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India's Energy Transition

A Handbook

Just Transition Research Centre
Department of Humanities and Social Sciences
Indian Institute of Technology Kanpur
September 2022

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Acknowledgment

We would like to thank SED fund for providing financial support. We are also thankful to the consultants and reviewers for taking time and effort to review the manuscript.

Cite this publication as:
Swarnakar, P., & Chauhan, S. (2022). India's Energy Transition: A Handbook. Just Transition Research Centre, Indian Institute of Technology Kanpur

Foreword

Climate change is one of the most significant threats that the world is facing today. Fossil fuels contribute substantially to greenhouse gas emissions that lead to global warming.

A transition towards cleaner sources of energy production is the most logical approach, which, however, does not come without complications.
As an emerging market economy, India's energy transition may be considered an opportunity to propel the nation towards a structural shift that builds the economy from the ground up. Whether through technological innovations or appropriate policy mechanisms, energy transition opens the window of an inclusive development plan that considers the needs of those who have been mainly neglected until now.

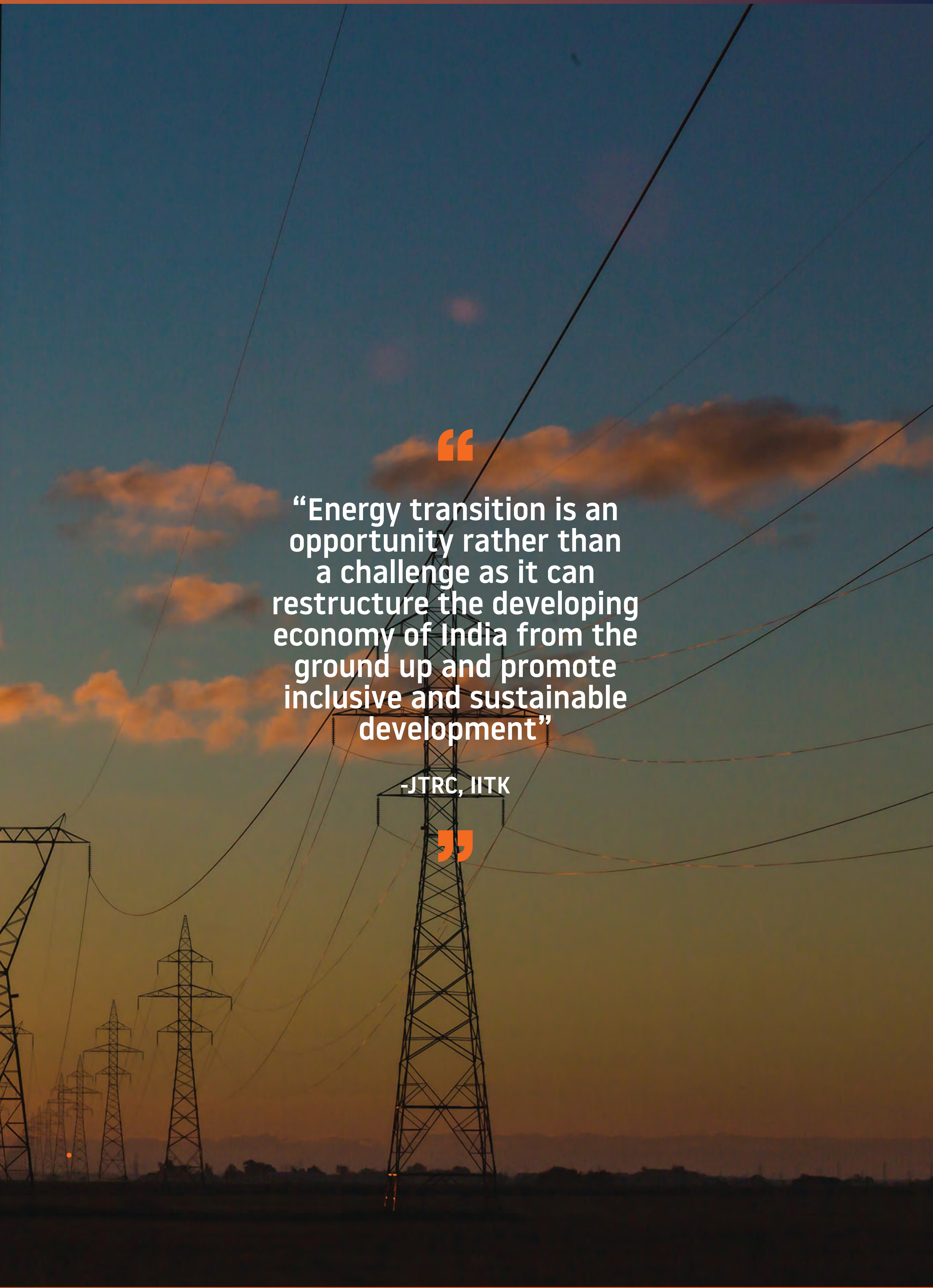
A look into the overall energy economy of India, which the report "India's Energy Transition: A Handbook" presents, will equip the reader with fundamental knowledge about the energy structure and coal dependence in India.
The report provides an objective assessment of the energy consumption scenario and insights into the nation's regulatory framework. In essence, the need for coal and its importance for the Indian economy is presented while suggesting means to transition away from it gradually.

I would like to appreciate the Principal Investigator, Dr. Pradip Swarnakar, Professor, Department of Humanities and Social Sciences, Associated Faculty, Chandrakanta Kesavan Center for Energy Policy and Climate Solutions for taking up this initiative.

The report proposes several recommendations based on extensive case studies. I believe this is a meaningful addition to the research in the energy sector in India and promotes future research that contributes to energy and mining policies that are sustainable, inclusive, and inspiring. The handbook will be a quick guide to the policymakers, researchers, and civil society organizations.

Professor Abhay Karandikar
Director, IIT Kanpur

Photo credit: Matthew Henry (www.unsplash.com)


“Energy transition is an opportunity rather than a challenge as it can restructure the developing economy of India from the ground up and promote inclusive and sustainable development”
-JTRC, IITK

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Abbreviations

Bcm	Billion cubic metres
CEA	Central Electricity Authority
CIL	Coal India Limited
CO_2	Carbon Dioxide
CoP	Conference of Parties
CPCB	Central Pollution Control Board
Cr	Crore
CSR	Corporate Social Responsibility
DMF	District Mineral Foundation
EU	European Union
FY	Financial Year
GDP	Gross Domestic Product
GST	Goods and Services Tax
GW	Gigawatt
GWp	Gigawatt power
INR	Indian Rupee
Kg	Kilogram
km^2	Kilometre squared
kVA	Kilovolt-ampere
kW	Kilowatt
kWh	Kilowatt hour
LCOE	Levelised Cost of Electricity
LED	Light-emitting diode
LPG	Liquefied Petroleum Gas
m	Metre
Mn Rs	Million Rupees
MNRE	Ministry of New and Renewable Energy
MT	Million tonnes
Mtoe	Million tonnes of oil equivalent
MW	Megawatt
NDC	Nationally Determined Contributions
OECD	Organization for Economic Co-operation and Development
PV	Photo-voltaic
Rs	Rupees
SDG	Sustainable Development Goals
SPV	Solar Photo-voltaic
STEPS	Stated Policy Scenario
TWh	Terawatt hour
PLF	Plant Load Factor
GoI	Government of India

Executive Summary

Anthropogenic climate change poses a severe threat to environment and society. The burning of fossil fuels to power the vehicles and electrical devices and manufacturing certain goods has taken its toll on the environment. Large-scale deforestation to clear out lands for farms and industries has reduced the planet's natural capacity to absorb carbon dioxide released from emission-intensive fuels and contributed to global warming. The shift in temperature and weather patterns over a long period resulted in changing climate of the planet, which, if not mitigated now, will have harsh consequences in terms of health hazards, loss of biodiversity and economic deterioration. This creates an urgency to transition to resources that are not emission intensive. Chapter one elaborates the background of energy transition in the context of climate change.

The world economy consumes over eight billion tonnes of coal annually to manufacture brick, steel, electricity, etc. India alone consumed almost a billion tonnes of coal in 2020-21, including an import of 215 metric tons. We explore specific topics related to India's current energy setting in chapter two, some of which are:

- The distinction between energy and electricity.
- The difference in the share of installed capacity and actual generation from different sources.
- Role of renewable and thermal energy in the development of the economy.

A transition occurs because of a shift in a significant part of consumption or production in the economic sector. Energy transition, therefore, implies a shift from the dominant fuel in the energy production sector, that is, coal, to other sources. However, it is not as straightforward as it seems. Some of the major challenges that we explore in chapter three are:

- The eastern part of India abounds in coal reserves, while its solar energy in the west and south, small hydropower potential in northern Himalayan states and wind energy in western coastal areas. This difference in resource availability across spaces increases the associated transaction costs.
- Provision for the battery to store energy at scales appropriate to large renewable energy systems at the moment is not cost-effective.
- Energy transitions require proper coordination among local, state and central governments, relevant industries, and local organisations. A lack of communication among and across people and organisations makes coordinated actions challenging to plan and implement.

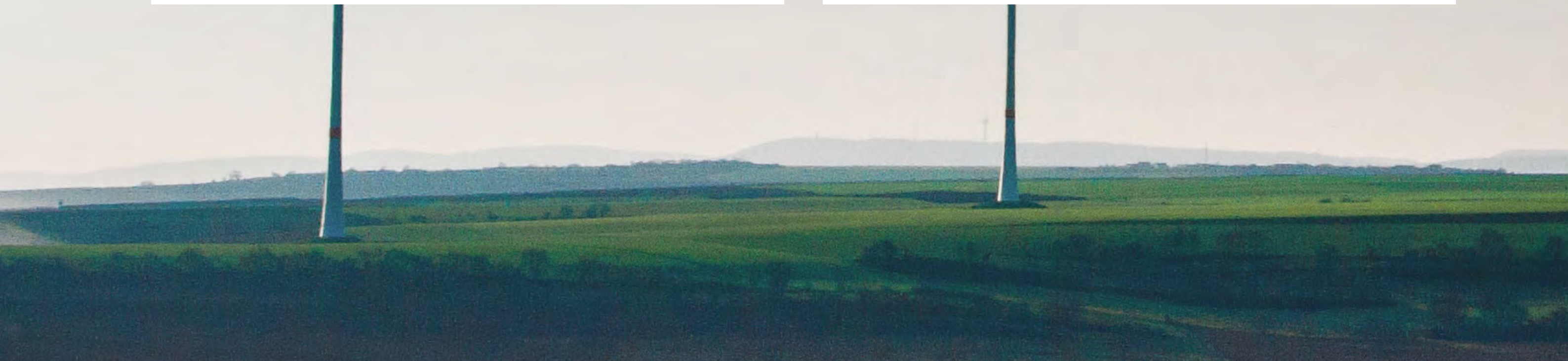
As an emerging country in the global economy, the energy transition will be an opportunity to restructure the economy using an inclusive and sustainable bottom-up approach. Also, the need for energy transition is slowly transforming into a preference for energy transition as renewable energy is becoming cheaper. Some of the strengths that can be used to propel energy transition and discussed in detail in chapter three are:

- Renewable energy is becoming highly cost-effective, with the lowest tariff recorded at INR 2.44 per kWh for solar power and INR 2.43 per kWh for wind energy.
- Pressure on political leaders to strengthen policy measures to promote energy transition through large-scale campaigns and targets set at the annual Conference of Parties (COP).
- Decentralised energy has the potential to supply electricity in remote villages for the long-term economic development of the area.

Notably, the mining regions of India are socio-economically backward. The loss of livelihood due to energy transition will make the formal and informal mineworkers and their dependents more vulnerable. In addition, the coal phase-out will also affect those indirectly involved with the current economic activities in ancillary or supporting jobs, such as a mechanic or a retail store worker around the coal-intensive region. We investigate the significance of stakeholders in the coal industry in chapter four and discuss the following stakeholders in detail:

- **Thermal power plants:** over seven lakh people are directly and indirectly dependent on the thermal power sector in India, which makes their rehabilitation and restructuring of the economy a critical element of decommissioning procedure.
- **Coal mining:** about three million people are directly or indirectly dependent on the coal sector. If not appropriately planned, a phase-out may worsen the country's socioeconomic profile.
- **Brick industry:** contributes 0.7% to the GDP and employs 10 million people.
- **Iron and steel industry:** contributes over 2% to the GDP and employs about 2.6 million people directly and indirectly.
- **State and central governments:** over INR 43,000 crore was collected in total in the form of royalty, cess, and other taxes from Coal India Limited alone in FY 2019-20.
- **Railways:** a significant contributor to the revenue of the Indian railways is the coal industry, primarily responsible for 44% of the freight revenue and 40% of the total revenue. About 370 million tonnes of coal is transported by rail annually.
- **Private sector:** in power generation, the private sector is the major player. With an installed capacity of 87 GW and a generation of 3,81,950 GWh in FY 2019-2020, it is the largest power producer in India.

Green energy proponents see coal as a polluter. Still, it is also a vehicle of



industrialisation, a source of revenue for both state and central governments, a source of employment for billions of workers, and a pillar of economic growth and development. Within the discourse on and around energy transition, one of the strong currents is energy justice, an essential aspect of which is participation in decision-making processes by all those affected by the energy transition. This further evolves into the concept of just transition that lies at the intersection of energy transition and energy justice. Multiple governments, organisations and academic institutions have developed frameworks for just transition that revolves around reskilling workers in the coal region, building institutional governance, economic diversification and participation of affected workers and communities. Recommendations in this regard are presented in chapter five, some of which are as follows:

- It is necessary to have a phase-down policy rather than a phase-out so that the people and the economy have the time to adjust to the changes.

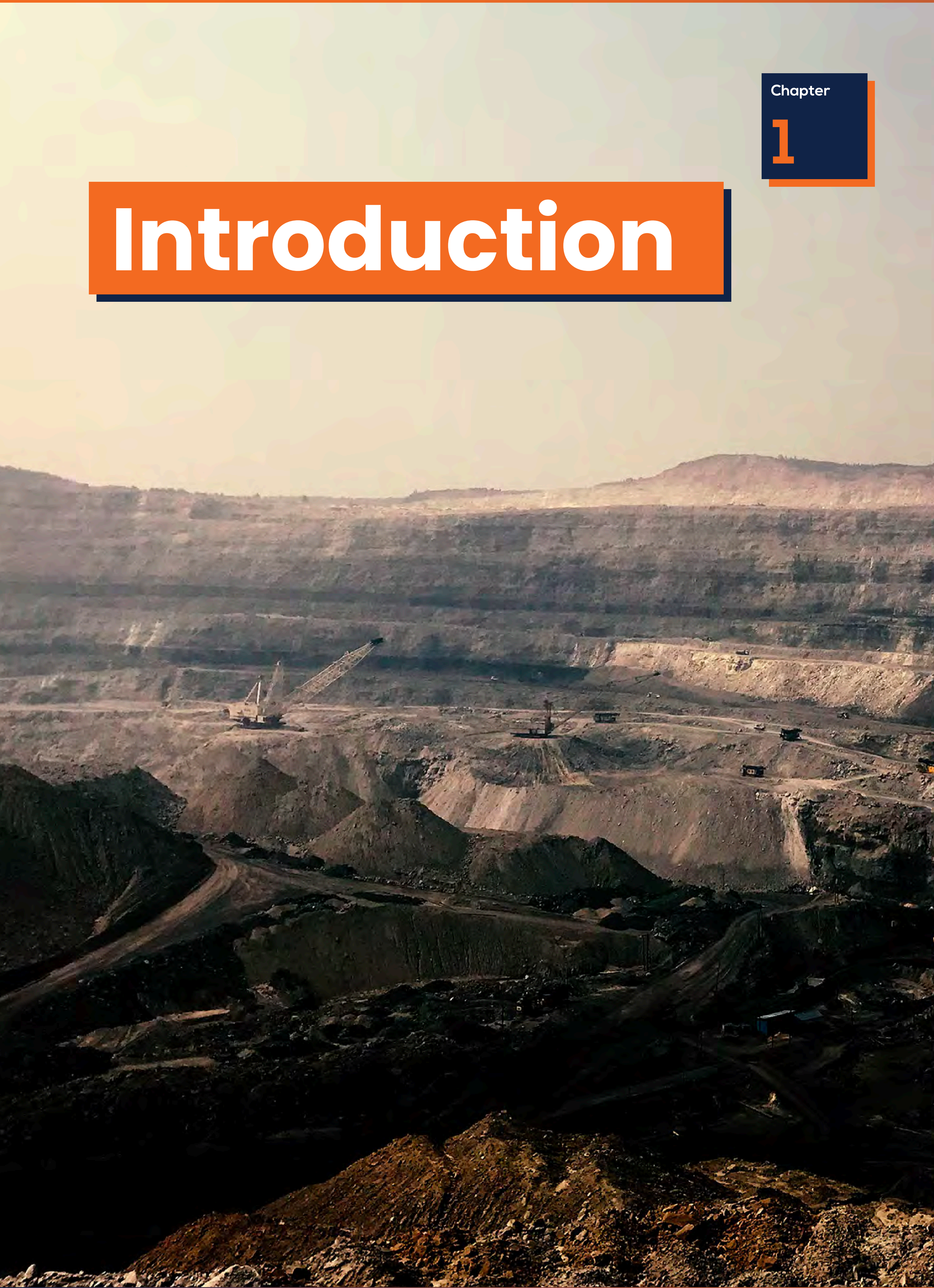
- Exploratory studies should be conducted near the coal industries before starting the phasing down process.

- The state, local authorities and academic institutions must work jointly for efficient data collection, assessment and publication of reports. It will be helpful to implement evidence-based decision-making.

Before delving into the issue of finding solutions to a problem, one must be aware of all aspects and characteristics associated with it. Therefore, this study's primary objective is to assist the planners, academicians, union leaders and investors with the available data, resources, insights and other information that one might need while creating just transition guidelines and policies. The study elucidates India's energy parameters for both thermal and renewable energy. The potential, installed capacity, generation, demand, revenue, environmental and social implications of energy consumption, the role of decentralised energy, and economic dependence on coal have been discussed, along with the impact on local or regional growth levels. Since energy transition is a complex and long-term procedure, further research is required to elaborate on several topics of this book that we have briefly covered. We hope this report serves as a guide for future energy research and promotes comprehensive and analytical studies.

Chapter 1

Introduction



Introduction

Findings of any study depend heavily on the definitions and concepts, associated theoretical frameworks and assumptions therein, methodologies used, and the sources of credible data. This chapter outlines the aims, objectives, and the approach of this report. The chapter is divided into four sections. Section 1.1 introduces the concept of energy transition, defines it, discusses the scope of energy justice and just transition, and how the three terms interact with each other. Section 1.2 contains the main objectives of the study. Section 1.3 sets forth the approach of the study, besides citing the sources of data used. Finally, Section 1.4 delineates the remaining part of the report.

1.1 Justice in Energy Transition

Etymologically, transition means 'a going across or over'; it is close to transient, meaning 'passing through a place without staying'. In an economic system, transition occurs with a shift in the constituents or compositions of consumption, or/and production, but in a major way. Likewise, an energy transition, implies a shift in the major input in the production of energy, namely fuel, from fossilized ones — "bottled sunshine"[1] — to other sources. It is a fact that combustion of fossil fuels to run almost all types of vehicles, power a plethora of electrical devices and produce most manufactured goods has contributed to massive emissions of greenhouse gases (GHGs) beyond the 'carrying capacity' of nature to absorb it.

Large-scale land use and land cover changes — primarily through deforestation — to get the space required for setting up both farms and firms has adversely affected the ecosystem's ability to perform its function to absorb the GHGs. The consequences include increased temperature, fluctuations in the historically ordinary or 'normal' rainfall patterns, a shift in weather conditions, and eventually a changing climate. It is widely acknowledged that unless mitigated immediately, there will be serious consequences in terms of more frequent 'extreme weather' events, pandemic-like health hazards, irreversible loss of biodiversity, and a fall in the scale of economic activities across the globe. Energy transition holds a key position in the efforts towards climate change mitigation as we shift towards cleaner sources that cause less or negligible emissions. Surely, there are multiple issues that may make this transition difficult — this report sheds light on these concerns.

Some already visible and plausible impacts on the economic system in a business-as-usual scenario

- Extreme weather events damaging urban infrastructure/transport affecting livelihoods
- Rural employment/agriculture affected by crop damage/droughts
- Rural employment and agricultural yield affected following Justus von Liebig's 'Law of the Minimum'[2] owing to inadequate, excessive and untimely water availability, excess heat or cold conditions, new pests induced by disruptions in local ecosystems
- Reduction in productivity of workers due to adverse human health owing to periodic epidemics and changes in everyday working conditions contributed by increasing temperatures, occasionally followed by rising worker turnover due to migration and mortality
- Increased pay-outs by insurance firms to owners of property and land affected by events owing to disruptions in nature

Within the discourse on and around energy transition, one of the strong currents is of energy justice. The seventh of the UN Sustainable Development Goals, (SDGs) adopted by the United Nations General Assembly on September 25, 2015 — "Ensure access to affordable, reliable, sustainable and modern energy for all" — captures this. However, conceptually, the notion predates the resolution adopted by many years, if not decades.

1 Bottled sunshine or stored energy implies the fossil fuels deposited in Earth's crust
2 Implies that plant growth is controlled not by the abundant resource but the one that is scarce. The growth will be hampered if one of the required nutrients is deficient even though all other nutrients are available in abundance.

Three core dimensions — distributional, procedural, and recognition-based — are associated with energy justice. Although, in the last few years, restorative and cosmopolitan dimensions[3] have been included, no reasonable consensus has been achieved so far. An important aspect of energy justice is participation in decision-making processes by all those who are affected by energy transition.

Distributional or distributive aspects are connected with the spatial aspects of the key impacts associated with the changes in the energy system. The location of a polluting thermal power plant in close vicinity to dwellings and/or workplaces of lower income groups may be considered as an instance. Here, the incidence of pollution will be felt most locally, but the benefits of electricity may elude the local population. This is also referred to as double inequality; it depicts unequal distribution of social and environmental costs of, and benefits from energy. This conceptualization helps to identify the location of and causes behind emergence of inequalities. In turn, this contributes to locating the 'focal points' (of tension or conflicts) in policy-making.

On the other hand, recognition-based dimension of justice warns against overlooking the impact on the neglected sectors of society. The impact of using kerosene or wood stoves on the female population who are more involved with cooking than their male counterparts — at least in the developing nations — can serve as an example. Those who belong to households with low income cannot afford cleaner but use (relatively) more expensive energy sources for cooking and lighting. In short, certain sections of the society are more vulnerable than the others and may not be in a position to either afford or participate in an 'energy transition' unless policy interventions address these aspects.

Finally, procedural dimensions of energy justice call for providing a platform to those directly affected by the decisions made in the energy sector. It involves initiatives both within the judicial space as well as at the community level. A pertinent example in this case is measures that could include restoring jobs lost in the fossil fuel sector as a result of transition to cleaner options, or even restoring the environment damaged by use of polluting energy sources. Here, the focus is on the processes that can repair the harm, either to the people and/or to the environment, rather than penalizing the polluter.

Just transition lies at the intersection of energy transition and energy justice. Its roots can be located in the U.S. labour movement of the 1980s and 1990s when workers demanded justice in the form of compensation, training, education, etc. to those who were displaced due to measures connected with the energy transition activities such as shutting down of a coal mine. To put in simple terms, just transition in the present case (of energy) integrates age-old developmental concerns at the macro level (such as inequality, and poverty) and workers at the micro level with the societal responses to a crisis that is of global nature, namely climatic changes. The connection across three spatial scales — global, regional/country, firm/farm — makes the matter interesting, complex, and challenging.

In the Indian context, among the many things that a just energy transition warrants include protecting the livelihood of those who are expected to be adversely affected. This includes those who are employed variously in the coal sector, from exploration and extraction to segregation and transportation. Further, in the developing nations, which are widely diversified, it is important to develop policies sensitive to what the needs of different regions are. For example, a region may be rich in human resource or in natural resources, and accordingly, investment can be pushed in these sectors so they can expand and absorb those displaced from the fossil fuel sector.

Some of the stylized facts are worth noting to understand and appreciate the significance of the matter: Coal contributes to over 70% of total electricity generation; many sectors with strong forward and backward linkages like cement, iron and steel, and railways are dependent largely on coal, if not other fossil fuels. Geologically, coal is mostly found in eastern and central India. On the other hand, use of renewable sources for electricity generation is mostly concentrated in other parts. For example, generation of solar energy is mostly in the western areas, hydro-electricity is in the northern, and wind in the south-eastern and Himalayan regions. All these together make phasing out coal, while also generating jobs through use of renewable sources, a challenging task. This has been discussed in detail later in this report. Some suggestions have also been made at the end.

3 An aspect of procedural justice includes restorative measures where the objective is to restore the harm rather than punishing the polluter. Cosmopolitan justice suggests universal application of all the justices to all humans regardless of ethnicity, gender and social status.

1.2 Objectives of the Study

The processes involved in any transition are many. The numerical dimension and qualitative complexity are directly proportional to the spread and depth of the matter in question in the broad scheme of things that are most powerful or deterministic, such as the economic systems. This increases the costs of transition as well.

In case of 'energy transition', in addition, temporal dimensions also assume significance, given the 'normalcy' or 'path dependency' associated with the use of fossil fuels across activities, classes, sectors, scales, time, and space.

The objective of the report is **to collect, collate, analyse and visualise information** along with qualitative insights before a variety of 'interest groups' — planners, academicians, union leaders, investors — (to be) involved and/or interested in the 'energy transition' per se, or in its specific dimensions such as justice.

Towards this end, the potential of renewable energy, raising its installed capacity, and environmental and socio-economic implications of both thermal and renewable energy are presented along with the economic, historical, and social dependencies of the coal sector, and the disproportionate impacts that a transition will have on workers — across direct, indirect, non-permanent categories — whose livelihoods are dependent on the continuous use of coal. Accordingly, estimates are arrived at the number of people who are directly dependent on not only coal industry per se (say, mining), and thermal power plants, but also in ancillary, or supporting jobs (say, a mechanic, or a retail store worker) in the spaces that host the 'coal sector' besides those industries that use coal as an input (say, iron and steel).

Further, the serious — fiscal and financial — consequences of a coal phase-out on the state and central governments have also been discussed here. In this quest, information is collected on the most prominent impacts that are already visible, or are most likely to emerge in the future against a falling use of coal in absolute terms.

In this report, an attempt has been made to discuss some of the just transition frameworks developed elsewhere, but used by many in the Indian context. Towards this end, some recommendations that may be found useful by the planners, entrepreneurs, and experts, while facilitating a just transition through policies and guidelines have been provided. This study aims to help the researchers who are introduced to the energy-economy sector and are looking for a study that would equip them with the foundational knowledge in this domain. As the report consists of brief but key information on nearly all aspects of a just energy transition in India, it can be construed as a handbook. The information is expected to be useful to trade unions, local political, and community leaders in the coal intensive regions — after all, they have some significant roles to play in facilitating a just transition.

1.3 Approach Followed in the Report

Energy justice is a fairly new concept, even in the domain of planning for energy production and distribution, leave alone larger discourses on economic development in India. As a result, a wide range of studies, reports, and news articles on energy scenario, energy transition, and energy justice from a broader context have been used to develop insights. Several case studies from non-Indian contexts have been included to showcase what happens during the process of energy transition, and in its absence, the impacts it has on economy and environment, and ultimately on health and livelihoods of people.

This study is based on secondary data which have been obtained from the Central Electricity Authority (Ministry of Power, GoI), the Ministry of New and Renewable Energy (GoI), the International Energy Agency, the Oxford Martin Programme on Global Development, the coal industry, published research papers and books across mediums, among others (Annexure).

> "Coal contributes to over 70% of total electricity generation in India"

1.4 Organization of the Report

To reiterate, the purpose of this report is to share the knowledge on the energy sector with researchers, governments, industries, and other stakeholders. Accordingly, information was brought together from a multitude of sources and was presented along with a brief discussion of what it implies, and what can be understood about the interconnections among various elements in the energy sector. The coverage of this study, however, is limited to secondary data only.

The second chapter sets the context of this study Comprehensive information on India's energy setting has been presented, which includes energy consumption and production, electricity consumption
and production, and the role of renewable, decentralised, and thermal energy. The purpose of this chapter is to familiarize the reader with some of the stylized facts vis-à-vis energy in India. This will help towards developing a better understanding of energy transition per se, and matters around justice in energy transition.

The third chapter discusses the economic and development aspects connected with energy consumption. Details of energy balance, particularly in thermal energy and in the electricity sector, are briefly discussed. Rural growth and development, investments in energy, and the impact on social development indicators are also explored here. This chapter highlights the need for energy transition, and the barriers and drivers associated with it.

The fourth chapter covers the major stakeholders associated with the coal sector in India. Interdependencies among individuals, industries, governments, and the coal industry have been explored to understand the impact coal phaseout may have on these stakeholders.

The fifth and final chapter delves into the justice element of energy transition. Several just transition frameworks from various countries have been presented along with just transition studies and reports developed in India for the purpose of formulating coal phaseout guidelines. On the basis of all the information from chapters 1 to 5, some recommendations have been provided as a stepping stone towards developing Just Transition policies and guidelines.

"Thermal power plants account for 60% of the total installed capacity but generate 75% of total electricity in India"

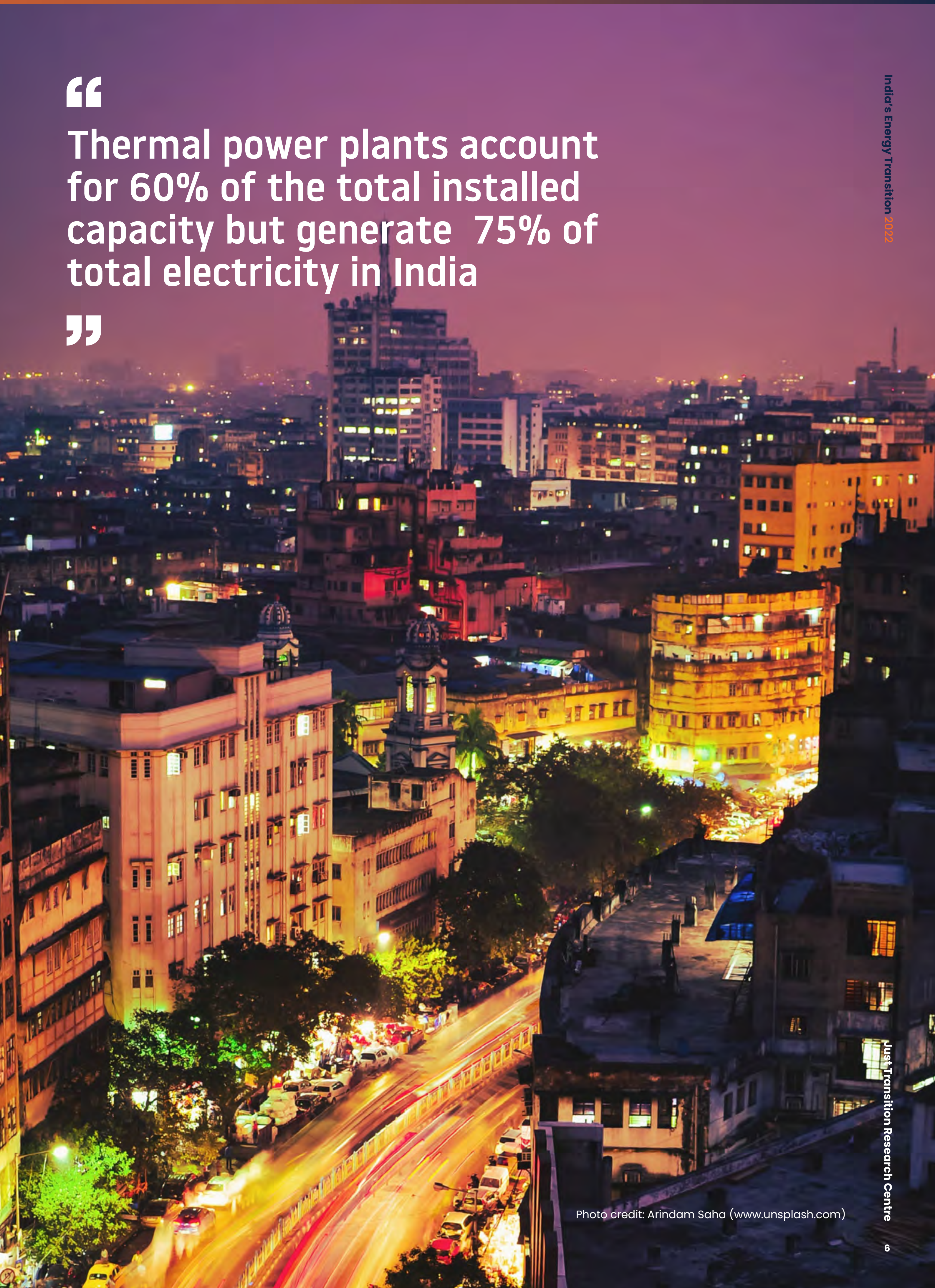


Photo credit: Arindam Saha (www.unsplash.com)

Chapter 2

Status of Energy in India

2.1 Introduction

The economic growth and development of any country depends on energy; only its nature and form changes with the underlying processes and resulting outcomes. For its ubiquitous presence, it influences several socio-economic and environmental attributes — across several sectors — and ultimately the sustainability of any society.

With the pace of urbanization and industrialization picking up, India's per capita energy use is also expected to rise. The total energy supply has almost tripled in the last two decades (IEA, n.d.) with a minor aberration in 2020, when the demand decreased by about 5% as a result of the COVID-19 pandemic. As the economy started showing signs of recovery, the demand and production of energy also increased. Given the worldwide concerns on GHG emissions, 'tipping points' vis-à-vis ecological disruptions of gigantic scales, and commitments to reach SDGs, it may not be an exaggeration to claim that we are at the crossroads: It involves the most appropriate 'energy mix', associated energy pathways and then decide on the roadmap for making new investments and divestments of existing assets, if any. A look at the status of energy production and consumption in India is necessary for this purpose — this is the objective of this chapter. We shall start with some basics on the physical aspects of energy.

In simple terms energy is the capacity of doing work such as moving, lifting, etc. From an economic standpoint it can be classified according to its source, that is, fossil fuel, water, wind, and sunlight. Technically these are called primary energy sources, as they are often converted into more usable 'secondary energy' forms like electricity. It can be further classified into commercial and non-commercial on the basis of its availability in the market. The former includes such sources and products that can be purchased in the market against a charge. The latter includes traditional fuels such as firewood, cattle dung, etc., that are collected by the end user themselves and are usually not traded in the market. These are mostly collected by the rural households for day-to-day activities such as cooking, lighting and heating. In National Income Statistics, these are recorded as self-consumption.

In ancient times, the sources of energy were mostly organic products such as wood, animal dung and straw, which, with economic development, were replaced by newer sources such as watermills. The Industrial Revolution in Great Britain in the early 18th century marked by the invention of the steam engine and the development of large factories boosted a further increase in the demand for energy in particular with a consequential steep incline witnessed in the extraction of coal. Needless to say, oil extraction also saw a similar rise subsequently.

Today, the world economy consumes over eight billion tonnes (BT) of coal per year for manufacturing brick, steel, electricity, etc. India alone consumed almost a billion tonnes of coal in 2020-21 including an import of 215 MT, making it one of the world's largest producer and consumer of coal (Ministry of Coal, n.d.). Although thermal power plants account for 60% of the total installed capacity, they account for 75% of the total electricity generated (CEA General Review, 2021). This chapter will cover some of the salient aspects of the production and consumption of energy, including their classification, besides making a case for energy transition and the implications thereof.

2.2 Energy and Electricity

At the outset there is a need to distinguish between energy and electricity. Energy, in its myriad forms, is intricately connected with our daily lives. For example, walking from one point to another entails some amount of work, which in turn requires some amount of energy. Power is defined as the use of energy per unit of time. In case the distance between the two points can be covered in half the time spent earlier, the amount of energy required may remain the same, but, the power applied will be doubled. In short, power is the time rate of doing work and is represented by 'watts'. On the other hand, energy is the capacity of doing work and is represented by 'watt-hours', Table 2.1 describes the various forms of energy that are available in the society.

Table 2.1
Forms and Types of Energy

Forms of Energy

Kinetic energy
Energy of moving objects

Potential energy
Energy that is stored in an object such as elastic energy

Types of Energy

Thermal energy
Energy stored in an object due to the movement of particles within the object

Radiant energy
Energy from the sun converted into electricity by solar cells

Sound energy
Energy produced by vibrating sound waves

Electrical energy
Caused by moving electrical charges or electrons such as a battery lighting up a bulb

Mechanical energy
Energy possessed by an object due to its motion or position

Chemical energy
Energy stored in the bonds of chemical compounds and released in chemical reactions which may also be converted into electrical energy

Gravitational energy
Energy stored in an object based on its height from the ground, such as water stored in a dam when released onto a turbine generates motion energy

Motion energy
Energy stored in moving objects, such as motion generated in a turbine from falling water which is further converted into electrical energy

Nuclear energy
Energy stored in the nuclei of atoms and released in the form of heat and radiation when the nuclei is fused together or split apart

Elastic energy
Energy from a deformed object such as a slingshot or an archer's bow when stretched

Source: Solar Schools, n.d.

It follows that electricity is also a form of energy which is used by converting into other forms of energy. For example, radiators or heat convectors convert electric energy into thermal energy or heat. Electricity, however, accounts for only a part of energy used by us on an everyday basis. We also use oil for transportation, wood and coal for cooking and heating (mostly) in rural areas. India's total electricity consumption was 1,560 Terawatt hours (TWh) in 2019-20 which is only 15% of the total energy consumption (Fig. 2.1). The terms energy and electricity have different meanings but unfortunately are often used synonymously in the popular writings. It is important to draw a clear distinction clear before proceeding further .

Consider a few examples:

An article published in The Economic Times in November 2021 contained a sentence, "Foreign Secretary also informed that PM Modi at COP 26 announced that by 2030, 50 per cent of India's energy needs would be met from renewable energy sources." (The Economic Times, 2021, emphasis added). It was referring to electricity only, not to total energy use. An article published in the Hindustan Times in October 2021 mentioned, "India has set a target of achieving 40% of electric power installed capacity from non-fossil fuel sources by 2030 in its Nationally Determined Contributions (NDC) under the Paris Agreement." (Kant, A. 2021). Here the reference to electric energy is clear.

In an article published in the Business Standard in November 2021 it was said, "Additionally, India has successfully produced energy from non-fossil fuel sources by more than 25% in the last 7 years thereby reaching 40% of the country's energy mix." (Kumar, 2021). This again refers to electricity.

A commentary from WRI India blogs says, "Sourcing 50% of energy requirement from renewables by 2030" and "The new 50% target of electricity generated by solar, wind, and hydropower is more ambitious than what would be achieved solely through market factors and falling prices of renewable energy" (WRI, n.d.) within the same blog. Here the term energy is not precisely defined.

Such conflation of terms causes confusion. It is unclear from the quoted texts above whether the target is to achieve 50% energy from renewables or 50% electricity consumption from renewable or 50% electric installed capacity from renewable energy!

> "India's total electricity consumption was 1,560 TWh in 2019-20 which is only 15% of the total energy consumption"

Figure 2.1(a)
Primary energy consumption in India

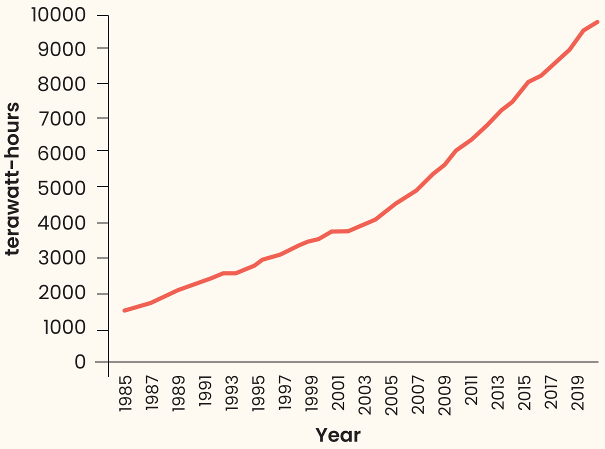


Figure 2.1(b)
Electricity consumption in India

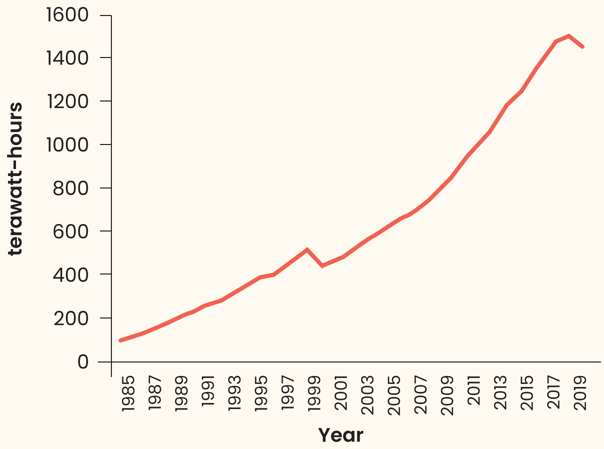


Figure 2.2(a)
India's per capita energy consumption

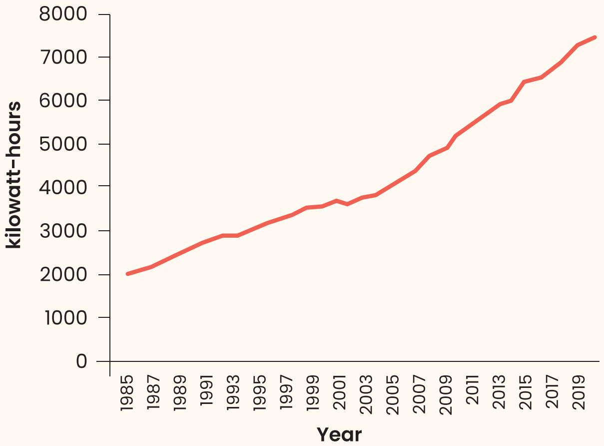
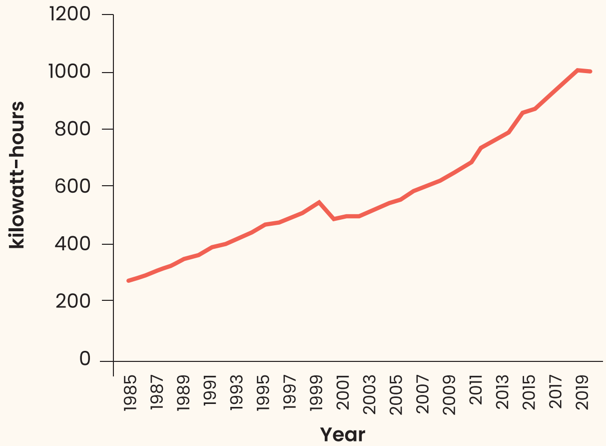


Figure 2.2(b)
India's per capita electricity consumption



Source: Created from Statistical Review of World Energy Report, 2020 (Fig. 2.1-2.2)

Table 2.2
India's Per Capita Primary Energy Consumption by source

Source	2000 (in kWh)	2019 (in kWh)
Coal	1809	3785
Oil	1205	2081
Gas	240	437
Nuclear	41	82
Hydropower	202	293
Wind	4	115
Solar	<1	84
Other renewables	4	46
Total	**3507**	**6923**

Source: Created from Statistical Review of World Energy Report, 2020

Table 2.3
Per Capita Electricity Consumption by source

Source	2000 (in kWh)	2019 (in kWh)
Coal	331	731
Oil	2	<1
Gas	41	35
Nuclear	13	33
Hydropower	70	118
Wind	2	46
Solar	<1	34
Other renewables	1	11
Total	**460**	**1009**

Source: Created from Statistical Review of World Energy Report, 2020

As can be seen, the per capita primary energy consumption nearly doubled in the last two decades while the per capita electricity consumption more than doubled (Fig. 2.2). The per capita primary energy consumption from renewable energy sources (including hydropower) increased from 211 kWh to 538 kWh while the per capita electricity consumption from renewable energy sources nearly tripled (Tables 2.2 and 2.3).

Some stylised facts on energy and electricity consumption in India (2000-19)

- Total electricity consumption is about 15% of total energy consumption (2020)
- Electricity consumption from coal accounts for only 10.7% of total energy consumption (2020)
- Renewable energy consumption (excluding large hydro and nuclear) accounts for almost 10% of total energy consumption (2020)

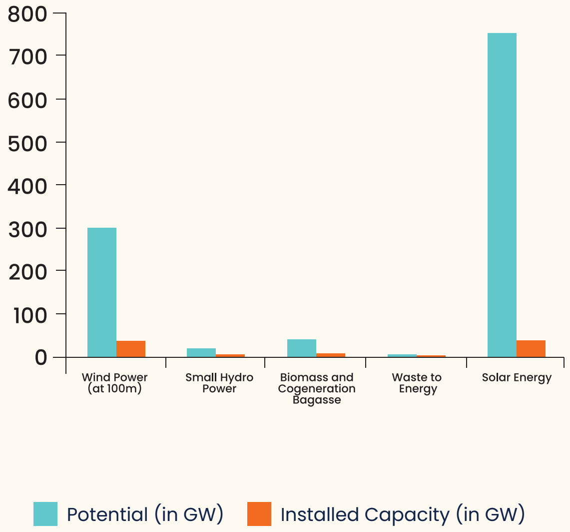
2.3 Renewable Energy

This section presents some facts about renewable energy and its importance in the preservation of the environment and facilitating the process of development in India at the same time.

2.3.1 Potential and Installed Capacity

The total renewable energy potential in India including wind power (at 100 m height), small hydro, biomass, cogeneration bagasse, waste to energy and solar sources amounts to around 1100 Gigawatt Power (GWp) (MNRE Annual Report, 2019)

Figure 2.3
Renewable Energy potential versus installed capacity



Source: Created from MNRE Annual Report, 2019

The growth in the installed capacity of renewable energy (RE) has been significant in the last couple of decades; however, the current capacity is less than a tenth of the overall potential as on December 2021 (MNRE, 2022). Solar and wind energies are dominant as they have a high potential, installed capacity and rate of growth. Notwithstanding such developments, the electricity generated and distributed is still mainly from conventional resources, although the share of installed capacity of thermal sources is about 60%, the amount of electricity actually generated is 75% (CEA Executive Summary, 2021) (see Fig. 2.4). This signifies the necessity of increasing the generation of electricity from RE sources instead of increasing just the installed capacity.

Figure 2.4(a)
Sourcewise installed capacity

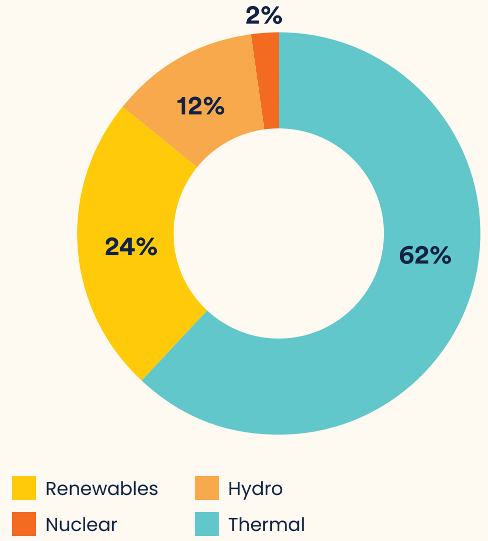
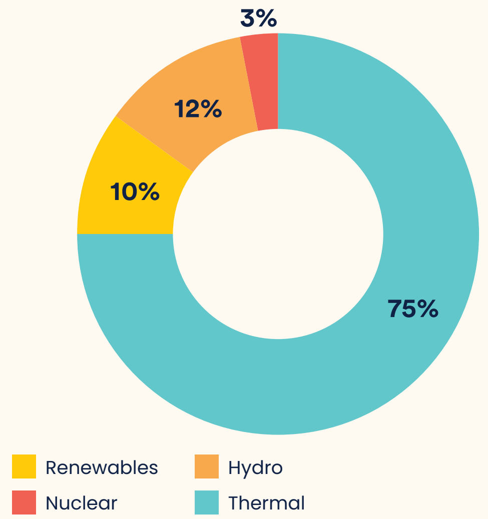


Figure 2.4(b)
Sourcewise electricity generation



Source: Created from Executive Summary, CEA, 2021

2.3.2 Socio-Economic Development fuelled by energy from Renewable sources

One of the major reasons behind investments towards harvesting of renewable energy is to make (at least future) socio-economic

development fuelled by sustainable sources. In the process this is expected to insulate the major sectors contributing to economic growth from energy price shocks/fluctuations besides addressing fossil fuel induced global warming.

To reiterate, energy is consumed in multiple forms including in transportation, cooking, lighting, agriculture, manufacturing, and other industrial processes. With increase in the scale of these activities — reflected in a rise in GDP captured through the rate of economic growth — overall energy consumption increases.

A rise in income leads to greater use of energy per capita to achieve higher standards of living. This in turn opens up possibilities for faster economic development through 'backward' and 'forward' linkages across connected sectors. This bi-directional causality has significant implications for policy formulation. For example, a unidirectional causality from GDP to energy consumption, also known as conservation hypothesis implies that a change in energy policies will not hamper economic growth significantly. However, a causality from energy consumption to GDP, also known as growth hypothesis implies that the economic growth is dependent upon energy and policies aimed at reduction of energy availability will negatively affect economic growth. On the other hand, bidirectional causality implies that both—use of energy and scale of economic activity — have an impact upon each other and hence policymakers need to incorporate these effects while changing policies in either.

This is called feedback hypothesis. Evidence shows its presence in developing countries like India. It follows that state intervention is necessary not only in both energy and economic systems but also in consideration with the chain of impacts of energy transition on the economy and then on energy transition and so on.

A number of empirical studies have been conducted to test the causal effects of renewable energy on economic indicators. The test conducted by Apergis & Payne (2010) considered twenty OECD countries between 1985 and 2005 and identified a bidirectional causality between renewable energy consumption and economic growth in both the short and long run. Other studies using different methods are presented in Table 2.4.

Together, these studies show a consistent manifestation of feedback hypothesis for several economies including India. This indicates that increase in renewable energy consumption will have a positive impact on economic growth and therefore the government needs to look at not only increasing installed capacity but also at increasing actual consumption levels from renewable energy sources. Investments, incentives, policies and schemes may be designed to push the production capacity of renewable energy to account for the increasing demand, and economic growth. Certainly, all these together will contribute towards the mitigation of climate change.

Table 2.4
Direction of causality between renewable energy and economic growth

Study	Period	Method	Result/direction of causality
Apergis et al. (2010)	1984-2007	Panel error correction model	Feedback
Ahmed and Shimada (2019)	1994-2014	Panel cointegration test	Feedback
Azam et al. (2021)	1990-2017	Panel cointegration test	Feedback
Pao and Fu (2013)	1980-2010	Panel cointegration test	Feedback
Amri (2016)	1990-2010	Dynamic Panel Estimation /2 step regression	Feedback
Steve et al. (2020)	1990-2018	Dumitrescu-Hurlin Granger Causality	Feedback and Growth
Eyuboglu and Uzar (2021)	1990-2015	Bootstrap Panel Causality	Neutrality
Ozcan and Ozturk (2019)	1990-2016	Bootstrap Panel Causality	Neutrality
Guan et al. (2021)	2011-2020	Panel cointegration test	Growth
Azam et al. (2021)	1990-2017	Panel Vector autoregressive model	Feedback
Hamit-Haggar (2016)	1971-2007	Panel cointegration test	Growth
Qayyum et al. (2021)	1980-2019	Vector Error Correction Model	Growth
Ali et al. (2018)	1995-2015	Vector Error Correction Model	Conservation
Destek and Aslan (2017)	1980-2012	Bootstrap Panel Causality	Neutrality
Rahman and Velayutham (2020)	1990-2014	Panel Causality testing	Conservation

2.3.3 Decentralised electricity

Electrification of villages can contribute immensely to the lives of non-urban population. Indeed, the central government, through its Ministry of Power, aims at electrification of all villages. Fulfilment of the following conditions makes a village to be declared electrified:

- Transformer and distribution lines have been set up in the vicinity of the village
- Public places like schools, dispensaries and Panchayat offices have electric connection
- At least 10 % of the households in the village are electrified

Although India has achieved nearly 100% electrification — defined in the manner above—still, a large number of households are without access to electricity. This is specifically true for remote villages.

Decentralised renewable energy mechanisms were put in place rather as a forerunner to electricity from the centralised grid reaching those remote locations. Interestingly, such systems have proved to be beneficial not only from the point of view of electricity supply but also from economic, environmental and social perspectives. In fact, some remote Himalayan villages are so inaccessible at times due to landslides, snowfall and heavy rainfall that decentralised electricity may be the only viable option in physical terms. Table 2.5 briefly summarises the renewable energy technologies that can play a significant role in the establishment of these systems.

Hybrid renewable energy technology mechanisms are gaining popularity in the domain of decentralised renewable energy systems. The name owes to the fact that these systems integrate more than one technology. Consider for example, a combination of solar and wind energy — this is more reliable when compared with a system utilizing a single resource (examples are in Table 2.6). Several tools have also been developed for this such as MODEST, developed by Henning (1997) which minimizes the costs associated with energy supply and demand management while taking into account the seasonal fluctuations in costs and capacities. Similarly software like HOMER, RETScreen, Hybrid Designer, ARES, etc are now available for conducting technical and economic evaluation of hybrid renewable energy technologies. Several studies have been conducted exploring the costs and benefits of decentralised renewable energy (Table 2.6).

Table 2.5
Renewable energy technologies for decentralised systems

Type	Description
Bio-energy	Energy from organic matter like crop residue, pine needles, etc.
Micro-hydro power	Energy from running water through “run-of-river” power plants that do not need extensive construction of infrastructure such as dams.
Wind energy	Energy extracted from moving air using rotor blades and electric generator.
Solar energy	Photovoltaic cells, more popularly established as rooftop SPV system.
Hybrid systems	A combination of various renewable energy technologies for a more cost efficient and reliable energy system.

Table 2.6
Feasibility of decentralised renewable energy

Study	Location	Objective	Results/Remarks
Baruah & Baruah (2021)	Jhawani village, Assam	Viability of a biomass gasifier based electricity generation system	"Dhaincha" feedstock in a gasifier with a LCOE of 0.20$/kWh
Mahapatra & Dasappa (2012)	-	Comparison between off-grid SPV, biomass gasifier and grid extension	Biomass gasification found to be more economically feasible
Chakrabarti & Chakrabarti (2002)	Sagar Dweep, West Bengal	Feasibility of decentralised SPV from economic and environmental perspective	SPV system found to be superior from both economic and environmental perspective
Nouni et. al. (2008)	-	Estimating cost of generation and distribution of electricity and preliminary assessment of decentralised systems	Decentralised energy systems found to be more financially attractive when compared with grid based alternatives
Singh & Baredar (2016)	Maulana Azad National Institute of Technology, Bhopal, Madhya Pradesh	Optimisation of SPV, fuel cell, bio-mass gasifier, battery backup and power conditioning unit using HOMER	Cost of energy of hybrid system found to be 15.06 Rs/kWh
Krishan & Suhag (2019)	Yamunanagar, Haryana	Techno-economic analysis and optimum design of hybrid renewable energy system using HOMER	Wind-SPV-battery based sys-tem found to be most cost effective
Murugaperumal & Ajay D Vimal Raj (2019)	Korkadu, Pondicherry	Optimal designing and techno economic feasibility of hybrid systems for remote locations	Hybrid systems more cost effective for remote locations
Chauhan et. al. (2021)	Darma Valley, Uttarakhand	Techno-economic study of hybrid system using wind, hydro, solar and diesel combination	Energy generation from micro hydro found to be most economically and environmentally feasible

Case Studies: Decentralised Energy

a

Jakhna Micro Hydro Plant

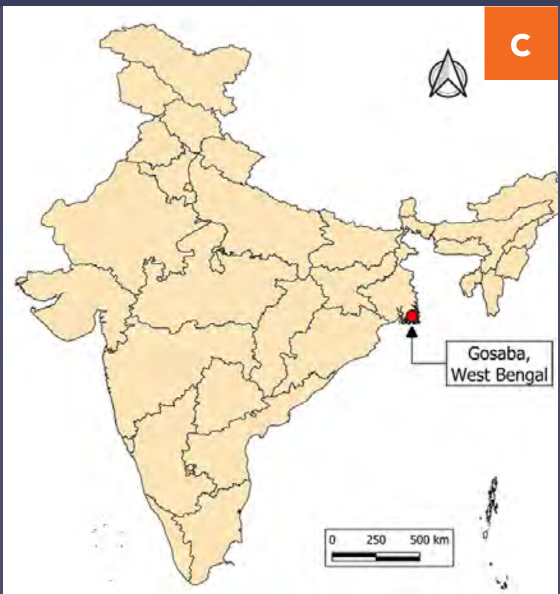
Jakhna micro hydro plant, a 100 kW (2*50 kW) system located in Tehri Garhwal district of Uttarakhand electrifies three villages with 260 households. The project was planned and constructed by the local residents. A Village Energy Committee (VEC) was formed for proper construction, operation and maintenance of the plant. The plant has provided employment for operation and maintenance and charges Rs 3 per unit for metered connections and Rs 50 per bulb per month for non metered connection. About 40% of the cost was born by MNRE, 8% by the VEC and the rest by Uttarakhand Renewable Energy Development Agency (Goel et al., 2008)

Udmaroo Micro Hydro System

Udmaroo, a remote village in Nubra valley of Ladakh remains cut off from the world for nearly three to four months every year due to excessive cold and snow. Ladakh Ecological Development Group along with efforts from the local population successfully set up a 32 kVA micro hydro system that caters to the need of about 90 households. The plant is owned, operated and maintained by the people who live there. A fixed tariff of Rs 90 is charged per month per household. Economic activities have since expanded while utilizing only 70% of the plant's capacity. The villagers were then approached to sell the excess electricity. They declined the proposal keeping in consideration the future needs of the village. (Leis India, n.d.)

b

c



Gosaba biomass gasifier

West Bengal Renewable Energy Development Agency (WBREDA) set up a 500 kW (5 x 100 kW) biomass gasifier in 1997 in the remote village of the Sundarbans, Gosaba. The plant is run and maintained by Gosaba Rural Energy Cooperative established by WBREDA. It caters to the need of approximately 10,000 people (TERI Envis, 2015) and several commercial stores and nearby hotels. Prior to the establishment, only a few households had access to electricity through a diesel generator and electricity was sold at a price much higher than the average market price. The decentralised gasifier system has proved to be highly efficient and reliable with uninterrupted power supply as it runs on locally available feedstock. Since its establishment, economic activities expanded, schools and hospitals received electricity, small businesses were set up and the average income increased.

2.4. Thermal Energy

2.4.1 Potential and Installed Capacity

Coal, oil and gas are the most popular conventional fuels that account for about 85% of total energy consumption in India. Among these, coal has a share of over 50% in the country's total energy mix followed by oil at 28% and gas at 6.7% (Ritchie and Roser, n.d.). India holds about 9% of the world's total proven coal reserves ranking 5th after US, Russia, Australia and China. The current proven reserves are over a hundred times India's current demand. If the 'indicated' and 'inferred' reserves are also included then there is a total of 319,020 million tonnes of coal. This is more than twice of the proven amount. The oil and natural gas reserves amount to 493.26 million metric tonnes and 1080.42 billion cubic meters respectively (Ministry of Petroleum and Natural Gas, 2021.).

> "India's proven coal reserves will last at least 100 years at the current rate of consumption"

India consumes about 1342 TWh of electricity of which coal accounts for over 70%. Within the thermal electricity mix, coal is dominant with a 95% share. Although the total thermal installed electricity capacity is 235 GW, which is 60% of the total installed capacity, the actual consumption share is 75%. The other sectors in which coal is dominant include the brick, cement and steel industries (see Chapter 4). Energy transition poses a major challenge from a geographical point of view as most coal fields are located in the east and south east of the country while the potential for renewable energy sources lie in other locations (Hussain et al. 2019; Purohit and Michaelowa, 2007; Lu et al., 2020). Wind energy potential lies majorly in the western part of the country and hydro power potential in the Himalayan states of India.

2.4.2 Environmental Implications

Thermal energy is certainly efficient and easy to access, but the adverse environmental implications caused by burning of fossil fuels are widely known. This section covers some short term or almost immediate adverse impacts caused by thermal power stations in the villages and towns located close to the plants.

Thermal power plants use heat to convert water into steam that runs a turbine which generates electricity and the water is then condensed and recycled until it cannot be used again. This water is usually discharged into the local streams and canals that not only pollutes the water source but also has an impact on local biodiversity, ultimately disrupting the natural ecosystem.

Apart from the metal infused wastewater, the ash discharged from the plants has serious effects on local flora and fauna, soil and water. These eventually have a negative impact on agriculture, vegetation and the health of the local residents. Similar to wastewater, this fly ash contains not only the metal ions but also radionuclides (radioactive nuclides) which could cause long term damage to the environment and people's health. Moreover, nearly 40% of the thermal power plants are located in regions which are already facing water scarcity (Luo, 2018). At the same time, thermal power plants are also responsible for major economic developments, even locally. This is discussed in the next section.

Case Study: Thermal Power

Thermal power plants, Nagpur district

Koradi (2400 MW) and Khaparkheda (1340 MW) thermal power plants in Nagpur came under heavy scrutiny because of excessive pollution in the area. Although, the plants are very important for providing electricity in Maharashtra, the improper waste disposal has affected the health and ecology of the local residents for years. The thermal power plant alone is found to be producing a much greater negative impact than coal and manganese mining that were taking place in this area. The area is endowed with natural resources like coal and manganese, the mining of which along with brick manufacturing in the vicinity were some major economic activities.

The power plants were discharging pollutants (including fly ash) directly into the local river which was contaminating the groundwater as well. The water was found to be polluted with arsenic, mercury, lithium, fluoride, and many other toxic substances in quantities much higher than the acceptable standards. This water was used for drinking, bathing by humans. The local residents also use this water for fishing and irrigation. The residents reported severe health impacts like asthma, skin ailments and bone related issues. Obviously, it impacted the health and environment, and in most cases beyond the local. Although the study included only a few villages near the power plants, the impacts have been observed in the surrounding villages and towns as well.

2.4.3 Role in Development

We have noted earlier that emissions of hazardous gases as a result of energy generated from fossil fuels is responsible for increasing the global temperatures, and also that, the need for augmented investments in renewable energy as a counter measure. It remains a fact that several economies, including India are highly dependent on fossil fuels, not just for its energy needs but also for the economic growth, associated increased employment opportunities (direct and indirect) and for the massive manufacturing and services sector. The justification is aided by 'growth hypothesis' (discussed in section 2.3.2) and assumes more importance in a developing country faced with a high population growth due to demographic transition. At the same time, for non-renewable energy, we observe conflicting results on the causal connection with economic growth — unlike conventional energy — as presented in Table 2.8.

Table 2.7
Direction of causality between conventional energy and economic growth

Study	Time Period	Method	Results
Ohlan (2016)	1971-2012	Multivariate model	**Growth Hypothesis**
Destek & Aslan (2017)	1980-2012	Bootstrap Panel Causality test	**Neutrality Hypothesis**
Pao & Fu (2013)	1980-2010	Vector Error Correction Model	**Conservation Hypothesis**
Apergis & Payne (2011)	1990-2007	Panel Error Correction Model	**Feedback Hypothesis**
Rahman & Velayutham (2020)	1990-2014	Panel Causality testing	**Growth Hypothesis**
Jebli & Youssef (2017)	1980-2011	Vector Error Correction Model	**Feedback Hypothesis**
Asafu-Adjaye et al. (2017)	1990-2012	Pooled Mean Group Estima-tor	**Feedback Hypothesis**
Dimitriadis et al. (2021)	1990-2014	Pooled Mean Group, Mean Group and Dynamic Fixed Effects	**Growth Hypothesis**
Pao et al. (2014)	1990-2010	Panel Cointegration	**Bidirectional**

Unlike the clear results vis-à-vis causal connections testing between renewable energy and economic growth, the one between conventional energy and economic growth present conflicting results. In developing countries growth and bidirectional hypothesis have been repeatedly observed that presents a dilemma of choosing between increasing energy production (and hence both pushing the economy forward and increasing emissions) and decreasing energy production (with lesser emissions and lower growth).

The apparent solution, i.e. transitioning towards production from renewable energy systems, is not as straightforward as it seems. Besides accounting for the high initial capital costs in renewable energy, one also needs to look at the cost of energy transition from the perspective of those currently dependent on the conventional energy sector. It needs to be stressed that the coal industry alone employs over three and a half million people in India (Aggarwal, 2021), directly and indirectly, which makes coal phase out a challenging task.

This energy transition also involves the question of just transition. The skill requirements, educational levels, social capital, cultural characteristics, personality traits and geographical basis of labour in energy production across renewable and non-renewable sources are not quite the same. In a situation of high employment and post-COVID rebuilding of economy it is doubtful that all those who will be displaced during the process of energy transition will be absorbed in green energy plants. Since the locations of two types of plants (green and thermal) and their employment potentials are not the same, the 'old energy' workers may not find an easy resettlement in the 'new energy' sector.

2.5 Towards Energy Transition

In sum, India's energy generation, consumption and demand have increased significantly over the last two decades. The government of India implemented several policies providing incentives and subsidies for adopting renewable energy mechanisms, both at household and corporate levels for domestic and commercial purposes respectively. With the energy consumption growing at an annual rate of 4.5% in the last two decades (World Bank, 2021), growth in fuel consumption by about 50% in a decade and extensive imports in oil (80% of total consumption) and coal industry (25% of total consumption), energy transition to cost effective cleaner technologies is becoming a necessity rather than a choice.

Although India's renewable energy installed capacity and renewable energy generation have improved significantly over the last decade, a reliable and affordable access of electricity to all is still a challenge. All forms of renewable energy are unpredictable in this regard and therefore apart from investing in renewable energy installation, focus need to be increased on battery storage systems and flexible energy trading system among the states to store and supply power at times of deficit.

The power sector, naturally, has been the focal point of energy transition as it is responsible for the largest share of carbon dioxide emissions (1,100 MT in 2019). The non-utilities sector, particularly the iron and steel, and the cement industries emit nearly half of this amount and yet it receives barely any attention (IEA, 2021). Reducing emissions from this sector is a challenge but there are several techniques that can be adopted that minimize emissions, such as directly reduced iron based on green hydrogen, biomass substitutes and electrolysis using renewable power (Gielen, et al., 2020).

India has performed remarkably well in terms of renewable energy installed capacity and reduction of emission intensity. Arguably there is a need for:

- Investment in "research and development" in the field of renewable energy technologies and battery storage systems
- Making energy trade amongstates flexible and establishing real time energy markets
- Investing in energy efficient mechanisms
- Working towards reduction of transmission and distribution losses which currently are about three times the world average
- Investment in decentralised energy, especially for remote and rural regions
- Better tariff and tax structure of small hydro power plants

Chapter 3

Energy and Development

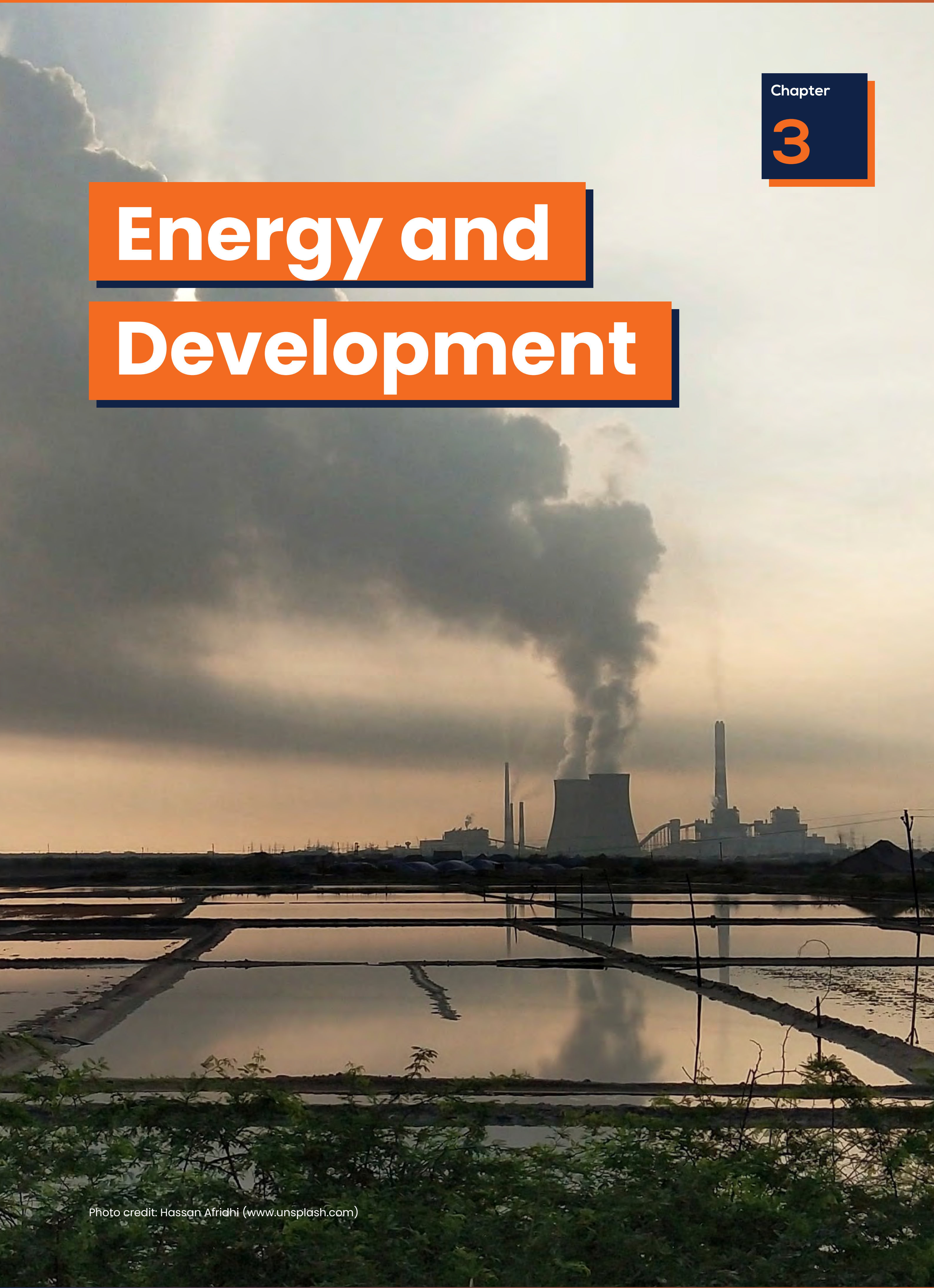


Photo credit: Hassan Afridhi (www.unsplash.com)

3.1 Introduction

Energy is a key component of growth and development in an economy. Whether the source of energy is conventional or non-conventional, there is also a need for adequate labour, capital and technology for production of energy itself. Specifically, developments in the technological and technical aspects of energy production and costs of production plays key roles. The presence and nature of competition in each of the three input markets, i.e. labour, capital and technology, impacts the functioning of energy markets. This in turn affects the energy prices at the users' end, which have important influences on the pace of growth and development of the economy. The direct sources of energy, such as electricity and petrol are some of the main drivers of economic growth. Studies have established a causal relationship between energy and economy (linkages between renewable energy and economy discussed in section 2.3.2).

The nature of relationship at macro and micro-economic levels need to be examined separately. The relationship at the macro level, that is the overall economic growth, is well established but impacts on a micro scale such as access to reliable electricity that contribute to development at local level has not been extensively captured. The establishment of, for example, a micro hydro power plant in a remote village holds the potential to develop local infrastructure like roads and hospitals, and is vital for education advancement, employment generation and even setting up of small and micro industrial enterprises enabled through access to electricity. This 'small' development then can induce increase in income and subsequent improvement in the quality of life.

At the macro level, energy is a critical factor in determining the growth of an economy at the national scale. For developing economies, access to affordable energy is crucial for the improvement of the quality of life. It also provides means to expand industrial activities, small businesses, utilize modern agricultural equipments and even offers accessibility to education. All of these are fundamental elements of a developing nation.

Taking note of this, the present chapter discusses the direct economic impact of energy on the Gross Domestic Product of the economy. It covers:

- Effects of energy transition on Indian energy trade and causal relationship with overall economic growth.
- Role of electricity in promoting growth at the micro level leading to decentralization of development.
- Social development covering changes in quality of life through increasing energy consumption reflected through social indicators.
- Identification of challenges and opportunities of transition to smoothen the process.

3.2 Economic Impact of Energy

Chapter 2 demonstrated the causal relationships between renewable energy and economic growth, and between thermal energy and economic growth. This chapter briefly covers the causal results between total energy and economic growth. Some aspects of the demand scenario, connections between rural growth and development and the investment scenario shall follow it.

3.2.1 Economic growth and Energy Balance

In the late 1990s and early 2000s, studies by Cheng (1999), Fatai, Oxley, and Scrimgeour (2004) and Paul and Bhattacharya (2004) demonstrated conservation hypothesis (direction of causality running from economic growth to energy consumption), growth hypothesis (direction of causality running from energy to economic growth) and feedback hypothesis (direction of causality running from energy to economic growth and vice versa) respectively. The time periods of the studies were nearly the same but the approaches were different leading to conflicting results. Similarly, studies conducted a decade later by Pradhan (2010), Alam et al. (2011) and Ozturk and Salah Uddin (2012) demonstrated conservation hypothesis, neutrality hypothesis (no causal relationship) and feedback hypothesis respectively for nearly the same time periods. More recent studies by Liu et al. (2019) , Carfora et al. (2019), Sultan and Alkhateeb (2019), Shastri et al. (2020) and Raghutla and Chittedi (2020) demonstrate feedback hypothesis, neutrality hypothesis, feedback hypothesis, growth hypothesis and feedback hypothesis respectively.

Figure 3.1 (a) India's GDP (1960-1990) at Current US$

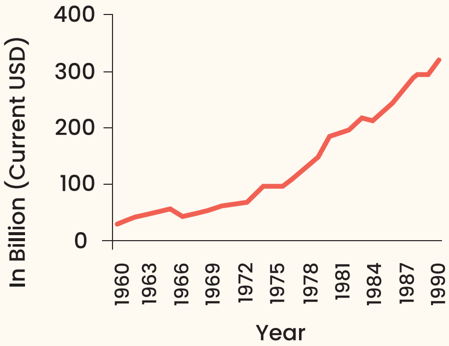


Figure 3.1 (b) India's GDP (1991-2020) at Current US$

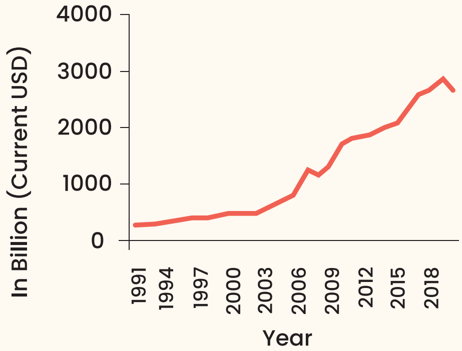


Figure 3.1 (c) GDP Growth Rate (%)

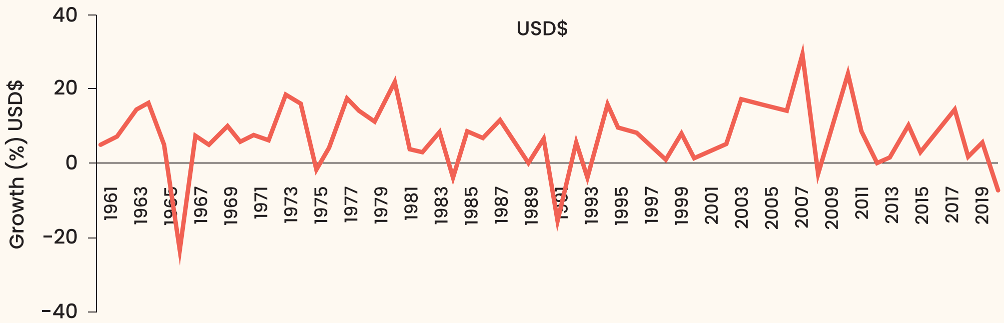


Figure 3.2 (a) Primary Energy Consumption (1965-1990)

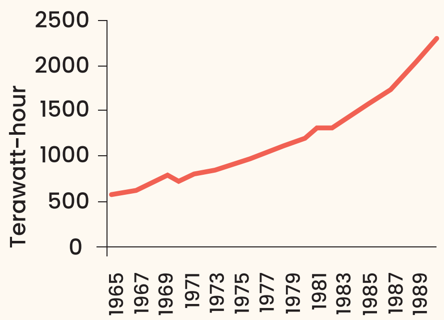


Figure 3.2 (b) Primary Energy Consumption (1991-2019)

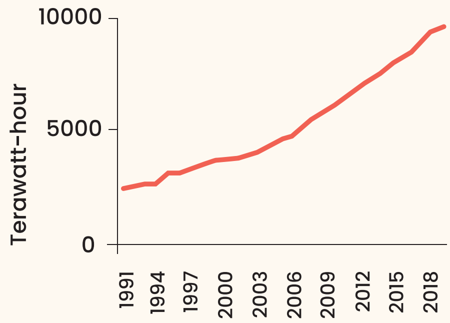
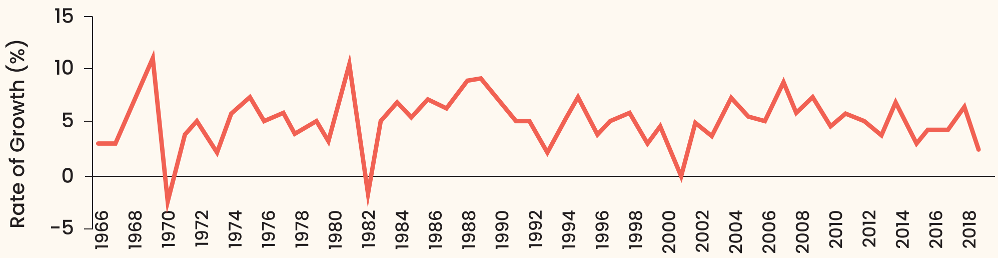
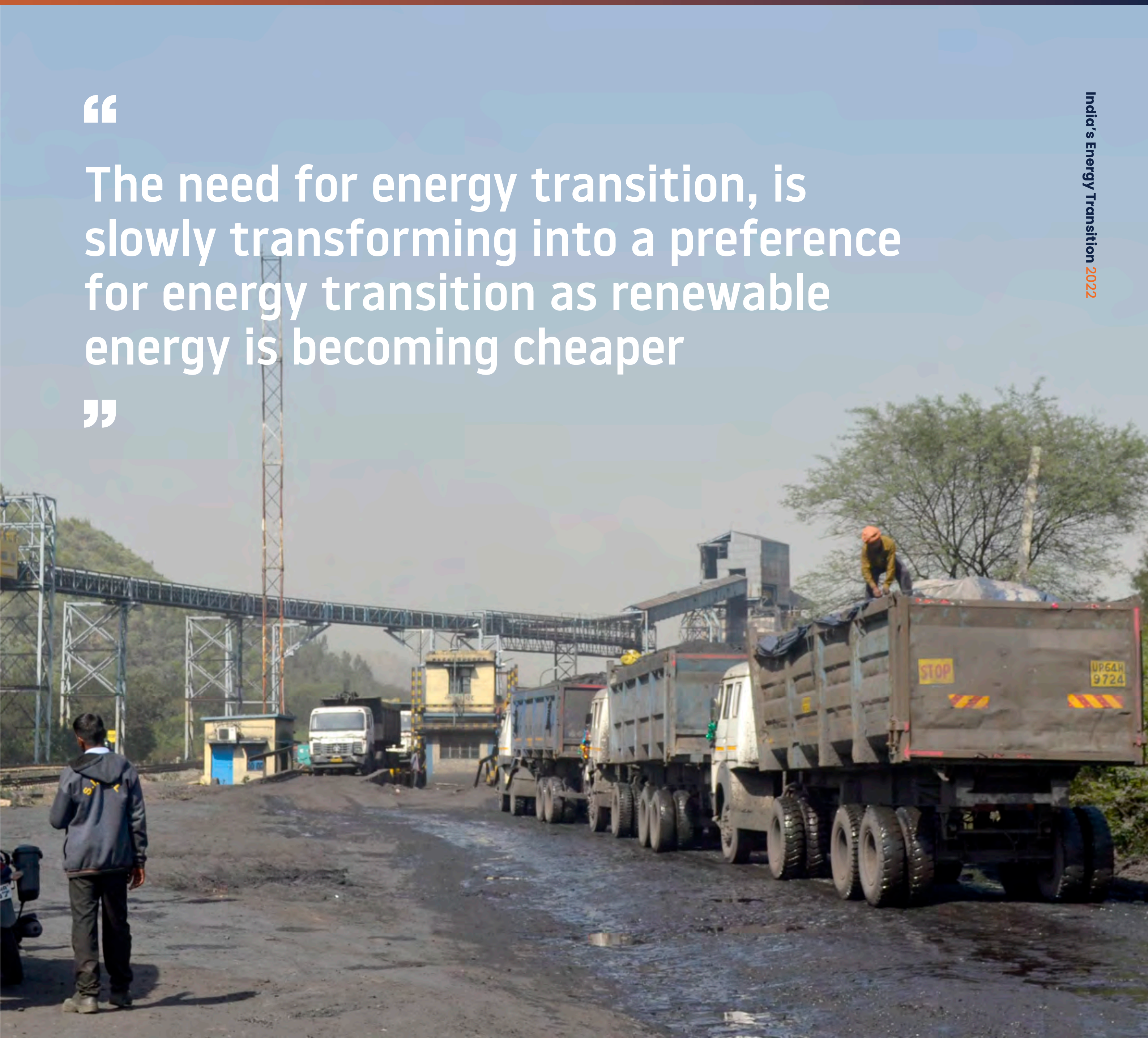


Figure 3.2 (c) Rate of growth of Primary Energy Consumption



Source: Created from World Bank Indicators, 1960-2020

> **The need for energy transition, is slowly transforming into a preference for energy transition as renewable energy is becoming cheaper**



After experimenting with industrial socialism for a long time, in 1990s India adopted various policies towards economic liberalisation in early nineties. The annual rate of growth of GDP in the subsequent periods, on average, was much higher than what was earlier (Figure 3.1). Even the per capita income has increased by about four times since 1991. Higher rates of economic growth and per capita income fuelled the demand for energy in the economy for obvious reasons (Figure 3.2). As explained earlier, this pushed up the rate of economic growth even further.

During the COVID-19 pandemic, the economy slowed down in India, as everywhere else, and so did the demand for energy. However, the Indian economy started showing signs of slowing down even before the start of the pandemic. The growth rate of GDP had been falling for several years, along with other economic indicators like growth in consumption, investments and industrial activity. This reduces income in the hands of the people leading to decreased demand for commodities such as fuel and electricity which further affects economic activities; hence, a bidirectional causality (or feedback hypothesis) is established. Some recent studies also establish the dominance of feedback hypothesis (Liu et al. 2019, Sultan and Alkhateeb, 2019 and Raghutla and Chittedi, 2020).

Figure 3.3 (a)
Coal Import Quantity

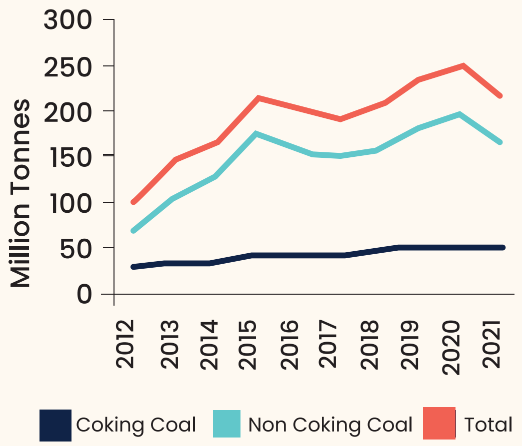
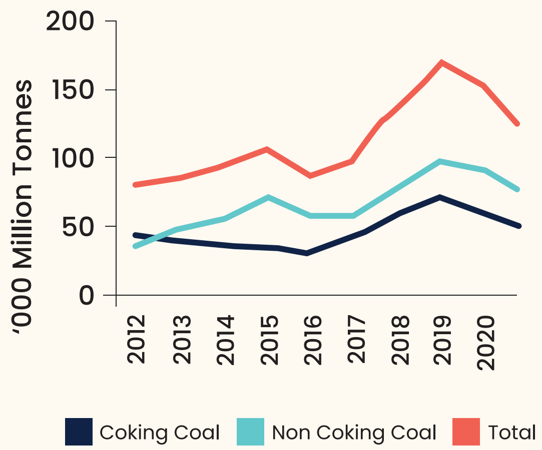


Figure 3.3 (b)
Coal Import Value



Source: Ministry of Coal (Provisional Coal Statistics,), 2021

Major portion of the total coal consumption flows into the power sector. Coking coal is mainly being imported by the steel manufacturing companies albeit of a smaller magnitude while non-coking coal is imported by thermal power plants, cement plants, sponge iron plants, captive plants and industrial consumers (Fig 3.3). Besides coal, oil is largely imported and flows into several sectors like industry, transportation, etc (Fig 3.4). On the other hand, India mostly exports electricity to Nepal, Bangladesh and Myanmar and imports it from Bhutan (Figure 3.5).

All these were to merely show that there exists some intricate relationship among energy trade, change in energy consumption and the impact on economy — all need to be considered together while formulating energy transition policies. For example, in theory, a decrease in consumption of oil and coal could reduce import bill and improve balance of payments for India. However, it is mostly the non-coking coal that is imported and India is mostly self-reliant on coking coal. The extent of dependence on non-coking coal will not be affected significantly due to reduction in consumption (or improvement in the efficiency of electrical devices), as long as there is no shift towards cleaner mechanisms to produce power.

Figure 3.4 (a)
Net import quantity crude oil and petroleum

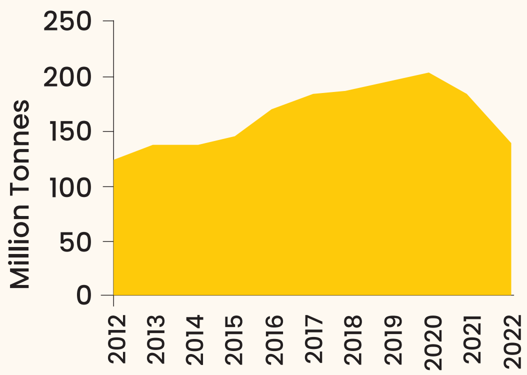
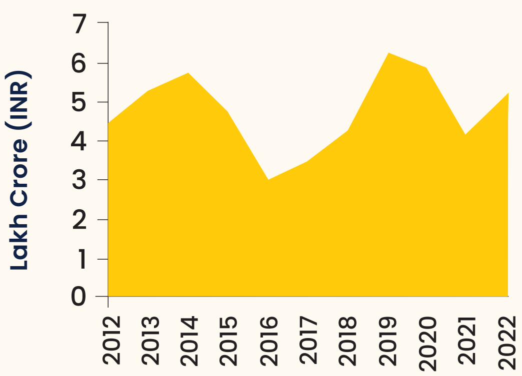
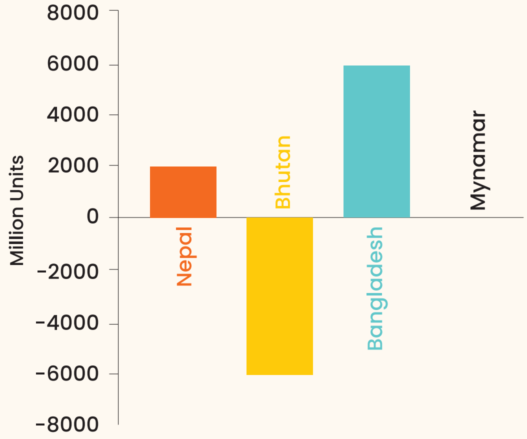


Figure 3.4 (b)
Net import value (lakh crores) crude oil and petroleum



Source: Created from Ministry of Petroleum & Natural gas, 2022

Figure 3.5
Net export of electricity (MU)



Source: Ministry of Power, 2020

3.2.2 Energy Demand Scenario

The IEA (International Energy Agency) predicts long term energy scenarios using their World Energy Model (WEM). The WEM uses simulations to construct alternative scenarios and then makes projections on future energy consumption, sector-wise demand and energy transition. In this sub-section we focus on the STEPS (Stated Policy Scenario) for India. It makes projections based on the current policies while also taking into account the economic slowdown brought about by COVID-19 (India Energy Outlook, IEA, 2021). While the share of electricity consumption in India's primary energy consumption is increasing steadily, WEM under STEPS predicts an increase from approximately 17% in 2021 to 25% by 2040 (India Energy Outlook, IEA, 2021). This can also be interpreted from the higher pace of forecasted demand for electricity than the primary energy (Fig 3.6).

Figure 3.6 (a)
Forecasted primary energy demand (Mtoe)

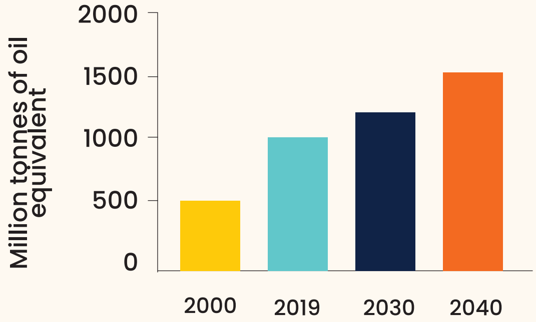
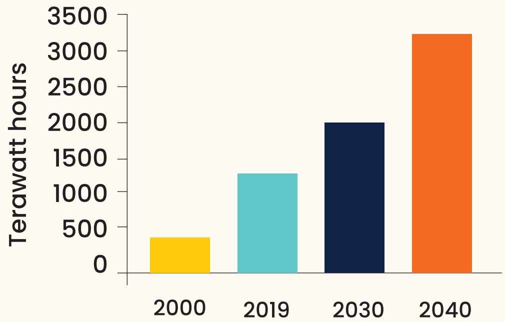


Figure 3.6 (b)
Forecasted electricity demand (TWh)



Source: India Energy Outlook, IEA, 2021

> Dependence on non-coking coal will not be affected significantly as a result of decreasing consumption, as long as there is no shift towards cleaner mechanisms to produce power

Figure 3.7 (a)
Forecasted demand for coal (Mtoe)

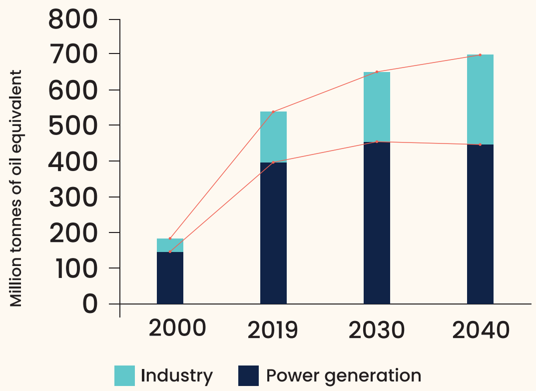
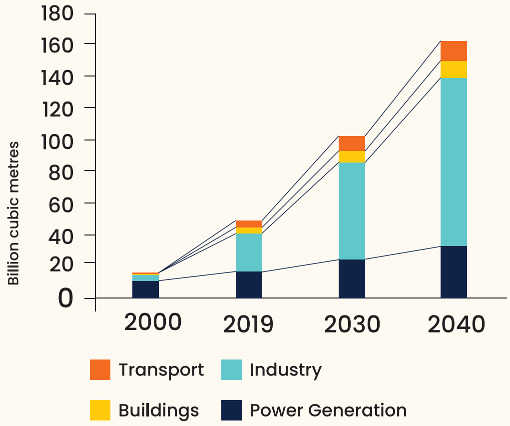
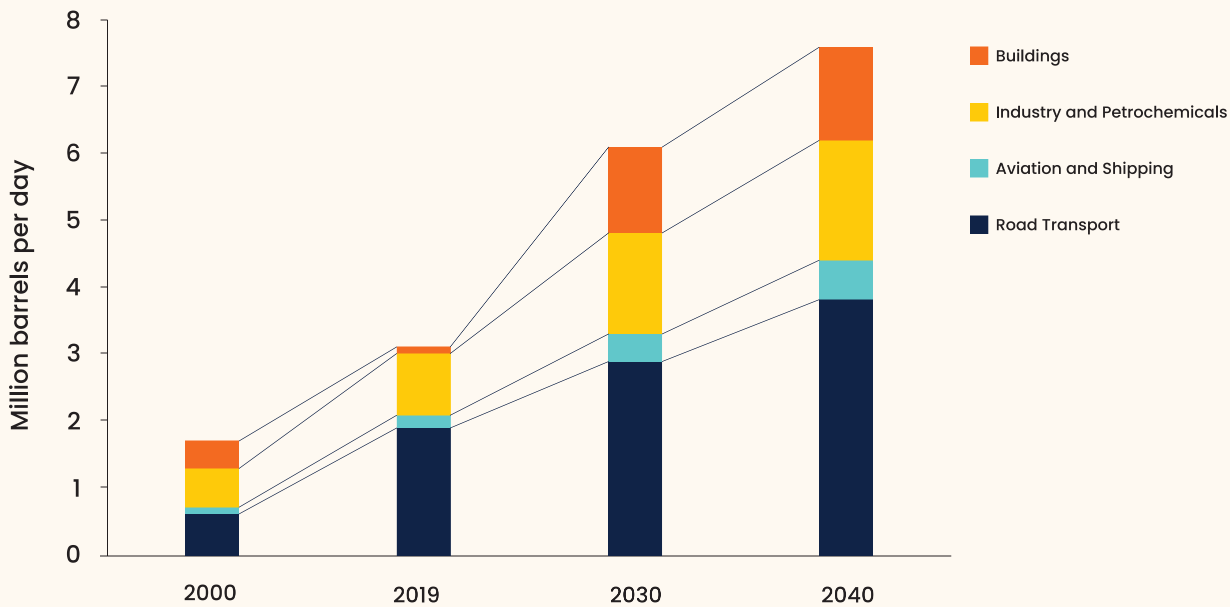


Figure 3.7 (b)
Forecasted demand for natural gas (bcm)



Source: Created from India Energy Outlook, IEA, 2021

Figure 3.8
Forecasted demand for oil



Source: Created from India Energy Outlook, IEA, 2021

With an expanding economy, it was expected that more people will be able to afford personal vehicles which will partly contribute towards doubling of oil demand by 2040 in comparison to 2021. Further, even the demand for coal, natural gas and oil from the industrial sector — that already accounts for a major share in total energy consumption — is expected to double by 2040(Fig 3.7 and Fig 3.8). According to calculations made under STEPS, about two thirds of the demand for coal comes from industry that makes this sector most accountable for CO2 emissions. To reiterate, growth of the industrial sector is significant for overall economic growth. At the same time formulating and executing any transition in this sector towards cleaner fuels is seemingly a challenging task.

3.2.3 Rural Growth and Development

There is a wide economic gap between urban and rural India and yet, both urban and rural populations lack adequate electricity supply. Access to reliable energy is still an issue in the urban areas and many rural areas have not even gained connection to grid electricity. A significant portion of the rural population is still dependent on firewood and oil for cooking, lighting and heating. Less than half of the population has access to clean cooking fuels and about 68.1 crore people are dependent on traditional biomass (Sharma and Dash, 2022). Using cleaner fuels has many benefits like reductions in indoor pollution leading to health improvements and cheaper sources for lighting (for example, electricity in comparison to kerosene). This also increases the disposable income available to the household. There are several factors that determine the demand for energy from various sources in a household. Sharma and Dash (2022) in their study examined the patterns of household energy use and compiled the factors that influence source-wise energy consumption in rural households (Table 3.1).

"Less than half of the population has access to clean cooking fuels and about 68.1 crore people are dependent on traditional biomass"

Table 3.1
Factors Determining Household Energy Choices

Household dimensions	Energy dimensions	Other dimensions
Demographic Factors: Age of household head, education, number of educated females, total number of children	Accessibility and affordability: cost of LPG connection, cost of refilling, cost of alternative fuels, time spent in collecting fuel, procuring distance	Taste, preferences, externalities, ethnicity and awareness
Physical Assets: Land, livestock, type of house	Satisfaction with sources of energy and their use: availability, cost, maintenance service, and safety in use	
Income and Expenditure: source of income and monthly expenditure		

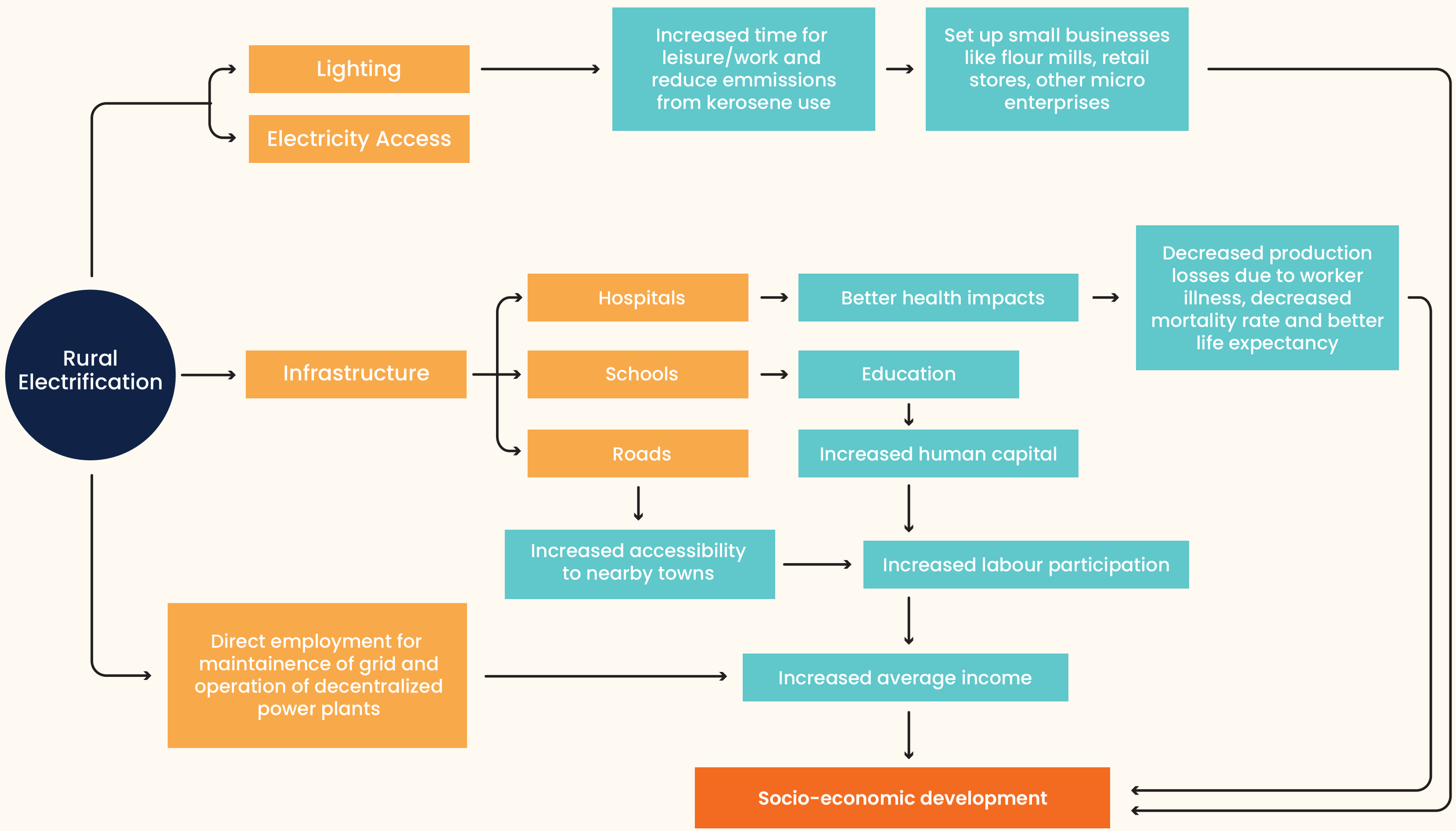
Source: Sharma and Dash (2022)

The study revealed that consumption of primary fuels is negatively associated with the age of household head, education, physical assets and income. The number of children in a household shared a positive correlation with the consumption of traditional biomass as children are not considered part of the labour force, but are involved in the execution of other chores, such as the collection of firewood. It was argued that this availability of 'free labour' reduces motivation for a household to adopt LPG or other cleaner fuels. This is significant from a policy perspective: the level of education, the size of population, and the choice of fuel(s) are interlinked, and policies on clean energy consumption need to reflect this.

In other words, efforts towards influencing the choices over energy sources should follow a holistic approach that accounts for all the factors instead of focusing only on some, like education, or awareness, or income alone.

Electrification is usually expected to have a positive impact on the socio-economic characteristics at the household level. This is particularly true for rural households and has been documented in various studies. Jimenez (2017), undertook 50 studies to examine the impacts of electrification on education, labour, and income of rural households in Asia, Africa, and Latin America. It was reported that many of these studies seemed to focus on the educational aspect as it ultimately transforms into greater accumulation of human capital, and in turn, increasing labour participation and income. In one of the reported studies, an increase in school enrolment (7% on average), labour market participation (25% on average) and income (30% on average) due to electrification was observed (Inter-American Development Bank, 2017). An overall decrease in energy consumption because of increase in electricity consumption was also observed for the rural settings in mountainous regions (Legros et al., 2012). Positive impacts of electrification on the value of land, agricultural innovation, (Barnes, 1986) and migration (Dinkelman, 2011) have also been recorded. We developed the following causal system (Fig. 3.9) mapping for the impact of rural electrification based on the stated literature:

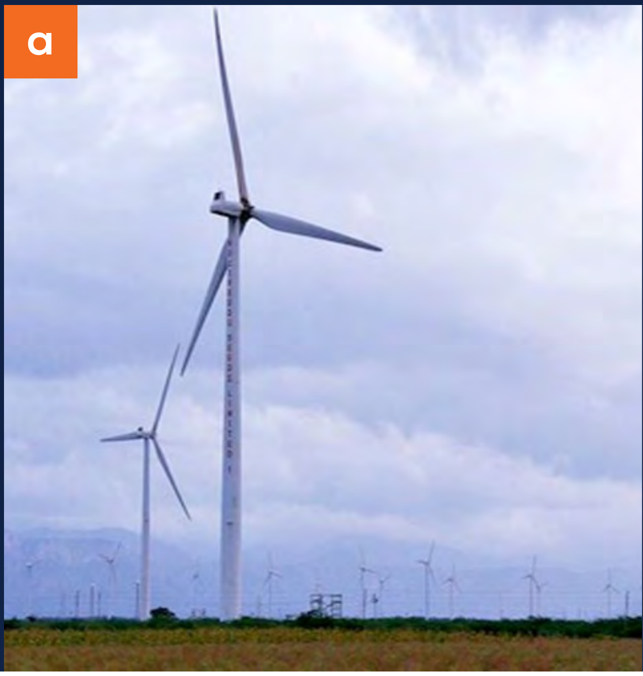
Figure 3.9
Economic flow resulting from rural electrification



Source: Created by author

Case Study

a



Odanthurai, Tamil Nadu

Odanthurai, a village in the Coimbatore district of Tamil Nadu has had a wind mill of capacity 350 kW since 2005. Not only does it generate sufficient electricity for the residents, but also sells nearly 30% of its total electricity generated to Tamil Nadu Electricity Board and earns a revenue of INR 20 lakh per annum. Out of the total installation cost of INR 1.55 crore, 35% was contributed by the village panchayat. The village not only generates renewable energy but has also set up a 9 kW biomass gasifier to run the drinking water plant that runs on waste produced at a sawmill. This has been discontinued due to rising wood prices. Streetlights that run on 2 kW solar power system have also been set up.

Photo by Odanthurai Panchayat, Source: Balasubramanian (2018)

3.2.4 Investments in Energy

India invests nearly 3% of its GDP towards energy (World Energy Model Documentation, IEA, 2021). The COVID-19 pandemic did cause an economic slump, however, the recovery has been phenomenal as indicated by the rise in installed capacity of renewable energy. The sector has received over US$ 10 billion of foreign direct investment (FDI) in the last two decades and over US$ 42 billion has been invested since 2014 making India one of the most attractive places for investment in renewable energy (IBEF, 2021). Many companies like Reliance New Energy Solar Ltd., REC Group, Suzlon, Adani Green Energy Ltd., Tata Power Solar, JSW Energy, NTPC, etc. secured heavy investments in the clean energy sector in 2021. Other steps taken by the Government of India include:

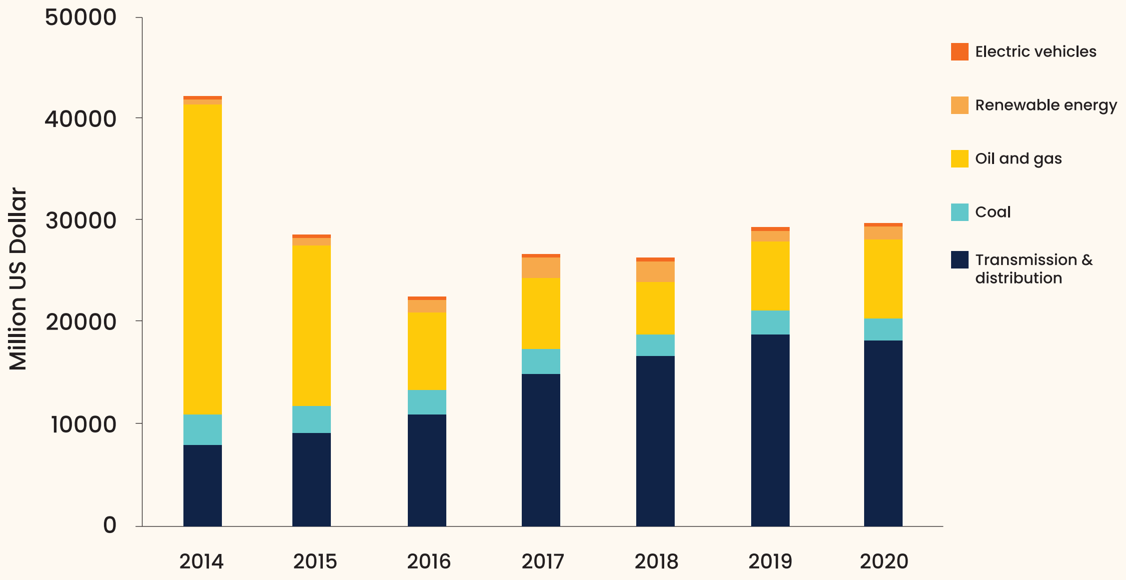
- US$ 132 million allocated to Solar Energy Corporation of India (SECI) in the 2022-23 Union Budget
- US$ 238 million investment announced for development of ultra-supercritical technologies
- Allocation of US$2.57 billion towards manufacturing of high efficiency solar modules

In order to push energy transition ahead, the government not only needs to pave the way for increased investments in the clean energy sector but also drive investment away from the fossil fuel industry. As of 2020, the subsidies provided to the fossil fuel industry were over seven times that of the renewable energy sector in India (Fig. 3.10). (IBEF, 2021)

Some facts about investments in Energy in India (2020)

- Subsidies on coal are greater than on renewable energy
- A subsidy of US$ 7.8 billion was provided to the oil and gas industry alone in 2020, an increase of 16% in one year
- Out of the total subsidy of US$ 29,564.71 million to energy sector, only 4% was allocated to renewable energy

Figure 3.10
Energy subsidies in India, 2020



Source: Viswanathan et al. (2021)

Apart from being costly, the fossil fuel subsidies are found to be 'inefficient' even otherwise in multiple ways. They impose huge costs on the public finances in developing economies (World Energy Outlook, IEA, 2011). For coal, and oil industry, the subsidies were found to be 0.2% of the GDP in India. This makes renewable energy industry less attractive to the investors, and this, in turn, reduces their competitiveness over a longer term.

It follows that the government needs to take necessary legislative action to incentivise investments into clean energy systems. Examples range from better tariffs, and subsidies to lower taxes to make the financial returns at least as attractive as the conventional energy systems. The tariffs are known to be particularly low for hydro power projects, and for small hydro power projects it is even more difficult to break-even due to reasons of (lack of) economies of scale. Even making the electricity and energy markets 'free' of State interventions could have a positive impact on both the end users and the manufacturers.

It is obvious that augmented investments in decentralised renewable energy systems can contribute towards lowering the cost of transmission and distribution if adopted at a large scale. However, there is a need for an extensive analysis to quantify these impacts.

3.3 Social Development

Unlike the above sections that discussed the direct and indirect economic impacts of growth on energy consumption, this section will focus on the social impacts: on education, health/healthcare systems, and employment.

There are several indicators of social development such as availability of food, water, electricity, education and life expectancy. Lloyd (2017) found a strong relationship between energy and nutrition, health, education and the degree of social inequality. The analysis was based on the World Development Indicators (2022) from a number of countries. The results are depicted in Table 3.2.

Table 3.2
Energy consumption and indicators of social development

Indicator	Nature of relationship	Remarks
Malnutrition	Inverse (negative) relationship	A strong likelihood that 15% of the population will be undernourished for energy use below 1000 kg oil equivalent per capita. The share of undernourished population decreases as energy consumption increases (indicating correlation, and not causality)
Value added from agriculture	Inverse relationship	If energy consumption is high contribution from agriculture towards GDP will be less indicating sufficient availability of food without diverting much energy to agriculture
Water availability	Direct (positive) relationship	Since energy is required to lift water from where it is usually located (groundwater in plains/natural streams in hills), energy use increases so does access to clean water
Access to road	Direct relationship	Increase in access to energy increases access to road as there is more demand for movement of goods and services (as a result of economic growth), however, only upto a point as the demand gets saturated after that
Access to electricity	Direct relationship	For almost the entire population to have access to electricity, energy consumption of atleast 2000 kg of oil equivalent per capita is required
Primary education	Direct relationship	A strong probability that if energy consumption is over 1000 kg of oil equivalent per capita, almost the entire population completes primary education
Access to ATM	Direct relationship	Eight times more ATMs for nations with high energy consumption in comparison to energy poor nations
Tendency for women to be married at a young age	Inverse relationship	The probability for a woman to be married by the age of 18 decreases by 10% for energy consumption above 1000 kg of oil equivalent per capita when compared with less than 500 kg consumption
Life expectancy	Direct relationship	Positive relationship for developing nations while no significant relationship for developed nations

Source: Lloyd, 2017

As energy consumption increases, the social indicators of an economy improve. However, there is also social costs associated with the adoption of renewable energy systems. This includes private cost of generation, social cost of carbon, health costs, cost of intermittency, opportunity cost of land, and stranded assets and costs of government interventions. Together, the social costs associated with the adoption of renewable energy systems was found to be three times that of conventional energy (Lloyd, 2017). This gap, however, is expected to decrease with time as renewable energy becomes more affordable and economically efficient, primarily owing to economies of scale.

Another important indicator vis-a-vis social development is inequality which is usually high in developing economies. Popularly known as the 'resource curse', an economy or a region rich in resources (including fossil fuels) fails to perform well in its socio-economic aspects due to several reasons like political conflict, weak institutions, and higher level of corruption. This is a challenge but can be addressed through proper monitoring of government spending, region-specific decentralised development schemes and policies aimed towards decreasing inequality (Alamanda, 2020; Adamou and Peters, 2016; Gupta et al. 2002) .

3.4 Energy Transition

Energy transition refers to a shift in production and/or consumption patterns of energy from conventional to non-conventional and cleaner resources. In this section the challenges faced (so far across spaces) in bringing about an energy transition and the strengths and opportunities that push this ahead are discussed. We conclude with arguments in favour of such a transition.

3.4.1 Challenges

The energy market has been functioning in India since a long time according to some established principles. The entry — and increasing importance over time — of renewable energy from installed capacity and utilisation of such additional capacities has started to destabilise the associated markets. As always, in this fast changing scenario, there are new gainers and losers. The dynamism has made the matter somewhat complex, if not uncertain too. Besides flexible pricing mechanisms and demand and supply volatilities, changes in tariffs, taxes, subsidies and administrative fiats, have created some new challenges for producers. In addition, this (both expected and actual) energy transition poses several other challenges:

- **Geographical issues:**
India is richly endowed with natural resources to generate energy; however, the geographical barriers limit the utilization and thus restrict the momentum of energy transition. The eastern part of India abounds in coal reserves, while its solar and small hydro power potential for Northern Himalayan states and wind energy for western coastal areas. This difference in resource availability across spaces increases the associated transaction costs. Certainly appropriate energy transmission and distribution policies can be formulated to address this issue but ceteris paribus they remain a significant challenge. One possibility is smooth and efficient transfer of electricity from regions with new energy sources to those with older ones (see below).

- **Transmission and distribution losses:** The difference in electricity generated and electricity delivered to end use consumers is transmission and distribution losses. They are caused due to technical inefficiency and theft. Transmission of electricity from a region richly endowed with renewable energy to coal dependent regions could overcome the geographical challenges but only when efficient technology for such transmissions is available.

- **Insufficient storage capacity:**
Renewable energy systems generate energy only when the resources are available. For example, solar energy will be produced in abundance only during non cloudy days. Likewise hydro power potential is affected by seasonal fluctuations: It is greatly reduced during the winter months and undergoes expansion during the monsoon season causing 'intermittency issues'.[4] Provision for battery to store energy at scales appropriate to large renewable energy systems at the moment is not cost effective.

- **Political framework:**
Energy transitions require proper coordination among local, state and central governments, fossil fuel-based industries and local

4 Electricity is not constantly available due to constraints on resource availability such as solar being available only during the day. Sufficient storage capacity is required to overcome this issue.

authorities. However, in India, a lack of such communication among and across people and organizations makes coordinated actions rather difficult to plan and implement.

- **Transport sector:**
  The transport sector is almost entirely dependent on conventional energy. With the demand in transportation services set to multiply (as discussed earlier), electric vehicles (EVs) can contribute towards limiting the level of pollutions in some spaces due to zero emissions from such vehicles. However, electricity for these vehicles is still mostly generated from fossil fuels. Also, EVs require further technical development because presently, they are not in a position to compete in terms of cost (price of product), range of the vehicle, and battery backup with vehicles running on either petrol, diesel, or LPG.

- **Non-utilities sector:**
  The non-utilities sector in India (including captive plants with a demand of 1 MW and above) such as aluminium, steel, cement, etc., used about 15% of the total electricity in FY 2019-20 with the industrial sector being the largest consumer (General Review CEA, 2021). Use of renewable energy during the manufacturing of these products will warrant some cost effective technological change. This, in turn will require strict regulatory interventions specifically, and large-scale multi-sector policy interventions in general.

- **Energy efficiency:**
  Energy efficiency in households, commercial and industrial buildings requires devices that use less energy, for example, LED bulbs. Although efficient devices are available for day to day needs yet their use is yet to be mainstreamed. Many studies have shown importance of changes in behavioural norms, additional infrastructure and adequate incentives to make this transition a reality.

Apart from these, there are some general challenges like insufficient infrastructure, lack of investment other than CSR and government initiatives, and absence of a fixed guideline for transition.

> "Global warming is expected to have serious consequences on people's health, particularly in the global south, in the form of natural disasters, climate change, infectious diseases, heat waves, respiratory diseases, and loss of agricultural productivity"

3.4.2 Strengths and Opportunities

In this section, the following strengths and opportunities for moving towards a coal phase-out in India have been discussed:

- **Cost-effective renewable energy:**
  The lowest tariff recorded in India was at INR 2.44 per kWh for solar power and INR 2.43 per kWh for wind power in 2017 (Chawla et al., 2019). As of 2021, the Central Electricity Regulatory Commission adopted tariffs of INR 2.83-2.84 per kWh for wind energy.

- **Political pressure:**
  Large scale awareness campaigns, visible impacts of climate change in the form of health impacts, extreme weather events and targets set at the annual Conference of Parties (COP) are putting pressure on political leaders to strengthen policy measures to promote energy transition.

- **Demand for electricity:**
  The peak demand for electricity increased by about 45% (December, 2011-2021) in the last decade and is expected to grow exponentially

in the coming years. This presents an opportunity to fulfil the increasing demand through cleaner mechanisms and reduce dependence on conventional means.

- **Decentralisation:**
  Remote villages often face difficulties in securing access to electricity. For high altitude Himalayan villages, given the present level of knowledge, it is not possible to set up a reliable grid infrastructure due to environmental factors like heavy rainfall, snowfall and landslides. Decentralised energy is vital in such cases, and can be developed on the basis of resource availability in the area. For example, a 50 kW decentralised micro hydro power plant was set up in 1996 in a remote village of Uttarakhand called Sorag which is still operated and maintained by the locals. Given the lower tariff, rooftop solar plants connected to the grid provide additional economic motivation to set them up.

- **Changing preferences:**
  Awareness campaigns and education of climate change impacts have motivated people to shift towards more sustainable products which in turn push businesses to produce sustainable outputs.

In the above context, it may be said that appropriate policies, schemes, incentives, subsidies and technological efficiency are the key factors in accelerating energy transition.

3.5 Summary

Transition implies a change from one state to another. Switching from cash to cashless economy, from feudalism to mercantilism to capitalism, from burning wood to using electric heaters and cookers, society has witnessed transition. Humankind is well aware of the multiple reasons like changing preferences, evolving technology and availability, accessibility, and affordability of resources, all of which are facilitating such transitions.

Energy transition implies changing consumption from conventional to non-conventional sources of energy. The need for this transition arose as emissions increased from burning fossil fuels to the extent that the climate of the planet started to change because of global warming resulting from green house gasses. The need for energy transition, is slowly transforming into a preference for energy transition as renewable energy is becoming cheaper. As discussed above, energy transition has certain social advantages, and contributes to decentralization, area-specific approach to development, education, health, and removal of inequality. In the energy sector, transition holds the potential to change the overall structure of the economy, and could be used as an opportunity for socioeconomic development if implemented through a planned and inclusive approach. Changes in technology that make energy more efficient and cost-effective, are paving the way for a complete change in consumption patterns of energy producing resources. Energy market plays a significant role through employing regulatory framework in the coal and natural oil and gas sector, and by providing subsidies in the renewable energy sector. Appropriate tariff and tax structure can push the growth of non-conventional means for both the producer and end user. Increased installations of energy producing mechanisms according to the resources available in the area, for example, wind power in the western coastal areas and small hydro power in the Himalayan villages can help solve the challenges of reliability and accessibility to electricity in the rural setting. Sharing focus with the agricultural, industrial, manufacturing and transport sector instead of only electricity provides a holistic approach towards a speedy transition.

Thus, growth in renewable energy consumption pushes economic growth (as discussed in chapter 2). Apart from the macro economic benefits, the changes brought about at the local level by adopting clean energy mechanisms can also be analysed. They include but are not limited to electricity availability for basic lighting needs, and use energy-efficient fuel for cooking instead of traditional biomass that has direct negative health impacts, especially on women and children. Global warming is expected to have serious consequences on people's health, particularly in the global south, in the form of natural disasters, climate change, infectious diseases, heat waves, respiratory diseases, and loss of agricultural productivity (Kasotia, P., n.d.). This intensifies the need to have a production and consumption shift in the energy sector.

Chapter 4

Mapping the Stakeholders

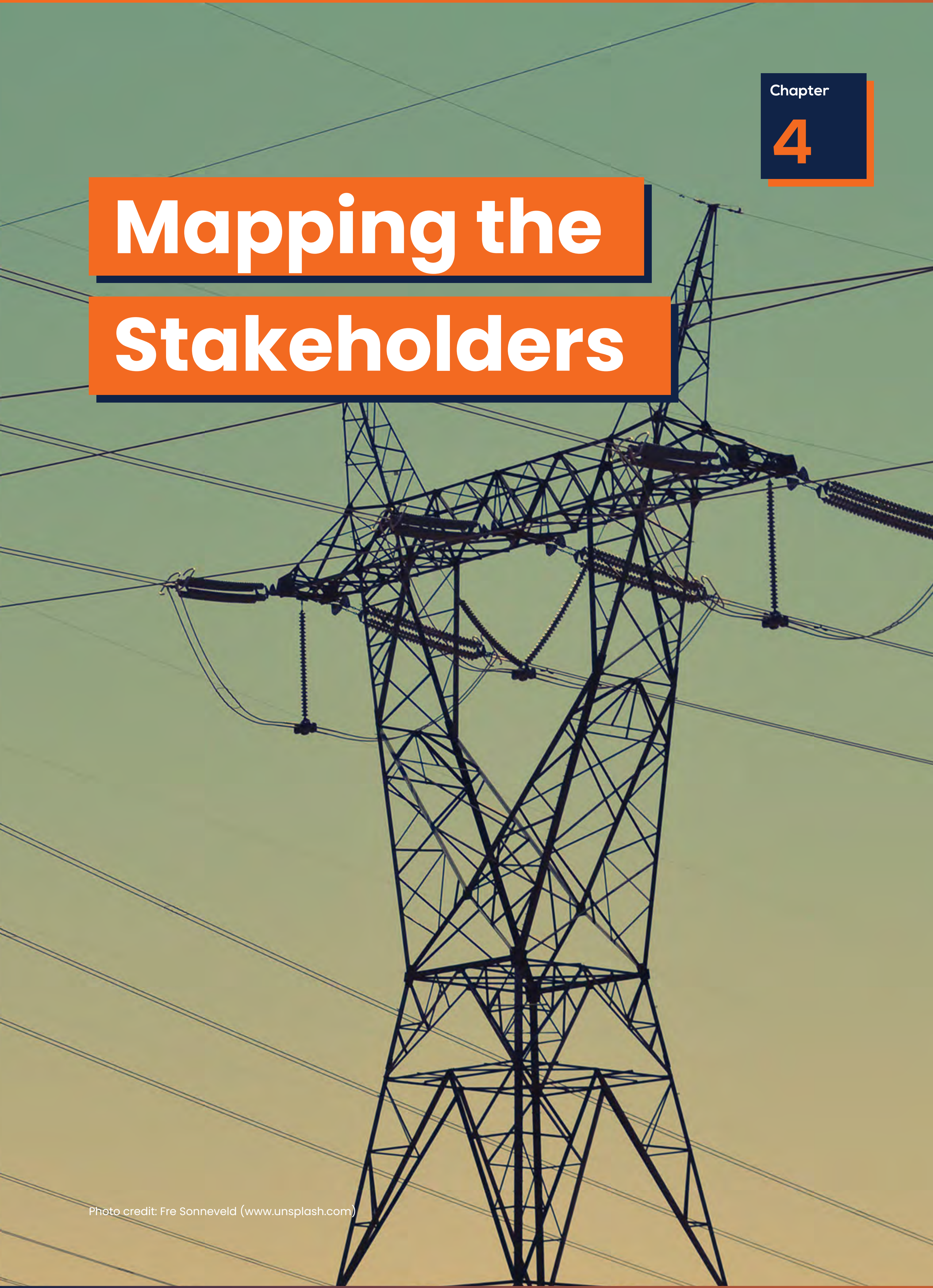


Photo credit: Fre Sonneveld (www.unsplash.com)

4.1 Introduction

The report, so far, has portrayed the following: the necessity of having an 'energy transition' in India, complexities involved with it, be it the spread (involvement of many sectors), scope (multiple contributions of energy in development), or space (distribution of old and new energy sources), and challenges for policy-making processes to imagine, plan, and execute not just a transition, but a 'just transition' too.

It is obvious that the costs incurred by all the affected parties or 'stakeholders' determine the time taken for a transition to complete. Low cost increases the chances of quicker acceptance, adapting to the new 'regime' or even adjusting to it. More interestingly there are trade-offs on the incidence of these costs. The trade-offs are not only within macro-concerns (say, at what pace to decouple energy and economic growth and where to begin it) or micro-concerns (say, who will be reskilled first from among the workers in the thermal sector), but also between macro- and micro-concerns. It follows that identification of all those who are likely to be affected — positively or adversely — will be the first step towards finding the 'solution', involving least social or aggregate costs. Ensuring a 'just' distribution of such costs shall be the next step (chapter 5).

It is not uncommon for someone interested in studying energy transition to make an assumption that the production and consumption of coal produces greenhouse gasses which make ecosystems dysfunctional, as a consequence of which people are adversely affected. It follows that to stall the rise in world temperature further, related activities may be stopped or restrained. A good starting point in this research is to acknowledge and understand that these connections, interlinkages and relationships among energy, economy and environment (if any) are to be seen at all the levels. With the growth of population and economic development they have become more complex. For example, multiple linkages between the coal industry and the local and national economies in developing countries have increased over time due to the inherent dependency of economy on coal. At the same time, due to lack of alternative sources of income and employment opportunities, a large number of coal mine workers can see no future for them outside the coal industry.

It may be noted that all the mining regions of India are socio-economically backward. Madhav Gadgil, one of India's most prominent ecologist calls them as 'resource rich-income poor' areas as opposed to other 'resource poor-income rich' areas. The loss of livelihood due to energy transition will make both the formal and informal mineworkers and their dependents in the mining regions more vulnerable. Therefore, it is vital for all the stakeholders to (at least) participate (if not contribute) in the decision-making processes leading to policy formulations and implementation of effective re-skilling/-training programs, which is a necessary condition to bring about a just transition.

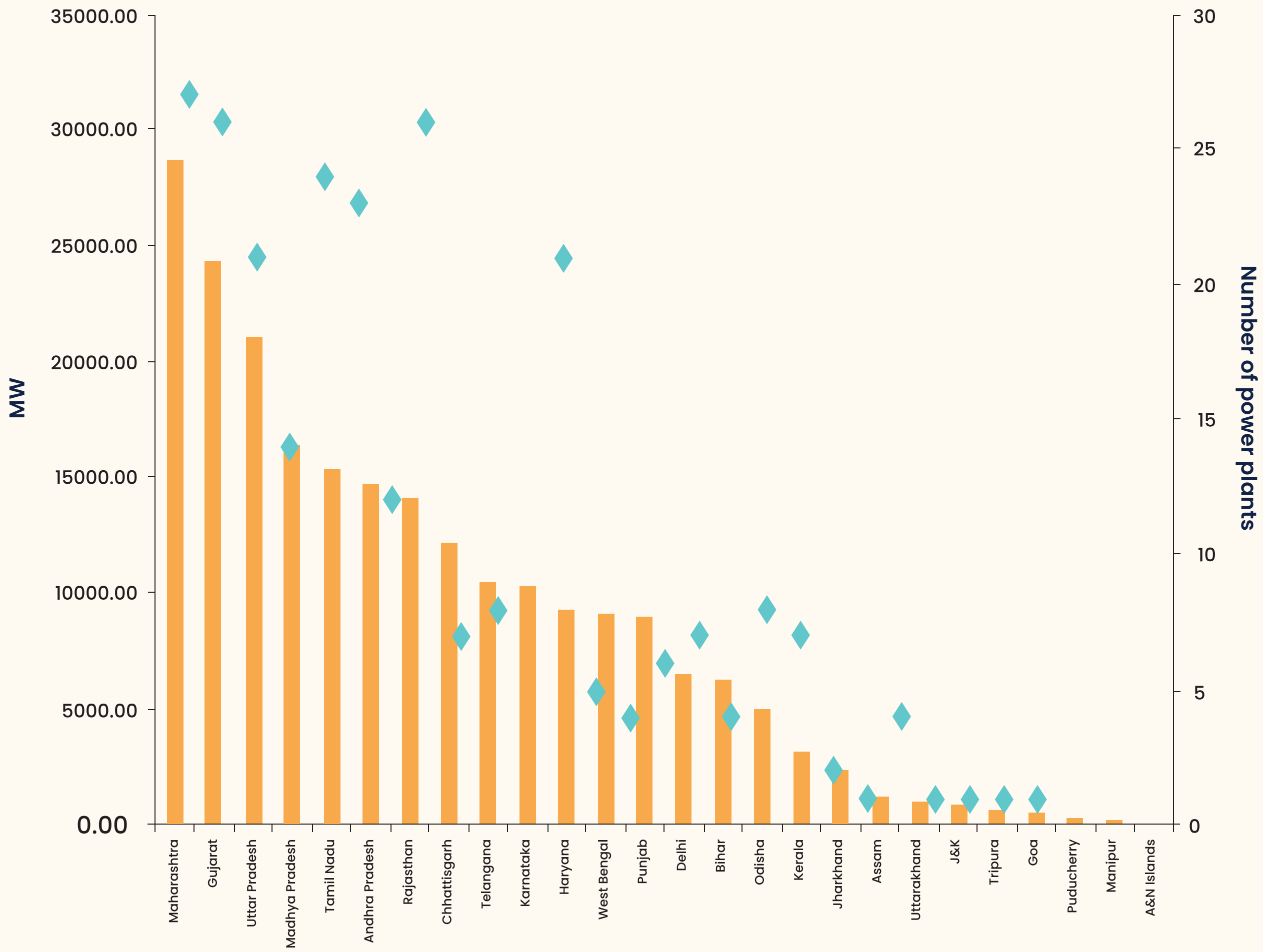
In this chapter, we will identify the major stakeholders of the coal sector, elaborate on who will be affected and how, besides the macro and micro level economic impacts of transition. We look at the conditions, needs and vulnerabilities of the different stakeholders. The list includes power or the electricity sector, and industries within the non-power sectors such as coal mining, brick industry, iron and steel industry, state and central governments, the Indian Railways, and the private sector. At this point, it may be pertinent to emphasise on a key difference between private and public sector: Restraining activities of the private sector which runs on the principle of profit, once they have been permitted to establish production units under the then prevailing relevant institutional and regulatory framework is an onerous task; for public sector, it may require just an inter-ministerial memo, at the most.

4.2 Power Sector

India has a total installed power generation capacity of about 395 GW, of which thermal plants account for 236 GW or 60% share as of January, 2022. Uttar Pradesh has the largest manpower to MW ratio (DSouza and Singhal, 2021) which implies a serious impact on employment/high level of job losses in the state in comparison to the rest of the states in case of power plants' closure. Over seven lakh people are directly and indirectly dependent on the thermal power sector in India (DSouza and Singhal, 2021) which makes their rehabilitation, and restructuring of the economy an important element of decommissioning procedure.

Figure 4.1
Number of Power Plants vs installed capacity

List of Power Stations, CEA, 2021, Executive Summary, CEA, 2022



Source: Created from List of Power Stations, CEA, 2021 and Executive Summary, CEA, 2022

Twenty-six TPPs have been running in India for over 30 years. Generally, the efficiency of any plant or machine reduces with time. Thus, it may make economic sense to either replace it by other plants or shut it down completely. Older plants often do not have pollution control measures and are highly emission-intensive. A study by Maamoun et al. (2020) identified 20 TPPs across the globe that are in need of immediate retirement, on the basis of their impact on the local population, the age of the power plant, its capacity, and the level of emissions. Three of these are in India: Vindhyanchal Power Station (4760 MW), Sasan Ultra Mega Power Project (3960 MW), and Kahalgaon Super Thermal Power Plant (2340 MW) that are of the ages 19, 4, and 17 years respectively. These can be considered relatively young in comparison to some of the plants commissioned in the 1970s in Uttar Pradesh, Madhya Pradesh, Tamil Nadu, and Gujarat, that are still running and did not make it to the list of necessary early retirement (List of Power Stations, CEA 2021). It follows that age cannot be the only consideration/parameter for retirement of a plant.

The guidelines developed by the Central Pollution Control Board (CPCB) for decommissioning of a thermal power plant (TPP) were developed from the environmental perspective. There are plants that have been running for decades, where the capacity may have been increased, employing more people. A TPP also facilitates the development of small businesses and enterprises that cater to the needs of the people directly employed at one, together with the enterprises supporting the TPP in various ways including its supply chain. It therefore makes more sense to include the social and economic (and not just environmental) aspects while developing guidelines to decommission a TPP. Several states such as Rajasthan, Tamil Nadu, Gujarat, etc., have a large number of TPPs (Figure 4.1) which indicates proportionally higher indirect employment in ancillary and allied activities around the area and subsequently a higher impact of TPP closure.

Keeping these in mind, we propose the following recommendations to facilitate a 'just transition' in the Indian power sector:

- **Short term:** Identification of the TPPs that are headed towards closure and determine how many people would be affected in terms of both direct and indirect jobs.
- **Short term:** Identification of the economic sectors that have the potential to absorb those who lost their jobs due to closure of TPPs and also the kind of training required (with least cost — both out-of-pocket and time-wise).
- **Short term:** Identification of the skill set and education level of the population that is to be potentially affected for moving them to another sector – this includes the workers, their dependents, and other household members respectively.
- **Medium term:** Re-training and re-skilling of the workers who are to be affected before decommissioning the plant.
- **Long term:** The inclusion of social and economic aspects of job losses in the official guidelines of decommissioning power plants.

4.3 Non-Power Sectors

This section discusses the impacts of coal phase-out on coal mining, bricks industry, and iron and steel industry that are majorly dependent on the coal sector. This complements the previous section (on impact of closure of TPPs).

4.3.1 Coal Mining

The consumption of coal, which gradually replaced wood as an energy source, first began in the 17th century in England. The consumption exploded during the 18th and 19th centuries as a result of the Industrial Revolution. In India, coal mining began over two centuries ago in Raniganj coalfield by the East India Company, but it was after the arrival of the steam locomotives that consumption witnessed an escalation. By the end of the 19th century, India was producing over six million tonnes of coal per annum. The production further increased during the First and Second World War, reaching nearly 30 million tonnes by mid 20th century.

India produced a total of 716 million tonnes of coal during FY 2019-20 and imported about 215 million tonnes that add up to almost a billion tonnes of coal usage per annum, making it the world's second largest coal producer and consumer. Coal mining was part of the private sector in India till 1956 when the government set up the National Coal Development Corporation to increase production. Then in the early 1970s, nearly all coal mines were nationalised leading to the formation of Bharat Coking Coal Limited and Coal Mines Authority to take charge of the coking and non-coking coal respectively (Fig. 4.2). These were merged together in 1975 to form the Coal India Limited (CIL), which as of 2021 is the world's largest coal producer and supplier. It supplies 83% of the total coal in India from its 352 mines spread across eight Indian states (CIL History, n.d).The Indian coal industry plays a pivotal role in the overall economic growth and also contributes about 10% to India's Index of Industrial Production. The coal industry in India is synonymous with Coal India Limited that has eight subsidiaries (Figure 4.3) and produced about 596 million tonnes of coal in 2020 (CIL Production, n.d.). Mahanadi Coalfields Limited, a subsidiary of the Coal India Limited produced the largest amount of coal (148 million tonnes) in FY 2020-21 from its seven opencast and three underground mines (Figure 4.4). The government of India currently holds 66.14% stake in CIL and earned revenue of INR 2.03 lakh crore between 2013 and 2019. Apart from CIL, the Singareni Collieries Companies Limited is a major player in the Indian coal industry. A few other private sectors have recently entered the coal industry and their projects are under development.

Figure 4.2
The Indian Coal Industry

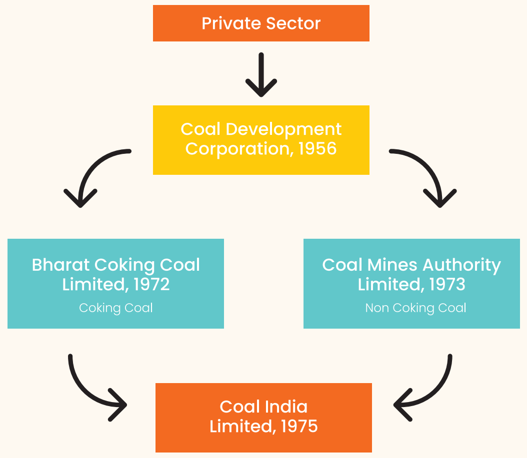
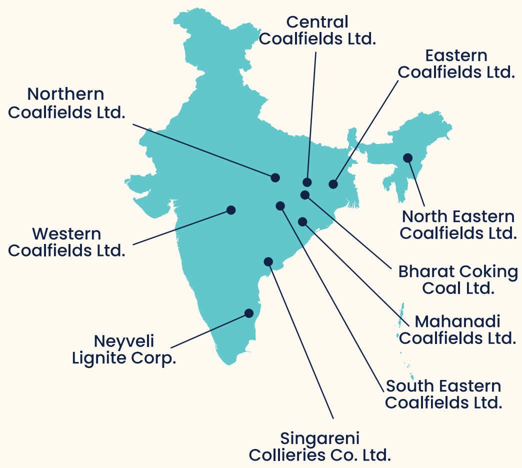
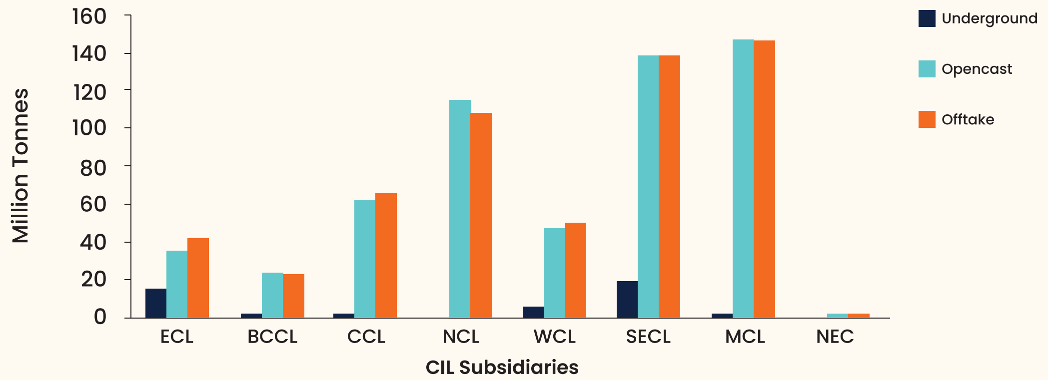


Figure 4.3
CIL subsidiaries



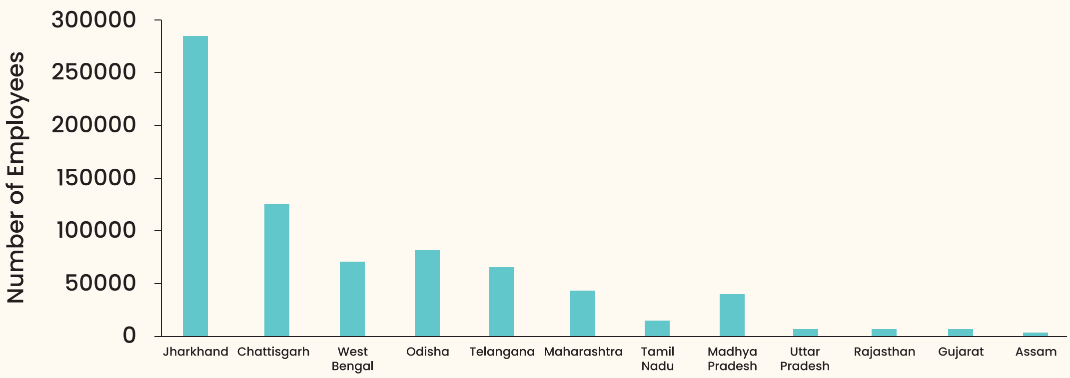
Source: Created from CIL, Production, n.d.

Figure 4.4
Coal Production from CIL Subsidiaries



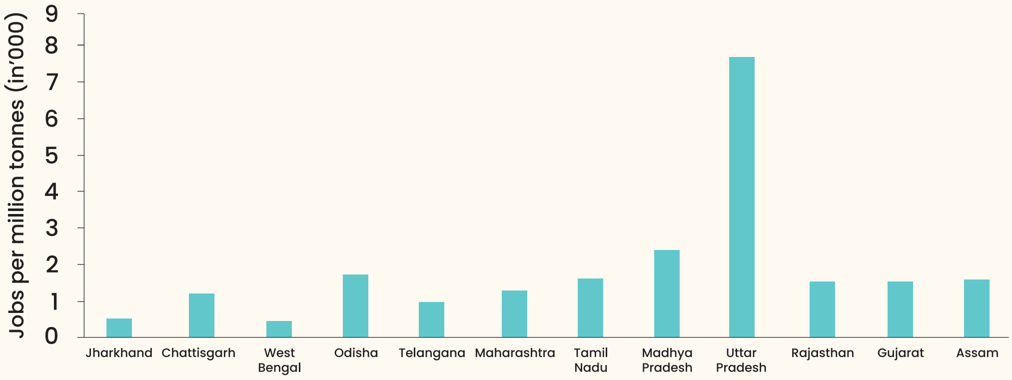
Source: Created from CIL, Production, n.d.

Figure 4.5
State-wise jobs in coal mining



Source: Created from study by Pai and Zerriffi (2021)

Figure 4.6
Direct jobs in coal mining per million tonnes



Source: Created from study by Pai and Zerriffi (2021)

An important stakeholder in the coal sector is Indian Railways. It is not only a major consumer of coal but also accounts for 87% of the total coal transportation cost (Economic Times, 2019; discussed below in section 4.4). Other important stakeholders here are the employees. CIL alone employs over 270,000 people directly. Jharkhand has the maximum number of jobs directly associated with coal mining (Fig. 4.5) with the minimum number of jobs per million tonnes of production (Pai and Zerriffi, 2021) (Fig. 4.6).

Given the Paris Agreement climate goals of keeping global warming well below 2° C, use of coal needs to rapidly decline in the global energy mix in the next few decades. In emerging economies such as India (the second largest producer and consumer of coal), this would call for reducing coal dependency, even if over a period of time. Prior works have focused on this matter in the Indian context, but primarily through the techno-economic lens. Little attention has been given to the socioeconomic dimensions of this aspect of energy transition. This is, in part, due to the lack of availability of datasets required for such an analysis.

The first step in this direction is to understand the extent of present socioeconomic dependency on coal at the subnational level. For example, Uttar Pradesh has the highest number of jobs per million tonnes of coal produced which implies the maximum impact of energy transition in terms of job losses (in proportion to production) if coal phase-out is not carried out in a planned and 'just' manner (in the manner discussed earlier in the report). It may be noted that this is exclusive of the job losses that will occur with thermal power plants shutting down. The District Mineral Foundations (DMF), that receive funds from mining companies, will be affected as a consequence, and that will further affect the welfare of the people for whom the DMFs have been set up for (local mining affected communities). In addition to this, the pensioners will also be affected as a result of coal phase-out and currently, there are about half a million of them (Pai, 2021). A total of 2,880,000 or almost three million people are directly or indirectly dependent on the coal sector and a phase-out, if not planned properly, holds the potential to worsen the socioeconomic profile of the country.

Some facts regarding dependency on the coal sector

- Over US$ 33 billion contributed by coal industry towards pension funds till date
- Over US$ 10 billion CSR spending
- Odisha is highly dependent on coal industries' CSR spending as they contribute nearly US$ 19 million annually.
- Second highest CSR spending in Jharkhand at US$ 13 million
- Korba district of Chattisgarh produces the maximum amount of coal and also contributes highest to the District Mineral Fund at about US$ 7 million per annum (DMF)
- Over 50,000 pensioners (the maximum among all districts) in Dhanbad and Paschim Bardhaman

Source: Pai, 2021

Case Study

a

Case Study: Singrauli Coalfields, Northern Coalfields Limited

Singrauli Coalfield (SCF) is spread over 2,200 square kilometers, of which an area of 220 km^2 has been identified as coal enriched region. The coalfield produces 15% of the nation's coal and is responsible for 10% of the total power generation. The area spans over two Indian states, with a major portion lying in Singrauli district of Madhya Pradesh and a small portion in Sonebhadra district of Uttar Pradesh. SCF is managed by Northern Coalfields Limited (NCL), a subsidiary of Coal India Limited established in 1985. It has a total proven reserve of 10.06 billion tonnes. The coalfield has ten opencast mines that cumulatively produced 115 million tonnes (MT) of coal in FY 2019-20: About 50% of this is supplied to nearby thermal power plants through eco-friendly transportation systems such as a conveyor belt and MGR (Merry Go Round) that move coal from the mines to power plants/ industries without disturbing the environment.

A total of five projects, namely Kakri, Bina, Krishna Shila, Dudhichua and Khadia are located in Sonebhadra district, that cumulatively produce 40 MT of coal per annum, with the maximum quantity coming from Dudhichua coal mine (approximately 18 MT), followed by Bina coal mine (9 MT) as of FY 2019-20. The latter is also set to become a mega project as clearances have been obtained to produce more than 10 MT of coal and has a target to produce 14 MT by 2025 (NCL, n.d). The projects cumulatively employ approximately 6000 people; however, indirect employment through the development of industrial areas following the establishment of coal mines is significantly higher. Almost the entire local population is directly or indirectly dependent on the job opportunities provided by the coal mines.

Several eateries/restaurants, mechanics, and general stores have been set up to provide services to the mining employees. In the pre mining era, the locals were dependent on forest produce as the land was not fertile enough for major agricultural production. The current scenario, however, is completely different as the area is highly industrialized. Due to the presence of coal mines, several Thermal Power Plants (TPPs) have been set up in and around areas such as Singrauli Super Thermal Power Station (2000 MW), Vindhyachal Super Thermal Power Project (4760 MW), Rihand Super Thermal Power Project (3000 MW), Anpara Thermal Power Plant (2630 MW), Lanco Thermal Power Plant (1200 MW). This proximity nearly eliminates the transportation cost and ultimately reduces the overall cost of power production (NTPC, n.d.). The employment opportunities and environmental issues created by the coal mines and TPPs raise a dilemma of choosing between economic development and environment conservation.

Source: NCL, 2021

4.3.2 The Brick Industry

India is the second largest brick producer in the world and the demand for coal just on this account is predicted to increase by at least three times in the near future due to rapid urbanization (Deore et al., 2019). The traditional red clay bricks are produced by sun drying and then firing the moulds in the brick kiln that has serious environmental impacts. India has over 190,000-280,000 brick kilns that produce about 250 billion bricks annually (Kumar, 2017). The most popular brick production method is Fixed Chimney Bull's Trench Kiln (FCBTK) in which bricks are warmed, fired and cooled simultaneously (GKSPL, 2014). The most commonly used fuel is coal, followed by biomass, agricultural residue and industrial waste.

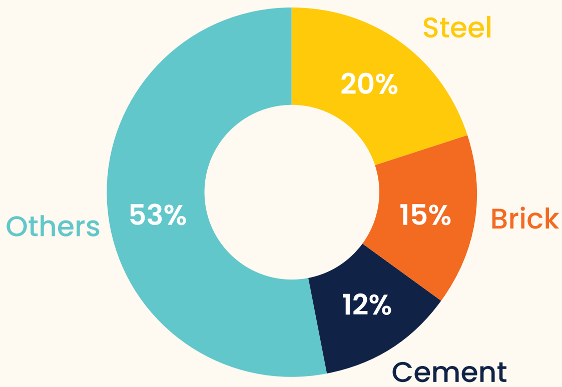
The contribution of the brick industry to GDP (0.7%) and employment (10 million people) is significant (Deore et al., 2019). Most of the people employed in this sector are migrant workers earning only a subsistent wage. Brick making in India is currently quite a labour-intensive job — from mixing to moulding to transfer in and out of the kiln. Even the transportation from one place to another generally is done by head load, 25-35 kg at a time. As per one estimate, 150 people are required to make 30,000 bricks per day in a kiln, of which 70% is involved in the moulding part of the job (Kumar et al., 2016). The industry is also one of the largest consumers of coal, consuming about 35 million tonnes of coal per annum (Figure 4.7).

As we move towards a coal phase out, the brick industry and hence the brick workers face a serious threat of job insecurity. The seasonal employment of the migrant workers makes it harder to track the number of people that will be affected, with a consequential worsening of the condition. 40% of the male population and 80% of the female population in the brick sector are illiterate and devoid of any skill. This makes it even more challenging to bring about energy transition (PLFS, 2021). Since only the process of firing the moulds in the brick kiln requires some skills, the rest of the workers are mainly unskilled, and it will be a difficult and expensive task to impart skills through development programs/schemes to such a large population.

Brick industry facts

- 80% of the brick kiln workers do not have any vocational training
- Lowest wage among all coal consuming sectors, at nearly INR 8000 per month
- 80% are contractual workers
- 37% people in this sector are illiterate

Figure 4.7
Major coal consumers (excluding the power sector)

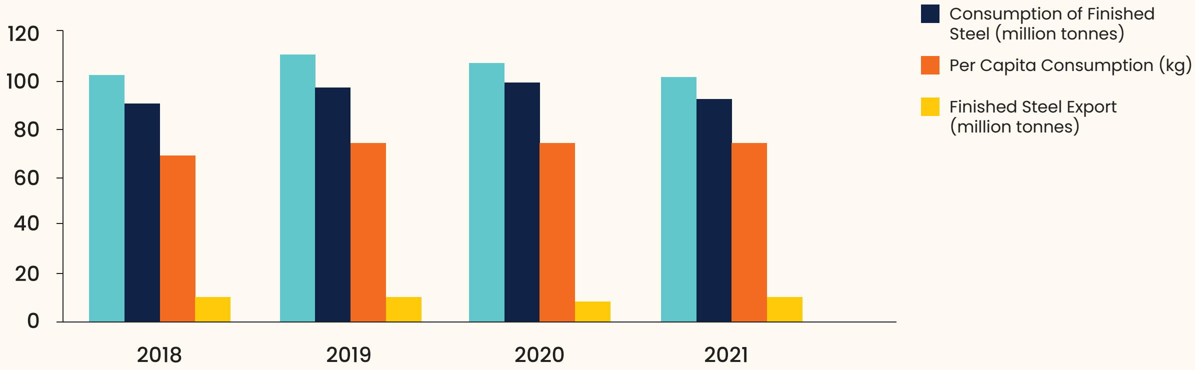


Source: Kumar, 2017

4.3.3 Iron and Steel Industry

Iron ore is the primary source for producing iron and steel. India produced 111.2 million tonnes of steel in FY 2018-19 making it the second largest steel producer in the world (World Population Review, 2022). The industry also contributes over 2% to the GDP and employs about 2.6 million people both directly and indirectly. The employment multiplier is also very high at 6.8 - meaning that, for every one job in the steel industry, 6.8 other jobs are created (JSW, n.d.). Steel is used in manufacturing utensils, vehicles, buildings, etc. and the demand for steel will only grow as the current per capita per annum consumption is 74.7 kg (rural per capita consumption is only 19.6 kg per annum) which is way below the world average of 208 kg (Fig. 4.8) (IBEF, 2021). The current target set by the National Steel Policy is to increase per capita rural steel consumption to 38 kg per annum and a total production capacity of 300 million tonnes by 2030-31 (IBEF, 2021). This is projected to increase the employment by about a million with an investment of INR 10 lakh crore.

Figure 4.8
Production and consumption of steel in India



Source: Created from study by IBEF (2021)

Some facts about investment in steel

- JSW Steel invested US$ 19.9 million to set up a steel plant in Jammu and Kashmir
- Tata Steel announced an investment of US$ 404.46 million in Jharkhand
- Tata Steel announced an investment of US$ 1.08 billion in capital expenditure to develop operations in India in FY22
- FDI of US$ 14.74 billion in Indian metallurgical industries reported between 2000 and 2021

Source: IBEF, 2021

In the iron making process, iron ore and coke (coking coal converted into coke by removing impurities) are put into a blast furnace and heated at 1200 degree Celsius. Steel is produced through three methods: the Blast Oxygen Furnace method, Electric Air Furnace and Induction Furnace method. Production of iron and steel accounts for 2.6 gigatonnes of carbon dioxide per annum globally (Iron and Steel IEA, n.d.) and a transition towards cleaner fuels is essential. Of India's total greenhouse gas emissions, 9% is from the steel industry alone. The annual import of coking coal for steel production is valued at US$ 8-10 billion which is about 2% of the total imports value ("A Green Approach", The Hindu, 2021). Shifting to cleaner sources is therefore necessary, both from economic and environmental perspective. However, a transition in this sector may not be as challenging as other sectors like coal mining and brick industry since the iron and steel industry has mostly skilled workers. Only 15% of the workers of this industry are unskilled, and 60% and 25% are skilled and semi-skilled respectively (DSouza and Singhal, 2021). However, those directly involved in coal handling need training to be absorbed into other sectors.

4.4 Other Stakeholders

Besides the social impacts caused as a result of coal phase-out, there will be huge economic impacts in terms of loss of revenue from coal transport in the rail sector and from the taxes collected by the state and central governments. This, in turn, can potentially affect the overall economy and also energy transition due to decreasing availability of public funds.

4.4.1 State and Central Governments

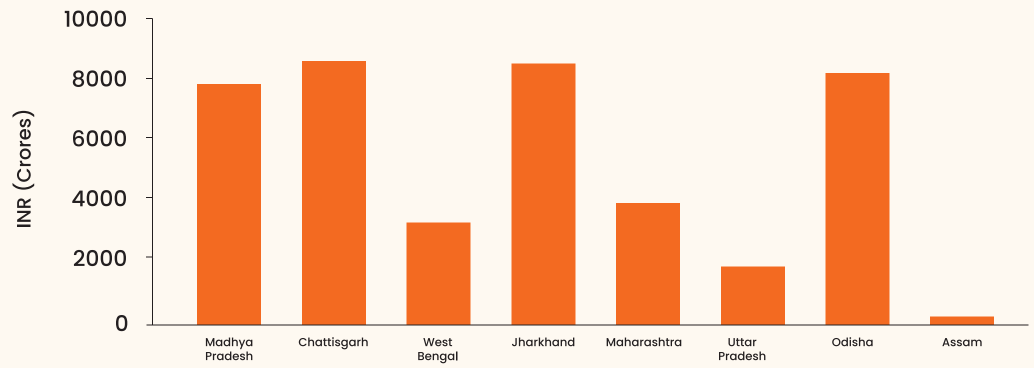
Chapters 2 and 3 focused on the importance of coal from the perspectives of energy access and economic development. The state and central governments are major stakeholders in the coal industry. Over INR 43,000 crore was collected in total in the form of royalty, cess, and other taxes from Coal India Limited alone (Table 4.1). As of FY 2019-2020, Jharkhand was the biggest contributor (INR 9074.02 crore), followed by Chhattisgarh (INR8940.21 crore) and Odisha (INR 8501.01 crore) (Fig. 4.9).

> "INR 43,000 crore paid to state and central government in taxes and royalties by Coal India Limited in Financial Year 2019-2020"

Among the eight subsidiaries of CIL, (section 4.3.1) South-eastern Coalfields (SECL; INR 10008.64 crore), Mahanadi Coalfields Limited (MCL; INR 8501.01 crore) and Northern Coalfields Limited (NCL; INR 8020.49 crore) account for about 62% of the total amount of tax collected (CIL Annual Report, 2020) (Fig. 4.10).

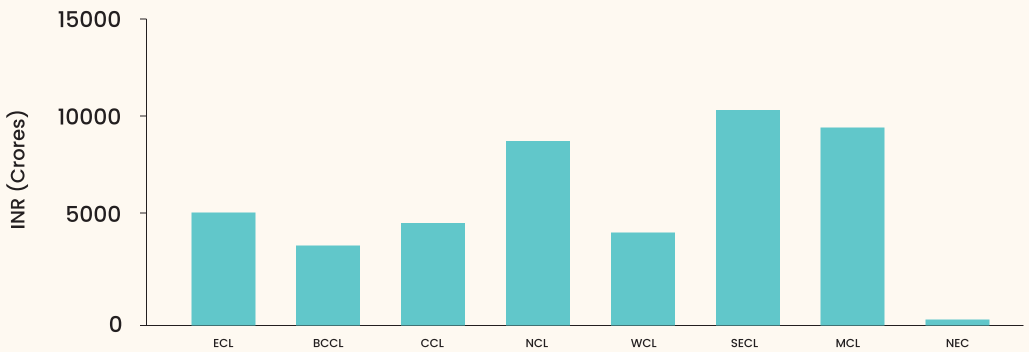
Coal is under the GST regime, but one of its main outputs, electricity, is not and the tax burden amounting to around INR 25000 crores falls on the users (Dutta, 2021). In this process, the pre-tax price of coal doubles post inclusion of the taxes for the power sector . The royalty and GST compensation cess alone account for 77% of the total taxes paid by CIL. GST compensation cess was previously 'coal cess' of INR 400 per tonne and the revenue collected here was put into the National Clean Energy and Environment Fund that basically worked as a sort of 'green tax'.[5] It may be pertinent to point out here that this levy was converted into GST compensation cess in 2017 to address the reducing tax revenues . It follows that both the state and central governments will suffer a substantial reduction in tax revenue as a result of coal phase-out. This may demotivate them from taking effective steps towards an energy transition.

Figure 4.9
State-wise Royalty, Cess, GST and other levies from CIL (2019-2020)



Source: Created from Annual Report and Accounts, CIL, 2021

Figure 4.10
Subsidiary-wise Royalty, Cess, GST and Other levies from CIL



Source: Created from Annual Report and Accounts, CIL, 2021

5 The tax levied on polluting objects such as older vehicles.

Table 4.1
State-wise taxes from CIL

	Madhya Pradesh	Chattis-garh	West Bengal	Jharkhand	Maharash-tra	Uttar Pradesh	Odisha	Assam	Total (in INR crores)
Royalty	1830.08	2111.06	15.77	2558.36	1149.06	393.25	1624.71	6.07	9688.36
DMF	569.47	665.85	4.73	738.69	344.73	118.64	541.23	1.83	2985.17
NMET	38.00	42.36	0.32	60.91	22.98	7.83	36.45	0.12	208.97
CGST	268.30	261.86	20.47	425.67	148.97	60.28	230.36	3.27	1419.18
SGST	268.30	261.86	20.47	425.67	148.97	60.28	230.36	3.27	1419.18
IGST	8.77	3.36	116.91	18.87	1.39	6.67	0.60	0.78	157.35
GST Com-pensation Cess	4271.71	5081.56	1005.41	4098.56	1806.12	496.79	5748.60	3.49	22512.24
Cess on Coal	-	-	2045.49	-	-	-	-	0.18	2045.67
State Sales Tax/VAT	-	3.77	1.06	0.85	-	-	-	-	5.68
Central Sales Tax	-	-	0.95	5.05	-	-	-	-	6
Others	859.41	289.92	-	322.16	-	68.5	-	-	1539.99
Total (in INR crores)	8114.04	8721.60	3231.58	8654.79	3622.22	1212.24	8412.31	19.01	41987.79

Source: Annual Report and Accounts, CIL, 2021

Table 4.2
GSTs levied on coal

Parameters (FY2018-19)	Value
Weighted average price of coal (INR/tonne)	**1480.95**
Weighted average GST paid on coal (INR/tonne)	**74.05**
GST Compensation Cess (INR/tonne)	**400**
Total GST paid on coal purchase (INR crore)	**22865.36**
Total GST paid on rail freight (INR crore)	**2543.64**

Source: Dutta, 2021

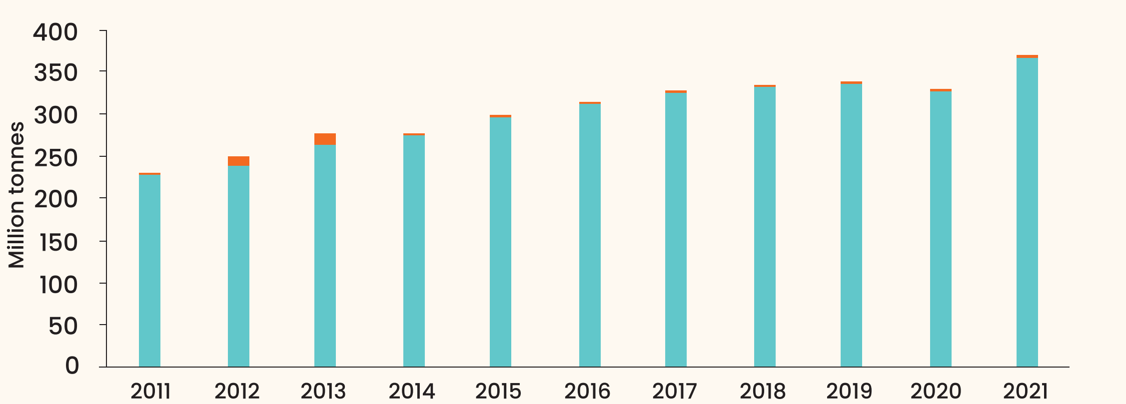
4.4.2 Railways

Indian Railways (IndRail) has one of the largest track networks in the world with about 68,000 km of route length (as of 2020). Historically the railways were heavily dependent on conventional fuels for operation; however, as of 2020, 39,328 km (58% of total route length) has been electrified and a net zero emission target has been set by IndRail, to be achieved by 2023 (Indian Railways, 2021). A significant contributor to the revenue of IndRail is the coal industry that is responsible for providing 44% of the freight revenue and 40% of the total revenue. About 370 million tonnes of coal is transported by rail annually (Fig. 4.11). A share of about 50% in the coal transport was maintained by the IndRail during the past decade (Fig. 4.12). Since most of the coalfields are located in the eastern part of the country and the thermal power plants are located across the nation, the IndRail play a key role in the coal industry in terms of coal transportation.

Coal is transported by IndRail, at times, for distances of over 200 km. There are other means of coal transport (such as road, MGR, conveyor belt, rope, etc.), but rail transport accounts for 87% share of coal transportation cost and transports about 54% of the total coal transported (Kamboj and Tongia, 2018, Ministry of Coal, 2020-21). As expected states located farther from a coal mine incur a higher transportation cost and that affects the overall cost of electricity supplied to the end user (Tongia and Gross, 2019). Quantity, distance and price are the three main parameters that decide the cost of coal transportation. If one of the component decreases, the cost of coal will also reduce, bringing down the overall revenue of the IndRail. In the recent years, due to decreasing Plant Load Factors (PLF)[6] of TPPs and better linkage of trains, the distance component decreased and subsequently the overall quantity of coal transported decreased.

The IndRail however, increased the price component or the freight charges to balance out the decreased distance to ensure 'revenue neutrality'. This highlights the interdependence between IndRail and the coal industry in India. The demand for coal will suffer a decline with an increase in renewable energy installed capacity across the country. The average passenger fare is much less in India as compared to other countries. This owes partly to the cross-subsidization of passenger transport from earnings from freight transport (and mostly from coal transport). A coal phase-out may not only adversely affect the balance sheet of the IndRail, but also the passengers for a possible decline in the cross subsidy component. As this Public Sector Undertaking is the largest civilian employer, a reduction in its revenue is likely to affect the number of jobs it can support directly.

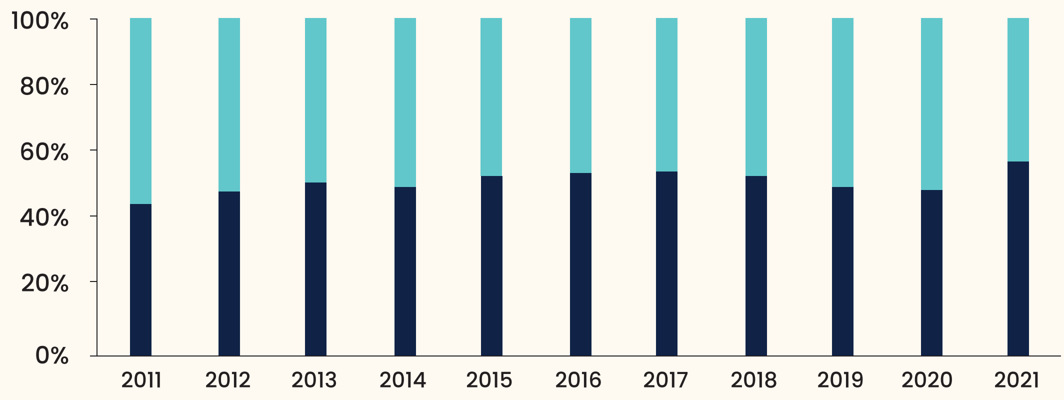
Figure 4.11
Quantity of coal transported by IndRail



Source: Created from Provisional Coal Statistics, Ministry of Coal, 2021

6 Plant load factor is the ratio of average power a plant generated to the maximum power it could have generated in a given time frame. Higher PLFs are associated with higher revenue.

Figure 4.12
Share of coal transported by IndRail



Source: Created from Provisional Coal Statistics, Ministry of Coal, 2021

It follows that the IndRail needs to diversify its profit making sources. Even though the demand for coal and hence the transportation quantity is bound to increase for at least a decade (Gupta et al. 2020), decreasing PLFs, better rail network and increased generation from renewable energy sources will reduce the overall coal dependency in the long term.
It may be interesting to note that the Central government, instead of slowly shifting from its dependence on coal, has decided to undertake railway projects in eastern India at a cost of INR 22,067 crores to facilitate coal transportation (Financial Express, 2021).

4.4.3 Private Sector

Coal is one of the most important inputs in India for industrial production such as steel, cement, and bricks, and electricity generation. Even though public sector remains a major player here, recently some provisions have been made in the regulatory framework to enable entry of private players. Specifically, in 2015, the Coal Mines (Special Provision) Act was passed with the aim of auctioning coal blocks to private companies. However, this legislative action was not found to be an attractive proposition to the private players as they were limited to captive use of mines only and were not allowed to trade in the market. Subsequently, in 2020, the Mineral Laws (Amendment) Act removed this restriction. The government expects — as a consequence of this removal of restriction on 'ease of entry'— an increased level of employment in the coal industry and a capital inflow of INR 33,000 crore (Raina et al., 2021). Other expected benefits include increased coal production, leading to decreasing cost of electricity and increased Foreign Direct Investment (FDI), both lending a helping hand to accelerate economic growth, lower coal imports, and generate higher revenue for the government. An inevitable consequence is serious ecological damage in areas that are densely forested and inhabited mostly by tribals, as most coal blocks are located in such spaces. Historically, such extractions have adversely affected the livelihoods of these forest dwellers as their income is mainly generated through sale of non-timber forest produces. In fact, India has been a witness to many conflicts in the past on the question of the right to extract sub-soil resources by firms versus the right to gather above-soil resources by inhabitants of forests. These are called ecological distribution conflicts in the literature. In some cases, the matter reached highest level of judiciary in India. Some often cited cases include Samata (Krishnakumar, 2004) and Niyamgiri (Sarin, 2008).

> "Rail transport accounts for 87% share of coal transportation cost and transports about 54% of the total coal transported"

> **Trade unions play an important role in the process of energy transition as they are the ones most familiar with the psyche, social conditions, wages, skills, and education of the people involved in coal-dependent economic activities**

However, in the area of power generation, private sector is the major player. With an installed capacity of 87 GW (37.8% of overall thermal capacity) and a generation of 3,81,950 GWh (36.6 % of total thermal generation) in FY 2019-2020, it is the largest power producer in India (CEA General Review, 2021). This is an increase of 27% for installed capacity and of 16% for total generation since the last decade, with absolute generation having more than doubled during this period. Out of a total 144 companies and co-operatives, 109 are generation-based; most of these private thermal power plants are located in the coastal regions of India as they rely on imported coal (Oskarsson et al. 2021). This imported coal contributes to the process of economic development variously, for example, through infrastructural activities such as building of roads and increasing railway capacity for coal transportation from ports to other non-coastal cities with a thermal power plant. Contextually speaking, the transportation of coal from Mormugao port in Goa to parts of Karnataka which enabled widening of roads and better linkage with cities can be considered as an example. However, parts of this route run through the ecologically sensitive Western Ghats leading to negative environmental externalities.

It follows that a phase-out — though necessary — will severely impact the rate of economic growth, electricity supply, infrastructural development, and employment generated by the private mines and power plants. At the same time, it is a fact that private sector runs on the principle of profit maximization and the government has limited options to make them adhere to macro level norms ex post, i.e., when such norms were not in place at the time of issue of license.

4.5 Institutional Factors: Stakeholder Collabouration in Planning Energy Transition

From the power sector to non-power sectors such as coal mining, brick, and iron and steel industry, state and central governments and the railways, sections 4.2 and 4.3 depicted all the major stakeholders of the coal industry and how they will be impacted as a result of coal phase-out. Discussions between and within the stakeholders are vital to develop pathways and roadmaps for coal phase-out. As the local or regional government authorities are equipped with the knowledge of the resources available and potential of the under-developed industries in the area, they will play a crucial role to develop micro level policies and schemes targeting the most prominent stakeholders. For example, the Singrauli coal mine area in Uttar Pradesh is also surrounded by dense forests, hills and a large water body that can be developed into eco-tourism destinations. The local authorities are also the first point of contact when it comes to a comprehensive regional data set that will be useful in developing a roadmap for any transition.

In the energy transition process, the role of trade unions cannot be overestimated. They play an important role as they are the ones most familiar with the psyche, social conditions, wages, skills, and education of the people involved in coal-dependent economic activities. Trade unions have a strong history of engaging with the welfare of labourers and other workers, especially in India's organized

sector. Acting as the voice of workers who will be directly impacted in the energy transition processes, trade unions can play a significant role in protecting the rights of workers whose livelihoods are in question. They, along with local political leaders, are more likely to have connections with both the 'contesting parties', i.e., the local population at the receiving end and the decision-making authorities. Their effective participation is expected to make the transition process a smooth one.

The coal mining companies in both private and public sectors have data on the regular employees. They are legally obliged to collect it in fact and share with government. It is generally the data on the contractual labour force that is lacking in most places and therefore can be collected to develop strategies for investments in other industries. The data on skill set and educational background will help determine the potential in which the local economy can grow, and therefore, a decision can be made on which industries can be targeted to substitute the coal sector as a source of livelihood opportunities. The accumulated information from local authorities, trade unions, and authorities of the coal-dependent sectors can then be used to develop and formulate policies incentivising potential industries to set up in that area.

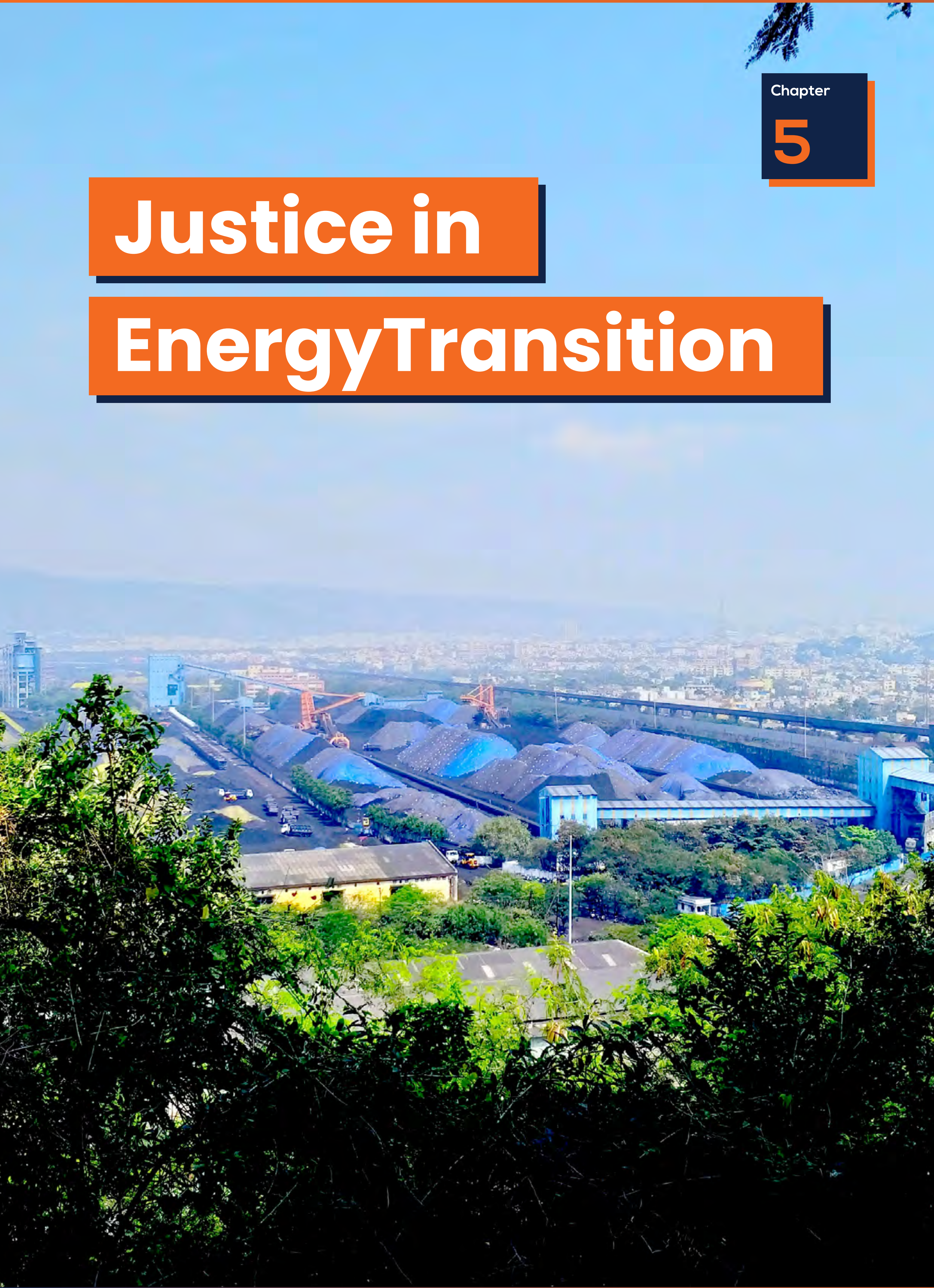
As noted earlier, some of the industries are heavily dependent on the coal sector such as the IndRail and there are certain coal mining districts where half of their GDP comes from coal (for example, Korba in Chhattisgarh). This can be resolved only by mobilising large amount of funds.

4.6 Summary and Conclusions

This chapter identifies the major stakeholders in the energy transition process and discusses the impacts of coal phase-out on them. In any discussion on 'just transition', it is important to see the gainers and losers at multiple levels. Coal is not only a polluter, but also a vehicle of industrialization, a source of revenue for both state and central governments, a source of employment for billions of workers, and a pillar of economic growth and development. The stakeholders include the power sector, coal mining, bricks industry, and iron and steel industry that are majorly dependent on the coal sector. The stakeholders include the power sector, coal mining, bricks industry and iron and steel industry that are majorly dependent on the coal sector. The government has already granted license to private players to invest in energy generation and infrastructure activities, and import coal for this purpose. With a caveat, we would like to end this chapter: The discussion has only been about the stakeholders related to the coal sector and not the entire thermal industry as the impacts from coal are more prominent and affect a large scale of industries and population. Arguably, trade unions and labour contractors — being important stakeholders — deserve more space. This issue will be discussed in the next chapter.

Chapter 5

Justice in EnergyTransition



5.1 Introduction

This chapter focuses on the matter of justice in energy transition or just transition in short. It traces the history of the concept, and major frameworks that have been proposed to implement policies facilitating a just transition. This is followed by a short discussion of the approaches specifically used in Canada and the suggestions made by the World Bank towards this end. Finally, summarized forms of two case studies around just transition issues in India have been presented along with some recommendations.

5.2 History of the concept of Just Transition

In conceptual terms, just transition can be traced back to the early 1990s where trade unions in the United States and Canada started demanding financial support and opportunities for those affected by the implementation of energy transition or other environmental protection policies. The idea was to make environmental conservation efforts equitable at the same time, be it at the community level or even an economy. Even while the idea of equality has found a place in the discourse on sustainable development, just transition is its most prominent expression. Arguably, development has always promoted inequalities of various kinds and an energy transition per se can just add another dimension to it. Unless it becomes a just transition, it may be a little more expensive for those already lagging behind in the so called development process to 'catch up'.

Figure 5.1 depicts the timeline of development of just transition as a concept. The idea has its roots in the demand made by US trade union leader Tony Mazzocchi for special funds for the welfare of workers who lost their livelihoods due to environmental protection policies. Gradually the same demand was raised by other union leaders in USA and Canada. In 1997, it was raised by the International Trade Union Confederation (ITUC) in the famous Kyoto Conference which made it a part of popular newspaper and magazine writings. In 2013, the International Labour Organization (ILO) developed guidelines for just transition and produced a framework for its use in all countries. Since 2015, several countries have taken interest in understanding the issue and created funds for undertaking research in this area. As a result, research in this field has expanded, but it is still a relatively new area in comparison to other energy related research areas. It is only within the last few years that technical studies, reports and guidelines have been published. The preceding chapters have explained the energy scenario in India, economic dependence on energy, need for transition and impacts on major stakeholders in the coal industry. In the previous chapter, it has been argued that, in the efforts towards mitigating climate change, livelihoods of people who depend on fossil fuels had been generally ignored. This chapter briefly discusses some of these studies, reports and guidelines, and put forth a few suggestions that are appropriate for implementation in the Indian context.

1993
US trade union leader Tony Mazzocchi demanded 'Superfunds for workers' whose livelihoods were affected due to environmental protection policies

1995
Just transition proposal laid by the president of Oil, Chemical, and Atomic Workers Union

1997
Official endorsement of Just Transition principle by US and Canadian Unions

1997
The ITUC (International Trade Union Confederation) included Just Transition in its statement to the Kyoto Conference

1998
Official use of the term 'Just Transition' in news articles

2006
Assessing the impact of climate change on jobs by the European Trade Union Confederation (ETUC)

2008
First study on the impact of climate change on workers "Green Jobs" published

2009
Trade union statement on Just Transition submitted to COP15

2010
Resolution towards Just Transition adopted by ITUC at its second World Congress

2010
ETUC adopted resolution towards Just Transition

2011
Concept of Just Transition included in final agreement of COP16

2013
The ILO adopted Just Transition Framework

2015
The ILO launches Just Transition guidelines

Since 2015
Several economies started developing Just Transition guidelines and research into impacts of energy transition on people's livelihood expanded

5.3 Globally Established Frameworks

5.3.1 ILO Framework

To reiterate, coal phase-out, certainly desirable from the environmental point of view, has varying impacts on different economic sectors, and sections of society. Therefore, a need is felt for the development of energy production technologies in a sustainable and non polluting manner and making the economies hitherto highly reliant on coal to depend on less polluting mechanisms and green energy, but have the same potential for growth and generation of employment opportunities. As mentioned earlier, the ILO developed guidelines that primarily focus on securing the livelihoods of the people who are currently dependent on the thermal industry (of which coal is a major element) directly and indirectly. The premise on which the guidelines of justice in energy transition by ILO is built, includes all aspects of energy, economy and environment, and has been presented in four boxes on the right.

The guiding principle of this framework revolves around providing green jobs to those affected and retraining them in industrial sectors which, in turn will stimulate the creation of more jobs/further job opportunities. The principle stated that a holistic approach involving government organisations, trade unions, businesses and enterprises may be adopted. A coordinated approach involving a dialogue between all stakeholders was advocated with the expectation that it would smoothen the process of transition. It was pointed out that growth, industrial and investment policies, skill development and social protection are the key areas that will simultaneously address the social, economic, and environmental aspects of a just transition. ILO's guidelines recommended the governments and social partners (such as trade unions and civil society organisations) to pertain to the following broad segments (Fig. 5.2) (ILO, 2015):

- Policy coherence and institutional arrangements for a just transition for all
- Social dialogue
- Macroeconomic and growth policies
- Industrial and sectoral policies
- Enterprise policies
- Skill development policies
- Occupational safety and health policies
- Social protection policies
- Active labour market policies

Figure 5.2
Key elements of ILO Framework

Decent Work Agenda
- Social dialogue
- Social protection
- Rights at work
- Employment

Dimensions of Sustainable Development
- Economy
- Society
- Environment

Opportunities
- Net gains from increasing investment into sustainable production mechanisms
- Improvements in income, job quality, and employment levels
- Social inclusion through restructuring the economy

Challenges
- Inequality: adverse impacts on poor households
- Displacement and job losses as a result of greening the businesses and enterprises
- Poverty
- Growing population

The larger objectives or the goal of the ILO guidelines is having a strategy that is clear, comprehensive, and which can be adopted by means of policy interventions developed through continuous dialogues between the stakeholders. For a developing economy like India that is highly dependent on coal, a comprehensive dialogue from the grounds up is an absolute necessity as every region will have different demands, resources, skill sets, educational backgrounds, and industrial structures. Involvement of the local authorities, community leaders and small business enterprises can help create a picture of the current scenario. A few examples that highlight the importance of coordination among stakeholders are given below.

Coordination among stakeholders

California, US
Environmental justice and labour groups worked together to come up with a "joint policy platform" where both the groups could put forth their concerns and a unanimous solution could be designed. Through this, a distributed generation model was developed that uses solar power and is a community-based project providing electricity to households and businesses while creating jobs for the members of affected community.

Ruhr region, Germany
Employment in the mining industry in the Ruhr region decreased dramatically, from about half a million people in the late 1950s to less than 12,000 as of 2013. Therefore a legal framework for phasing out was developed. This was based upon early retirement, foregoing wage increase for work redistribution program, social compensation plan, managing labor market transitions, mapping existing skills to create skill development targets, and having a comprehensive re-employment strategy as the main elements of the transition process. Negotiations between the coal associations and trade unions led to the formation of localised solutions that catered to the economic needs of the affected people and environmental needs of the society.

5.3.2 Framework by Just Transition Initiative

Just Transition Initiative (JTI), by CSIS Energy Security and Climate Change Program and the Climate Investment Funds (CIF), was developed to create policy recommendations and guidelines for a just energy transition through systematic analysis, case studies and stakeholder consultations. It also aims to create a dialogue for knowledge-sharing between stakeholders and scholars for a better understanding of just transition and strategic development of policies and guidelines.

The framework focuses on social inclusion in the process of transition, by including stakeholders and vulnerable groups in the decision-making process. It also focuses on the distributional impacts that include historical injustices, current outcomes, and also the future impacts of transition. Another element is planning for transition through social, political, and economic changes. JTI developed four approaches to just transition: systems change, narrow transition, incremental reform, and a top-down approach.

Systems change considers multiple stakeholders during transition planning and a broad range of sectors that will be impacted. The idea is to rebuild systems that do not harmonize with sustainable development and social equity. Narrow transition includes a focused approach and considers diverse stakeholders, but limited range of impacts on specific sectors. Empowerment is the key element of this approach. For example, a community-owned energy generation system such as a micro hydro project that is operated and maintained by the locals. Incremental reform suggests considering limited stakeholders and sector-based impacts. The idea is to pursue transition through incremental changes in the existing system. Lastly, a top-down transition approach involves an expansive approach towards transition, including a wide range of sectoral impacts and stakeholders.

Thus, the JTI framework captures a wide range of approaches that can be adopted and implemented to achieve a just transition. The focus could be very narrow with limited stakeholders, or expansive with multiple sectors. The approach towards social and economic change could be radical or incremental. For a diverse and developing country like India, one may need an area-specific approach, i.e., different approaches could be adopted for different regions. For example, a rural and remote region could pursue a narrow transition through community-based projects. The main objective would be to transform the social and economic structure in a way that is sustainable and equitable, indicating 'systems change' approach; however, an incremental and localized approach could be the stepping stone for a large scale transformation (CSIS and CIF, 2021).

5.3.3 Just Transition Roadmap for Canada

A target of net zero emission by 2050 has been set by Canada. To achieve this, it is imperative to move away from coal, oil, and gas. Over one lakh people are directly dependent on the fossil fuel sector while many more depend on it indirectly (Stanford, 2021), which makes the transition to a cleaner economy very challenging. Kirkwood and Duncalfe (2021) collated certain guiding principles to minimize harm to the vulnerable groups and maximize benefits, and sharing of those benefits as a result of decarbonization:

- **Recognition of rights:** It focuses not just on basic human rights (clean air, water, food, shelter, education), but also labour rights, indigenous rights, and migrant rights. Labour rights include employment standards, safety, and security, etc. Indigenous rights include rights of indigenous people such as prior and informed consent. Migrant rights include rights such as rehabilitation of displaced workers.

- **Participation of affected workers and communities:** It suggests that people affected by transition, from a social and/or economic stance, may be included in the decision-making process. Trade unions can play a key role in representing organised labour as they have an influence on both sides, the decision-making side and the affected people.

- **Expansion of the social safety net:** It includes compensation, retraining/reskilling of people displaced from their jobs. The inclusion of not just those who are directly employed in the fossil fuel sector, but also those indirectly dependent, is of vital importance.

- **Creation of new economic opportunities:** This is about designing energy transition policies in a way that promotes investment in other industries within regions that are heavily dependent on fossil fuels in order to create a structural shift in the economy.

- **Inclusive workforce development:** It suggests that training in green jobs should be provided to people currently being displaced from their jobs along with incorporating an increase in demand for these jobs in the future.

In the light of the above principles, six component frameworks for just transition in Canada were developed (Kirkwood and Duncalfe, 2021):

- Enshrine Just Transition principles, rights, and definitions.

- Establish a Just Transition Commission to oversee and guide the transition.

- Establish a Just Transition Benefit to support workers in affected communities.

- Establish an Economic Diversification Crown Corporation to invest in affected communities.

- Establish a Just Transition Training Fund that prioritizes the inclusion of historically marginalized groups.

- Establish a new federal-provincial/territorial Just Transition Transfer to deliver funding for the social programs created under the act.

5.3.4 World Bank's Initiative for Just Transition

The World Bank has developed an approach, based on which they assist local and national authorities to develop a just transition map. Its "Just Transition for All" approach is built upon three pillars:

- **Institutional Governance**
- **People and Communities**
- **Environmental Remediation and Repurposing of Land and Assets**

It has designed methods to follow during the pre closure, closure, and regional transition phases. The focus is also on the reskilling of workers and implementing projects in coal regions through private and public capital as a way to gradual transition in a planned manner.

The pre closure phase focuses on building visions and developing inclusive policies for a structural shift in the economy. During this phase, building labour profiles for generation of social protection plans and rehabilitation policies are initiated. Assessment of land, assets, and other resources in a region is also conducted to develop a plan for transition (World Bank Group, 2021). Coordination between local, regional, and national authorities for properly decommissioning power plants and coal mines is a part of the closure phase. It also includes reskilling programs and providing assistance to former workers of the coal industry. The closure phase also focuses on transferring of assets such as a coal mine to a local community to develop community-based pilot projects post implementation of environmental guidelines in and around power plants and coal mines. The regional transition phase takes place after about a decade of the closure phase and the pilot projects are made long-term by managing funds and training people for future jobs in the area. Attracting big, private investors for long term growth and overall structural shift is also a part of the final phase.

The approach to start developing methodologies and guidelines years before closure is a significant part of a smooth transition process. As stated previously, although guidelines for closure of power plants were developed for India, it was done with a very narrow vision by taking into consideration only the environmental aspect. A more inclusive approach involving the social and economic aspects of the region is necessary to ensure a just transition.

5.4 Just Transition in India

5.4.1 Studies and Reports

As mentioned earlier, justice in energy transition is a relatively new concept and research in this field has just begun. Some studies, reports, and frameworks have been published, highlighting the need for transition and role of coal and renewable in it. Some examples are as follows:

a

Just Transition in India: An inquiry into the challenges and opportunities for a post coal future by iForest, 2020 (Bhusan, C., et al., 2020)

Proposes a framework for just transition based on innovation, policy, and planning. Developing a timeframe, inclusive transition policies, restructuring the economy, infrastructure development and generating investment towards just transition are the main elements of the framework.

b

Supporting Just Transition in India by Climate Investment Funds and The Energy and Resources Institute, 2021 (Ward et al., 2021)

Highlights the importance of complex systems modelling to understand energy transition and empowering stakeholders to develop inclusive policies and guidelines. Partnerships among local, regional, and national governments, regional planning, economic diversification, funding requirements, social safeguards and a broad transformation are the key points of the study.

c

India Energy Outlook 2021 by International Energy Agency (IEA, 2021)

Highlights the importance of a just transition as jobs in the fossil fuel sector decrease gradually. The study predicts a rapid increase in jobs in electric vehicle sector, clean power production and even appliance manufacturing reaching about 1.6 million by 2030 in a Sustainable Development Scenario (SDS).[7] Also highlights the importance of location of jobs as most mining and manufacturing jobs are geographically specific and therefore just transition guidelines need to be location specific or flexible to adjust to the local needs.

e

Socio-economic impacts of coal transitions in India by National Foundation for India, 2021 (DSouza and Singhal, 2021)

13 million people are dependent on coal related sectors such as mining, brick industry, cement industry, and iron and steel industry. The transition is also likely to have a higher impact on the central and eastern parts of India where the majority of coal mines are located. Quantification of coal job data, risk assessment and how to approach just transition in India are the key highlights of the study.

d

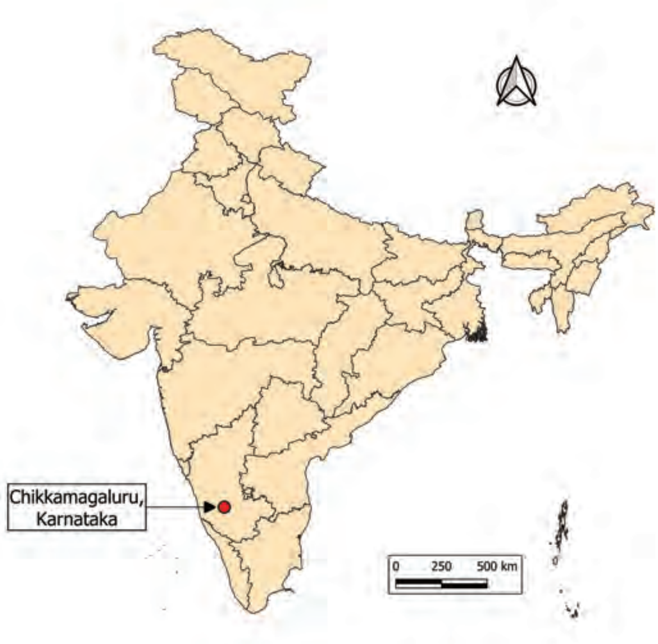
Fossil fuel phase outs to meet global climate targets: investigating the spatial and temporal dimensions of Just Transitions by Sandeep Pai, 2021 (Pai, 2021)

Estimated that 3.6 million people are directly or indirectly dependent on the coal and power sector. Also highlighted the importance of mineral funds and CSR funding. Half a million pensioners were also found to be dependent on the coal sector. The study advances the understanding of just transition that assists in a holistic development of guidelines for a just transition.

7 IEA's India Energy Outlook 2021 report presents multiple views on India's energy future based on today's energy markets, technologies and policies. One of these scenarios is the Sustainable Development Scenario that is based on clean air and energy access goals and examines what combination of actions is required to achieve these goals.

Case Study

a



The brick industry in Chikkamagaluru

Rajanna (2020) conducted a study on the working conditions and issues of the brick industry in a rural area of Chikkamagaluru district of India. The socioeconomic conditions were assessed and 94% of the workers were found to be below poverty line. The study also revealed high levels of migration in the industry which make the process of transition even more challenging as it is hard to collect data and develop guidelines based on the specific needs of the population.

b

Coal dependency in Ramgarh, Jharkhand

A study conducted by iForest in Ramgarh (Bhushan C et al., 2020), that is among the top five coal-producing districts of Jharkhand, captured the vulnerabilities of the local community due to high dependency on coal through focus group discussions and primary data collection of 406 households. Only 7% of the households were found to have a formal job in the coal sector and the rest were casual labourers and daily wagers. A decline in other industries such as fisheries and service sector was observed due to high dependence on coal mining which makes the need for transition urgent to bring economic diversification.

Case Study

c

Impact of mining in the Vindhya region, Uttar Pradesh

The Centre for Social Forestry and Eco-Rehabilitation evaluated the socioeconomic impacts of mining and mining policies on the livelihoods of the local population in the Vindhyan region of Uttar Pradesh (Dubey, 2017). The population was found to be mostly unaware of the mining policies, regulations, and other development programs. People dependent on agriculture had to change occupations due to land acquisition for mining activities, resulting in loss of assets and increased dependence on mining. As an inevitable consequence of mining, the area became critically polluted and the health of the people took a toll. A strong support for land reclamation and eco-restoration was observed which would be helpful for a smooth transition away from coal.

Impact of coal mines and closure in Betul, Madhya Pradesh

A study conducted in Betul, Madhya Pradesh (Gupta, 2021) by The Energy and Resources Institute (TERI) depicted the impact of coal on the local economy, employment and agrarian sector in the district. High dependency of the economy on coal was reflected by the fact that royalty from coal accounts for 33% of the district's non tax revenue. High recruitment drives decades ago led to a high influx of workers into the sector; however no such recruitments are happening anymore. This decreasing regular workforce has been substituted with contractual workers and a further increase in this is expected making the transition process all the more challenging.

d

5.5 Recommendations

What kind of dataset is required for policymaking in just transition?

A comprehensive dataset containing all relevant information is fundamental in the policy formulation process for the justice-oriented energy transition. In the approach toward energy transition, data on various indicators are pertinent to policymaking. For example, data on overall energy consumption, per capita energy consumption, types or forms of energy consumed (in the form of electricity, petrol, gas, etc.), and uses of that energy (such as for lighting, heating, cooking and transport), cost of per unit energy, amount of energy produced and from what sources (such as coal and renewable energy sources) are some of the fundamental requirements. For just transition, however, a different kind of dataset is needed containing information on three major categories: employees, local population and local industry. In the employee category, data on the number of employees in a coal mine or thermal power plant, nature of employment (contractual or regular), nature of duties, daily or monthly wages, skills and education of employees and information on migration are needed. For the local population (or those indirectly dependent on the thermal industry), data on current employment, nature of work, income, skills, education and migratory behaviour/pattern is required. While transitioning to cleaner energy sources, it is crucial to understand a particular area's current economic and industrial structure. Hence, to determine the industrial potential, data on operating local industries, small and medium enterprises, along with the demand for products or services of these industries, are essential. All the above data mentioned needs to be collected locally and nationally to develop focused and general policies. Given the vast amount of data, surveys in a decentralised manner through the local authorities would be efficient.

What should be the role of the state?

From allocating funds to implementing policies, the state plays a vital role during a structural shift. A committee or a project needs to be set up to monitor and evaluate the transition indices to develop policies to bring about "Just Transition". This project may also be responsible for collecting data from the stakeholders such as employees of the thermal industries and other relevant parties. Since energy transition will lead to a structural shift, the state has an opportunity to push the economy in the desired direction. In other words, for the job creation of existing employees in the coal industry, the government can promote specific high-growth manufacturing and services sectors by means of fiscal and monetary measures. Although the responsibilities and decision-making authority will have to be transferred to the local authorities, the state still has to develop a general guideline that will be followed by the local government regarding equal access to energy, electricity tariff and industrial subsidies. The state will be responsible for collaboration among various governmental institutions and departments, especially at the local level, since they will be ultimately responsible for implementing just transition policies and guidelines set up by the state. The central government will also be instrumental in mobilising funds to push sustainable enterprises or industries, as well as providing incentives such as subsidies and tax rebates.

What should be the role of local authorities?

Local authorities or district/village government officials are crucial in implementing just transition guidelines. With the in-depth knowledge of energy demand in the area, resource availability and industrial structure, they play a pivotal role in developing transition policy guidelines for the region in several ways. First, they can be made solely or partially responsible for rigorous data collection at the local level. Second, they can facilitate the restoration of the coalfields by setting up community-owned projects. Third, they can bring together several groups of people to discuss and decide the way forward, concerning reskilling and rehabilitation.

What are the environmental restoration measures that can be adopted?

Restoration and in situ remediations of the land occupied by coal mines and thermal power plants will mitigate the environmental degradation caused by mining and deliver environmental justice. Some restoration suggestions are given as follows:

- The land could be used for further energy generation by installing solar and wind farms.

- The land can be left as is and used as a tourism site managed by local government authorities or as part of community ownership projects.

- Transformation in the form of forest rejuvenation to restore flora and fauna of an area.

- Water bodies contaminated by fly ash disposal should be restored through appropriate technical intervention.

- Land that cannot be restored to its natural state may be used as a place for industrial set-up for the new or existing industries that will be expanding due to structural shifts.

What is the role of research institutions?

First, multiple exploratory research needs to be conducted primarily for regions heavily dependent on the thermal industry. Second, the feasibility and employment potential of non-conventional energy production mechanisms, employment potential of other sectors in a particular area, the demands of the local residents and impact on the environment, among other things, need to be assessed for developing just transition guidelines. Third, the state and local authorities can work jointly with academic institutions for efficient data collection and publication of evidence-based research reports. Fourth, as unbiased and autonomous entities, academic institutions can regularly monitor and report the progress of energy transition in a particular area. This could include monitoring energy accessibility and affordability, changes in wages and socio-economic structures, and the impact on the local ecosystem, such as animal habitats and water quality, as thermal industries gradually close down.

How to increase access to clean energy?

As a first step, it is essential to determine what percentage of the population has access to energy. This can be further categorised into types of energy such as electricity, oil, etc. Data on demand for different types of energy also need to be assessed. This demand can be variable as different people use different devices that may or may not be efficient such as an LED bulb or cleaner and efficient firewood stoves. The affordability and willingness to pay for such commodities must also be determined. A decentralised clean energy production system may be more feasible for providing access to remote locations than connecting the area with the state grid. The decentralised system will not only increase access to clean energy but also serve as means to provide employment.

How to incorporate equality in the transition process?

The needs and demands of the population, which will be rendered vulnerable due to the coal phase-down, must be considered in the decision-making processes to bring about a more equitable distribution of benefits from the energy transition. Education, training and re-skilling of those affected are vital to ensure that they can be absorbed in other jobs. Since women are relatively more affected due to using polluting energy sources, such as firewood for cooking, schemes and programmes must be implemented with a specific focus on women's health.

It is imperative to focus on equity, as without it, the benefits and costs of the transition process will be disproportionately distributed. A negative impact on the low-income groups will be disadvantageous to the economy as a whole.

How to create jobs?

Creating new jobs is one of the biggest challenges in achieving a just transition. Therefore, in the initial stages, it is important to implement a gradual phase-down policy rather than a sudden or complete phase-out so that the local communities and the economy have the time to adjust to the changes. The following points enumerate the required steps for a just phase-down of coal:

- Exploratory studies on which industries will better thrive in the area should be done before starting the phasing down process. Accordingly, fiscal and monetary measures can be adopted to push specific industries. Small-scale enterprises must be encouraged, and the local population must be aware of the subsidies, benefits and other incentives in setting up small businesses.

- Local authorities and academic institutions may be given the task of identifying the potential industries and assessing their feasibilities, respectively.

- If possible, setting up renewable energy plants will absorb some of the labour force; however, most will still have to look for employment opportunities elsewhere.

- Trade unions can play a significant role as they can very efficiently collect data on the skills and education level of the population, which would make a selection of specific and compatible skill development programmes a relatively simple task. For a holistic plan of alternative employment, trade unions can collect data on non-formal workforce who are generally not affiliated with unions. For this they can collaborate with research institutions.

- Since energy transition is a long-term process, education becomes a critical criterion for pushing the overall economy in a positive direction. As dependence on clean energy increases, there will be a higher demand for those having a skill-set in the clean energy domain. Dedicated courses at undergraduate and postgraduate level can contribute in skill development for clean energy innovation, deployment and expansion. The technical expertise of eminent institutes like IITs can be leveraged for policy making around renewable and non-conventional energy sources.

- Courses on clean energy can be introduced to children and young adults at a pre-university level and Industrial Training Institute (ITI) which in due course will serve its purpose of providing the required labour force.

What is the importance of engaging stakeholders in the decision making processes?

Dialogue among stakeholders such as trade unions, government officials and coal-dependent communities is vital for a successful energy transition. A just transition requires input from all the involved parties to develop policies and guidelines which are inclusive and locally appropriate. Several nations, including Germany, South Africa, Poland and Canada, have set up forums, commissions and task forces to bring all the stakeholders together. Since there are several dependents of the coal mining and thermal power sector in India, it will be challenging to bring together representatives of all groups. This calls for a democratic approach that requires decision-making by involving all parties at a local level. This approach will be more efficient as stakeholders from the same region will better understand each other's perspectives and requirements.

> "In the initial stages, it is important to implement a gradual phase-down policy rather than a sudden or complete phase-out so that the local communities and the economy have the time to adjust to the changes"

How to improve quality of life through energy transition?

A just transition is not only about creating jobs. Improving the quality of life should be an equally important factor in terms of providing access to clean energy, clean air and water, and quality jobs. Clean cooking fuel will significantly change people's health, particularly women, and reduce emissions to some extent. Other than this, capacity-building programs can be regularly conducted for the growth of small industries. Local authorities can also be responsible for creating awareness about efficient electrical devices and provision to purchase them at a subsidized price. This will lower energy bills as well as decrease the pressure of increasing energy demand, though marginally. Finally, to take care of psychological wellbeing, personal and professional counselling services can be offered to the affected communities.

5.6 Summary and Conclusion

Through the preceding text, it has hopefully been established that coal is an integral part of the Indian economy. It supports the production of a variety of goods such as cement, steel, bricks, and electricity; provides employment to millions of people and is a source of sizeable revenue for both the central and state governments. However, the high emission intensity of this fuel causes health hazards such as respiratory illnesses and lung diseases, besides impacting the environment in a way that is changing the climate of the planet altogether. This creates a predicament – to choose between the well-being of an economy or the well-being of the environment. Sustainable development suggests a course of action to switch to clean sources of energy, which cannot be achieved in the short run. The necessity, therefore, arises to develop a plan that has its basis in the transition to clean energy, even if it takes a longer period of time.

In this report, India's energy parameters for both thermal and renewable energy have been elucidated. The potential, installed capacity, generation, demand, revenue, environmental and social implications of energy consumption, role of decentralised energy, economic dependence on coal have been discussed along with the impact on local or regional growth levels. Electricity, coal mining, brick industry, iron and steel industry, state and central governments, and Indian railways have been identified as the major stakeholders of the coal industry. People working in these industries and revenue/tax collections from coal could suffer if appropriate policies and guidelines are not put in place before phasing out coal. Keeping this in mind, some recommendations have been made, which, to a certain degree, are distinct from those published earlier as the focus was on systemic evaluations of locally-based resources and employment opportunities instead of the general centralized approach. A transition in the energy sector may be looked at from all aspects instead of only electricity or only coal. Changes in consumption patterns such as using locally available resources for housing and other infrastructure, developing energy-efficient systems, and diversifying sources of economic dependence are some of the key features that could be adopted for a sustainable way forward. A just energy transition provides an opportunity to adopt such changes and shift the economic structure, while managing the requirements of those whose livelihoods are affected during and post transition.

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Annexure

Central Electricity Authority

We used the Executive Summaries and General Review reports by the Central Electricity Authority (CEA). The CEA was established under section 3 of the Electricity (Supply) Act, 1948. It is responsible for developing plans for the power systems of the country and also acts as an advisory body to the government in matters of electricity policy formulations. It sets up technical standards and safety requirements for construction, operation, maintenance and transmission of power. It also collects extensive data on generation, transmission, trade and use of electricity as part of routine administrative activities. It publishes monthly, quarterly, and annual reports that depicts a multitude of electricity parameters. Through this, we obtained a variety of information on the electricity scenario of the country. In particular, through the most recent Executive Summary (December, 2021), we determined the difference in the level of installed capacity and the actual amount of generation from renewable energy sources. The energy scenario information is collected from other sources that are discussed later. The information spread across a couple of decades were utilized to construct the most recent energy scenario and the trend so far in terms of rate of growth. These reports also provide extensive data on non-utilities sector, that is, electricity consumed by cement, brick, and steel industries.

URL: https://cea.nic.in/

Ministry of New and Renewable Energy

Ministry of New and Renewable Energy (MNRE) was originally established as Commission for Additional Sources of Energy (CASE) in 1981. It acts as the nodal ministry for all matters relating to new and renewable energy. The Ministry was created in 1992 as the Ministry of Non-Conventional Energy Sources which was renamed as MNRE in 2006. We used annual reports to collate data on potential and installed capacity of new projects on wind energy, small hydro power, waste to energy, solar energy and biomass and cogeneration projects.

URL: https://mnre.gov.in/

International Energy Agency

The International Energy Agency (IEA), established in 1974, was originally created to secure oil supply and it later evolved into all aspects of energy ranging from electricity availability and impacts of energy use on climate. We created a simplified version of the energy flow diagram of the IEA that includes only thermal sources of power generation, where the power is supplied and power losses, exports and captive use are depicted. We use IEA's World Energy Model (WEM) which simulates various scenarios of the energy market and predicts energy consumption and production. The India Energy Outlook report (2021) includes different scenarios and provides a framework to understand the implications of following alternative policy and economic scenarios. This includes the Stated Policy Scenario (STEPS) which is based on India's current policies. The India Vision Care scenario, on the other hand, assumes a rapid economic growth, the Delayed Recovery Scenario provides implications on the basis of a delayed recovery from the Covid-19 pandemic. The Sustainable Development Scenario is based on high energy investments..

URL: https://www.iea.org/sankey/

https://www.iea.org/reports/india-energy-outlook-2021#:~:text=Prior%20to%20the%20global%20pandemic,in%20the%20Delayed%20Recovery%20Scenario.

Oxford Martin Programme on Global Development

The Oxford Martin Programme on Global Development provides a collection of wide ranging data for several countries on economic variables, environmental factors, energy, etc. Using this information, we collated total and per capita energy and electricity consumption over the last few decades. We also computed total and per capita source-wise energy and electricity consumption to arrive at the share of non-conventional sources in total energy consumption over several decades.

URL: https://www.oxfordmartin.ox.ac.uk/global-development

https://ourworldindata.org/

Research papers

We reviewed several research papers that made attempts to determine causal relationships between energy sources and economic performances. The direction of causality in different time frames using different methodologies was assessed for energy and economic growth, renewable energy and economic growth and thermal energy and economic growth. For renewable energy and economic growth, we covered five studies that explore the direction of relationship between the two. All studies were similar in terms of time period but differ on method. A different set of five studies were covered to evaluate the same between non-renewable energy and economic growth for more or less similar time periods. The focus of these sets was to look into the energy-economy causal relationship in developing economies. We present differences in the results of both the sets. Persistent patterns in the data as well as conflicting nature of the results of the studies yielded some interesting insights. Research published by individuals, and academic and non-academic organisations were studied to capture the scenario in the coal dependent sectors of bricks, steel and railways.

For the potential of decentralised or off-grid/ hybrid renewable energy mechanisms to provide electricity to remote and inaccessible towns and villages, we reviewed eight such feasibility studies . The studies evaluated levelised cost of electricity, lifetime cost of systems and tested optimality of renewable energy systems separately and also in combination..

We also used research papers to collate information on the social impacts of energy consumption on education, and healthcare. After all, with the increase in energy consumption levels, the social development indicators of an economy improve. We explore several indicators of social development such as malnutrition, value added from agriculture, access to water, road, electricity, and primary education, and discuss the nature of relationship between these indicators and energy consumption.

Coal Industry

Coal India Limited (CIL) was established in 1975 by merging Bharat Coking Coal Limited and Coal Mines Authority. As of 2020, CIL is the largest producer of coal and supplies 83% of the total coal in India from its 345 mines spread across eight Indian states. We collected data on coal import quantity and value, production and level of employment. The data on coal consumption, transportation, output, price, and taxes was obtained from reports by CIL, Coal Controller's Organisation and Ministry of Coal. Information on some recent developments in taxes, subsidies and new investments were obtained from news articles of the prominent Indian newspapers.

URL: https://www.coalindia.in/

http://www.coalcontroller.gov.in/

https://coal.nic.in/

Just Transition Research Centre (JTRC) leverages high quality academic environment to conduct cutting edge research to address the academic and policy requirements of the national and sub-national levels. The centre's aim is aligned primarily with the seventh sustainable development goal of the United Nations: affordable and clean energy for all.

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