JUST ENERGY TRANSITION IN MAHARASHTRA

An Opportunity for Green Growth and Green Jobs

iFOREST
INTERNATIONAL FORUM FOR ENVIRONMENT, SUSTAINABILITY & TECHNOLOGY

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An Opportunity for Green Growth and Green Jobs

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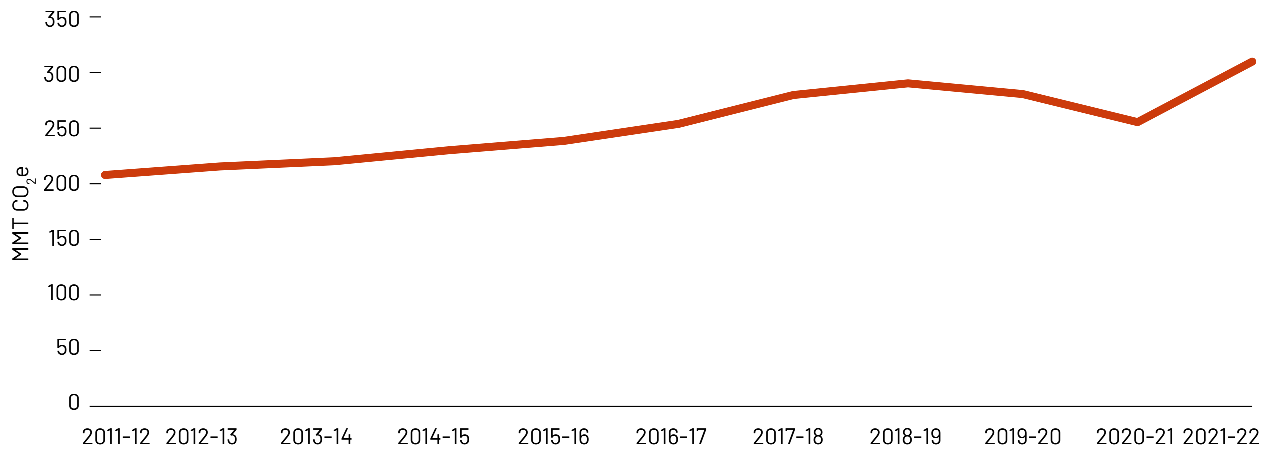
List of Abbreviations

ACM	Auto Component Manufacturer
BAT	Best Available Technologies
BEE	Bureau of Energy Efficiency
CAGR	Compound Annual Growth Rate
CCO	Coal Controller Organisation
CDQ	Coke Dry Quenching
CCUS	Carbon Capture, Utilisation and Storage
CEPI	Comprehensive Environmental Pollution Index
CGST	Central Goods and Service Tax
CIL	Coal India Limited
CM	Continuous Miner
CNG	Compressed Natural Gas
CO_2e	Carbon dioxide equivalent
CSR	Corporate Social Responsibility
DMF	District Mineral Foundation
EAF	Electric Arc Furnaces
EIA	Environmental Impact Assessment
EV	Electric Vehicles
FCBTK	Fixed Chimney Bull Trench Kiln
FGD	Flue Gas Desulfurization
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GSDP	Gross State Domestic Product
GVA	Gross Value Added
ICE	Internal Combustion Engine
ICPPA	Indian Captive Power Producers Association
IGBT	Insulated Gate Bipolar Transistors
IGST	Integrated Goods and Service Tax
LHD	Low Haul Dump Machine
LPG	Liquefied Petroleum Gas
Mahagenco	Maharashtra State Power Generation Co. Ltd.
MDO	Mine Developer and Operator
MSEB	Maharashtra State Electricity Board
MSME	Micro, Small and Medium Enterprises
NATRIP	National Automotive Testing and R&D Infrastructure Project
NIT	Notices Inviting Tenders
NMEEE	National Mission for Enhanced Energy Efficiency
NZS	Net Zero Scenario
OB	Overburden
OC	Opencast
OEM	Original Equipment Manufacturer
PAT	Perform Achieve and Trade
PLF	Plant Load Factor
PNG	Piped Natural Gas
PWD	Public Works Department
RE	Renewable Energy
REB	Resource-Efficient Bricks
RPO	Renewable Purchase Obligations
SDS	Sustainable Development Scenario
SEC	Specific Energy Consumption
SGST	State Goods and Service Tax
SPCB	State Pollution Control Board
SPM	Suspended Particulate Matter
STPS	Super Thermal Power Station
TPP	Thermal Power Plant
TRL	Technology Readiness Level
TRT	Top-Pressure Recovery Turbines
TSR	Thermal Substitution Rate
UG	Underground
VRS	Voluntary Retirement Scheme
VSBK	Vertical Shaft Brick Kiln
WCL	Western Coalfields Limited

Summary for Stakeholders

Maharashtra, as a key industrial state, is crucial in steering the country towards an accelerated and just energy transition, establishing the groundwork for a net zero emissions economy. The emission of the state has increased at a compound annual growth rate (CAGR) of 4.1% over the last decade, with the state currently accounting for 10% of India's GHG emissions (310 million metric tonnes of CO_2e). About two-thirds of the emission comes from five key sectors - thermal power plants (TPPs), road transport, iron and steel, cement, and brick. With the third-largest number of factories in the country, including the largest automobile industry, the state needs a comprehensive cross-sectoral approach to decarbonise its economy, augment opportunities for green jobs, and ensure green growth.

Figure 1: GHG emissions in Maharashtra



Source: iFOREST analysis

A. Just Transition Landscape: Sectors, Geographies and Dependency

1. Coal Transition

Over the next decade, the state is set to undergo a gradual reduction of coal mining activities, highlighting the necessity for a just transition strategy that safeguards economic development and employment in the impacted regions and communities.

COAL MINING

Maharashtra is India's sixth-largest coal-producing state, accounting for over 7% of the country's coal production. The state has a coal production capacity of 87 million metric tonnes per annum (MMTPA) and produced about 63 MMT of coal in 2022-23. The sector supports over 89,000 formal and informal jobs (29,087 formal jobs and at least twice informal) in the three mining districts—Chandrapur, Nagpur, and Yavatmal.

Coal mining is facing challenges of economic unviability, resources exhaustion and closures.

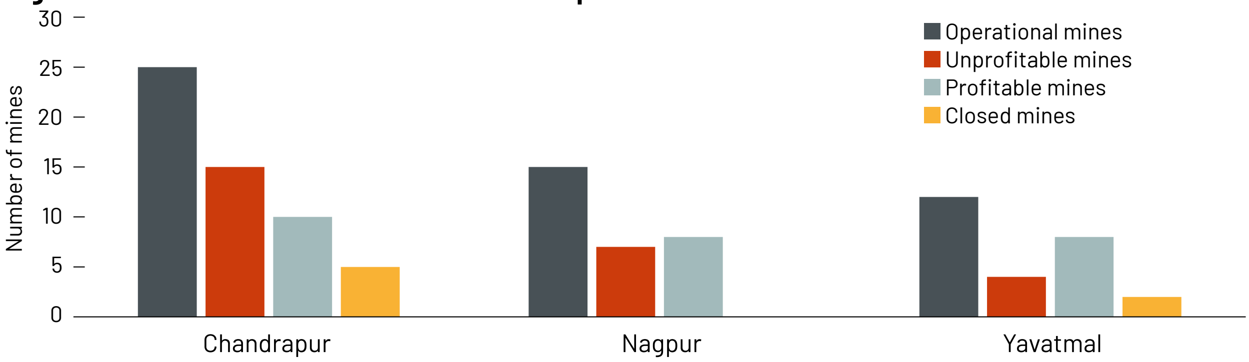
Table 1: Status of operational mines

Mine type	Number of mines	Production capacity (MMTPA)	Formal workforce
Opencast*	37	83.6	21,757
Underground	15	3.3	7,330
Total	52	86.9	29,087

Source: Western Coalfields Limited, April, 2023; Latest environmental clearance letters of mines. *Includes two mixed mines.

The coal sector is facing challenges of economic unviability, resource exhaustion (old mines), and closures. At least half of the operational coal mines in the state are unprofitable, and one-fourth will soon exhaust their resources. Consequently, there are a significant number of mines that are already closed. Further, over 60% of the currently operational mines will close in the next 10 years due to such reasons.

Figure 2: District-wise status of closed and unprofitable mines



Source: iFOREST analysis based on information obtained from Western Coalfields Limited, April, 2023. Financial status of mines provided for 46 mines out of 52. Mines for which financial details were not shared have been considered as profitable.

A just transition planning is urgently needed for unprofitable and end-of-life mines.

The unprofitable and old mines, however, have high income dependence considering formal and informal workers and the induced economy in mining areas. For example, the unprofitable mines collectively account for about half of the formal workforce (about 15,000 workers) of the Western Coalfields Limited (WCL), the public sector undertaking (PSU) operating in Maharashtra.

Therefore, planning a just transition of the unprofitable and end-of-life mines is urgently required in Maharashtra. Overall, transition planning will be necessary for at least 32 mines (with a total capacity of over 40 MMT) through intervention by the coal company, as well as the state government.

COAL-BASED THERMAL POWER

Maharashtra has the largest coal-based thermal power capacity in India which is 11.3% of the country's total. The total capacity of utility-scale coal-based TPPs is about 24 gigawatts (GW). Besides, the state also has a significant captive power capacity of 3GW, which accounts for about 7.4% of India's total captive power capacity.

The sector formally employs about 45,570 people, out of which over 95% are with the utility plants. The informal jobs are likely to be much higher.

Coal power plants are the single-largest source of GHG emissions accounting for 42% of the total state emissions.

Table 2: Coal-based thermal power planst

Type	Capacity (MW)	Formal workforce
Utility	23,856	43,561
Non-utility (captive)	3,332	2,099
Total	27,188	45,570

Source: Capacity data based on report of Central Electricity Authority, 2023. Worker numbers as provided for NTPC plants, Chandrapur STPS, and MAHAGENCO operated plants by respective companies, for others, estimated as per CEA thumb rule of 0.63 persons per MW of installed capacity.

While Maharashtra has a relatively younger coal power fleet, about 20% of the units are over the age of 25 years. Many of these units are also inefficient with low plant load factor (PLF below 60%). There are also challenges to environmental compliance with the old units as most of them do not have Flue Gas Desulphurisation (FGD) systems. In the next 10 years, therefore, about one-fourth of the capacity will likely be decommissioned due to techno-economic and environmental factors.

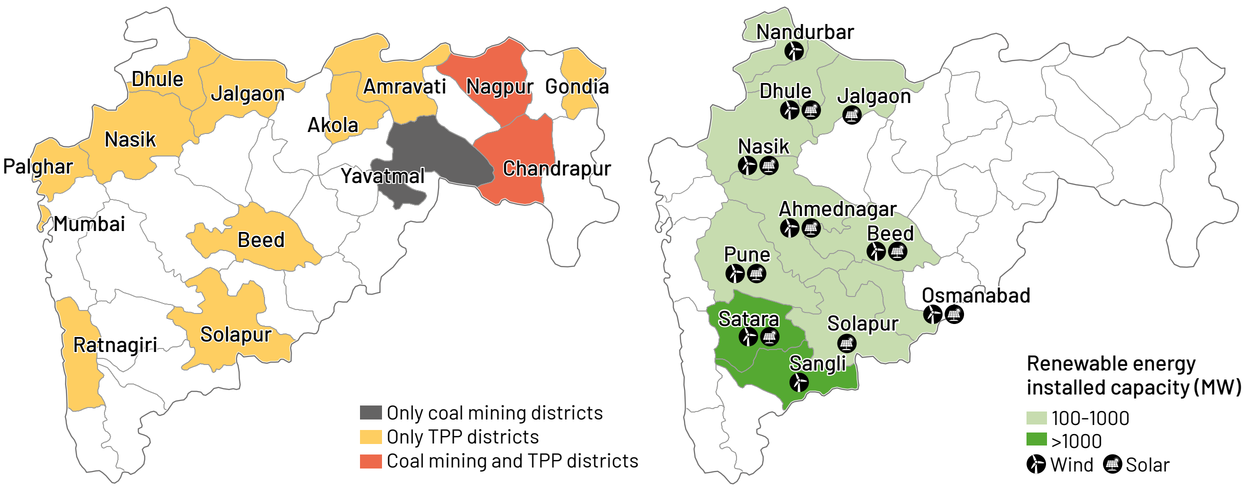
25% of the coal-based capacity is likely to be decommissioned in the next 10 years.

Transition hotspots, challenges and opportunities

Hotspot: The districts of Chandrapur, Nagpur, and Yavatmal are most vulnerable to coal transition due to the concentration of old, economically unviable, and closed mines in these districts. Furthermore, most of the old TPPs are in Chandrapur and Nagpur districts.

Challenges: There is a regional imbalance in the growth of renewable energy (RE) in Maharashtra. RE is growing in the Southern and Central districts, while coal transition districts are mainly in the Northern and Eastern parts.

Figure 3: Renewable energy disparity



Source: iFOREST analysis

Opportunities: There are two key opportunities for just transition in the coal districts. These include repurposing of land available with coal mines, and repurposing of the retired thermal power units.

i. Repurposing of land available with coal mines provides a crucial opportunity for economic diversification, green growth, and green jobs in the coal districts.

Over 42,000 hectares (ha) of land is currently available with operational and closed coal mines in Maharashtra. Besides, over 13,000 ha of land is available with the TPPs. A large proportion of this land (about 50%) is available in the blocks that need to start addressing transition challenges starting this decade.

An immediate opportunity lies in repurposing the land that is available with the unprofitable mines after their scientific closure and reclamation. This land is prime for local economic diversification, RE development, green industry development, and job creation.

About 20,000 ha of land is available with the opencast and underground mines that are likely to be closed by 2030.

Table 3: Land with unprofitable coal mines

District	Total number of operational mines	Unprofitable mines			Available land (ha)		
		Total	UG	OC	Total	UG	OC
Chandrapur	25	15	8	7	11,016	5,210	5,806
Nagpur	15	7	6	1	4,329	3,981	348
Yavatmal	12	4	1	3	5,224	1,697	3,528
Total	52	26	15	11	20,569	10,888	9,682

Source: iFOREST analysis based on information obtained from WCL, 2023, and environmental clearance letters of mines.

ii. Repurposing the retired thermal power units can support green energy and green industry development in coal areas.

Maharashtra also has 14 TPP units with a cumulative capacity of 2.7 GW that were retired between 2016 and 2021 for techno-economic reasons. Besides, 4.4 GW (involving 15 units) of the coal fleet is likely to retire in the next 10 years.

Repurposing the retired units into industrial parks, green hydrogen plants, and RE development provides significant opportunities for supporting green energy and industry development, creating jobs, and strengthening state-level climate action.

Overall, Maharashtra will require a comprehensive strategy urgently to deal with the coal transition in the next 10 years.

2. Oil and Gas Transition

The transition to electric vehicles and innovation in non-conventional fuels are some of the early triggers to plan for the transition of the oil and gas sector.

Maharashtra is the second largest consumer of petroleum products, accounting for 10.5% of India's consumption. The state is also the second largest consumer of petrol and diesel, accounting for 10.9% and 10.8% of the country's total consumption, respectively.

The state has two refineries with 21.5 MMTPA oil refining capacity which account for 8.6% of the country's refining capacity. Besides the state has about 7,256 petrol pumps which is over 9% of India's total.

Maharashtra is the second largest petrol and diesel consuming state in India.

For the natural gas sector, the distribution segment involving the supply of compressed natural gas (CNG), piped natural gas (PNG), and liquefied petroleum gas (LPG) has significance from a just transition perspective. There are at least 802 CNG stations in the state which is 13.2% of India's total. For PNG, there are a total of 3.1 million connections, accounting for 26% of India's total. Concerning LPG, there are over 2,231 distributors, reflecting a share of 9% of the country's total.

Combining the oil refineries, retail, and LPG distributors, the oil and gas sector provides at least 158,259 formal employment in the state. Besides there are workers associated with CNG stations, and also with PNG supply.

Table 4: Downstream segment of the oil and gas sector

	Facilities	Production capacity	Formal employment
Oil refinery	2 refineries	21.5 MMTPA refining capacity	33,239
Oil retail	7,256 petrol pumps		116,096
LPG distribution	2,231 LPG distributors		8,924
CNG	802 CNG stations		
Total			158,259

Transition hotspots, challenges and opportunities

Hotspots: The hotspots for the oil and gas sector include districts where the oil refineries are located (and thus have direct employment dependence), and also the locations of retail shops (petrol pumps), LPG distributors, and CNG stations. While the oil refineries are located in Mumbai, considering the distribution of oil retailers, LPG distributors, and CNG stations in various districts of the states, the transition geography is all across Maharashtra.

Challenges and opportunities: The key transition challenge for the oil and gas sector is the shift to Electric Vehicles (EVs). However, the impact of the transition is likely to happen only in the next decade, as EVs are likely to become dominant only after 2030. Therefore, in addition to developing new infrastructure for EVs, the state should also start planning for repurposing the existing oil retail infrastructure to support EVs.

3. Just Energy Transition in Industry

With a share of over 14.5% of the state's GVA and more than 2 million formal employment, a just transition of industry will be a central agenda for greening Maharashtra's economy and boosting green job opportunities.

Maharashtra is the third largest state in India in terms of both the number of factories (25,610) and those in operation (19,462). About 9.8% of all operational factories in India are located in the state. The economic output of factories is the second largest in India, about 13.8%, and it accounts for 14.5% of the gross value added (GVA). The factories provide formal employment to about 2.04 million people.

Industries in Maharashtra have been classified into 'high, moderate, and low impact' categories for energy transition, considering their reliance on fossil fuels and the intensity of their energy use.

IMPACT CATEGORY OF FACTORIES

Factories are defined as "any premises including the precincts thereof— (i) whereon ten or more workers are working, or were working on any day of the preceding twelve months, and in any part of which a manufacturing process is being carried on with the aid of power, or is ordinarily so carried on, or (ii) whereon twenty or more workers are working, or were working on any day of the preceding twelve months, and in any part of which a manufacturing process is being carried on without the aid of power, or is ordinarily so carried on". (The Factories Act, 1948).

The following are the various sectors that will fall under the high, moderate and low-impact segments in the event of energy transition.

High impact: Sectors including iron and steel, cement, bricks and refractories, automobile and automobile components, basic chemicals, nitrogen fertilizer, coke oven and refined petroleum products, electric motors, generators, batteries, and appliances, will be highly impacted.

Moderate impact: Sectors including textile, pulp and paper, and pharmaceuticals will be moderately impacted due to direct-use of fossil fuels like coal and natural gas for process heat and electricity.

Low impact: Sectors including food processing, apparel and footwear, wood-processing and product industries, fabricated and structural metal products, computers and electronics, consumer goods, machineries, etc., will be less impacted due to energy transition.

High impact

Approximately 5,500 operational factories, making up about 27% of Maharashtra's total, will be highly impacted by the energy transition. These factories are highly significant for the economy for the following reasons:

- They account for 44% of the total output and 39% of the Gross Value Added (GVA) from all factories.
- Provide 43.3% of total factory employment and engage 33% of all factory workers.
- A notable characteristic is their higher ratio of contractual workers. Approximately 55% of employees in these sectors are contractor-based, in contrast to 43% in the low impact sectors.
- These are highly energy-intensive and are responsible for around 60% of the total industrial energy consumption.

Overall, about 41% of the factories in Maharashtra, employing about half of the formal workers, will be highly or moderately impacted by the energy transition.

Moderate impact

Approximately 2,485 operational factories, making up 13% of the state's total, will be moderately impacted by the energy transition. These factories account for the following:

- They account for about 8.7% of the total output and 13.6% of the total GVA.
- These sectors employ about 15% of the workforce.
- They consume about 14% of the total energy used by all factories and exhibit moderate energy intensity.

Low impact

Approximately 11,478 operational factories, making up 60% of the state's total, will be moderately impacted by the energy transition. These factories account for the following:

- They account for approximately 48% of both the total output and GVA.
- They provide 52% of total factory employment and engage 51% of the workers.
- Notably, nearly 80% of all directly-employed female workers are in these sectors.
- These have low energy consumption and responsible for about 26% of the total energy usage.

Table 5: Characteristics of industries likely to be impacted by the energy transition

Characteristics	All factories	Low impact sectors		Moderate impact sectors		High impact sectors	
	Value	Value	Share of total (%)	Value	Share of total (%)	Value	Share of total (%)
1. Number of factories	25,610	15,301	59.7	3,373	13.2	6,941	27.1
a. Number of factories in operation	19,462	11,478	59	2,485	12.8	5,505	28.3
2. Total output (₹ Lakh)	12,39,76,857	5,83,38,486	47.1	1,08,45,093	8.7	5,47,93,277	44.2
3. Gross Value Added (GVA) (₹ Lakh)	2,15,86,010	1,02,69,044	47.6	29,28,914	13.6	83,88,050	38.9
4. Number of persons engaged	20,38,255	10,61,126	52.1	3,04,463	14.9	6,72,670	33
5. Total number of workers	14,54,788	7,40,883	50.9	2,17,001	14.9	4,96,905	34.2
a. Percentage of workers employed through contractors (%)	48	42.8		48.8		55.5	
b. Number of directly employed women workers	90,884	70,637	77.7	10,293	11.3	9,960	11
6. Total energy use (as per cost in ₹ Lakh)	44,70,441	11,66,768	26.1	6,23,454	13.9	26,80,220	60

Source: iFOREST Analysis based on Annual Survey of Industries 2019-20

IRON AND STEEL

Maharashtra currently has about 12 MMTPA of crude steel production capacity which is about 7.4% of India's total. Crude steel production has grown by 34% in the last five years, from 8.5 MMT in 2017-18 to 11.4 MMT in 2021-2022.

With a CAGR of over 5%, GHG emissions from the steel sector has increased significantly due to growing steel demand.

Simultaneously, emissions from the steel sector have increased at a CAGR of 8.9% over the corresponding time period. It is the highest GHG emitter among industrial sectors, with estimated emissions of 21.2 MMT CO_2e in 2021-22.

Iron making in the state is largely based on the Direct Reduction process using coal and natural gas. Electric arc furnace and induction furnace are used for steel making.

The state also has a large number of foundries, accounting for about 15% of the foundry units in the country. A large number of foundries are involved in casting of automobile components. About 90% of these units belong to the micro, medium and small industries (MSME) category.

The iron and steel sector, including foundry, employ a large number of people. An estimated 86,150 workers are formally employed by these units. The overall employment dependence is much higher considering high proportion of informal engagement in manufacturing sectors.

Table 6: Iron and steel sector

Type of units	No. of units	Production capacity (MMTPA)	Formal workforce
Iron making units	9	7.7	13,107
Crude steel	57	11.99	18,043
Total iron and steel	66	19.69	31,150
Foundry	409		55,000
Total			86,150

Source: iFOREST analysis based on Joint Plant Committee, Indian Iron and Steel database-2019-20, MIS data obtained from Indian Institute of Foundrymen, 2023,and Company-specific Annual Reports and Accounts, 2022-23.

Transition hotspots, challenges and opportunities

Hotspots: Nagpur and Jalna have the largest capacity of iron and steel-making, whereas Pune and Kolhapur host the largest numbers of foundries.

Challenges: The key transition challenge with the iron and steel sector is the transition of the MSMEs, essentially the small induction furnaces and foundries. The foundry sector will experience technological changes due to shift to EVs.

Opportunities: With a steady growth in crude steel production in the state, and anticipated steel demand, a just energy transition of the sector is crucial for reducing industrial emissions. The iron and steel sector will witness technological shift in iron making from coal and natural gas to hydrogen in the future. Steel making in Maharashtra is already based on electricity and hence no major disruptions are expected.

CEMENT

Maharashtra is one of the key cement producers in Western India. With a total of 18 integrated plants and grinding units, the state's current production capacity stands at over 49 MMTPA.

The cement sector remains the second largest source of industrial process emissions after steel.

Cement production in the state has steadily increased over the past decade, from 10.2 MMT in 2011-12 to 14.7 MMT in 2021-22, driven by construction demand. Correspondingly, GHG emissions from the sector has also increased exhibiting a CAGR of 3.7%, with estimated emissions in 2021-2022 being 14.7 MMT CO_2e.

While the sector's employment dependence is less than the steel sector, it still remains significant. Overall, the formal workforce associated with integrated plants and grinding units is about 14,470. Further, the sector is estimated to employ about 20,000 people downstream for every million tonnes of cement produced.

Table 7: Status of integrated cement plants and grinding units

Type of unit	No. of units	Production capacity (MMTPA)	Formal workforce
Integrated plant	6	27.35	10,591
Grinding unit	12	21.75	3,879
Total	18	49.10	14,470

Source: iFOREST analysis based on IBM Cement Yearbook, September 2023; Directorate of Industrial Safety and Health, Government of Maharashtra, 2023; Company-specific Annual Reports and Accounts, 2022-23

Transition hotspots, challenges and opportunities

Hotspots: While cement plants and grinding units are located in 10 districts of Maharashtra, Chandrapur alone accounts for 48% of the total capacity. Five out of the six integrated plants are located in the district (the only other being in Yavatmal).

Challenges: Despite adopting commendable energy efficiency measures, a critical issue of energy transition for the cement sector remains the shift to non-conventional and green energy sources for cement production. The cement industry currently relies heavily on coal, both for fuel and electricity.

Opportunities: To decarbonise the cement industry, reducing the proportion of clinker in cement will be essential. Clinkers can be substituted with alternative materials, such as fly ash, metal slag, or calcined clay. The use of limestone instead of clinker is also being considered as a viable option.

Shifting to non-conventional energy sources in the production process will also be required. This may include waste-derived fuels and hydrogen-based energy.

BRICK

Maharashtra is estimated to have nearly 17,000 brick manufacturing units producing about 28 billion bricks annually. The sector is a major source of employment in rural and peri-urban areas of the various districts where the brick-making units are clustered. There are primarily five clusters which include Sangli, Pune, Mumbai-Thane, Nashik-Ahmednagar, and Nagpur.

The brick sector employs about 0.25 million people in rural and peri-urban areas of Maharashtra.

The use of coal as the most predominant fuel by the brick kilns, and the use of inefficient clamps for brick-making in most clusters, adds to the sector's pollution and emission burden. The overall coal consumption for producing burnt clay bricks in the state is estimated to be 2.3 MMT per year. The sector's CO_2 emissions per year is about 6 MMT.

Table 8: Brick production

No. of units	Production (number)	Workforce
17,000	28 billion bricks annually	248,000 (largely informal)

Source: iFOREST analysis based on other scholarly studies and on-ground interactions

Transition hotspots, challenges and opportunities

Hotspots: Sangli, Nagpur, and Mumbai-Thane clusters are the major producers of burnt clay bricks, using clamp technology. Coal is the main fuel used in brick-making in these clusters. To reduce pollution and GHG emissions, the transition of brick-making process and fuel use is essential in these clusters.

Challenges: The key energy transition issue for the brick sector is the shift towards cleaner technologies and resource efficient ways for producing bricks. At the same time, there is large-scale income dependence on the sector among low-income people and informal workers. This makes the sector highly sensitive to any unplanned transition.

Opportunities: A key opportunity for the brick sector is changing brick-making technology that is already viable and widely used in India. This includes changing traditional kilns like clamps and Fixed Chimney Bull Trench Kilns (FCBTK) to Vertical Shaft Brick Kiln (VSBK) and Zigzag technologies. For example, most brick kilns in the states of the Indo-Gangetic region have already moved to Zigzag technology. These kilns can be run with biomass to reduce coal dependence.

There is also an opportunity to move to alternative walling materials, such as AAC blocks, fly ash bricks, hollow and perforated bricks, compressed soil bricks, to improve resource efficiency in the brick sector.

AUTOMOBILE

Maharashtra's automobile sector is the largest in the country and remains a cornerstone for the state's economy. The sector's contribution to the gross state domestic product (GSDP) is about 7%, which is highest among all manufacturing sectors and 15.3% of industrial GSDP.

The automobile sector has a share of over 15% in Maharashtra's industrial GSDP.

Overall, the state's automobile industry accounts for 20% of the vehicle production, 21% of parts and accessories and 24% of other transport equipment produced in India.

The state is also a front-runner in the transition to EVs. In 2023, Maharashtra accounted for 12.6% of the country's EV sales. The penetration of EVs in the state has increased from 0.4% in 2020 to 7.6% in 2023, surpassing India's average of 6.5%.

There are at least 16,602 enterprises involved in the manufacturing of automobiles and automobile components. This includes 26 Original Equipment Manufacturers (OEMs) and 16,576 Auto Component Manufacturers (ACMs). Overall, micro and small enterprises dominate the manufacturing segment, with 97% of all automobile enterprises belonging to these categories.

The OEMs and ACMs collectively account for the direct employment of at least 0.34 million people in the state. Besides, there are a significant number of informal workers associated with the sector, particularly in the MSMEs.

Table 9: Distribution of automobile enterprises

Type of enterprise	Sub-type	No. of units	Workforce
OEMs		26	95,201
ACMs	Micro enterprises	13,174	71,114
	Small enterprises	2,950	74,845
	Medium enterprises	352	50,633
	Large enterprises	100	43,444
Total ACMs		16,576	240,036
Total automobile enterprises		16,602	335,237

Source: iFOREST analysis, based on information obtained from the Directorate of Industries, Government of Maharashtra, 2023

The growth in EVs makes the sector a key one for developing a strategic roadmap for supporting a just energy transition in the sector. With increasing investments in electric mobility and the steep penetration of EVs in the state, the automobile sector is already experiencing a transition. While the impact on the business and workforce is not likely to be immediately apparent for the next few years, some sections of the industry will start experiencing transitional challenges by 2030. While four-wheelers are expected to transition slowly, in a phased manner, two and three-wheelers are likely to transition rapidly and thereby cause significant market disruption. Therefore, developing a strategic roadmap and a plan for just transition of the sector is essential.

Transition hotspots, challenges and opportunities

Hotspots: While all districts in Maharashtra have automobile-related enterprises, about 26% are concentrated in Pune (a total of 4,250). About 0.18 million are formally employed by the automobile manufacturing industry in the district. Overall, just five districts, Pune, Kolhapur, Aurangabad, Thane, and Mumbai Suburban account for 60% of the automobile enterprises.

Challenges: The EV transition will have an impact across the auto value chain, including ACMs, OEMs, and service centers. The ACMs who are involved in the manufacturing of various powertrain components required by internal combustion engine (ICE) vehicles will face challenges of equipment redundancy. Besides, the shift from producing components for mechanical power-based vehicles to components for EVs will require different skill sets, which will impact many existing workers of the ACMs.

The transition to EVs is also anticipated to bring about significant changes to the business structures of OEMs, including changes in product mix and supply chains of various parts. Besides, the OEMs will also need a skilled workforce capable of handling the unique aspects of EV technology. A crucial aspect of the EV transition will be the altered nature of maintenance and repair work which will have a differential impact on both established and informal service centres.

Opportunities: While the transition to EVs is already well underway, the impact on the businesses and workforce is not likely to be immediately apparent for the next few years. Therefore, there is time to strategise and plan for the transition.

The automobile industry in Maharashtra, with many leading private players, is also well-positioned to support a well-planned and well-managed transition by enterprise-level intervention, and government engagement. A key requirement will be investments in skilling and re-skilling programmes, support for the reorientation of enterprises involved in ICE component manufacturing towards EV components, and develop a 'Right to Repair and Servicing' policy to enable EV manufacturers to involve local service centers in repair and servicing, among others.

FERTILIZER

Maharashtra contributed to about 7.7% of India's total urea production in 2022-23 (2.2 MMT). The state has two urea fertilizer plants with a combined annual production capacity of slightly over 2 MMT.

The annual combined GHG emissions from the two plants is estimated to be 1.7-1.8 MMT CO_2e.

Use of green hydrogen in the production process will be a crucial step for a transition of the fertilizer sector.

Table 10: Production of urea fertilizer

Number of plants	Production capacity (MMTPA)	Formal workforce
2	2.04	3,812

Source: Rashtriya Chemicals and Fertilizers Limited Annual Reports, 2021-22 and 2022-23

Transition hotspots, challenges and opportunities

Hotspots: The urea fertilizer producing units in the state are located in two districts, Raigad and Mumbai Suburban.

Challenges and opportunities: A significant share of CO_2 emissions from urea production is a result of the use of natural gas as feedstock to produce hydrogen. Therefore, a key issue for the sector's energy transition is moving to less carbon-intensive methods to produce hydrogen to reduce the process-related emissions from urea production. The opportunity lies in utilizing green hydrogen (hydrogen production via water electrolysis powered by renewable energy) as a feedstock in the production process.

In fact, electrolysis was a common means of producing hydrogen in areas with cheap power before hydrocarbon-based processes took over. Fertilizer Corporation of India's Nangal plant employed electrolysis to produce hydrogen until it switched to hydrocarbons (then LSHS and fuel oil) in the 1970s due to shortage of power in the Bhakra grid. The Green Hydrogen/ Green Ammonia Policy (2022) of the Government of India also provides the necessary impetus.

OTHER INDUSTRIES – BOILERS

Other industrial sectors depend on the direct use of fossil fuels for generating process heat and electricity through boilers. Maharashtra has 5,988 registered boilers across diverse industrial sectors. The sectors with the maximum number of boilers include food/agriculture, textile, chemical, sugar, and pharmaceutical/healthcare, collectively accounting for over 70% of the total.

About 44% of the boilers are based on fossil fuels.

The boilers used by various industrial units are primarily of small capacity. The analysis of the inspected boilers in the state last year (1,543), shows that over 73% fall within 1-10 tonnes per hour (tph) capacity range.

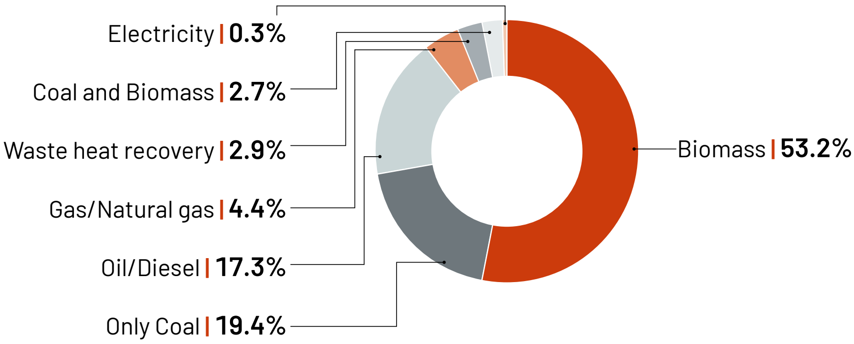
Table 11: Status of boilers

Number of boilers	Estimated workforce
5,988	18,000 workers directly engaged in just operating the boilers

Source: Directorate of Steam Boilers, Government of Maharashtra, 2023

More than half of the boilers in the state are based on biomass. About 44% of the boilers use fossil fuels.

Figure 4: Fuel use by boilers



Source: iFOREST analysis based on information of Directorate of Steam Boilers, Government of Maharashtra, 2023

Transition hotspots, challenges and opportunities

Hotspots: Pune has the highest number of boilers followed by Thane, Raigad, Kolhapur, Nashik and Nagpur districts. These five districts collectively account for over 52% of the registered boilers in the state. The key sectors using boilers in these districts include food and agriculture, textile, chemical, pharmaceutical and healthcare and manufacturing/automobile.

Challenges and opportunities: Maharashtra have an opportunity to decarbonise the boilers through biomass and electricity. Already more than half the boilers are based on biomass. In addition, most of the boilers are of less than 10 tph capacity. These small-capacity boilers, which are dependent on coal, oil and natural gas, can be shifted to electric boilers. Therefore, adoption of electric boilers by industrial units, particularly those in food processing, textiles, pharmaceutical, etc., is a crucial opportunity to reduce fossil fuel dependence.

B. Overall Outlook

The energy transition unfolding in the coming years will impact a large number of workers across various sectors and districts in Maharashtra.

1. The energy transition will impact about 50% of the workforce involved in mining and manufacturing, excluding construction.

The green energy transition will affect coal mining, thermal power, refineries, and 41% of all factories operating in Maharashtra. They collectively employ more than a million formal workers. It will also impact the brick sector, which employs about 0.25 million informal workers. Overall, close to half of the workforce involved in mining and manufacturing, excluding construction, will be impacted.

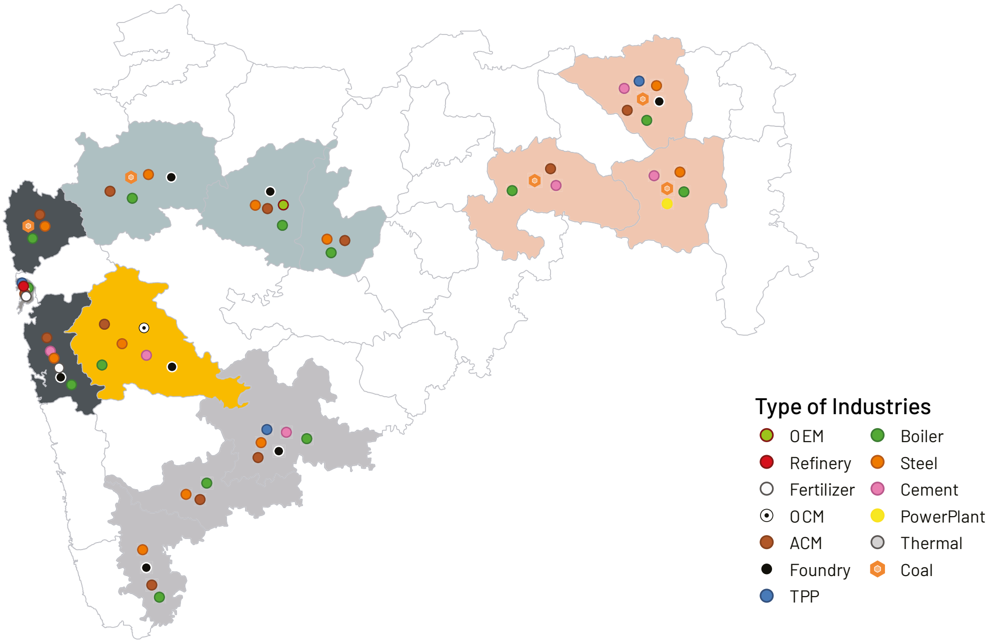
2. Fourteen districts, including the Chandrapur-Nagpur-Yavatmal coal and industrial region, and the Pune industrial region, remain hotspots for just energy transition.

Overall, 14 districts remain highly significant from an energy transition perspective. These include Nagpur, Chandrapur, Yavatmal, Pune, Nashik, Aurangabad, Ahmednagar, Kolhapur, Sangli, Solapur, Palghar, Raigad, Thane and Mumbai Suburban (including Mumbai city). These districts will require priority intervention to ensure net-positive environmental and socio-economic outcomes.

These districts account for 100% of the coal mines, oil refineries, and fertilizer plants. Besides, they are home to 65% of the coal-based TPP units (and over 60% of the capacity), 77% of the iron and steel units (and 93% of the foundries) and 78% of steel capacity, over 60% of the cement units (combining integrated plants and grinding units) and 74% of the capacity, 75% of the automobile enterprises (combining ACMs and OEMs), and about 78% of the boilers. Besides, these districts also cover all five brick-making clusters.

The districts overall employ 0.4 million people formally and many more informally across the value chain of various sectors, including, 0.25 million brick workers.

Map 1: Hotspot regions for just energy transition



Source: iFOREST analysis

C. Fostering of Green Growth and Green Jobs

A key objective of just transition is to ensure economic continuity and social vitality of regions that will be impacted by the energy transition and enhance opportunities for green jobs for the impacted workforce and the local community. Fostering green growth and green jobs in the transition regions will require the development of policies and plans, boosting opportunities for green investments, and mobilising financial resources.

1. The development of a State Just Transition Policy will be necessary to ensure a just and inclusive energy transition.

Considering the scale of impact and the diversity of sectors involved, a comprehensive State Just Transition Policy will be required to ensure a well-planned and well-managed transition. The policy should include the following components:

i. **Economic diversification and innovation:** Will be essential to support the economic vitality and development of regions impacted by the transition.

ii. **Labour support and human resource development:** Will be required to ensure adequate job security, payments at the time of retrenchment (severance pay), and compensation for all workers engaged in industries that the transition will impact.

iii. **Social welfare:** Will be required to provide timebound support to informal workers, old and disabled people, widows, marginalised communities in the fossil fuel areas to be impacted by the transition and to safeguard against immediate transition shocks.

iv. **Augmenting social and physical infrastructure development:** Will help to improve social capital and attract businesses and investors to ensure economic vitality.

2. Development of regional just transition plans will help to support inclusive growth.

Given the regional concentration of various industrial activities, regional just transition plans will be necessary to strengthen opportunities for inclusive growth. These plans will also help to attract green investments and ensure economic stability and job preservation in these areas. They will also be crucial for addressing the needs of informal and migrant workers. These workers often move between regions and industries based on available opportunities.

The priority clusters for the development of regional just transition plans are the Chandrapur-Nagpur-Yavatmal cluster and Pune. These two are going to witness the impacts of green energy transition within the next 10 years.

The regional just transition plans could be structured around a 10-year transition strategy, providing a framework for crafting just transition measures at the district level.

3. Balanced development of green energy and green industries will be required to improve clean energy access and prospects of green jobs.

There is a clear regional disparity between the transition geography of the coal districts and where RE investments are happening.

To address this, the State Government should create enabling environments for RE investments in the coal districts and address the regional imbalance in RE growth in the state. The state may provide fiscal and non-fiscal incentives to support RE investments in these regions. At the same time, the government can work along with Western Coalfields Limited (WCL) to repurpose the coal mining land for RE development, besides leveraging other opportunities for economic diversification and job creation.

4. Repurposing of land and infrastructure will be crucial for economic diversification, development of green industries, and green energy infrastructure, in the coal regions.

Repurposing the land and infrastructure available with coal mines and power plants provides a huge opportunity for undertaking various economic activities once the mines are closed. For this, the government, industry, financial institutions, and investors need to engage collectively.

Maximising land repurposing potential will also require the reform of land-related laws and the development of necessary guidelines, to ensure the transfer of land to the State Government by the industry (such as coal mining land after mines are closed) for supporting diverse economic activities that can enhance income and livelihood opportunities of the local community.

5. Reskilling and skilling the workforce for the transition to low-carbon economy will be crucial for retaining jobs and creating a future-ready workforce.

As traditional industries associated with high carbon emissions will need to transition in the coming years, there will be chances of job losses and socio-economic disruptions if timely measures are not implemented. Investments in skilling and reskilling programmes for the workforce, both by the government and the industries will be essential to minimize job loss, help workers adapt to new roles within emerging green sectors, and make them more adaptable to the changing job market. Besides, skilling will be essential to develop a future-ready workforce, as the skills required for jobs in a low-carbon economy will in many ways be different from those in the existing enterprises.

The current skill development programmes and schemes in Maharashtra focus majorly on information technology (IT), automobile, accounting, construction, and healthcare. There are a handful of solar energy and auto (EV) transition-related skill development programmes implemented by both the government and the industry.

To support a just transition of the workforce, integrated skilling programmes across sector-specific value chains will be required. Considering future job prospects, workforce development for the following five sectors will be important.

i. **Green construction and green infrastructure:** This will involve material transformation and use in construction and infrastructure development. It will require the skilling of the workforce across the value chain in brick manufacturing, cement manufacturing, green steel making, etc., use of sustainable building materials, life cycle assessment, green certification,

ii. **Green mobility:** Developing skilling and reskilling programmes across the auto value chain, including OEMs, ACMs, servicing, research and development (R&D), and charging stations, is a necessity across Maharashtra. The industry is already planning skilling for EV transition, and the government must support these steps by planning courses that are designed according to the needs and demands of the auto industry.

iii. **Green energy:** Transitioning the workforce toward green energy will require a combination of technical, analytical, and practical skills. Skilling will be required for the design, installation, and maintenance of RE systems, smart grid technologies, energy storage, green hydrogen use, transportation, and operation, among others.

iv. **Repurposing and decommissioning:** Design skilling courses and programmes aligned to support skilling for decommissioning and repurposing of fossil fuel-related infrastructure and energy assets. This will involve skilling for impact evaluation, risk assessment and management, waste disposal and management, remediation, etc.

v. **Green industry:** A key aspect of industrial transition will be the use of electric boilers by various industries in the future. This will require the development of a workforce for handling electric boilers in the green industry, including, installation and commissioning, handling of control system, operation, and maintenance, among others.

6. The creation of a dedicated Just Transition Fund from state, national, and international sources will be necessary.

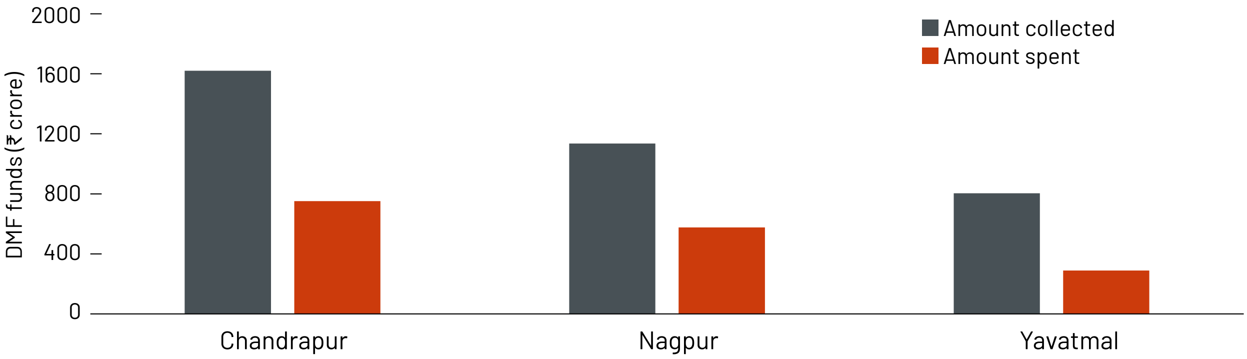
A dedicated fund for just transition needs to be created at the state level to allow interventions outside the planned investments, especially to provide income and welfare support and protection to the informal workers and vulnerable groups in the induced economy during the transition.

7. Repurposing of District Mineral Foundation funds can support just transition in coal districts.

District Mineral Foundation (DMF) funds provide an important opportunity to support just transition of the local communities in the coal districts. The objective of the DMF and priority issues towards which the funds should be used are well aligned with key intervention areas of just transition. These include investments in sustainable livelihood and income generation activities, skilling, education, social infrastructure development, improving clean energy access, etc. All these are important for improving income opportunities and building community resilience.

So far, over ₹4,841 crores has been accrued to DMFs in Maharashtra, out of which the three coal districts have a share of about 74% (₹3,559 crores). Only about 45% of the accrued amount has been spent so far. Moreover, DMFs in these districts are expected to receive about ₹150 crore per year, at least in the coming 10 years.

Figure 5: DMF fund accrual and expenditure in coal districts



Source: iFOREST analysis based on information of the Ministry of Mines and district DMFs, 2024

DMF funds, therefore, can be crucial seed money and provide an opportune window. The State Government can provide the necessary direction for using DMF funds to support just transition-aligned investments in these districts, particularly in blocks where mines are likely to close in the near future due to resource exhaustion and economic unviability.

Introduction

At the 28th session of the Conference of the Parties (COP 28) to the United Nations Framework Convention on Climate Change (UNFCCC) that concluded in December 2023, countries have agreed to 'transition away from fossil fuels in energy systems in a just, orderly and equitable manner' to achieve a global net zero target by 2050. A comprehensive strategy involving public and private actors, enabling policies, and investments are necessary to support a transition away from all fossil fuels and accelerate climate change action at scale for limiting global warming to 1.5 °C.

As a strong emerging economy, India stands at a decisive moment to tackle the climate crisis and build a low-carbon and resilient economy to meet the country's inclusive development and growth ambition. The country's commitment to achieve a net zero economy by 2070, while contributing to the global climate goals, is nothing short of requiring a comprehensive transformation of our energy systems and industrial processes that support our economy. However, to achieve such transformative changes, the action of the Central Government alone will not be enough. The role of the State Government will be equally important, as it will be at the forefront of planning and executing the transition measures. Besides, collective and collaborative action will be necessary on the part of industry players, investors and financial institutions, civil society organizations, workers representatives, and all other concerned stakeholders.

Maharashtra, being one of the top industrialised states of the country, and a growth engine of India's economy, holds a central position in steering India's energy transition, which is also just and inclusive. Due to the presence of a large number of coal-based thermal power plants (TPPs) and other fossil fuel-based industries, the state remains one of the key contributors to India's greenhouse gas (GHG) emissions. Overall, Maharashtra is estimated to have a share of nearly 10% of India's emissions. However, the state also remains highly vulnerable to climate change impacts, and has been identified as one of the top 50 regions that are highly at risk from climate impacts.

Maharashtra, therefore, constitutes an important case to assess the just energy transition landscape of the state, to understand the prospective impacts and implications of the energy transition in the coming years, identify the sectors and the regions that remain at high risk from transition challenges, and identify opportunities of fostering green growth and green jobs.

This report focuses on assessing the fossil fuel sectors and the fossil fuel-dependent industries in the state that will require just energy transition planning in the coming years. The key sectors evaluated include the following:

1. Fossil fuel sectors- Coal, oil and gas
2. Electricity sector- Coal-based thermal power plants
3. Manufacturing sector/factories
   a. Steel;
   b. Foundry;
   c. Cement;
   d. Brick;
   e. Automobile;
   f. Fertlizer; and,
   g. Boilers.

The sectors have been analysed with respect to their scale of operation, spatial distribution to determine regional impact, their employment and livelihood dependence, transition opportunities (and challenges if any), and the existing policies and regulations for supporting a transition.

The assessment is based on a systematic process of collecting and analysing secondary data, stakeholder meetings carried out at the state level and in districts, and site visits in coal mining and industrial areas of Chandrapur, Nagpur, and Pune.

Based on the comprehensive assessment of the various sectors as mentioned above, the report aims to provide a comprehensive understanding of the just energy transition landscape of the state and inform the development of targeted strategies, policies, and investment measures, by both the State Government and various industries, that will be necessary to guide the state towards a more sustainable and equitable energy future.

SECTION I

FOSSIL FUEL SECTOR

CHAPTER 1

Coal

1.1 Production and reserves

Maharashtra is India's sixth-largest coal-producing state, accounting for 7% of the country's coal production. The state has a coal production capacity of 87 million metric tonnes per annum (MMTPA) and produced about 63.6 MMT of coal in 2022-23.[1] There are five coalfields with a reserve of 12,677.16 MMT, constituting 3.9% of the country's total coal reserves.[2]

Table 1.1: Coal resources

Category	Proved (MMT)	Inferred (MMT)	Indicated (MMT)	Total (MMT)
Wardha Valley	4,517.11	1,723.27	1,440.98	7,681.36
Kamthi	2,046.24	937.91	107.21	3,091.36
Umrer Makardhokra	308.41	0	160.70	469.11
Nand Bander	691.44	596.19	117.70	1,405.33
Bokhara	10.00	0	20.00	30.00
Total	7,573.20	3,257.37	1,846.59	12,677.16

Source: India Mineral Yearbook Volume III, 2019

The state's share in the country's coal production has ranged from 6% to 7.5%. The growth rate is non-linear and has varied significantly between 2012 and 2023. The steepest dip was observed in 2020-21. One reason for the decline could be the Covid-19-induced lockdowns when demand for electricity was low, which resulted in lower-than-usual demand for coal.

Table 1.2: Coal production

Year	Production (MMT)
2012-13	39.13
2013-14	37.22
2014-15	38.25
2015-16	38.35
2016-17	40.56
2017-18	42.22
2018-19	49.82
2019-20	54.75
2020-21	47.43
2021-22	56.33
2022-23	63.6

Source: Provisional Coal Statistics 2022-23, Coal Controller Organisation, New Delhi

1.2 Operational status

The state's coal production comes mainly from opencast (OC) mines, which contribute to 97.5% of its output. The 15 underground (UG) mines, constituting 30% of the state's mines, contribute to only 2.5% of total production. Overall, mines have a production capacity of 83.56 MMT while the UG mines have a capacity of 3.25 MMT.

Table 1.3: Operational coal mines

District	Block	OC			UG			Total		
		No. of mines	Production capacity (MMTPA)	Production (MMTPA) 2022	No. of mines	Production capacity (MMTPA)	Production (MMTPA) 2022	No. of mines	Production capacity (MMTPA)	Production (MMTPA) 2022
Chandrapur	Ballarpur	1	0.62	0.265	1	0.6	0.08	2	1.22	0.353
	Bhadrawati	4	12.5	4.85				4	12.5	4.85
	Chandrapur	4	7.96	3.79	5	0.56	0.29	9	8.52	4.08
	Chimur				1	0.28	0.07	1	0.28	0.07
	Korpana	1	6.30	6.30				1	6.3	6.3
	Rajura	5	10.75	6.26	1	0.36	0.04	6	11.11	6.30
	Warora	2	3.02	2.69				2	3.02	2.69
Nagpur	Parseoni	3	6.50	6.84				3	6.5	6.84
	Saoner	2	3	1.24	6	1.24	0.60	8	4.24	1.84
	Umrer	4	12.97	10.28				4	12.97	10.28
Yavatmal	Wani	9	19.72	11.69	1	0.21	0.05	10	19.93	11.75
	Zari-Jamni	2	0.54	0.37				2	0.54	0.37
Total		37	83.56	54.58	15	3.25	1.14	52	87.15	55.72

Source: Data as obtained from WCL, 2023; Environmental clearance lettersof respective mines.

Coal mining in Maharashtra is dominated by the public-sector undertaking Western Coalfields Limited (WCL). Apart from some small expansion projects, the company has no plan for any major expansion as can be ascertained from the company's annual report and feedback of officials.

However, there are six upcoming commercial privately-owned mines allocated to different companies as per the provisional coal statistics 2021-22. The combined production capacity of these mines is 12.35 MMT.

Table 1.4: Upcoming coal mines

Name of the mine	District	Block	Type	Operational status	Ownership	Production capacity (MTPA)
Bhivkund	Chandrapur	Ballarpur	OC	Upcoming	Private	3.10
Takli Jena Bellora (North) & Takli Jena Bellora (South)	Chandrapur	Bhadrawati	Mixed	Upcoming	Private	1.50
Gondkhari	Nagpur	Kalameshwar	UG	Upcoming	Private	1.00
Mahajanwadi	Nagpur	Hingna	Mixed	Upcoming	Private	6.06
Nerad Malegaon	Yavatmal	Zari-Jamni	OC	Upcoming	Private	0.36
Marki Mangli II	Yavatmal	Zari-Jamni	OC	Upcoming	Private	0.33
Total						12.35

Source: Provisional Coal Statistics 2021-22

Considering the scale of mining operations, there is a large amount of land available with coal mines. An assessment of land available with operational coal mines in various districts of the state show that over 42,000 hectares (ha) of land is available with OC and UG mines.

Table 1.5: Land available with coal mines

District	Block	Land with operational mines (ha)			Land with closed mines (ha)		
		OC	UG	Total (ha)	OC	UG	Total (ha)
Chandrapur	Ballarpur	243		243		1,620	1,620
	Bhadrawati	3,014		3,015			
	Chandrapur	3,619	1,447	5,066			
	Chimur		2,143	2,143			
	Korpana	744		744			
	Rajura	4,244		4,244			
	Warora	2,063		2,063			
Nagpur	Parseoni	2,203		2,203			
	Saoner	942	3,981	4,923			
	Umrer	3,999		3,999	1,181		1,181
Yavatmal	Wani	7,604	1,696	9,300	452		452
	Zari-Jamni	275	731	1,006			
Total land		28,950	9,267	38,948	1,632	1,620	3,252

Source: Data as obtained from WCL, 2023.

1.3 Spatial distribution

Coal mines in Maharashtra, both operational and closed, are spread over three districts. These include Chandrapur, Nagpur and Yavatmal located in the eastern part of the state. Among the three districts, Chandrapur has the largest number of coal mines with 25 mines located in seven blocks. This is followed by Nagpur with 15 mines in three blocks and Yavatmal with 12 mines in two blocks.

Map 1.1: Spatial distribution of coal mines in Maharashtra

Source: iFOREST analysis

1.4 Financial status

While Maharashtra has 52 operational mines, a large number of the mines are unprofitable.[3] Information obtained for 46 operational (out of 52) mines from the company shows that 20 are making profits and 26 are running at a loss. Of the loss-making mines, 15 are underground and 11 are opencast. The 20 profit-making mines contribute to approximately 75% of the total production.

Table 1.6: Distribution of unprofitable mines

District	Block	Profitable (All OC)			Unprofitable Opencast			Unprofitable UG		
		No. of mines	Capacity (MMTPA)	Current production (MMTPA)	No. of mines	Capacity (MMTPA)	Current production (MMTPA)	No. of mines	Capacity (MMTPA)	Current production (MMTPA)
Chandrapur	Ballarpur				1	0.62	0.27	1	0.60	0.09
	Bhadrawati	2	5.50	3.60						
	Chandrapur	1	1.47	1.30	3	6.50	2.49	5	0.56	0.29
	Chimur							1	0.28	0.07
	Korpana	1	6.30	6.30						
	Rajura	2	3.85	3.85	3	6.90	2.41	1	0.36	0.04
	Warora	1	2.75	2.42						
Nagpur	Parseoni	3	6.50	6.84						
	Saoner	1	1.85	0.61	1	1.15	0.63	6	1.24	0.60
	Umrer	4	12.98	10.28						
Yavatmal	Wani	5	11.23	7.01	3	7.00	4.69	1	0.21	0.05
Total		20	52.42	42.20	11	22.17	10.48	15	3.25	1.14

Source: Data as obtained from WCL, 2023

The challenges of the unprofitable and low-producing mines has been also recognised by the PSU. To deal with the large number of unprofitable and low-producing mines, WCL set up a committee to understand the feasibility of closing loss-making mines or merging them to improve their output and financial status. The report of the committee was submitted in 2022.[4] The committee used financial year 2020-21 progressive data till December 2021 to analyse the reasons for losses of both UG and OC mines and gave its recommendations for 13 UC mines and 10 OC mines. The recommendations of the committee are outlined below.

Table 1.7: WCL committee underground mine assessment

District	Mine	Reasons for loss
Chandrapur	Mana Incline	Mines retreating. Non-availability of working patch. Resources on verge of exhaustion.
	Nandgaon Incline	Mines retreating. Non-availability of working patch. Resources on verge of exhaustion.
	Durgapur Rayatwari RPR	Limited scope to improve output. Mines have low-grade coal.
	Mahakali	Production stopped in 2021-22 for safety and viability reasons.
	Ballarpur RO	Techno-economic reasons.
	Sasti RO	Production discontinued in 2021-22 due to conversion to Dhoptala OC mine.
Yavatmal	Rajur	Adverse geo-mining conditions such as poor roof, high percolation of water from roof, soft floor, etc. Long travelling and hauling distance (>4.5km). Mine has low-grade coal.

Table 1.7 continued

District	Mine	Reasons for loss
Nagpur	Silwersa-II	Adverse geo-mining conditions and low-grade coal.
	Patansaongi RPR	Adverse geo-mining conditions and low-grade coal.
	Saoner-I	Non-availability of working patch for development and low-grade coal.
	Saoner-II	Limited working patch and low-grade coal.
	Saoner-III	Depillaring not possible due to non-availability of surface right of land. Low-grade coal.
	Murpar	Working area in Eco-Sensitive Zone (ESZ) of Tadoba-Andhari Tiger Reserve, Chandrapur. Working of mine is subject to NOC from Wildlife Dept. Adverse geo-mining conditions and low-grade coal.

Source: Committee report on amalgamation/clubbing of small area and feasibility of closing loss-making mines, 2022

Table 1.8: WCL committee opencast mine assessment

District	Name of the mine	Reasons for loss
Chandrapur	Pouni	Property exhausted and merged with Gouri mine.
	Gouri	Merged and will expand after diversion of PWD road running along boundary of Gouri and Pouni OC.
	Sasti	Space constraints due to working near mine boundary and also due to inconsistent performance of dragline. Work is now being shifted towards the railway siding area. Expansion approved.
	Padmapur	Limited working patch for production due to non-diversion of Mota-Ghat nullah, restriction imposed by DGMS due to waterlogged adjoining quarry.
	Durgapur	Limited working patch, geological constraint.
	Hindustan Lalpet	Started operation in Dec '21 after taking possession of forest land.
	NMOC IA & HA	Geo-technical constraints.
Nagpur	Kamptee Deep	Land problem.
Yavatmal	Ghonsa	Mine is being worked by department as there is no response for outsourcing labour.
	Junaid	Working near mine boundary, quality deterioration. May be exhausted in FY 2022-23.

Source: Committee report on amalgamation/clubbing of small area and feasibility of closing loss-making mines, 2022

Table 1.9: Proposed solution for loss-making underground mines

Option for loss-making underground mines	Applicable for share of UG mines
Close within 3 or 4 years on resource exhaustion	19%
Proposed for conversion to opencast operation	14%
MDO/Outsourcing/Revenue sharing	14%
Scheme MDO with continuous miner	5%
Continuous miner employed	14%
Continuous miner approved	5%
Other option like LHD, manpower reduction	29%

Source: WCL committee report on amalgamation/clubbing of small area and feasibility of closing loss-making mines, 2022

The WCL committee had considered various technical options to turn loss-making UG mines into profitable operations. For the OC mines, the company divided the mines into two groups—high-potential and low-potential. The low-potential mines are those on the verge of reserve exhaustion. On the other hand the high-potential mines are those which can become profitable with increased production through revival. Other improvement strategies included continuous miners of different capacity and reduction in manpower, as these are considered to be viable and effective solutions to turn around the financial status of mines.

However, the overall assessment of the reasons of loss for the UG mines clearly suggest that it is not economically or technically feasible to continue with these mining operations. The mines are saddled with problems of resource exhaustion, low-grade coal (which has implications for their profitability), and other geological constraints.

For the OC mines, the mines that have already merged (such as Puni and Gouri) or have obtained the necessary permits can continue with operations till the resources can be extracted in a profitable manner. For the others it will be difficult to continue with the mining operations.

1.5 Employment and workforce

The coal mines employ a large number of workers in the coal producing districts directly and indirectly. As per information provided by the company, the total number of formal workers (including departmental and contract workers) is 29,087.[2] The highest number of jobs is in Chandrapur district, which is also Maharashtra's highest coal-producing district. Within the district, Chandrapur and Rajura blocks have the highest coal dependency.

Table 1.10: Formal employment in the mines

District	Block	Departmental workers	Contractual workers	Total formal workers
Chandrapur	Ballarpur	1,092	58	1,150
	Bhadrawati	1,144	450	1,594
	Chandrapur	4,371	730	5,101
	Chimur	433	0	433
	Korpana	533	910	1,443
	Rajura	2,903	911	3,814
	Warora	224	450	674
Nagpur	Parseoni	1,565	754	2,329
	Saoner	2,868	409	3,277
	Umrer	1,573	742	2,315
Yavatmal	Wani	4,434	2,533	6,967
Total		21,140	7,947	29,087

Source: As per information provided by WCL, 2023.

1.5.1 Skill profile of formal workforce

The distribution of the formal coal workers as per their skills can be assessed from the worker data as provided by WCL for about 28,000 workers. The assessment shows that out of the total departmental workers, about 61% are skilled workers, which includes both executive grade (1,774) and non-executive grade employees. These jobs are not only in the mines, but also include employment in the area general manager's office, company headquarters and other non-mining establishments like hospitals, workshops and training institute. Unskilled labour constitutes a significant portion of the departmental workforce (39%). It is important to note the gender disparity in the unskilled workforce, where the proportion of female unskilled workers are much higher than the male counterpart.

Table 1.11: Skill of departmental workers

Skill type	Male	Female	Workforce	Percentage of total
Skilled*	16,488	887	17,375	61%
Unskilled	9,633	1,301	10,934	39%
Total	26,121	2,188	28,309	100%

Source: WCL HR Department *Skilled includes executives and company trainees

With respect to the contractual workers, there are both skilled and semi-skilled workers. The contractual workers are primarily engaged in various types of mining activities, coal transportation, civil works in colonies and other areas owned by the coal company, etc.

Table 1.12: Contractual worker by job type

Job Type	Male	Female
Mining activities	6,680	0
Transportation of coal	2,101	0
Civil work	765	105
Other (E&M electricals)	1,305	7
Total	10,851	112

Source: Contract Management Cell, WCL, 2022.

Overall, transportation of coal provides significant contractual employment (20%) besides core mining operations. These transportation workers primarily operate heavy trucks to take the coal from the operational patch to the loading point or stock. Female employment accounts for roughly 1% of the total contractual employment.

1.6 Age assessment of workers

The age profile of workers provides an understanding of the number of employees/workers who will retire in the coming years. An age assessment of the departmental workers of non-executive and executive workers of WCL show that about 63% of the non-executive workers are above the age of 40. For executives, 58% if above the age of 40 years.

The trend clearly suggests that the company has a majority of aging employees/workers across various grades. Therefore, for departmental workers, securing retirement benefits, and VRS provisions (for employees close to retirement) will be a key issue during the event of transition..

Table 1.13: Age profile of coal mine workers (non-executive)

Age group (Years)	Share (%)
Under 25	5
26-30	9
31-35	12
36-40	12
41-45	12
46-50	14
51-55	16
56-60	21
Total	100

Source: WCL Personnel Department, 2023. Almost half the total non-executive work force would retire in the next 20 years.

Table 1.14: Age profile of coal mine workers (executive)

Age group (Years)	Share (%)
Under 25	6
26-30	11
31-35	15
36-40	10
41-45	6
46-50	8
51-55	20
56-60	24
Total	100

Source: WCL Personnel Department, 2023.

1.7 Induced economy

Coal mining does not only provide direct employment, but also creates what is called an induced economy in the mining areas. The induced economy creates a multiplier effect in the region and helps in socio-economic growth. To estimate the flow of money into the local economy by WCL, the profit and loss (P&L) balance sheet of the financial statement(s) of the company has been considered. The P&L line items, especially on the expense side, can help to identify the impact on the economy directly dependent on the mine. For arriving at a unit cost, the financial statement(s) of the past three years were considered. As per the analysis, WCL drives an economy of about ₹10,837.33 crore[3] (USD 1.32 billion) annually in Maharashtra.

Table 1.15: Expenditure assessment of WCL

Particulars	Expenditure (₹ crore)		
	2022	2021	2020
Salary, wages, allowances, bonus, etc	3,667.57	3,579.83	3,634.72
Leave encashment	80.89	133.68	150.19
Others	1,016.38	669.88	707.40
Cost of materials consumed	1,290.05	987.75	937.70
Changes in inventories of finished goods/ work in progress and stock in trade	513.55	-338.81	-508.98
Power and fuel	303.76	284.14	269.72
Repairs and maintenance	94.02	55.73	64.57
Contractual expenses	2,644.18	1,995.02	1,559.64
Other expenses	484.73	386.06	439.55
Corporate Social Responsibility expenses	11.69	5.55	8.94
Total	10,106.83	7,758.83	7,263.45

Source: Annual Reports of Western Coalfields Limited.
Note: In the annual report, expenditures of both the Maharashtra and Madhya Pradesh mines of the company are given. The production proportion 0.93 is taken into consideration to derive the contribution to Maharashtra

The flow of money in each district local economy is determined by using the production for the respective districts. Chandrapur district receives a major part of the WCL spending, followed by Nagpur and Yavatmal.

Table 1.16: District-wise expenditure assessment of WCL

Parameter	Value	Chandrapur	Nagpur	Yavatmal
Annual coal production of WCL (MMT) in Maharashtra	53.82	-	-	-
Net spending per MT of coal production for WCL (₹/MMT)	187.79	-	-	-
Coal production in different districts	-	23.12	18.96	11.47
Estimated spending by WCL in coal district (₹ Cr)	-	4,341.69	3,560.49	2,153.95

Source: Analysis based on Annual Report of Western Coalfields Limited and district-wise coal production

To understand the impact at the micro level, stakeholder discussions were undertaken in the mining regions. Group discussions with coal workers revealed that expenditure by employees and workers in nearby areas for their basic necessities keeps the local economy afloat. Thus, the impact on the local economy and markets, especially small businesses, can be if mines are closed without a just transition plan for the local community.

1.8 Coal dispatch

Power sector is the primary consumer of coal and 89% of the coal dispatched is supplied to the power plants. Rail is the major mode of dispatch of coal. Road transport is the second major mode of transportation. Road transport also creates indirect employment for locals.

Table 1.17: Coal dispatch (consumer type)

Sector	2022-2023(MMT)	Share (%)
Power	56.14	90.3
Cement	1.20	1.9
Sponge iron	0.24	0.4
Others	4.57	7.3
Total dispatch	62.15	100

Source: WCL Annual Report 2022-2023

Table 1.18: Coal dispatch (transport mode)

Years	Rail (MMT)	Road (MMT)	Merry-go-round (MMT)	Other modes (MMT)	Total dispatch (MMT)
2022-2023	33.54	26.32	0	2.27	62.14
2021-2022	37.99	24.1	0.176	1.89	64.16

Source: WCL Annual Report 2022-2023.

1.9 Coal washeries

Maharashtra has eight coal washeries with a cumulative processing capacity of 20.85 MMTPA. All washeries are privately owned.[6] Five of the eight are in Chandrapur, whereas two are in Nagpur and one in Yavatmal.

Table 1.19: Operational coal washeries

Owner company	Name of washery	Year of commissioning	Block	District	Production capacity (MMTPA)
Aryan Coal Beneficiation (India) Limited	Pander Pauni	2003-04	Ballarpur	Chandrapur	2.62
	Kartikay	2005-06	Wardha	Chandrapur	2.50
Hind Maha Minerals LLP	Pimpalgaon	2013	Yavatmal	Yavatmal	2.40
	Yavatmal	2005	Chandrapur	Chandrapur	2.40
	Gondegaon	2008	Nagpur	Nagpur	2.40
Rukhmai Infrastructure Private Limited	Indo Unique Flame Ltd	2005	Punwat	Chandrapur	2.40
	Nimbala	2002	Nimbala	Chandrapur	3.73
	Maha Mineral Mining & Beneficiation Private Ltd	2006	Majri	Nagpur	2.40
Total					20.85

Source: Provisional Coal Statistics, Coal Controller's Organisation 2021-22 .

1.10 Public revenue contribution

WCL's total contribution to the state exchequer was ₹ 5,592 crore (USD 570 million) in 2022-23. The compensation cess paid to the central government is the stand alone highest share of contribution to the public exchequer. For the state, the most significant sources are from the payment of royalty and DMF. The later also goes directly to the districts for developmental works in the mining-affected areas and generation on sustainable livelihood.[6]

Table 1.20: Contribution to the government exchequer

Particulars	Contribution amount (₹ Crore)
Royalty	1,954.31
National Mineral Exploration Trust	39.09
District Mineral Foundation	586.3
GST	244.85
SGST	244.85
IGST	0.79
Compensation Cess	2,466.19
Transit Fees	17.73
MPGATSVA	38.3
Total contribution	5,592.41

Source: WCL annual statement 2021-22

Besides taxes and revenues, the funds generated from Corporate Social Responsibility (CSR) initiatives constitute another contribution that the company makes towards welfare activities in the mining region. As per latest information of WCL, in 2021-22, the total fund outlay under CSR was ₹12.54 crore (USD 1.56 million).

1.11 Just energy transition issues for coal mining sector

India is committed to a net-zero target by 2070, which will lead to a phasing down of coal production in the coming decades. However, the phasing down of coal mining activities needs to be planned in a strategic manner so that the mines are closed in an environmentally and socially responsible way while causing least disruptions for workers and the local community.

There are five crucial aspects for planning a just transition of coal mines in Maharashtra. These include:

i. Determining a phase down time frame ensuring least socio-economic disruption;

ii. Repurposing of coal mining land for economic diversification and job creation;

iii. Transition of the workforce, including, formal and informal workers;

iv. Prioritising intervention in hotspot transition areas; and,

v. Utilisation of social welfare funds to support just transition of the coal districts.

Coal mine phase down with a focus on unprofitable and end-of-life mines

The time frame for phase down of coal mines has been considered under a business as usual scenario under current policies. For coal mines, it assumes that existing and upcoming mines can be closed following completion of their operational lives.

Given the status of coal mines, three key assumptions to develop the phase down schedule:

- For UG mines which are running at a loss and have low production capacity, closure has been assumed by 2030.
- For allocated blocks, the start year of 2030 has been assumed.
- For the allocated coal blocks, where no mining plan is available, a mine life of 33 years has been considered. This is typically regarded as the duration by which a mine has recovered its cost of investment and extracted most of the coal.[7]

Considering the assumptions, a coal mine phase down in the state can be planned in four phases. The sequence of phase down is outlined below.

Phase I – By 2030: By the end of this decade (or in the next 10 years), the unprofitable and low-producing UG mines can be considered for a transition. This will involve a closure of 32 operational mines. Of the 32 mines, 15 are UG and the rest are OC. These 17 OC mines will reach the end of their life due to resource depletion. A large number of these mines are concentrated in Chandrapur district.

Phase II – Between 2030 and 2040: In this phase, 10 mines will reach the end of their life due to resource exhaustion. The total production capacity of these mines is 28.7 MMT and these mines are almost equally spread over three districts—three each in Chandrapur and Yavatmal and four in Nagpur. In 2030, six new mines will start production with a total capacity of 12.35 MMT.

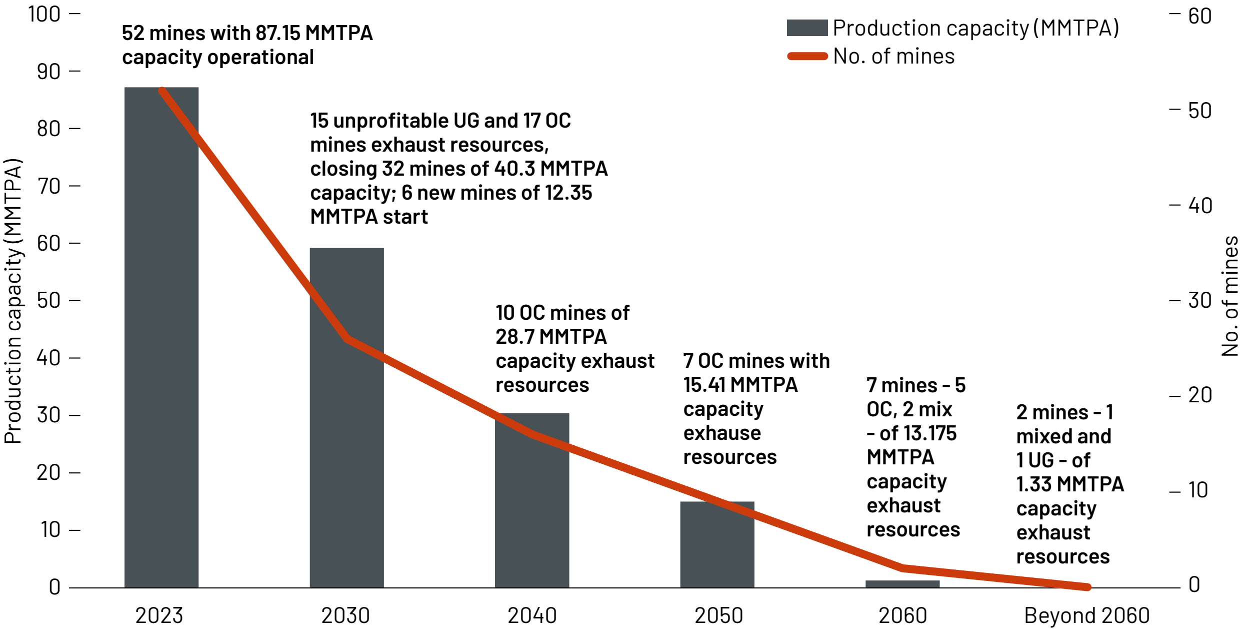
Phase III – Between 2040 and 2050: In this phase seven opencast mines will be closed due to resource exhaustion. The combined production capacity of these mines is 15.41 MMT.

Phase IV – Between 2050 and 2060: In this period seven mines (including OC and mixed mines) with a combined production capacity of 13.2 MMTPA can be closed.

Post 2060: After 2060, the remaining mines can be closed, which includes two mines with a small production capacity of about 1.3 MMTPA.

Overall, the next 10 years will be crucial for planning transition of coal mines in Maharashtra. These involves the unprofitable and end-of-life mines. A well-planned just transition of these mines can result in positive economic outcomes for the coal company, as well as the local community.

Figure 1.1: Coal mines phase down scenario



Source: iFOREST analysis

Table 1.21: Proposed mine-wise phase down schedule

Name of mine	District	Block	Type	Production capacity (MMTPA)	Production in 2022 (MMT)	Mineable reserves as of 2022 (MMT)	Phase down timeline
Nandgaon Incline	Chandrapur	Chandrapur	UG	NA	0.077	4.495	By 2030
Mahakali	Chandrapur	Chandrapur	UG	0.4	0.03	5.86	By 2030
Durgapur Rayatwari	Chandrapur	Chandrapur	UG	0.16	0.11	35.05	By 2030
Manna Incline	Chandrapur	Chandrapur	UG	NA	0.073		By 2030
HLC No. 1	Chandrapur	Chandrapur	UG	0	0	1.33	By 2030
Padmapur Deep	Chandrapur	Chandrapur	OC	2.5	0.19	14.18	By 2030
Hindustan Lalpeth	Chandrapur	Chandrapur	OC	1	0.46	5.87	By 2030
Durgapur	Chandrapur	Chandrapur	OC	3	1.84	40.56	2037
Bhatadi Expansion	Chandrapur	Chandrapur	OC	1.465	1.302	49.63	2057
Ballarpur UG	Chandrapur	Ballarpur	UG	0.6	0.088	16.37	By 2030
Ballarpur OC	Chandrapur	Ballarpur	OC	0.62	0.265	2.48	By 2030
Sasti UG	Chandrapur	Rajura	UG	0.36	0.042	5.25	By 2030
Sasti OC	Chandrapur	Rajura	OC	2.5	1.463	1.8	By 2030
Gouri Expansion	Chandrapur	Rajura	OC	3.5	0.944	5.013	By 2030
Gouri Deep	Chandrapur	Rajura	OC	0.6	0.6	3.57	By 2030
Paoni-II	Chandrapur	Rajura	OC	3.25	3.25	24.3	2030
Paoni	Chandrapur	Rajura	OC	0.9	0	24.31	2050
New Majri-II (A) Expansion	Chandrapur	Bhadrawati	OC	2.5	1.667	6.93	By 2030
Dhurwasa	Chandrapur	Bhadrawati	OC	2	0		By 2030

Table 1.21 continued

Name of mine	District	Block	Type	Production capacity (MMTPA)	Production in 2022 (MMT)	Mineable reserves as of 2022 (MMT)	Phase down timeline
New Majri UG to OC	Chandrapur	Bhadrawati	OC	3	1.93	33.69	2034
Penganga	Chandrapur	Korpana	OC	6.3	6.3	20.91	By 2030
Murpar	Chandrapur	Chimur	UG	0.28	0.07	4.35	By 2030
Amalgamated Yekona I&II	Chandrapur	Warora	OC	2.75	2.42	56.29	2043
Silewara Colliery	Nagpur	Saoner	UG	0.55	0.08	4.45	By 2030
Patansaongi	Nagpur	Saoner	UG	0.3	0.054	12.68	By 2030
Saoner-I	Nagpur	Saoner	UG	NA	0.21	12.29	By 2030
Saoner-II	Nagpur	Saoner	UG	NA	0.133	12.06	By 2030
Saoner-III	Nagpur	Saoner	UG	NA	0.12	12.06	By 2030
Waghoda	Nagpur	Saoner	UG	0.39	0	18.65	By 2030
Amalgamated Gondegaon Ghatrohana	Nagpur	Parseoni	OC	2.5	3.5	15.28	By 2030

iFOREST analysis

Repurposing of land

Land is a crucial requirement for industrial development and economic diversification. Repurposing of land available with coal mines will be an essential component of just energy transition as such land is an important resource for diversifying the local economy, developing green energy and green industries and creating local employments opportunities. Global studies also suggest that repurposing of mining land has been a key factor for local employment generation and supporting economic transition.[8]

At the same time, repurposing of infrastructure developed by coal companies will also be important. In the event of a just transition, the facilities maintained by these companies can become assets for the use of the local community. This can also complement the social infrastructure investment that will be necessary for a just transition.

In Maharashtra, about 42,200 hectares of land could become available for repurposing over the next three to four decades. The maximum potential is with the land available with OC mines. The total area available with these mines is about 30,582 hectare.

An analysis of the proposed post-closure land use for opencast mines in Maharashtra shows that it largely involves plantation activity. As assessment of mines for which post closure land use plan was available at the time of this research shows that over 45% of the land available with these mines is identified for plantations and 16% for water body creation.

However, going ahead in the coal mining land is properly reclaimed and repurposed, it will have enormous value for economic diversification and local job creation besides the environmental gains. There are three economic activities that can be undertaken on repurposed land. These are:

i. Installation of solar PV

ii. Development of industrial parks to support green industries

iii. Development of fisheries and tourism

The disturbed area, primarily including the excavation area and external overburden (OB) dump can be used as potential land for setting up renewable energy (RE) such as solar PV, and some other activities, such as horticulture. The undisturbed area, built-up area, etc. can be suitably repurposed for developing green industries, including green small and medium-scale industries, industrial parks, etc. Areas under public use and township can be used for providing low-income and affordable housing and other social infrastructure development.

Table 1.22: Decade-wise land availability

Land use type	Total land availability (ha)	By 2030 (ha)	2030-2040 (ha)	2040-2050 (ha)	Beyond 2050 (ha)
Excavation	5,299.33	2,188.89	1,717.51	1,208.08	184.85
External OB dump	7,005.47	2,765.84	2,252.96	1627.05	359.62
Internal OB dump	388.87	388.87	0	0	0
Backfilled area	271.06	65	0	0	206.06
Waterbody	3,636.08	1,252.62	1,417.03	777.09	189.34
Plantation	2,300.59	1,610.74		191.45	498.4
Undisturbed area	5,530.92	2,553.53	1,734.86	659.24	583.29
Built up area	884.56	262.16	333	273.5	15.9
Other mining-related area*	3,009.31	1,048.28	792.25	862.62	306.16
Public use	557.05	286.63	188.6	48.5	33.32
Township	224.28	14.58	153	20	36.7
Total	29,107.52	12,437.14	8,589.21	5,667.53	2,413.64

Source: Information as available from environmental clearance letters and indicated post closure land use for OC mines. The UG mines are not considered given that other activities are ongoing on the top and surface right issues are settled at a late time.
Note: * Other mining-related area include embankment, blasting zone, rationalisation zone, nallah diversion and top soil storage.

Transition of the workforce

As coal mining is phased down, there will be a large number of workers who will be impacted by the transition. The sector currently supports over 89,000 formal and informal jobs (29,087 formal jobs and at least twice informal) in the three mining districts—Chandrapur, Nagpur, and Yavatmal. Besides, there are many people who are indirectly dependent on the coal mining sector for income.

Therefore, supporting workforce transition will be a central issue for the coal mining sector. This will require intervention by the mining company (primarily for the formal workers) and the State Government (primarily for the informal workers). The key aspects of worker transition will include the following:

- **Skilling and reskilling:** The labour force directly impacted by the mine closure will require 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, need to be compensated for their income loss due to closures.
- **Transition support:** A one-time payoff (against a fixed time duration) need to be provided to the transitioning workforce to cover re-employment and relocation support. This is especially required for the informal workers.
- **Pension support:** Being a PSU, WCL will need to plan for providing pension support to the employees who remain eligible for a pension and shall be retiring in the coming years.

Prioritising hotspot transition areas for intervention through planning and investments

The assessment of spatial distribution of the coal mines in Maharashtra show that they are located in 12 blocks in the three districts-Chandrapur, Nagpur and Yavatmal. Among them, the unprofitable and closed mines are concentrated in eight blocks. Therefore, in the coal districts, these blocks can be prioritised for transition planning immediately.

Table 1.23: Hotspot blocks for just transition of coal mines

District	Block	Total no. of mines	No. of profitable mines	No. of unprofitable mines	No. of closed mines
Chandrapur	Ballarpur	2		2	1
	Bhadrawati*	4	2		4
	Chandrapur	9	1	8	
	Rajura	6	2	4	
Nagpur	Saoner	8	1	7	
Yavatmal	Wani	10	6	4	2

Source: iFOREST analysis based on information received from WCL, 2023
*Financial status of two mines not provided

EMPLOYMENT IN PROFITABLE AND UNPROFITABLE MINES

An assessment of workers in profitable and unprofitable mines show that more than 50% of the formal workforce are associated with the unprofitable mines. Considering that half of the mines of WCL are unprofitable, with almost all of the UG mines likely to close down in the near future, the transition of these workers remain a key concern.

Table 1.24: Employment in profitable and unprofitable mines

District	Block	Profitable			Unprofitable			Total
		Departmental workers	Contractual workers	Total formal workers	Departmental workers	Contractual workers	Total formal workers	
Chandrapur		3379	2719	6098	7321	790	8111	14209
	Ballarpur				1092	58	1150	1150
	Bhadrawati	1144	450	1594				1594
	Chandrapur	826	225	1051	3545	505	4050	5101
	Chimur				433	0	433	433
	Korpana	533	910	1443				1443
	Rajura	652	684	1336	2251	227	2478	3814
	Warora	224	450	674				674
Nagpur		3257	1520	4777	2749	385	3134	7911
	Parseoni	1565	754	2319				2319
	Saoner	119	24	143	2749	385	3134	3277
	Umrer	1573	742	2315				2315
Yavatmal		2278	1142	3420	2156	1391	3547	6967
	Wani	2278	1142	3420	2156	1391	3547	6967
Total		8914	5381	14295	12226	2566	14792	29087

Source: WCL, 2023.

Utilisation of social welfare funds to support just transition of the coal district

District Mineral Foundation (DMF) was instituted as a non-profit Trust under the Mines and Minerals (Development and Regulation) Amendment Act in 2015. The law mandated the establishment of DMF in every mining district of the country with the objective to work towards the benefit of mining-affected areas and local community. With prioritized investments in sectors such as education, healthcare, livelihood, skill development, energy access, environmental remediation, etc. the funds of DMF are meant to be used for alleviating poverty and improving development outcomes of these communities. The Maharashtra DMF Rules, formulated in 2016, also provide the similar guidance for using DMF funds.[9]

So far, over ₹4,841 crores have been accrued to DMFs in Maharashtra, out of which the three coal districts have a share of about 74% (₹3,559 crores). Only about 45% of the accrued amount has been spent so far.[10] Moreover, DMFs in these districts are expected to receive about ₹150 crore per year, at least in the coming 10 years.

DMF funds, therefore, can be crucial seed money for supporting just transition measures in Chandrapur, Nagpur and Yavatmal districts. The State Government can provide the necessary direction for using DMF funds to support just transition-aligned investments in these districts, particularly in blocks where mines are likely to close in the near future due to resource exhaustion and economic unviability.

DMF funds can be utilised specifically for the following purposes:

- **Economic diversification of coal districts:** DMF funds can be used to support the diversification of local economy in mining-dependent regions. This can involve investing in RE projects, promoting sustainable and resilient agro and forestry-based livelihoods, supporting small-scale industries, and fostering entrepreneurship in sectors aligned with a low-carbon economy, etc. Such initiatives can create new job opportunities and reduce the reliance on mining activities.
- **Skill development:** DMF can allocate funds for skill development programmes and vocational training to equip local communities with the necessary skills for employment in sustainable industrial sectors, RE, and other tertiary sector jobs.
- **Augmenting social infrastructure:** The funds can be directed towards improving social infrastructure. This can involve investing in healthcare facilities, education institutions, low-income housing projects, etc. Enhancing social infrastructure can help to improve resilience and adaptive capacity of the local community and can provide the necessary social support in the event of a transition.
- **Community engagement and capacity building:** DMF can be used for building capacity of the local community to ensure their meaningful engagement in the just energy transition process. Engagement of the local community and stakeholders, and ensuring inclusive decision-making is a central tenet of just energy transition. Such engagement will also help to capture the needs and aspirations of the affected communities and address them suitable through necessary investments.

A concerted implementation of the action points as mentioned above can help the State Government and the industry to ensure a just energy transition of the coal mining sector in the coming years. These measures will not only provide the state with the necessary guidance and learnings, but can also provide crucial learnings to other states and districts.

CHAPTER 2

Oil and Gas

2.1 Oil sector

India is the third-largest consumer and importer of crude oil in the world, and its refining capacity ranks fourth globally.[11] From a just transition perspective, the downstream sector of the oil industry holds a high significance for India. This includes refining and production of petroleum products, and their marketing and distribution.

The upstream sector, which includes exploration and production of oil, is less significant as India is heavily reliant on import of crude oil, which contributes more than 85% of the oil demand.[12] In fact, in the last 10 years, India's crude oil production has experienced a negative compound annual growth rate (CAGR) of -2.7%. In 2022-23, India's domestic oil production stood at 29.18 million metric tonnes (MMT), while 232.7 MMT was imported in 2022-23.[13]

2.1.1 Capacity and production of refineries

The Indian refinery industry has made significant strides in recent years with India being the fourth largest refiner in the world and the second largest in Asia, after China. The refinery industry is also becoming more efficient. The capacity utilization of refineries has increased to 96.99% in 2021-22, from 88.76% in 2020-21.[14] This is due to a number of factors, such as the modernization of refineries, the adoption of new technologies, and the integration of refineries with petrochemical plants.

There are a total of 23 refineries in the country – 18 in the public sector, three in the private sector, and two in Joint Venture[15]– with a cumulative production capacity of about 254 million metric tonne per annum (MMTPA).[16]

Maharashtra has two refineries with a combined capacity of 21.5 MMTPA. The refineries are operated by the Central Public Sector Undertakings (CPSU) Hindustan Petroleum Corporation Limited (HPCL) and Bharat Petroleum Corporation Limited (BPCL). The two refineries account for 8.6% of the country's refining capacity.[17]

The refinery operated by HPCL in Mumbai is India's largest 'Lube Refinery'. The refinery produces lube oil base stocks with a capacity of 0.42 MMTPA.[18] The second refinery operated by BPCL currently handles the processing of 72 types of oil products. The refinery also has a lube base oil unit for the production of environment-friendly Group-II base oil.[19]

Table 2.1: Refinery-wise details for the state of Maharashtra (2021-22)

Refinery name	Year of commencement	Petroleum refining capacity in 2021-22 (MMT)		Crude oil processed in 2021-22 (MMT)		Production of petroleum products in 2021-22 (MMT)	
		In Maharashtra	Share of India's total (%)	In Maharashtra	Share of India's total (%)	In Maharashtra	Share of India's total (%)
BPCL	1955	12.0	4.8	14.4	6.0	13.7	5.4
HPCL	1954	9.5	3.8	5. 6	2.3	5.1	3.0
Total		21.5	8.6	20.00	8.3	18.97	8.4

Source: Indian Petroleum & Natural Gas Statistics 2021-22, Ministry of Petroleum and Natural Gas

Table 2.2: Year-wise crude oil processed by refineries

Year	Crude oil processed by HPCL Mumbai (MMT)	Crude oil processed by BPCL Mumbai (MMT)	Total crude oil processed in the state of Maharashtra (MMT)
2011-12	7.5	13.0	20.5
2012-13	7.7	12.7	20.5
2013-14	7.7	12.7	20.4
2014-15	7.4	12.8	20.2
2015-16	8.0	13.4	21.4
2016-17	8.5	13.5	22.1
2017-18	8.6	14.1	22.7
2018-19	8.7	14.8	23.4
2019-20	8.1	15.0	23.1
2020-21	7.4	12.9	20.3
2021-22	5.6	14.4	20.0
2022-23 (P*)	9.8	14.5	24.4

* provisional
Source: Petroleum Planning & Analysis Cell, 2023

2.1.2 Sales of petroleum products

The total annual sales of all petroleum products in Maharashtra has mostly seen a steady increase, except during the years impacted by the COVID-19 pandemic, before recovering by the year 2022-23, during which total sales amounted to 21 MMT. In that year, Mobile Spirit (MS) and High Speed Diesel (HSD) accounted for over 62% of total sales (14.1 MMT).[20]

Table 2.3: Annual industry sales of petroleum products in Maharashtra

Year	Total annual industry sales (MMT)	Annual industry sales of MS (MMT)	Annual industry sales of HSD (MMT)
2010-11	16.4	2.0	6.7
2011-12	17.1	2.1	7.5
2012-13	17.4	2.2	7.7
2013-14	16.8	2.3	7.3
2014-15	16.9	2.5	7.3
2015-16	18.2	2.8	7.8
2016-17	19.3	3.0	8.1
2017-18	20.6	3.2	8.7
2018-19	21.0	3.4	9.3
2019-20	20.8	3.5	9.5
2020-21	17.8	3.0	8.0
2021-22	19.1	3.4	8.3
2022-23	21.0	3.8	9.3

Source: Petroleum Planning & Analysis Cell, 2023

2.1.3 Marketing and distribution

In the oil industry, major marketing and distribution happens for products such as diesel, petrol, and domestic fuel. The marketing and distribution segment is extremely significant for a just transition because this is where the most immediate impacts of oil transition will be experienced in India.[21] The triggers, such as the penetration of electric vehicles (EV), is already there.

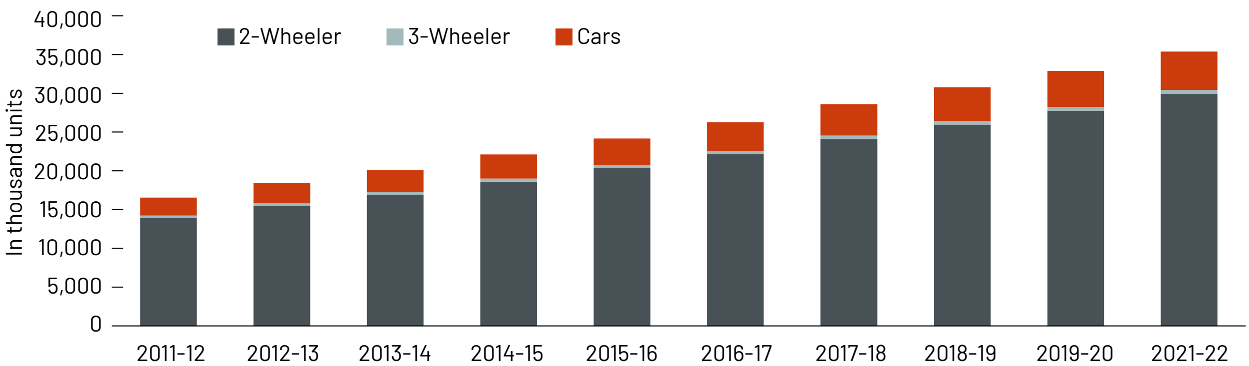
The marketing and distribution segment of the oil sector has been evaluated in terms of the impact on retail outlets, more specifically, petrol pumps. The evaluation shows that the number of petrol pumps in Maharashtra had registered a staggering increase to 7,256 petrol pumps in 2022, compared to 4,160 in 2012 in the state.[22] This growth also parallels the increase in registrations of cars and two-wheelers in the state.

Table 2.4: Number of petrol pumps

Year	Number of petrol pumps (including private co.)
2012	4,160
2013	4,644
2014	5,025
2015	5,207
2016	5,419
2017	5,684
2018	5,970
2019	6,148
2020	6,457
2021	7,048
2022 (P*)	7,256

* provisional
Source: Petroleum Planning & Analysis Cell, 2023.

Figure 2.1: Trend of registration of two-wheelers, three-wheelers and four-wheelers in Maharashtra



Source: Data from 2011-12 to 2019-20 collated from Annual Road Transport Year Books, Ministry of Road Transport and Highways; Data of 2021-22 procured from CEIC Data Global Database, "Registered Motor Vehicles: Maharashtra: Light Goods Vehicle"
* For the year 2020-21, the annual report was not released by the Ministry of Road Transport and Highways due to COVID-19 outbreak

2.1.4 Employment in refineries, and marketing and distribution

The employment in the oil sector has been estimated for the two refineries operating in the state and the employment associated with the retail outlets. In fact, from an employment perspective in an energy transition scenario, the marketing and distribution segment is highly important as it will be more impacted by the energy transition in terms of job loss. The marketing and distribution segment also employs a large number of semi-skilled and contract workers.

The total number of employees, both permanent and contractual, in BPCL refineries nationwide (total three refineries) stood at 33,027 for the year 2022-23.[23] Out of this, 74% are contractual employees/workers. For HPCL refineries (two refineries), the total number of employees stood at 47,499. Out of this 82% are contractual employees/workers.[24]

While the annual reports of the PSUs mention the total employees and workers in all the refineries in the undertaking, location-based employee data is not available. To estimate refinery-wise employment, an employment facto approach has been applied. As per this, the total employees at the Mumbai HPCL refinery can be estimated to be about 22,012 (including contractual), and at the Mumbai BPCL refinery is about 11,227 (including contractual).

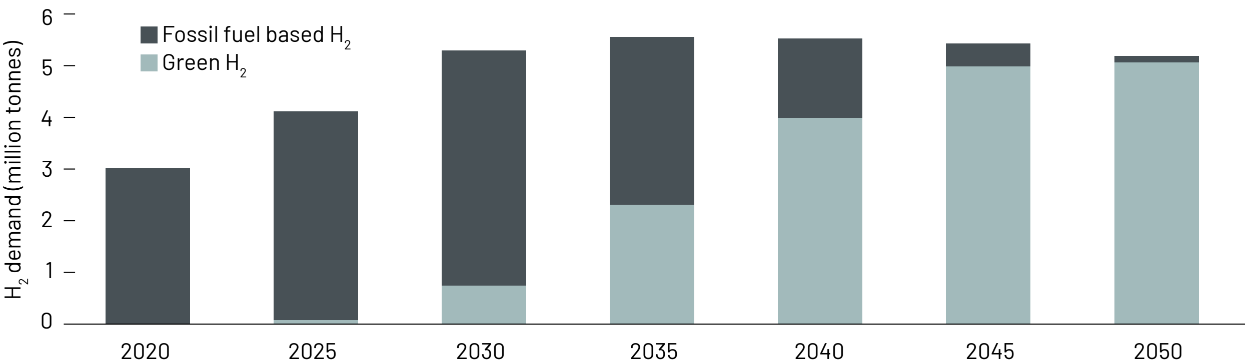
For the marketing and distribution segment, petrol pumps can be estimated to be about 116,096.[25]

2.1.5 Just energy transition issues for oil sector

The key green transition issue for India's oil sector will be greening the refining process by using green hydrogen in the coming years.[26]

India's refinery sector processes almost 250 MMT of crude oil per year requiring about 3 MMT of hydrogen. This is about 46% of the country's total hydrogen demand. The majority of this hydrogen is generated from on-site. The production of this hydrogen contributes to about 27 MMT of CO_2 emissions currently, which are expected to rise to 47 MMT by 2050. However, adoption of green hydrogen can help to neutralize CO_2 emission from hydrogen production by 2050.[27]

Figure 2.2: Hydrogen demand outlook for refineries in India



Source: Figure adopted from NITI Aayog and RMI, 2022

For state-run refineries, the Central Government is providing fiscal incentives for greening the sector. In 2023 union budget, an outlay of ₹300 billion Indian rupee ($3.66 billion) was announced to help such refiners move towards cleaner energy.[28]

Besides use of green hydrogen, application of carbon capture and storage (CCUS) technology is also being proposed by international expert agencies, such as the International Energy Agency (IEA).[29] The application of CCUS to refining operations can be an important mechanism to reduce emissions from the oil value chain. While refineries consist of a variety of CO_2 emission sources across different processing units, there are some units and systems that could be equipped with CCUS units. This includes hydrogen production units using steam methane reforming, fluid catalytic cracking units and co-generation systems.[30]

With respect to workforce transition, key intervention will be necessary in the marketing and distribution segment. Following the growth of electric vehicles (EVs), there will be reduction in the number of petrol pumps or modification of these infrastructures commensurate with electrification of vehicular fleet. Considering the large-scale low income-dependence in this segment, state and central government intervention for transition of the workforce, through reskilling, reemployment, and transition support will be necessary.

2.2 Natural gas

Among the three fossil fuel sectors, the natural gas sector is likely to see the least disruption during the process of energy transition in the immediate future. Both policymakers and energy experts envision an increased use of natural gas to meet the local pollution and GHG emission reduction targets.[31] All the net-zero models project three to four folds increase in natural gas demand by 2050.[32] The Government of India (GoI) has also set a target to raise the share of natural gas in the energy mix to 15% in 2030 from about 6.3% in 2022.[33] Natural gas consumption, therefore, is projected to increase in the industrial sector, as well as in the power sector.[34]

However, natural gas use has significant implications for global warming, notwithstanding uncertainty regarding its actual contributions, in particular the level of methane emissions – whether by accident or by design – from well to the burner. A 2019 study published in Nature found that methane leaks from the fossil fuel industry were underestimated by at least 40%.[35]

Methane is a more potent greenhouse gas than CO_2, but has a lower atmospheric life than CO_2. The Global Warming Potential (GWP) of methane, compared to CO_2, averaged over 100 years is 25. If averaged over 20 years, the GWP of methane rises to 84. Some studies, however, peg the 20-year GWP of methane at 105.[36] As the GWP of methane is high, any significant release of methane during the life-cycle of natural gas increases the climate footprint significantly. It is estimated that at a GWP of 105, if 3% of natural gas production is emitted from well-to-burner, then gas loses all its GHG emissions advantage over coal.[37] The growth in natural gas use in India and worldwide, therefore, will largely depend on better understanding regarding its global warming impacts.

2.2.1 Production and consumption

While India is ambitious of a gas economy, the country until now is heavily reliant on natural gas imports to meet its demand. For instance, in 2022-23, India produced about 33.66 billion cubic meters (BCM) of natural gas and the import was nearly 26.30 BCM. In fact, over the past decade, the import of liquified natural gas (LNG) in India has increased steadily, from 17.85 BCM in 2011-12 to about 26.30 BCM in 2022-23.[38] Domestic production has gone down during this period, from 46.45 BCM in 2011-12 to 33.64 BCM in 2022-23.[39]

In Maharashtra, the production of natural gas from the Mumbai off-shore basin, owned by Oil and Natural Gas Corporation Limited (ONGCL), fell from 1.87 BCM in 2016-17 to 1.04 BCM in 2019-2020. Moreover, in the subsequent years of 2020-21 and 2021-22, the production from the basin has been nil.[40]

With respect to consumption, the total consumption of natural gas in India in 2022-23 was about 60 BCM, which was a 7% reduction from the 2021-22 levels of 64.16 BCM.[41] The largest consumer of natural gas is the fertilizer sector, which is largely dependent on natural gas as a feedstock and fuel. In 2021-22, the fertilizer sector had a share of about 30.4% of the natural gas consumption. This is followed by City and Local Natural Gas Distribution Network (including for road transport) at 20.4%, power sector at 15.0%, and refinery at 8.9%.[42]

2.2.2 Marketing and distribution

The major distribution segments of the gas sector (including its derivatives and products) include compressed natural gas (CNG), piped natural gas (PNG), and liquefied petroleum gas (LPG). These cater to various domestic, commercial, and industrial uses.

In Maharashtra, as of the latest estimates (October, 2023), there are at least 802 CNG stations in the state which is 13.2% of India's total. For PNG, there are a total of 3.1 million connections, which constitutes for than 26% of India's total.[43]

Table 2.5: PNG connections

Connection type	No. of PNG connections	Share of India total (%)
Domestic	3,129,438	26.3
Commercial	4,736	12.0
Industrial	936	5.3
Total	3,135,110	26.2

Source: Petroleum Planning & Analysis Cell, 2024

With respect to LPG distributors, as of the latest estimates (October 2023), the state has over 2,231 distributors, depicting a near-doubling over the past decade (1,241 in 2012). This accounts for more than 9% of the LPG distributors in India.[44] Subsequently, the number of LPG consumers has also increased in the state. As per information available for active LPG consumers, there are currently about 30 million active consumers, which is 10% of India's total.[45]

Table 2.6: Number of LPG distributors

Year	Number of LPG distributors
2012	1,241
2013	1,303
2014	1,375
2015	1,549
2016	1,697
2017	1,756
2018	1,827
2019	2,134
2020	2,184
2021	2,206
2022	2,219
2023 (P*)	2,231

Source: Petroleum Planning & Analysis Cell, 2024; * provisional.

Table 2.7: Number of active LPG consumers

Year	2017	2018	2019	2020	2021	2022
Active LPG consumers	22,192,528	24,102,724	26,928,428	27,628,751	28,757,177	29,854,482

Source: Indian Petroleum & Natural Gas Statistics 2021-22, Ministry of Petroleum and Natural Gas, 2023

2.2.3 Employment

The employment for the gas sector could only be estimated for LPG distributors in the state. Based on the review of letter of intent of oil marketing companies, the total employment in LPG distribution can be estimated to be about 8,924 (considering two office staff and two loaders/unloaders who also do delivery).

2.2.4 Just energy transition issues for natural gas sector

Presently, the gas sector does not seem to have major transition challenges because of the projected growth in this sector till 2050. If alternatives like hydrogen and electricity become cheaper than imported LNG, then gas use will not grow as much as it is projected by various agencies.

However, a reduction in natural gas consumption is immediately necessary for the fertilizer sector, which is the key consumer. Urea fertilizer produced using natural gas has a high carbon footprint. Overall, in India, an average of 0.714 MT of CO_2 equivalent (CO_2e) is estimated to be emitted for each MT of urea during the production stage. The just energy transition issue of the fertilizer section is discussed in detail in the later chapter.

In the marketing and distribution segment, while, there is no immediate transition challenge for the PNG segment, however, the CNG and the LPG distribution segments remain vulnerable to the transition. The CNG will be impacted by the EV transition, while the LPG will face challenges with the rise in PNG supply for cooking, especially for households, and also electric cooking gadgets. A review of the existing PNG network suggests that urban India will move to PNG. The Government is planning to spend ₹120,000 crores over the next 10 years to expand the city gas distribution (CGD) network across the country to cover 407 districts, and about 70% of the population. Maharashtra, Maharashtra Natural Gas Limited (MNGL), a joint venture of two Maharatna PSUs, GAIL (India) Limited and BPCL, has a network in various districts.[46] From a just transition perspective, therefore, the CNG and LPG distributing companies, along with their workforce hold significance.

SECTION II

ELECTRICITY SECTOR

Chapter 3: COAL-BASED THERMAL POWER

CHAPTER 3

Coal-Based Thermal Power

3.1 Operational status

The power sector in Maharashtra has played a critical role in accelerating the state's economic growth. It is a frontrunner in quality of power supply, adoption of digitalisation, financial performance and promotion of clean energy.[1]

Maharashtra has the largest coal-based thermal power capacity in India which is 11.3% of the country's total. The total capacity of utility-scale TPPs is about 24 gigawatts (GW). Besides, the state has 3GW of coal-based captive power capacity, which accounts for about 7.4% of India's total.[2] Overall, Maharashtra State Power Generation Co. Ltd. (MSPGCL) has a share of about 40% of the utility-scale installed capacity.

Table 3.1: Operational TPPs

Owner	Name of TPP	Unit No.	Installed capacity (MW)	District	Block	Coal consumption (MMT)
MSPGCL	Bhusawal TPS	3	210	Jalgaon	Bhusawal	0.52
		4	500			
		5	500			
	Chandrapur STPS	3	210	Chandrapur	Chandrapur	0.8
		4	210			
		5	500			
		6	500			
		7	500			
		8	500			
		9	500			
	Khaparkheda TPP	1	210	Nagpur	Mauda	0.53
		2	210			
		3	210			
		4	210			
		5	500			
	Koradi TPP	6	210	Nagpur	Kamthi	0.89
		8	660			
		9	660			
		10	660			
	Nashik TPP	3	210	Nashik	Sinnar	0.18
		4	210			
		5	210			
	Paras TPP	1	250	Akola	Balapur	0.21
		2	250			
	Parli TPP	6	250	Beed	Parli	0.21
		7	250			
		8	250			

Table 3.1 continued

Owner	Name of TPP	Unit No.	Installed capacity (MW)	District	Block	Coal consumption (MMT)
Sinnar Thermal Power Limited	Nashik (P) TPP	1	270	Nashik	Sinnar	
		2	270			
		3	270			
		4	270			
		5	270			
GMR Energy Limited	GMR Warora TPP	1	300	Chandrapur	Warora	0.24
		2	300			
Adani Power Limited	Tirora TPP	1	660	Gondia	Tiroda	1.28
		2	660			
		3	660			
		4	660			
		5	660			
Gupta Energy Private Limited	GEPL TPP Phase-1	1	60	Chandrapur	Chandrapur	
		2	60			
Vidarbha Industries Power Limited	Butibori TPP	1	300	Nagpur	Hingana	
		2	300			
Ideal Energy Projects Limited	Bela TPP	1	270	Nagpur	Umred	0.1
RattanIndia Power Limited	Amravati TPP	1	270	Amravati	Amravati	0.51
		2	270			
		3	270			
		4	270			
		5	270			
JSW Energy Limited	JSW Ratnagiri TPP	1	300	Ratnagiri	Ratanagiri	0.06
Abhijeet MADC Nagpur EPL	Mihan TPP	1	246	Nagpur	Nagpur	
Adani Electricity Mumbai Limited	Dahanu TPP	1	250	Palghar	Dahanu	0.17
		2	250			
Wardha Power Company Limited	Wardha Warora TPP	1	135	Chandrapur	Warora	0.15
		2	135			
		3	135			
		4	135			
Dhariwal Infrastructure Private Limited	Dhariwal TPP	1	300	Chandrapur		0.16
		2	300			
Shirpur Power Private Limited	Shirpur TPP	1	150	Dhule	Shirpur	
Tata Power Company Limited	Trombay TPP	5	500	Mumbai	Chembur	0.13
		8	250			

Table 3.1 continued

Owner	Name of TPP	Unit No.	Installed capacity (MW)	District	Block	Coal consumption (MMT)
NTPC	Mauda TPP	1	500	Nagpur	Mauda	0.91
		2	500			
		3	660			
		4	660			
	Solapur STPS	1	660	Solapur	South Solapur	0.42
		2	660			
Total		68	23,856			7.47

Source: Central Electricity Authority, list of thermal power plants in India, 2021; Central Electricity Authority, Report on fly ash generation at coal and lignite thermal power plants and its utilization in the country, 2020-21; Central Electricity Authority, monthly coal statement of thermal power stations for February-2023; Blank spaces indicates number not available.

In addition to operational TPPs, Mahagenco further plans for an capacity addition of 2,170 MW by 2029.[3]

Table 3.2: Upcoming TPPs

Owner	Name of TPP	Unit no.	Capacity (MW)
MSPGCL	Uran CCPP Unit/s	NA	850
	Koradi TPS	11	660
	Koradi TPS	12	660

Source: Mahagenco, 2023

The state also has a few TPPs that have previously been started, but due to lack of new bids for long-term Power Purchase Agreements (PPA), liquidation orders and other financial constraints, the projects are on hold and unlikely to be commissioned. These include five private TPPs with a total capacity of 4,230 MW.

Table 3.3: List of TPPs under construction not likely to be commissioned as of 2023

Owner	Name of the project	Unit No.	Capacity (MW)
RattanIndia Power Limited	Amravati TPP Phase-II	1	270
		2	270
		3	270
		4	270
RattanIndia Nashik Power Limited	Nashik TPP Phase-II	1	270
		2	270
		3	270
		4	270
Lanco Vidarbha Private Limited	Lanco Vidarbha TPP	1	660
		2	660
Jinbhuvish Power Generation Private Limited	Bijora Ghanmukh TPP	1	300
		2	300
Shirpur Power Private Limited	Shirpur TPP	2	150
Total		13	4,230

Source: Central Electricity Authority, broad status report of under-construction thermal power projects, February 2023

Maharashtra also has 14 TPP units with a cumulative capacity of 2,740 MW that were decommissioned between 2016 and 2021 for techno-economic reasons. The latest one is unit 7 (210 MW) of Koradi TPP which was decommissioned in August 2021, as it was more than 38 years old and most of its control systems were obsolete, and their replacement would have been economically unviable.[4]

In terms of area, the total land of all TPPs in the state is about 13,089.39 ha. Among this, the total area with Mahagenco is 7,348.7 ha, which is 56% of the total area of the TPPs, while private TPP land is approximately 32.26%. NTPC, which is the only central-sector power entity in the state, has approximately 11.5% of the total TPP land.

Table 3.4: Land details of TPPs

Name of TPS	Block	Capacity (MW)	Power station land area (ha)	Ash pond* (ha)	Total (ha)
Chandrapur STPS	Chandrapur	2,920	1,051.34	2,492.68	3544.02
Khaparkheda TPP	Mauda	1,340	162.9	691.19	854.09
Koradi TPP	Kamthi	2,190	324.24	576.23	900.47
Paras TPP	Balapur	500	255.16	89.75	344.91
Bhuswal TPP	Bhusawal	1,210	349.63	145	494.63
Nashik TPP	Sinnar	630	126.58	297.41	423.99
Parli TPP	Beed	750	306.03	480.65	786.68
Nashik (P) TPP	Sinnar	1,350	1077.5	-	1077.5
GMR Warora TPP	Warora	600	114		114
Tirora TPP	Tirora	3,300	402		402
GEPL Phase-1	Chandrapur	120	62.4		62.4
Butibori TPP	Hingana	600	111.2		111.2
Bela TPP	Umred	270	140.4		140.4
Amravati TPP	Amravati	1,350	546.3	292	838.3
JSW Ratnagiri TPP	Ratnagiri	300	350		350
Mihan TPP	Nagpur	246	127.9		127.9
Dahanu TPP	Dahanu	500	260		260
Wardha Warora TPP	Warora	540	114		114
Dhariwal TPP	Warora	600	178.7		178.7
Shirpur TPP	Shirpur	150	56.5		56.5
Trombay TPP	Chembur	750	390		390
Mauda TPP	Mauda	2,320	728.4		728.4
Solapur STPS	South Solapur	1,320	789.3	-	789.3
Total		23,856	8024.48	5064.91	13,089.39

Source: Data for all Mahagenco TPPs procured from department, while EC letters used for rest; for units for which land data was not available, data has been extrapolated based on available data for units of the same plant; otherwise a thumb rule of 1.3 acres or 0.52 ha per MW is used. For TPPs that did not have specific details on ash pond and plant area, the total area as mentioned in the EC letters is taken. * Blanks indicate no data available.

Table 3.5: Company-wise availability of TPP land

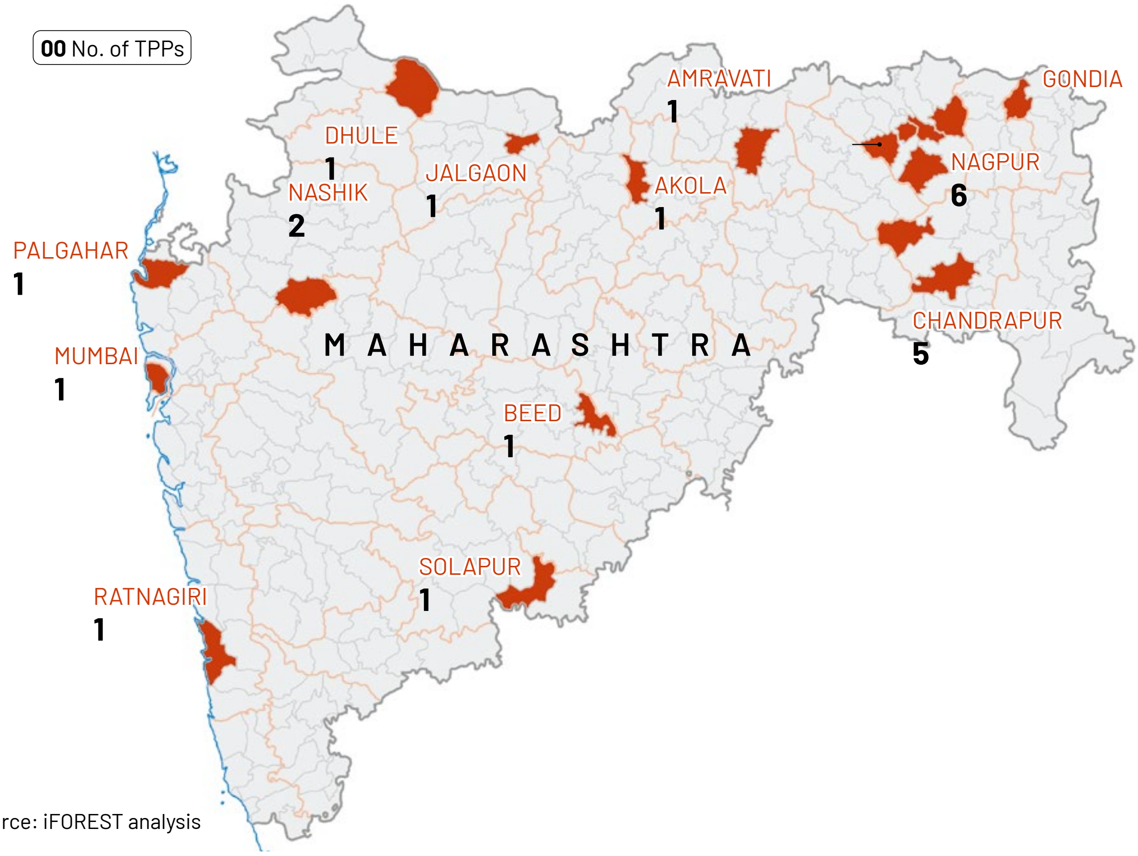
Company	No. of TPPs	Land area (in ha)
MSPGCL	7	7,348.70
NTPC	2	1,517.70
Private	14	4,222.90
Total	23	13,089.30

Source: Environmental clearance letters and EIA reports of power plants.

3.2 Spatial distribution

Of Maharashtra's currently operational 23 TPPs with a cumulative installed capacity of 23,856 MW, five are located in Nagpur district and six in Chandrapur. These two districts, along with Gondia and Nashik, account for 70% of the installed capacity in the state. Overall, there are 68 operational TPP units across the state, with the maximum number in Nagpur, Chandrapur and Nashik. Besides, utility-scale coal power plants, there are several captive power plants operational in the state associated with various industrial sectors. Overall, the state has over 3,331 MW of coal-based captive capacity *(see section below)*.

Map 3.1: Spatial distribution of TPPs in Maharashtra



Source: iFOREST analysis

The distribution of TPPs reflects the coexistence of power infrastructure with coal mines in Nagpur and Chandrapur. As such, the power plants in the two eastern districts are majorly supplied coal by WCL mines.[5] Besides some of the TPPs, such as the Khaparkheda TPP in Nagpur, also source coal from other subsidiaries such as South Eastern Coalfields Limited (SECL).[6]

Table 3.6: Spatial distribution of operational utility-scale TPPs in Maharashtra

District	Block	No. of TPPs	No. of units	Installed capacity (MW)
Akola	Balapur	1	2	500
Amravati	Amravati	1	5	1,350
Beed	Parli	1	3	750
Chandrapur	Chandrapur	2	9	3,040
	Warora	3	8	1,740
Dhule	Shirpur	1	1	150
Gondia	Tiroda	1	5	3,300

Table 3.6 continued

District	Block	No. of TPPs	No. of units	Installed capacity (MW)
Jalgaon	Bhusawal	1	3	1,210
Mumbai	Chembur	1	2	750
Nagpur	Mauda	2	9	3,660
	Kamthi	1	4	2,190
	Hingana	1	2	600
	Umred	1	1	270
	Nagpur	1	1	246
Nashik	Sinar	2	8	1,980
Palgahar	Dahanu	1	2	500
Ratnagiri	Ratnagiri	1	1	300
Solapur	South Solapur	1	2	1,320
Total		23	68	23,856

Source: iFOREST analysis

Captive power in Maharashtra

Maharashtra has a total of 5.5 GW of captive power capacity, which includes both fossil fuel-based and RE-based sources. Overall, the coal-based captive power capacity is about 3 GW, which accounts for about 7.4% of India's total captive capacity. This is followed RE-based capacity (solar, wind and hydro) at 19.4% and oil and gas-based captive power plants at 16%.

The Indian Captive Power Producers Association (ICPPA) is the apex industry body supporting captive power in the state.[8] In March 2022, the association in its comments on Draft (Terms and Conditions for Renewable Energy Certificates for Renewable Energy Generation) Regulations, 2022[6] suggested having captive power generated through biomass co-firing units. Co-firing biomass pellets with coal is considered as a strategy for reducing GHG emissions from coal-based power plants.[10]

Table 3.7: Fuel type-wise installed capacity of captive power plants

Fuel type	Installed capacity (MW)	Share of total state capacity
Steam	3,331.81	61%
Diesel	704.05	13%
Gas	324.98	6%
Solar	901.16	16%
Wind	182.16	3%
Hydro	21.00	0.38%
Total	5,465.17	100%

Source: All India Electricity Statistics, 2023.

With respect to industry-type captive power plants are used by various industries in the state. In terms of installed capacity, the captive power plants under the iron and steel industry in the state account for the highest capacity at 1383.92 MW. This is about 8.6% of the total captive capacity of with iron and steel sector across India. The other key industries using captive power units include, sugar chemical, mineral oil and petroleum, cement, and automobiles.

Table 3.8: Industry-wise captive capacity in Maharashtra

Industry type	State-installed capacity (MW)	All-India installed capacity (MW)	Share of all-India capacity (%)
Iron and Steel	1,383.92	16,025.40	8.6
Sugar	729.95	5,966.45	12.2
Chemical	490.53	4,454.35	11
Mineral oil and Petroleum	419.87	6,250.56	6.7
Cement	261.79	6,013.70	4.4
Automobiles	246.38	2,777.29	8.9
Paper	156.19	1,830.68	8.5
Fertiliser	121.80	1,412.35	8.6
Electrical engineering	108.37	1,769.26	6.1
Textile	79.16	3,972.45	2
Light Engineering	73.43	814.93	9
Plastic	48.19	289.97	16.6
Rubber	14.30	634.31	2.3
Food products	17.13	1,306.44	1.3
Aluminium	6.50	9,097.52	0.07
Miscellaneous	1,307.67	6,685.35	019.56%
Total	54,65.17	76,732.44	7.12%

Source: All India Electricity Statistics, 2023

3.3 Employment and workforce

The total formal employment (including departmental and contractual workers employed by the companies) in all power utilities in the state is approximately 43,561. As per data acquired for Mahagenco TPPs, it can be inferred that about 70% of them are contractual workers. Besides, the captive power plants are estimated to employ about 2,099 people.. Overall, the TPPs in the state formally employ about about 45,570 people.

Table 3.9: Employment in operational TPPs

Owner	Name of TPP	Unit No.	Total formal	Departmental	Contractual
MSPGCL	Bhusawal TPP	3	4,424	1,106	3,318
		4			
		5			
	Chandrapur STPS	3	8,576	2,144	6,432
		4			
		5			
		6			
		7			
		8			
		9			
	Khaparkheda TPP	1	4,568	1,142	3,426
		2			
		3			
		4			
		5			

Table 3.9 continued

Owner	Name of TPP	Unit No.	Total formal	Departmental	Contractual
	Koradi TPP	6	5,472	1,368	4,104
		8			
		9			
		10			
	Nashik TPP	3	2,684	671	2,013
		4			
		5			
	Paras TPP	1	2,160	540	1,620
		2			
	Parli TPP	6	3,824	956	2,868
		7			
		8			
Sinnar Thermal Power Ltd	Nashik (P) TPP	1	850	285	565
		2			
		3			
		4			
		5			
GMR Energy Limited	GMR Warora TPP	1	378	126	252
		2			
Adani Power Limited	Tirora TPP	1	2,080	695	1,385
		2			
		3			
		4			
		5			
Gupta Energy Private Limited	GEPL TPP Phase-I	1	76	26	50
		2			
Vidarbha Industries Power Limited	Butibori TPP	1	378	126	252
		2			
Ideal Energy Projects Ltd	Bela TPP	1	170	57	113
RattanIndia Power Limited	Amaravati TPS	1	850	285	565
		2			
		3			
		4			
		5			

Table 3.9 continued

Owner	Name of TPP	Unit No.	Total formal	Departmental	Contractual
JSW Energy Limited	JSW Ratnagiri TPP	1	189	63	126
Abhijeet MADC Nagpur EPL	Mihan TPP	1	155	52	103
Adani Electricity Mumbai Limited	Dahanu TPP	1	316	106	210
		2			
Wardha Power Company Limited	Wardha Warora TPP	1	340	112	228
		2			
		3			
		4			
Dhariwal Infrastructure Private Limited	Dhariwal TPP	1	378	126	252
		2			
Shirpur Power Private Limited	Shirpur TPP	1	95	32	63
Tata Power Company Limited	Trombay TPP	5	473	158	315
		8			
NTPC	Mauda TPP	1	3,231	1,077	2,154
		2			
		3			
		4			
	Solapur STPS	1	1,849	616	1,233
		2			
Total			43,516	11,869	31,647

Source: Total worker numbers as provided for NTPC plants and Chandrapur STPS by company departments; and departmental workers as provided by Mahagenco; for others, estimated as per CEA thumb rule of 0.63 persons per MW of installed capacity.
Note: As per information shared by Mahagenco, contractual workers are approximately 3 times of total formal workers. The same has been used for TPPs where data was not available.

3.4 Environmental performance and operational efficiency of TPPs

The environmental performance and operational efficiency of TPPs of Maharashtra has been evaluated considering five factors. These include, the fly ash generation and utilisation., emission, installation of Flue gas desulfurization (FGD) equipments, age of TPPs, and the plant load factor (PLF). All these factors collectively have implications for reducing GHG emissions from TPPs.

3.4.1 Fly ash

Generation and effective use of fly ash are major concerns for coal-based TPPs and fly ash management is a major issue of environmental compliance by the TPPs. Maharashtra accounts the highest fly-ash generation in the past decade. Collectively there is about 52.4 MMT of fly ash in various ash ponds.[7] Overall, fly ash generated in Maharashtra as of 2022 was 28.93 MMT; its utilisation was 46.40 MMT.[8] The percentage utilisation was approximately 60% higher than the generation. This can be attributed to the use of 'legacy ash' by the TPPs.

Table 3.10: Fly ash generation and utilisation

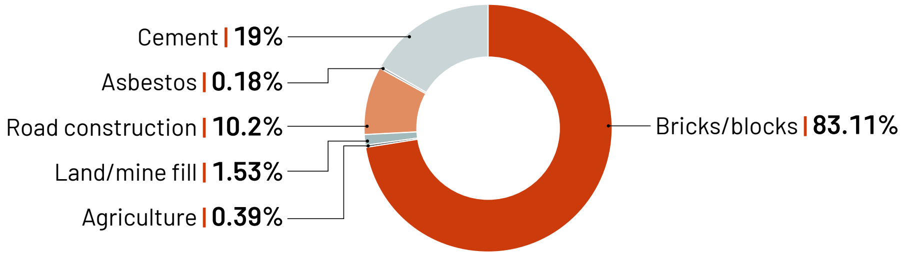
Name of TPP	Fly ash generated (MMT)	Proportion of fly ash used (%)
Solapur STPS	1.1357	75.54
Mouda STPS Stage I	3.4059	111.17
Chandrapur TPP	4.5013	19.48
Bhusawal TPP	1.9071	100
Khaperkheda TPP	2.5825	73.22
Koradi TPP	2.957939	81.13
Nashik TPP	0.6670	803.91
Paras Power Station	0.8072	148.78
Parli TPP	0.7856	2428.62
Amravati TPP	2.3922	81.19
Dahanu TPP	0.6346	105.74
Dhariwal TPP	0.9511	100
GMR Warora TP	0.8208	125.41
JSW Ratnagiri TPP	0.3599	100.02
Tirora TPP	4.5451	78.23
Trombay TPP	0.0548	100
Wardha Warora TPP	0.4221	100

Source: Central Electricity Authority, Report on fly ash generation at coal and lignite thermal power plants and its use in the country, 2021-22. Note: Fly ash generation for Mouda Super Thermal Power Plant Stage II, Butibori Power Project, Bela Power Station, Mihan TPP, Nashik RattanIndia Thermal Power Project, Shirpur Power Project are nil or not available as per the report.

In December 2021, the Ministry of Environment, Forests and Climate Change (MoEFCC) issued a notification on fly ash (revising the earlier notifications), that prohibited the fly ash dumping and made it mandatory to use it in an eco-friendly manner, such as in the manufacture of bricks and cement and construction of roads and flyover embankmen.[9]

Following the notification the TPPs are increasing their fly ash utilisation for various activities. For example, in Mahagenco, of the total fly ash generated, approximately 83%, is used in brick making, followed by cement (19%), and road construction (10.2%).

Figure 3.1: Category-wise fly-ash utilisation in Mahagenco



Source: Mahagenco Fly Ash Generation and Utilisation Status, 2022.

3.4.2 Emissions

The MoEF&CC issued a notification in 2015 elaborating the emission norms for coal-based thermal power plants.[10] These include norms for four major pollutants—suspended particulate matter (SPM), sulphur dioxide (SO_2), oxides of nitrogen (NOx), and mercury (Hg).

Considering these, some of the power plants in Maharashtra are highly polluting. Of the 23 units of Mahagenco for which data were procured, all units (except Bhusawal unit 3) have SO_2 emissions much above the prescribed standards of 600 mg/Nm3 (for units with more than 500 MW capacity) and 200 mg/Nm^3 (for units with less than 500 MW capacity). These units have an average SO_2 emission of 1165 mg/Nm^3.

Table 3.11: Emissions from Mahagenco TPPs

Name of TPP	Unit no.	Average monthly SPM (mg/Nm^3)	Average monthly SOx (mg/Nm^3)	Average monthly NOx (mg/Nm^3)
Bhusawal TPP	3	89.50	524.00	178.00
	4	46.00	1282.25	221.50
	5	45.33	1285.43	215.43
Chandrapur STPS	3	98.67	1224.11	319.44
	4	99.33	1225.56	315.56
	5	102.00	1281.89	322.67
	6	100.78	1274.56	319.00
	7	100.57	1277.43	323.14
	8	21.67	1271.11	308.67
	9	20.22	1275.78	302.67
Khaparkheda TPP	1	195.33	1207.33	306.00
	2	205.71	1238.88	314.88
	3	99.67	1205.89	311.22
	4	94.13	1195.00	302.63
	5	40.56	1455.89	319.56
Koradi TPP	6	96.33	1035.89	308.11
	8	44.88	1419.50	332.38
	9	44.00	1414.11	332.00
	10	44.22	1382.00	329.67
Nashik TPP	3	93.00	1232.67	150.50
	4	142.75	1215.38	148.38
	5	143.44	1148.44	146.11
Parli TPP	6	46.56	700.67	185.33
	7	44.78	691.44	183.33
	8	45.44	678.22	169.89

Source: Mahagenco, March 2023

3.4.3 FGD installation status

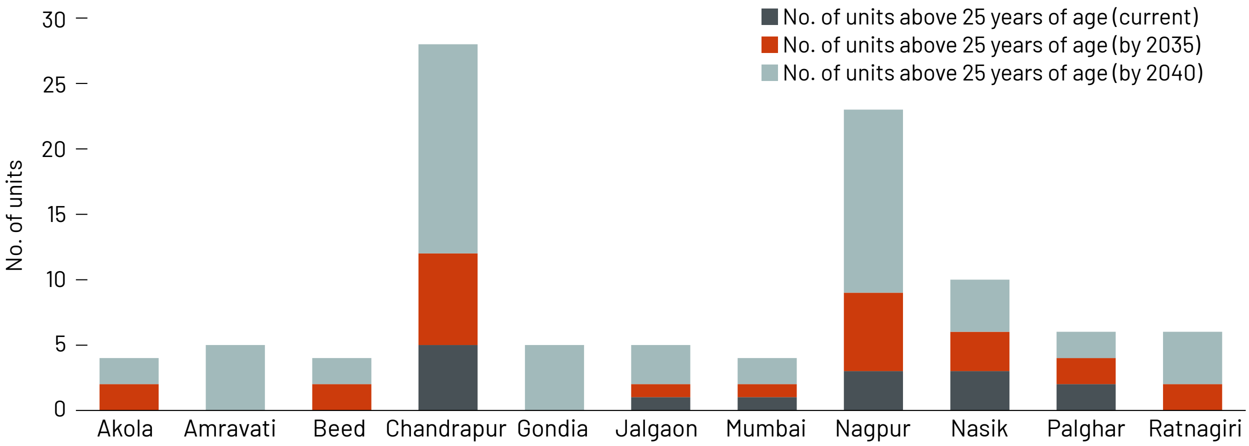
The Environment (Protection) Amendment Rules, 2015 for thermal power plants has made it necessary for TPPs across the country to install Flue Gas Desulfurization (FGD) units to curtail the emission of SO_2. Installation of FGDs is costly. The per MW cost of an FGD package may vary from ₹0.50 to ₹1.20 crore.[11] Considering the costs involved, stressed assets will not be able to install FGDs. Currently, all five units of Sinnar Thermal Power Limited Nashik (P) TPP with an installed capacity of 1350 MW are considered stressed units.

3.4.4 Age

While Maharashtra has a relatively young thermal power fleet, but the state also has some old TPPs. The Paras TPP (Stage 1) in Akola district was the oldest TPP of Mahagenco commissioned in 1961 with an installed capacity of 30 MW using stroke boiler technology.[12]

Overall, about 20% of the units (corresponding to 4.4 GW capacity) are over the age of 25 years. By 2040 this share will increase to over 58%. Geographically, Chandrapur district has the highest percentage of old TPP units, followed by Nagpur and Nashik. Currently, 18% (4.4 GW) of the grid-connected TPP capacity is over the age of 25 years. This includes 15 units across 10 districts. By 2040, this share will be 67%.

Figure 3.2: Age assessment of TPPs



Source: iFOREST analysis based on environmental clearance letters.

3.4.5 Plant load factor

The plant load factor (PLF) is an important metric to understand optimal performance of the TPP. An analysis of the PLF of various TPPs show that most of the old units (above 25 years age) are highly inefficient and have PLF below 60%. Even for units below 25 years, only 30% have PLF over 60%.[13]

3.5 Just energy transition issues for coal power plants

Time frame for phase down of TPPs

The time frame for phase down of TPPs has been considered under a business as usual scenario. The scenario assumes that existing and upcoming TPP units can be phased down at the end of their design life (considering an average design life of 25 years as per the Central Electricity Authority (CEA).

The decadal closure scenario for phasing down coal-based power production in Maharashtra has been determined considering three factors—age (considering an average design life of 25 years as per the Central Electricity Authority),[14] PLF and FGD installation status. Overall, for determining a phase down schedule the following factors have been taken into account:

1. The upcoming utility plants have been included in estimating the retirement timeline;
2. The closure timeline is determined on the basis of the age of the plant, the PLF and FGD installations;
3. For plants which are operating efficiently with better PLF, (considered above 60% for average of five years) or has FGD installed or are installing, an operational period of 10 more years has been assumed; and,
4. For plants where no PLF or FGD assessment was available, only the age has been considered as the criterion for retirement.

Considering this, a prospective phase down scenario considering the above-mentioned factors is outlined below.

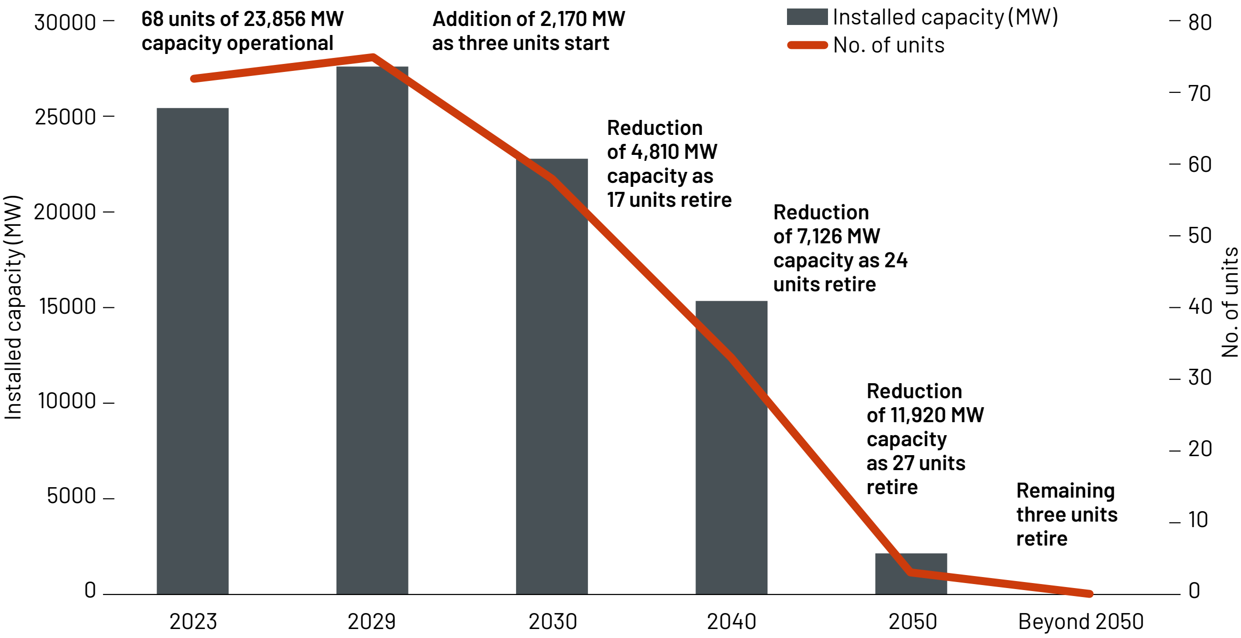
Phase I – By 2030: In this phase, 17 units—14 of Mahagenco, two of Adani Power Limited, and one unit of Tata Power will be retired. These units (except two units of Khaparkheda TPP) have already completed 25 years of operation. Their retirements will lead to a reduction in capacity of 4,810 MW.

Phase II – Between 2030 and 2040: In this phase, 24 units with a cumulative capacity of 7,126 MW will be retired.

Phase III – Between 2040 and 2050: This phase is marked by the retirement of maximum units. Overall, 27 units with a cumulative capacity of 11,920 MW will be retired. These include 16 units that completed 25 years of design life between 2030 and 2040 but got 10 extra years because they were operating at a PLF of more than 60%.

Phase IV– Beyond 2050: In this phase, the three upcoming units of Mahagenco, with a cumulative capacity of 2,170 MW will be retired.

Figure 3.3: TPP phase down scenario



Source: iFOREST analysis

Table 3.12: Multi-factor analysis of TPPs in Maharashtra (operational units)

Company	Plant	Unit No.	Year of commissioning	Installed capacity (MW)	Age (as of 2023)	PLF (%)	FGD installed status	Year of retirement (considering 25-year life cycle)
MSPGCL	Bhusawal TPP	3	1982	210	41	33.5	To be decommissioned	2007
		4	2012	500	11	69.8	Bid opened	2037
		5	2012	500	11	67.4	Bid opened	2037
	Chandrapur STPS	3	1985	210	38	27.6	Feasibility study started	2010
		4	1986	210	37	38.8	Feasibility study started	2011
		5	1991	500	32	64.6	Bid opened	2016
		6	1992	500	31	48.8	Bid opened	2017
		7	1997	500	26	57.8	Bid opened	2022
		8	2015	500	8	63.9	Bid opened	2040
		9	2016	500	7	74.9	Bid opened	2041
	Khaparkheda TPP	1	1989	210	34	39.5	Feasibility study started	2014
		2	1990	210	33	52.2	Feasibility study started	2015
		3	2000	210	23	32.6	Bid awarded	2025
		4	2001	210	22	48.4	Bid awarded	2026
		5	2011	500	12	68.5	Bid opened	2036
	Koradi TPP	6	1982	210	40	NA	Bid awarded	2008
		8	2015	660	8	54.3	Bid opened	2040
		9	2016	660	7	45.7	Bid opened	2041
		10	2016	660	7	54.5	Bid opened	2041
	Nashik TPP	3	1979	210	44	44.3	To be decommissioned	2004
		4	1980	210	43	68.8	To be decommissioned	2005
		5	1981	210	42	43.9	To be decommissioned	2006
	Paras TPP	1	2007	250	16	NA	Bid awarded	2032
		2	2010	250	13	NA	Bid awarded	2035
	Parli TPP	6	2007	250	16	62.9	Bid opened	2032
		7	2010	250	13	38.5	Bid opened	2035
		8	2016	250	7	38.7	Bid opened	2041
Sinnar Thermal Power Ltd	Nashik (P) TPP	1	2014	270	9	NA	Stressed asset	2039
		2	2017	270	6	NA	Stressed asset	2042
		3	2017	270	6	NA	Stressed asset	2042
		4	2017	270	6	NA	Stressed asset	2042
		5	2017	270	6	NA	Stressed asset	2042
GMR Energy Ltd	GMR Warora TPP	1	2013	300	10	76.1	Bid opened	2038
		2	2013	300	10	66.4	Bid opened	2038
Adani Power Ltd	Tirora TPP	1	2012	660	11	64	Bid awarded	2037
		2	2013	660	10	48.5	Bid awarded	2038
		3	2013	660	10	61.7	Bid awarded	2038
		4	2014	660	9	59.8	Bid awarded	2039
		5	2014	660	9	70.3	Bid awarded	2039

Table 3.12 continued

Company	Plant	Unit No.	Year of commissioning	Installed capacity (MW)	Age (as of 2023)	PLF (%)	FGD installed status	Year of retirement (considering 25-year life cycle)
Gupta Energy Pvt Ltd	GEPL TPP Phase-1	1	2012	60	11	NA	Feasibility Study started	2037
		2	2012	60	11	NA	Feasibility Study started	2037
Vidarbha Industries Power Ltd	Butibori TPP	1	2012	300	11	42.2	NIT installed	2037
		2	2014	300	9	83.6	NIT installed	2039
Ideal Energy Projects Ltd	Bela TPP	1	2013	270	10	3.4	Claims to be SO_2 compliant	2038
Rattan India Power Ltd	Amravati TPP	1	2013	270	10	51.3	Tender specification done	2038
		2	2014	270	9	47.6	Tender specification done	2039
		3	2015	270	8	36.6	Tender specification done	2040
		4	2015	270	8	38.8	Tender specification done	2040
		5	2015	270	8	27.5	Tender specification done	2040
JSW Energy Ltd	JSW Ratnagiri TPP	1	2010	300	13	80.2	Installed	2035
Abhijeet MADC Nagpur EPL	Mihan TPP	1	2012	246	11	NA	CFBC	2037
Adani Electricity Mumbai Ltd	Dahanu TPP	1	1995	250	28	86.4	Installed	2020
		2	1995	250	28	74.9	Installed	2020
Wardha Power Company Limited	Wardha Warora TPP	1	2010	135	13	NA	NIT issued	2035
		2	2010	135	13	NA	NIT issued	2035
		3	2011	135	12	38.5	NIT issued	2036
		4	2011	135	12	57	NIT issued	2036
Dhariwal Infrastruc-ture Pvt Ltd	Dhariwal TPP	1	2013	300	10	9.8	Bid opened	2038
		2	2014	300	9	81.2	Bid opened	2039
Shirpur Power Pvt Ltd	Shirpur TPP	1	2017	150	6	NA	Feasibility Study started	2042
Tata Power Co Ltd	Trombay TPP	5	1984	500	39	73.2	FGD installed	2009
		8	2009	250	14	79.3	FGD installed	2034
NTPC	Mauda TPP	1	2012	500	11	58.1	Bid awarded	2037
		2	2013	500	10	54.1	Bid awarded	2038
		3	2016	660	7	31.9	Bid awarded	2041
		4	2017	660	6	33.3	Bid awarded	2042
	Solapur STPS	1	2017	660	6	39.6	Bid awarded	2042
		2	2019	660	4	NA	Bid awarded	2044
Total		68		23,856				

Source: Central Electricity Authority, list of thermal power plants in India, 2022; Central Electricity Authority, Report on fly ash generation at coal and lignite thermal power plants and its utilization in the country, 2020-21; Unit wise FGD implementation status and summary, 2023

RENEWABLE ENERGY IN MAHARASHTRA

Maharashtra currently has an installed capacity of 10.657 MW.[15] Among this, wind power has a share of 47% followed by solar and bio-power, each with a share of 25%.

The state has adopted a new renewable policy called 'Unconventional Energy Generation Policy, 2020' which aims to generate electricity from new and renewable energy sources of approximately 17,385 MW for transmission-linked projects.[16] Additionally, for non-transmission projects, the state has proposed to install 500,000 solar pumps for agriculture, 10,000 solar pumps for water supply, and a decentralised micro-grid project for 100 villages, among other initiatives.[17]

To give priority to green energy, Mahagenco Renewable Energy Limited constructs solar energy projects under the central government's Solar Park Scheme, as well as under the Thermal and Renewable Energy Blending Policy, Mukhyamantri Solar Krishi Vahini Yojana, etc. Currently, it has solar projects with a total installed capacity of 862.14 MW as of 2022, and an expected capacity addition of 132.5 MW for projects to be commissioned by 2025.[18] The company has also commissioned a green hydrogen plant with a capacity of 20 nm^3/hr.[19]

According to the latest tariff policy of the Ministry of Power, which provides for bundling of RE with thermal energy, flexibility has been provided to generation companies to reduce emissions, increase RE generation and enable compliance with Renewable Purchase Obligations (RPOs).[20] In that regard, Maharashtra TPPs have the potential to add 3,276 MW of solar capacity by replacing thermal power in 11 major TPPs in the state.

Table 3.13: Installed RE capacity

	Small hydro	Wind	Bio-Power				Solar	Total
			Biomass/Bagasse Cogeneration	Biomass Cogeneration (NonBagasse)	Waste to Energy	Waste to Energy (Off-grid)		
Capacity (MW)	381.1	5,012.8	2,568	16.4	12.6	35.2	2,631	10,657.1

Source: All India Electricity Statistics, 2023

Table 3.14: Replacement of thermal energy with RE in TPPs in Maharashtra

Name of TPP	Thermal energy to be replaced (MU)	Equivalent solar capacity (MW)
Mauda TPP	1,747	906
Solapur STPS	438	227
Bhusawal TPP	485	251
Chandrapur TPP	1,019	529
Khaparkheda TPP	600	312
Koradi TPP	875	454
Nashik TPP	50	26
Paras TPP	190	99
Parli TPP	40	21
Dahanu TPP	404	210
Trombay TPP	464	241
Total	6,312	3,276

Source: Ministry of Power, May 2022

Augmenting RE development in the state in the coming years remain crucial for the state's green energy transition, boosting potential of green growth and supporting green jobs. This needs to be supported through strong State and Central Government policies and investments in the sector.

Overall, Maharashtra has ambitious RE targets, with initiatives to build solar projects of a total 12 GW over the next six years, alongside goal of increasing power availability and lowering purchase costs.[21] The State Government has also been issuing policies from Year 1996 for promotion of RE within the state.

However, the potential realisation of RE remains suboptimal. While the state has an installed RE capacity of about 10,657 MW, however, so far it has achieved only about 6% of its potential RE capacity. As per Maharashtra Energy Development Agency (2023), the state's total RE potential remains 169010 MW. Of this, the potential of wind energy is 58% and the potential of solar is 38%.

The state is making massive investments in RE, which is considered among the top investment sectors in the state, besides sectors like steel and information technology.[22] Aligned with the Paris Agreement, the state is committed to generating 40% electricity from renewable sources by 2030.

Repurposing the retired thermal power units can support green energy and green industry development in coal areas.

Repurposing TPPs for green energy and green industry is a strategic and sustainable approach to transition away from traditional fossil fuel-based (coal-based) energy generation. Repurposing involves decommissioning the existing assets and utilising the existing land and infrastructure to support the development of cleaner and more environmentally friendly technologies, such as, RE, battery energy storage system (BSES), green hydrogen plants, etc.

Maharashtra has 14 TPP units with a cumulative capacity of 2.7 GW that were retired between 2016 and 2021 for techno-economic reasons. Besides, 4.4 GW (involving 15 units) of the coal fleet is likely to retire in the next 10 years. Repurposing the retired units into industrial parks, green hydrogen plants, and RE development provides significant opportunities for supporting green energy and industry development, creating jobs, and strengthening state-level climate action. Overall, the state will require a comprehensive strategy to deal with the coal transition in the next 10 years.

Transition of the workforce

As coal-based power generation is phased down, there will be a large number of workers who will be impacted over the next three decades. The sector formally employs about 45,570 people, out of which over 95% are with the utility plants. The informal jobs are likely to be much higher as per ground experiences in coal districts.

Therefore, supporting workforce transition of both formal and informal workers will be a central issue for the TPPs in Maharashtra. This will require intervention by the large number of power companies operating in the state (primarily for the formal workers) and also by State Government (primarily for the informal workers). The key aspects of worker transition will include the following:

- **Skilling and reskilling:** The labour force directly impacted by the closure of TPP units will require reskilling for re-employment in new economic sectors, especially green energy sector and green industries. The workforce engaged in the TPPs have some of the skills required for operating energy infrastructure. Therefore, reskilling/ upskilling can help them to get re-employed in RE industries, green hydrogen plants, etc. which also has demand in the state from various industrial activities.

  Transitioning the workforce toward green energy will require a combination of technical, analytical, and practical skills. Skilling will be required for the design, installation, and maintenance of RE systems, smart grid technologies, energy storage, green hydrogen use, transportation, and operation, among others.

A skilled workforce will also be required for decommissioning and repurposing of retired TPP units and old TPPs. This will involve skilling the workforce for impact evaluation, risk assessment and management, waste disposal and management, remediation, etc.

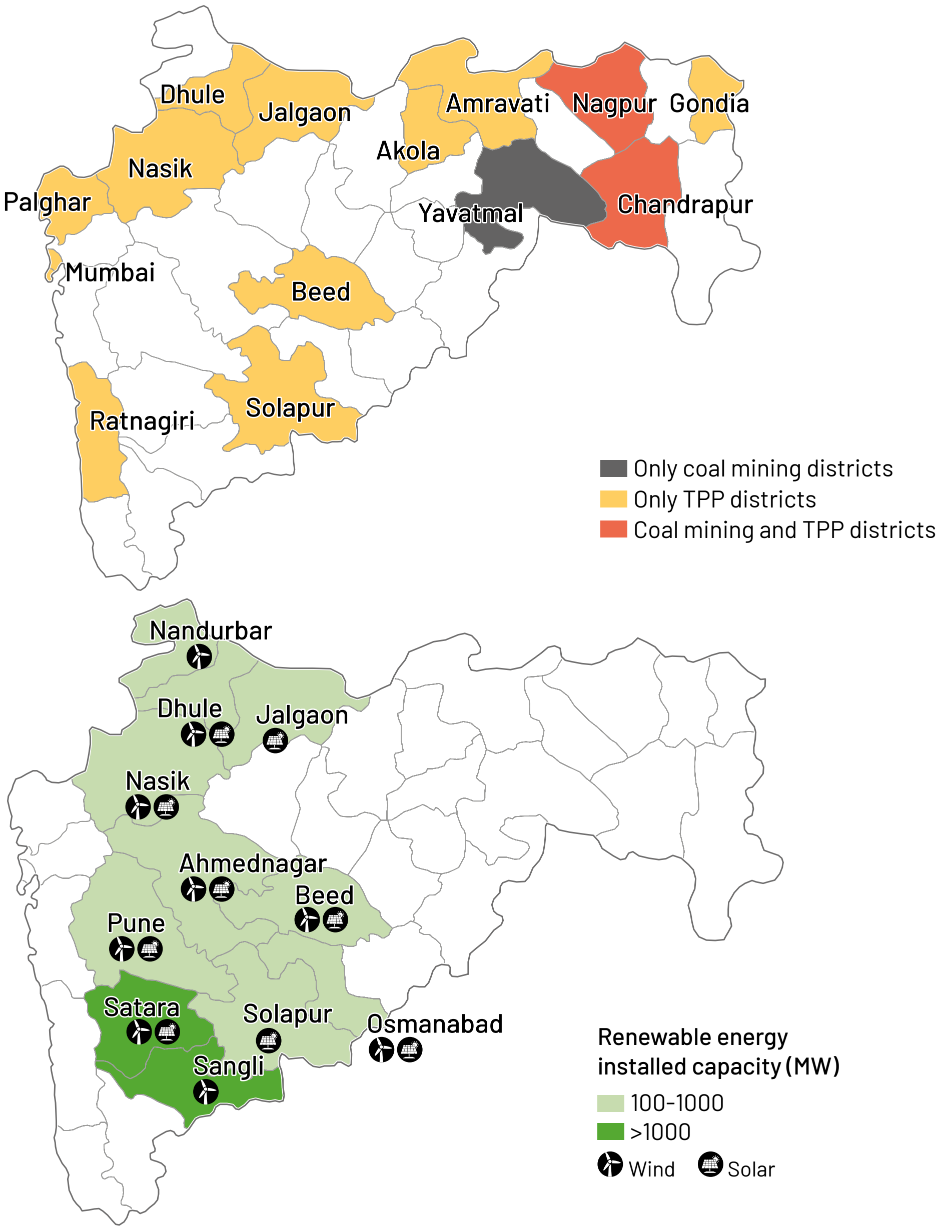
- **Compensation:** In the event of an energy transition, retrenched workers, including contractual and informal workers, need to be compensated for their income loss due to closures.
- **Transition support:** A one-time payoff may be required for the transitioning workforce to cover re-employment and relocation support. This is especially required for the informal workers.
- **Pension support:** Central and State Government PSUs, such as Mahagenco, NTPC Ltd. will need to plan for providing pension support to the employees who remain eligible for a pension and shall be retiring in the coming years.

Supporting RE investments in coal districts and transition regions

The state of Maharashtra has already embarked on an energy transition with significant growth in RE in the past years. In the last 10 years, there has been an 67% increase in the RE installed capacity.

However, there is a regional disparity in RE investments. The investments are largely concentrated in districts located in the southern and central parts of the state. Some of the key districts include Satara, Sangli, Solapur, Osmanabad, among others. There is little or no investments in RE in the coal districts of the state that are going to impacted by the energy transition in the coming decades. Overall, the coal districts have only 86 MW of RE capacity. Therefore, there is an immediate need of RE development in these districts.

Map 3.2: Disparity in RE development



Source: iFOREST analysis

SECTION III

FACTORIES

Factories overview

Factories with various industrial sectors are central to the economy of Maharashtra. As per the Annual Survey of Industries 2019-20, The state has 25,610 factories of which 19,462 were operational during the reference year 2019-20. The factories collectively employ about 2.04 million people.

Overall, Maharashtra is the third largest state with respect to the number of factories accounting for nearly 10.4% of the country's total. It is also the third largest state with respect to number of factories in operation and with respect to the number of people employed, with a respective share of 9.8% and 12.3% of India's total. The economic output of factories is the second largest in India with the share of gross value added (GVA) of 14.53%. The latest economic outlook of the state (as per report of the Maharashtra Economic Advisory Council, 2023) further underscores massive plans of industrial expansion in the next five years, with the target of increasing the manufacturing GVA from $64 billion in fiscal year 2022 to $182 billion in 2028. A green energy transition of the factories. therefore, is an immediate necessity for the state.

To evaluate the impact of the energy transition on factories, a multi criteria-based analysis has been considered. These include:

i. Energy intensity, defined as energy costs as percentage of total input costs. Based on energy intensity, three impact categories have been determined:
   a. Low impact- <5%
   b. Moderate impact- 5%-10%
   c. High impact- >10%

ii. Sectors that will go through technological disruptions due to energy and environmental transition:
   a. From an energy transition perspective, this will include manufacturing of electric motors, generators, batteries, wiring and wiring devices, lighting equipment, domestic appliances, etc.
   b. From an environmental transition perspective, this will include plastic industry, waste treatment and disposal, material recovery, etc.

Based on such criteria, the factories that will face high impact, moderate impact, and low impact due to the energy transition have been determined.

Overall, the analysis shows that about 41% of total factories in the state will be highly or moderately impacted by the energy transition. They account for about 53% of total output, 49% of employment, and about 75% of the energy use by all factories. They also have high employment dependence, including higher proportion of workers employed through contractors.

ENERGY TRANSITION IMPACT ON FACTORIES

The energy transition will impact various fossil fuel-dependent factories in Maharashtra differentially in the coming years. While for some the impact will be low, for many the impact will be very high requiring urgent intervention, through policy support, investments and innovation. Based on a multi-criteria-based impact evaluation, factories falling under the various impacted categories—high, moderate, and low— are outlined below.

High impact

27.1% of total factories	44% of outputs from all factories	39% GVA from all factories	60% of total energy use in factories	43.3% of the total employment and 33% of the total workers employed in factories; 55% are contractual

Sectors including iron and steel, metal casting and related sectors, non-metallic mineral products like cement, bricks, and refractories, automobile and automobile components, basic chemicals, fertilizer and nitrogen compounds, plastics, glass and rubber, coke oven and refined petroleum products, electric motors, generators, batteries, lighting, wiring and appliances, will be highly impacted by the transition. Also, those involved in waste treatment, disposal and material recovery will also be highly impacted.

Moderate impact

13% of total factories	8.7% of outputs from all factories	13.6% GVA from all factories	14% of total energy use in factories	15% of the total workers employed in factories

Sectors including textile, pulp and paper and pharmaceuticals will be moderately impacted due to direct-use of fossil fuels like coal and natural gas for process heat and electricity.

Low impact

60% of total factories	48% of outputs from all factories	48% GVA from all factories	26% of total energy use in factories	52% of the total employment and 51% of the total workers in factories; 80% of all directly-employed women workers

A wide variety of industries, including, food processing, apparel and footwear, wood-processing and product industries, fabricated and structural metal products, computers and electronics, consumer goods, machineries, etc., will have low impact from the transition.

Characteristics of industries likely to be impacted by the energy transition

Characteristics	All factories	Low impact sectors		Moderate impact sectors		High impact sectors	
	Value	Value	Share of total (%)	Value	Share of total (%)	Value	Share of total (%)
1. Number of factories	25,610	15,301	59.7	3,373	13.2	6,941	27.1
a. Number of factories in operation	19,462	11,478	59	2,485	12.8	5,505	28.3
2. Total output (₹ Lakh)	12,39,76,857	5,83,38,486	47.1	1,08,45,093	8.7	5,47,93,277	44.2
3. Gross Value Added (GVA)(₹ Lakh)	2,15,86,010	1,02,69,044	47.6	29,28,914	13.6	83,88,050	38.9
4. Number of persons engaged	20,38,255	10,61,126	52.1	3,04,463	14.9	6,72,670	33
5. Total number of workers	14,54,788	7,40,883	50.9	2,17,001	14.9	4,96,905	34.2
a. Percentage of workers employed through contractors (%)	48	42.8		48.8		55.5	
b. Number of directly employed women workers	90,884	70,637	77.7	10,293	11.3	9,960	11
6. Total energy use (as per cost in ₹ Lakh)	44,70,441	11,66,768	26.1	6,23,454	13.9	26,80,220	60

Source: Anaysis based in Annual Survey of Industries data, 2019-20

This section evaluates the following industrial sectors to evaluate the impacts and opportunities of a just energy transition of the factories. This includes, steel, foundry, cement, brick, automobile, fertilizer, and boilers.

The sectors have been analysed with respect to their scale of operation, spatial distribution, employment dependence, transition opportunities (and challenges if any), and the existing policy and regulations for supporting a transition.

CHAPTER 4

STEEL AND FOUNDRY

4.1 Steel sector overview

India is currently the world's second-largest producer of crude steel and the largest producer of sponge iron. The sector is expected to experience significant growth in the coming decades owing to the growing demand in construction and various other economic sectors. Concerning steel demand, India currently remains the second largest consumer of finished steel after China.[1]

Maharashtra is one of the top ten steel-producing states in India[2] and is the largest consumer of finished steel and steel products.[3] The iron and steel industry of Maharashtra is important due to the large presence of other industries that require manufactured steel, including automobile, construction, infrastructure, etc. The steel industry is largely dominated by the private sector with the presence of steel industry stalwarts like JSW Steel Limited and TATA Steel.

The steel industry also remains the key focus of the state's future investments. Between June 2020 to December 2022, the State Government signed MoUs (124 total) worth ₹2,74,202 crore of investments. Of this 70% of the investments are related to the renewable energy, steel manufacturing, and Information Technology sectors.[4]

4.1.1 Steel production

Maharashtra has 174 iron and steel units (including units producing pellets and sponge iron, crude steel, and finished steel products) with a total production capacity of 47.7 million metric tonnes (MMT) per annum. Out of this, the annual production capacity of crude steel is 11.9 MMT.[5]

Table 4.1: Iron and steel making units

Type of units	No. of units	Production capacity (MMTPA)
Iron making units	9	7.7
Crude steel	57	11.99
Finished steel	108	28.1
Total	174	47.7

Source: Joint plant committee, Indian Iron and Steel database-2019-20; Company annual reports, 2022-23

4.1.2 Spatial distribution

The iron and steel-making units are spread across various districts in Maharashtra. The steel-making units (blast furnace and sponge iron units) are concentrated in the two coal producing districts, Nagpur and Chandrapur.

Table 4.2: Distribution of iron making units

District	No. of units	Production capacity (MMTPA)
Bhandara	1	0.3
Chandrapur	3	0.6
Nagpur	3	5.3
Raigad	1	0.9
Wardha	1	0.7
Total	9	7.7

Source: Joint plant committee, Indian Iron and Steel database-2019-20; Company annual reports, 2022-23

The crude steel-making units are distributed across 15 districts. Nagpur has the highest crude steel production capacity of over 5 MMT with six crude steel-making units located in the district. The other key districts include, Jalna, Wardha, Palghar and Pune.

Table 4.3: Distribution of crude steel making units

District	No. of units	Production capacity (MMTPA)
Ahmednagar	1	0.17
Aurangabad	1	0.14
Bhandara	1	0.53
Chandrapur	1	0.08
Jalna	10	1.56
Kolhapur	5	0.05
Nagpur	6	5.19
Nashik	5	0.34
Palghar	10	1.14
Pune	5	0.76
Raigad	3	0.34
Sangli	5	0.02
Solapur	1	0.002
Thane	1	0.31
Wardha	2	1.36
Total	57	11.99

Source: Joint plant committee, Indian Iron and Steel database-2019-20; Company annual reports, 2022-23

For finished steel products, the top district is Raigad, with 20 units having over 7.3 MMT capacity of producing various steel products. The other key districts include Pune, Jalna and Palghar.

Table 4.4: Distribution of finished steel units

District	Re-Rolling		HR Prodcuts		CR Products		GP/GS Sheets		Colour Coated Products		Pipes		Total in district	
	No.	Production capacity (MMTPA)	No.	Production capacity (MMTPA)	No.	Production capacity (MMTPA)	No.	Production capacity (MMTPA)	No.	Production capacity (MMTPA)	No.	Production capacity (MMTPA)	No.	Production capacity (MMTPA)
Aurangabad	1	0.15											1	0.15
Bhandara	1	0.50											1	0.50
Jalna	21	1.70											21	1.70
Kolhapur	4	0.06											4	0.06
Nagpur	9	2.20	1	3.5	1	0.6	1	0.6	1	0.2			13	7.10
Nanded					1	0.3	1	0.2					2	0.50
Nashik	2	0.12			1	0.24							3	0.36
Palghar	14	1.10			1	0.3					1	0.04	16	1.44
Pune	6	0.88			1	0.6	1	0.45	1	0.4	1	0.48	10	2.81
Raigad	4	0.19			5	3.7	4	1.7	3	0.45	4	1.3	20	7.34
Sangli	1	0.02											1	0.02
Satara	1	0.10											1	0.10
Solapur	1	0.00											1	0.00
Thane	3	0.61			2	1.1	2	1.5	2	0.5	1	0.2	10	3.91
Wardha	1	0.56	1	1	1	0.35	1	0.25					4	2.16
Total	69.0	8.2	2.0	4.5	13.0	7.2	10.0	4.7	7.0	1.6	7.0	2.0	108	28.1

Source: Joint plant committee, Indian Iron and Steel database-2019-20

4.1.3 Employment

The data related to the number of persons employed in a steel plant is not available in secondary sources. Therefore, an estimate has been made to determine the number of people employed in the steel industry, based on the environmental impact assessment (EIA) reports of some Indian steel plants and for large plants analysis of employees in major steel-producing units.[6]

The workforce estimate for the steel industry has been done for the iron-making units and the crude steel-producing units in the state. As per the estimation, the total number of workers formally employed in the iron-making units and the crude steel-producing units is estimated to be about 31,000. The highest employment dependence is in Nagpur district which has nearly 50% of the workforce. Besides, formal workers, there is also a significant informal dependence on the industry.

Table 4.5: District-wise estimated formal workforce in iron and steel industry

District	Estimated formal workers		Total formal workers
	Iron-making units	Crude steel -producing units	
Ahmednagar		336	336
Aurangabad		288	288
Bhandara	445	525	970

Table 4.5 continued

District	Estimated formal workers		Total formal workers
	Iron-making units	Crude steel -producing units	
Chandrapur	1,000	188	1,188
Jalna		3,115	3,115
Kolhapur		320	320
Nagpur	8,942	5,541	14,483
Nashik		844	844
Palghar		2,337	2,337
Pune		1,479	1,479
Raigad	1,530	765	2,295
Sangli		250	250
Solapur		50	50
Thane		465	465
Wardha	1,190	1,540	2,730
Total	13,107	18,043	31,150

Source: Estimations based on employment factor approach for iron-making units and crude steel-making units respectively.

4.1.4 Technology use

For the production of iron, the Direct Reduction (DR) process and blast furnace are used. Out of the seven sponge iron units, five use coal-based DR process while two use gas-based DR process. The coal-based sponge iron units are concentrated in the coal-rich districts of Chandrapur and Nagpur. The other iron-making units are the two blast furnace units located in Nagpur and Wardha, which use coal as the primary fuel.

Table 4.6: Technology and fuel use in iron-making

District	Enterprise (DR for sponge iron)		Enterprise (Blast Furnace)	
	Capacity (MMTPA)	Fuel	Capacity (MMTPA)	Fuel
Bhandara	0.26	Coal		
Chandrapur	0.14	Coal		
	0.14	Coal		
	0.3	Coal		
Nagpur	0.06	Coal	3.6	Coal
	1.6	Gas		
Raigad	0.9	Gas		
Wardha			0.7	Coal

Source: Joint plant committee, Indian Iron and Steel database-2019-20

For the production of crude steel, induction furnaces (IF) and electric arc furnaces (EAF) are used. An analysis of furnaces by various crude steel-producing units shows that most of the units use induction furnaces. Out of the 57 units, 48 units use induction furnaces with a total production capacity of 4.4 MMT. For EAF, while only nine units in the state use the technology, but it accounts for 7.6 MMT of crude steel production capacity.

Table 4.7: Furnaces used in steel production

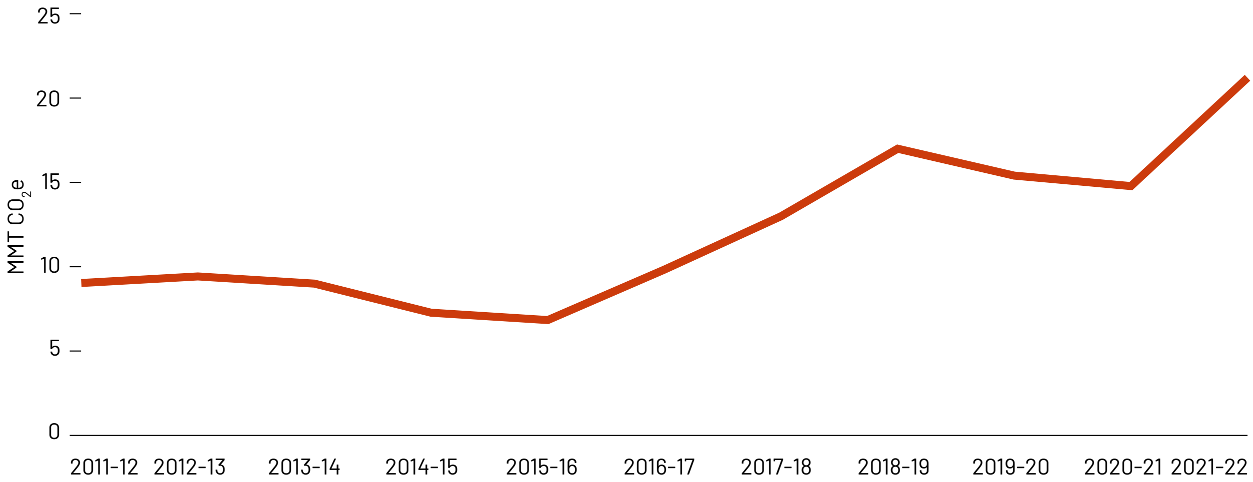
District	Induction Furnace		EAF	
	No. of units	Production capacity (MMTPA)	No. of units	Production capacity (MMTPA)
Ahmednagar	1	0.17		
Aurangabad	1	0.14		
Bhandara			1	0.5
Chandrapur	1	0.08		
Jalna	10	1.56		
Kolhapur	4	0.05	1	0.005
Khopoli	1	0.03		
Nagpur	4	0.19	2	5
Nashik	5	0.34		
Palghar	10	1.14		
Pune	3	0.21	2	0.6
Raigad	1	0.07	1	0.2
Sangli	5	0.02		
Solapur	1	0.002		
Thane			1	0.3
Wardha	1	0.36	1	1
Total	48	4.36	9	7.6

Source: Joint plant committee, Indian Iron and Steel database-2019-20

4.1.5 Emission issues

The iron and steel sector is the largest industrial emitting sector in Maharashtra accounting for nearly. The emissions from the steel industry have increased by a staggering 135% in the last decade, from 9 MMT/CO_2e in 2011-12 to 21.2 MMT/CO_2e in 2021-2022. This translates to a compound annual growth rate (CAGR) of 8.9%. The increase in emissions is directly correlated to the increase in crude steel production, particularly since 2015-16. While there has been a decline in steel production around the COVID-19 times, production has again increased in 2021-22.

Figure 4.1: Emissions from iron and steel sector



Source: iFOREST analysis

4.1.6 Just energy transition issues for the iron and steel industry

The transition of the iron and steel sector will be crucial for reducing the country's overall CO_2 emissions and also reducing the emission intensity of the GDP. For this, the overall energy- and resource-intensive nature of the steel industry will have to change.

i. Technological opportunities: The low-carbon transition pathway of the steel sector will primarily involve a transformation of the production fleet to reduce coal dependence, and support low-emission technologies and infrastructure. The good news is that some of the technologies are in hand to reduce the sector's emission footprint, which is being used by some countries already. Further, there are others that will be available in the next 10 years.[7]

The main technologies that can lead to reduced emissions in the iron and steel production processes include carbon capture, utilisation and storage (CCUS), hydrogen-based technologies, direct electrification, and bioenergy. A synopsis of these technologies and their application in various production processes is provided below. The evaluation provides an understanding of the availability of the key technologies with respect to production processes, the Technology Readiness Level (TRL), the timeframe of availability, as well as effectiveness in emission reduction.[8]

For India, it is expected that within the next 15-20 years, some of the more radical decarbonisation technologies, that are currently being demonstrated, will be commercially available. This particularly includes hydrogen-based production, which involves the substitution of coal or natural gas as a reducing agent with hydrogen. Supported by India's RE advancements, if hydrogen is produced from emissions-free electricity, the total emissions from the iron and steel industry can be reduced by 94%. It is also further estimated that if hydrogen can be delivered at a cost of 2.5-3.5 USD/kg, it will be cost-competitive with the BF-BOF route of steel production.[9]

In the immediate years, the sector can maximise its operational efficiency through investing in existing best available technologies (BAT). For instance, around 40% of blast furnaces in India are currently equipped with top-pressure recovery turbines (TRTs), and over 30% of coke ovens are equipped with coke dry quenching (CDQ), two examples of BAT. It is projected that by support of the right policy levers for energy transition, the share of both of these can rise up to 70%. This along with efforts of material efficiency, can contribute to considerable emission reductions.[10]

Table 4.8: Technological readiness of steel sector transition

Technology	Process	TRL	Year available	Potential for emission reduction
CCUS	Blast furnace: Off-gas hydrogen enrichment and/or CO_2 removal for use or storage	5	2030	Very high
	Blast furnace: Converting off-gases to fuels	8	Today	Medium
	Blast furnace: Converting off-gases to chemicals	7	2025	Medium
	DRI: Natural gas-based with CO_2 capture	9	Today	Very high
	Smelting reduction	7	2028	Very high
Hydrogen	Blast furnace: Electrolytic H2 blending	7	2025	Medium
	DRI: Natural gas-based with high levels of electrolytic H2 blending	7	2030	High
	DRI: Based solely on electrolytic H_2	5	2030	Very high
	Ancillary processes: H_2 for high temperature heat	5	2025	High
Direct electrification	Electrolysis: Low temperature	4	-	Medium
	Electrolysis: High temperature molten oxide	4	-	Medium
Bioenergy	Blast furnace: Torrefied Biomass	7	2025	Medium
	Blast furnace: Charcoal	10	Today	Medium

Source: Adopted from IEA, 2020

ii. Policy support for green steel: The Government of India is adopting major policy reforms to support the green growth of the steel industry. The National Green Hydrogen Mission promulgated by the Ministry of New and Renewable Energy (MNRE) in January 2023, aims to boost the use of green hydrogen by various industrial sectors, including the steel industry. Further, the Union Minister of Steel and Civil Aviation has approved 13 Task Forces for defining the roadmap for Green Steel.[11]

Besides, these, the Government had also earlier promulgated policies to improve environmental performance and reduce emissions from the steel sector. These include the Steel Scrap Recycling Policy, 2019, which enhances the availability of domestically generated scrap to reduce the consumption of coal in steel making, and the Perform, Achieve, and Trade (PAT) scheme under the National Mission for Enhanced Energy Efficiency, which incentivizes the steel industry to reduce energy consumption.

iii. Private sector targets and investments: The steel industry is also adopting measures for reducing emissions from the sector. For example, JSW Steel, one of the key players in Maharashtra, has allocated ₹100 billion ($1.26 billion) to meet its energy requirements from green energy sources and replace conventional ones. The company has also implemented a CCS facility with a 100 tonnes per day (TPD) capacity at its plant at Dolvi, Maharashtra.[12]

Similarly, Tata Steel has announced long-term plans (till 2050) for increasing sustainable production of steel and using hydrogen use across the steel value chain. The company has commissioned a 5 tonnes per day (TPD) carbon capture plant at Jamshedpur Works.[13]

Jindal Steel and Power Limited (JSPL) has also outlined various measures to achieve its goal of producing green steel, including using hydrogen instead of coal in DRI and adopting CCUS technologies to reduce GHG emissions. The company has also signed an agreement with Greenko to procure 1,000MW of green power for its steelmaking operations in Angul, Odisha. This arrangement will reduce approximately seven MMT of CO_2 emissions annually.[14]

iv. Workforce transition: A key issue for green transition of the iron and steel sector will be a just transition of the workforce. The large formal and informal dependence on the sector will require development of policies and plans to ensure the workforce transition.

A primary focus of the workforce transition will be skilling and reskilling, given the technological changes in the sector for decarbonization. For this, policies by the government as well as the enterprises will be requires.

Out of the 13 Task Forces set up for transitioning to green steel, one of them is specifically focused on skill development. The 'Skill Development Task Force' will identify and outline an approach for "skilling, upskilling and re-skilling of the manpower of the steel industry for ensuring the just transition". One of the key emphasis is on the need to create and empower educational institutions to meet evolving skill demands.[15]

For the private sector, enterprise-level transition planning will be necessary to ensure a just transition of the workforce.

4.2 Foundry overview

The foundry industry in India is one of the most important segments of Micro, Small, and Medium Enterprises (MSME) involved in manufacturing. Out of the 4.500 (approximately) foundry units in the country, 90% are MSMEs.[16]

The primary manufacturing product of the foundry industry is metal cast components which are used for a variety of uses in auto and auto components, tractors, railways, aerospace, defense, machine tools, sanitary equipment, pipe fittings, earth moving equipment, pumps, etc.[17] As per the Census of the World Casting Production, India is among the top three producers of casting in the world, along with China and the United States. As per the last Census of 2019, the country produces about 1,491,810 metric tonnes casting annually, which is about 14% of the global casting production.[18]

Maharashtra has a large number of foundries, accounting for about 15 % of the foundry units in India. The industry in the state is driven by the auto industry, with a large number of foundries being involved in casting manufacturing.[19]

4.2.1 Operation and spatial distribution

As per the completeness of data on foundries obtained from the Indian Institute of Foundrymen (2023) for a total of 409 foundries, there are at least 333 registered units in the state that are involved in casting manufacturing and manufacturing of various foundry materials.[20] About 90% of these units belong to the MSME category. Besides, there are a large number of foundry equipment manufacturers, patterns and dye makers.[21]

However, ground studies show that there are also units that are not completely listed in the verifiable dataset as obtained from the Indian Institute of Foundrymen.

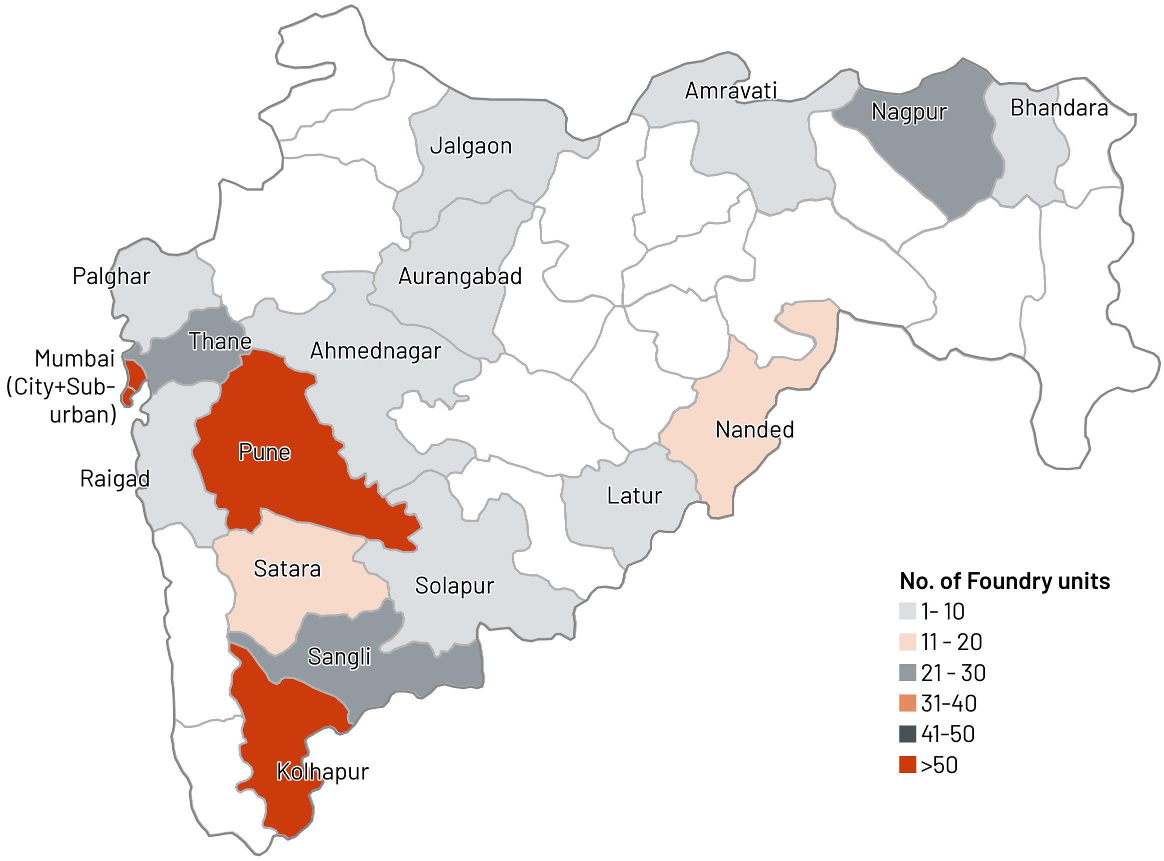
Table 4.9: Types of foundry-related industrial units

Type of unit	Number	Products
Casting manufacturers	190	Copper alloys, ferro alloys, alum alloys, zinc alloys, grey iron, etc.
Foundry material manufacturers	143	Copper alloys, ferro alloys, scrap (ferrous / non-ferrous), alum alloys, magnesium alloys, binders, etc.
Foundry equipment manufacturers and suppliers	62	Heat treatment furnace, melting furnace, core handling trolleys, furnace accessories, etc.
Pattern and die makers	14	Dies, moulds, patterns, etc.

Source: iFOREST analysis based on MIS data obtained from Indian Institute of Foundrymen, 2023

While the foundry units are spread across various districts in the state, there are three key districts where these industries are clustered. These include, Kolhapur, Pune and Mumbai. Kolhapur and Pune are considered to be two of the most important foundry cluster for automotive castings.[21] The units are considered to have significant environmental pollution problems, and therefore remain important for green energy transition.[22]

Map 4.1: District-wise distribution of foundries



Source: iFOREST analysis based on MIS data obtained from Indian Institute of Foundrymen, 2023.

4.2.2 Employment

The employment data for the foundry industry in Maharashtra remains inconclusive. However, as per the data shared by the Indian Institute of Foundrymen of workers associated with the 190 casting manufacturers in the state, there are over 39,5000 workers associated with these units.[23] Besides, there are about 13,000 workers involved in foundry material manufacturing, and an additional 2,200 involved in foundry equipment manufacturing and pattern/die making.[24] However, the actual number are much higher, and requires further estimations through primary survey.

4.2.3 Furnace type and energy use

A key issue for the foundries is the type of furnace the units are using. For the purpose of casting metal for various industrial uses, primarily two types of furnaces are used to melt the metal to cast it into moulds. These include the cupola furnace and the blast furnace, both of which use coke as the fuel source. Besides, there are induction furnaces and electric arc furnaces that use electricity for melting scraps.[25] Overall, the production process of these metal components is energy-intensive. The melting process in the furnaces is the most energy-intensive segment and accounts for the consumption of over 83% of the input energy.[26]

In Maharashtra, however, many of the foundries associated with casting manufacturing are already shifting to induction and/or arc furnaces. For example, an assessment of 167 casting manufacturing units in the state shows that over 67% have induction furnaces.[27] Besides some of the units are also using arc furnaces. The analysis also corroborates with inputs obtained from officials and surveys undertaken in the Kolhapur cluster, which also suggests that 60-70% of the units have induction furnaces.[28] The induction furnace units typically have an electricity consumption of up to 600 kWh of per tonne of metal melt.[29]

Table 4.10: Types of furnaces in casting manufacturing units

Furnace type	Number of units
Induction	107
Arc	11
Crucible and oil/gas fired	27
Cupola	16
Others	6
Total	167

Source: iFOREST analysis based on MIS data obtained from Indian Institute of Foundrymen, 2023

4.2.4 Just energy transition issues for foundries

The foundry clusters in Maharashtra are primarily driven by the demand from the auto industry. One of the key factors that have implications for the foundry sector in the state is the transition to electric vehicles (EV). The EV transition will reduce the demand for ferrous casting with a simultaneous increase in demand for aluminium casting.[30] Therefore, the casting manufacturing units need to transition to keep the industry viable with the growing demand from the EV sector.

There is also a need for improving the energy efficiency of the induction furnaces. One of the key technology shifts can be the use of insulated gate bipolar transistors (IGBT). The use of IGBT technology can help in improving furnace efficiency by offering high switching speeds while minimising electrical losses. This will overall translate to reduced electricity consumption and operating costs.[31]

For workers associated with the sector, the most important aspect will be reskilling and upskilling. Since the main transition in the foundry industry will be technology change, the workers directly associated with the industry will need to be upskilled to retain workers and minimize job losses.

CHAPTER- 5

Cement and Brick

5.1 Cement sector overview

India is the second largest producer of cement in the world, with over 590 million metric tonnes (MMT) of production capacity per year. The country accounts for over 8% of the global installed capacity. However, the overall capacity utilization of the cement industry remains suboptimal. Over the last ten years, the capacity utilization in the sector has fallen from 83% to 60%. Given the utilization capacity, the country produced about 360 MMT of cement in 2021-2022 and over 370 MMT in 2022-23 (283.6 MMT up to December 2022 recorded and the overall estimated).[1]

With the growing demand from urban infrastructure, commercial buildings, roads, etc., the demand for cement is expected to be 550–600 MMT per year in 2025. The increased demand will also drive the increase in production, which is expected to rise between 5% to 7%.[2]

The cement industry in India is primarily concentrated in the Southern and Northern states, which account for nearly 55% of the installed capacity. The western states account for almost 13% of the installed capacity, primarily driven by Gujarat and Maharashtra's cement industry.[3]

5.1.1 Cement value chain and spatial distribution

There are 18 cement plants in Maharashtra, including integrated plants and grinding units, with a cumulative production capacity of over 49 MMT per year.[4] Besides, there are 22 other enterprises related to the cement supply chain as per the registered factories list of the Directorate of Industrial Safety and Health, Government of Maharashtra.[5]

Table 5.1: Number of various cement enterprises

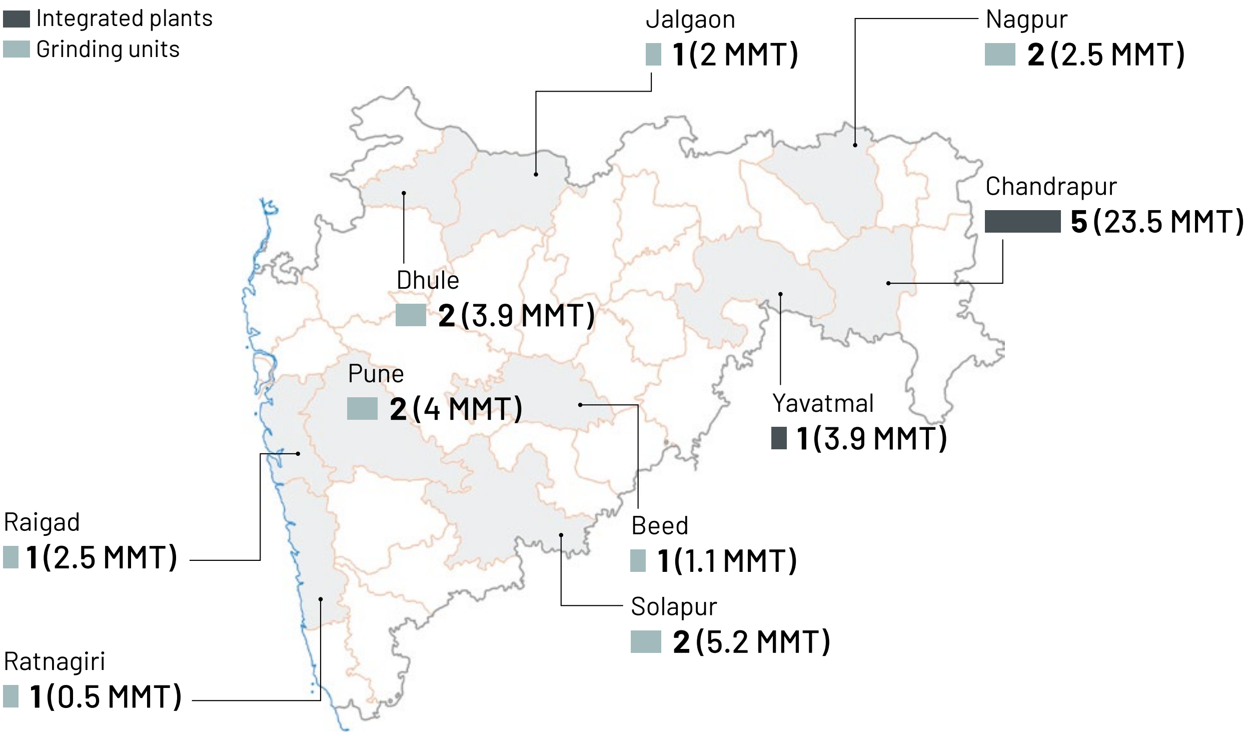
Type of unit	No. of units	Capacity (MMTPA)
Integrated plant	6	27.35
Grinding unit	12	21.75
Total	18	49.10

Source: IBM Cement Yearbook, September 2023; Directorate of Industrial Safety and Health, Government of Maharashtra, 2023; Company-specific Annual Reports and Accounts, 2022-23

A district-wise assessment of the cement-producing units and various enterprises along the supply chain shows that the integrated plants are concentrated in Chandrapur district, with only one plant in Yavatmal district. Chandrapur has five integrated plants with total production capacity of 23.45 MMTPA. Grinding units are present in eight districts, with the highest capacities in the manufacturing hubs, such as Pune, Solapur, and Dhule.

The other enterprises along the supply chain are primarily located near the metro cities of Mumbai, Pune, Raigad, and Thane districts. These include plants involved in readymade mixing/ready mix commercial plants manufacturers of aluminous slags and hydraulics, etc.

Map 5.1: District-wise distribution of cement plants



Source: IBM Cement Yearbook, September 2023; Directorate of Industrial Safety and Health, Government of Maharashtra, 2023; Company-specific Annual Reports and Accounts, 2022-23

5.1.2 Employment in the cement sector

The cement sector, like most manufacturing sectors, employs a large number of people formally and informally. As per estimates of the Directorate of Industrial Safety and Health, Government of Maharashtra, and industry-specific data, the integrated cement plants and grinding units formally employ at least 14,470 people.

Table 5.2: Formal employment in the cement sector

Unit type	Number of workers
Integrated	10,591
Grinding units	3,879
Total in integrated plants + grinding units	14,470
Other enterprises	1,781
Total	16,251

Source: Directorate of Industrial Safety and Health, Government of Maharashtra, 2023

A district-wise assessment of formal employment in the cement industry shows that the maximum employment dependence is in the Chandrapur district, owing to the concentration of integrated cement plants. Besides, there are a large number of informal workers associated with the sector. While the number of such workers is unavailable, many informal workers are associated with the sectors, considering the high proportion of informality in the manufacturing and construction sectors as per the National Sample Survey.[6]

As a key driver of many manufacturing and construction activities, the sector also has significant implications for downstream employment. The sector is estimated to employ about 20,000 people downstream for every million tonnes of cement produced.[7]

Table 5.3: District-wise employment in the cement sector

District	Integrated cement plant	Grinding units	Other enterprises	District total
Beed		150		150
Chandrapur	9,091			9,091
Dhule		1,000		1,000
Jalgaon		200		200
Kolhapur			100	100
Mumbai			432	432
Nagpur		431		431
Palghar			210	210
Pune		720	307	1,027
Raigad		400	616	1,016
Ratnagiri		250		250
Solapur		728		728
Thane			116	116
Yavatmal	1,500			1,500
Total	10,591	3,879	1,781	16,251

Source: Directorate of Industrial Safety and Health, Government of Maharashtra, 2023

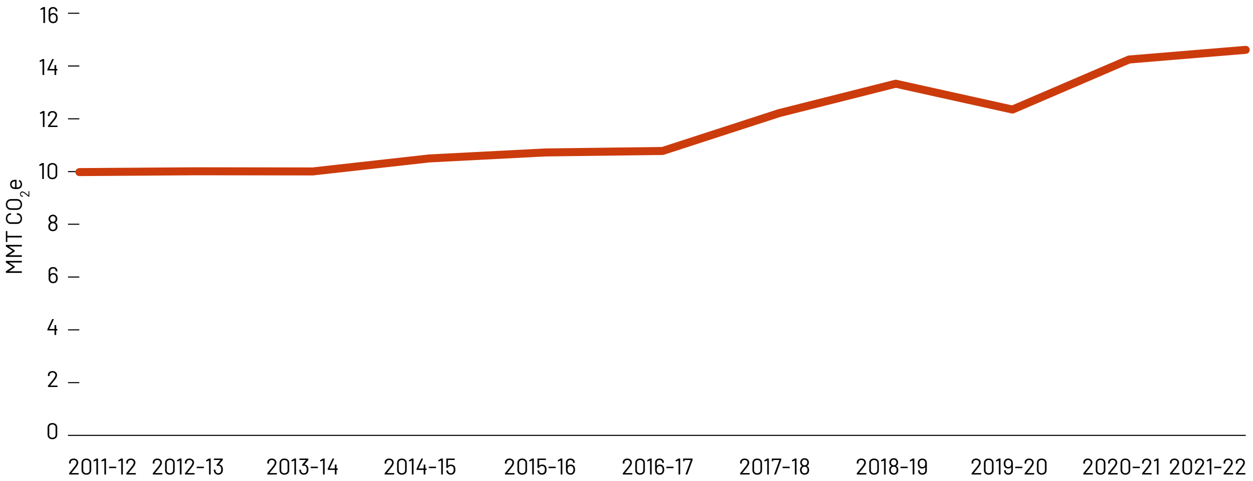
5.1.3 Emission from cement production

Cement is considered a "hard-to-abate" sector in terms of GHG emissions, as it is technologically challenging to reduce emissions related to the core production process.[8] About 50% to 60% of the CO2 emissions are "process emissions" generated during the decomposition of limestone and other calcareous material to produce clinker. The thermal energy required for calcination is provided by coal/lignite. Besides, about 30% of CO_2 emissions result from burning fossil fuels, mainly to reach the required high temperatures in the kiln and associated equipment—the remaining 10% results from transportation and the generation of electricity necessary for other plant processes.[9]

The cement industry is one of the key contributors to GHG emissions in India and the second largest emitting industrial sector after iron and steel in Maharashtra. While the Indian cement industry has reduced GHG emissions by reducing CO_2 emission factors from 1.12 tCO_2/t of cement in 1996 to 0.670 tCO_2/t of cement in 2017[10], the emission remains significant. As per the latest estimates of the Global Carbon Atlas (2022), the sector's emission remained at 164.323 $MtCO_2$.[11]

With the increase in cement production in Maharashtra, the emission from the sector has increased significantly over the last decade. With production increasingly at a CAGR of 3.7% over the last decade, correspondingly emission from the sector has grown 50% in the last 10 years, at a CAGR of 3.9%.

Figure 5.1: Emissions from cement sector



Source: iFOREST analysis

5.1.4 Just energy transition issues for cement industry

India's residential building stock is projected to grow nearly 3.4 times over the next decades, from 15.47 billion m2 in 2017 to 52.5 billion m2 by 2047. At the same time, the commercial building stock is predicted to grow by nearly 7.5 times, from 0.9 billion m^2 in 2017 to 6.8 billion m^2 by 2047. Reliability of primary construction materials, such as cement and steel, will be essential to meet this demand.[12] With dense metro cities and urban agglomerations, Maharashtra is poised to cater to this increased demand.

For India to meet its net zero target and to reduce the emission intensity of the country's GDP, for which the construction and manufacturing sectors are significant contributors, the energy transition of the cement industry is essential. The critical issues of energy transition of the cement sector will be the transition to low-carbon technology and non-conventional and green energy sources for cement production. At the same time, measures need to be adopted for a just transition of the workforce in tandem with the technological shift in the sector.

The following measures can be adopted to ensure a just energy transition of the sector in Maharashtra over the next three decades.

i. Changes in material use, fuel use, and technology: Reduction of CO_2 emission from the cement industry can be achieved by a combination of approaches, including improving energy efficiency, reducing the proportion of clinker in cement, using non-conventional or alternative fuels, and adopting innovative technologies as per their market readiness including, improving changes in technology, material use, and fuel use for producing cement can reduce the emission intensity of the sector.

a. Reducing the proportion of clinker in cement: The ratio of clinker to cement is a determining factor for the emission intensity of the sector. While the percentage depends on regional standards of the amount of cement that must be integrated into concrete products to meet the required mechanical and durability properties for different end-use applications, portland cement, which is the most commonly used cement for construction purposes, typically contains more than 90% clinker, with the remainder being gypsum and fine limestone.[13] Since process emissions related to clinker production account for about 90% of the emissions related to cement production, a high proportion of clinker in cement results in high CO_2 emissions during the production process.[14]

To decarbonize the industry, clinkers can be substituted with alternative materials, such as fly ash, metal slag, or calcined clay. The use of limestone instead of clinker is also being considered as a viable option. Limestone-containing cement typically has a reduced water demand, which results in better workability for concrete.[15] Besides, there are considerations for the use of Supplementary Cementitious Materials (SCM), such as geopolymer/alkali activated cement, calcium sulfoaluminate (CSA) cement, magnesia binder, celitement, etc., that will help reduce the use of clinker for cement production.[16] Clinker demand can also be reduced through innovations in construction, design, and material mixes and developing low-binder cement and reusable concrete modules.[17]

b. Using non-conventional fuels in production: The cement industry currently relies heavily on coal-based energy. The six integrated cement plants now have about 349 MW of captive power.

In recent years, the Indian cement industry has started using alternative fuels to reduce emissions. While the Thermal Substitution Rate (TSR), which refers to the percentage of alternative fuel used to replace fossil fuels, of the Indian cement industry, on average, remains at about 4% (in 2010, it was 0.6%), the industry aims to achieve 25% TSR by 2025 and 30% by 2030.[18]

For decarbonisation, the thermal energy intensity of the industry must continue to decrease, which can be achieved through waste-derived fuels and hydrogen-based energy.[19] Green hydrogen can replace fossil fuels in cement manufacturing processes as a thermal heat source.[20]

c. Improving energy efficiency: The Indian cement industry remains more efficient than the global average. For example, the thermal Specific Energy Consumption (SEC) of the Indian cement industry is 3,084 MJ/t clinker as compared to the global average of 3,510 MJ/t clinker. Similarly, the electrical SEC is 76.6 kWh/t cement compared to the global average of 104 kWh/t cement.[21] However, additional energy efficiency in the sector can be achieved by various interventions, such as waste heat recovery, uptake of high energy efficient coolers, grinding systems, etc.[22]

d. Technological opportunities: Technological opportunities and changes in fuel sources and alternative materials are being explored for the cement sector. Some of the main technological opportunities identified include carbon capture, utilisation, and storage (CCUS) and oxy-fuel combustion technology. However, these technologies currently remain at the demonstration level.[23]

ii. Workforce transition: The energy transition of the cement sector will involve a transition of material use, fuel use, and production processes. Therefore, a workforce transition will primarily involve reskilling and upskilling workers along the value chain. For Maharashtra, a strategic approach must be adopted for districts with a significant income dependence on the sector, such as in Chandrapur, Yavatmal, Pune, and Raigad. For districts such as Chandrapur, Yavatmal, and Pune, the transition of the coal mining and automobile sectors can further add to the challenge if timely interventions are not adopted.

iii. Policy support: The cement industry lacks a comprehensive decarbonization strategy and framework to ensure a just energy transition of the sector. The current policy and regulatory instruments are targeted toward improving the sector's energy efficiency. One of the most important ones is the Perform Achieve and

Trade (PAT) scheme, a flagship Bureau of Energy Efficiency program under the National Mission for Enhanced Energy Efficiency (NMEEE). The scheme is a market-based mechanism, focussed primarily on enhancing the energy efficiency of large energy-intensive sectors, including cement, through accelerated adoption of efficient and low-carbon technologies.[24] Besides the PAT schemes, the Carbon Credit Trading Scheme, notified by the union Government in June 2023, can also be instrumental in the "reduction or removal or avoidance" of GHG emissions by some hard-to-abate and emission-intensive industrial sectors, like cement.[25]

iv. Private sector engagement: One of the most crucial aspects of the cement industry's energy transition will be the primate sector's role. The private players in the industry will have a pivotal role in supporting a green transition of the sector through investments in technology and innovation.

Several industrial leaders in Maharashtra have made pledges and are taking measures to green their production lines. The four key industries operating integrated cement plants in Maharashtra have announced net zero commitments and have set targets for reducing their emission intensity. For example, Ultra Tech Cement, one of the key operators in Chandrapur district, has announced a net zero pledge for 2050. The company also targets to reduce its Scope 1 GHG emission intensity by 27% and Scope 2 GHG emission intensity by 69% by 2032 from the base year of 2017.[26] The company has also partnered with Coolbrook, a Finland-based technology and engineering company, to introduce Roto Dynamic Heater TM technology in cement manufacturing. This technology aims to reduce the need for fossil-fuel-based thermal energy in cement manufacturing by using RE-based energy sources. Other key players, such as ACC Ltd. And Ambuja Cement Limited, have also announced a net zero pledge by 2050. The companies have also committed to reducing their Scope I and II GHG emissions. ACC Ltd. has set a target of reducing 21.3% of Scope 1 GHG emissions intensity and 48.4% of Scope 2 GHG emissions intensity per tonne of cementitious material by 2030 from the 2018 base year. Ambuja Cement Ltd. has set a target of reducing 20% of Scope 1 GHG emissions intensity and 43% of Scope 2 GHG emissions intensity per tonne of cementitious material by 2030 from the 2020 base year.[27]

Therefore, a holistic just energy transition of the cement industry will involve the industry's leadership, support of government instruments and policies, engagement of concerned agencies, such as for skilling and workforce development, and informed engagement of various stakeholders along the value chain.

5.2 Brick sector overview

India is the world's second-largest producer of bricks, with an annual production of around 250 to 300 billion bricks (440-530 million m^3) per year.[28] The unorganized sector primarily dominates the production of bricks. Solid burnt clay bricks, the type of brick that is produced predominantly, are manufactured in small kilns. The estimated number of such kilns in India ranges from 1,50,000 to 2,80,000.[29] Besides, there are 50,000 - 60,000 relatively bigger units. A few medium/large scale enterprises also operate and mainly produce perforated and hollow burnt clay bricks.[30]

Considering the expanse of operation of the brick sector in various parts of the country, the sector remains one of the largest employers after agriculture.[31] While estimates vary, it is estimated that 15 million to 17 million workers are employed in the brick sector in rural and peri-urban areas.[32]

In Maharashtra, brick-making is an important rural industry widely practiced in community pockets to augment household income.[33] Construction demand in urban and rural areas has been a key driver for the sector. The annual brick demand is projected to increase significantly in the coming years. As per estimates, the yearly demand for bricks by 2032 will be about 71 billion[34], nearly 2.5 times the current demand, which is estimated to be 28 billion per year (Refer to the section below on brick production).[35] About 70% of the demand share will be from the residential sector, with the demand in urban areas being 35 billion bricks per year and in rural areas about 13 billion.[36]

5.2.1 Brick production

Maharashtra is estimated to have nearly 17,000 brick manufacturing units, most of which are micro and small enterprises. The annual production from all these units is about 28 billion.[37]

Table 5.4: Brick production in Maharashtra

State	Number of brick kilns	Annual production	Total annual energy consumption (toe)	Main fuels
Maharashtra	17,000	28 billion	2.1 million	Coal, biomass

Source: TERI, 2022

The primary technology used for manufacturing bricks is clamp kilns. Besides there are also some Fixed Chimney Bull Trench Kilns (FCBTK). Both clamps and FCBTK are highly energy inefficient with poor heat transfer characteristics and require higher fuel. The raw materials used primarily include clay and fly ash[38]; coal and biomass-based fuel are the primary fuel sources.[39]

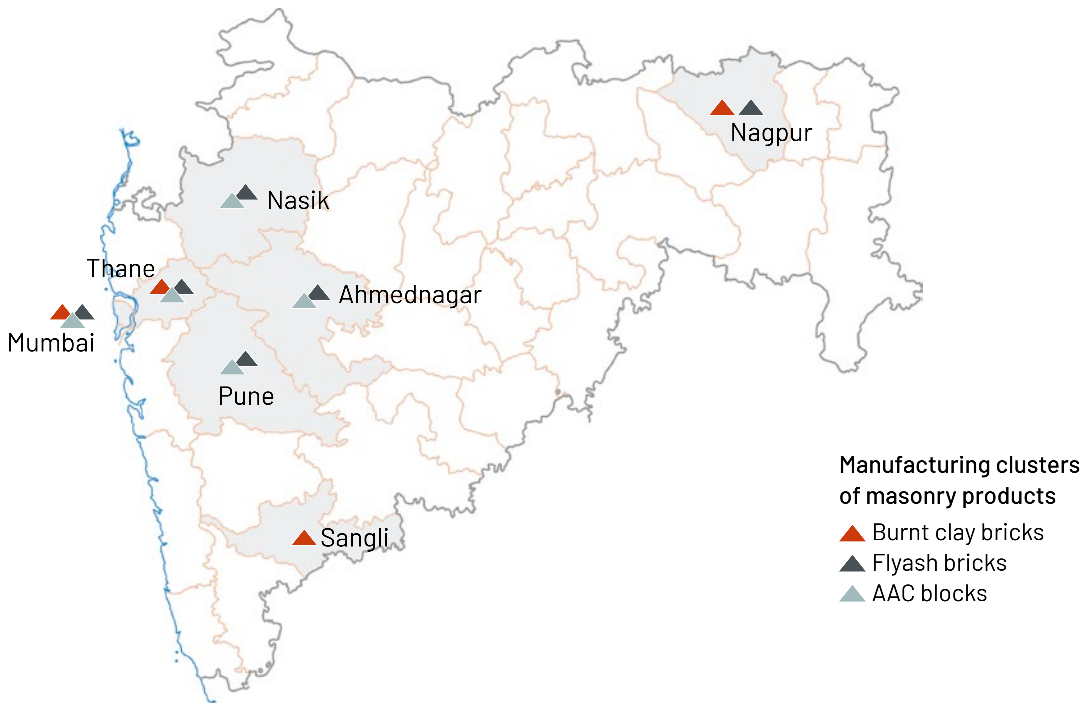
5.2.2 Spatial distribution

The brick-making units are distributed in various districts of the state. Among them, there are five clusters where brick-making is concentrated. The clusters include Sangli, Pune, Mumbai-Thane, Nashik-Ahmednagar, and Nagpur.

Burnt clay bricks are produced primarily in the Mumbai-Thane, Sangali, and Nagpur clusters. Fly ash bricks are made in Nagpur, Nashik-Ahmednagar, Pune, and Mumbai-Thane clusters, considering the supply of fly ash from power plants in these areas, many of which are located within 100 km. The AAC block production is primarily concentrated in the Mumbai-Thane, Pune, and Nashik-Ahmednagar clusters.

Except for the Nagpur cluster, where there are FCBTKs, the other clusters primarily rely on clamps for burnt clay brick-making.[40]

Map 5.2: Brick-manufacturing clusters



Source: Greentech Knowledge Solutions Pvt. Ltd., 2017

Table 5.5: Raw material, fuel and technology used in brick-making

Cluster	Type of bricks	Raw material	Primary fuel type	Predominant technology used for firing clay bricks
Sangli	Mostly burnt clay bricks	Clay, fly ash, and foundry waste	Coal and wood	Clamps
Nagpur	Fly ash bricks and Burnt clay bricks	Clay and fly ash	Coal	FCBTK for burnt clay bricks and different technology for fly ash brick production.
Mumbai-Thane	Combination of fly ash, clay, and AAC blocks.	Clay, fly ash, lime and gypsum	Coal, wood, and bagasse	FCBTKs, clamps for burnt clay bricks, and other advanced technology for making fly ash and AAC blocks.
Pune	Fly ash bricks and AAC blocks.	Fly ash, lime, and gypsum	Electricity	Advanced technology
Nashik-Ahmednagar	Fly ash and AAC blocks	Fly ash, lime, and gypsum	Electricity	Advanced technology

Source: Greentech Knowledge Solutions Pvt. Ltd., 2017

5.2.3 Employment

The brick sector in Maharashtra is highly informal and unregulated.[41] As per information from the State Pollution Control Board (SPCB), only a handful of brick-making units are registered.[42]

Employment in the brick-making sector is estimated based on the daily output per worker. As per survey studies undertaken in brick clusters in Maharashtra, one person, on average, can mould up to 625 bricks per day.[43] Since brick-making is a seasonal activity, an average of six months or 180 days is considered the total working days per person per year. Considering the labour productivity, the total number of workdays, and the total annual brick production in the state (28 billion), it is estimated that the total number of workers involved in brick-making is 248,000.

5.2.4 Fuel and energy consumption and emissions

Most of India's brick-making units depend on coal as a fuel source. It is the third largest industrial sector, after thermal power and steel, with respect to coal consumption.[44] The sector is estimated to consume about 35 million tonnes (MMT) of coal per year to produce about 233 billion bricks.[45]

Coal and biomass-based sources are primarily used in brick-making in Maharashtra. While there is no official estimate of total coal consumption for brick-making in the state, it is estimated that for the production of 100,000 bricks, about 12 tonnes of coal is required.[46]

The overall coal consumption by the brick sector in Maharashtra is estimated for the burnt clay brick production, which is about 68% of the total brick produced in the state.[47] Considering this, the total number of burnt clay bricks produced in the state currently can be estimated at 19 billion. Therefore, the total coal consumption for producing burnt clay bricks can be estimated at 2.3 MMT.

The use of coal and inefficient technologies dominating the sector is a crucial reason for the sector's poor environmental performance. For example, the energy consumption and CO_2 emission intensity of the solid burnt clay bricks through clamps and FCBTK is the highest compared to other brick manufacturing methods. Consequently, the PM emissions associated with it are also very high.

Table 5.6: Energy consumption and emissions from brick-making technologies

Parameters	Energy consumption (MJ/ m^3)	CO_2 emission intensity (tCO_2/m^3)	PM emission (g/ m^3)
Solid burnt clay- FCBTK	2080	0.19	1888
Solid burnt clay - Zigzag kiln	1680	0.15	368
Solid burnt clay fly ash - FCBTK	1558	0.14	1547
Autoclaved aerated concrete blocks	1276	0.14	151
Perforated burnt clay - Zigzag kiln	1512	0.14	331
Hollow clay blocks - Tunnel kiln	1275	0.12	178
Cellular light-weight concrete	1003	0.15	210
Pulverized fuel ash-lime bricks	1025	0.08	83
Pulverized fuel ash-cement bricks	811	0.12	161
Solid concrete blocks	774	0.12	167
Hollow concrete blocks	581	0.09	125
Compressed stabilised earth blocks	653	0.10	139
Construction and demolition waste bricks	1533	0.24	327

Source: Greentech Knowledge Solutions Pvt. Ltd., 2017

Overall, the CO_2 emission from the brick sector in the state has been estimated considering the typical size of brick in the state, the total brick production in the state annually and the corresponding volume (m^3), and the CO_2 emission intensity of brick manufacturing which is estimated to be 0.14 tCO_2/m^3. Considering this, the brick sector's total CO_2 emission per year is estimated to be about 6 MMT.

Table 5.7: Emissions from the brick sector

Parameters	Values
Typical size of brick	$0.19 \times 0.09 \times 0.09$ m^3 = 0.001539 m^3
Bricks per m^3	650
Total brick volume	28 billion
CO_2 emission intensity	0.14 tCO_2/m^3
Total annual emission	6 MMT

Source: iFOREST analysis

5.2.5 Just energy transition issues for the brick sector

Studies have shown that brick kilns are a key source of particulate matter (PM) emissions and contribute nearly 400,000 tonnes of PM2.5 and over 660,000 tonnes of PM10 each year.[48] Besides, brick kilns are a major source of black carbon emissions and contribute to global warming. The sector is estimated to contribute to about 0.4% of total GHG emissions in India (as of 2019 estimates).[49]

Therefore, a green transition of the brick sector will have the dual benefits of lowering industrial GHG emissions and improving local environmental conditions. A transition of the brick sector will require a shift to more advanced technology(ies) for brick production, using alternative fuels for brick-making, and optimising the use of raw materials. However, considering the large-scale income dependence on the sector, a plan for workforce transition will be essential. The following are some of the key transition opportunities for the sector.

i. Technology shift: Scientific and technological studies for the brick sector in South Asia[50] and India[51] show that energy consumption can be reduced by adopting more efficient technologies. These include changing traditional kilns like clamps and FCBTK to Zigzag and Vertical Shaft Brick Kiln (VSBK) technologies.[52] The VSBKs can reduce black carbon approximately ten-fold compared to other existing technologies. The shift to these technologies is also highly cost-effective, with costs equal to the setting up of FCBTK.[53]

Table 5.8: Comparative cost of upgrading to new technology

Technology change	Cost (INR million)
Establishing a new FCBTK kiln	5
Establishing a new Zigzag kiln	5
Upgrading an existing FCBTK to a Zigzag kiln	2

Source: BEE, 2019

ii.Raw material optimization and resource-efficient bricks: The production and use of resource-efficient bricks (REBs), such as perforated bricks and hollow blocks, can help reduce GHG emissions from brick manufacturing.[54] Overall, resource efficiency in the brick sector can also be enhanced by using locally available raw materials. For example, in the Nagpur cluster with good access to fly ash, producing resource-efficient fly ash bricks can be better than producing burnt clay bricks. On the other hand, the production of resource-efficient clay and concrete bricks will be significant opportunity in the Aurangabad, Nashik, and Pune clusters, which do not have good availability of fly ash.[55]

iii. Alternative fuel: Scientific studies have shown that the use of alternative fuels, such as biogas and biomass, has the potential to reduce the environmental impact of the brick industry.[56] Shifting to such fuels can also reduce brick production costs depending on the local availability and supply of materials.

Table 5.9: Technology used and associated energy consumption in the brick sector

Brick type	Energy used	Assumption for estimating energy
Solid burnt clay brick – Clamp kiln	3200 MJ/m^3	Average Specific Energy Consumption (SEC) 2.0 MJ/kg; Average brick density of 1600 kg/m^3
Solid burnt clay brick – FCBTK	2100 MJ/m^3	Average SEC 1.3 MJ//kg; Average brick density of 1600 kg/m^3
Solid burnt clay brick – Zigzag kiln	1800 MJ/m^3	Average SEC 1.125 MJ//kg; Average brick density of 1600 kg/m^3
Burnt perforated clay brick – Zigzag kiln (around 25% perforation)	1600 MJ/m^3	Average SEC 1.175 MJ//kg; Average brick density of 1350 kg/m^3
Burnt hollow clay block – Tunnel kiln (around 60% perforation)	1300 MJ/m^3	Specific Manufacturing Energy Consumption of around 1.6 MJ/kg of fired brick; Average brick density of 800 kg/m^3.

Source: Greentech Knowledge Solutions Pvt. Ltd., 2017

iv. Policy support: A just transition of the brick sector will also require developing and implementing comprehensive policies by the national and state governments. Currently, the regulations and policies developed for the sector focus on curbing emissions and increasing energy efficiency. These include the standards for pollution abatement in brick kilns of the Ministry of Environment, Forest, and Climate Change (MoEFCC)[57] and the mandate for fly ash utilisation by all brick manufacturing units within the 300-km radius of a thermal power plant for manufacturing bricks,[58] among others.

The BEE's Energy Efficiency rating also seeks to accelerate the shift in the brick manufacturing sector towards energy efficiency through voluntary adoption of improved production technologies and encouraging the production of energy-efficient bricks in India. As per the strategy, brick manufacturers who volunteer to adopt energy-efficient manufacturing shall be awarded a new BEE accredited mark named "Energy Efficient Enterprise (E3)" mark. BEE shall generate market awareness for the E3 mark to encourage sourcing bricks from manufacturing units awarded the E3 mark.[59]

However, a just energy transition of the brick sector will require a holistic policy, particularly considering the large numbers of small units and the informal nature of the sector. The key policy considerations should include the following:

- Develop a pathway for resource-efficient brick production in the state;
- Facilitate green financing for brick kiln owners/brick manufacturers who want to invest in energy-efficient technologies and resource-efficient brick production;
- Promote technical support programs for resource-efficient brick production through District Industries Centres (DICs);
- Develop market incentives for sustainable bricks, such as certification programs or preferences in public procurement for environmentally friendly products;
- Invest in workforce transition measures associated with the brick sector, with a specific focus on skilling and reskilling;
- Support formalization of the brick-making industry to improve monitoring and enforcement of various environment-related regulations, improve overall environmental performance, and reduce GHG emissions.

Overall, a combination of State and Central Government policies will be crucial for transitioning the brick sector to build a green industrial economy and support green jobs in peri-urban and rural areas of the state.

CHAPTER 6

AUTOMOBILE

6.1 Introduction

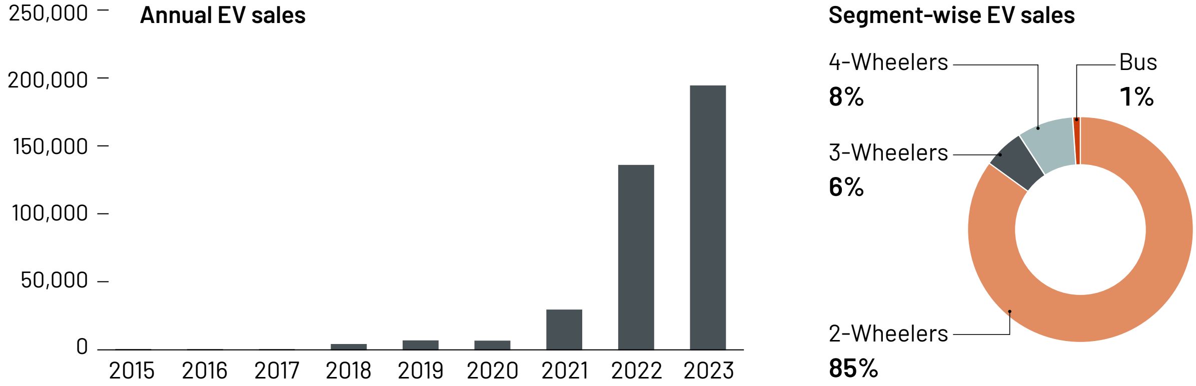
India is the world's fourth-largest vehicle manufacturer and produced over 25.93 million vehicles in 2022-23 . In 2022-23,[1] India also became the third-largest automobile market in terms of vehicles sold[2]. The automobile industry thus contributes significantly to India's Gross Domestic Product (GDP), accounting for 7.5% of the national GDP and a massive 49% of the manufacturing sector's GDP . Whether directly or indirectly, this industry alone generates approximately 19 million jobs.[4]

Maharashtra has the largest automobile industry in the country; it alone accounts for the production of 20% of vehicles, 21% of parts and accessories and 24% of other transport equipment in India.[5] The sector supplies 7% of the Gross State Domestic Product (GSDP) -the highest in the manufacturing sector- and 15.3% of Industrial GSDP.[6]

The automotive industry is expected to play a critical role in India's green transition. As per the latest Economic Survey, the domestic electric vehicle (EV) market is expected to grow at a compound annual growth rate (CAGR) of 49% between 2022 and 2030[7]. By 2030, the annual sales of EVs are expected to reach about 10 million units[8], from about 1.38 million presently[9]– a nearly seven-fold increase.

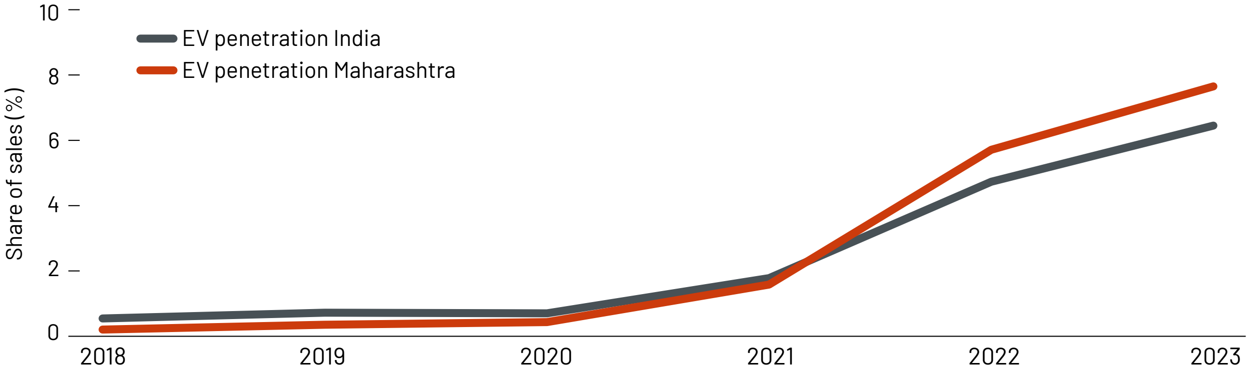
Maharashtra is also a front-runner in the transition to electric mobility. In 2023, the state saw the highest sales of EV cars and 2-wheelers in the country, and the second-highest total EV sales.[10] This amounts to around 12.6% of national EV sales. The penetration of EVs in the state has increased drastically; EV sales accounted for just 0.4% of all vehicle sales in 2020 but jumped to 7.6% by 2023.[11]

Figure 6.1: EV sales in Maharashtra



Source: E-Vahan Dashboard January 2024

Figure 6.2: Share of EV sales in total vehicle sales: Maharashtra and India



Source: E-Vahan Dashboard January 2024

As the automobile sector transitions to EVs, it will have implications on the entire business value chain as well as the workforce. Therefore, evaluating the prospects of a just transition will be essential to ensuring a positive outcome for the industry and the workforce, thereby enabling inclusive green growth.

6.2 Enterprises

Maharashtra has 16,602 enterprises involved in the manufacturing of automobiles and automobile components. There are 26 Original Equipment Manufacturers (OEMs) and 16,576 Auto Component Manufacturers (ACMs). Of the ACMs, about 79.5% are micro-enterprises and 17.8% are small enterprises. In total, 97% of all automobile enterprises in Maharashtra are small and micro-scale.[12]

Table 6.1: Number of automobile enterprises

Type of enterprise	No. of units
Original Equipment Manufacturers	26
Auto Component Manufacturers	16,576
a. Large	100
b. Medium	352
c. Small	2,950
d. Micro	13,174
Total automobile enterprises	16,602

Source: iFOREST analysis of data from Directorate on Industries, Government of Maharashtra, 2023.

6.3 Spatial distribution

There are seven industrial clusters in Maharashtra where various auto enterprises are located. However, 95% of all enterprises are concentrated in five clusters — Pune, Mumbai, Aurangabad, Nashik, and Nagpur.[13]

The Pune cluster is the largest automobile manufacturing hub in Maharashtra, and one of the largest in India. Over 41% of all enterprises are concentrated in this cluster, including 23 out of the 26 OEMs.

Table 6.2: Cluster-wise distribution of OEMs, large enterprises and MSMEs

Type of enterprise	Pune	Mumbai	Aurangabad	Nashik	Nagpur	Amravati	Thane	Total
OEM	23 (88%)	0	2 (8%)	0	0	0	1 (4%)	26
ACMs – Large	61 (61%)	23 (23%)	7 (7%)	8 (8%)	1 (1%)	0	0	100
ACMs - Medium	213 (61%)	51 (14%)	50 (14%)	26 (7%)	9 (3%)	1 (0.3%)	2 (0.6%)	352
ACMs - Small	1,606 (54%)	412 (14%)	439 (15%)	299 (10%)	83 (3%)	19 (1%)	92 (3%)	2,950
ACMs - Micro enterprises	4,974 (38%)	3,412 (26%)	1,777 (13%	1,439 (11%)	755 (6%)	337 (3%)	480 (4%)	13,174
Total	6,877 (41%)	3,898 (23%)	2,275 (14%)	1,772 (11%)	848 (5%)	357 (2%)	575 (3%)	16,602

Source: iFOREST analysis based on data from Directorate on Industries, Government of Maharashtra, 2023

A district-wise distribution of automobile enterprises shows that 37 districts in Maharashtra have automobile-related enterprises. Of these, about 26% are concentrated in Pune.

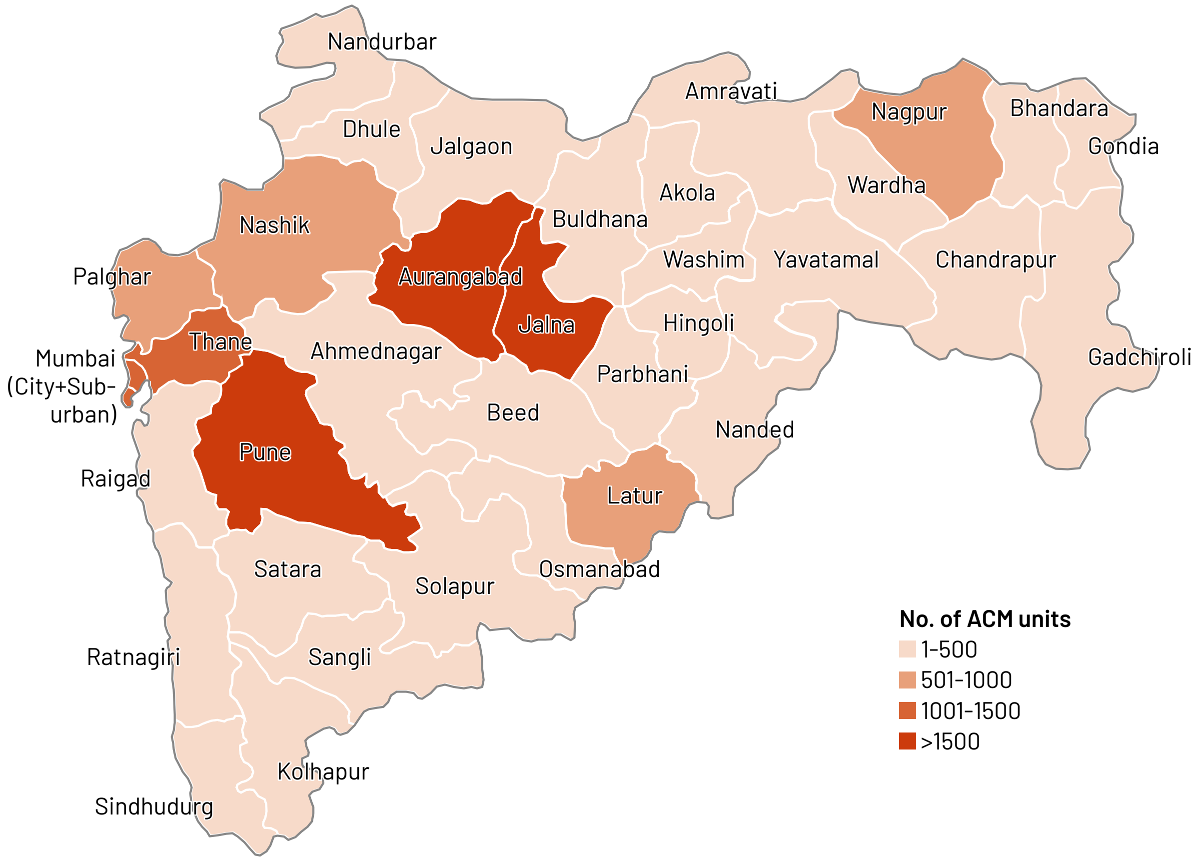
The top five districts include Pune, Kolhapur, Aurangabad, Thane, and Mumbai Suburban. These districts collectively account for 60% of the automobile enterprises.

Table 6.3: Top-5 districts with automobile enterprises

District	No. of enterprises					Total
	OEM	ACM - Large	ACM-Micro	ACM-Small	ACM-Medium	
Pune	23	56	2,977	1,039	154	4,249
Kolhapur	-	2	1,147	496	46	1,691
Thane	1	3	1,102	154	10	1,270
Aurangabad	2	7	1,174	418	49	1,650
Mumbai suburban	-	3	1,041	113	20	1,177
Total	26	71	7,441	2.220	279	10,037

Source: iFOREST analysis based on data from Directorate on Industries, Government of Maharashtra, 2023

Map 6.1: District-wise distribution of automobile units



Source: iFOREST analysis of data from Directorate on Industries, Government of Maharashtra, 2023

6.4 Employment

The employment data has been estimated based on multiple sources including Department of Industries, individual OEMs, and survey of industries.

Table 6.4: Formal employment in the automobile sector in Maharashtra

OEM	ACM				Total
	Large	Micro	Small	Medium	
95,201	43,444	71,114	74,845	50,633	335,237

Source: iFOREST analysis based on data from the Department of Industries, individual OEMs, and survey of enterprises.

As per the information, the automobile sector provides direct employment to around 335,237 people in the state. These are formal employees either directly employed by companies or employed through contractors. However, surveys conducted by iFOREST in Pune indicate that there exists a significant number of informal workers associated with the sector –especially in MSMEs– who are not counted in these employment statistics.

Overall, ACMs account for 72% of the formal employment offered by the auto industry in Maharashtra, while OEMs provide the remaining 28%. MSMEs account for close to 60% of all formal jobs.

In terms of geographical spread, 54% of all automobile jobs are in Pune. This is followed by Kolhapur with 7% and Mumbai with 5.8% of total jobs. The top 5 districts account for 81% of the total formal jobs in the auto sector.

Table 6.5: District-wise formal employment in automobile enterprises

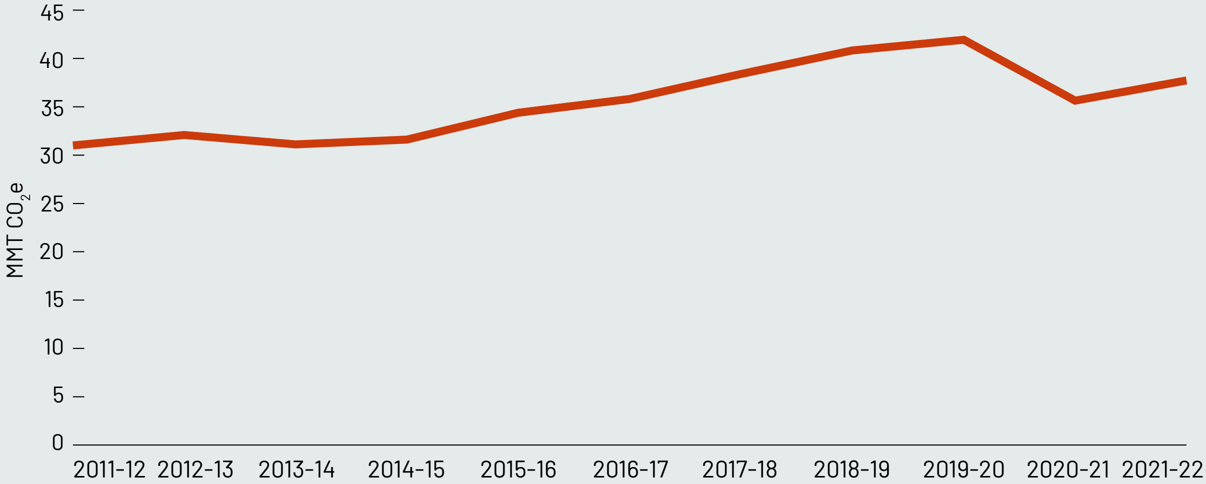
District	Total Employment	% of total
Pune	180,610	54
Kolhapur	23,488	7.0
Ahmednagar	4,846	1.4
Thane	14,463	4.3
Aurangabad	30,631	9.1
Akola	348	0.1
Amravati	286	0.1
Beed	596	0.2
Bhandara	189	0.1
Buldhana	513	0.2
Chandrapur	282	0.1
Dhule	444	0.1
Gadchiroli	81	0.0
Gondia	161	0.0
Hingoli	96	0.0
Jalgaon	1,353	0.4
Jalna	799	0.2
Latur	821	0.2
Mumbai	19,519	5.8
Mumbai city	3,008	0.9
Mumbai suburban	13,150	3.9
Nagpur	5,151	1.5
Nanded	331	0.1
Nandurbar	166	0.0
Nashik	16,738	5.0
Osmanabad	626	0.2
Palghar	4,254	1.3
Parbhani	148	0.0
Raigad	2,762	0.8
Ratnagiri	605	0.2
Sangli	1,775	0.5
Satara	4,156	1.2
Sindhudurg	105	0.0
Solapur	2,019	0.6
Wardha	322	0.1
Washim	83	0.0
Yavatmal	311	0.1
Total	335,237	

Source: iFOREST analysis based on data from various sources. ACM's employment data was obtained from the Department of Industries, Government of Maharashtra, 2023; OEM's employment number was obtained from the Department of Industries and company specific information.

BOX: EMISSIONS FROM THE ROAD TRANSPORT SECTOR

With 37.7 MMT CO_2e emissions, the road transport sector is the second largest CO_2 emitting sector in Maharashtra (after thermal power), accounting for 12.2% of the total emissions in 2021-22. Overall emissions have increased moderately in the last 10 years, with emissions still being below the pre-COVID period peak seen in 2019-20.

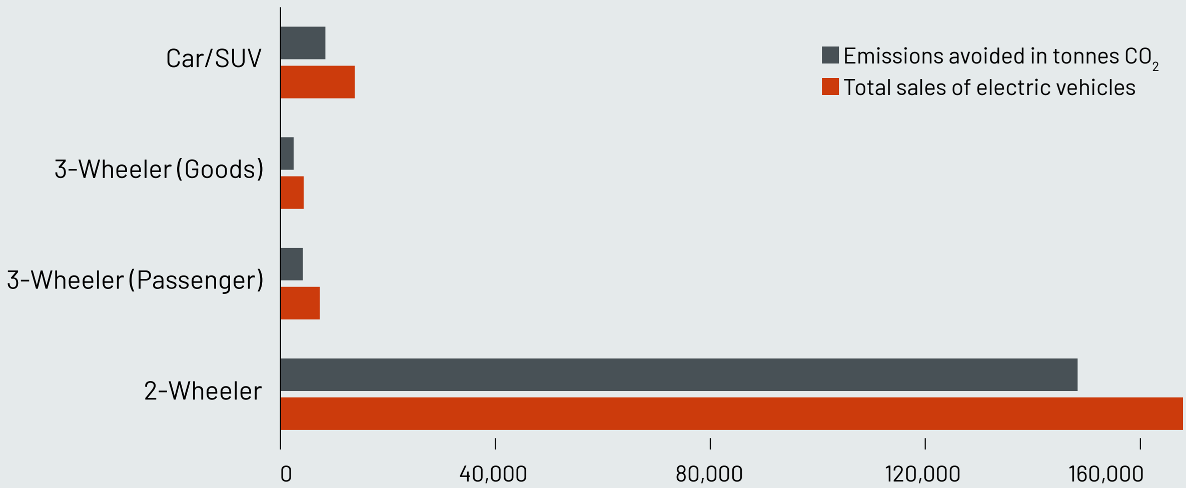
Figure 6.3: Emissions from road transport (MMTCO_2e)



Source: iFOREST analysis

To reduce GHG emissions from this sector, the transition of road transport from being built on fossil-fuel-based Internal Combustion Vehicles to EVs will be crucial. Modelling studies indicate a high potential for avoided emissions from the use of EVs in Maharashtra.[14] For example, in the year 2023, the sale of 0.16 million two-wheelers in Maharashtra translated to about 0.1 MMT of CO_2 emission avoidance. Overall, in 2023 the sales of EVs across vehicle segments translated to a CO_2 emission avoidance of 0.16 MMT.[15]

Figure 6.4: Emissions avoided by adoption of EVs in Maharashtra



Source: OMI EV Ready India Dashboard , 2023

6.5 Just energy transition issues for the automobile sector

A green transition of the automobile sector in Maharashtra will have impacts on enterprises and businesses associated with the conventional auto sector, as well as the workforce engaged at different points in the value chain. ACMs and OEMs will both undergo substantial modifications in their assembly lines. Current production lines dedicated to fuel storage and use, transmission lines, and other key components of internal combustion engine (ICE) powertrains, will become obsolete. These will need to be replaced by new assembly lines focused on EV motors, batteries, and sophisticated electrical systems. Spare parts dealers will also see a shift as the demand for traditional parts will decline.

The key transition issues of the automobile sector are outlined below.

i. Overall impact on enterprises: The various segments of the automobile sector will experience different transition challenges depending on the impact that the types of equipment and parts they manufacture will experience in the transition from ICE vehicles to EVs.

ii. ACMs: The EV transition presents a unique set of challenges and opportunities for ACMs, especially MSMEs. The following are some of the key challenges for such enterprises:

- **Technology change:** The shift to EVs introduces a fundamental change in automotive technology. MSMEs, typically with limited resources for technological upgrades, may find it challenging to adopt and integrate advanced electric powertrain technologies. This transition necessitates not only capital investments in technology but also the upskilling of operators to handle new, often complicated, equipment.
- **Redundancy of parts:** A transition to EVs will have major impacts on the ACMs who are involved in the manufacturing of various powertrain components required by ICE vehicles. These enterprises will face challenges of inventory management, repurposing, and finding alternative applications. Micro and Small enterprises, which are often agile in diversifying, may find it less challenging to adapt to changes in market demands. However, large and medium enterprises may find this diversification far more challenging, considering their heavy investments in existing plants and machinery.
- **Change in business models and value chain:** The EV era will create new business models and different value chains. With fewer powertrain components, EVs will require more specialised ACMs. The value chain is also likely to become more integrated with EV companies relying on a few larger suppliers for powertrain components like batteries and motors. This will impact the MSMEs significantly. Therefore, MSMEs that focus heavily on ICE powertrain components might need to explore diversification strategies, partnerships, or new market segments to sustain their businesses.
- **Meeting new demand:** Those ACMs engaged in manufacturing electrical components may experience a surge in demand for the specialized parts needed in EVs. Meeting this demand requires significant investments in upgrading manufacturing capabilities and diversifying production lines.
- **Workforce impact:** As the powertrain of ICE vehicles is fundamentally different from those of EVs, there will certainly be an impact on the skilled labour force that currently produces these components. The shift from producing components for mechanical power-based vehicles to components for electric vehicles will certainly require different skill sets. Therefore, workforce skilling and reskilling will be crucial for the sector.

iii. OEMs and large enterprises: The transition to EVs is anticipated to bring about significant changes to the business structures of OEMs. The following are some of the key aspects:

- **Changes in product mix:** As OEMs strategically diversify their businesses towards EVs, there will be a shift in their product mix. Traditional ICE vehicles will likely see reduced emphasis, with a more substantial focus on electric and hybrid models. OEMs and large enterprises in the state of Maharashtra have already started investing substantial amounts in R&D for the transition to EVs.

- **Changes in the supply chains of various parts:** The sources for parts will change alongside changes in the kinds of parts required. While traditional automotive components associated with ICE vehicles may experience a decline in demand, there will be an increased need for components specific to EVs. Competition in the demand for batteries is a likely source of component bottlenecks. OEMs will need to reassess their supply chains and establish new partnerships and sourcing strategies to secure a reliable and cost-effective supply of EV-specific components.
- **Workforce impact:** The transition to EVs necessitates a skilled workforce capable of handling the unique aspects of electric vehicle technology. OEMs and large enterprises will need to invest in reskilling programs for their workers to ensure that they are proficient in the processes of EV manufacturing, assembly, and maintenance. Alternatively, a large skilled labour force will be rendered obsolete and unemployed.

iv. Service centres and informal repair shops: A crucial aspect of the EV transition will be the nature of maintenance and repair work. Unlike traditional ICE vehicles, EVs have fewer moving parts and, as a result, require less frequent maintenance. This shift poses a challenge for service centres, impacting their revenue streams that were traditionally tied to the need for regular servicing and part replacement.

Workers specifically servicing powertrain components such as engines, fuel systems, exhausts, transmission lines and so on are likely to find that their skills have become obsolete. As such, they would need to reskill in order to be able to service non-powertrain components and EV powertrain components. For informal repair shops, the challenges will be more pronounced, as the workers in such facilities often do not have any formally certified skills that would make them eligible for other reskilling programmes.

v. Spare part dealers: The sales of spare parts will also be impacted by the EV transition. Fewer moving parts in EV powertrains result in the need for fewer part replacements. However, the EV ecosystem relies heavily on battery technology– the battery itself constitutes a substantial portion of the vehicle's value. As such, spare part dealers may do well if they focus on storing and supplying batteries and battery components.

The impacts on various segments of the automobile sector as discussed above is not a distant future. A transition is already underfoot in the automobile industry of Maharashtra. While the impact on the business and workforce is not likely to be immediately apparent for the next few years, some sections of the industry will start experiencing transitional challenges by 2030.[16] While 4-wheelers are expected to transition slowly, in a phased manner, 2 and 3-wheelers are likely to transition rapidly and thereby cause significant market disruption. Thus, a just transition plan for the sector is essential and must include both progressive government policies and a proactive role for industry.

On the policy front, the concern of the Central and State Governments so far has been primarily focused on supporting the growth of EVs. Over the last decade, the Centre has promulgated several policies to support this transition to EVs. Some key ones include the FAME scheme, the Production-Linked Incentive (PLI) scheme, the Battery Swapping Policy, and the Battery Waste Management Rules, among others.[17]

The Centre has also made investments in Research and Development (R&D) centres. These aim to align the Indian automotive industry with global standards. Implemented under the National Automotive Testing and R&D Infrastructure Project (NATRIP), five testing and research facilities have been operational in India since 2015.[18]

The Government of Maharashtra has also unveiled supportive policies in recent years. In July 2021, the state unveiled its EV Policy that aims to make Maharashtra the country's top producer of BEVs (Battery EVs) in India, in terms of annual production capacity. The policy further aims to achieve 10% of all new vehicle registrations being electric by 2025. The other targets set for 2025 include achieving 25% electrification of public transport and fleet operators in six targeted urban agglomerations. These are Mumbai, Pune, Nagpur, Nashik, Aurangabad, and Amravati.[19]

On the industry side, businesses at all levels (OEMs, ACMs large and small, service centers and so on) are diversifying their businesses to accommodate the EV transition. Some strategies involve a transition from one assembly line to another related but less vulnerable product line. Alternatively, firms are also diversifying towards electrical products which may not have any link to their initially manufactured products.[20]

For example, Tata Motors -one of the state's largest automobile companies- is producing electric passenger cars from the Pune plant. The company in 2022 also announced an investment of ₹15,000 crores over 5 years in the EV segment. This was in order to support the budding EV ecosystem largely focused on Maharashtra.[21]

Separately, Tata Power has signed an MoU with the National Real Estate Development Council to set up 5,000 EV charging points across Maharashtra.[22]

Mahindra Electric signed a Memorandum of Understanding (MoU) with the Government of Maharashtra to invest around ₹10,000 crore in Maharashtra towards building EVs and EV infrastructure.[23]

Gogoro, an electric two-wheeler manufacturer and battery-swapping service provider from Taiwan, has joined forces with the State Government and Belrise Industries to develop battery-swapping infrastructure. Together, they are embarking on the construction of a $2.5 billion battery-swapping infrastructure over span of eight years. This ambitious initiative is set to become the world's largest system of its kind.[24]

Building on the policies of the government and the initiatives of industry, the following additional interventions can be considered over the next five years to support a just energy transition in the automobile sector.

i. **MSME transition fund:** The creation of an MSME Transition Fund to support the reorientation of enterprises involved in ICE component manufacturing towards EV components.

ii. **Right to Repair and Servicing policy:** Develop a 'Right to Repair and Servicing' policy to enable EV manufacturers to involve local service centres in repair and servicing and address job loss.

iii. **Skilling and reskilling of Workforce:** The following measures can be undertaken for the skilling and reskilling of workers engaged at ACMs and OEMs:

- Launch reskilling programs in collaboration with vocational institutes and industry partners to empower the existing workforce with skills tailored for the evolving needs of EVs.
- The Skill Employment, Entrepreneurship and Innovation Department, Maharashtra could adopt the "Learning on the Job" model, known as the Dual System of Training, to encourage greater participation in skilling courses.
- Adapt curricula to align with the (still) evolving demands of the Maharashtra EV supply chain by developing new EV-aligned courses.
- Industrial Training Institutes (ITIs) or Skill Sector Councils can collaborate with educational institutions to design credit-based, continuous learning-oriented courses.
- Work with technology partners to design on-demand 'Phygital' learning courses for up-skilling existing workforce.

CHAPTER 7

FERTILIZER

7.1 Introduction

Nitrogenous fertilizers, particularly urea (which dominates India's fertilizer sector), is a significant contributor to GHG emissions. The emissions are from the production process, as well as from the use of urea in the field.

For the production process, urea is produced from ammonia which in turn is primarily produced from natural gas in India. In India, it is estimated that on an average about 0.7 MT of CO_2e is emitted for each tonne of urea produced.[1]

However, emissions from production constitute only a small part of the lifecycle GHG emissions from urea. The bulk of emissions come from the use of urea in agricultural fields, particularly the emissions of nitrous oxide (N_2O), which is a highly potent GHG. Overall, GHG emissions from the use of urea is 4.2 MT CO_2e per MT of urea consumed, which is six times the average GHG emissions from the production plant[2]. Thus, GHG emission reduction requires on one hand green energy transition, especially the use of hydrogen, in urea production. On the other hand, it requires optimisation of urea use in the agriculture sector.

7.2 Production and spatial distribution

Urea is the main fertilizer produced and used in the India. In 2022-23, the production of total fertilizer products was 48.68 MMT. This included 28.49 MMT of urea, which is about 58.5% of the total fertilize products. Additionally, India also imported 7.58 MMT of urea. Correspondingly, urea consumption in the country was 35.7 MMT.[3]

Maharashtra contributed to about 7.7% of the total urea production in 2022-23 (2.2 MMT). There are two fertilizer plants, located in the districts of Raigad and Mumbai Suburban. Both the plants are operated by the Public Sector Enterprises, Rashtriya Chemicals & Fertilizers (RCF) Limited. The two plants have a combined annual production capacity of slightly over 2 MMT.[4]

Besides, these two plants, RCF is also setting up a Nano Urea Plant of 75 KL per day capacity at Trombay. The project is in the process of final environment-related clearances.[5]

Table 7.1: Urea plants in Maharashtra

District	Reassessed capacity (MMTPA)	Production in 2022-23 (MMT)
Raigad	1.71	1.88
Mumbai Suburban	0.33	0.32
Total	2.04	2.2

Source: Rashtriya Chemicals and Fertilizers Limited Annual Report, 2022-23

7.3 Employment

The RCF operated plants in Maharashtra has a total number of 3,812 employees, as per the company reports of 2021-2022. Out of them, 2,635 are permanent employees and 1,177 are casual/ temporary/ contractual employees. Besides, as a manufacturing industry, it is estimated to have a large number of informal dependences in the value chain, as per the National Sample Survey 68th round of data.[6]

7.4 Emissions

The annual combined GHG emission from the two urea fertilizer plants in the state can be estimated to be 1.7-1.8 MMT CO_2e per annum.[7]

Table 7.2: Annual GHG emissions from urea manufacturing plants in Maharashtra

Plant name	Annual GHG emission (MMT CO_2e)						
	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
RCF Trombay	1.14	1.16	1.14	1.17	1.20	1.12	1.10
RCF Thal	0.66	0.65	0.66	0.63	0.67	0.65	0.65
Total	1.8	1.81	1.8	1.8	1.87	1.77	1.75

Source: iFOREST analysis

7.5 Just energy transition issues for urea fertilizer

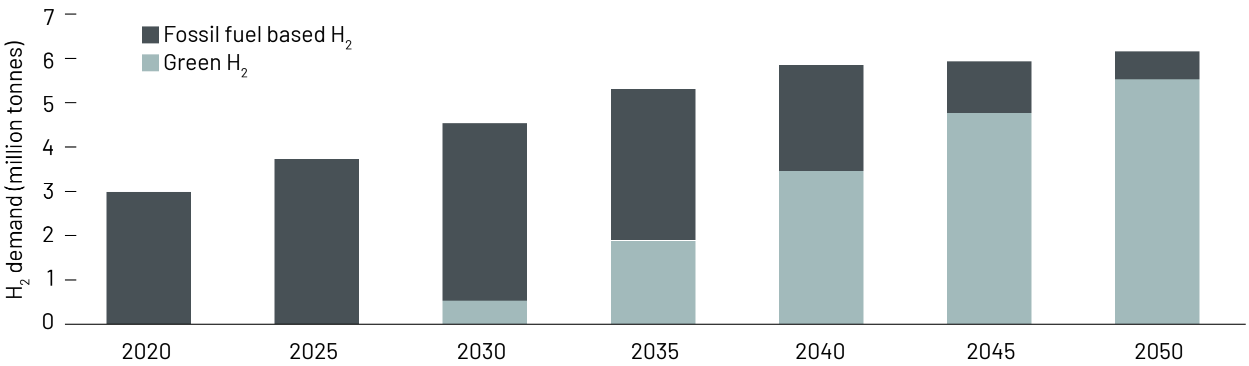
A significant share of CO_2 emission from urea production is a result of the use of hydrocarbons as feedstock to produce hydrogen. Therefore, less carbon-intensive methods are required to produce hydrogen to reduce the process-related emission from urea production.

A key step will be to utilise 'green' hydrogen (hydrogen production via water electrolysis powered by renewable energy) as a feedstock in the production process.[8] In fact, electrolysis was a common means of producing hydrogen in areas with cheap power before hydrocarbon-based processes took over. Fertilizer Corporation of India's Nangal plant employed electrolysis to produce hydrogen until it switched to hydrocarbons (then LSHS and fuel oil) in the 1970s due to shortage of power in the Bhakra grid.

The GoI's Green Hydrogen/ Green Ammonia Policy promulgated in 2022, provides the necessary policy impetus for the industry to adopt greener production processes.[9] Besides, industrial strategy and investments in innovation by the industries themselves will be important for a green transition of the urea plants.[10]

With the projected increase in hydrogen demand for ammonia production in the coming years, a majority of which will be for supplying ammonia to the fertilizer industry, moving to green hydrogen through government and industry intervention will be necessary. It is projected that in the next five years green hydrogen-based ammonia will be cost-competitive with natural gas-based ammonia. By 2050, with the necessary impetus, green hydrogen-based ammonia can reach 88% share.[11]

Figure 7.1: Projected hydrogen demand from ammonia for fertilizer and share of green-hydrogen



Source: Figure adopted from NITI Aayog and RMI, 2022

With respect to the transition of the workforce, the key intervention necessary will be re-skilling of the existing workforce and development of future capacity. A combination of technological innovation and investments in workforce transition can help to achieve a just energy transition of the sector.

CHAPTER 8
BOILERS

8.1 Introduction

Industrial boilers are utilised in many different industries for a wide variety of purposes. There are various industrial sectors in Maharashtra that use boilers in the production process. As per information obtained from the Directorate of Steam Boilers, there are 5,988 registered boilers in the state which are used by various industries.[1] Out of these, the top five industrial sectors with the largest number of boilers include, food and agriculture related industries, textile, chemical, sugar and pharmaceutical/healthcare. These industries account for over 70% of the registered boilers in the state.

Table 8.1: Distribution of boilers in various industrial sectors

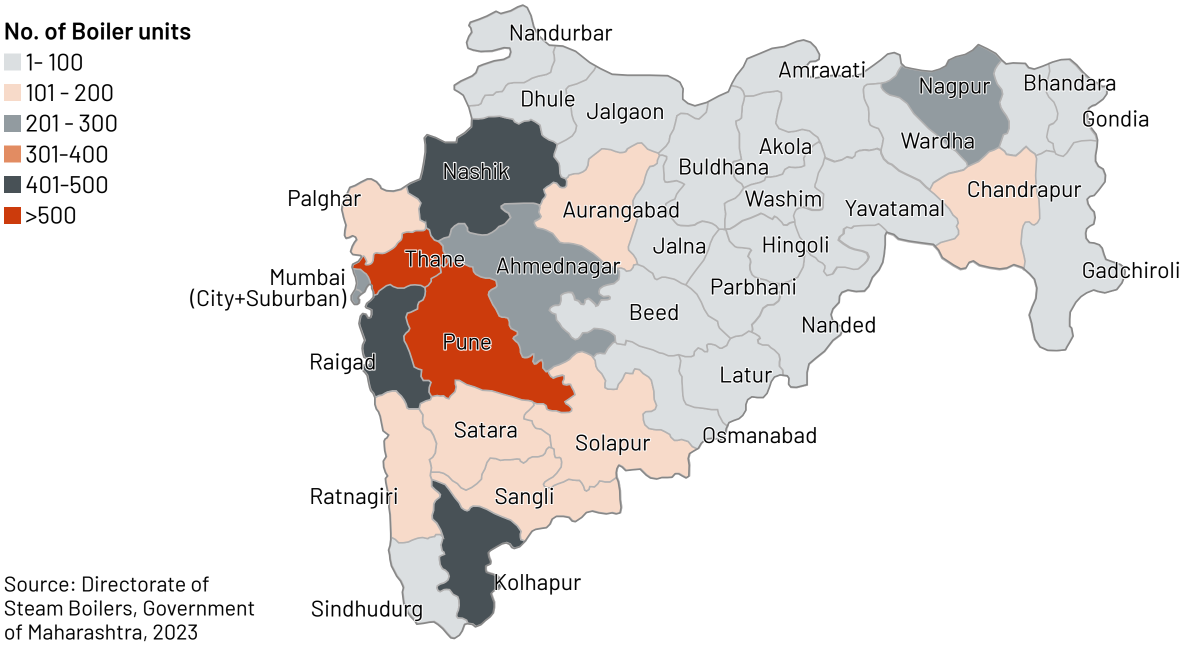
Sector	No. of boilers
Food/ Agriculture	1,832
Textile	881
Chemicals	553
Sugar	542
Pharmaceutical/Healthcare	496
Engineering /Automobile	342
Construction and building material	318
Paper	240
Plastic/Polymers/Rubber	230
Power	187
Petroleum and Refineries	178
Ordnance factories (Defence equipment)	65
Hospitality/Hotel Industry	49
Laundry	47
Electrical/ Electronics	22
Cosmetics/Jewellery	10
Institutes	5
Not mentioned	1
Total	5,998

Source: Directorate of Steam Boilers, Government of Maharashtra, 2023

8.2 Spatial distribution and capacity

With respect to a district-wise distribution, Pune has the highest number of boilers followed by Thane, Raigad, Kolhapur, Nashik and Nagpur districts. The key sectors using boilers in these districts include, food and agriculture, textile, chemical, pharmaceutical and healthcare and manufacturing/automobile.

Map 8.1: District-wise distribution of boilers



Source: Directorate of Steam Boilers, Government of Maharashtra, 2023

Table 8.2: District and sector-wise distribution of boilers

District name	Total No. of boilers	Sector wise Distribution										
		Food/ Agriculture	Textile	Chemical s	Sugar	Pharmaceutic al/ Healthcare	Engineering Parts/ Automobile/ Manufacturing/Industrial	Paper	Plastic/Po lymer/Ru bber	Power	Petroleum and Refineries	Others*
Pune	961	355	43	82	58	108	71	49	47	20	19	109
Thane	833	105	301	115	3	102	56	27	48	9	3	64
Raigad	459	94	23	154	1	53	25	7	15	5	31	51
Kolhapur	447	151	169	3	57	7	32	10	3	10	1	4
Nashik	420	96	172	12	23	21	7	22	32	7	5	23
Nagpur	236	104	15	3		9	22	18	17	23		25
Ahmednagar	214	106	7	3	68	10	3	6		3	5	3
Satara	190	72	4	10	46	16	10	5	8	3	3	13
Palghar	190	24	36	35	1	54	4	11	9	1		15
Mumbai City	190	23	4	13		10	6	2	9	4	95	24
Aurangabad	174	52	5	16	9	45	11	20	4	1	3	8
Solapur	170	56	20	11	61	11	4	3	1	1		2
Sangli	166	57	14	5	39	8	17	8	3	1	1	13
Chandrapur	132	30		2			7	7	2	32	1	51
Ratnagiri	127	58	2	23	2	6	21	1	4	8	1	1
Jalgaon	100	47	2	13	5	1	2	10	5	4	1	10
Latur	76	36	1	1	32	1		4				1
Gondia	74	50		2			5		1	14		2
Bhandara	68	30		2			4	3	1	2		26
Dhule	65	36	10	7		1	2		6	1	1	1
Mumbai Suburban	58	15		3	2	5		2		11	3	17
Nanded	51	28		3	10	2	2	1	1	1		3
Beed	50	15		3	25		1	1		4	1	
Osmanabad	48	11		7	26	1	2					1
Wardha	35	7	6	1		1	1	6	2	4		7
Amravati	31	7	7	1		4	3	1	1	5		2
Jalna	30	14	5	1	8					2		
Yavatamal	29	4	10	1	7			1				6
Gadchiroli	26	19					3			4		
Buldhana	26	11	3	1	1	1		6	1			2
Akola	23	13	1	1		1	1	1		2	1	2
Nandurbar	17	2	1	3	9			1		1		
Parbhani	16	3			11		1					1
Sindhudurg	15	12				1	2					
Hingoli	13	3	1		9							
Washim	9	7		1			1					
Dindori	7	4						2		1		
District unspecified*	222	75	19	15	29	17	16	5	10	3	3	30
Grand Total	5998	1832	881	553	542	496	342	240	230	187	178	517

Source: Directorate of Steam Boilers, Government of Maharashtra, 2023
*(Hospitals, Construction & Building Materials, Hotels, Chemicals & Jewellery, Acdemic Institutes, Ordance Factories, Electricals & Electronics)

The capacity assessment of boilers has been done for a total of 1,543 registered boilers in the state based on latest annual inspection data. The reason for this is that boiler capacity is only available from the annual inspection data of the Directorate of Stem Boilers. The assessment shows that most of the boilers in the state are of smaller capacity which is less than 10 tonnes per hour. Out of the total 1,263 boilers for which data could be analysed, about 73.5% are of small capacity.

Table 8.3: Boiler capacity

Boiler capacity (tonnes/hour)	No. of boilers	Share of total (%)
Less than 1	165	13.1
1-10	764	60.5
10-20	93	7.4
20-50	61	4.8
50-100	31	2.5
Above 100	149	11.8
No capacity given	280	
Total	1,543	
Total analyzed	1,263	100.0

Source: Directorate of Steam Boilers, Government of Maharashtra, 2023

Table 8.4: Industry-wise share of boilers below 10 tonnes/hr capacity

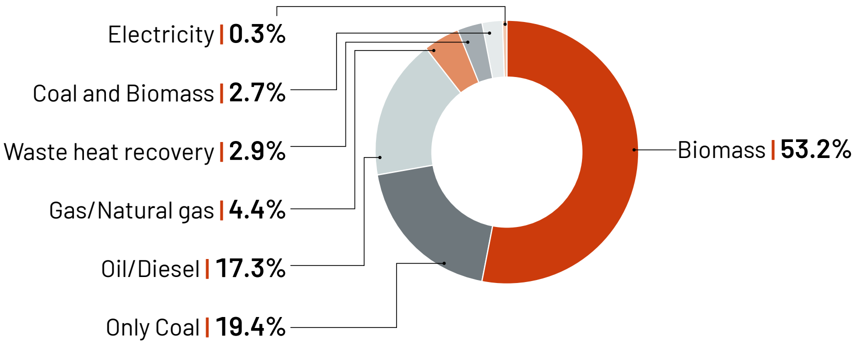
Sectors	Share of boilers below 10 tonnes/hr capacity (%)
Textile	93.2
Pharmaceuticals	88.5
Paper	86.7
Plastic/Polymer/Rubber	77.9
Construction and Building Material	74.1
Food and Agriculture	72.2
Electrical	70
Chemicals	67.8
Engineering Parts/Automobile	57.1
Ordnance Factories	100
Power	27
Sugar	14.8
Laundry	40
Academic Institute	50
Cosmetics/Jewellery	100
Soap	66.7
Petroleum and Refineries	50
Waste Handling and Management	50
Hospitality	100

Source: Directorate of Steam Boilers, Government of Maharashtra, 2023

8.3 Fuel use and GHG implications

With respect to fuel use, more than half of the boilers in the state are based on biomass and about 44% of them (out of 1,390 for which data is available), use fossil fuels in production processes. This includes boilers reliant solely on coal, oil/diesel, and gas, and those using a combination of coal and biomass.

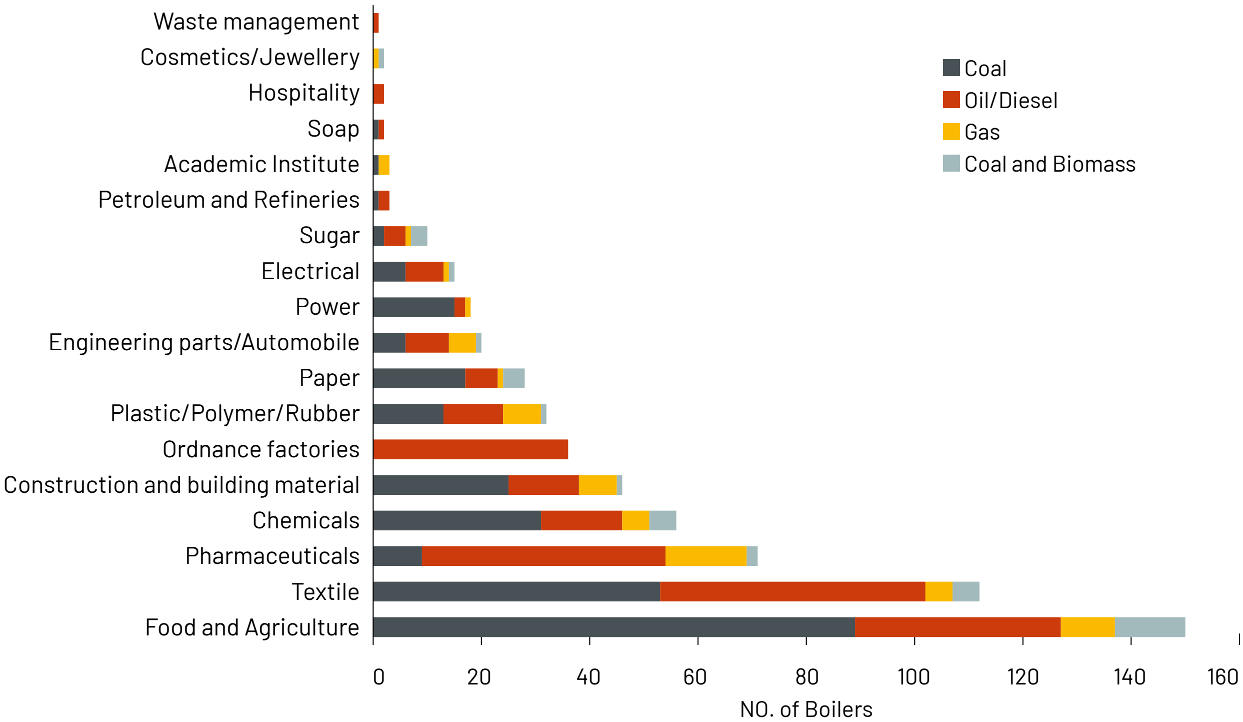
Figure 8.1: Fuel use by boilers



Source: Directorate of Steam Boilers, Government of Maharashtra, 2023; Fuel use of 153 inspected boilers were not recorded.

Coal is used as a major fuel source in boilers in the food and agriculture industry, textile, chemicals, paper, construction and building materials. Overall, the coal and oil/diesel is the primary source of fuel in 84% of the boilers using fossil fuels.

Figure 8.2: Type of fossil fuel use in boilers



A district-wise assessment further shows that over 57% of the coal-based boilers are concentrated in just four districts- Nagpur, Pune, Nashik and Chandrapur, which are the coal producing districts and/or have a high engineering/manufacturing units. Pune and Nashik also have a high concentration of oil/diesel boilers.

Table 8.5: District-wise distribution of fossil fuel-based boilers

District	Coal	Oil/Diesel	Gas	Coal and Biomass	Total
Nagpur	59	13	2	1	75
Pune	43	87	28	1	159
Nashik	37	54	3	9	103
Chandrapur	15	8			23
Jalgaon	13	7	1	5	26
Wardha	12	1	1	1	15
Amravati	11	1			12
Satara	10	22	9	1	42
Dhule	9	7		4	20
Thane	9	8	1		18
Palghar	8	4	2	3	17
Bhandara	6	19			25
Raigad	7	3	4	1	15
Akola	5	3			8
Buldana	5		1		6
Aurangabad	3	1	1	3	8
Latur	3			1	4
Sangli	2			1	3
Kolhapur	2				2
Washim	2				2
Nandubar	2				2
Yavatmal	1		4		5
Ahmednagar			3	2	5
Gondiya	1	1		1	3
Mumbai suburban		1	1		2
Jalana				2	2
Hingoli	1			1	2
Solapur	1				1
Ratnagiri	1				1
Beed	1				1
Total	269	240	61	37	607

Source: Directorate of Steam Boilers, Government o Maharashtra, 2023

Overall, the assessment of boilers shows that there is a large number of boilers which are still dependent on fossil fuels in various industrial sectors. For example, as noted above about 44% of the boilers use fossil fuels in production processes. As per records, the use of electric boilers is negligible, only 0.3%.

Also, there is a high dependence on fossil fuel in boilers used in the manufacturing sub-sectors. For example, an assessment of the key manufacturing sub-sectors shows that, except for sectors like sugar, on an average there is about 40%-50% dependence of fossil fuel-based boilers in these industries. This also results in high GHG emission from the manufacturing sector contributing to overall emission intensity of the state GSDP, as manufacturing sector contributes to about 18% of the state GSDP.[2]

Table 8.6: Status of manufacturing sector using fossil fuel-based boilers

Sector	No. of boilers	No. of boilers monitored	No. of fossil fuel-based boilers among monitored boilers	Share using fossil fuels (%)
Textile	881	272	112	41.2
Chemicals	553	105	56	53.3
Pharmaceutical	496	126	71	56.3
Paper	240	81	28	34.6
Engineering parts/ Automobile/ Electrical	364	64	35	54.7
Sugar	542	90	10	11.1
Contruction and building material	318	94	46	48.9
Plastic polymer	230	80	32	40
Ordnance factories	65	39	36	92.3

With respect to spatial clusters, particularly boilers those reliant on coal and oil/diesel, are highly concentrated in the industrial districts of Nagpur, Pune and Nashik.

8.4 Employment

The industry-wise data related to employment generated through the operation of boilers was unavailable from the Directorate of Boilers or the industry departments. However, as per feedback received from the Directorate, the average number of people required to run a boiler is estimated as three. Considering this, it is estimated that there are at least 18,000 workers associated directly with the operation of boilers. However, the actual employment dependence is much higher and requires further investigation as the total workforce associated with each of the boiler-based industrial unit is much higher.

8.5 Just energy transition issues for boilers

The boiler-based industries will experience transition challenges this decade considering the emission associated with boilers using fossil fuels. A key transition that is necessary for the industry is a shift to electric boilers.

Scientific studies show that electrification of boilers in these various industrial sectors provides a cross-cutting opportunity for GHG emissions reduction, and improving the performance efficiency of these sectors.[3] Overall, electric boilers have high thermal efficiency (about 99%), fast ramp-up times, and low downtime. Further they do not require onsite pollution abatement, combustion accessories (such as tanks, fuel links, and exhaust flues), or expensive combustion inspection. They can also offer other non-energy benefits, such as lower capital, maintenance, and administrative costs and physical footprints. But the high cost of electricity relative to other fuels has affected their economic feasibility.[4]

However, the adoption of electric boilers is contingent on how green is the grid electricity mix. For example, study by the National Renewable Energy Laboratory (2023), suggest that if the fossil fuel is the predominant energy source in the grid, then the fuel required to electrify boilers will exceed the fuel savings from replacing conventional boilers and will lead to an increase in total fossil fuel consumption and overall emissions.[5]

Therefore, a key factor for the adoption of electric boilers at scale is scaling of renewable-based power capacity, and electricity prices from green sources. However, with India's ambitious RE target, and the growing cost competitiveness of RE, the electrification of boilers is a feasible proposition by 2030. In the mean-time hybrid electric-gas boilers may be used the industries. These systems offer flexibility and allow one to choose between electric heating and fossil heating depending on the prices of electricity.[6]

The state government may upport the electrification of the boiler-based industries through fiscal and non-fiscal instruments. For example, the Government can adopt tax policies that encourage investment in electric boilers, adopt electricity rate designs for the industrial sectors that encourage electrification, and support the scaling up of RE production, which will have co-benefit of energy transition for the electricity sector, as well as the boiler-based industries. The Government can also support the demonstration and deployment of electric boilers that are market-ready on a pilot basis, to enable its adoption by industry players.[7]

With respect to workforce transition, a key factor will be support for reskilling. The industrial sectors and the government can work together with the workers to provide necessary training on electric boilers and their installation, integration, operation, and maintenance.

Annexure 1

List of operational mines

Name of Mine	District	Block	Type	Operational status	Ownership	Production capacity (MTPA)	Current production (MT) 2022
Ballarpur OC	Chandrapur	Ballarpur	OC	Operational	Government	0.62	0.27
New Majri-II (A) Expansion	Chandrapur	Bhadrawati	OC	Operational	Government	2.5	1.67
New Majri UG to OC	Chandrapur	Bhadrawati	OC	Operational	Government	3	1.93
Baranj i-IV, Kiloni and Manohardih	Chandrapur	Bhadrawati	OC	Operational	Government	5	1.26
Durgapur	Chandrapur	Chandrapur	OC	Operational	Government	3	1.84
Padmapur Deep	Chandrapur	Chandrapur	OC	Operational	Government	2.5	0.19
Bhatadi Expansion	Chandrapur	Chandrapur	OC	Operational	Government	1.47	1.3
Hindustan Lalpeth	Chandrapur	Chandrapur	OC	Operational	Government	1	0.46
Nandgaon Incline	Chandrapur	Chandrapur	UG	Operational	Government	NA	0.08
Mahakali	Chandrapur	Chandrapur	UG	Operational	Government	0.4	0.03
Durgapur Rayatwari	Chandrapur	Chandrapur	UG	Operational	Government	0.16	0.11
Manna Incline	Chandrapur	Chandrapur	UG	Operational	Government	NA	0.07
HLC No. 1	Chandrapur	Chandrapur	UG	Operational	Government	0	0
Murpar	Chandrapur	Chimur	UG	Operational	Government	0.28	0.07
Penganga	Chandrapur	Korpana	OC	Operational	Government	6.3	6.3
Sasti OC	Chandrapur	Rajura	OC	Operational	Government	2.5	1.46
Gouri Expansion	Chandrapur	Rajura	OC	Operational	Government	3.5	0.94
Gouri Deep	Chandrapur	Rajura	OC	Operational	Government	0.6	0.6
Paoni	Chandrapur	Rajura	OC	Operational	Government	0.9	0
Paoni-II	Chandrapur	Rajura	OC	Operational	Government	3.25	3.25
Sasti UG	Chandrapur	Rajura	UG	Operational	Government	0.36	0.04
Alamgated Yekona I&II	Chandrapur	Warora	OC	Operational	Government	2.75	2.42
Belgaon (Captive)	Chandrapur	Warora	OC	Operational	Private	0.27	0.27
Inder UG to OC+ Kemptee Deep	Nagpur	Parseoni	OC	Operational	Government	3.2	2.22
Amalgamated Gondegaon Ghatrohana	Nagpur	Parseoni	OC	Operational	Government	2.5	3.5
Singhori	Nagpur	Parseoni	OC	Operational	Government	0.8	1.12
Bhanegaon	Nagpur	Saoner	OC	Operational	Government	1.15	0.63
Adasa UG to OC	Nagpur	Saoner	OC	Operational	Government	1.85	0.61
Silewara Colliery	Nagpur	Saoner	UG	Operational	Government	0.55	0.08
Patansaongi	Nagpur	saoner	UG	Operational	Government	0.3	0.05
Saoner-I	Nagpur	Saoner	UG	Operational	Government	NA	0.21
Saoner-II	Nagpur	Saoner	UG	Operational	Government	NA	0.13
Saoner-III	Nagpur	Saoner	UG	Operational	Government	NA	0.12
Waghoda	Nagpur	Saoner	UG	Operational	Government	0.39	0

Annexure 1 continued

Name of Mine	District	Block	Type	Operational status	Ownership	Production capacity (MTPA)	Current production (MT) 2022
Umrer Expansion (AMB River Diversion Phase-IV)	Nagpur	Umrer	OC	Operational	Government	4.9	3.55
Makardhokra-I	Nagpur	Umrer	OC	Operational	Government	2	3.72
Makardhokra-III/ Dinesh	Nagpur	Umrer	OC	Operational	Government	4.2	1.13
Gokul	Nagpur	Umrer	OC	Operational	Government	1.88	1.88
Niljai Deep	Yavatmal	Wani	OC	Operational	Government	4.9	3.75
Bellora-Naigaon Deep	Yavatmal	Wani	OC	Operational	Government	1.25	0
Mugoli Nirguda Extn, Deep	Yavatmal	Wani	OC	Operational	Government	4.38	4.17
Kolgaon	Yavatmal	Wani	OC	Operational	Government	0.6	0.6
Ukni Deep	Yavatmal	wani	OC	Operational	Government	3.5	1.5
Kolarpimpri	Yavatmal	Wani	OC	Operational	Government	1.5	0.51
Ghonsa	Yavatmal	Wani	OC	Operational	Government	0.6	0.43
Junad	Yavatmal	Wani	OC	Operational	Government	1.5	0.74
Rajur/Bhandewada Inc	Yavatmal	Wani	UG	Operational	Government	0.21	0.05
Marki Mangli I (Captive)	Yavatmal	Zari-Jamni	Mixed	Operational	Private	0.33	0.24
Marki Mangli III (Captive)	Yavatmal	Zari-Jamni	OC	Operational	Private	0.21	0.13
Total						83.05	55.63

Source: Data collected from WCL, EC Letter and Provisional Coal Statistics2021-22
The total production capacity of all the mines including the upcoming mines are 105 MT. The 49 mines which are under production has produced 55.72 MT of coal in the year 2021-22.

Annexure 2

List of closed mines

Name of the mine	District	Blocks	Type of mine	Operational status	Ownership type (Government/ Private	Production capacity (MTPA)
Telwasa	Chandrapur	Bhadrawati	OC	Permanently closed	Government	2
Navin Kunada (A)	Chandrapur	Bhadrawati	OC	Permanently closed	Government	2
Juna Kunada	Chandrapur	Bhadrawati	OC	Permanently closed	Government	1.5
Nakoda	Yavatmal	wani	OC	Permanently closed	Government	0
Ballarpur UG	Chandrapur	Ballarpur	UG	Temporarily closed	Government	0.6
Dhurwasa	Chandrapur	Bhadrawati	OC	Temporarily closed	Government	2
Pimpalgaon	Yavatmal	Wani	OC	Temporarily closed	Government	1.5
Total						9.6

Source: WCL Project and Planning Department Data, Nagpur WCL
Note: As per the company closed mines are those mines for which the production is not planned for the current fiscal year. Besides the total 49 operating mines in the state, there are 7 non-operational mines These include 3 temporarily closed and 4 permanently closed mines. Geographically, Yavatmal has 2 non-operational mines, while Chandrapur, has 5 such mines.

Annexure 3

List of mines by financial status

Name of mine	District	Block	Type	Current production (MT)	Financial status
Nandgaon Incline	Chandrapur	Chandrapur	UG	0.08	Unprofitable
Mahakali	Chandrapur	Chandrapur	UG	0.03	Unprofitable
Durgapur Rayatwari	Chandrapur	Chandrapur	UG	0.11	Unprofitable
Manna Incline	Chandrapur	Chandrapur	UG	0.07	Unprofitable
HLC No. 1	Chandrapur	Chandrapur	UG	0	Unprofitable
Durgapur	Chandrapur	Chandrapur	OC	1.84	Unprofitable
Padmapur Deep	Chandrapur	Chandrapur	OC	0.19	Unprofitable
Bhatadi Expansion	Chandrapur	Chandrapur	OC	1.30	Profitable
Hindustan Lalpeth	Chandrapur	Chandrapur	OC	0.46	Unprofitable
Ballarpur UG	Chandrapur	Ballarpur	UG	0.09	Unprofitable
Sasti UG	Chandrapur	Rajura	UG	0.04	Unprofitable
Ballarpur OC	Chandrapur	Ballarpur	OC	0.26	Unprofitable
Sasti OC	Chandrapur	Rajura	OC	1.46	Unprofitable
Gouri Expansion	Chandrapur	Rajura	OC	0.94	Unprofitable
Gouri Deep	Chandrapur	Rajura	OC	0.60	Profitable
Paoni	Chandrapur	Rajura	OC	0	Unprofitable
Paoni-II	Chandrapur	Rajura	OC	3.25	Profitable
New Majri-II (A) Expansion	Chandrapur	Bhadrawati	OC	1.67	Profitable
Alamgated Yekona I&II	Chandrapur	Warora	OC	2.42	Profitable
New Majri UG to OC	Chandrapur	Bhadrawati	OC	1.93	Profitable
Penganga	Chandrapur	Korpana	OC	6.30	Profitable
Murpar	Chandrapur	Chimur	UG	0.07	Unprofitable
Silewara Colliery	Nagpur	Saoner	UG	0.08	Unprofitable
Patansaongi	Nagpur	saoner	UG	0.05	Unprofitable
Saoner-I	Nagpur	Saoner	UG	0.21	Unprofitable
Saoner-II	Nagpur	Saoner	UG	0.13	Unprofitable
Saoner-III	Nagpur	Saoner	UG	0.12	Unprofitable
Waghoda	Nagpur	Saoner	UG	0	Unprofitable
Inder UG to OC+ Kemptee Deep	Nagpur	Parseoni	OC	2.22	Profitable
Amalgamated Gondegaon Ghatrohana	Nagpur	Parseoni	OC	3.50	Profitable
Bhanegaon	Nagpur	Saoner	OC	0.63	Unprofitable
Singhori	Nagpur	Parseoni	OC	1.12	Profitable
Adasa UG to OC	Nagpur	Saoner	OC	0.61	Profitable
Umrer Expansion (AMB River Diversion Phase-IV)	Nagpur	Umrer	OC	3.55	Profitable
Makardhokra-I	Nagpur	Umrer	OC	3.72	Profitable
Makardhokra-III/Dinesh	Nagpur	Umrer	OC	1.13	Profitable
Gokul	Nagpur	Umrer	OC	1.87	Profitable
Niljai Deep	Yavatmal	Wani	OC	3.75	Unprofitable
Bellora-Naigaon Deep	Yavatmal	Wani	OC	0	Profitable
Mugoli Nirguda Extn, Deep	Yavatmal	Wani	OC	4.17	Profitable

Annexure 3 continued

Name of mine	District	Block	Type	Current production (MT)	Financial status
Kolgaon	Yavatmal	Wani	OC	0.6	Profitable
Rajur/Bhandewada Inc	Yavatmal	Wani	UG	0.05	Unprofitable
Ukni Deep	Yavatmal	wani	OC	1.5	Profitable
Kolarpimpri	Yavatmal	Wani	OC	0.51	Unprofitable
Ghonsa	Yavatmal	Wani	OC	0.43	Unprofitable
Junaid	Yavatmal	Wani	OC	0.74	Profitable

Annexure 4

Major industrial clusters along with districts included in the cluster

Aurangabad	Amravati	Mumbai	Nagpur	Nashik	Pune	Thane
Aurangabad	Akola	Mumbai City	Bhandara	Ahmednagar	Kolhapur	Thane
Beed	Amravati	Mumbai Suburban	Chandrapur	Dhule	Pune	Palghar
Hingoli	Buldhana	Raigad	Gadchiroli	Jalgaon	Sangli	
Jalna	Sangli	Ratnagiri	Gondia	Nandurbar	Satara	
Latur	Washim	Sindhudurg	Nagpur	Nashik	Solapur	
Nanded	Yavatmal	Mumbai	Wardha			
Osmanabad		Raigad				
Parbhani		Ratnagiri				
		Sindhudurg				

Source: Directorate of Industries, Government of Maharashtra, 2024

Annexure 5

District-wise employment in automobile enterprises

District	OEM	ACM				Total
		Large	Micro	Small	Medium	
Pune	88,289	24,329	19,402	27,858	20,732	1,80,610
Kolhapur		869	7,332	9,907	5,380	23,488
Ahmednagar		869	2,013	1,922	42	4,846
Thane	1,300	1,303	5,257	5,191	1,412	14,463
Aurangabad	5,612	3,041	8,704	8,777	4,497	30,631
Akola			272	76		348
Amravati			212	74		286
Beed			487	79	30	596
Bhandara			145	44		189
Buldhana			401	112		513
Chandrapur			241	41		282

Annexure 5 continued

District	OEM	ACM				Total
		Large	Micro	Small	Medium	
Dhule			223	216	5	444
Gadchiroli			63	16	2	81
Gondia			161			161
Hingoli			84	12		96
Jalgaon			1,071	282		1,353
Jalna			457	342		799
Latur			674	147		821
Mumbai		7,385	2,578	3,153	6,403	19,519
Mumbai city			614	1,485	909	3,008
Mumbai suburban		1,303	4,977	2,277	4,593	13,150
Nagpur		434	2,424	1,476	817	5,151
Nanded			331			331
Nandurbar			116	50		166
Nashik		2,607	3,378	6,689	4,064	16,738
Osmanabad			626			626
Palghar			2263	1911	80	4254
Parbhani			148			148
Raigad			1784	978		2762
Ratnagiri			520	85		605
Sangli			1040	389	346	1775
Satara		869	1462	1005	820	4156
Sindhudurg			105			105
Solapur		434	1029	90	466	2019
Wardha			186	136		322
Washim			83			83
Yavatmal			251	25	35	311
Total	95,201	43444	71,114	74,845	50,633	3,35,237
Share of total workforce	28.4	13	21.2	22.3	15.1	

Source: iFOREST based on data from various sources. ACM's employment data was obtained from the Department of Industries, Government of Maharashtra, 2023; OEM's employment number was obtained from the Department of Industries and company specific information.

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INTERNATIONAL FORUM FOR ENVIRONMENT, SUSTAINABILITY & TECHNOLOGY

International Forum for Environment, Sustainability & Technology (iFOREST) is an independent non-profit environmental research and innovation organisation. It seeks to find, promote and scale-up solutions for some of the most pressing environment–development challenges. It also endeavours to make environmental protection a peoples' movement by informing and engaging the citizenry on important issues and programs.

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