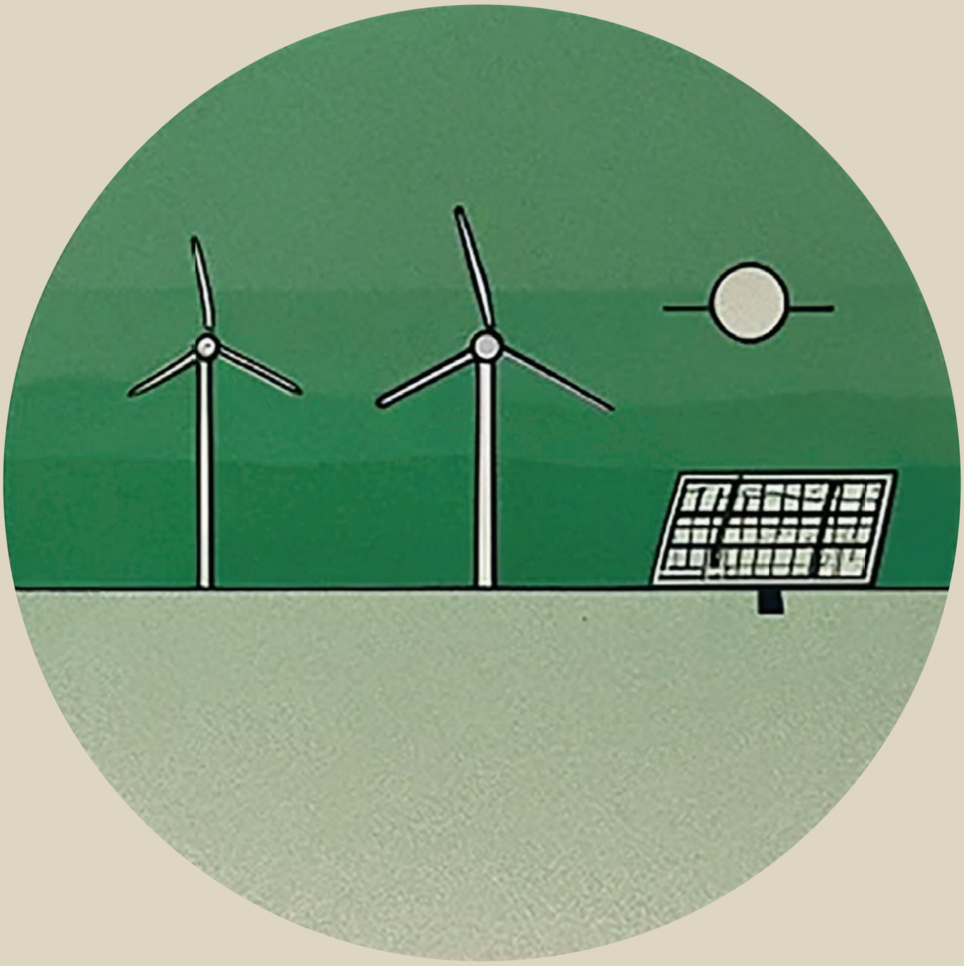
JUST TRANSITION, JUST FINANCE

Methodology and Costs for Just Energy Transition in India

Chandra Bhushan



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INTERNATIONAL FORUM FOR ENVIRONMENT, SUSTAINABILITY & TECHNOLOGY

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Abbreviations

BESS	Battery Energy Storage Systems
BALCO	Bharat Aluminium Company Limited
BAU	Business-As-Usual
CEA	Central Electricity Authority
CMPDI	Central Mine Planning and Design Institute
CBT	community-based targeting
CSR	Corporate Social Responsibility
CEEW	Council on Energy, Environment and Water
DGMS	Director General of Mines Safety
DDP	District Domestic Product
DMF	District Mineral Foundation
ESCOM	Electricity Supply Corporation of Malawi Limited
EC	Environmental Clearance
EIA	Environmental Impact Assessment
EU	European Union
GW	Gigawatt
GoI	Government of India
GDP	Gross Domestic Product
Hectare	ha
HPC	High Power Committee
₹	Indian Rupee
IRADe	Integrated Research and Action for Development
JET IP	Just Energy Transition Investment Plan
JET-P	Just Energy Transition Partnerships
JTF	Just Transition Fund
LT-LCDC	Long-Term Low-Carbon Development Strategy
MCL	Mahanadi Coalfields Limited
MER	Market Exchange Rate
MW	Megawatt
MWh	Megawatt-hour
MT	Million tonne
MTPA	Million tonne per Annum
MDO	Mine Developer and Operator
NALCO	National Aluminium Company Limited
NTPC	National Thermal Power Corporation
NGO	Non-Government Organizations
OSH Code	Occupational Safety, Health and Working Conditions Code
OC	Opencast
PV	Photovoltaic
PLF	Plant Load Factor
PSU	Public Sector Undertakings
RE	Renewable Energy
SECL	Southeastern Coalfields Limited
SAIL	Steel Authority of India Limited
STPS	Super Thermal Power Station
TJTP	Territorial Just Transition Plan
TPP	Thermal Power Plants
TPS	Thermal Power Station
T&D	transmission and distribution
UG	Underground
USA	United States of America
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
$	US Dollar
VRS	Voluntary Retirement Scheme

Summary for stakeholders

There is no established empirical method to estimate the cost of a just energy transition. The just transition investment plans of countries like Germany, Poland, South Africa and Spain have used different methods and thumb rules to estimate the costs. Apparently, transition investments in the Territorial Just Transition Plans of the European Union (EU) member states are a negotiated outcome rather than based on empirical formulae. However, the absence of a comprehensive empirical approach makes just transition investment plans arbitrary and incomparable. This has implications for the nature of financial support and the flow of capital from developed countries and multilateral institutions required for implementing just transition measures in developing countries.

Therefore, there is an urgent need for an empirical basis to determine the cost of just energy transition, which would assist countries in developing just transition plans, making necessary investments and fostering global partnerships. Our study is an endeavour to fulfil this necessity.

Our research introduces a novel approach to estimating the cost of a just energy transition at the sub-national and national levels. Moreover, this methodology can also be tailored to estimate transition costs for a coal mine or a power plant. We have incorporated a broad spectrum of investments, including grants and subsidies, necessary to decommission and repurpose coal mines and power plants, supply green energy alternatives, promote economic diversity, assist workers and businesses, and strengthen community resilience.

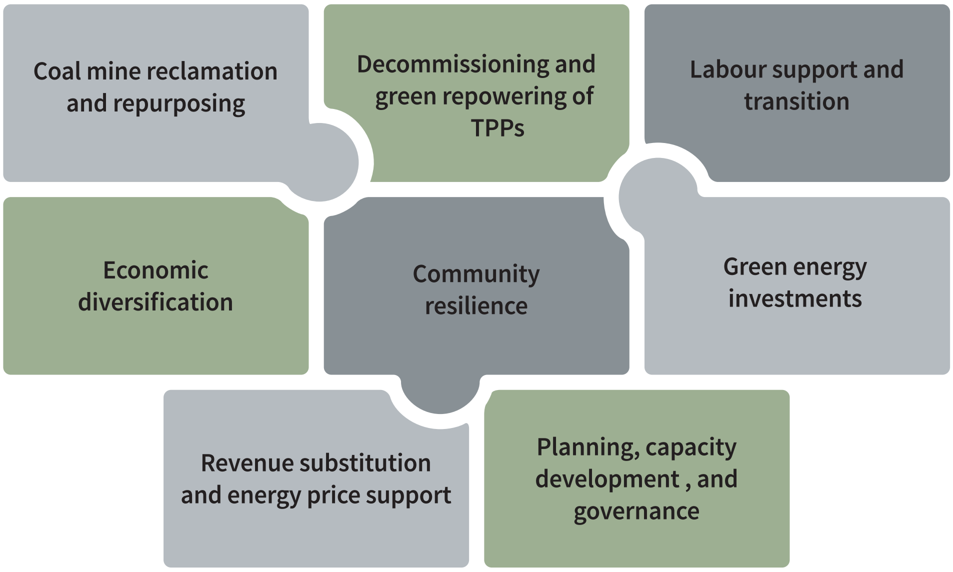
Through detailed district-level analysis, our study provides a realistic cost estimate for a just transition of India's coal and thermal power sectors. While the study focuses on India, the ultimate goal is to establish a method that enables developing nations to estimate the costs of just transition and secure the required financial support.

A. The 5-step approach

Our study employs a comprehensive five-step approach to ascertain the costs of a just energy transition. These steps are crucial in producing a reliable cost estimate that aligns with the distinct needs of fossil fuel industries and associated regions while simultaneously considering the unique national circumstances.

1. **Defining just transition:** The first step involves formulating a precise definition of a just transition. This definition serves as the foundation for identifying the costs of a just energy transition as per national circumstances and priorities.
2. **Identifying cost components:** Based on the definition, cost components are identified. The study identifies eight key cost components. These include coal mine reclamation and repurposing, decommissioning and green repowering of coal-based thermal power plants (TPPs), labour support and transition, economic diversification, community resilience, green energy investments, revenue substitution and energy price support, and planning, capacity development and governance.
3. **Defining cost components and establishing a method for cost estimation:** Once the cost components are identified, the next step is to define them (and associated sub-components) and establish a methodology for estimating the costs.
4. **Undertaking sub-national studies:** Undertaking sub-national/district-level studies in regions with significant coal mines and TPPs is critical to provide detailed insights into the costs involved. Our study scrutinises four major coal mining and coal-based power producing districts in India – Ramgarh, Bokaro, Angul and Korba -- to shed light on the various cost components. The district studies involved extensive primary surveys and secondary data analysis to ascertain the techno-economic status of mines and power plants, the dependence of the community on these industries, the situation of direct, indirect and induced workers, revenue contribution by coal mines, and community resilience to changes in the economic structure of the region.
5. **Determining cost factors and total cost:** The concluding step involves an analysis of various costs derived from the district studies, followed by their aggregation to form cost factors and determine the total costs of a just transition.

Figure 1: Just transition cost components



B. Results

India will require more than a trillion dollars over the next three decades to transition its coal mining and thermal power sectors.

The cost of a just transition in India over the next 30 years to systematically phase down operations of the existing coal mines and TPPs by 2050 is estimated to be more than a trillion dollars. These investments will facilitate a smooth shift from coal to renewable energy (RE), ensuring minimal disruption to existing infrastructures and jobs, while maintaining energy access and security and supporting green jobs and growth in the coal-dependent regions.

These investments reflect the cost of closing coal mines with a 1,315 million tonne per annum (MTPA) cumulative production capacity and phasing out 237.2 Gigawatts (GW) of coal-based power capacity. The associated costs of these include rehabilitation and repurposing of 343,504 hectares (ha) of coal mining land, green repowering of 124,789 ha of land available at TPP sites, and transition support for about 5.9 million workers whose income is dependent on or induced by these industries.

However, the cost estimates are conservative. It does not include the investments needed to set up new green energy plants and infrastructure to meet the country's future energy demand, estimated to be in trillions of dollars. In addition, the costs of transitioning industries where coal is directly used, such as in steel and cement sectors, are excluded. Moreover, the cost of just transition will escalate further, as at least till 2030, India will add new TPPs and coal mines to meet the country's increasing energy demand.

Green energy investments, including green repowering of TPPs, are the largest share of just transition costs, accounting for nearly 52% of the total.

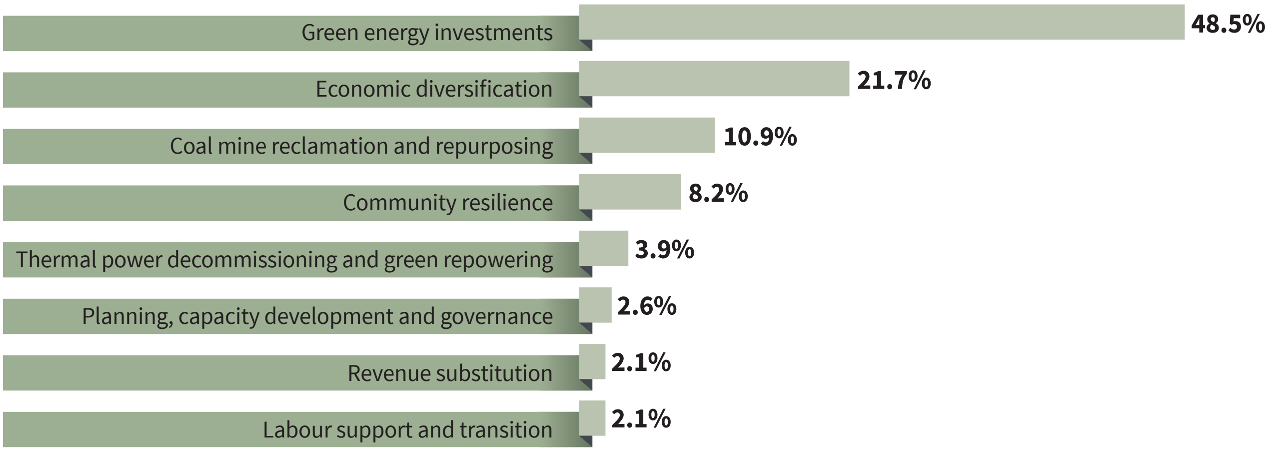
The total cost of a just energy transition can be divided into two components – the 'green energy' costs and the 'non-energy' costs.

The green energy investments are about 52% of the total just transition cost. These include the costs of building green energy plants and repowering existing TPPs to ensure that equivalent energy services are provided compared to the currently operational coal-based TPPs. The costs also include Battery Energy Storage Systems (BESS) and upgradation of the grid.

About 48% of the just transition costs are 'non-energy' related investments, with economic diversification alone accounting for 22% of the total costs.

The non-energy cost is about 48% of the total cost for just transition. These are the costs of ensuring the smooth transition of all impacted workers, supporting green growth and economic vitality in the fossil-fuel-dependent regions and ensuring improved development outcomes. The largest share of non-energy costs is for economic diversification (about 21.7% of the total just transition cost), which will support green growth, create green jobs and help to substitute government revenue.

Figure 2: Share of cost components in total just transition cost



Grants and subsidies, through domestic and international support, will be determining for implementing just transition measures.

The financial requirements for a just transition will be met through private investments and grants and subsidies from public sources. The analysis of just transition costs for India shows that there will be substantial requirements for grants and subsidies from domestic sources and through international support. About 40% of the financial requirement will have to be met through such mechanisms, primarily for the 'non-energy' components. While the financial needs for green energy will be principally met through private sector investments, grants and subsidies would be required for coal mine reclamation and repurposing, economic diversification, community resilience, and labour support.

Table 1: Support requirement through grants and subsidies

Cost components	Total cost ($ billion)	Amount supported through grants and subsidies ($ billion)	Share of the total cost to be supported through grants and subsidies (%)
Green energy investments	504	50	10
Economic diversification	225	87	39
Coal mine reclamation and repurposing	113	110	97
Community resilience	85	85	100
Thermal power decommissioning and green repowering	41	16	39
Planning, capacity building and governance	27	27	100
Labour support and transition	22	22	100
Revenue substitution	22	22	100
Total	**1,039**	**420**	

Overall, the mechanism for just transition financing must be designed in a manner that it does not increase the financial burden of fossil fuel-dependent regions, nor creates a situation where the focus on green energy investments sidelines the need for broad-based development interventions. Also, it is vital to ensure that international support does not enhance the country's debt burden through loans.

DMF and CSR funds are important resources to initiate just transition measures at the district level.

Considering the financial unviability of many of the existing coal mines, and the ageing fleet of TPPs, India is already looking at closing nearly 250 coal mines and decommissioning 224 TPP units over the next ten years. These mines and TPPs are in districts with poor socio-economic conditions. Therefore, investments in just transition measures must start in these districts to minimise social and economic disruptions and hardship in the local communities.

An immediate opportunity is using social welfare funds, such as the District Mineral Foundation (DMF) and Corporate Social Responsibility (CSR) funds, available in these districts. The latest available data (as of March 2023) on DMF funds show that to date (from 2015-16), at least $3.7 billion (₹29,707 crore) has been accrued to DMFs in various coal districts.

Considering that $420 billion will be required through grants and subsidies over the next 30 years, which means that about $15 billion will be required yearly from public funds, resources such as DMF and CSR funds hold much significance. These funds must be used in the best possible way to support transition measures. However, these resources will only be sufficient for initial investments, and new sources of funds will be required for implementing comprehensive transition plans.

International financial mechanisms and institutions will require a re-look to support just transition measures in India and other developing countries.

The quantum of financial requirements for just transition in India clearly shows that international financing will be necessary to implement just transition measures comprehensively. India's Long-Term Low-Carbon Development Strategy (LT-LCDC) rightly recognises this. The deliberations on just and inclusive energy transition financing at the G20 platform under India's Presidency and other multilateral fora also recognise the need for international funding.

However, current just transition financing mechanisms for developing countries must be reconsidered to render such support. The Just Energy Transition Partnerships (JET-P) forged by the developed countries (the International Partners Group) will not be able to support a just transition in India because the size of these deals and their grant component is relatively small compared to the requirements. Therefore, international financial support will need to be more ambitious, increase the scope of providing grants and concessional loans, and create enabling environments for private investments. Similarly, multilateral institutions and banks should raise their commitment to financing just transition measures alongside energy transition.

01

Introduction

India's Long-Term Low-Carbon Development Strategy (LT-LCDC), presented to the United Nations Framework Convention on Climate Change (UNFCCC) at COP27 in 2022, highlights the need for significant financial resources to decarbonise the country's electricity sector in a just and equitable manner.[1] The strategy mentions that financial resources will be required to install renewable power plants, upgrade the transmission grid, and introduce energy storage systems. It also elaborates on the resource requirements to support a just transition of workers and communities, which includes investments in social and physical infrastructure, ecological restoration of affected areas, building capabilities of the local community to adapt to the transition, and creating new livelihood opportunities.[2] But the strategy has not mentioned the financial resources required for a "just and equitable" decarbonisation of India's electricity sector. Therefore, the crucial question is, what is the cost of just energy transition in India?

Since India announced its pledge to reach net zero by 2070, several reports have been published on net zero pathways, primarily from the perspective of technology and policy options.[3] Some studies have also estimated investments required to achieve a net zero target by 2070.[4] However, the cost of just energy transition in India has not been estimated until now. This study is the first attempt to calculate the cost of a just energy transition for India.

The study focuses on the coal mining and coal-based thermal power plants (TPPs), which are the mainstay of India's energy sector and key sectors from an energy transition perspective. Currently, coal accounts for about 55% of India's commercial energy requirements[5] and coal-based TPPs produce more than 70% of electricity[6]. Besides, these two sectors employ a large number of workers directly and indirectly in various districts of India and also play a significant role in the growth and development of these districts.

Furthermore, these two sectors also require immediate attention, given that many economically unviable and end-of-life mines and old TPPs are primed for closure (see Box 1). A just transition of these old mines and TPPs can be a win-win for the industry, labour, and dependent communities.[7] Considering the centrality of coal to India's energy security, planning and investments in just transition measures for coal-dependent regions need to start now so that the energy transition process can be strategised and the net zero target can be achieved with the least disruption.

Our study has adopted a novel approach to estimate the financial requirements for a just energy transition. The data used for developing the cost factors is based on the primary survey of four major coal districts of India, which include Ramgarh and Bokaro districts of Jharkhand, Korba district of Chhattisgarh and Angul district of Odisha. In addition, a detailed review of the just transition investment plans of three major coal/lignite regions outside India (Mpumalanga province in South Africa, Lusatian lignite mining area in Brandenburg, Germany, and Silesia voivodeship in Poland) has been done to develop an understanding of the just transition costs.

The financial requirements have been categorised under investments (made by the private and public sectors) and grants and subsidies (provided from public sources, both domestic and international) needed to support just transition measures and achieve the "long-term goals of eradicating poverty, increasing employment and income opportunities, increasing climate resilience, and reaching a new level of prosperity in the pathway towards a net zero economy"[8].

The methodology and costs outlined in the report are intended to inform policy and financing decisions for a just energy transition of India's coal mining and coal-based power sectors. The observations are context-specific and should not be directly applied to other regions of the world without appropriate "localisation".

Assessing financial requirements is key to implementing a realistic just transition plan. To begin with, it provides an idea about the quantum of the funds needed and the possible sources of funds – investments or grants and subsidies. Secondly, it enables policymakers and businesses to identify the areas where investments should be prioritised and how they should be allocated. Thirdly, it will help obtain the required funding and support from the government, investors, multilateral and bilateral agencies, and other stakeholders. Finally, it facilitates informed discussions around the just transition partnerships between developed and developing countries at multilateral platforms like the UNFCCC. We hope this report will provide a solid reference point for an informed discussion on just transition financing in India and worldwide.

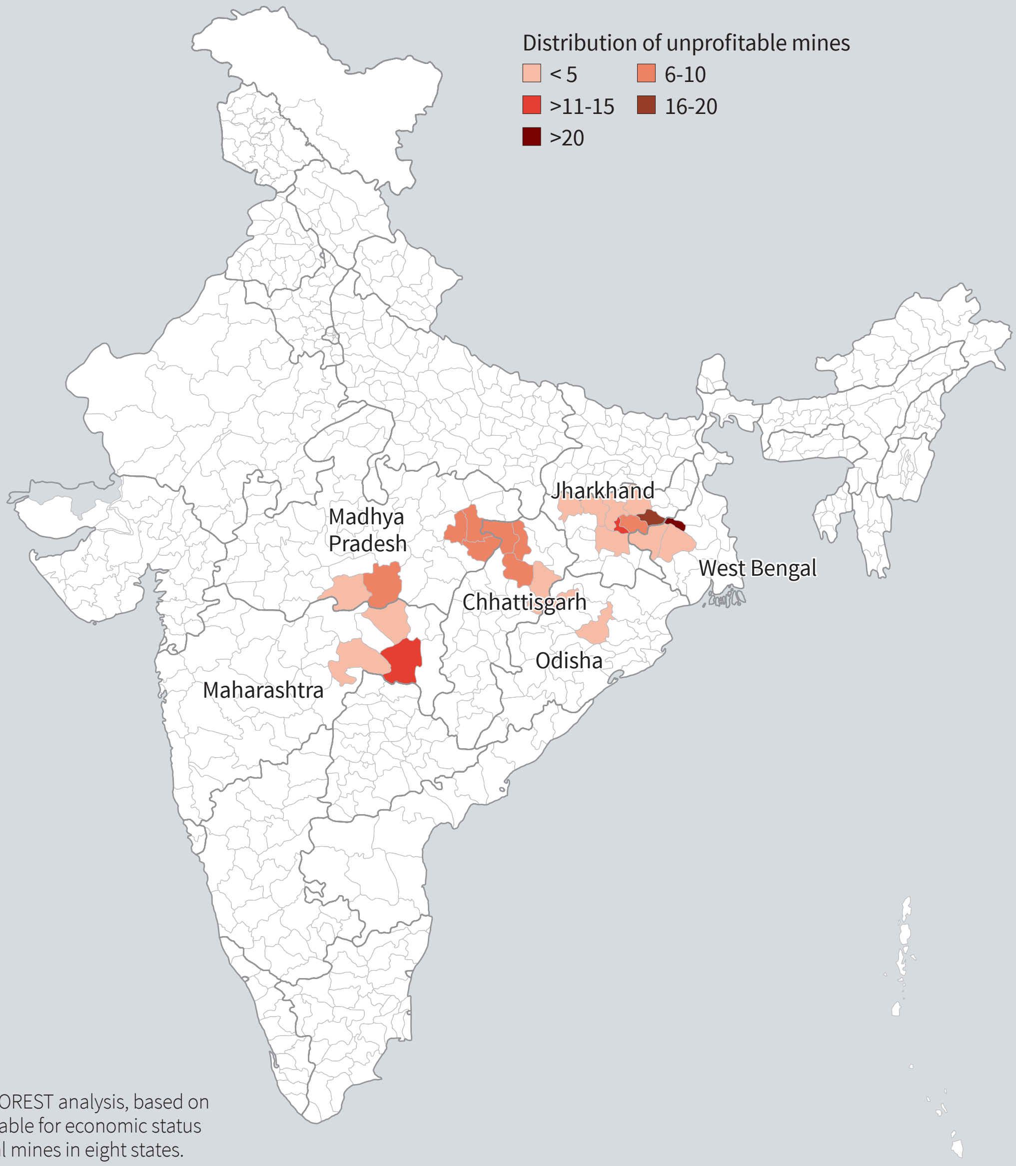
Box 1: Old and unprofitable coal mines and TPPs

Presently, there are 417 operational coal and lignite mines in India — 226 opencast (OC), 156 underground (UG) and 35 mixed operations mines.[9] In 2021-22, these mines produced over 778 million tonnes (MT) of coal and 47.5 MT of lignite.[10]

However, a large proportion of coal and lignite production is concentrated in a few districts and mines. Only 12 districts (in 9 states) accounted for 72% of the coal and lignite production in 2021-2022. The biggest coal-producing district was Madhya Pradesh's Singrauli (120 MT production), followed by Chhattisgarh's Korba (113 MT) and Odisha's Angul (96.7 MT).[11] These three districts alone produced 42% of India's coal.[12] Overall, 37 large coal mines (only 9% of the total mines) produced about 70% of the country's coal.[13] Conversely, 91% of the remaining mines produced only 30% of the total coal.

The above statistics clearly show that most mines are small and produce very little coal; many are also unprofitable. The information available for 293 currently operating mines shows that at least 188 are unprofitable. In other words, 64% of mines for which data is available are unprofitable. Of these, 120 are UG, 52 are OC, and 16 are mixed operations.[14] These small, low-producing, and unprofitable mines are primed for closure. But there are a large number of workers and communities dependent on these mines. Therefore, these mines and the regions where they are located must start preparing for the transition.

Map 1.1: Districts with distribution of unprofitable mines



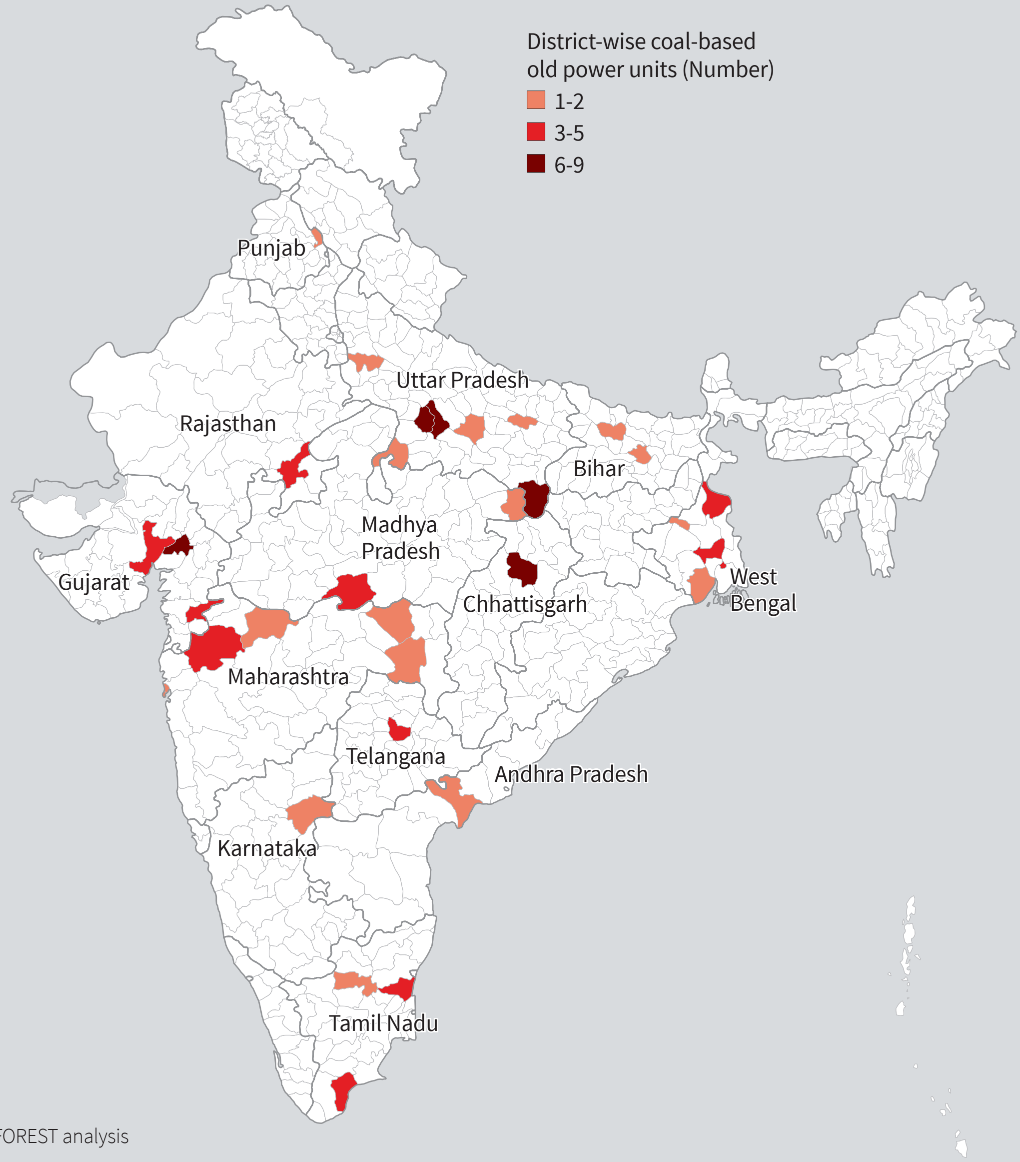
Source: iFOREST analysis, based on data available for economic status of 293 coal mines in eight states.

Table 1.1: Unprofitable coal mines

State	Total mines	Unprofitable mines*				Profitable mines	Data not found
		Total	Open cast	Under ground	Mixed		
Jharkhand	107	55	29	15	11	35	17
West Bengal	72	48	4	42	2	15	9
Chhattisgarh	49	31	5	24	2	9	9
Madhya Pradesh	52	30	3	26	1	8	14
Maharashtra	50	21	11	10	0	20	9
Odisha	22	3	0	3		15	4
Uttar Pradesh	3	0	0	0	0	3	0
Telangana	43						43
Assam	1						1
Total	**399**	**188**	**52**	**120**	**16**	**105**	**106**

Source: Ministry of Coal, Government of India, December 2022.
*Unprofitability status as per RTI responses from the CIL subsidiaries, as of August-September 2022
** Mines for which data were unavailable include 39 private and non-CIL public-sector operations such as NTPC mines.

Map 1.2: District-wise distribution of old power plants (units)



Source: iFOREST analysis

For the coal-based power sector, which is the largest consumer of coal, there are also immediate transition challenges. India has 634 operational coal-based power units with a total capacity of 237.16 Gigawatts (GW) located across 17 states. In terms of installed capacity, over 50% of the country's capacity is concentrated in only 21 districts in 11 states. Singrauli (also the biggest coal producing district) has the highest installed capacity of 10,040 Megawatt (MW), followed by Gujarat's Kutch district (9,020 MW). Other key TPP districts include Raigarh (Chhattisgarh), Nagpur and Chandrapur (Maharashtra), which are also big coal mining districts.

The coal-based TPP fleet in India is relatively young, with over three-fourths of the existing capacity being under 20 years of age. However, the country is inching towards a large-scale decommissioning of power plants in the coming years.[15]

A unit-wise assessment of the country's operational power plants shows that if an average design life of 25 years is considered, 52.5 GW of capacity across 224 units will reach that age by 2030 and hence can be retired. In fact, by 2040, over 67% of the current capacity (159 GW capacity across) will be over 25 years old.[16] Besides, over 169 coal power units have already been retired, including 126 units since 2016.[17]

Table 1.2: Vintage of India's Thermal Power Plants

States	Units to be decommissioned (Nos.)				Capacity to be decommissioned (MW)				Total	
	By 2030	By 2040	By 2050	Beyond 2050	By 2030	By 2040	By 2050	Beyond 2050	Units (Nos.)	Capacity (MW)
Andhra Pradesh	10	17	6		2,680	6,470	4,040		32	13,190
Assam		1	2			250	500		3	750
Bihar	8	6	12		1,270	3,015	5,405		26	9,690
Chhattisgarh	10	37	14		2,940	14,563	6,015		61	23,518
Gujarat	21	22	3		3,647	11,145	1,300		46	16,092
Haryana	3	9			710	4,620			12	5,330
Jharkhand	5	8	7		870	3,090	4,880		20	8,840
Karnataka	9	7	6		1,730	3,050	4,700		22	9,480
Madhya Pradesh	16	24	10		3,930	11,935	6,085		50	21,950
Maharashtra	18	41	14		5,020	14,006	6,600		73	25,626
Odisha	8	7	4	2	3,420	3,450	2,470	1320	21	10,660
Punjab	6	6	3		1,260	3,220	1,200		15	5,680
Rajasthan	11	22	3		2,295	5,545	1,980		36	9,820
Tamil Nadu	22	14	11		4,660	6,300	7,240		47	18,200
Telangana	10	3	13		3,162.5	1,600	8,410		26	13,172.5
Uttar Pradesh	37	29	21		9,169	7,620	13,540		87	30,329
West Bengal	30	20	6		5,745	7,020	2,072		56	14,837
Total	**224**	**273**	**135**	**2**	**52,508.5**	**106,899**	**76,437**	**1320**	**634**	**237,164.5**

Source: iFOREST analysis based on data obtained from the Central Electricity Authority, 2023

Therefore, the financial viability of many coal mines and the vintage of numerous TPP units indicates that as many as 250 coal mines and 224 TPP units might be closed by 2030. Considering the scale of these closures over the next ten years, it is essential to start planning for a just transition, including estimating the financial resources required for the transition.

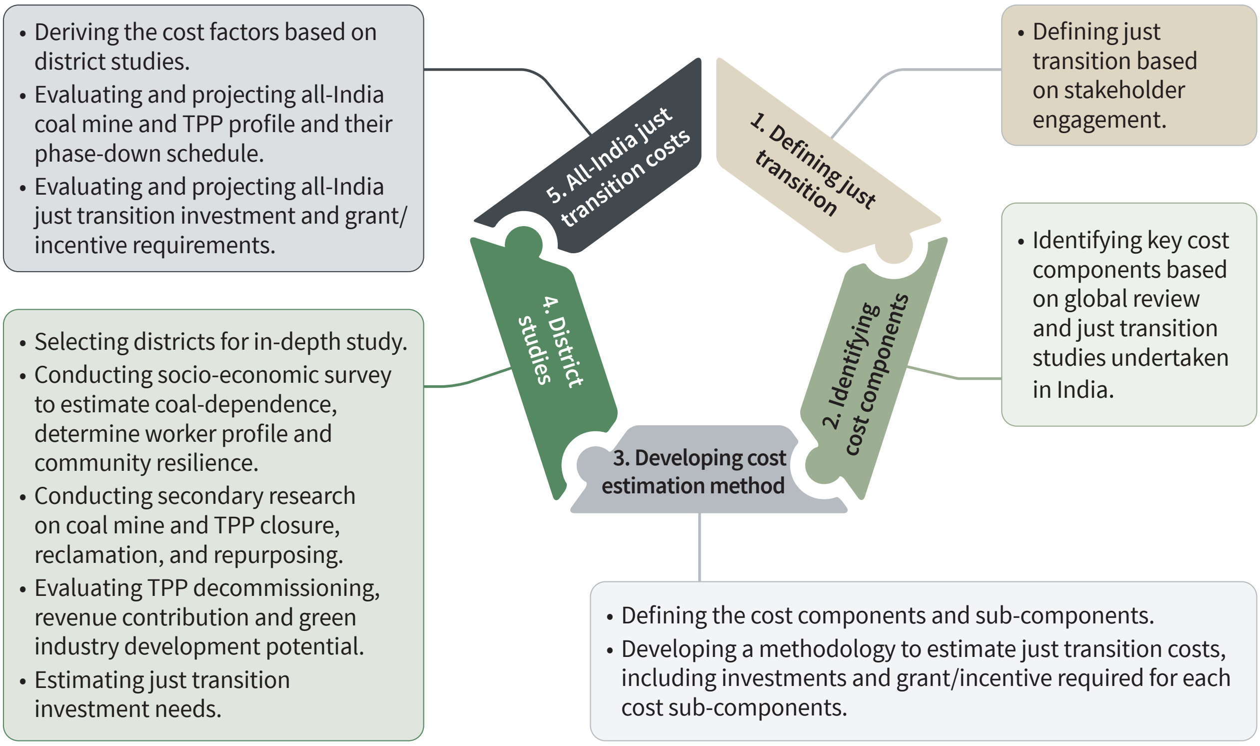
02

Methodology

The costs of a just transition are highly place and context-specific. The costs vary as per the techno-economic aspects of the fossil fuel industries, the scale and conditions of direct, indirect and induced workers, the social, economic and environmental conditions of the region, and the region's potential for economic diversification and investments, among others. Therefore, it is crucial to consider the realities of a fossil fuel region while developing a just transition investment plan.

The current study has developed an empirical approach to provide a realistic estimate of the costs associated with the just transition of India's coal mining and coal-based power sectors. The methodology involves primary and secondary research, stakeholder consultation and statistical analysis. The five-step process of estimating the cost of a just transition is outlined in Figure 2.1. The details of each step are outlined in the subsequent sub-sections.

Figure 2.1: Steps for estimating just energy transition costs



2.1 Defining just transition

To cost a just transition, the first step is to define it. For the purpose of estimating the cost of a just energy transition in India, specifically for the coal-dependent regions, the study has adopted the following outcome-oriented definition based on extensive stakeholder consultations:

A just energy transition is a development intervention to achieve the following outcomes:

i. Builds a resilient green economy to meet the net zero target by developing new green businesses and by supporting fossil-fuel dependent businesses to shift to green energy and industry;

ii. Improves the social, economic, and environmental resilience of coal-dependent regions, including from climate change impacts;

iii. Supports workers and communities affected by the fossil-fuel phase-down in a manner that they are better off than before;

iv. Enhances energy security and access by at least substituting the existing fossil-fuel dependent energy generation systems with equivalent green energy; and,

v. Ensures an inclusive process by including all stakeholders, especially affected workers and communities, in the decision-making."

Investments would be needed in every aspect of the economy to achieve the outcomes mentioned above. The investment needs for specific outcomes are outlined below in Table 2.1.

It is to be noted that while some of the investments will help to achieve multiple outcomes, for the sake of simplicity, investments have been put under one specific outcome, which is the most significant one related to it. For instance, coal mine repurposing will help build a resilient green economy, improve social and economic resilience, and enhance energy security by installing renewable energy (RE) plants on the reclaimed mining land. However, coal mine repurposing has been placed against the outcome of 'build resilient green economy' as it is the most significant outcome of such investment and for simplification.

Table 2.1: Outcomes and investment needs for a just transition

S.N.	Outcomes	Investment needs
1	Build a resilient green economy to meet the net zero target, by developing new green businesses and by supporting fossil fuel-dependent businesses to shift to green energy and green industries.	a. Repurposing of coal mines. b. Development of green industries on reclaimed coal mine land. c. Repowering of TPP sites. d. Compensation to coal mining companies for early closure. e. Compensation to TPP owners for early closure. f. Business support for economic diversification in regions to be impacted by the energy transition.
2	Improve the social, economic, and environmental resilience of fossil fuel-dependent regions to energy transition and biophysical impacts of climate change.	a. Maintaining and enhancing social infrastructure. b. Building new physical and digital infrastructure. c. Creating and enhancing climate-resilient livelihood opportunities. d. Substituting revenue, including taxes, royalty, cess paying by the industries. e. Environmental remediation of coal mines and TPP sites.
3	Support workers and communities affected by the fossil fuel phase-down in a manner that they are better-off than before.	a. Skilling and workforce development for a green economy. b. Reskilling of existing workers. c. Compensation packages to formal workers, such as severance pay, voluntary retirement scheme (VRS), etc. d. Compensation to informal workers. e. Transition support for induced workers.
4	Enhance energy security and access by at least substituting the existing fossil fuel-dependent energy generation systems with equivalent green energy.	a. Developing and augmenting green energy infrastructure. b. Upgrading the transmission and distribution systems. c. Providing energy price support to industries and communities.
5	Ensure an inclusive decision-making process by including all stakeholders, especially affected workers and the local communities, including women and youth.	a. Building technical and administrative capacity of the state and the local government(s). b. Strengthening communication and outreach mechanisms. c. Building capacity of stakeholders.

Source: iFOREST analysis

2.2 Identifying cost components

A just transition of a coal-dependent economy/region entails a set of activities and outputs to achieve the intended outcomes. The investments needed for these activities and outputs can be grouped into broad cost components.

The cost components were developed after a detailed review of the just transition investment plans of three coal regions of the world.[18]

i. The Just Energy Transition Investment Plan (JET IP) of South Africa for 2023-27, which aims to retire about 30% of the coal-based power capacity and reduce the coal use in electricity generation by about 30% by 2027. The plan particularly focuses on the Mpumalanga province, which has the highest coal dependence.

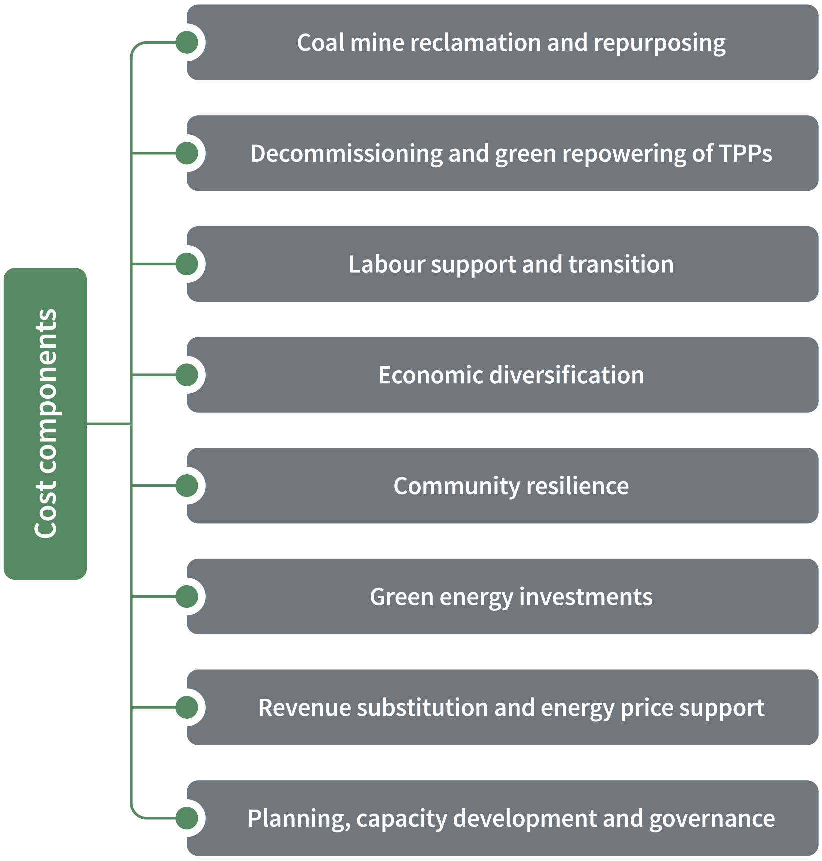
ii. The Territorial Just Transition Plan (TJTP) of the Lusatian lignite mining area in the state of Brandenburg, Germany for 2021-2027, which aims to retire about 50% of the coal-based power capacity and reduce 37% of the lignite production by 2027.

iii. The TJTP of Silesia voivodeship (province), Poland for 2021-27, covering the Upper Silesia coal basin, which aims to retire about 75% of the coal-based power capacity and reduce about 23% of the coal production by 2027.

The understanding of the cost components from the above-mentioned global examples was supplemented by just transition studies undertaken by iFOREST in some of the major coal-dependent districts of India, including Bokaro and Ramgarh in Jharkhand,[19] Korba in Chhattisgarh,[20] and Angul in Odisha.[21]

Based on the above approach, eight key cost components have been identified for estimating the just transition costs for India's coal mining and coal-based power sectors, as outlined in Figure 2.2.

Figure 2.2: Cost components for a just transition



Source: iFOREST analysis

2.3 Defining the cost components

Defining the cost components and developing a rigorous method for estimating the costs associated with each component is crucial to ensure that the costs are verifiable and replicable. The following approach has been used to develop the method:

i. Each cost component has been further split into subcomponents for the precision of cost estimation.

ii. Each cost component and corresponding subcomponent has been defined to establish the boundaries for cost estimation.

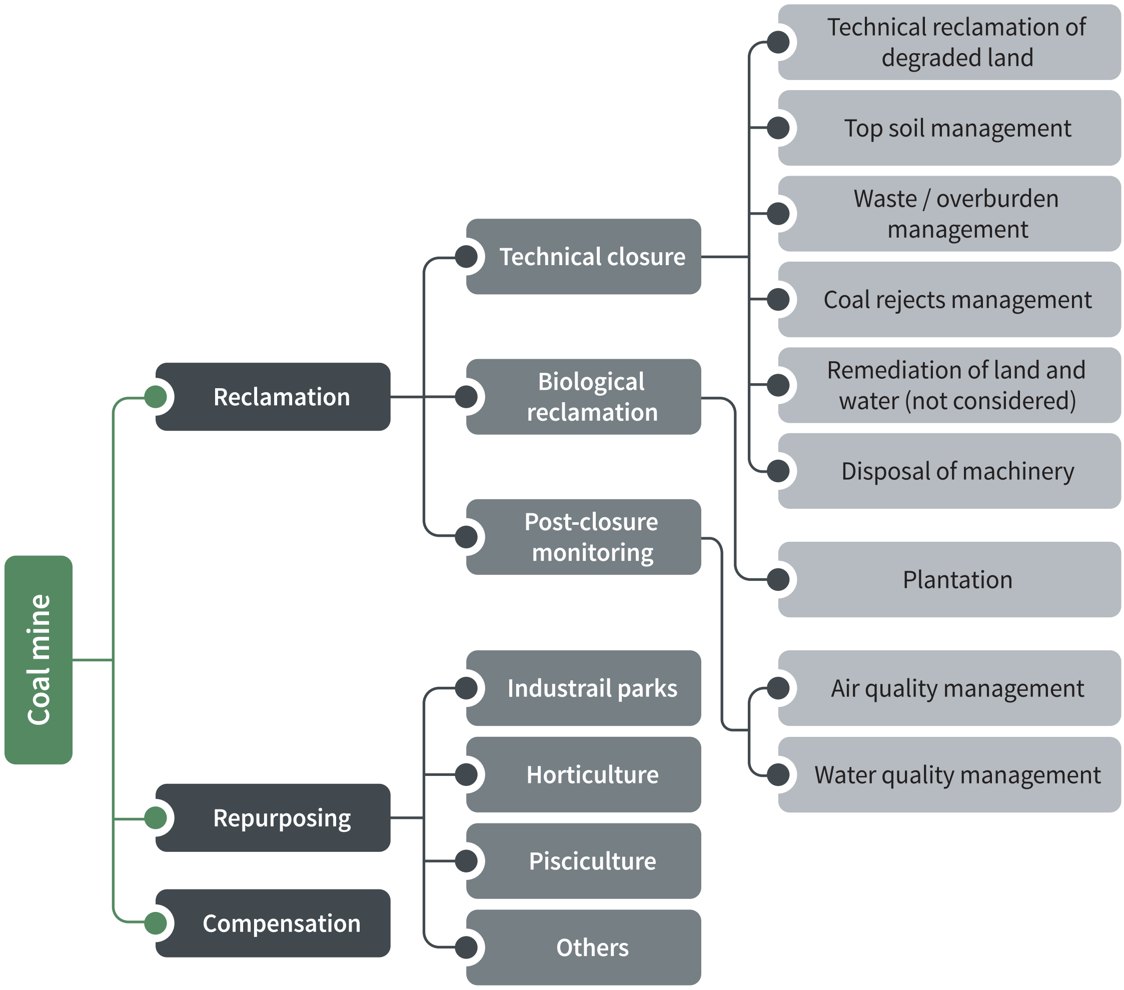
iii. Finally, a methodology was developed to estimate the investment requirements for each subcomponent.

The following section comprehensively explains the definitions and methods used for cost estimation.

2.3.1 Coal mine reclamation and repurposing

Reclamation and repurposing of coal mining land can play a significant role in building a green economy in coal-dependent regions. The definitions and the methodology for estimating respective costs are outlined below.

Figure 2.3: Costs for coal mine reclamation and repurposing



Source: iFOREST analysis

a. Reclamation: Reclamation of coal mines is a complex and multi-step process aimed at restoring the environmental and ecological conditions of the mined-out area and enabling post-mining land use for economic activities as appropriate.[22] It includes the following set of interventions.

i. Technical closure of mine: This refers to the scientific closure of a coal mine site through the following set of activities:

- Waste/overburden management;
- Coal rejects management;
- Topsoil management;
- Environmental remediation;
- Disposal of infrastructure and machinery; and,
- Reclamation of the mined-out land.

ii. Biological reclamation: This is a type of land reclamation under which the degraded coal mine land is modified to an ecologically functional state and entails activities such as the plantation of suitable species on the designated reclaimed area and the creation of an aquatic ecosystem in the mining void.

iii. Post-closure monitoring: This accounts for the monitoring and managing environmental parameters of air, water and noise for a specific period identified by relevant laws/regulations. In India, the period for post-closure monitoring is three years.

b. Repurposing: Repurposing of coal mining land refers to interventions that are necessary, in addition to technical mine closure, to prepare the land for social and economic use, such as the development of infrastructure (roads, electricity line, water supply etc.), industrial park, horticulture, pisciculture, etc. However, it excludes the cost of setting up the new business on the land (such as investments in renewable energy projects, setting up of a factory etc.).

c. Compensation: The closure of a coal mine before the end of its useful life entails financial payouts to the company(ies) to cover the outstanding liability and foregone profits over the remaining period of its useful life.

Besides the above costs, labour and community transition is also an important component of coal mine closure that is gaining attention worldwide.[23] The interventions necessary for labour and community transition are outlined separately as dedicated cost components of labour support, economic diversification, and community resilience.

The methodology used for estimating the costs of coal mine reclamation and repurposing is given in Table 2.2.

Table 2.2: Methodology for estimating coal mine reclamation and repurposing costs

Cost components	Methodology	Information source
Coal mine reclamation	i. The reclamation cost has been considered as a direct cost of just transition as the current mine closure plan and closure practices do not leave the post-mining land in a status that can be readily repurposed. The costs of closure have been estimated for an optimum closure practice to maximise repurposing potential (availability of maximum usable surface). ii. Closure costs for mines depend on mine type, geological and geophysical characteristics of the deposit, mining plan and final closure plan. Considering this, the opencast (OC) mines have been categorised into six categories according to their stripping ratio, gradient, number and thickness of seams, and the volume of external dump. The six categories of mines is assumed to cover all the OC mines in India. No such categorisation has been done for the underground (UG) mines due to limitation of data. iii. The six categories that OC mines have been categorised into, include the following: 1. Shallow depth deposit with low gradient seams and low stripping ratio; 2. Moderate depth deposit with low gradient seams and high stripping ratio; 3. Large depth deposit with low gradient and thick seams; 4. High gradient deposits with external dumping; 5. Large depth deposit with multiple seams; and, 6. Moderate gradient, moderate depth deposit with moderate stripping ratio. iv. The closure cost for each of the six categories of open cast mines and for the underground mine has been estimated. **Cost estimation** i. A sample size of at least 5 mines were considered in each of the six categories to estimate the cost of various activities related to technical and biological closure. A total of 50 mines were analysed to develop the cost factors for OC mine reclamation. ii. A total of 15 mines were analysed to develop the cost factors for UG mine reclamation.	Mine related information are obtained from the following sources: i. The operational status of mines including production, are obtained from the coal companies. ii. Geological reserves, estimated mine life, volume of external and internal overburden dumps, post mine land use plan, etc., have been obtained from the environmental impact assessment (EIA) reports, mine plans, final closure plans, and environmental clearance (EC) related documents. iii. In absence of information regarding key parameters, such as the height of external and internal overburden dumps, suitable estimations are done by evaluating the Director General of Mines Safety (DGMS) guidelines, industry standards and approximate estimate of similar mines. **Closure cost rates** The cost rates has been determined by considering the following: i. Average cost rates for each activity for six OC mine categories and the UG mines have been determined through review of mine closure plans and progressive mine closure audit reports.

Table 2.2 continued

Cost components	Methodology	Information source
	iii. Based on the cost factors (as derived) for each activity, the total cost of closing a mine to a state fit for repurposing has been calculated (i.e., the void left after mining is filled by rehandling the wastes from external overburden dumps and internal overburden dumps). iv. For UG mines, cost factors for mine closure are determined and applied on costs per hectare (ha) of lease area basis.	ii. Expert consultations with subsidiaries of Coal India Limited (CIL), Central Mine Planning and Design Institute (CMPDI), and private companies, such as Tata Steel to validate the costs.
Coal mine repurposing	i. Based on the feedback received from the coal companies, trade unions and the local communities from Jharkhand, Odisha and Chhattisgarh, the post-mining land can be most suitably used for economic activities, such as setting up solar plants, development of industrial parks, horticulture, and pisciculture. ii. For this, the final mine closure must ensure maximum amount of reusable land through proper closure activities and levelling of land (as discussed in coal mine reclamation). **Cost estimation** i. The total mine lease area has been considered as the post-mining land to be available for repurposing. ii. The land available has been divided equally for setting up solar plants, industrial parks, and horticulture. The water bodies left as voids are considered for pisciculture. iii. The land area available for each of the activities has been multiplied by corresponding cost factors. These cost factors have been determined by taking the average cost of such investments in coal states/ districts. iv. This cost does not include the cost of setting up the new business on the land (such as investments in solar projects or the cost of factories in the industrial parks).	i. The cost of setting-up industrial parks is the average cost of five recent industrial parks developed/planned in Jharkhand. These include, Mega Food Park, Getalsud in Ranchi, Silk Park in Ranchi, Auto Park in Adityapur, Pharma Park in Ranchi, and Electronics Park in Adityapur. ii. The cost of horticulture and pisciculture has been take from the Department of Agriculture, Animal Husbandry and Co-operative, Government of Jharkhand,[24] and National Horticulture Board.[25]
Incentive for coal mine reclamation and repurposing	i. As per the coal mine closure guidelines,[26] coal companies are required to put a certain amount in an escrow account for securing the costs of closure in case the mine owner fails to complete the relevant closure activities. The amount to be escrowed for an OC mine and an UG mine are ₹9 lakhs ($11,250) per ha and ₹1.5 lakhs ($1,875) per ha of the leasehold area, respectively. However, the actual cost of mine reclamation to maximise repurposing potential is estimated to be at least 10 times higher than the escrowed amount (see Chapter 4). Therefore, public funds will be required to achieve proper closure and reclamation. ii. To attract investments on post-mining land, financial incentives will be necessary from the government. **Cost estimation** i. The incentive for the mine reclamation is the difference between the mine reclamation cost and the escrowed amount. ii. For land repurposing, typical financial incentives provided by the state governments of Jharkhand, Odisha, and Chhattisgarh for promoting industries has been considered from the state industry policies and renewable energy (RE) policies.	i. Mine reclamation cost is estimated by iFOREST for six categories of OC mines and for the UG mines. ii. State policies, such as the Jharkhand Industrial Promotion Policy 2021,[27] Odisha Renewable Energy Policy 2022,[28] and Industrial Policy 2019-2024, Government of Chhattisgarh.[29]

Table 2.2 continued

Cost components	Methodology	Information source
Compensation to coal mines for early closure	i. Compensation should be paid to coal mine owners in scenarios where a mine is being closed before the end of its economic life or prior to end of the mine lease. ii. The compensation amount for capacity 'buy-out' varies across countries, depending on the negotiation between government and companies. However, largely the compensation to be paid to mine owners needs to account for the profits foregone and the remaining liability of the mine. iii. For the purpose of this study, it has been assumed that all the coal mines will be closed by 2050. While this is a very ambitious goal, it has been assumed so to meet the net zero target by 2050. **Cost estimation** i. A cost factor has been developed to account for the profits foregone and the remaining liability of the mines based on a sample of coal mines from Korba, Angul, Ramgarh and Bokaro coal fields. ii. The compensation is equal to the average compensation cost factor per tonne of coal in these four districts multiplied by the amount of coal that will be left unmined in the existing and upcoming coal mines in 2050.	i. Data for coal mines are from four district-level studies done by iFORESTin Ramgarh[30] and Bokaro[31] districts of Jharkhand, Korba district of Chhattisgarh,[32] and Angul district of Odisha.[33]

Source: iFOREST analysis

2.3.2 Decommissioning and green repowering of TPPs

Decommissioning a coal-based TPP entails several technical, environmental, social, and economic interventions to ensure that the closed power plant site is fully remediated, the workforce and impacted communities are compensated for their losses, and new economic opportunities and environmental outcomes are created for communities to benefit from. The following interventions are necessary to achieve these outcomes:

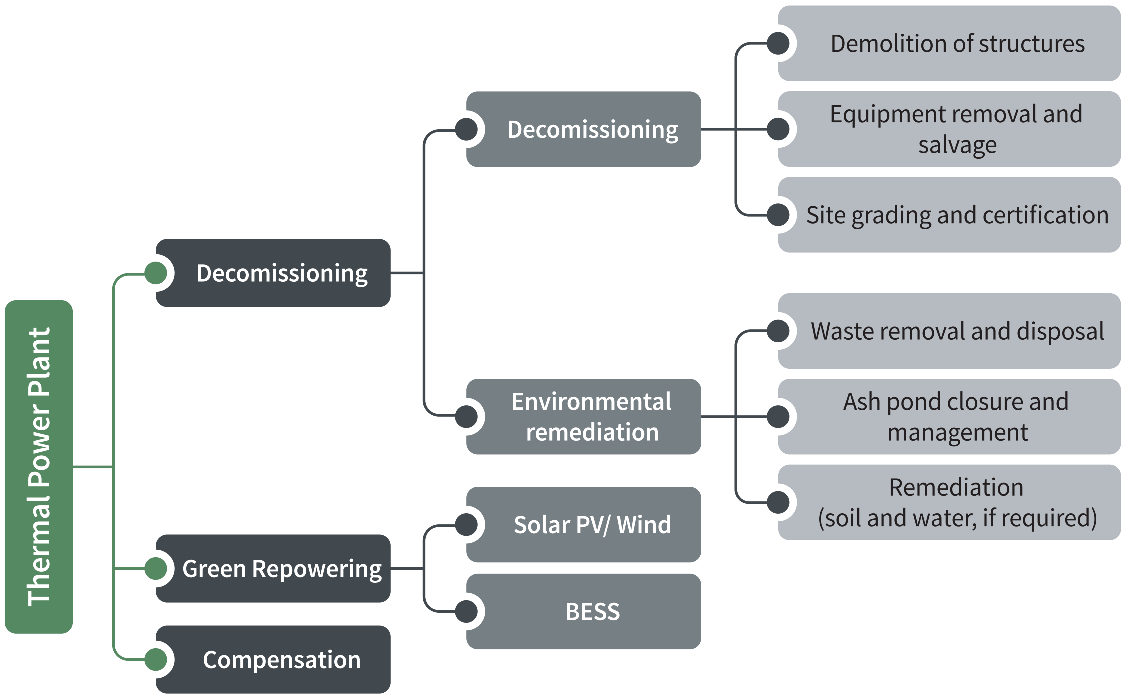
a. **Closure, demolition, and remediation:** This refers to interventions pertaining to the demolition of structures, removal of equipment and salvage and remediation of the site, including remediation of contaminated areas, particularly the ash handling area.

b. **Green repowering:** This is repowering the plant site with RE and Battery Energy Storage Systems (BESS).

c. **Compensation:** The closure of power plants before the end of life would require financial payouts to the owner companies to cover the return on equity, interest on the capital loan and depreciation costs over the remaining period of the useful life.

d. **Labour and community transition:** These have been considered separately as dedicated cost factors under labour support, economic diversification, and community resilience.

Figure 2.4: Costs for decommissioning and green repowering of thermal power plants



Source: iFOREST analysis

The methodology for estimating the costs for decommissioning and green repowering of TPPs is given in Table 2.3.

Table 2.3: Methodology for estimating decommissioning and green repowering costs

Cost components	Methodology	Information/ data source
Decommissioning TPPs	i. The cost of decommissioning a TPP includes power plant demolition, management of waste (including toxic & hazardous) as per environmental regulations, and remediation of land and water bodies. ii. There are multiple factors that can influence decommissioning costs, such as the extent of existing environmental degradation, particularly the state of ash pond, and the subsequent use of the power plant site, where the costs are lower in case the plant is planned to be repurposed using an alternate greener fuel (say biomass).	i. The cost of decommissioning of TPPs in the US are considered as per the Decommissioning Handbook for Coal-Fired Power Plants published by the Electric Power Research Institute, United States of America (USA).[34]

Table 2.3 continued

<table>
<tr><th>Cost components</th><th>Methodology</th><th>Information/ data source</th></tr>
<tr><td></td><td>In general, it is appropriate to assume the costs of decommissioning is directly proportional to the plant size, as a larger effort and investment is required for power plants with higher installed capacity.

Cost estimation
i. Actual decommissioning costs for five coal-based TPPs were considered for developing the cost factors based on vintage. The sample included two TPPs in the US (Watts Bar Fossil and Port Washington power plant), two in India (National Thermal Power Corporation's Badarpur Thermal Power Station and Guru Nanak Dev Thermal Plant, Bathinda), and one in South Africa (ESCOM's Komati Thermal Power Plant).
ii. The cost factors were multiplied with capacities to arrive at the decommissioning cost of the existing fleet by 2050.</td><td>ii. The cost of decommissioning of TPPs in India are based on iFOREST research on 'just transition of coal-based power plants in India.[35]
iii. The cost of decommissioning of power plant in South Africa is taken as the estimated cost mentioned in the Project Information Document related to the Komati Power Station shutdown and dismantling (2022).[36]</td></tr>
<tr><td>Repowering of power plant sites</td><td>i. Repowering through RE and BESS is the most cost-effective and convenient options for repurposing of the TPP site.
ii. It is assumed that up to two-third of the TPP area can be used for green energy projects, such as for RE generation (solar and wind) and BESS. The rest can be used by the community.

Cost estimation
i. For determining the cost of green energy investments, it is considered that for 1 Megawatt (MW) of solar 5 acres of land is required.
ii. For every 1 MW of solar installed, 3.25 Megawatt-hour (MWh) of battery storage is also installed to deliver same services as a coal-based power plant operating at 60-65% plant load factor (PLF), the average PLF of TPPs in India.
iii. The cost of Solar Photovoltaic (PV) and battery is assumed to be as follows:
<table>
<tr><th></th><th>2022-2030</th><th>2030-2040</th><th>2040-2050</th></tr>
<tr><td>Solar PV (₹ Cr./MW)</td><td>4</td><td>3</td><td>3</td></tr>
<tr><td>BESS (₹ Cr./MWh)</td><td>1</td><td>0.75</td><td>0.6</td></tr>
</table>
iv. The total RE and the total storage to be installed at the plant site has been multiplied by respective cost factors (as ₹ Crore/MW and ₹ Crore/ MWh) to determine the total repowering cost.</td><td>i. Solar PV and BESS prices from iFOREST study on cost of RE in Angul, Odisha.[37]</td></tr>
<tr><td>Incentive for TPP decommissioning and repowering</td><td>i. There is no financial provision for the decommissioning of TPPs. TPPs are allowed to depreciate for 90% of their value and the remaining 10% is assumed to be the value of the salvage, which can be sold and used for decommissioning. However, studies across the world shows that the value of scrap is not sufficient to pay for the cost of decommissioning. Therefore, public funds will be required to achieve proper decommissioning.
ii. For repowering based on RE and BESS, state and central government incentives will be required.</td><td>i. Incentive for decommissioning based on the study of two TPPs in India -- Badarpur Thermal Power Station (TPS) and Guru Nanak Dev Thermal Plant, Bathinda – and Komati Power Station, South Africa.</td></tr>
</table>

Table 2.3 continued

Cost components	Methodology	Information/ data source
	Cost estimation i. The incentive for decommissioning is the difference between the cost of decommissioning and the value of salvage. ii. For repowering, the financial incentives provided by the state governments of Jharkhand and Odisha for RE has been considered.	ii. Incentive for repowering assumed to be same as the incentives given for renewable energy under the Odisha Renewable Energy Policy 2022[38] and Jharkhand State Solar Policy 2022.[39]
Compensation to power plant owners for early closure	i. Compensation should be paid to power plant owners in scenarios where a TPP unit is being closed before the end of its economic life or prior to termination of the power purchase agreement. ii. The compensation amount for capacity 'buy-out' varies across countries, depending on the negotiation between government and companies. However, largely the compensation to be paid to plant owners needs to account for the profits foregone and the remaining liability of the plant. **Cost estimation** i. The compensation is determined as ₹ Crore/MW for each year of remaining economic life of the power plant. ii. The amount to be paid is equivalent to the present values of return on equity, interest on the capital loan and depreciation costs. iii. The estimated compensation amount considered is based on Council on Energy, Environment and Water's (CEEW) detailed study of tariff orders of 130 TPPs in India. iv. It is considered that only plants with remaining life lower than 35 years in 2050 will require compensation. This is considering that going forward TPPs in India will typically retire at an age of 35 years with simultaneous growth in reliable and affordable clean energy.	i. The per MW compensation for decommissioning a power plant is based on the report published by the CEEW on the costs of early decommissioning of power plants in India.[40] ii. For estimating the number of TPPs to be compensated in 2050 and the remaining life of these power plants in 2050, the Central Electricity Authority (CEA) database of existing and upcoming thermal power plants was used (as of December 2022).[41]

Source: iFOREST analysis

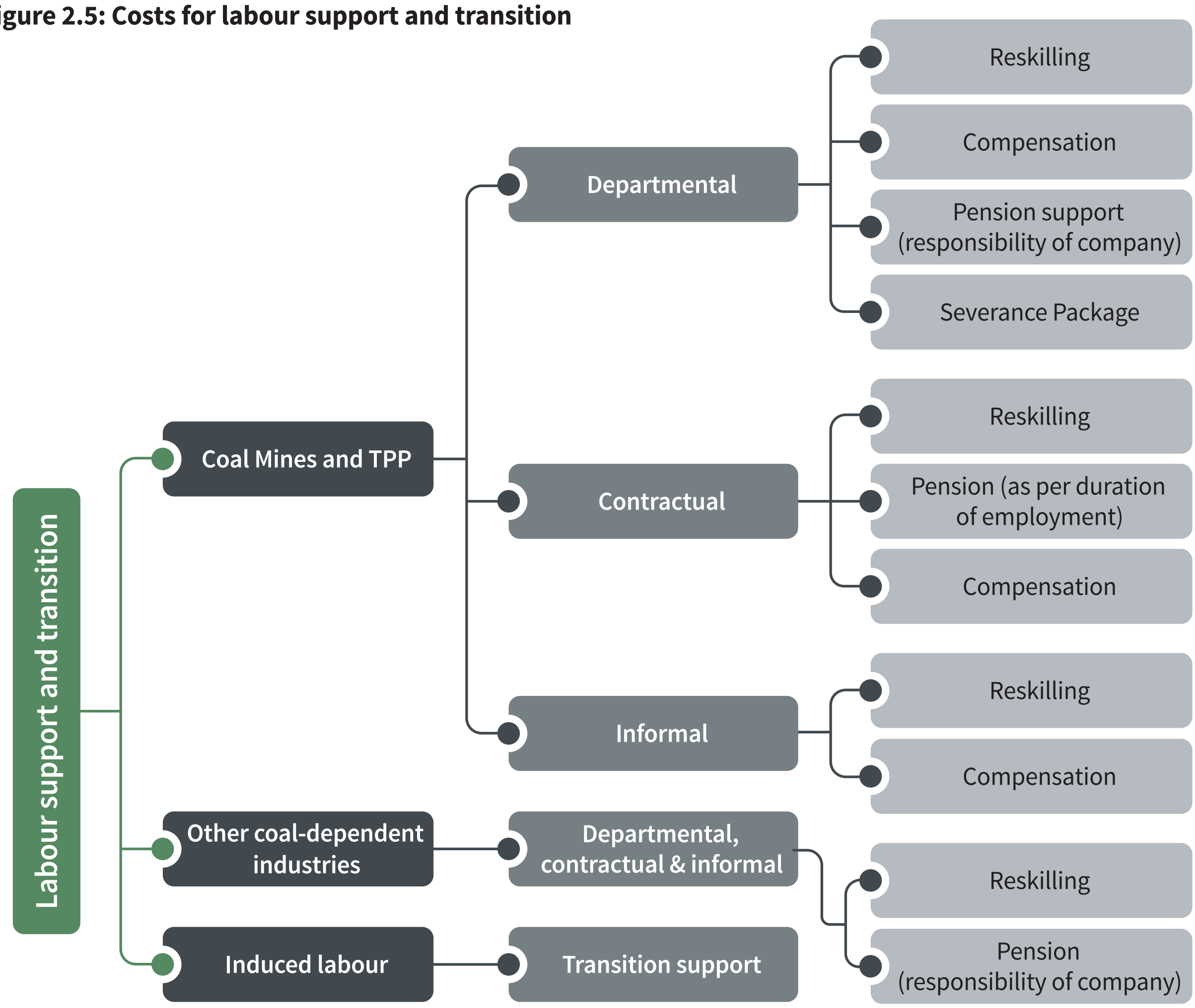
2.3.3 Labour support and transition

When coal mines and power plants are closed, targeted measures are required to provide transition and re-employment support to all affected workers. The cost component includes the following set of interventions:

- **Skilling and reskilling:** The labour force directly impacted by the mine closure and closure of industrial operations requires reskilling for re-employment in new economic sectors, especially green industries. Reskilling of workers can be done by developing and investing in workforce development/training programmes, pre-apprenticeship programmes, etc. Similarly, investments in higher education, vocational and technical education, and new skilling programmes (including higher-order skills) are required to develop a new generation of workforce for the green economy.
- **Compensation:** Retrenched workers, including contractual and informal workers, must be compensated for their income loss due to closures.
- **Pension support:** The liability of providing pension to retiring and retired workers is on the companies or private pension funds. However, in certain cases, pension support may be required if the plants/mines are closed before the end of their economic life.
- **Severance package/ Voluntary retirement scheme:** Severance packages or VRS are often considered part of the transition plan to enable certain workers to negotiate a one-time settlement.
- **Transition support:** A one-time payoff (against a fixed time duration) is provided to the transitioning workforce to cover re-employment and relocation support. This is especially required for the induced workers.

These cost sub components for labour support and transition remain similar for coal mines, TPPs and all other fossil fuel-dependent industries and include the costs for formal, informal, and induced workers.

Figure 2.5: Costs for labour support and transition



Source: iFOREST analysis

The methodology for estimating the labour support and transition costs is given in Table 2.4.

Table 2.4: Methodology for estimating labour support and transition costs

Cost components	Methodology	Information/ data source
Reskilling	i. Both formal (departmental and contract workers) and informal workers will require reskilling. ii. Workers in the above-mentioned categories include those engaged in coal mines, TPPs and other coal dependent industries (that will face transition). iii. Workers considered for reskilling include: a. Departmental coal mining and TPP workers below 40 years age, and 50% of the workers between 50 to 60 years age, at the time of closure of the mine/TPP. b. Contractual coal mining and TPP workers below 40 years age, and 50% of the same between 50 to 60 years age, at the time of closure. c. All informal workers, as age profile is difficult to ascertain. d. Other coal-based industry workers, only departmental.	**a. Number of workers for reskilling** i. For coal mines, number of departmental and contractual workers, and their age distribution is based on mine-wise information obtained from the coal companies for four districts – Korba, Angul, Bokaro and Ramgarh -- covering total 46 operational mines. This has been further extrapolated to the country level. ii. For coal-based TPPs, number of departmental and contractual workers and their age distribution is based on information obtained from a total of five TPPs located in Angul, Korba and Bokaro districts. This has been further extrapolated to the district and then country level.

Table 2.4 continued

Cost components	Methodology	Information/ data source
	iv. For determining number of workers at the time of closure, three parameters have been considered: the current age profile of workers, the operational life of the mine/TPP, and the associated change in the age profile at the time of closure, assuming recruitment will be 50% of attrition given technological changes and productivity improvement over the years. v. A training period of six months to one year is considered. **Cost estimation** i. The reskilling costs for informal workers has been considered based on the current rates for training by Ministry of Skill and Entrepreneurship, Government of India (GoI). ii. For departmental and contractual workers, the cost factor for reskilling has been derived from the current training costs by private coal companies/Mine Developer and Operators (MDOs) for such employees/workers, which is nearly five times the cost for informal workers.	iii. Number of informal workers for coal mines and TPPs is estimated from detailed worker assessments based on primary survey in four coal districts. This has been further extrapolated to the country level. iv. Number of workers in other coal-dependent industries is based on detailed worker assessments based on primary survey in four coal districts. **b. Reskilling cost data source** i. For informal workers, the Common Norms published by the Ministry of Skill and Entrepreneurship (2017).[42] ii. For departmental and contractual workers, based on data from coal industry, including MDOs.
VRS/ Severance pay	i. A one-time severance pay is considered for departmental workers of coal mines and TPPs. **Cost estimation** i. It is assumed that 50% of executives and workers in the age group of 50 and above will opt for a severance package. ii. The severance package has been estimated as the three-year salary, based on the last drawn salary for executives and non-executives separately. An average of last drawn salaries has been taken based on review of pay brackets and from a cost curve.	Review of average pay of executives and non-executives in the age group of 50 years and above from selected mines of CIL and its subsidiaries, and TPPs of NTPC.
Compensation	i. All contractual and informal workers of coal mines and power plants will be eligible for a compensation, which includes support for job search and placement. **Cost estimation** i. Compensation has been estimated for a 12-month period. This includes support during their training period (six months) to compensate for the wage loss, and an additional six months after that for job search and placement. ii. Compensation has been calculated considering the daily wage rate specified by the High-Power Committee (HPC)/ Joint Committee (consisting of management of CIL and its subsidiaries and central labour union representatives), for workers of contractors and sub-contractors.	Recommendations of the Joint Committee on wages of coal workers, 2022.[43]

Table 2.4 continued

Cost components	Methodology	Information/ data source
Transition support for induced workers	i. It is assumed that the induced workers will require transition support for a defined period as their income will be impacted by industrial transitions and its impact on the local economy. ii. A radius of 10 km from the mines and power plants has been considered as the area where economic activities have been induced by the presence of coal mines and coal-dependent industries. **Cost estimation** i. Transition support will be provided for a period of nine months. ii. Transition support is determined based on national minimum wage rate, as applies to the administrative units of the coal states/ districts. iii. Induced workers has been estimated from detailed worker assessments based on primary survey in four coal districts.	**a. Induced workers data source** i. The number has been determined considering people engaged in the following occupation within a 10 km radius from mines and power plants. These include, retail/small businesses, servicing and repairing, construction/ masonry, non-coal transportation, manufacturing, services like banking and education, and miscellaneous labour (non-coal causal workers/daily wagers involved in various construction sites, loading unloading activities in local businesses, etc.). ii. The total number of workers engaged in these occupations, has been extrapolated to the district level for all four districts in proportion to the total contribution of the mining, manufacturing, and electricity sectors to the District Domestic Product (DDP). An induced labour factor was developed from the four districts and used for country level extrapolation. **b. Transition support data source** National minimum wage rates, as published periodically by the Ministry of Labour and Employment, GoI. Wage rates for 2022 has been considered.[44]

Source: iFOREST analysis

Box 2: Worker categories

1. Departmental or permanent worker

As per the Industrial Employment (Standing Orders) Central Rules, 1946, workers who have been engaged on a permanent basis, are appointed for an unlimited period, and/or who have satisfactorily put in three months' continuous service in a permanent post as probationers are permanent workers. The permanent employees are entitled to various social security benefits provided by the employer.

2. Contractual worker

The Contract Labour (Regulation and Abolition) Act of 1970 defines that a workman shall be considered as 'contract labour' in an establishment, or in connection with the work of an establishment when such workman is hired by/ through a contractor, with or without the knowledge of the principal employer.

The new Occupational Safety, Health and Working Conditions Code (OSH Code), 2020, has extended the interpretation of contractual workers and provided an exclusion criterion. It says that workers who are regularly employed by the contractor for any activity of his establishment and their employment is governed by mutually-accepted standards of the conditions of employment (including engagement on a permanent basis), and get periodical increments in the pay, social security coverage and other welfare benefits in accordance with the law for the time being in force in such employment, shall not be considered as a contractual worker.

However, it is to be noted that the right of a contractual worker employed/ engaged by a contractor who has a very small operation is disputable. This is because the OSH code provisions only apply to a contractor(s) "who employs, or who employed on any day of the preceding twelve months 50 or more workmen".

3. Informal worker

As per the National Commission for Enterprises in the Unorganised Sector (NCEUS) and the Labour Bureau of India, informal workers include those who do not have employment security or social security provided by the employer. These workers participate in a work arrangement and earn from such activities outside of traditional employer-employee relationships. The informal workers can be part of both the formal sector, as well as the informal sector.

As per the Social Security Code 2020, informal workers are entitled to certain benefits such as skilling, career counselling etc.

4. Induced worker

There is no official definition of an induced worker. For this study, an induced worker is a formal, contractual or informal worker who doesn't directly work in coal mining and related industries, but his job is due to the presence of coal mining and related industries. If mines and related industries are phased out, this job would also be lost. For example, people employed in shops in a coal township would fall under the induced worker category.

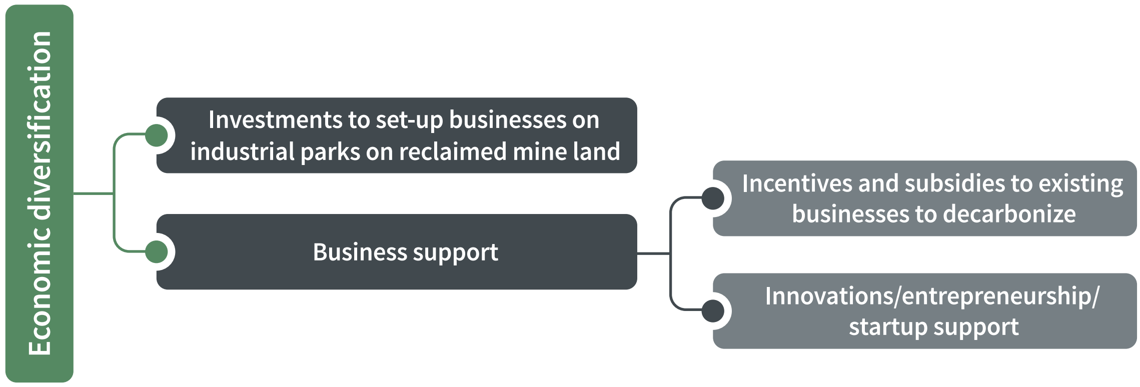
2.3.4 Economic diversification

Economic diversification entails transitioning a fossil fuel-dependent economy to non-fossil fuel-dependent sectors. This cost component includes investment and business support for new industries and entrepreneurship in the fossil fuel-dependent region and setting up new businesses on reclaimed coal mine land. However, it excludes the green energy investments required to compensate for the reduction in fossil fuel energy at the grid level. This is dealt with separately as a dedicated cost sub-component – green energy investments.

Providing business support is a key part of economic diversification, which is the financial assistance given to public and private enterprises to develop new green businesses and the existing businesses to shift from fossil fuel-dependent industrial processes. This entails the following set of interventions:

- Development of green industries on reclaimed coal mine land;
- Decarbonisation of existing businesses; and,
- Innovation and entrepreneurship support to upcoming businesses/start-ups to create new green jobs.

Figure 2.6: Costs for economic diversification



Source: iFOREST analysis

The methodology used for estimating the costs of economic diversification is given in Table 2.5.

Table 2.5: Methodology for estimating economic diversification costs

Cost components	Methodology	Information/ data source
Economic diversification	i. Economic diversification investments is the cost to set-up new businesses on the reclaimed coal mine land. ii. It is assumed that reclaimed mine land is divided equally for setting up solar/wind plants, industrial parks, and horticulture. The water bodies left as voids are assumed to be used for pisciculture and tourism. iii. The land area available for each of the activities has been multiplied by corresponding cost factors. These cost factors have been determined by taking the average cost of such investments in coal states/ districts. **Cost estimation** i. The cost of setting-up businesses in the industrial park has been estimated based on the study of five industrial parks in Jharkhand. It is to be noted that the investment needed to set-up industrial park is an underestimation because most coal mines are in remote areas and would require more investments compared to the industrial parks established in cities like Ranch or Jamshedpur. ii. The cost of horticulture and processing is estimated to be ₹37.5 lakh/ha ($46,875/ha). iii. The cost of pisciculture is assumed to be ₹10.0 lakh/ha ($12,500/ha). iv. The cost of setting-up RE on reclaimed land is estimated under Green Energy Investments. iv. Based on the cost factors (as derived) for each businesses, the total investments for economic diversification has been estimated.	i. The cost of setting-up businesses in industrial parks is the average cost of five recent industrial parks in Jharkhand. These include, Mega Food Park, Getalsud in Ranchi, Silk Park in Ranchi, Auto Park in Adityapur, Pharma Park in Ranchi, and Electronics Park in Adityapur. ii. The cost of horticulture and pisciculture has been take from the Department of Agriculture, Animal Husbandry and Co-operative, Government of Jharkhand,[45] and National Horticulture Board.[46]
Business support for economic diversification	i. This is the amount of financial incentives given by the state governments for setting-up new industries. **Cost estimation** i. The incentives are average incentives given under the industrial policy of Jharkhand, Odisha, and Chhattisgarh.	State policies, such as Jharkhand Industrial Promotion Policy 2021,[47] and Chhattisgarh Industrial Policy 2019-2024.[48]

Table 2.5 continued

Cost components	Methodology	Information/ data source
Support to existing businesses to decarbonise and move to green energy	It is difficult to estimate this cost in the absence of a detailed enterprise-level study. Hence this cost has not been estimated. However, it is possible that some of the existing businesses would move to the industrial parks to avail the incentives.	
Support for innovation and start-ups	Investments and incentives would be required for innovation and to support start-ups in the fossil fuel regions. In the TJTP of the European Union (EU) member states, and the JET IP of South Africa, significant investments have been directed towards innovation and start-ups. While India has developed a robust ecosystem for innovation and start-ups, it is not specifically focussed on energy transition or fossil-fuel dependent areas. Therefore, financial resources will be needed to support innovation and start-ups in fossil fuel regions. **Cost estimation** The cost factor for innovation and start-up support has been developed based on: 1. The JET-IP of South Africa for 2023-27. 2. The TJTP of the Lusatian lignite mining area, Brandenburg, Germany for 2021-27. 3. The TJTP of Silesia voivodeship (province), Poland for 2021-27.	Assessment by iFOREST of just transition costs and cost factors.[49]

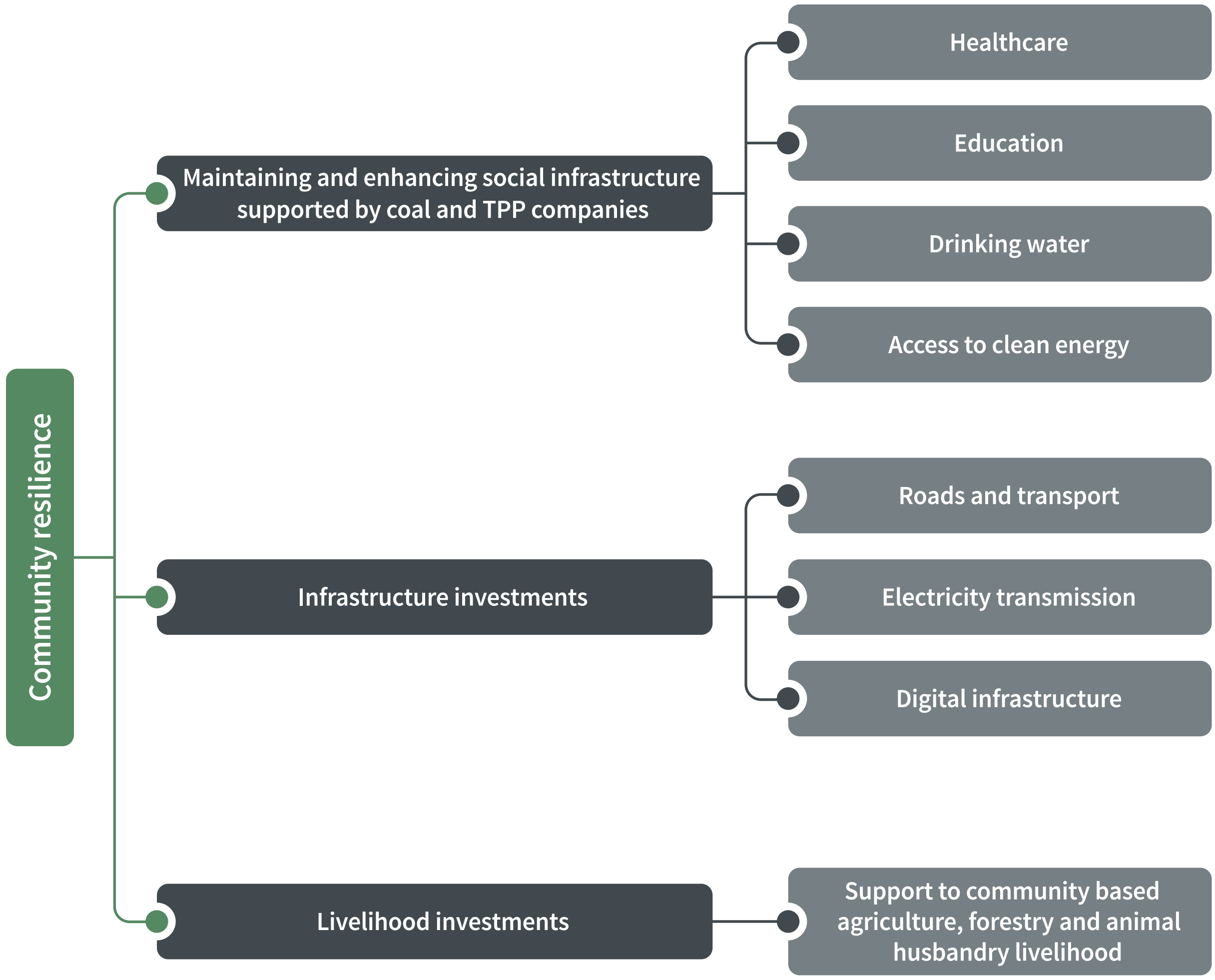
Source: iFOREST analysis

2.3.5 Community Resilience

Building community resilience requires investments to improve social and physical infrastructure in fossil fuel-dependent regions and secure basic amenities and services for communities affected by the phase-down and closure of mines and TPPs. This entails the following set-of interventions:

- **Maintaining and enhancing social infrastructure:** Coal mining and power companies often provide healthcare, education, drinking water and electricity to the dependent workers and the local communities. These services should be compensated in the event of closures.
- **Infrastructure investments:** Depending on the existing gap, investments are needed to build physical infrastructure (transport, electricity, communication etc.) in affected regions. Climate change adaptation measures are also required to bolster the resilience of communities during the transition phase to build resilience to climate-linked disasters.
- **Livelihood investments:** Transitioning away from fossil fuels will impact the population indirectly dependent on fossil fuel industries and employed in a range of economic activities induced by such industrial operations. Strengthening economic opportunities for the indirectly dependent/induced population necessitates investments to build safety nets through community-based targeting (CBT)[50] that cater to the socio-economic requirements of the local community, particularly the poor and the disadvantaged, during transition. This may include investments in sectors such as land, water, agriculture, forestry, and animal husbandry. Overall, investments in economic diversification and community resilience are important to address the requirements of induced workers and the affected community.

Figure 2.7: Costs for community resilience



Source: iFOREST analysis

The methodology for estimating the costs of community resilience is given in Table 2.6.

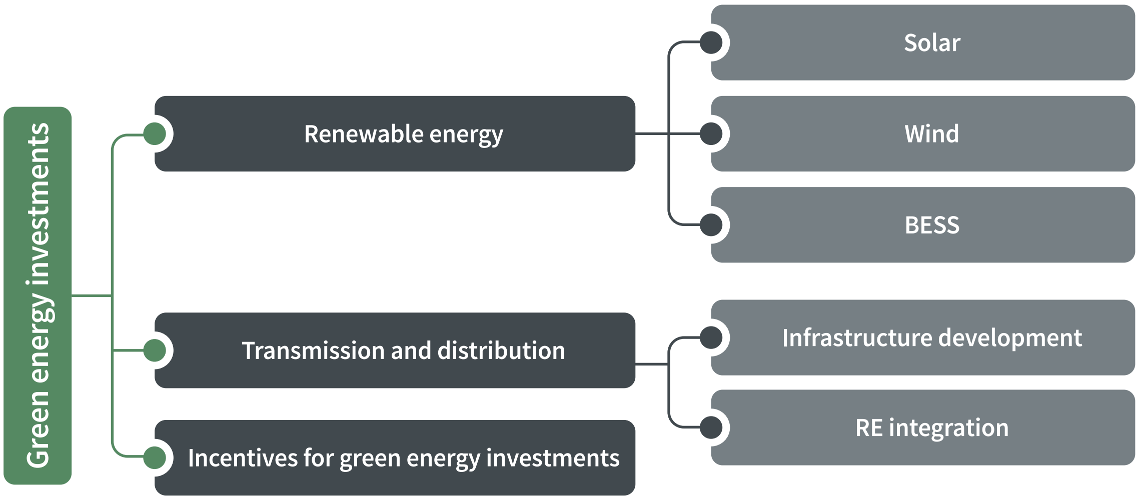
Table 2.6: Methodology for estimating community resilience costs

Cost components	Methodology	Information/ data source
Community resilience	i. Community resilience includes investments to improve social and physical infrastructure of a mining area that will be impacted by the fossil fuel transition. It depends on the infrastructure deficit in a region and hence varies from region to region. ii. There is no standard methodology to estimate the investment needs for community resilience. **Cost estimation** i. The community resilience investment is a percentage of the total just transition investments, excluding the Green Energy Investments. ii. This percentage has been derived based on: 1. The JET-IP of South Africa for 2023-27. 2. The TJTP of the Lusatian lignite mining area, Brandenburg, Germany for 2021-27. 3. The TJTP of Silesia voivodeship (province), Poland for 2021-27.	Assessment by iFOREST of just transition costs and cost factors.[51]

2.3.6 Green Energy Investments

Green energy investments include investments in RE, BESS, hydrogen, grid infrastructure, energy efficiency, energy access, etc., to compensate for the phase-out of fossil fuel-based electricity generation. A green energy equivalency factor has been used to estimate this cost. The green energy equivalency factor is the amount of RE and storage required to replace the electricity services provided by the existing TPPs. The objective is to improve clean and affordable energy access in fossil fuel-dependent regions, aid economic diversification, and create jobs.

Figure 2.8: Green energy investments



Source: iFOREST analysis

The methodology used for estimating green energy investments is given in Table 2.7.

Table 2.7: Methodology for estimating green energy investments

<table>
<tr><th>Cost components</th><th>Methodology</th><th>Information/ data source</th></tr>
<tr>
<td>Green energy investments</td>
<td>
i. For determining green energy investments, an equivalency factor has been considered. The green energy equivalency factor is the amount of RE and BESS needed to replace 1 MW of TPP capacity operating at 60% PLF.
ii. It is estimated that 1 MW of coal-based power capacity can be replaced by 2.75 MW of new RE capacity (solar/wind) and of 9.00 MWh of BESS.
iii. The required solar and storage capacity that can come up within the TPP site (green repowering of TPPs) and outside, including on one-third of reclaimed coal mine land.
iv. The average land requirement for 1 MW of TPP capacity is assumed to be 1.3 acres, and 1 MW of solar PV as 5 acres.
Cost estimation
i. The cost of Solar PV and battery is assumed to be as follows:
<table>
<tr><th></th><th>2022-2030</th><th>2030-2040</th><th>2040-2050</th></tr>
<tr><td>Solar PV (₹ Cr./MW)</td><td>4</td><td>3</td><td>3</td></tr>
<tr><td>BESS (₹ Cr./MWh)</td><td>1</td><td>0.75</td><td>0.6</td></tr>
</table>
ii. The estimated total RE and the total storage to be installed based on the equivalency factor has been multiplied by respective cost factors (as Rs. Crore/MW and Rs. Crore/ MWh) to determine the green energy investment cost.
iii. The green repowering of TPP has been subtracted from the total investment.
</td>
<td>
i. Solar PV and BESS prices from iFOREST study on cost of RE in Angul, Odisha.[52]
ii. The average land availability/ requirement is based on average of a sample of actual projects.
</td>
</tr>
</table>

Table 2.7 continued

Cost components	Methodology	Information/ data source
Incentives for green energy investments	i. For green energy investments based on RE and BESS, state and central government incentives will be required. **Cost estimation** i. For green energy investments, typical financial incentives provided by the state governments of Jharkhand and Odisha for renewable energy has been considered.	i. Odisha Renewable Energy Policy 2022.[53] ii. Jharkhand State Solar Policy 2022.[54]
Transmission & Distribution upgradation costs	i. Investments in generation necessitate investments in transmission and distribution (T&D), including to integrate variable power sources. In India, significant investments in T&D development would be needed as solar is likely to be installed in an increasingly distributed manner. Also, additional investments will be needed to build storage capacity in the grid to increase flexibility and resilience. **Cost estimation** i. T&D costs will not be needed for RE and BESS installed at the TPP and coal mine sites. However, a large amount of green energy will have to be installed outside coal mines and TPPs. ii. Total T&D costs is estimated based on the CEEW and Integrated Research and Action for Development (IRADe) study.	iFOREST estimation based on: i. CEEW's report on Investment Sizing India's 2070 Net-Zero Target (2021).[55] ii. Report of IRADe-Pathways to net zero emissions for the Indian power sector (2022).[56]

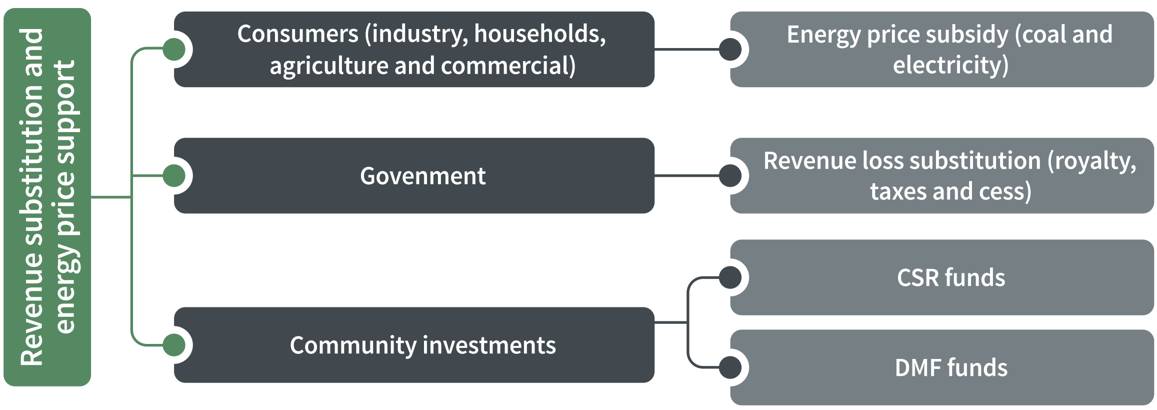
Source: iFOREST analysis

2.3.7 Revenue Substitution and Energy Price Support

Financial support is needed to prevent any undue economic burden that the local governments might face due to revenue loss from the phase-down of coal mining and TPPs. Likewise, support is also needed to cover the increase in energy prices, if any, for the communities and industries as they transition to using clean energy sources. It includes the following costs:

- **Revenue substitution:** Revenue substitution includes measures to compensate for the financial loss of the state and district governments due to earnings forgone from royalty, cess, and taxes paid by the fossil fuel industry. This also includes welfare contributions and investments made by fossil fuel companies that will be foregone, such as Corporate Social Responsibility (CSR) and District Mineral Foundation (DMF) funds.
- **Energy price support:** It includes provisions to cover the increase in energy prices for domestic and industrial consumers. This support is necessary to maintain the region's competitiveness and to secure and maintain the residents' cost of living. However, this cost has not been included in the current estimation.

Figure 2.9: Revenue substitution and energy price support



Source: iFOREST analysis

The methodology for revenue substitution is given in Table 2.8.

Table 2.8: Methodology for revenue substitution

Cost components	Methodology	Information/ data source
Revenue substitution – Tax, royalty, and cess	i. Coal companies contribute significantly to the exchequer. As some coal mines are closed before their resources are exhausted, there will be loss of public revenue, which is a direct cost of just transition and need to be substituted. ii. It is assumed that coal mines will continue to operate under Business-As-Usual (BAU) scenario. By 2050, mines will cease operation considering the net zero target. **Cost estimation** i. To estimate the revenue that will be foregone post 2050, the amount of coal production that will be potentially foregone beyond 2050 is determined. The foregone production is multiplied with the current rates (payment against per tonne of coal production) of royalty, coal cess, and other taxes, to estimate the total amount foregone. ii. It has been assumed that rate of royalty, taxes and cess would remain constant over the life of these mines.	Annual reports of CIL and its subsidiaries
Community investment fund	i. Coal companies contribute to the DMF funds and CSR. As some coal mines are closed before their resources are exhausted, there will be loss of DMF and CSR funds to the community, which is a direct cost of just transition and need to be substituted. **Cost estimation** i. To estimate the DMF and CSR that will be foregone post 2050, the amount of coal production that will be potentially foregone beyond 2050 is determined. The foregone production is multiplied with the current rates (payment against per tonne of coal production) of DMF and CSR, to estimate the total amount foregone. ii. It has been assumed that rate of DMF and CSR would remain constant over the life of these mines.	i. CSR portal. ii. DMF data from Department of Mines of coal-producing states and Ministry of Mines, GoI.
Energy price support	To assess this cost, a detailed study is required to estimate the existing energy subsidies to the industries and other consumers. Thus, this cost has been excluded from the study.	

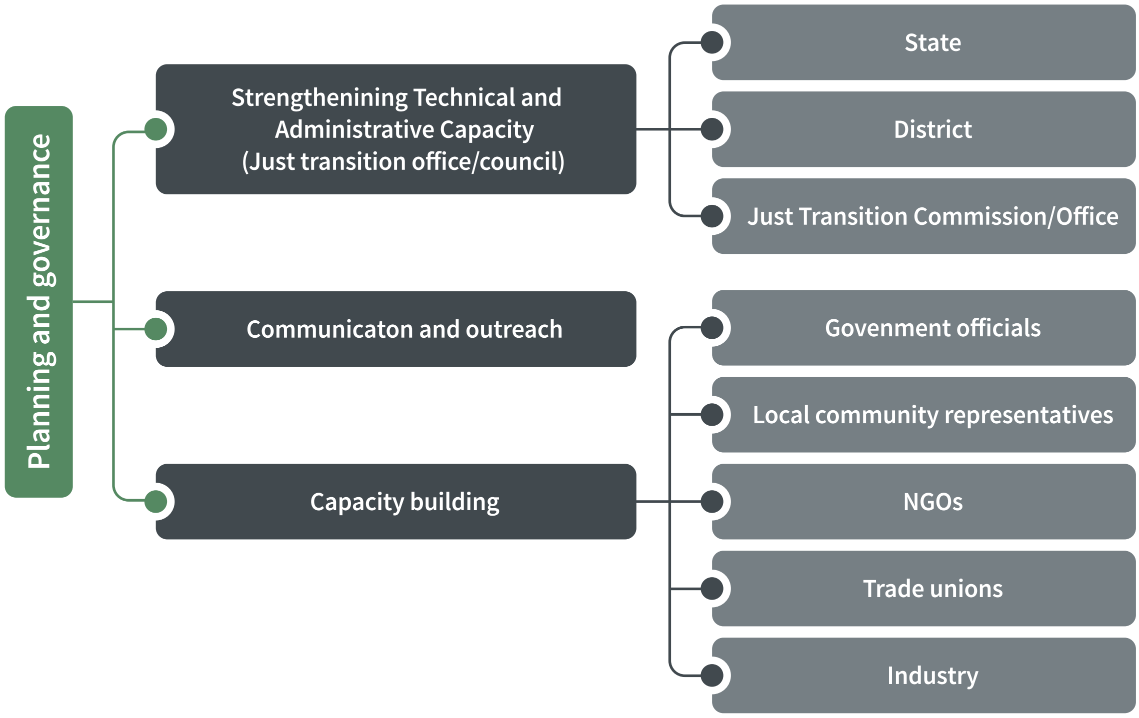
Source: iFOREST analysis

2.3.8 Planning, Capacity Building and Governance

Managing the transition process entails capacity development, planning, and administrative and managerial costs.

- **Technical and administrative capacity:** Implementation of just transition action plans requires investments in offices, councils and advisory bodies dedicated to the purpose, as well as strengthening the technical and administrative capacity of the local (state and district) administration in terms of knowledge, skills, and human resources.
- **Communication and outreach:** Just transition requires a broad-based stakeholder engagement to build consensus and support of various stakeholders on the transition process.
- **Capacity building:** This includes costs for building the capacity of various stakeholders to engage with the just transition process, including the development of plans and implementation. The key stakeholders include government agencies/bodies, non-government organisations (NGOs), the local community and industry.

Figure 2.10: Costs of planning, capacity building and governance



Source: iFOREST analysis

The methodology for estimating planning and governance costs is given in Table 2.9.

Table 2.9: Methodology for estimating planning, capacity building and governance costs

Cost components	Methodology	Information/ data source
Planning and governance	i. Just Transition will need planning, capacity building, stakeholder engagement and administrative expenses as observed from global just transition experiences. However, there is no standard methodology to estimate the costs of planning and governance. **Cost estimation** i. The planning and governance cost is assumed to be 2.5% of the total just transition investments. ii. This percentage has been derived based on: 1. The JET-IP of South Africa for 2023-27. 2. The TJTP of the Lusatian lignite mining area, Brandenburg, Germany for 2021-27. 3. The TJTP of Silesia voivodeship (province), Poland for 2021-27.	Assessment by iFOREST of just transition costs and cost factors.[57]

2.4 District study

To estimate the costs and cost factors for a just transition, comprehensive studies were undertaken in major coal districts of India.

2.4.1 Selection of Districts

Four major coal-producing districts in India were chosen. These districts were selected to provide a diverse representation of the coal sector, encompassing regions with declining, plateauing, and rapidly expanding coal production.

- **Ramgarh, Jharkhand:** Ramgarh faces financial viability and resource exhaustion challenges in its coal mining sector. Of 25 mines, 18 are non-operational (six are permanently and 12 are temporarily closed). Only seven mines are operational, with three of them being unprofitable. Consequently, coal production in the district has peaked and is now declining.
- **Bokaro, Jharkhand:** Coal mine closures are also happening in Bokaro. Seven mines have become non-operational due to exhausted reserves or unviable operations. Of the 11 currently operational mines, four are unprofitable. Although three new mines are set to open, increasing production slightly, the district's coal production will peak by 2025 and experience a significant decline by 2030.
- **Korba, Chhattisgarh:** As the second-largest coal-producing district with some of the world's largest coal mines, Korba's coal production is plateauing and is expected to peak by 2030. The district will experience a substantial decrease in coal production between 2030-40.
- **Angul, Odisha:** Angul is India's third-largest coal-producing district, contributing over 12% of the nation's total production. Coal mining in Angul is rapidly expanding. If the current trend continues, the district will likely produce over 300 million tonnes (MT) of coal by 2033—triple its current production. No significant reduction in coal production is expected even by 2040.

Map 2.1: Districts selected for estimating just transition costs

2.4.2 Coal dependence study

A detailed socio-economic survey was conducted in each district to assess coal dependence, worker profiles, and community resilience. The survey gathered data on the demographics of coal-dependent communities, the number and income of direct, indirect, and induced workers, the capacity of these communities to adapt to changes in the coal industry, including the status of social and physical infrastructure, the potential for economic growth and jobs in other economic sectors and other related aspects.

2.4.3 Techno-economic Study

Extensive research was carried out on coal mines and TPP closure scenarios and the potential for land reclamation and repurposing. This research aimed to gather information on the costs of closing and repurposing coal mines and TPPs and the possibility of developing green energy and industries in these regions. Additionally, the research examined the revenue contribution of coal mines and TPPs to the local economy and analysed the prospect for alternative sources of revenue.

2.4.4 Estimation of district transition costs

Based on the data collected from the socio-economic and labour surveys, techno-economic studies and the methodology for estimating the costs mentioned above, the costs of a just transition for the districts were estimated. These costs include worker retraining and reskilling costs, income support for affected workers and their families, investments in infrastructure and public services, and the costs of decommissioning and repurposing coal mines and TPPs. The estimated just transition costs provide a comprehensive understanding of the financial resources required to ensure a fair and equitable transition for coal-dependent communities and workers while promoting sustainable development in the affected regions.

The details of the districts and their transition costs are given in Chapter 3.

2.5 Just transition costs for India

To estimate the costs of a just transition for India's coal mining and thermal power sectors, a comprehensive methodology was developed and applied that involved several interconnected steps:

i. **Estimating cost factors based on district studies:** The first step involved analysing the costs associated with the transition of the four selected districts to estimate cost factors for various cost components/sub-components. Thus, cost factors for coal mine and TPP reclamation and repurposing, worker retraining and support, community resilience, etc., were developed.

ii. **All-India coal mine and TPP profile and their phase-down schedule:** A comprehensive profile of all coal mines and TPPs across India was created, and a phase-down schedule for them was constructed. This was based on factors such as the coal reserves of each mine, the prospective life of mines, and the remaining design life of TPPs.

iii. **All-India just transition costs:** The total investment needed to support a just transition across India for the coal mining and TPP sector was estimated. This step involved aggregating the cost factors developed from the district studies and applying them to the national context, considering the all-India coal mine and TPP phase-down schedule. This comprehensive analysis also provides insights into the financial flow necessary from public and private sources to ensure a fair and equitable transition from coal in India.

03

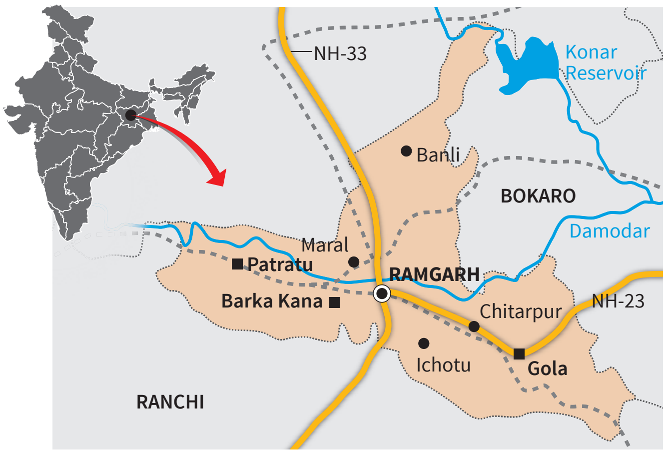
Transition Costs at the District Level

3.1. Ramgarh

3.1.1 District profile

Ramgarh is among Jharkhand's top five coal-producing districts, along with Bokaro, Dhanbad, Chatra and Hazaribagh. It is an old coal mining region with over 100 years of coal production history.[58]

Map 3.1: Administrative map of Ramgarh



Ramgarh has six administrative blocks spread across 136,008 hectares (ha). The estimated population of the district is 1.08 million (in 2020). The district is significantly urbanised, with about 48% of its population living in urban areas.[59]

The district's economy largely depends on coal mining, contributing 20.4% to the District Domestic Product (DDP). Overall, the tertiary sector has the highest contribution to the DDP, with a share of nearly 49%. This is mainly attributable to its proximity to two major economic hubs -- the state capital Ranchi, and the industrial town of Bokaro. The manufacturing sector in the district is not significantly developed. The large and medium-scale industrial units in Ramgarh include steel and steel alloys, billets, mild steel ingots, sponge iron, and cement.[60]

With respect to development indicators, about 29.8% of its population is multidimensionally poor, which is better than the state average of 42.1%, but higher than the national average of 25%.[61]

Table 3.1: Share of economic sectors in DDP

Sector	Share in the DDP (%)
Primary	**32.3**
Agriculture	8.1
Forestry and Logging	3.3
Fishing	0.5
Mining and Quarrying	20.4
Secondary	**18.9**
Manufacturing	7.0
Electricity, Gas and Water Supply	2.5
Construction	9.4
Tertiary	**48.8**
Trade, Hotel & Restaurants	15.1
Railways	1.3
Transport by other Means and Storage	4.8
Communication	2.2
Banking and Insurance	3.4
Real Estate	7.7
Public Administration	6.6
Other Services	7.7

Source: iFOREST estimates based on the data from the Directorate of Economics and Statistics, Jharkhand, 2009.

3.1.2 Coal context

Coal mining in Ramgarh is grappling with financial viability and resource exhaustion challenges. At the time of the analysis, at least 12 mines were temporarily closed.[62] According to government and company officials, these mines have been operating intermittently for various durations during the year. Additionally, six underground (UG) mines have been closed permanently.[63]

Overall, there are seven mines operational in the district. Of these, six are opencast (OC) and one underground (UG), with a total production capacity of 15.7 million tonnes per annum (MTPA). Among the operational mines, three OC mines are unprofitable.[64] There are no new mines coming up in the district, and no capacity expansion of the current mines is planned. In 2021-22, the district produced about 8 million tonnes (MT) of coal. Combining the operational and temporarily closed mines, the district's total coal production capacity is 26.6 MTPA.[65]

Ramgarh does not have any utility-scale coal-based thermal power plant. Among other major coal-dependent industrial units, there is one integrated steel plant operated by Jindal Steel and Power Limited, which has a production capacity of 6 MTPA.[66] Additionally, there are seven sponge iron units and four mild steel ingot units. The district also has two small privately operated cement plants.[67]

3.1.3 Worker dependence

Over 59,000 workers (14,535 formal and 44,962 informal) are employed in coal mining and other coal-dependent industries. The economy created by coal further provides jobs to 45,454 induced workers in the district. About 6,830 pensioners of coal and coal-based industries reside in the district.

Table 3.2: Workers dependent on coal in Ramgarh

Category		Workers			
A.	**Direct Jobs**	**Departmental**	**Contractual**	**Informal**	**Total**
	Coal mining	9,430	212	33,098	42,740
	Thermal Power Plant	0	0	0	0
	Other coal-dependent industry	4,893		11,652	16,545
	Total	**14,323**	**212**	**44,962**	**59,285**
B.	**Induced Jobs**				**45,454**
C.	**Pensioners**				**6,830**

Source: iFOREST analysis

3.1.4 Land availability for repurposing

About 10,637 ha of land is under operational and temporarily closed mines in Ramgarh. Of this, 7,667.6 ha is under OC and 2,969.3 ha under UG mines. A total of 7,636.4 ha of land can be made available in Ramgarh for repurposing after proper reclamation of the OC mines.

3.1.5 Coal mine phase-down scenario

The phase-down timeline for Ramgarh considers 20 coal mines (seven operational as well as 12 temporarily closed mines and one mine for which details are not available), assuming that some of them have been operating intermittently and are likely to come into operations in the near future, given the availability of reserves.

Considering the current status of coal mines, Ramgarh will witness the closure of 11 out of 20 mines by 2030. A gradual closure would continue in the next two decades. In a Business-As-Usual (BAU) Scenario, last mine will close by 2050.

Table 3.3: Coal mine closure schedule for Ramgarh

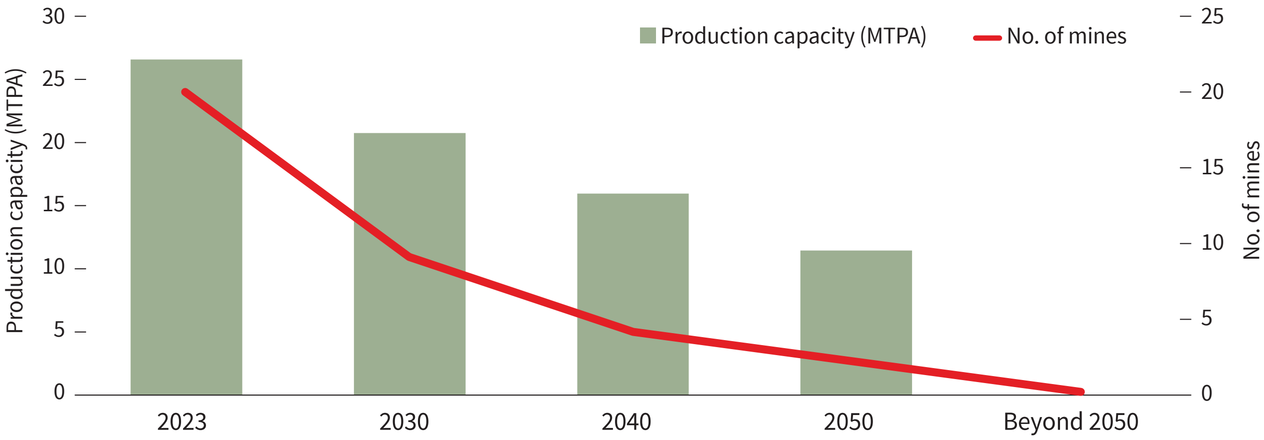
Name of mine	Operation type	Production capacity, 2022 (MTPA)	Status of Operation	Year of Retirement with planned expansion
Kedla	UG	0.2	Temporarily Closed	2025
Pindra	UG	0	Operational*	2027
Kuju	UG	0	Temporarily Closed	2027
Central Saunda	UG	0	Temporarily Closed	2027
Ara/Chanipur/Sarubera	UG	0	Temporarily Closed	2027
Argada Sirka Group	UG	0	Temporarily Closed	2027
Laiyo	UG	0.38	Non-Operational**	2027
Hesagarha	UG	0	No Data***	2027
Karma	OC	1	Operational	2029

Table 3.3 continued

Name of mine	Operation type	Production capacity, 2022 (MTPA)	Status of Operation	Year of Retirement with planned expansion
Parej East	OC	1.75	Operational	2029
Tapin	OC	2.5	Operational	2030
Bhurkunda	UG	2.1	Temporarily Closed	2032
Bhurkunda	OC	0.24	Temporarily Closed	2033
Jharkhand	OC	1	Operational	2039
Ara/Chanipur/Sarubera	OC	0.76	Temporarily Closed	2040
Kedla	OC	0.7	Temporarily Closed	2040
Rajrappa	OC	3	Operational	2046
Argada Sirka Group	OC	1.5	Temporarily Closed	2050
Pundi	OC	5	Temporarily Closed	2051
EPR Topa	OC	6.45	Operational	2055

Source: iFOREST based on data from Central Coalfields Ltd. and Ministry of Coal
*To be merged with Topa
** To be merged with Jhakhand OCP
*** The status of Hesagarha could not be ascertained. This mine, however, has been considered as part of the phase down schedule.

Figure 3.1: Coal mine closure schedule for Ramgarh



Source: iFOREST analysis

3.1.6 Cost of just transition

The cost of just transition for the district is estimated to be ₹93,271 crore ($11.66 billion). Of this, ₹49,300 crore ($ 6.16 billion) or 52.9% of the total investments will have to be made through grants and incentives.

Table 3.4: Just transition costs for Ramgarh

Cost components	Total Investments		Grant and incentives	
	₹ crore	$ millions	₹ crore	$ millions
Coal mine reclamation and repurposing	13,855	1,732	13,120	1,640
Economic diversification	50,909	6,364	12,727	1,591
Green energy investments	5,615	702	562	70
Labour support and transition	2,935	367	2,935	367
Revenue substitution	1,184	148	1,184	148
Community resilience	14,597	1,825	14,597	1,825
Capacity building and governance	4,174	522	4,174	522
Total	**93,271**	**11,659**	**49,300**	**6,163**

Source: iFOREST analysis

3.2 Bokaro

Bokaro is one of the most industrialised districts of Jharkhand. Besides being one of the top five coal-producing districts of the state, it has an integrated steel plant and seven thermal power plants (TPPs), including captive TPPs. The presence of coal mines, TPP and the steel industry, along with good connectivity to the state capital of Ranchi, has made Bokaro a major industrial hub.

3.2.1 District profile

Map 3.2: Administrative map of Bokaro

Spread across 2,88,101 ha, Bokaro is divided into nine administrative blocks and two municipal corporations. The district's total population is estimated to be 2.3 million (in 2022), with over 52% of the population being urban.[68]

The district's economy is largely dependent on coal mining and manufacturing. Mining contributes nearly 20% to the DDP. The total contribution of the manufacturing, electricity, gas, and water supply is 34%. Overall, mining, coal-based power and coal-dependent industries contribute about 54% to Bokaro's DDP. The contribution of the tertiary sector to the economy is also significant and is primarily linked to the presence of local manufacturing.

Table 3.5: Share of economic sectors in DDP

Sector	Share in DDP (%)
Primary sector	**21.5**
Agriculture	1.1
Forestry	0.5
Fishery	0.3
Mining and quarrying	19.6
Secondary sector	**44**
Manufacturing	30.6
Electricity, gas, and water supply	3.4
Construction	10
Tertiary sector	**34.5**

Source: iFOREST estimates based on the data from the Directorate of Economics and Statistics, Jharkhand, 2005-06.

Regarding development indicators, Bokaro performs better than the rest of Jharkhand. About 29.5% of the district's population is multidimensionally poor, which is much lower than Jharkhand's average of 42.1%, but higher than the national average of 25%.[69]

3.2.2 Coal context

Bokaro falls in Jharkhand's old coal mining regions, where mining began nearly a century ago. All the mines are operated by the Public Sector Undertakings (PSU) – Central Coalfields Limited (CCL) and Bharat Coking Coal Limited (BCCL).

Presently, there are 11 operational mines, of which 10 are OC and one UG, with a cumulative production capacity of 31.3 MTPA. The district produced 15.6 MT of coal in 2021-22.[70] In the next five years, three new coal mines are expected to commence operations, adding 7.0 MTPA to the existing capacity.

But the district is also witnessing coal mine closures. There are two UG coal mines which are temporarily closed.[71] Besides, seven mines are closed due to reserve exhaustion or unprofitability. Even among the 11 operational mines, four are unprofitable operations.[72]

There are seven operational TPPs with an installed capacity of 1,780.3 megawatts (MW). These include five utility and two captive power plants. An additional 1,320 MW of capacity is planned through one upcoming power plant (Tenughat Thermal Power Station) in the next four to five years.

One of the biggest steel plants in the country – Bokaro Steel plant – operated by the Steel Authority of India Limited (SAIL), is in the district. The plant has a crude steel production capacity of 5.77 MTPA.[73] Another private steel plant (owned by ESL Steel Limited, a Vedanta Limited undertaking) is currently non-operational due to violations of environmental conditions.[74] Besides, there is a cement plant of Dalmia Cement Bharat Ltd. with a production capacity of 2.1 MTPA.[75]

3.2.3 Worker dependence

Around 1,38,589 workers - 40,244 formal and 1,03,317 informal – are employed in coal mining, TPPs and other coal-dependent industrial sectors, such as steel and cement. The economy created by coal further provides jobs to 1,30,884 induced workers in the district. Over 23,000 people are estimated to rely on pensions from coal and coal-based industries.

Table 3.6: Coal-dependent jobs in Bokaro

Category		Workers			
A.	**Direct Jobs**	**Departmental**	**Contractual**	**Informal**	**Total**
	Coal mining	8,014	794	35,422	44,230
	Thermal Power Plant	2,017	4,178	11,497	17,692
	Other coal-dependent industry	25,241		51,425	76,666
	Total	**35,272**	**4,972**	**103,317**	**138,589**
B.	**Induced Jobs**				**130,884**
C.	**Pensioners**				**23,082**

Source: iFOREST analysis

3.2.4 Land availability for repurposing

Overall, 4,359 ha of land is under the operational and temporarily closed mines, of which 3,017.6 ha is under OC and 1,342 ha is under UG operations. About 2,906 ha of land will be available for repurposing after proper reclamation of the coal mines. Additionally, 2,595 ha of land is available with the utility power plants, including the upcoming TPP.

3.2.5 Coal mine and TPP phase-down scenario

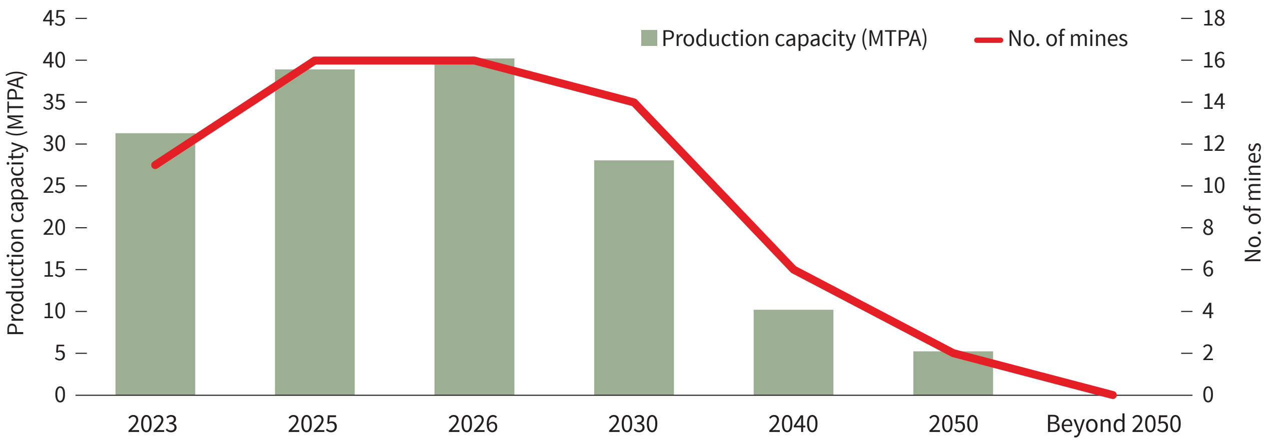
The coal production capacity in Bokaro is likely to peak by 2026 at 40.2 MTPA. However, mine closures will start soon after due to reserve exhaustion, with the first mine closing in 2028. In BAU Scenario, the last mine is likely to close by 2053.

Table 3.7: Coal mine closure schedule for Bokaro

Name of coal mine	Type of operation	Production capacity (MTPA)	Status of operation	Year of closure
Damoda	OC	1.17	Operational	2024
EPR Karo	OC	11	Operational	2028
EPR Konar (AKK)	OC	8	Operational	2031
Dhori Khaas	OC	0.16	Operational	2032
Kargali	UG	0.35	Temporarily closed	2032
Jarandih	UG	0.28	Temporarily closed	2033
Amlo (AAD)	OC	2.5	Operational	2034
Govindpur	UG	0.8	Operational	2034
Kathara RCE	OC	1.9	Operational	2037
Jarandih	OC	1.5	Operational	2039
Govindpur Phase II	OC	1.2	Operational	2040
Kalyani	NA	2	Proposed	2049
Bokaro OC	OC	0.8	Operational	2050
Swang Pipradih	UG	2	Proposed	2050
SDOCM	OC	2.25	Operational	2052
Godo	NA	3	Proposed	2052

Source: iFOREST based on data from Central Coalfields Limited, Bharat Coking Coal Limited and Ministry of Coal
Note: The proposed and temporarily closed mines are assumed to start operation by 2025, which is an optimistic scenario.

Figure 3.2: Coal mine closure schedule for Bokaro



Source: iFOREST analysis

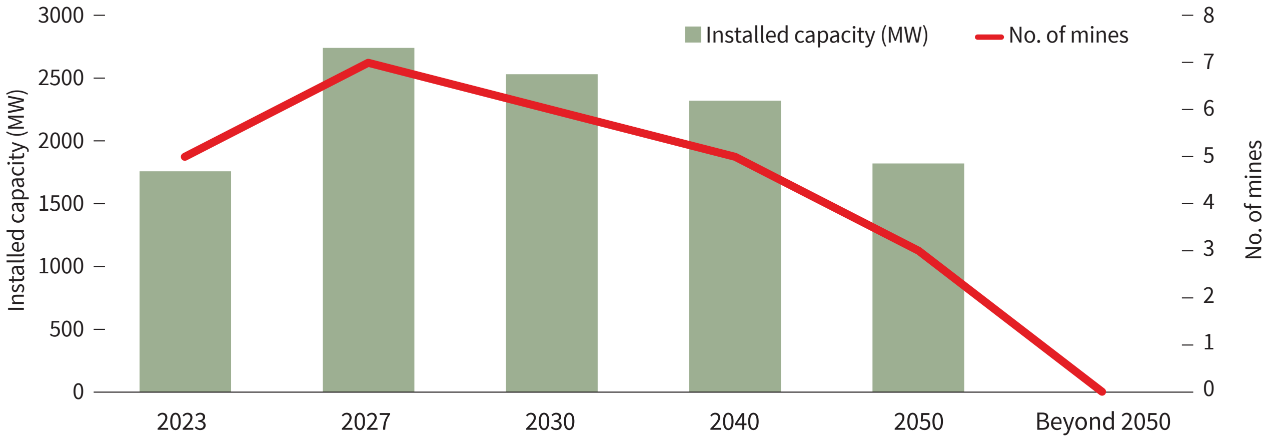
For TPPs, the phase-down schedule is only considered for utility plants. However, apart from the two units of the old Tenughat Thermal Power Station (TPS), there will be no major reduction in coal-based capacity, as the fleet is relatively young. Further, in 2027, the installed capacity will increase from 1780.3 MW to 2,740 MW due to capacity additions at TPS. The phase-down will start after 2040 and gradually happen over the next 15 years.

Table 3.8: Retirement schedule of TPPs in Bokaro

Name	Units	Installed capacity (MW)	Year of commissioning	Retirement year
Bokaro `A` TPS	1	500	2016	2051
Chandrapura	7	250	2009	2044
Chandrapura	8	250	2010	2045
Tenughat TPS	1	210	1994	2029
Tenughat TPS	2	210	1996	2031
Tenughat TPS new	1	660	2027	2062
Tenughat TPS new	2	660	2027	2062

Source: iFOREST based on data from Central Electricity Authority, 2021.
Note: The year of commissioning for Tenughat TPS New has been taken as 2027, based on official feedback; The year of retirement is assumed based on a 35-year planned life.

Figure 3.3: TPP retirement schedule for Bokaro



Source: iFOREST analysis

3.2.6 Cost of just transition

Considering all the factors mentioned above and the decadal phase-down scenario, the cost of just transition for the district is estimated to be ₹1,01,688 crore (US$ 12.7 billion). Of this, ₹41,437 crore (US$ 5.2 billion) or 40.7% of the total investments must be supported through grants and incentives.

Table 3.9: Just transition costs for Bokaro

Cost components	Total Investments		Grant and incentives	
	₹ crore	$ millions	₹ crore	$ millions
Coal mine reclamation and repurposing	9,565	1,196	9,274	1,159
Thermal power decommissioning and green repowering	8,576	1,072	4,077	510
Economic diversification	19,377	2,422	4,844	606
Green energy investments	45,474	5,684	4,547	568
Labour support and transition	7,187	898	7,187	898
Revenue substitution	541	68	541	68
Community resilience	8,529	1,066	8,529	1,066
Capacity building and governance	2,439	305	2,439	305
Total	**1,01,688**	**12,711**	**41,437**	**5,180**

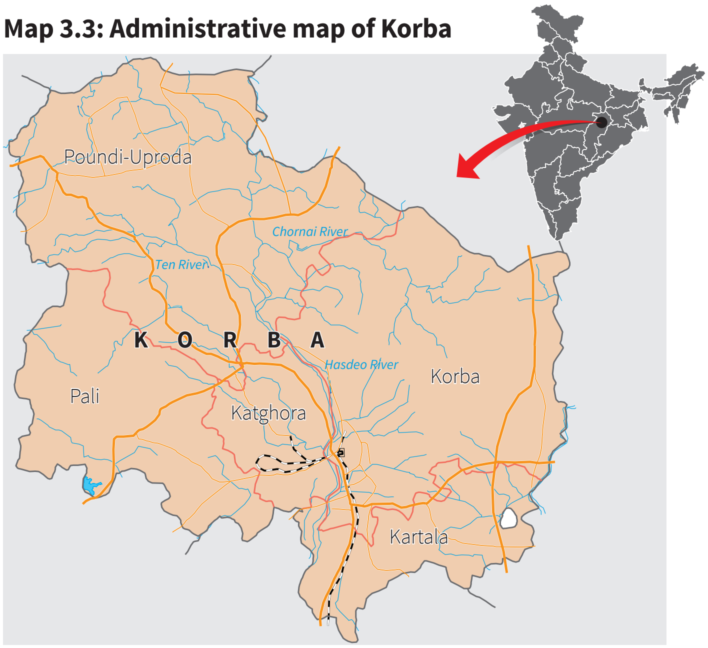
Source: iFOREST analysis

3.3 Korba

Korba is the second largest coal-producing district in India. In 2021-22, Korba produced 113 MT of coal.[76] In the preceding year, it was the topmost district with a production of 117 MT.[77]

3.3.1 District profile

Map 3.3: Administrative map of Korba



Korba district is spread across 714,544 ha and is administratively divided into five blocks, one municipal corporation and two *Nagar Palika Parishads*. The district's population is about 1.36 million (2021 estimates), with about 60% rural and 40% urban population.[78] The urban population is concentrated mainly in municipal areas adjoining the coal mines and TPPs.

The district's economy is heavily dependent on coal mining, which contributes to over 50% of the DDP. The other key industries besides coal mining are coal-based TPP and one aluminium plant. The other economic sectors in the district remain largely untapped and underdeveloped.

With respect to development indicators, nearly 32% of the district's population is multidimensionally poor. This is worse than the state average of 29.9% and the national average of 25%.[79]

Table 3.10: Share of economic sectors in DDP

Sector	Share in DDP (%)
Primary sector	**56.3**
Agriculture	4.8
Forestry	0.5
Fishery	0.6
Mining and quarrying	50.4
Secondary sector	**31**
Manufacturing	10.3
Construction	4.5
Electricity, gas, water	16.2
Tertiary/ Service sector	**12.7**

Source: iFOREST estimates based on Directorate of Economics and Statistics. Government of Chhattisgarh, 2007.

3.3.2 Coal context

Korba has 13 operational mines, of which five are OC and eight UG. However, only three OC mines – Gevra, Dipka and Kusmunda – account for nearly 95% of Korba's coal production. The eight UG mines are low-producing and are unprofitable.[80] The Southeastern Coalfields Limited (SECL), a central PSU, owns all the mines.

Besides the operational mines, four additional OC mines are expected to start operations by 2025-2027.[81] The district has only one closed mine, where the coal reserve has been exhausted.

Korba is also a thermal power hub of Chhattisgarh and is among India's top five coal-based power producers.[82] There are 11 grid-connected TPPs (26 units) with a combined capacity of 6,428 MW.[83] The TPPs are operated by PSUs such as the National Thermal Power Corporation (NTPC) Limited and private companies.

Linked to the coal mining and coal-based power sectors, there are also other industrial activities in Korba. These include five coal washeries (all operated privately) and many fly ash brick units (about 85 units, including registered and unregistered).[84] There is also an aluminium smelter operated by Bharat Aluminium Company Limited (BALCO).

3.3.3 Worker dependence

About 64,511 workers are employed in coal mining, TPPs and the coal-dependent industries in Korba. Among them, 33,672 are formal and 30,889 informal workers. The economy created by coal further employs around 105,159 induced workers.

Table 3.11: Worker dependence on coal in Korba

Category		Workers			
A.	**Direct Jobs**	**Departmental**	**Contractual**	**Informal**	**Total**
	Coal mining	11,936	64,49	7,056	25,441
	Thermal Power Plant	9,106		8,612	17,718
	Other coal-dependent industries	6,131		15,221	21,352
	Total	**27,173**	**6,449**	**30,889**	**64,511**
B.	**Induced Jobs**				**105,159**

Source: iFOREST analysis

3.3.4 Land availability for repurposing

About 15,875 ha of land is under coal mining in Korba, of which 8,858.5 ha is with OC mines and another 7,717.3 ha is with UG mines. Overall, about 8,017.7 ha of land can be available for repurposing. Additionally, over 1,000 ha of land is with the TPPs.

3.3.5 Phase-down scenario

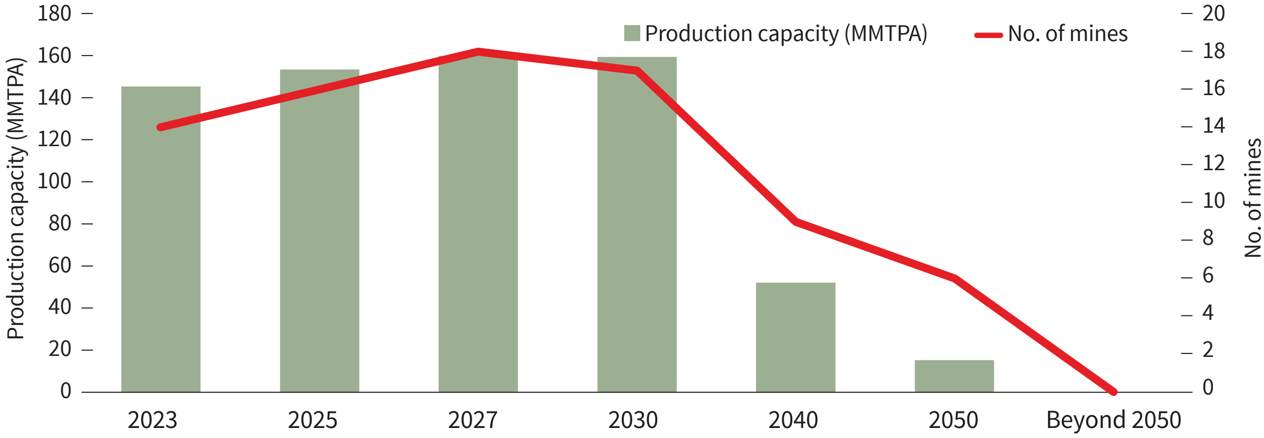
The coal phase-down for Korba considers both the operational and the upcoming mines. The coal production in the district will peak in 2027 at 159.79 MT. This will continue till the end of 2030. Between 2030-2040, the district will experience a major decline in coal production of about 107 MT due to the closure of eight mines. In the subsequent decade, there will be further closures with a reduction of 36.8 MT production capacity. In BAU Scenario, the last mine is likely to close in 2058.

Table 3.12: Coal mine closure schedule for Korba

Name of mine	Operation type	Production capacity 2022 (MTPA)	Status of operation	Year of retirement
Rajgamar (4 and 5)	UG	0.45	Operational	2028
Raniatari	UG	0.48	Operational	2031
Vijay West	UG	0.5	Operational	2031
Ambika OC	OC	1	Proposed	2031
Manikpur	OC	4.9	Operational	2035
Bagdeva	UG	0.76	Operational	2036
Gevra	OC	49	Operational	2037
Kusmunda	OC	50	Operational	2037
Balgi	UG	0.6	Operational	2037
Saraipalli	OC	1.4	Operational	2045
Surakacchar	UG	0.45	Operational	2047
Dipka	OC	35	Operational	2048
Singhali	UG	0.42	Operational	2049
Chotia II	OC	1	Operational	2055
Gidhimuri and Paturia	OC	5.6	Proposed	2055
Kartali OC	OC	2.5	Proposed	2055
Madanpur South	OC	5.4	Proposed	2057
Delwadih	UG	0.33	Operational	2058

Source: iFOREST based on data from Southeastern Coalfields Limited

Figure 3.4: Coal mine closure schedule



Source: iFOREST analysis

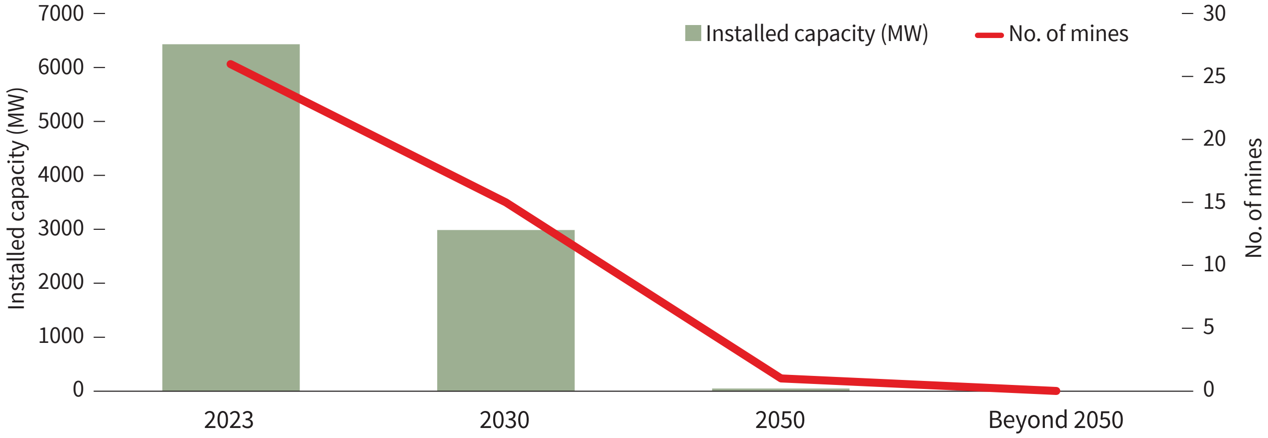
With respect to TPPs, Korba has a mix of ageing and new fleets. Currently, 11 units with 3,440 MW of capacity are already 35 years of age and can be retired before 2030. By 2050, almost all its remaining units – 14 units of 2,938 MW capacity – can be retired. Only one unit will remain operational, which can also be closed by 2051.

Table 3.13: Retirement schedule for TPPs in Korba

Name of Thermal power	Units	Installed Capacity (MW)	Year of Commissioning	Retirement Year
Korba West TPS	1	210	1984	2019
	2	210	1983	2018
	3	210	1985	2020
	4	210	1986	2021
	5	500	1986	2021
Korba STPS	1	200	1983	2018
	2	200	1983	2018
	3	200	1984	2019
	4	500	1987	2022
	5	500	1988	2023
	6	500	1989	2024
	7	500	2010	2045
DSPM TPS	1	250	2007	2042
	2	250	2007	2042
Pathadi TPP	2	300	2010	2045
	1	300	2011	2046
Kasaipalli TPP	1	135	2012	2047
	2	135	2012	2047
Chakabura TPP	2	30	2014	2049
Ratija TPS	1	50	2013	2048
	2	50	2016	2051
SVPL TPP	1	63	2011	2046
Swastik Korba TPP	1	25	2015	2050
Bandakhar TPP	1	300	2015	2050
Balco TPP	1	300	2015	2050
	2	300	2015	2050

Source: iFOREST based on data from Central Electricity Authority, 2021

Figure 3.5: TPP retirement schedule for Korba



Source: iFOREST analysis

3.3.6 Cost of just transition

The cost of just transition for Korba is estimated to be ₹2,68,076 crore ($33.5 billion). Of this, ₹1,13,190 crore ($14.14 billion) or 42.2% of the total investments, will have to be supported through grants and incentives.

Table 3.14: Just transition cost estimate for Korba

Cost components	Total Investments		Grant and incentives	
	₹ crore	$ millions	₹ crore	$ millions
Coal mine reclamation and repurposing	39,986	4,998	39,037	4,880
Thermal power decommissioning and green repowering	5,142	643	1,448	181
Economic diversification	53,452	6,681	13,363	1,670
Green energy investments	1,22,394	15,299	12,239	1,530
Labour support and transition	4,372	546	4,372	546
Revenue substitution	12,417	1,552	12,417	1,552
Community resilience	23,573	2,947	23,573	2,947
Capacity building and governance	6,742	843	6,742	843
Total	**2,68,076**	**33,510**	**1,13,190**	**14,149**

Source: iFOREST analysis

3.4 Angul

Angul is India's third largest coal-producing district, accounting for over 12% of the country's total production. In 2021-22, it produced 96.7 MT of coal.[85] The district is also among the key industrial areas of Odisha due to the presence of coal-based TPPs, steel and aluminium industries. Besides, Angul is also close to and well-connected with the state capital, which puts the district in an advantageous position for industrial investments.

3.4.1 District profile

Map 3.4: Administrative map of Angul

Angul district is spread across an area of 637,499 ha with eight administrative blocks, two municipalities and one notified area council. The district's population is about 1.4 million (2020-21)[86] , with 81% of the population living in rural areas. The urban population is largely concentrated near the coal mines, the steel and aluminium industries, and other induced economic activities.

The economy of Angul is dominated by mining and manufacturing. Manufacturing contributes to the highest share (32%) of the DDP. This is due to heavy manufacturing industries such as steel and aluminium. The share of mining is the second largest (21.6%). Cumulatively, mining, electricity, gas and water supply and manufacturing contribute 61% to the DDP, making the economy highly coal-dependent.

With respect to development indicators, about 24.5% of Angul's population is multidimensionally poor, which is slightly better than the India average of 25% and Odisha's average of 29.3%.[87]

Table 3.15: Share of economic sectors in DDP

Sector	Share in DDP (%)
Primary Sector	**31.1**
Agriculture	7.4
Forestry	1.6
Fishery	0.5
Mining and Quarrying	21.6
Secondary Sector	**42.8**
Manufacturing	32.1
Electricity, Gas and Water supply	7.2
Construction	3.6
Tertiary Sector	**26.1**

Source: iFOREST estimates based on Directorate of Economics and Statistics, Odisha, 2011-12

3.4.2 Coal context

Angul has nine operational mines, including eight OC and one UG mine.[88] All mines are operated by the PSU Mahanadi Coalfields Limited (MCL). The district currently has six closed mines, of which five are UG. All closed mines have exhausted their coal reserves.

Coal mining in Angul is set for rapid expansion due to capacity enhancement of current projects and the opening of new mines. Capacity expansion is proposed for three of its key mines, and seven new mines are at various stages of development, including commercial and captive mines.

Further, eight coal blocks have been allotted by the Ministry of Coal to various private and public bidders for development. Considering all these, Angul will likely produce over 300 MT of coal by 2033. [89]

Concerning coal-based industries, there are four coal-based TPPs, including two captive plants, with a combined capacity of 6,210 MW. Additionally, one 1,320 MW ultra-supercritical TPP is in the pipeline.

There is also an integrated steel plant of 6 MTPA production capacity (with a plan to increase production to 25 MTPA), an aluminium smelter and a planned aluminium park, a fertiliser plant, and several medium and small-scale industries.

3.4.3 Worker dependence

About 1,16,466 workers – 44,458 formal and 85,466 informal – are employed in coal mining, TPP and other coal-dependent industries. The economy created by coal further provides jobs to 78,671 induced workers in the district.

Table 3.16: Worker dependence on coal in Angul

Category		Workers			
A.	**Direct Jobs**	**Departmental**	**Contractual**	**Informal**	**Total**
	Coal mining	10,673	9,858	16,471	37,002
	Thermal Power Plant	938	3,600	13,660	18,198
	Other coal-dependent industries	19,389		41,877	61,266
	Total	**31,000**	**13,458**	**85,466**	**116,466**
B.	**Induced Jobs**				**78,671**
C.	**Pensioners**				**3,677**

Source: iFOREST analysis

3.4.4 Land availability for repurposing

About 14,997 ha is currently under coal mining in Angul, including closed mines. Of this, 9,254.8 ha of OC mine area will be available for repurposing. Additionally, 2,515 ha is with the TPPs and will be available for repurposing in the coming years.

3.4.5 Coal mine and TPP phase-down scenario

The operational and upcoming coal mines have been considered for constructing the phase-down schedule. The allocated blocks have not been included due to lack of data. As per the analysis, Angul's coal production will peak at 303.8 MT in 2027. Only one mine is likely to close by 2030.

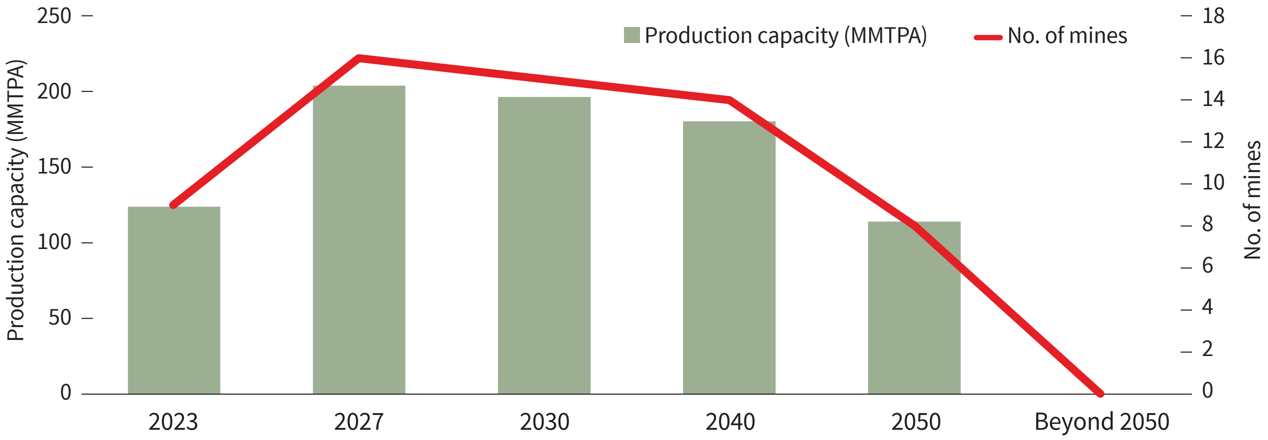
Between 2040-2050, the district will experience a decrease in production by 66 MT due to the reserve exhaustion of six mines. However, it will still have 114 MT of capacity operational, which will eventually phase out after 2050. The last mine will close in the 2060s in the BAU scenario.

Table 3.17: Coal mine closure schedule for Angul

Name of mine	Operation type	Production capacity, 2022 (MTPA)	Status of Operation	Year of closure
Jagannath	OC	7.5	Operational	2029
Lingaraj	OC	16	Operational	2040
Radhikapur East	OC	5	Upcoming	2044
Balaram	OC	8	Operational	2046
Ananta	OC	15	Operational	2046
Bhubaneswari	OC	28	Operational	2046
Nandira	UG	0.3	Operational	2050
Balabhadra	OC	10	Upcoming	2050
Mandakini B (Captive)	OC	20	Upcoming	2051
Bharatpur	OC	20	Operational	2052
Radhikapur West (Captive)	Mixed	6	Upcoming	2053
Utkal D, E (Captive)	OC	4	Upcoming	2053
Kaniha	OC	14	Operational	2054
Subhadra	OC	25	Upcoming	2054
Hingula	OC	15	Operational	2056
Naini	OC	10	Upcoming	2060

Source: iFOREST based on data from Mahanadi Coalfields Limited and Ministry of Coal

Figure 3.6: Coal mine closure schedule for Angul



Source: iFOREST analysis

With respect to TPPs, the phase-down schedule for Angul considers both operational utility and captive power plants and two units of an upcoming plant.

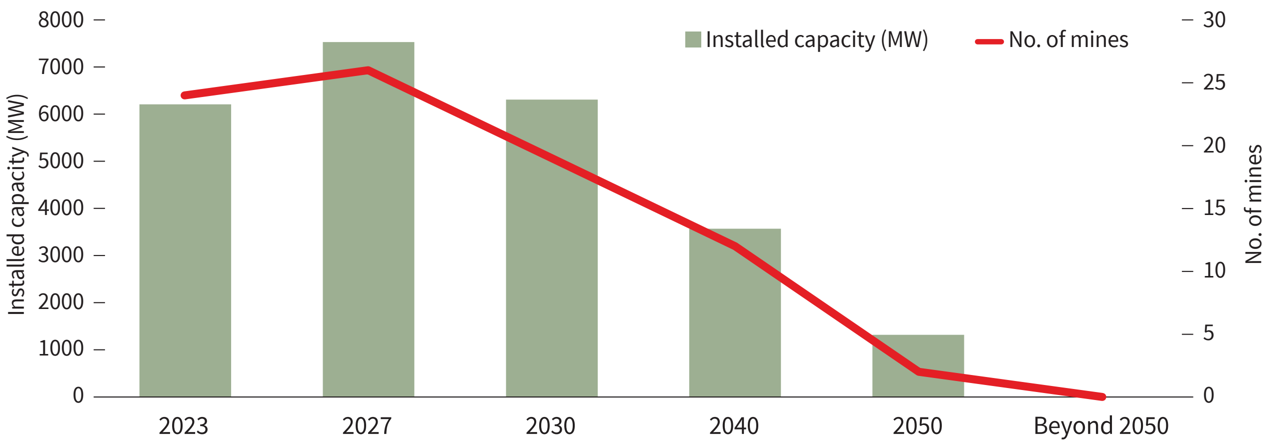
For TPPs, the biggest capacity reduction will occur post-2030. By 2040, about 2,740 MW of production capacity will be reduced due to the retirement of seven units. In the next decade, 10 units of 2,250 MW will retire. Only two units of the upcoming TPP will retire after 2050.

Table 3.18: Retirement schedule of TPPs in Angul

Name of Thermal power	Unit	Installed Capacity (MW)	Year of Commissioning	Closing Year
Talcher STPS	1	500	1995	2030
	2	500	1996	2031
	3	500	2003	2038
	4	500	2003	2038
	5	500	2004	2039
	6	500	2005	2040
National Aluminiun Company Limited (NALCO) TPP (Captive)	1	120	1986	2021
	2	120	1987	2022
	3	120	1987	2022
	4	120	1988	2023
	5	120	1989	2024
	6	120	1994	2029
	7	120	2002	2037
	8	120	2004	2039
	9	120	2009	2044
	10	120	2010	2045
Derang TPP	1	600	2014	2049
	2	600	2015	2050
Angul TPP (Captive)	1	135	2011	2046
	2	135	2012	2047
	3	135	2012	2047
	4	135	2012	2047
	5	135	2013	2048
	6	135	2013	2048
Talcher Ultra Supercritical	1	660	2027	2062
	2	660	2027	2062

Source: iFOREST based on data from Central Electricity Authority, 2021

Figure 3.7: TPP retirement schedule for Angul



Source: iFOREST analysis

3.4.6 Cost of just transition

Considering the analysis above, the cost of just transition for Angul district is estimated to be ₹388,312 crore ($48.5 billion). Out of this, 57.4% of the total investments will have to be supported through grants and incentives.

Table 3.19: Just transition cost estimate for Angul

Cost components	Total Investments		Grant and incentives	
	₹ crore	$ millions	₹ crore	$ millions
Coal mine reclamation and repurposing	68,243	8,530	67,246	8,406
Thermal power decommissioning and green repowering	8,735	1,092	4,666	583
Economic diversification	63,019	7,877	15,755	1,969
Green energy investments	125,583	15,698	12,558	1,570
Labour support and transition	6,327	791	6,327	791
Revenue substitution	61,124	7,641	61,124	7,641
Community resilience	42,985	5,373	42,985	5,373
Capacity building and governance	12,296	1,537	12,296	1,537
Total	388,312	48,539	222,958	27,870

Source: iFOREST analysis

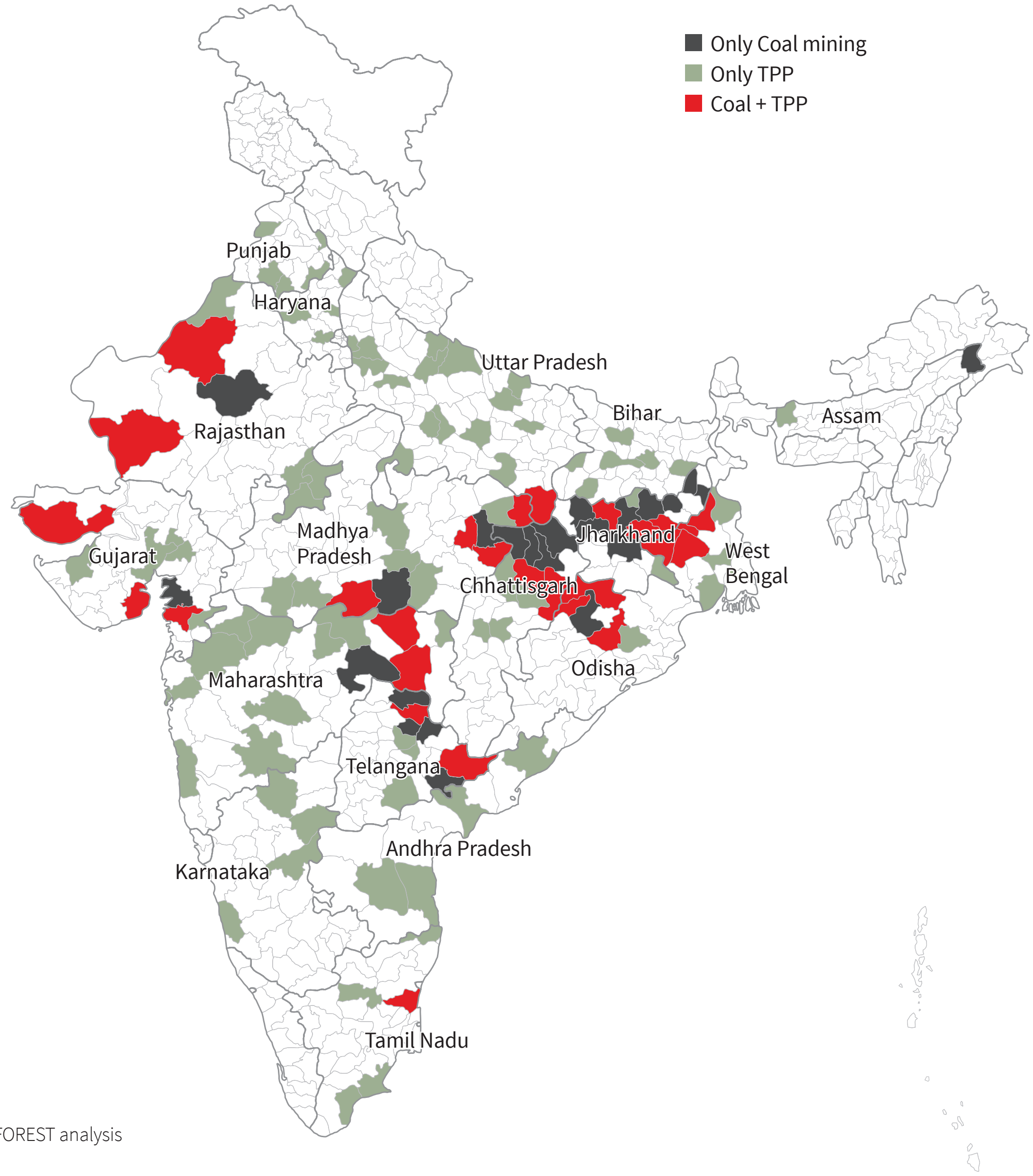
04

All India Cost Factors and Just Transition Cost

The study assesses the costs of transitioning away from coal by 2050 and includes all the existing coal mines and coal-based Thermal Power Plants (TPPs), excluding captive TPPs. The geographic distribution of these coal mines and TPPs is as follows:

- Twenty-eight districts have both coal mines and TPPs.
- Twenty-three districts have only coal mines.
- Eighty-six districts have only TPPs.

Map 4.1: Geographical distribution of coal mines and TPPs



Source: iFOREST analysis

As elaborated in Chapter 2, the costs of just transition have been derived based on the cost factors developed from the four district studies of India (see Chapter 3) and the review of just transition investment plans of three major coal/lignite regions outside India (Mpumalanga province in South Africa, Lusatian lignite mining area in Brandenburg, Germany, and Silesia province in Poland)[90]. The costs have been estimated separately for each of the three district categories, viz., those with coal mines and TPPs, those with only coal mines, and those with only TPPs. The key information of these districts relevant for estimating transition costs is summarised below.

Overall, the just transition costs cover 1,315 million tonne per annum (MTPA) capacity of coal mining and 237.2 Gigawatts (GW) of coal-based TPP capacity. The total mine lease land considered for rehabilitation and repurposing is 343,504 hectares (ha), and the land for green repowering of TPP sites is 124,789 ha. The total number of workers dependent on coal mining and coal-based industries requiring transition support is about 5.9 million.

Table 4.1: Scope of the all-India just transition cost estimation for coal mines and TPPs

No. of districts: 137			
Coal mines		TPPs	
Total production capacity (MTPA)	**1315**	**Total capacity (GW)**	**237.2**
OC mine	1134	Existing	208.65
UG mine	89.2	Upcoming	28.55
Mixed mine	91.8		
Total lease area (ha)	**343,504**	**Land area (ha)**	**124,789**
OC mine	212,599	Existing	109,795
UG mine	105,232	Upcoming	14,994
Mixed mine	25,673		
Workers (million)	**5.897**		
Formal	1.243		
Informal	2.397		
Induced	2.257		

Source: iFOREST analysis

Table 4.2: Capacity, land, and labour distribution in districts with coal mines and TPPs

No. of districts: 28			
Coal mines		TPPs	
Total production capacity (MTPA)	**1058.7**	**Total capacity (GW)**	**93.5**
OC mine	904.8	Existing	86.5
UG mine	63.8	Upcoming	7.0
Mixed mine	90.1		
Total lease area (ha)	**268,877**	**Land area (ha)**	**49,189.5**
OC mine	166,237	Existing	45,506.9
UG mine	78,929	Upcoming	3682.6
Mixed mine	23,712		
Workers (million)	**4.060**		
Formal	0.764		
Informal	1.476		
Induced	1.819		

Source: iFOREST analysis

Table 4.3: Capacity, land, and labour in districts with only coal mines

No. of districts: 23	
Total production capacity (MTPA)	**256**
OC mine	229
UG mine	25
Mixed mine	2
Total lease area (ha)	**74,626**
OC mine	46,363
UG mine	26,303
Mixed mine	1,961
Workers (million)	**1.009**
Formal	0.140
Informal	0.431
Induced	0.438

Source: iFOREST analysis

Table 4.4: Capacity, land, and labour in districts with only TPPs

No. of districts: 86	
Total capacity (GW)	**143.7**
Existing	122.2
Upcoming	21.5
Total land area (ha)	**75,599.3**
Existing	64,288.3
Upcoming	11,311.0
Workers (million)	**0.828**
Formal	0.339
Informal	o.489
Induced	NA

Source: iFOREST analysis
Note: Induced workers have not been estimated for the districts with only TPPs.

4.1 Just transition costs

4.1.1 Coal mine reclamation and repurposing

There are three major costs associated with coal mine reclamation and repurposing. These include costs for:

- Closure and reclamation.
- Repurposing of reclaimed land; and,
- Compensation to industries if the mines are closed before their economic life.

These costs are highly dependent on the type of mine, the life of the mine, the geology of the deposit, the mining plan and the final closure plan. To estimate the costs, the opencast (OC) mines were categorised into six types according to their stripping ratio, gradient, number and thickness of seams, and the volume of external dumps. No such categorisation was done for the underground (UG) mines due to data limitations. These costs were then applied to all mines in a district to estimate the district costs. From the district costs, the cost factors for the country were developed.

The total cost of reclamation and repurposing of coal mines in India will be about ₹9,07,268 crore ($113.4) billion. Over 97% of this cost must be borne through public sources as the escrow amount contributed by the coal companies is extremely low compared to the investments required for mine rehabilitation and repurposing.

Table 4.5: Costs for mine reclamation and repurposing

	Amount	
	₹ Crore	$ billion, MER
Total cost	9,07,268	113.4
Escrow amount	23,888	3.0
Grant and subsidy	8,83,380	110.4

Source: iFOREST analysis

4.1.2 Decommissioning of TPPs and green repowering

Decommissioning of TPPs and green repowering of the site will be important for economic diversification, ensuring energy security, and maintaining the economic vitality of the local communities. There are three major costs associated with it:

- Decommissioning (plant closure and demolition);
- Green repowering with solar energy and storage; and,
- Compensation to industrial facility owners for early closure.

As mentioned in Chapter 2, the cost factor for decommissioning has been developed based on the study of two power plants in the United States (US), two in India and one in South Africa. Studies done in India have been referred to for green repowering and compensation.

The total cost of TPP decommissioning and green repowering is estimated to be ₹3,29,651 crore ($41.2 billion). Nearly 40% of this will need to be in the form of grants and subsidies. Grants will be required for decommissioning and compensation, whereas subsidies will be needed for green repowering of the site.

Table 4.6: Cost of thermal power decommissioning and green repowering

	Amount	
	₹ Crore	$ billion, MER
Total cost	3,29,651	41.2
Grant and subsidy	1,31,668	16.5

Source: iFOREST analysis

4.1.3 Labour support and transition

Labour support and transition constitute a key cost component, as it is essential to ensure that no worker dependent on the fossil fuel industries is left behind in the energy transition process, and necessary transition and skilling support are provided to them to secure decent jobs in the low-carbon economy. The workers to be supported not just include the departmental employees engaged in coal mining and TPPs but also include contractual workers who work with minimum social security, the informal workers who work without any social security, and those workers who are part of the local induced economy, deriving livelihood from the opportunities induced by the coal-based economy.

The key costs for labour support and transition include:

- Retraining and reemployment;
- Severance package; and,
- Transition support.

While pension is often a major liability of the employers, it has been excluded from the current calculations as it is ensured for the formal workforce. The costs also exclude the investments required in foundational education and training of the new generation, as this is part of the normal developmental investment from the exchequer.

The cost factors, based on various combinations of worker type, age, place of employment, etc., are described in Section 2.3.3. Based on this, the total cost of labour support and transition is estimated at ₹1,73,665 crore ($21.7 billion). Most of this will be supported by public funds.

Table 4.7: Cost of labour support and transition

	Amount	
	₹ Crore	$ billion, MER
Total cost	1,73,665	21.7
Grant and subsidy	1,73,665	21.7

Source: iFOREST analysis

4.1.4 Economic diversification

In most of the coal-dependent regions in India, a significant share of the District Domestic Product (DDP) comes from coal mining, TPPs and other coal-based industries, such as steel, aluminium, or cement.[91] Therefore, investments in economic diversification are essential to create alternate income opportunities, boost jobs, ensure green growth, and substitute government revenue.

The greatest opportunity for economic diversification is to use the reclaimed coal mine and TPP land for green energy and industries. This would entail investments in new businesses and support for green businesses, innovations, and start-ups. The cost factors have been developed based on a robust review of sub-national policies and plans in India, Europe and South Africa.

The costs of economic diversification (excluding the investments in green energy, which is also a component of economic diversification) are the biggest cost of just transition in India. An estimated ₹17,98,991 crore ($225 billion) would be needed to diversify the economy in the fossil fuel-dependent regions. About 38.5% of these will have to come from public sources such as grants and subsidies.

Table 4.8: Cost of economic diversification

	Amount	
	₹ Crore	$ billion, MER
Total cost	17,98,991	224.9
Grant and subsidy	6,92,166	86.5

Source: iFOREST analysis

4.1.5 Community resilience

Building community resilience is critical for a just transition as most fossil fuel regions in India, particularly the coal mining districts, have poor socio-economic indicators, limiting their capacity to transition.

While investments in physical and social infrastructure are being made by the national and sub-national governments to build resilience, this will not be sufficient as even developed countries of Europe are investing additional resources in community resilience as part of their transition investments.[92]

However, there is no established methodology to estimate the community resilience costs. For example, the three sub-national just transition investment plans reviewed for this study (the plans for Mpumalanga province of South Africa, Lusatian lignite mining area in Brandenburg, Germany, and Silesia province of Poland) suggest that the costs of community resilience more often have been determined through negotiations or as investments in ready-to-execute projects. As explained in Section 2.3.5, various community resilience costs have been assumed to be a percentage of the total just transition cost, excluding the green energy investments. These percentages have been derived from the three sub-national just transition investment plans. Most of these investments will have to be supported through public funds.

Table 4.9: Community resilience cost

	Amount	
	₹ Crore	$ billion, MER
Total cost	6,78,887	85
Grant and subsidy	6,78,887	85

Source: iFOREST analysis

4.1.6 Green energy investments

Currently, the fossil fuel-dependent regions in India are not attracting investments in renewable energy (RE) due to multiple factors, including the fact that fossil fuel-based energy is meeting their needs. However, as coal mines and TPPs start phasing down, these regions will need to install and scale up RE to maintain their energy security and ensure economic vitality and quality of life.

To estimate the green energy investment needs, a green energy equivalency factor has been used. The green energy equivalency factor is the amount of RE and storage required to replace the electricity services provided by the existing and upcoming TPPs. The cost factors for green energy investments are given in Section 2.3.6.

The total green energy investments required to replace the existing and upcoming TPPs (total 237.2 GW) is estimated to be ₹40,29,275 crore ($503.7 billion). This excludes investments needed for repowering TPP sites, which has been included in the cost component' decommissioning and repowering of TPP'. If the repowering costs are included, the total green energy investment will be $531 billion, accounting for 51.5% of the total transition costs.

For green energy, investments will primarily be made by public and private companies, and the requirement of grants and subsidies will be about 10% of the total investments. This is similar to what is currently being given by the coal-dependent states to promote RE but for a limited capacity. For large-scale green energy installation, financial support, over and above what is being given by the state and the central government, would be required.

Table 4.10: Green energy investments

	Amount	
	₹ Crore	$ billion, MER
Total cost	40,29,275	503.7
Grant and subsidy	4,02,927	50.4

Source: iFOREST analysis

4.1.7 Revenue substitution and energy price support

Coal companies contribute significantly to the central and state exchequer through taxes, royalties, and cess. In addition, they also directly contribute to socio-economic development by contributing to the District Mineral Foundation (DMF) and making investments as part of their Corporate Social Responsibility (CSR). If coal mines are closed before the end of their economic life, these revenues will also cease prematurely and need to be substituted.

The cost of revenue substitution is calculated as the total revenue foregone due to the closure of coal mines by 2050. This has been estimated by multiplying the foregone production with the current rates of royalty, coal cess, and other taxes, assuming that the rates would remain unchanged.

On the other hand, energy price support is the subsidy that consumers get in fossil fuel areas and will need to be substituted in case of a shift to clean energy. This cost, however, has not been estimated due to inadequate data.

The total revenue substitution required due to the closure of mines by 2050 is estimated to be ₹1,78,575 crore ($22.3 billion). This can be replenished by taxes collected from new businesses and partly by external support. In fact, economic diversification, including investments in green energy and green industries in the fossil fuel regions, will be crucial for revenue substitution.

Table 4.11: Revenue substitution

	Amount	
	₹ Crore	$ billion, MER
Total cost	1,78,575	22.3

Source: iFOREST analysis

4.1.8 Planning, capacity building and governance

Building stakeholder capacity and developing appropriate governance mechanisms will be essential to ensure that just energy transition planning is inclusive and the investments are suited to the needs of the impacted workers, communities and regions. This will require building the administrative and technical capacity of the state and local government institutions and the capacity of members of local institutions (such as Panchayati Raj Institutions), local communities, and civil society groups. The cost of planning, capacity building, and governance is estimated to be 2.5% of the total just transition investments.

The estimated cost for planning, capacity and governance is ₹2,17,208 crore ($27 billion). This percentage has been derived from the review of the three sub-national just transition investment plans as mentioned above. This investment will have to be supported through grants.

Table 4.12: Planning, capacity building and governance costs

	Amount	
	₹ Crore	$ billion, MER
Total Cost	2,17,208	27
Grant and subsidy	2,17,208	27

Source: iFOREST analysis

4.2 All India just transition costs

The total cost of just transition for phasing out the existing coal mines and coal-based TPPs in India will be about ₹83.1 lakh crore ($1039 billion) over the next three decades (until 2050). About 40% of this cost will have to be supported through grants and subsidies. However, the cost estimates are conservative. It does not include the investments needed to set up new green energy plants and infrastructure to meet the country's future energy demand, estimated to be in trillions of dollars. In addition, the costs of transitioning industries where coal is directly used, such as in steel and cement sectors, are excluded. Moreover, the cost of just transition will escalate further, as at least till 2030, India will add new TPPs and coal mines to meet the country's increasing energy demand.

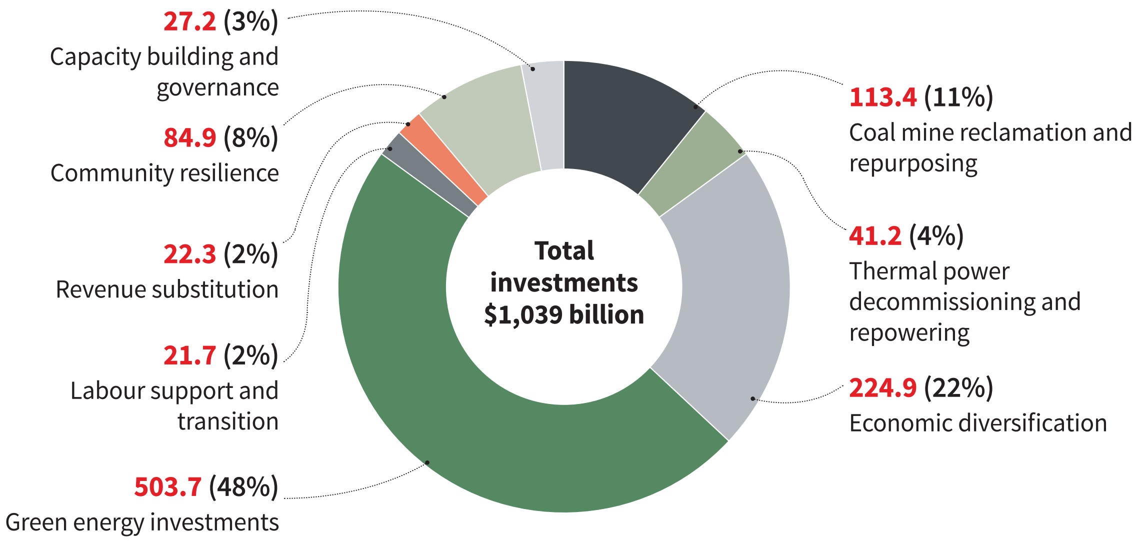
Table 4.13: Just transition investments, grants, and subsidies

Cost components	Investments		Grants and subsidies	
	₹ Crore	$ billion, MER	₹ Crore	$ billion, MER
Coal mine reclamation and repurposing	9,07,268	113	8,83,380	110
Thermal power decommissioning and green repowering	3,29,651	41	1,31,668	16
Economic diversification	17,98,991	225	6,92,166	87
Green energy investments (excluding green repowering of TPP)	40,29,275	504	4,02,927	50
Labour support and transition	1,73,665	22	1,73,665	22
Revenue substitution	1,78,575	22	1,78,575	22
Community resilience	6,78,887	85	6,78,887	85
Capacity building and governance	2,17,208	27	2,17,208	27
Total	83,13,520	1,039	33,58,477	420

Source: iFOREST analysis

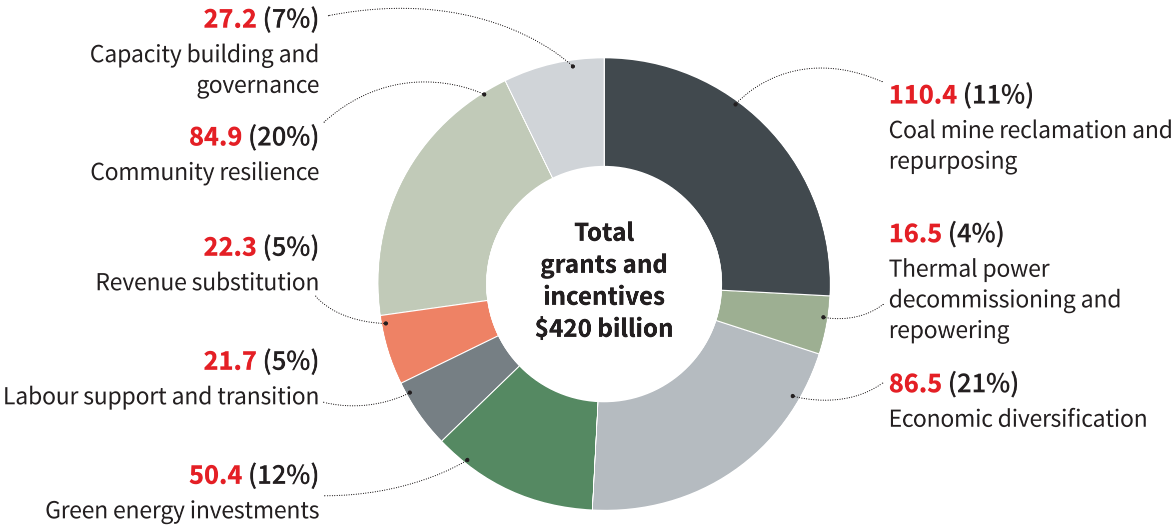
The highest cost will be incurred for green energy investments (48.5% of total cost), followed by economic diversification (21.6%), coal mine reclamation and repurposing (11%) and community resilience (8.2%). The green energy-related and non-energy related cost components almost have an equal share in the total just transition cost.

Figure 4.1: Total cost of just transition in India



On the other hand, the highest share of grants and subsidies would be required for coal mine reclamation and repurposing (26% of total grants and subsidies), economic diversification (21%), community resilience (20%) and green energy investments (12%). Overall, the non-energy related cost components will account for about 85% of the total grants and subsidies.

Figure 4.2: Total grants and subsidies required for just transition in India



Spatially, the costs incurred will differ widely between coal districts (many of which also have TPPs) and non-coal districts (where only TPPs are located). Coal districts alone account for two-thirds of the total cost for just transition ($695 billion).

Table 4.14: Just transition cost for coal and non-coal districts

Cost components	Coal districts		Non-coal districts	
	₹ Crore	$ billion, MER	₹ Crore	$ billion, MER
Total	55,57,439	695	27,56,080	345

Source: iFOREST analysis

05

Conclusion

In the last few years, just transition has emerged as an essential fulcrum of climate action. In response, many countries have introduced laws, policies, and plans to phase-down coal mining and coal power while addressing the adverse impacts on workers and communities and fostering green growth in fossil fuel-dependent regions. For instance, Germany enacted 'The Act to Reduce and End Coal-Powered Energy and Amend Other Laws' (Coal Exit Act) and the 'Structural Development Act' in 2020 to phase out coal-powered electricity by 2038. To achieve this, the country has allocated more than $55 billion to close coal and lignite mines and thermal power plants (TPPs) and support the development of regions affected by the transition.

At the sub-national level, states or provinces in many countries have enacted specific laws, policies, and investment plans for a just transition. A prime example is the Territorial Just Transition Plans (TJTP) developed by the European Union (EU) member states and supported through the EU's Just Transition Mechanism and Just Transition Fund (JTF). These plans specify phase-down targets and corresponding investment requirements.

For example, the TJTP for the Lusatian lignite mining region in Brandenburg, Germany, aims to retire approximately 1,860 megawatts (MW) of lignite-based generation capacity by 2028 (around 55% of the current capacity), reduce lignite production capacity by 13 million tonne per annum (MTPA), a decrease in production capacity by about 37%, and support 9,536 workers likely to be affected by the closures. Correspondingly, the TJTP allocates $879 million for supporting various just transition measures. Similar TJTPs have been developed for other coal/lignite regions by other EU member states.

However, it is not only in the global North where just transition policies and plans are being developed. In the global South, Just Energy Transition Partnerships (JET-Ps) have emerged as a catalyst for developing just transition policies and plans in some large coal-dependent countries. The JET-P, promoted by G7 countries, is offering financial support to developing countries to phase-down coal-based power. As part of a JET-P deal, South Africa has formulated 'A Framework for Just Transition' and prepared its Just Energy Transition Investment Plan (JET-IP) worth $98.7 billion. Besides South Africa, Indonesia and Vietnam have signed JET-P deals with developed countries to phase-down coal power.

But the JET-Ps have been criticised by many. The primary critique is that these are more "energy transition" plans than "just energy transition" plans, as most investments are allocated for developing new clean energy infrastructure, leaving scant resources for the non-energy components of the transition. In South Africa, for example, over 90% of the JET-IP budget is allocated for developing green energy infrastructure, with minimal funds reserved for worker and community transition. The other critique is that the G7 countries are primarily offering loans (some concessional and some at the market rate) and limited grants, potentially exacerbating the debt problems of developing nations.

Presently, G7 countries are encouraging India to sign a JET-P deal to phase-down coal mining and coal-based TPPs. However, India has not yet agreed to a deal, mainly because there is no consensus within the country on the nature of a JET-P deal. There is also a need for more clarity on what a just transition would entail and what it would cost.

This lack of clarity arises from the absence of an empirical method to estimate the cost of a just transition. The just transition investment plans of countries like Germany and Spain and TJTPs of the EU are the result of negotiation rather than empirical formulae. Thus, there is an urgent need for an empirical basis to determine the cost of a just transition, which would assist countries in creating just transition plans and fostering global partnerships. The current study is an endeavour to fulfil this necessity.

The study introduces a novel approach to estimating the cost of a just energy transition at sub-national and national levels. This methodology can also calculate the cost of a just transition for a specific mine or a power plant after suitable modifications.

The result

- The cost of just transition in India, which involves phasing out the existing coal mines and power plants by 2050, supplying equivalent clean energy, and enabling a smooth transition of workers and communities, is more than a trillion dollars. This cost does not include the investments needed to set up new green energy plants and infrastructure to meet the country's future energy demand, which is estimated to be in trillions of dollars.[93] In addition, the costs of transitioning industries where coal is directly used, such as in steel and cement sectors, are excluded. Moreover, the cost of just transition will escalate further, as at least till 2030, India will add new TPPs and coal mines to meet the country's increasing energy demand.
- The total cost of just transition can be divided into two parts – the 'clean energy' costs and the 'non-energy' costs. The clean energy cost, which is the cost to build green energy plants to supply equivalent energy services to the current coal-based TPPs, is about 52% of the total cost. The non-energy cost, which is the cost to diversify the economy, support workers and communities, etc., is about 48%. So, the energy and non-energy part of the transition costs is about the same.

- While close to 60% of transition costs will be in the form of investments, about 40% will have to come from public sources, such as grants and subsidies. Most of these grants and subsidies will be required for the non-energy components. So, the burden on the public purse is about $400 billion or about $15 billion annually until 2050. This must come from either domestic sources or international support.
- India can start just transition investments from local resources such as the District Mineral Foundation (DMF) and Corporate Social Responsibility (CSR) funds. For example, to date, over ₹29,707 crore ($3.7 billion) has been accrued in DMF by contributions through coal and lignite mining companies.[94] This money can be used for some of the 'non-energy' investment components of the just transition, such as economic diversification, green energy investments (particularly decentralised renewable energy to improve access), workforce development measures, increasing community resilience by augmenting social infrastructure, etc. Such investments also align with the objective and scope of these funds. However, given the substantial investments necessary, this will only be sufficient for initial interventions, and new sources of funds will be required for implementing a comprehensive transition plan.
- Though India's Long-Term Low-Carbon Development Strategy (LT-LCDC) has rightly identified the need for international finance, the current financial mechanism, including JET-P, will not be able to support a just transition in India because the size of the deal and its grant component is relatively small compared to the requirements.

India, being the second largest coal economy after China, faces significant challenges in undertaking a just energy transition. With an industry that is approximately six times larger than Germany's and four times more expansive than South Africa's, the scale of India's coal sector is truly substantial. To put it into a more concrete perspective, Odisha and Maharashtra's combined coal and power sector are equivalent in size to the entirety of South Africa's coal sector.

Given this context, the costs associated with India's just transition will be much higher than countries like South Africa, Indonesia, and Vietnam, which have signed the JET-P deals, and countries of the global North. For example, the Government of Germany has allocated €40 billion ($44.8 billion) to create jobs, boost regional economies, and develop physical and social infrastructure in the coal/lignite regions under the Structural Development Act (2020).[95] Compared to this, a conservative estimate of economic diversification costs for India's coal and TPP regions is about $225 billion. Besides, about $85 billion will be required for physical and social infrastructure and building community resilience.

Considering the scale of financial resources that will be necessary, it is also clear that just transition will require substantial support from both domestic and international sources. Domestic finance will primarily come from the budget allocations of the central and state governments and special funds such as DMF, CSR, coal cess, and private sector investments. International financing could involve a variety of mechanisms, such as grants and loans through bilateral/multilateral collaboration, from international development institutions, foreign direct investment, and perhaps mechanisms such as carbon markets. All these sources will have to be leveraged to meet the financial requirements.

In conclusion, India's just transition is not merely an environmental endeavour but a profound socio-economic transformation. This transition will require large-scale financial resources, comprehensive strategies, and forward-thinking policies. As the world's second largest coal economy, the journey towards a greener and more sustainable future will undeniably present unique challenges for India. However, with careful planning and international collaboration, this transition also offers an opportunity to promote green growth, transform the economy of some of the country's poorest regions, and improve the lives of millions.

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