progress and ensure accountability. The agency will be mandated to regularly review policies and adapt to technological and socio-economic changes and promote participatory governance, involving local communities and civil society in decision-making.

By adhering to this timeline together with intermediate course correction, India can achieve a just energy transition that secures its development goals, addresses climate challenges, and ensures an equitable future for its people.

Notes: Python codes for the numerical example of the dynamic energy transition model, dynamic CGE, and ultimatum games are available upon request from k.r.bhattarai@hull.ac.uk.

Web Links:

Tata Energy: https://www.tatapower.com/renewables

ReNew: https://www.renew.com

Adani Group: https://www.adanigreenenergy.com

Infosys: https://www.infosys.com

Reliance: https://www.ril.com/businesses/new-energy-materials

Manindra and Mahindra: https://www.mahindra.com/our-business/renewable-energy

Bajaj: https://www.bajajenergy.com

Niti Ayog: https://iced.niti.gov.in