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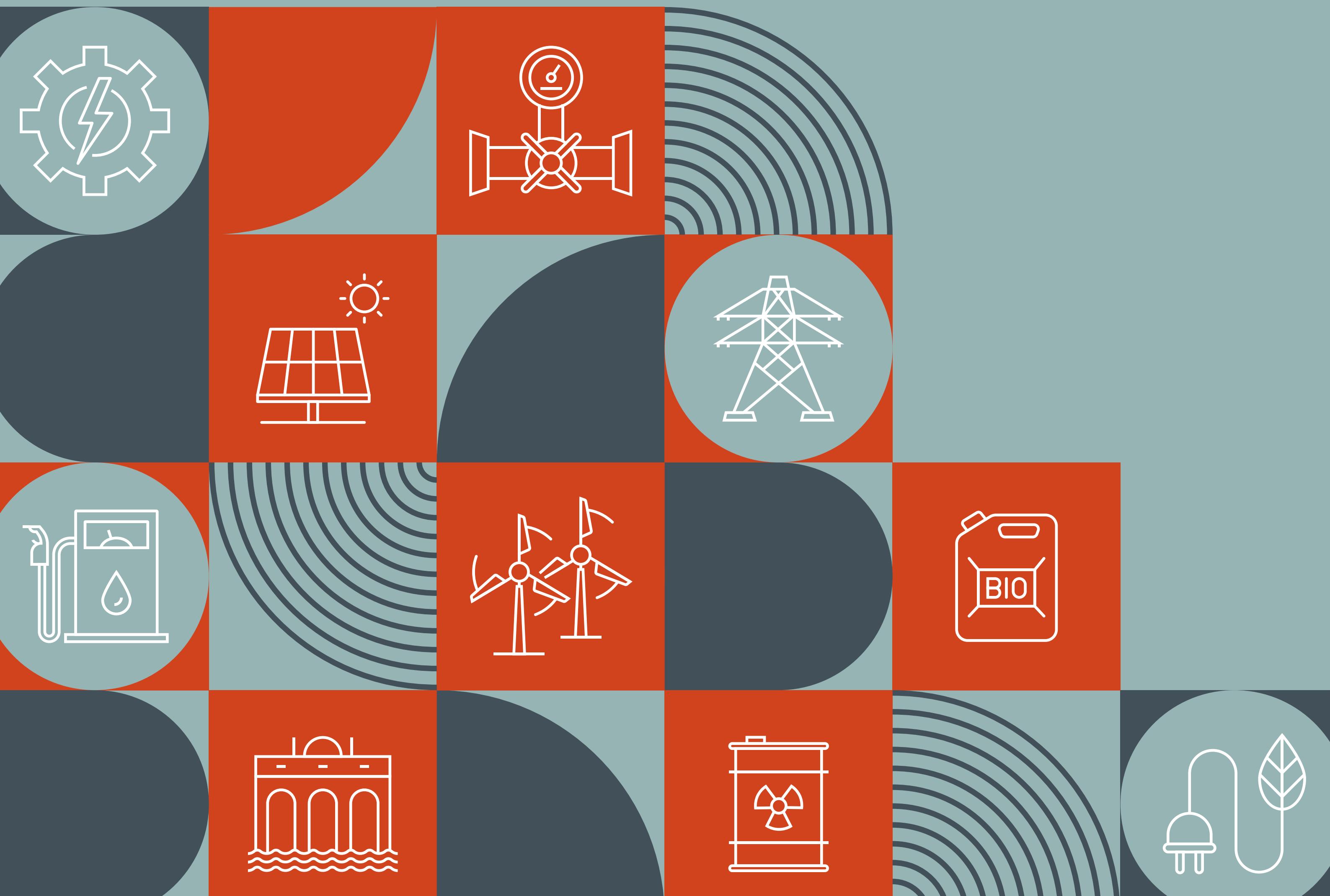
JUST TRANSITION IN ODISHA FOR GREEN GROWTH & GREEN JOBS



JUST TRANSITION IN ODISHA FOR GREEN GROWTH & GREEN JOBS

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List of Abbreviations

BAT	Best Available Technologies
BSES	Battery Energy Storage System
CAGR	Compound Annual Growth Rate
CCUS	Carbon Capture, Utilisation and Storage
CEA	Central Electricity Authority
CNG	Compressed Natural Gas
CPP	Captive Power Plant
CGST	Central Goods and Services Tax
CIL	Coal India Limited
CSR	Corporate Social Responsibility
DDUGKY	Deen Dayal Upadhyaya Grameen Kaushalya Yojana
DMF	District Mineral Fund
DRI	Direct Reduced Iron
EC	Environment Clearence
ECBC	Energy Conservation Building Code
EV	Electric Vehicle
FGD	Flue Gas Desulfurization
FTE	Full-time Employment
FY	Financial Year
GHG	Greenhouse Gas
GoI	Government of India
GRIDCO	Grid Corporation of Odisha
GRIHA	Green Rating for Integrated Habitat Assessment
GSDP	Gross State Domestic Product
GSVA	Gross State Value Added
GW	Giga Watt
IBPIL	Ind-Barath Power Infra Limited
IGBC	Indian Green Building Council
ILO	International Labour Organization
IPR	Industrial Policy Resolution
IOCL	Indian Oil Corporation Limited
JSL	Jindal Stainless Limited
JSPL	Jindal Steel and Power Limited
LEED	Leadership in Energy and Environmental Design
LFPR	Labour Force Participation Rate
LPG	Liquefied Petroleum Gas
MCL	Mahanadi Coalfields Limited
MDO	Mine Development Operator
MOEFCC	Ministry of Environment, Forest and Climate Change
MMT	Million metric tonnes
MMTPA	Million metric tonnes per annum
MNRE	Ministry of New and Renewable Energy

MSME	Micro, Small and Medium Enterprises
MW	Mega Watt
NALCO	National Aluminium Company Limited
NAPS	National Apprenticeship Promotion Scheme
NSQF	National Skill Qualification Framework
NUA	Nutana Unnata Abhilasha
OC	Opencast
OMCL	Odisha Mining Corporation Limited
OPGCL	Odisha Power Generation Corporation Limited
OREP	Odisha Renewable Energy Policy
OSDA	Odisha Skill Development Authority
PAT	Perform, Achieve and Trade
PMKVY	Pradhan Mantri Kaushal Vikas Yojana
PNG	Piped Natural Gas
PLF	Plant Load Factor
PLFS	Periodic Labour Force Survey
PLTP	Placement-linked Training Programme
PSU	Public Sector Undertaking
PV	Photovoltaic
R&D	Research and Development
RE	Renewable Energy
RES	Renewable Energy Sources
RPO	Renewable Purchase Obligation
SAIL	Steel Authority of India Limited
SCCL	Singareni Collieries Company Limited
SDTE	Skill Development and Technical Education
SGST	State Goods and Services Tax
SPCB	State Pollution Control Board
STPS	Super Thermal Power Station
TPP	Thermal Power Plant
TPS	Thermal Power Station
UG	Underground

Summary for Stakeholders

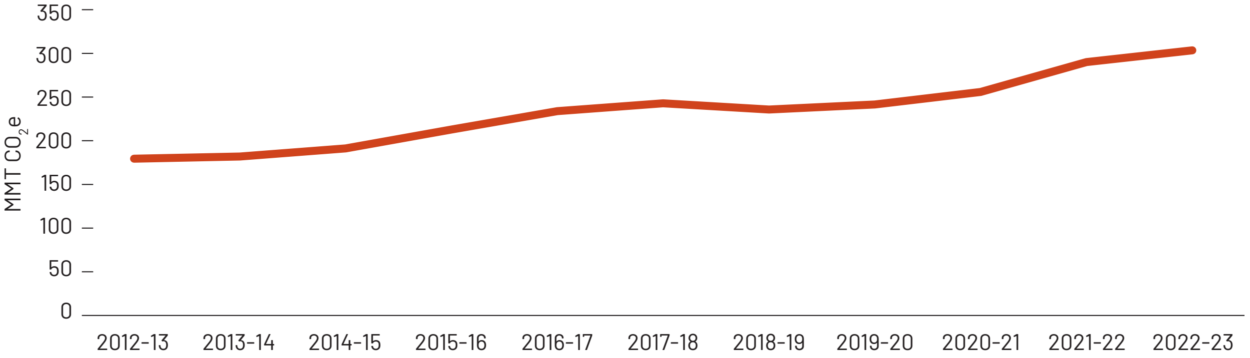
Odisha is one of India's most resource-rich states, being endowed with abundant coal, iron ore, and other mineral resources. The state is home to major industries such as steel, aluminium, cement, among others. In 2023-24, industrial sector contributed about 43.3% to the Gross State Value Added (GSVA), much higher than the national average of 27.6%. The state envisions becoming the 'industrial hub of Eastern India' and the trade and commerce gateway to South and East Asia.

Considering the trajectory of industrial growth, Odisha is a key state in realising India's net zero goals and steering the course of an accelerated and just energy transition. The state's greenhouse gas (GHG) emissions have increased at a compound annual growth rate (CAGR) of slightly over 5.6% over the last decade. As per 2022-2023 estimates, the total GHG emission is 305.2 million metric tonnes of CO_2 equivalent (MMT CO_2e), which is about 9.7% of India's total.

Depending on the growth rate of the Gross State Domestic Product (GSDP), emission intensity, and green economy policies, Odisha's total GHG emissions are projected to range between 493-782 MMT CO_2e by 2035-36. In a business as usual scenario, with trends similar to the past decade, emissions could reach 665 MMT CO_2e—more than double the current levels. Under a high-growth scenario, with 8% annual GSDP growth and unchanged emission intensity reductions, emissions may rise to 782 MMT CO_2e. However, in an NDC-aligned scenario, with 8% GSDP growth and a 45% reduction in emission intensity from 2005 levels, emissions would be 493 MMT CO_2e.

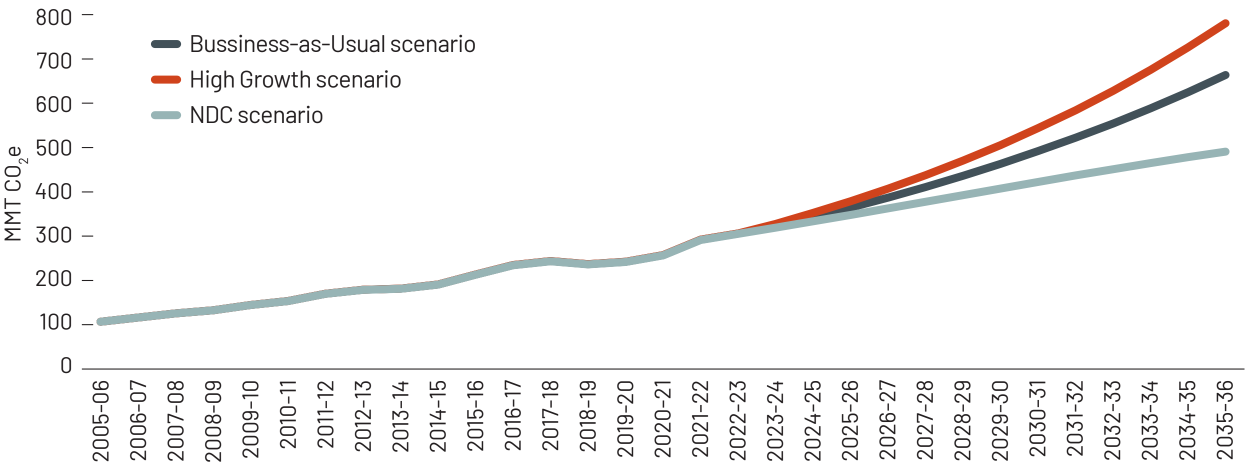
With large-scale industrial expansion planned—especially in the coal, iron and steel, and construction sectors—Odisha requires a comprehensive, cross-sectoral strategy to reduce the emission intensity of its economy and meet the emission intensity and renewable energy (RE) targets set by India. This approach must also focus on creating opportunities for green jobs, promoting sustainable economic growth, and ensuring an inclusive and just transition.

Figure 1: GHG emissions in Odisha



Source: iFOREST analysis

Figure 2: Projected GHG emissions under different scenarios



Source: iFOREST analysis

A. Just Transition Landscape: Sectors, Geographies and Dependency

1. Coal mining

The coal mining sector faces the risk of stranded assets due to climate goals and increasing competition from the renewable energy sector. Over the next 10 years, the state is likely to close six coal mines, highlighting the necessity for a just transition strategy that safeguards economic development and employment in the impacted regions.

About 24% of India's coal production comes from Odisha

Odisha is India's largest coal-producing state, accounting for about 24% of the country's coal production. The state has a coal production capacity of about 353 million metric tonnes per annum (MMTPA) and produced over 237 MMT of coal in 2023-24, combining commercial and captive mines. The Public Sector Undertaking (PSU) Mahanadi Coalfields Limited (MCL), a subsidiary of Coal India Limited (CIL), alone produced 206 MMT of coal.

The sector supports over 40,500 formal jobs and at least 1.6 times informal workers. Out of the total formal workers, 35,440 are with MCL. About 57% of the workers are engaged in mining activities in Talcher block of Angul district.

Table 1: Status of operational mines

Mine type	No. of mines	Production capacity (MMTPA)	Formal workforce
Opencast*	22	350.55	38,000
Underground	4	2.42	2,515
Total	**26**	**352.97**	**40,515**

Source: CIL, August, 2024, and latest environmental clearance letters of mines operational in the state. *Includes 15 commercial and seven captive mines.

Transition hotspots, challenges, and opportunities

Hotspots: Commercial and captive coal mines in Odisha, are spread over four districts. These include Angul, Sundargarh, Jharsuguda, and Sambalpur. Over 46% of the mines (12 mines) are in Angul district with a cumulative production capacity of 145 MMTPA.

Overall, Talcher block of Angul is the most important transition hotspot with nine operational mines with over 121 MMTPA production capacity. The block also has three closed mines. Apart from Talcher, the other important region is the Jharsuguda and Lakhanpur blocks of the Jharsuguda district. There are five operational mines in these two adjoining blocks with a cumulative production capacity of about 62 MMTPA. Additionally, in Jharsuguda block, there are three closed mines.

By 2030, six mines—four underground (UG) and two opencast (OC)—can be closed in the state. These mines are concentrated in Talcher and Jharsuguda blocks. Except for the two OC mines, all are low-producing, and out of the four UG mines, three are unprofitable. Additionally, by 2040, Talcher block will experience the transition of key mines, such as Lingaraj, Ananta, and Jagannath, due to exhaustion of resources. Overall, a total of six mines with about 80 MMT capacity will exhaust resources.

Coal mining sector should mitigate stranded asset risks by optimising production from existing mines

Challenges: A major concern for Odisha is the risk of stranded assets in the coal sector due to planned expansion and underutilisation of existing capacity. While the state has a coal production capacity of 352 MMT, the current output is only 235 MMT, meaning mines are operating at just 67% capacity. With the potential to increase production by over 100 MMT from existing mines, opening new coal blocks is inefficient, and may have no takers in the future.

Besides, nearly 99% of Odisha's coal produced by MCL is dispatched for power generation. As India advances towards renewable energy (RE) goals, coal demand is expected to peak by the mid-2030s, making new mines economically unviable.

Opportunities: In the next decade, the coal mining sector should focus on improving operational efficiency and optimising resource extraction from the operational mines. All the new mines being planned for the state must go through an assessment of the prospects of demand considering the coal peak to mitigate the risk of stranded assets. Optimising the output from existing mines will also ensure more sustainable resource management.

11,000 hectares of coal mining land can be planned for repurposing by 2030

Planning economic diversification of coal districts will also be important to start creating alternative livelihood opportunities to ensure a smooth transition of the local communities and prevent any socio-economic disruptions. Repurposing of land available with coal mines provides a crucial opportunity for this.

In the immediate future, the opportunity lies with repurposing the land available with closed mines, and those that are going to exhaust their extractable resources or are economically unviable. Considering this, collectively, over 11,000 hectares (ha) of land can be planned for repurposing by 2030. This land is primarily in Talcher and Jharsuguda blocks.

Overall, in the coming decades, a planned reclamation and repurposing of mining land through a collaborative approach between the mining company(ies), the state government, and the local community will be crucial for optimising productive economic use of this valuable asset and ensuring economic continuity in mining districts and blocks.

Table 2: Land available with coal mines

Mine type	Land available (ha)
Commercial operational mines*	24,895.5
Captive operational mines	6,830
Closed mines	4,734
Total	**36,459.5**

Source: iFOREST analysis based on information obtained from MCL, 2024, and environmental clearance letters of mines; * Includes one mine to start operation soon

2. Coal-based power

The captive power plants associated with various industrial sectors should accelerate the integration of renewables to align with the Renewable Purchase Obligation targets and support overall industrial decarbonisation measures.

Odisha has one of the largest captive power plant (CPP) capacities in India, which is 16% of the country's total, given its large-scale industrial operations. Of the total 12.5 gigawatts (GW) of captive power capacity, 93% (11.7 GW) is coal-based. Overall, the total capacity of coal-based power in the state is 21 GW.

The sector is a key contributor to the state's GHG emissions. As per estimates for 2022-23, the coal-based thermal power plants (TPPs) contribute to about 49% (149.8 MMT CO_2e) of the state's total GHG emissions. The emissions from TPPs have grown at a CAGR of 6.3% over the last decade.

Overall, the sector formally employs nearly 32,300 people, out of which about 59% are with the CPPs. The informal jobs are likely to be much higher.

Table 3: Coal-based thermal power plants

Type	No. of plants	Capacity (GW)	Formal workforce
Utility	7	9.4	13,247
Non-utility (captive)	79	11.6	19,046
Total	**86**	**21**	**32,293**

Source: Capacity data based on the report of Central Electricity Authority, 2024, and Odisha Renewable Energy Development Agency, 2024. Worker numbers have been estimated based on company data, manpower requirement norms of Central Electricity Authority, 2024, and district-wise CPP data as obtained from GRIDCO, 2024

The coal-based power fleet in Odisha is relatively young considering both utility-scale and captive plants. Of utility-scale plants, only about 1.4 GW will reach 35 years of age in the next six to seven years. Considering CPPs, the assessment for plants with 100 MW and above capacity shows that these units started operating during the first decade of this century.

Transition hotspots, challenges, and opportunities

Hotspots: About 88% of the coal-based power capacity (combining utility-scale and captive plants) is concentrated in five districts- Angul, Dhenkanal, Jharsuguda, Sundargarh, and Sambalpur, which are the hubs of coal mining and industrial operations. Among these, Angul has the maximum installed capacity, about 6.7 GW, considering the operation of the NTPC plant, and three CPPs. Jharsuguda, which is a close second with about 5.7 GW installed capacity, has 11 plants (eight captive and three utility-scale).

Challenges: Odisha has a substantial number of CPPs, primarily fueled by coal. These plants help industries meet their electricity demands while reducing reliance on the state's grid. However, the heavy dependence on coal for power generation in these plants contributes significantly to GHG emissions. With the state's ambition and potential of industrial growth, the number of CPPs will also increase. Therefore, it is important to plan a transition of the CPPs to green energy sources.

1.4 GW of TPP capacity combining four units can be planned for repurposing by 2035

Opportunities: There are two crucial opportunities for transitioning the state's coal-based power sector - green transition of the CPPs, and repurposing of the existing old thermal power plants (TPPs) and energy assets.

Considering that greening the power sector and industrial decarbonisation will be crucial for Odisha's green transition, integrating RE sources in CPPs will be necessary. These units must accelerate RE integration to align with the Renewable Purchase Obligation (RPO) targets (43.33% overall RPO target by 2030) to support decarbonisation efforts. Further, the target of 11 GW of RE capacity by 2030, set by the State Government provides the necessary impetus for this.

The Odisha Renewable Energy Policy (2022) already offers several non-fiscal and fiscal incentives to support RE adoption by CPPs. These include fast-track approvals, specific exemptions on Electricity Duty, State Transmission Utility charges, and wheeling charges, among others.

Concerning the repurposing of energy assets, about 1.4 GW capacity combining four TPP units can be planned for repurposing by 2035. These include two units (200*2=400 MW) of the IB Valley Thermal Power Station (TPS) and two units (500*2=1,000 MW) of Talcher power station.

Table 4: Repurposing of TPP units by 2035

Plant name	Company	Location	Units that can be retired and repurposed	Capacity	Year by which reaching 35 years age
IB Valley TPS	Odisha Power Generation Corporation Ltd. (OPGCL)	Jharsuguda	1	200	2029
			2	200	2030
Talcher STPS	NTPC Ltd.	Angul	1	500	2030
			2	500	2031

Source: iFOREST analysis based on data of Central Electricity Authority, 2024, and environmental clearance letters of plants

Overall, repurposing the land available with TPPs is an important opportunity for industries to develop green energy infrastructure. Nearly 4,200 ha of land is available with the utility-scale plants. Besides, an estimated 5,904 ha of land is available with the CPPs operating in various districts. About 69% of the CPP land is concentrated in just three districts, Angul, Jharsuguda, and Sambalpur, the biggest industrial districts of the state.

3. Industry

With the ambition to make Odisha the industrial and manufacturing hub of Eastern India, and with more than 3.2 lakh formal employment in various factories, a just transition of industry will be a central agenda for greening Odisha's economy and boosting green job opportunities.

Odisha has 3,207 factories of which 2,697 were operational during the reference year 2021-22. The industries in the state with which these factories are associated 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, coke ovens, refined petroleum products, electric motors, generators, batteries, cement, bricks, refractories, automobile and automobile components, basic chemicals, fertilizer, and nitrogen compounds, among others, will be highly impacted.

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

Low impact: Sectors including food processing, wood-processing and product industries, tobacco, computer and electronics, consumer goods, types of machinery, etc., will be less impacted due to energy transition.

High impact

Over 40% of the factories in Odisha will be highly impacted by the energy transition. These factories are highly significant for the economy for the following reasons:

- They account for over 90% of the total economic output and over 92% of the Gross Value Added (GVA) from all factories.
- They have over 78% of total factory employment and engage 80% of all factory workers.
- This segment also has a very high share of women workers, which is about 71% of all women workers (total women workers in factories is 16,403) engaged in various factories.
- These are highly energy-intensive and are responsible for around 96% of the total energy consumption from industries.

40% of the factories that will be highly impacted by the energy transition engage 80% of all factory workers

Moderate impact

Approximately 36% of the state's total factories will be moderately impacted by the energy transition. These factories account for:

- About 4.7% of the total economic output and 5.4% of the total GVA.
- Over 11.5% of total factory employment.
- About 3.4% of the total energy used by all factories and exhibit moderate energy intensity.

Low impact

Approximately 24% of the factories will face low impact from the energy transition as these have very low energy consumption and are responsible for about 0.8% of the total energy usage. These factories account for:

- About 4.4% of the total economic output and 2.3% of the total GVA.
- Over 10% of total factory employment.

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

Characteristics	All factories	High impact		Moderate impact		Low impact	
		Value	Share of total (%)	Value	Share of total (%)	Value	Share of total (%)
1. Number of factories	3,207	1,297	40.4	1,149	35.8	761	23.7
a. Number of factories in operation	2,697	1,057	39.2	941	34.9	699	25.9
2. Total output (₹ Lakh)	4,68,79,707	4,26,12,003	90.9	22,03,707	4.7	20,63,997	4.4
3. Gross Value Added (GVA) (₹ Lakh)	1,00,09,291	92,36,293	92.3	5,41,582	5.4	2,31,416	2.3
4. Number of persons engaged	3,20,649	2,51,105	78.3	36,882	11.5	32,662	10.2
5. Total number of workers	2,70,401	2,16,370	80	28,797	10.7	25,234	9.3
a. Percentage of workers employed through contractors (%)	58.4	61.7		47.8		42.2	
b. Number of directly employed women workers	16,403	11,701	71.3	589	3.6	4,113	25.1
6. Total energy use (as per cost in ₹ Lakh)	35,05,724	33,55,888	95.7	1,20,600	3.4	29,236	0.8

Source: iFOREST analysis based on Annual Survey of Industries 2021-22, Government of India

IRON AND STEEL SECTOR

With about half of India's iron ore resources, Odisha is India's largest steel producer with a crude steel production capacity of about 33.5 MMTPA (as per the latest estimates). This is about 21% of the country's total. The state aims to massively expand the production capacity to 100 MMTPA by 2030 which will account for one-third of the crude steel production that the Government of India targets by 2030-31.

This will also mean a massive expansion of iron ore production in the state, with the state already having a production capacity of about 297 MMTPA and producing 169 MMT annually.

The sector is one of the largest contributors to the state's GHG emissions. As per estimates for 2022-23, the steel sector accounts for over 35% (105.7 MMT CO_2e) of the state's total GHG emissions.

The steel sector accounts for over 35% of Odisha's total GHG emissions

About 1.5 lakh (0.15 million) workers are associated with the crude steel plants. As per government information, over 48,000 of them are direct workers and the rest are indirect workers. The overall employment dependence can be still higher considering the high proportion of informal engagement in manufacturing sectors.

Besides crude steel-making units, over 22,700 workers are engaged with the sponge iron plants in various districts of the state.

A large number of workers are also associated with the iron ore mines that are closely related to steel production. Overall, it is estimated that over 31,800 workers are formally employed by these mines. Therefore, considering the value chain of the iron and steel sector, including employment in the factories (direct and indirect workers) and the mines, over two lakh (0.2 million) workers are formally employed.

Table 6: Iron and steel sector

Type of units	No. of units	Production capacity (MMTPA)	Formal workforce
Iron and steel plants	52	33.5	48,114
Sponge iron units	83	13.4	22,759
Total iron and steel units	**147**		**70,873**
Total iron ore mines	**67**	**297.2**	**31,800**

Source: iFOREST analysis based on data provided by the Department of Steel and Mines, Government of Odisha, 2024; and Joint Plant Committee Report 2022-23

Transition hotspots, challenges, and opportunities

Hotspots: The iron and steel-making units are concentrated in districts that are the largest producers of iron ore and coal. There are two large iron and steel clusters in the state.

Sundargarh district and adjoining Sambalpur and Jharsuguda districts constitute the largest crude steel-producing region with 24 plants and a cumulative production capacity of over 12.5 MMTPA. The other key steel production cluster is Angul and adjoining Dhenkanal district, with about 12.25 MMTPA collective production capacity. For sponge iron, Sundargarh has 50% of the sponge iron units with a production capacity of 3.3 MMTPA.

Challenges: With an ambitious target of reaching 100 MMT of crude steel production capacity by 2030, the key transition issue for the steel sector is the rapid transition to green steelmaking to reduce emissions from the sector while increasing efficient resource use. Another important aspect will be shifting the sponge iron units to cleaner production processes. At the same time, considering the large direct and indirect income dependence on this sector, a plan for workforce transition with well-designed skilling and reskilling measures will be crucial.

100 MMT crude steel production target by 2030 necessitates rapid decarbonisation measures for the sector

Opportunities: Odisha, with its significant share of India's steel production, holds a pivotal position in achieving India's industrial decarbonisation and energy transition goals. The state has an ambitious plan for developing green hydrogen/green ammonia hubs and developing a dedicated policy, which should be leveraged to develop a green steel sector in the state. One of the initiatives the state can take is to ensure that the future steel plants are hydrogen-ready.

Besides, the steel sector's growth trajectory in the state also needs to be aligned with the decarbonisation vision for the sector set forth by the Ministry of Steel, including enhancing energy efficiency, material efficiency, RE use, process transition, and deployment of carbon capture, utilization, and storage (CCUS) technologies.

ALUMINIUM

Odisha is the largest aluminium-producing state in India, accounting for 54% of the country's aluminium smelting capacity. The state also has almost 75% of India's total bauxite reserves which has supported the growth of the industry in the state.

80% of primary aluminium GHG emissions are related to the smelting process

The GHG emissions from the aluminium sector in Odisha have rapidly grown over the last decade, with a CAGR of 10% from 2012-13 to 2022-23. The estimated emissions from the sector in 2022-23 is about 4.5 MMT CO_2e.

Combining aluminium smelters and alumina refineries, the sector employs about 19,700 formal workers. The actual employment dependence is much higher considering informal workers associated with the sector.

Table 7: Aluminium sector

Unit type	No. of units	Production capacity (MMTPA)	Formal workforce
Aluminium smelter	5	2.79	15,398
Alumina refinery	3	5.78	4,300
Total aluminium and alumina units	**8**		**19,698**
Total bauxite mines	**5**	**21.61**	**4,830**

Source: iFOREST analysis based on data of Indian Bureau of Mines, 2023, and Odisha State Pollution Control Board, 2024

Transition hotspots, challenges, and opportunities

Hotspots: The aluminium smelters are located in key industrial districts, Angul, Sambalpur, and Jharsuguda. The refineries are located in the rural districts of Koraput, Rayagada, and Kalahandi. The latter three districts are also where the state's bauxite mines are concentrated.

Challenges: Aluminium production is an energy-intensive process and requires a constant supply of electricity. The key transition challenge in the aluminium sector is the change in the source of electricity, particularly for smelting, as about 80% of primary aluminium GHG emissions are generated from the smelting process.

Opportunities: The most important measure to reduce emissions from this sector is to source electricity from low-carbon or RE sources such as hydroelectric, solar, or wind power. Enhancing energy efficiency in both alumina refining and aluminium smelting processes will also be important.

CEMENT

Unlike the steel and aluminium sectors, while Odisha does not dominate India's cement-producing landscape, it is important to consider a just energy transition as the industry leaders are considering that eastern and southern regions can lead the sector's expansion in the coming years.

60% of the cement production capacity is in Sundargarh, an industrial and mining hotspot

There are 20 cement plants including integrated units, grinding units, and clinker units. While employment dependence on these plants is much less than in the steel sector, nonetheless it is significant. Overall, the formal workforce associated with the cement plants is about 6,116. Further, the sector is estimated to employ about 20,000 people downstream for every MMT of cement produced.

Table 8: Cement sector

Type of Unit	No. of units	Production capacity (MMTPA)	Formal workforce
Integrated unit	3	11.7	2,454
Grinding unit	15	23.1	2,312
Clinker unit	2	5.4	1,350
Total cement units	**20**		**6,116**
Total limestone mines	**5**	**21.6**	**865**

Source: iFOREST analysis based on data provided by Odisha State Pollution Control Board, 2024, and Indian Bureau of Mines, 2023

Transition hotspots, challenges, and opportunities

Hotspots: While cement units are located in six districts of Odisha, about 64% of the production capacity is concentrated in two districts, Sundargarh (over 13 MMTPA) and Cuttack (over 12 MMTPA). One integrated plant, both the clinker units, and 10 out of 15 grinding units are located in these districts.

Sundargarh also has the largest number (four) of limestone mines in the state, a raw material for cement production, and accounts for over 88% (15.43 MMTPA) of the state's limestone production capacity.

Challenges: Despite adopting commendable energy efficiency measures, a critical issue of energy transition for the cement sector is 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.

BUILDING AND CONSTRUCTION

The building and construction sector is a significant contributor to GHG emissions, primarily driven by energy use in construction processes, embodied carbon in building materials, and operational energy consumption.

Overall, buildings account for over 40% of India's total energy consumption, increasing at an annual rate of 8%

With over 98 lakh projected urban population by 2031, reducing emissions from the building and construction sector will be crucial

(including embodied plus operational energy). The sector contributes 32% to India's total GHG emissions, with embodied emissions making up 40% and operational emissions accounting for 60%.

The construction sector is an important component of Odisha's economy contributing 6.9% of the State GSVA and 16% of the industrial GSVA in 2023-24. The sector is also a significant employment generator. As of 2022-23 estimates, 17% of the total workforce in the state is engaged in the construction sector.

Transition hotspots, challenges, and opportunities

Hotspots: The urban and peri-urban areas of Odisha remain the hotspots for the green transition of the building and construction sector. The data on registered construction workers show that over 63% of the registered construction workers are concentrated in Cuttack, Sundargarh, and Khorda districts. Overall, about 14 districts in the state have at least over one lakh registered construction workers.

Challenges: The construction sector in Odisha is expected to grow significantly due to demographic and spatial changes from urbanisation, inter-state and intra-state migration, and the expansion of peri-urban areas. Between 2001 and 2011, the urban population in the state increased by 26.8%, which is double the national growth rate, reaching about 70 lakh people. By 2031, the urban population is expected to reach about 98.5 lakhs. The growth will create increased demand for buildings and other construction.

Opportunities: A key opportunity lies with the optimisation of material and resource use for the building and construction sector. Increasing material efficiency will involve the optimisation of resource use in the design, construction, and operation of buildings. Also, the construction of green buildings and increasing energy efficiency will be important. Simultaneously, decarbonisation of the cement, steel, and aluminium sectors will be crucial to minimise embodied emissions.

B. Overall Outlook

Considering Odisha's heavy reliance on fossil fuel sectors and fossil fuel-dependent industries, a just transition policy and strategy, addressing the socio-economic and environmental aspects of the energy transition will be crucial.

1. A planned transition of coal mining, coal-based power, and steel sector will be crucial for ensuring a comprehensive just energy transition and green growth over the next 30 years.

Odisha, with India's largest coal production capacity and a strong industry base powered by coal, will need comprehensive planning across various sectors to ensure a just energy transition in the state. However, three sectors are most significant to planning the transition — coal mining, coal-based power (utility and captive plants), and the steel sector. They account for about 84% of GHG emissions in the state. Besides, they account for about 14% of the formal workforce.

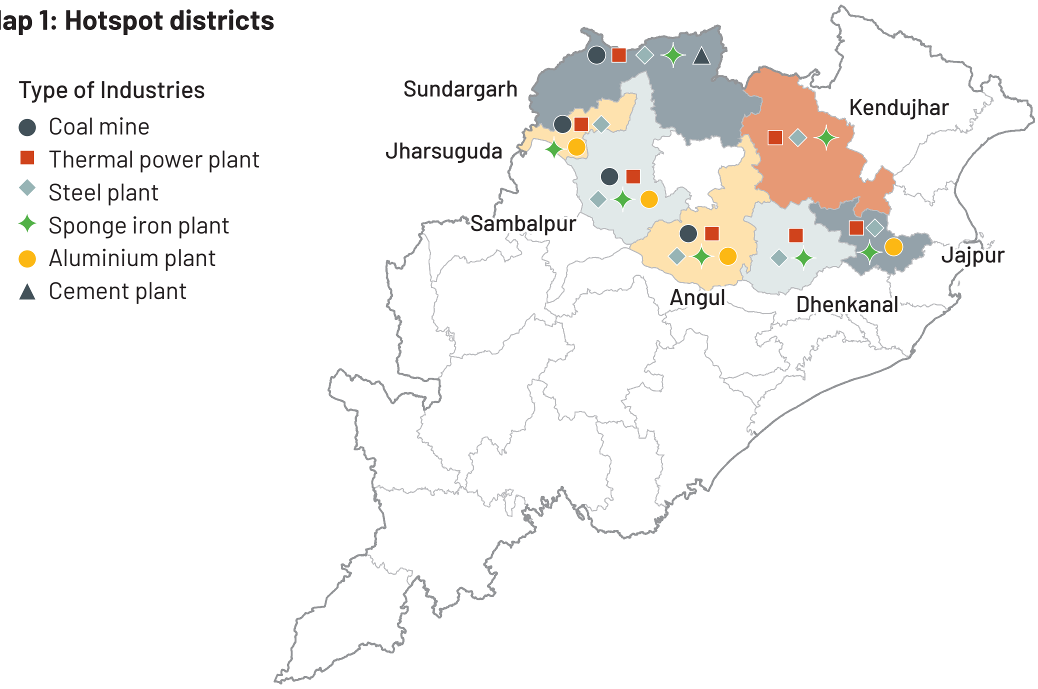
A planned transition of these sectors will help minimise disruptions to the workforce, manage the socio-economic impacts on local communities, and ensure that green growth pathways through industrial investments and restructuring emerge as viable alternatives to support robust green economic growth in the state in the coming years.

2. Seven districts, including the Angul-Dhenkanal energy and industrial cluster in the eastern part, and Jharsuguda-Sundargarh-Sambalpur in the north-western part are the hotspots for just energy transition.

Overall, seven districts are highly significant from an energy transition perspective. These include Angul, Dhenkanal, Jajpur, Jharsuguda, Sundargarh, Sambalpur and Kendujhar districts. These districts account for 100% of the coal mines and utility-scale coal-based power capacity. Besides, they also account for 88% of the coal-based captive power capacity considering the large presence of industrial activities.

Considering factories, these districts also are the key producers of iron and steel. They account for 97% of the crude steel capacity, 94% of the sponge iron capacity, and a majority of the iron ore mines, accounting for 99% of the production capacity. They also account for 100% of the aluminium (aluminium smelter) production capacity and 65% of the cement capacity (integrated plants).

Map 1: Hotspot districts



3. The energy transition can potentially impact about 9.3 lakh workers formally and informally engaged in the mining, electricity and manufacturing sectors.

The green energy transition will primarily have implications for coal mining, coal-based power, and at least 76% of all factories (those in the high-impact and medium-impact category) operating in Odisha.

About 9.3 lakh workers are formally and informally engaged by these industries. Besides, there are a large number of workers associated with the value chain. Therefore, a key aspect of the transition will be skilling and reskilling of the workforce for integration in the low-carbon economy.

C. Fostering Opportunities for Green Growth and Jobs

A key objective of just transition is to ensure green growth 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.

1. Repurposing mining and industrial wasteland to develop green energy and green industry infrastructure can support the achievement of renewable energy targets while boosting local employment opportunities.

Repurposing mining lands in Odisha offers a strategic opportunity to develop green energy infrastructure and promote green industries, aligning with the state's RE and other decarbonisation targets. These broken-up land parcels can be repurposed for such activities as they already have the necessary infrastructure around them.

An assessment done by iFOREST shows that Odisha has 1,680 ha of mining wasteland and 3,990 ha of industrial wasteland. Besides, about 11,000 ha of coal mining land can be available for repurposing by 2030 following the scientific closure of mines.

Table 9: Availability of mining and industrial wasteland

Land type	Land available (ha)
Mining wasteland	1,680
Industrial wasteland	3,990
Total	**5,670**

Source: iFOREST analysis based on wasteland atlas of the Government of India and ISRO remote sensing data

The Government of India has also recognised the merits of repurposing mining land available to the coal industry. In April 2022, the Union Cabinet gave a nod to a set of policy guidelines allowing the development of certain coal and energy infrastructure and social infrastructure in land acquired under the Coal Bearing Areas (Acquisition and Development) Act of 1957. Recently in June 2024, the Ministry of Coal promulgated (draft) revised guidelines for coal mine closure, under which for the first time the repurposing of mining land has been specified in the context of 'just transformation' of the local communities.

2. Setting renewable energy targets for the mining sector can help to reduce direct and indirect emissions related to mining operations.

Mining operations use fossil fuels and electricity for activities like extraction, processing, material movement, and transportation. Switching to RE sources can help reduce Scope 1 and Scope 2 emissions from the sector.

Considering the expansive ongoing mining activities in the state and the foreseeable future, it will be important to set progressive RE adoption targets for the sector. Such targets will not only improve the sector's green performance but will also boost the confidence of financial institutions and investors, as RE-powered operations improve ESG (Environmental, Social, and Governance) ratings of industries, making companies more attractive to investors.

3. To decarbonise the steel sector, a phased approach of green hydrogen adoption by the industry will be essential.

Decarbonisation of the steel sector in Odisha will be essential for green industrial growth and overall reducing emission intensity of the state's economy. The government can mandate the establishment of greenfield 'hydrogen-ready steel plants' from 2025 onwards, and also retrofit the pre-existing ones.

Thereafter, a phased adoption of green hydrogen as energy can be mandated. This can be 10% hydrogen as energy by 2030, 25% by 2035, 50% by 2040, 75% by 2045 and 100% by 2050. This will complement Odisha's green hydrogen ambition. Essentially, by 2035, the focus should shift to green hydrogen-based steelmaking alongside the adoption of CCUS technologies as they become viable.

4. Promoting green growth will be crucial for enhancing jobs and economic opportunities.

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. Boosting employment opportunities in green economic sectors will be crucial for retaining jobs and creating new employment opportunities.

The Industrial Policy Resolution (IPR, 2022), and the latest Economic Survey Report (2024), of the State Government have also emphasised certain sectors to support the state's industrial and economic growth and employment generation. These include green energy, green manufacturing, and electric mobility (e-mobility), among others. The Government has also emphasised the development of an industry-ready skilled workforce.

i. Green energy: Odisha has significant potential for green energy development and boosting employment opportunities in the RE sector. For example, considering the state's 11 GW RE target by 2030, the sector can generate at least 32,300 full-time employment (FTE).

Table 10: Employment opportunities in RE

Sector	Parameters	Total
Solar	Capacity target (GW)	7.5
	Estimated FTE	25,875
Wind	Capacity target (GW)	2
	Estimated FTE	2,540
Small hydro	Capacity target (GW)	0.19
	Estimated FTE	760
Large hydro	Capacity target (GW)	0.06
	Estimated FTE	Not estimated
Pumped Storage Plant	Capacity target (GW)	1.2
	Estimated FTE	3,000
Total RE	**Capacity target (GW)**	**10.95**
	Estimated FTE	**32,175**

Source: iFOREST job assessment based on Energy Department, Government of Odisha targets noted in September 2024 and using employment factor approach for each category.
The solar employment estimates are based on the employment factor for ground-mounted solar.

However, the overall potential of RE jobs is much higher considering the RE potential of the state that can be harnessed. An assessment of RE potential by iFOREST, considering the modest use of wasteland and reservoirs, shows that solar potential alone is about 170 GW.

Besides RE, the state also has set a target of achieving a production target of green ammonia at 5.8 MMTPA by 2030, along with 0.1 MMTPA green hydrogen and 0.5 MMTPA other derivatives. These will also be important for creating green jobs.

ii. Green metals and mining: Odisha, with its vast reserves of minerals such as iron ore, bauxite, and manganese, holds a central role in India's green transition by enabling the growth of green metals and sustainable mining practices. This transition presents significant opportunities for Odisha to diversify its mining sector, sustainable mining technologies, and mineral recycling, while simultaneously generating green jobs through responsible mineral extraction, beneficiation, and value-added processing.

iii. Green manufacturing: The manufacturing sector in Odisha remains crucial for the state's green growth and green jobs pathway with already a share of 54% of the industrial GSVA. To maintain a strong manufacturing sector, it will be essential to increase green manufacturing. The state can promote the manufacturing of electric vehicles (EVs), solar PV panels, and batteries for energy storage, which will not only drive the transition to clean energy but also boost domestic production of high-value products and create jobs.

iv. Green construction and green infrastructure: Odisha is experiencing rapid urbanisation with the urban population expected to reach 98.5 lakhs by 2031. Therefore, green construction will be crucial for the sector. This will involve material transformation and use in construction and infrastructure development. It will require the development of a workforce across the value chain, such as the use of sustainable building materials, energy efficiency of buildings, green utilities, and green certification, among others.

4. Strengthening the skilling ecosystem through government and industry engagement will be necessary to develop the future workforce.

To enable a just transition for workers from fossil fuel industries and prepare them for emerging opportunities, integrated skilling programs across sector-specific value chains are essential. Both government and industry investments in skilling and reskilling will be critical to help workers adapt to new roles in green sectors and remain agile in a dynamic job market.

The State Government has taken significant initiatives in recent years to expand the skilling ecosystem in the state. Some of the relevant key schemes are Nutana Unnata Abhilasha (NUA) Odisha, the Placement-linked

Training Programmes (PLTP), the Nanu Unicorn scheme, and Swakalpa. A state-of-the-art skilling institute, the World Skill Centre (WSC), augments the skilling infrastructure and resources besides the Industrial Training Institutes (ITIs) and polytechnics.

However, the current skilling ecosystem does not yet adequately address the growing demand for jobs in various renewable energy segments, and other emerging green and high-tech industrial sectors.

To meet the rising demand, the green skills ecosystem needs further strengthening. Initiatives like the WSC and flagship schemes such as NUA Odisha, with their emphasis on advanced technology and digital skills are well-positioned to accommodate the need for workforce development for renewables, green manufacturing, and green construction. The courses and training modules need to be further strengthened based on in-depth skill gap assessment, potential demands, and market outlook. The PLTP, which has one of the highest placement rates, should also modify the courses and training modules to incorporate emerging green sectors to leverage its outreach and employability focus.

Industry involvement is equally crucial in workforce transition efforts. Subsidiaries of Coal India Limited (CIL), including Mahanadi Coalfields Limited (MCL), have established just transition cells to support the transition of coal mines and local communities. Similar industry-led initiatives will play a vital role in workforce transition within other sectors such as power, steel, and aluminium.

These collaborative efforts will ensure that workers are not only equipped to meet current demands but are also prepared to thrive in a sustainable economy.

D. Policy Support

Having well-designed policies, plans and institutional mechanisms will be important to support a well-planned and well-managed just energy transition.

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 in Odisha. The policy will be important to guide the following aspects:

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

ii. **Fostering an ecosystem for green investments:** This will be important for accelerating the transition to green energy and green industries, with a focus on districts where fossil fuel industries are concentrated.

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

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

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

vi. **Mobilising financing:** A well-designed policy will be essential for mobilising public and private finances to support a just transition.

vii. **Institutional structure:** The policy will provide the necessary guidance to develop a dedicated institutional structure and mechanisms for supporting a just energy transition.

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

The priority clusters for the development of regional just transition plans are the Angul-Dhenkanal cluster, the Sundargarh-Sambalpur cluster, and the Jharsuguda cluster. These are going to witness the impacts of green energy transition within the next 10 years.

3. Utilisation of coal cess and repurposing of District Mineral Foundation funds can support just transition in coal districts.

As Odisha plans for a just energy transition, it is essential to allocate social welfare funds toward sustainable livelihoods, skilling and reskilling, and strengthening resilient social infrastructure. The District Mineral Foundation (DMF) funds and coal cess represent the most critical public financing sources for supporting localised transition measures. These funds align with broader goals of environmental sustainability, clean energy promotion, and public welfare.

Odisha has the maximum DMF accrual in India amounting to over ₹25,858 crore (₹258.58 billion) which is nearly 30% of India's total. Further a long-term assessment of DMF contributions over the next four decades estimates that ongoing and planned coal mining expansions (excluding allocated coal blocks) could generate over ₹39,764 crore (₹397.64 billion) by 2060. Additionally, DMF funds from the extraction of other major minerals will be instrumental in supporting just transition efforts in key mining districts such as Sundargarh, Kendujhar, Jharsuguda, and others that are essential to the industrial supply chain.

The coal cess, currently integrated into the GST compensation cess, is another significant financing tool. With a levy of ₹400 per tonne of coal production and imports, it is estimated that ₹3,52,592 crore (₹3.53 trillion) could be generated. This provides a substantial pool of resources to fund just energy transition initiatives across the state. Odisha and other coal-producing states should work with the central government to meaningfully utilise coal cess for green growth and just energy transition.

Overall, effective management of these funds will be crucial for enabling a smooth transition, ensuring both economic growth and social welfare in Odisha's key industrial and mining regions.

Introduction

Odisha, one of India's most resource-rich states, is endowed with abundant coal and mineral resources. The availability of coal and other raw materials for industries has played a central role in positioning the state as a significant contributor to the country's energy and industrial production. The state is home to major industries such as steel, aluminum, and cement, among others.

The industrial sector remains pivotal for the state's economy, contributing 43.3% to the Gross State Value Added (GSVA) at current prices.[1] Within this sector, manufacturing leads with a 54% contribution to the industrial GSVA. This is followed by mining and quarrying with a share of 22%, the construction sector with 16%, and electricity, gas, water supply, and other utility services having a share of 8%.[2]

However, the industrial sector in Odisha is highly fossil fuel-dependent and energy-intensive, which has resulted in overall elevated GHG emissions.[3] The state's greenhouse gas (GHG) emissions have increased at a compound annual growth rate (CAGR) of about 5.6% over the last decade. As per estimates for 2022-2023, the total GHG emission is estimated to be 305.2 million metric tonnes of CO_2e (MMT CO_2e), which is about 9.7% of India's total GHG emissions. The emission intensity of the state is 671 MT CO_2e per crore GSDP (real). While the emission intensity has reduced by 7.3% below 2005 levels in 2022-23, it is much lower compared to the country's overall achievement of 33% reduction of emission intensity from 2005 level, signaling need of rapid measures.

The state is also highly vulnerable to climate change impacts and frequented by extreme weather events, such as cyclones, heat waves, storm surges, and floods. Rainfall patterns in the state have been more erratic since the 1960s, with below-normal rainfall across all districts being recorded for most years. The normal 120 days of monsoon rain has been reduced to 60-70 days. Besides, extreme rainfall days of over 200-250 millimetres/day have become more frequent. Besides, there are also heatwaves which are worst for industrial districts and areas.[4] The state's latest climate action plan (2021-2030) further predicts the frequency of extreme weather events such as droughts and floods, will exacerbate in the coming years if proper mitigation measures and climate-resilient developmental planning are not undertaken.[5]

The economic growth trajectory based on coal mining and fossil fuel-dependent industries, therefore, is counterintuitive for Odisha. As per observations of the state government, the state's rapidly growing economy, increasing urbanisation, and per capita energy consumption, which currently is 1,200 KWh (higher than India's average of 1,119 KWh) and expected to be 1,535 KWh in 2030, will pose a challenge to climate action.[6] Therefore, the state must plan and build a low-carbon and climate-resilient economy in the coming years.

This report provides a cross-sectoral assessment of the just energy transition in Odisha. The report focuses on assessing the fossil fuel sectors and the fossil fuel-dependent industries in the state which remain central for the state's industrial and economic growth in the future, but will also require a transition planning considering the imperatives of building a low-carbon and resilient economy. The key sectors evaluated include fossil fuel sectors including coal mining, oil, and gas, the electricity sector, the factories with focus on the iron and steel, aluminium and cement sectors, and the building and construction sector.

The sectors have been analysed concerning their scale of operation, and spatial distribution to determine the prospective regional impact from transition, the employment and livelihood dependence on these sectors, and the transition opportunities and challenges. The assessment is based on secondary data and stakeholder consultations at the state and district levels.

Based on the comprehensive assessment of the various sectors and considering the scale of the transformation required, 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.

The overarching goal is to ensure that Odisha's transition to a low-carbon economy is not only environmentally sustainable but also socially inclusive, protecting the livelihoods of those most affected by the shift and promoting new economic opportunities for a resilient future.

SECTION I

FOSSIL FUEL SECTORS

CHAPTER 1

Coal mining

1.1 Overview

Coal is critical for India's energy security, with the country being the world's second-largest coal producer. Currently, coal accounts for nearly 70% of India's electricity generation. In 2023-24, India produced over 998 million metric tonnes (MMT) of coal to meet its domestic energy demand. Odisha, currently India's top coal mining state, alone accounted for 25% of the total production[1].

Coal production in has grown at a CAGR of 7.3% from 2014-15 to 2023-24. Mahanadi Coalfields Limited (MCL), a subsidiary of Coal India Limited (CIL), is the key producer of coal the state. The sector is further poised for expansion with Odisha currently having the highest estimated coal reserves in the country, which is about 24.5% of India's total estimated reserves of 3,52,126 MMT. It is also viewed as a key player in meeting India's coal demand in the coming years.

1.2 Production

In the year 2023-24, Odisha produced about 237 MMT of coal combining operational and captive mines[2]. Out of this over 206 MMT was produced by commercial mines of MCL. Overall, the state accounted for nearly one-fourth (24%) of the country's total production.

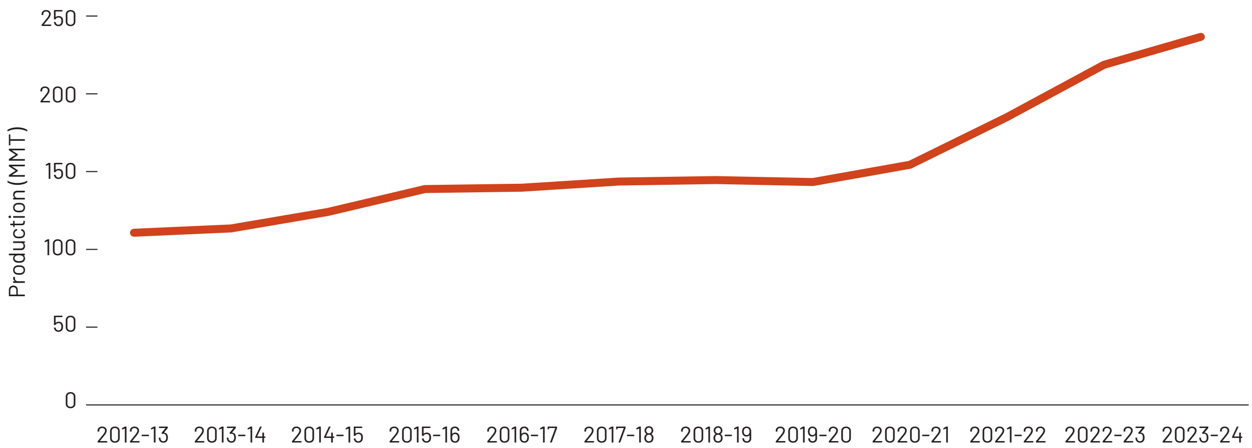
Overall, the state's share in the country's coal production has ranged from 19.95% -24.52% over the last ten years. The coal production has seen a steady growth between 2012 and 2023.

Table 1.1: Coal resources in Odisha

Proved (MMT)	Inferred (MMT)	Indicated (MMT)	Total (MMT)
48,572.58	34,080.42	5,451.6	88,104.6

Source: Provisional Coal Statistics 2022-23

Figure 1.1: Year-wise coal production in Odisha



Source: Provisional Coal Statistics, 2022-23; and Department of Steel and Mines, Government of Odisha, 2024

1.3 Operational status

Odisha's coal production comes mainly from opencast (OC) mines, which contribute 99% of its output. The underground (UG) mines contribute only 1% of total production.

Coal production in the state is dominated by MCL. There are 19 operational mines of MCL with a production capacity of over 294 MMTPA. Another opencast mine (Subhadra) with a capacity of 25 MMT is expected to start operation in 2026 in the Angul district. This will take the total production capacity of MCL mines to about 319 MMTPA.

Besides, MCL commercial mines, there is also a coal mine of SCCL (Naini) located in Angul. The mine with a production capacity of 10 MMTPA is supposed to commence production in 2024.

Table 1.2: Operational coal mines (commercial)

Mine name	District	Block	Type of mine (OC/ UG)	Production capacity (MMTPA) as per 2023-24	Production (MMT) in 2023-24
Talcher	Angul	Talcher	UG	0.27	0
Nandira			UG	0.33	0.06
Lingaraj			OC	20	17.54
Kaniha			OC	14	11.81
Ananta			OC	20	20
Hingula			OC	15	13.06
Bharatpur			OC	20	11.12
Jagannath			OC	7.5	7.5
Bhubaneswari			OC	30	24.24
Balram			OC	8	7.74
Kulda	Sundargarh	Hemgir	OC	21	21
Garjanbahal			OC	18.2	18.2
Basundhara			OC	8.75	1.43
Siarmal			OC	50	7.24
Lajkura	Jharsuguda	Jharsuguda and Lakhanpur	OC	4.5	4.5
Samaleswari			OC	15	8.06
Integrated Belpahar, Lakhanpur, Lilari			OC	40	32.2
Orient Mine No. 1&2			UG	0.87	0.2
Hirakhand Bundia Incline (HBI)	Jharsuguda	Jharsuguda	UG	0.95	0.2
Total				**294.37**	**206.1**

Source: Coal India Limited as of August 2024

CLOSED MINES

Seven coal mines in Odisha are temporarily or permanently closed. The closed mines are located in Talcher block of Angul district and Jharsuguda block of Jharsuguda district, which are key coal-producing regions in Odisha.

Overall, above 4,700 ha of land is available with these mines. Out of this about 1,285 ha of land is available with OC mines and the rest with UG mines. The land available with OC mine, such as South Balanda, can be considered for repurposing to support local economic activities.

Table 1.3: Closed coal mines

Mine name	District	Block	Type of mine (OC/UG)	Operational status	Total lease area (Ha)
Chhendipada	Angul	Chhendipada	OC	Temporarily closed	76.3
Deulbera		Talcher	UG	Temporarily closed	954.1
Handidua		Talcher	UG	Temporarily closed	553.6
South Balanda		Talcher	OC	Permanently closed	1208.7
Orient Mine No.3	Jharsuguda	Jharsuguda	UG	Temporarily closed	1421.8
Orient Mine No.4		Jharsuguda	UG	Temporarily closed	519.5
Hindegir Rampur colliery		NA	UG	Permanently closed	NA
Total					**4,733.7**

Source: Mahanadi Coalfields Limited, 2022 and 2024; NA= Not available

Apart from the commercial coal mines, there are also several captive coal mines with a production capacity of about 58.6 MMTPA. These mines are operated by companies such as NLC Limited, NTPC, NALCO, Odisha Coal and Power Limited (OCPL), Vedanta Limited, and GMR Chhattisgarh Energy Limited (GCEL).[3]

Table 1.4: Captive coal mines

Name of the mine	District	Block	Type of mine	Company name	Production capacity (MMTPA)	Production (MMT) 2022-23
Dulanga	Sundargarh	Hemgir	OC	NTPC	7	5.3
Talabira II & III	Sambalpur	Rengali/ Katerbaga	OC	NLC India Limited	20	6.36
Talabira I	Sambalpur	Rengali/ Katerbaga	OC	Adani Enterprises Limited	3	0
Manoharpur and Dip-side of Manoharpur	Sundargarh	Hemgir	OC	Odisha Coal and Power Limited	16	5.25
Jamkhani	Sundargarh	Hemgir	OC	Vedanta Limited	2.6	2.6
Utkal D&E	Angul	Chennipada	OC	NALCO	4	4
Radhikapur West	Angul	Chennipada	OC	Vedanta Limited	6	6
Total					**58.6**	**29.51**

Source: Department of Steel & Mines, Govt. of Odisha, 2024, and Environmental Clearance Letters of concerned mines

Overall, considering the operational commercial and captive mines, and mines that are supposed to commence production (based on the current status of statutory permits), the state will have a total coal capacity of 388 MMTPA within the next two to three years.

Table 1.5: Overall coal production capacity by 2025-26

Production type	Production capacity (MMTPA)
Commercial	319
Captive	58.6
Total	**377.6**

Source: iFOREST analysis

Besides old operating mines and planned expansions, overall 21 coal blocks have been allocated in the state since 2015 with a combined estimated extractable reserve of over 6,762 MMT. However, except for six mines starting in these blocks, most of these blocks have not come into production yet. As per available information, Naini is expected to commence production this year (2024).

Table 1.6: Allocated coal blocks

Coal blocks allotted	No. of blocks	Extractable reserve (MMT)	Date of allotment	Allottee
Dulanga	1	141.55	08/09/2015	NTPC
Manoharpur & Dipside of Manoharpur	2	46.05	31/08/2015	Odisha Coal & Power Ltd.
Naini	1	270.00	13/08/015	SCCL
Talabira - I	1	2.40	23/03/2015	GMR Chhatisgarh Energy Ltd.
Utkal E & D	2	171.37	02/05/2016	NALCO
Talabira II & III	1	546.61	02/05/2016	NLC
Chandrabila	1	550.00	24/02/2016	Tamil Nadu Generation and Distribution Corp. Ltd.
Jamkhani	1	132.73	10/02/2020	Vedanta Ltd.
Mandakini	1	287.89	02/03/2020	KPCL
Utkal A	1	332.85	18/11//2021	MCL
Radhikapour (East)	1	172.00	03/03/2021	EMIL Mines and Mineral Resources Ltd.
Radhikapour (West)	1	258.00	03/03/2021	Vedanta Ltd.
Kurloi (A) North	1	1,680.23	03/09/2021	Vedanta Ltd.
Utkal - C	1	196.35	10/10/2022	Jindal Steel and Power Ltd.
Utkal B1 & B2	2	347.08	10/10/2022	Jindal Steel and Power Ltd.
Bijahan	1	327.05	10/10/2022	Mahanadi Mines & Minerals Pvt. Ltd.
Bankhui	1	800.00	10/10/2022	Yazdani Steel and Power Ltd.
Alaknanda	1	500.00	12/12/2022	Rungta Sons Pvt. Ltd.
Total	**21**	**6,762.16**		

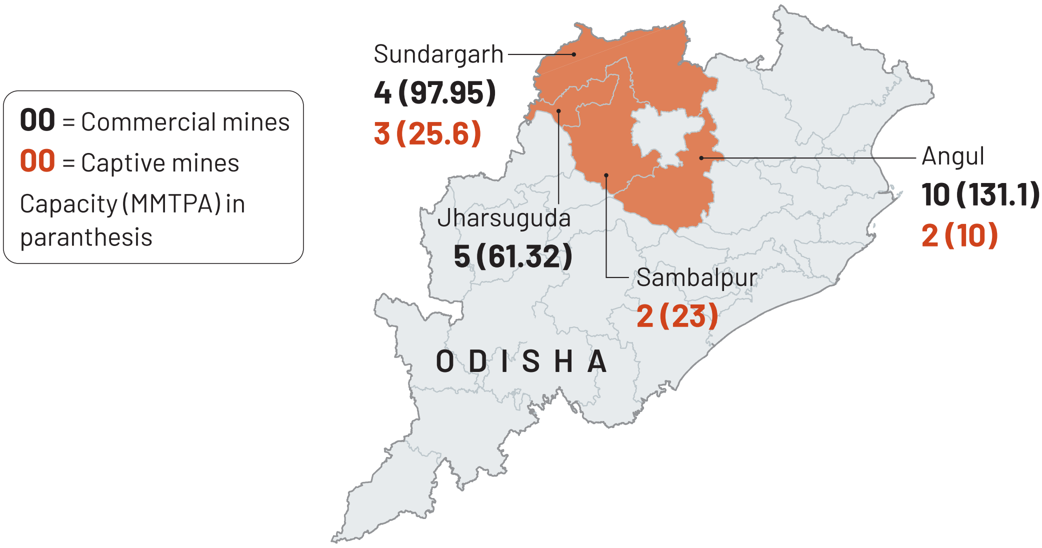
Source: Provisional Coal Statistics, 2022, MSTC e-commerce portal, Ministry of Coal

Overall, the analysis of production and expansion plans of the coal mining sector shows that the state is poised for a significant expansion in coal production over the coming years. The state will have 21 commercial mines with a production capacity of 329 MMT by 2026. Besides, there are captive mines with a capacity of 58 MMT. In addition to that 21 coal blocks have been allocated, which might come into production sometime in the future.

1.4 Spatial distribution

Commercial and captive coal mines in Odisha, are spread over four districts. These include Angul, Sundargarh, Jharsuguda, and Sambalpur. Among the four districts, Angul has the largest number of coal mines with 12 mines located in three blocks i.e., Talcher, Chhendipada and Kaniha. This is followed by Sundargarh with seven mines Jharsuguda with five mines, and Sambalpur with two mines.

Map 1.1: Spatial distribution of operational coal mines



Source: iFOREST analysis

1.5 Land availability

Considering the scale of mining operations, a large amount of land is available for coal mines. An assessment of land available with operational mines and closed mines, and mines to commence operation (by 2026) in various districts of the state shows that over 29,600 hectares (ha) of land is available with these mines. Besides, the commercial mines, about 6,830 ha of land is available with the captive mines.

Table 1.7: Land available with operational and closed coal mines

District	Land available with operational mines (ha)			Land available with closed mines (ha)			Land with mine to start operation Total Land (ha)	Total land with commercial operational+ closed+ upcoming mines (ha)	Total land with captive mines (ha)
	OC mines	UG mines	Total land	OC mines	UG mines	Total land			
Angul	8,929.7	1,510	10,439.7	1,285	1,507.7	2,793	1,145	14,377.5	1,349.3
Sundargarh	3,902.4	0	3,902.4	0	0	0		3,902.4	3,396.5
Jharsuguda	6,455.5	2,953	9,408.4	0	1,941.2	1,941*		11,349.6	
Sambalpur	0	0	0	0	0	0		0	2,084.3
Total	**19,287.6**	**4,463**	**23,750.5**	**1,285**	**3,448.9**	**4,734**	**1,145**	**29,629.5**	**6,830**

Source: Data as obtained from MCL, 2024; Latest EC letters of various captive mines
*The area reflects the total lease area of two out of the three closed UG mines. For one mine, which is over 120 years old, land area was not available.

A block-wise analysis further shows that the maximum amount of land is concentrated in just two blocks, Talcher in Angul district, and Jharsuguda block in Jharsuguda district. These two blocks have about 77% of the land that is available with the operational mines. Besides, six out of the seven closed mines in the state are located in these two blocks (three in Talcher and three in Jharsuguda). In Talcher block, the total land available with the closed mines is about 2,716 ha, and in Jharsuguda block is at least 1,941 ha.

Table 1.8: Block-wise mine land availability (under operational and about to commence operation)

District	Block	Commercial mines (ha)		Captive mines (ha)
		Operational	Closed	
Angul	Talcher	9,721.73	2,716.44	-
	Talcher-Chhendipada	1,145	-	-
	Chhendipada	-	76.3	1,349.25
	Kaniha	718	-	-
Sundargarh	Hemgir	3,902.4	-	3,396.5
Jharsuguda	Jharsuguda	9,408.4	1,941.23	-
Sambalpur	Rengali/ Katerbaga	-	-	2,084.3
Total		**24,895.53**		**6,830.05**

Source: iFOREST analysis

1.6 Employment and workforce

The coal mines employ a large number of workers in the coal-producing districts directly and indirectly. As per information obtained from MCL, the total number of formal workers (including departmental and contractual workers) is 35,440[4]. Talcher block in Angul district has the highest income dependence, with about 57% of MCL's formal workers.

Concerning the captive mines, while mine-wise worker data could not be obtained for all mines, however, by applying an employment factor approach, it can be estimated that about 5,075 formal workers are associated with these mines.

Overall, considering both commercial operations and captive mines, currently, about 40,515 people are formally employed by these mines.

For informal workers, district-level workforce assessment in the Angul district shows that the number of informal workers is about 1.6 times the number of formal workforce[5]. Considering this proportion, the number of informal workers associated with the coal mines in Odisha can be estimated to be 64,824.

Table 1.9: Workforce of MCL mines (as of April 2024)

Mine name	District	Block	Departmental workers	Contractual workers	Total formal workers
Ananta	Angul	Talcher	1,283	2,274	3,557
Jagannath			1,020	715	1,735
Bhubaneswari			738	1,461	2,199
Bharatpur			2,048	1,267	3,315
Lingaraj			1,762	1,584	3,346
Hingula			1,388	1,268	2,656
Balaram			1,382	812	2,194
Nandira			793	94	887
Talcher			210	52	262
Kaniha		Kaniha	555	887	1,442
Samaleswari	Jharsuguda	Jharsuguda	627	1,077	1,704
Lajkura			382	516	898
Integrated Lakhanpur, Belpahar, Lilari			1,575	3,707	5,282
Orient Mine 1&2			591	59	650
Hirakhand Bundia Incline			652	64	716
Kulda	Sundargarh	Sundargarh	324	729	1,053
Garjanbahal			645	1,535	2,180
Siarmal			57	795	852
Basundhara			360	152	512
Total			**16,392**	**19,048**	**35,440**

Source: As per information provided by MCL, 2024

Table 1.10: Estimated formal workers in coal mines

Type of mine	Total formal workers
Commercial	35,440
Captive	5,075
Total workers	**40,515**

Source: iFOREST analysis

Besides formal and informal employment related to coal mining activities, a large number of workers are associated with coal transportation. Besides, there is also employment dependence on coal washeries. Since the income of these workers is directly tied to coal production in the state, therefore, they constitute an important part of the workforce who are dependent on the coal sector for income.

While there is no official information on the number of coal transportation workers in the state, district-level studies undertaken by iFOREST in Angul and official feedback received from the coal companies provide an understanding of the number of workers associated with coal transportation (by trucks/road).[6] As per the study, nearly 55,000 workers are involved in coal transportation activities (including drivers, cleaners, helpers, etc.), which is equivalent to the total number of formal and informal workers directly dependent on coal mining.

Concerning coal washeries, there are eight washeries in the state with a cumulative processing capacity of about 26 MMTPA. All the washeries are privately owned. Four of the eight are in Angul, whereas two are in Jharsuguda, and one each in Sambalpur and Sundargarh. One Coal washery by MCL is under construction i.e. IB Valley Washery at Lakhanpur Project for despatch of washed coal[7].

While an official workforce estimate was not shared by the coal washeries, however, considering the EC letter of the Aryan coal washeries and by applying an employment factor approach, it is estimated that about 1,200 workers are formally associated with these washeries.

Table 1.11: Operational coal washeries

Owner	Name of washery	District	Production capacity (MMTPA)
ALPS Mining Services	ALPS washery (formerly Bhatia coal washery)	Jharsuguda	2
Aryan Coal Beneficiation (India) Ltd.	Talcher Aryan washery	Angul	2.3
	Talcher ACB washery	Angul	7
	Aryan Ispat & Power Pvt. Ltd. washery	Sambalpur	0.7
	Hemgir washery	Sundargarh	5
Global Coal & Mining Pvt. Ltd. (GCMPL)			
	GCMPL Talcher washery	Angul	4
	GCMPL Jharsuguda washery	Jharsuguda	4
Utkal Energy Ltd.	Utkal	Angul	1.08
Total			**26.12**

Source: Provisional Coal Statistics, Coal Controller's Organisation 2022-23

Besides, such direct and indirect dependence, coal mining also creates significant induced employment among the local community. An induced economy in a mining area typically includes sectors that are not coal mining and related industries, but sectors that are affected by coal mining[8].

While there is no estimate of coal-induced workers, iFOREST survey in the Angul district of Odisha shows that over 78,600 induced jobs are created due to coal mining in the district. This includes people engaged in retail/ small businesses, servicing and repairing, construction/ masonry, non-coal transportation, manufacturing, services like banking and education, and miscellaneous labour (non-coal causal workers/daily wagers involved in various construction sites, loading unloading activities in local businesses, etc.), within a 10 km radius from mines/ mine clusters[9]. The induced economy creates a multiplier effect in the region and helps in socio-economic growth.

1.7 Financial status

The financial status of operational coal mines in Odisha is robust. Out of 19 operational mines, data from 17 shows that 14 are profitable, while 3 are operating at a loss—all of which are underground mines. In total, MCL has four loss-making mines, including the three operational ones and one that is temporarily closed. The unprofitable mines are concentrated in Jharsuguda block, except for one located in Talcher.[10]

Table 1.12: Unprofitable mines

District	Block	Mine	Operational Status	Unprofitable mines (UG)	
				Capacity (MMT)	Current production (MMT)
Angul	Talcher	Nandira	Operational	0.33	0.08
Jharsuguda	Jharsuguda	Orient Mine No. 1 & 2	Operational	0.87	0.2
		Orient Mine No. 4	Temporary Closed	0.5	0
		Hirakhand Bundia Incline	Operational	0.95	0.2

Source: Data as obtained from MCL; Lok Sabha Unstarred Question No. 2359 Profitability of Coal Mines 2021-22

1.8 Revenue contribution

The coal industry is a significant contributor to public revenue through taxes and cess. MCL's total contribution to the state exchequer was ₹18,546 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 the payment of income tax, Royalty, and DMF. The DMF funds also go directly to the districts for developmental works and welfare activities in the mining-affected areas and the generation of sustainable livelihood.

Table 1.13: Taxes and revenue contribution to central and state government

State/ Center	Particulars	Contribution amount (₹ Crore)
State Government Both State & Central Government	Royalty	3,607.86
	District Mineral Foundation	1,086.25
	SGST	427.64
Central Government Central Government	CGST	427.64
	National Mineral Exploration Trust	71.68
	GST Compensation Cess	7,675.51
	Income tax	5,250.00
Total contribution		**18,546.58**

Source: MCL Annual Report 2022-2023

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. In the year 2022-23, the company has spent ₹207.97 Crore against the mandatory CSR budgetary allocation of ₹ 195.68 crore.[11]

1.9 Just transition issues and opportunities

India is committed to a net-zero target by 2070, which will lead to a phasing down of coal production in the coming decades. The country is expected to reach a coal peak around 2035.[12] Odisha remains a crucial state for meeting the country's coal demand.

Besides, Odisha's industry is also financially strong. Unlike, other coal states, such as Jharkhand, Chhattisgarh, Madhya Pradesh, and West Bengal, most of the mines in the state are operating profitably.

Overall, an analysis of the operational coal mines in the state and planned expansions, suggests that there are some challenges as well as opportunities in the next 15 years.

1.9.1 Mine closure challenges

Coal mines in Odisha are relatively new. Hence, many mines are likely to continue production beyond 2050. However, considering India's net zero timeline, and the opportunities that can be harnessed simultaneously to phase-in green growth in the coal regions, a phase-down scenario for the sector is outlined below.

To determine a strategic phase-down schedule for the coal sector in the state, the following assumptions have been taken into consideration:

a) The temporarily closed mine(s) and operational mines that are currently economically unviable and those that are going to exhaust resources as per currently estimated reserves, can be closed by 2030.

b) For other mines, the approach will be to let them operate till the end of their life.

c) However, very old mines, that started operating in the 1980s-1990s, but have still a significant mine life left, can be considered for closure between 2040-2050.

Considering this, by 2030, six mines (4 UG and 2 OC) can be closed. These mines are largely concentrated in Talcher and Jharsuguda blocks. Except for the two OC mines, all are low-producing, and out of the 4 UG mines, 3 are unprofitable.

Between 2031-40, Talcher block will experience the transition of key mines, Lingaraj, Ananta, and Jagannath due to exhaustion of resources. Overall, a total of six mines with about 80 MMT capacity will exhaust resources.

Between 2041-50, an additional three mines with 43 MMT capacity can be transitioned. However, three mega mines will continue operating until 2060. The four mines that will continue to operate post-2050 have a total annual production capacity of 134 MMT.

Overall, considering the concentration of mines and the transition scenario, the Talcher block in Angul district, and the Jharsuguda block in Jharsuguda district remain most vulnerable to the transition starting this decade.

Table 1.14: Phase-down schedule of operational mines

Year	Name of mine	Block	Mine type	Capacity (MMT)	Lease area
By 2030	Talcher	Talcher	UG	0.27	1140
	Nandira	Talcher	UG	0.33	370
	Kulda	Hemgir	OC	21	634.2
	Samaleswari	Jharsuguda	OC	15	1334.91
	Orient Mine No. 1&2	Jharsuguda	UG	0.87	1857.24
	Hirakhand Bundia Incline	Jharsuguda	UG	0.95	1095.71
Total by 2030				**38.42**	**6,432.06**
2031-2040	Lingaraj	Talcher	OC	20	1493.2
	Ananta	Talcher	OC	20	1419.82
	Jagannath	Talcher	OC	7.5	553.95
	Garjanbahal	Hemgir	OC	18.2	653.83
	Basundhara	Hemgir	OC	8.75	323.92
	Lajkura	Jharsuguda	OC	4.5	721.29
Total between 2031-2040				**78.95**	**5,166.01**
2041-2050	Hingula	Talcher	OC	15	1870
	Bharatpur	Talcher	OC	20	927.42
	Balram	Talcher	OC	8	1309
Total between 2041-2050				**43**	**4,106.42**
2051-2060	Kaniha	Kaniha	OC	14	718
	Bhubaneswari	Talcher	OC	30	638.34
	Siarmal	Hemgir	OC	50	2290.45
	Integrated Belpahar, Lakhanpur, Lilari	Jharsuguda	OC	40	4399.25
Total between 2051-2060				**134**	**8,046.04**

Source: iFOREST analysis

1.9.2 Standard asset

A major concern for Odisha is the risk of stranded assets in the coal sector. This is due to the following reasons:

i. Capacity vs. Production

The current coal production capacity is about 352 MMTPA, whereas the production is 235 MMTPA, considering both commercial and captive mines. The mines are, therefore, operating at 67% capacity. Odisha can easily produce more than 115 MMT from the existing mines by increasing operational efficiency.

Therefore, opening new coal blocks in the state while previously allocated blocks remain non-operational is inefficient. The fact that the existing mines are not operating at full capacity further compounds the issue. The focus should shift towards improving the operational efficiency of current mines, optimising resource extraction, and minimising environmental impacts. Prioritising 100% operational efficiency in existing mines would reduce the need for additional coal mines and ensure the effective use of existing resources, thereby mitigating the risk of stranded assets in Odisha's coal sector.

ii. Coal peaking

Odisha's coal is largely used for power generation. As per the review of the coal dispatch records of MCL, nearly 99% of the coal produced in the state is dispatched for consumption in the power sector[13].

Table 1.15: Sector-wise coal dispatch

Sector	Target (MMT)	Actual (MMT)
Power	146.2	149.03
CPP and others	29.7	43.7
Cement	0.05	0.12
Colliery consumption	0	0.0006
Total	**176**	**192.8**

Source: MCL Annual Report 2022-2023

According to the Ministry of Coal, coal demand is likely to peak between 2030-2035, and consumption by 2035-2040.[14] In addition, GoI has committed to meet net zero by 2070.

Independent assessment shows that renewable energy plus battery storage will become cheaper than coal-based power by 2030[15]. If this happens then coal peak in power sector can happen even before the year forecasted by MOC. Odisha should evaluate the expansion of its coal sector by considering this information, otherwise the risk of stranded assets is quite high.

1.9.3 Opportunities for land repurposing

The land is a crucial requirement for industrial development and economic diversification. Repurposing of land available with coal mines will be essential for diversifying the local economy, developing green energy and green industries, and creating local employment opportunities. Global studies also suggest that repurposing of mining land has been a key factor for local employment generation and supporting economic transition[16].

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.

As discussed earlier, an assessment of land available with operational, closed, and mine to commence operation (by 2026) shows that over 29,600 ha of land is available with OC and UG mines that are operating commercially. Besides, more than 4,700 ha of land is currently available with closed mines, which are either temporarily or permanently closed.

In the immediate future, the opportunity lies with repurposing the land available with closed mines, and those that are going to exhaust their extractable resources or remain economically unviable. Considering this, collectively, over 11,000 ha of land can be planned for repurposing by 2030.

This land is primarily in Talcher and Jharsuguda blocks. The mines that can be considered for repurposing include, Samaleswari mine in Jharsuguda block, Chhendipada mine in Chhendipada block and South Balanda mine in Talcher considering that these are OC mines and has significant amount of land parcels.

Table 1.16: Mines that can be considered for repurposing by 2030

Mine name	Location		Type of mine	Current operational status	Land area (ha)
	District	Block			
Talcher	Angul	Talcher	UG	Operational	1,140.00
Nandira	Angul	Talcher	UG	Operational	370.00
Kulda	Sundargarh	Hemgir	OC	Operational	634.20
Samaleswari	Jharsuguda	Jharsuguda	OC	Operational	1,334.91
Orient Mine No. 1&2	Jharsuguda	Jharsuguda	UG	Operational	1,857.24
Hirakhand Bundia Incline	Jharsuguda	Jharsuguda	UG	Operational	1,095.71
Chhendipada	Angul	Chhendipada	OC	Temporarily closed	76.30
Deulbera	Angul	Talcher	UG	Temporarily closed	954.10
Handidua	Angul	Talcher	UG	Temporarily closed	553.64
South Balanda	Angul	Talcher	OC	Permanently closed	1,208.70
Orient Mine No.3	Jharsuguda	Jharsuguda	UG	Temporarily closed	1,421.76
Orient Mine No.4	Jharsuguda	Jharsuguda	UG	Temporarily closed	519.47
Hindegir Rampur colliery	Jharsuguda	Jharsuguda	UG	Permanently closed	NA

Source: iForest analysis

Repurposing the coal mining land, however, will require a revision in the mine closure plans of various coal mines in the state. An analysis of the proposed post-closure land use for opencast mines in Odisha shows that it largely involves plantation activity. Over 63% of the land available with these mines is identified for plantations and 14% for water body creation. This renders about 77% of land unusable for green energy or green industry development once mines are closed. Only about 23% of the total land can be categorized as readily available, including undisturbed areas, green zones, safety zones, or land for public use, such as infrastructure development, built-up areas, cultivable land, and grassland.

Going ahead if 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. The following types of repurposing activities can be undertaken after scientific mine land reclamation:

- 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) infrastructure, such as solar PV.
- 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.
- Besides these, horticulture activities, eco-tourism activities engaging local people, and pisciculture activities in mine voids can create important avenues of sustainable employment.

Repurposing coal mining land for developing green energy infrastructure and creating local employment opportunities has also been recognised by the Government of India (GoI). In April 2022, the Union Cabinet chaired by the Prime Minister of India gave a nod to a set of policy guidelines developed by the Ministry of Coal allowing the development of certain coal and energy infrastructure and social infrastructure in land acquired under the Coal Bearing Areas. (Acquisition and Development) Act, 1957. The guidelines aim to repurpose the land lying idle with the coal public sector undertakings (PSUs). This includes land where coal mining is not economically viable or the areas that have been de-coaled and reclaimed. The PSU, which is currently holding the land, can lease it to other central PSUs, state government agencies/PSUs, and other private entities for certain activities for a defined period[17].

Among the various repurposing activities mentioned in closed mining land, setting up RE projects on the closed mine land remains a key one. For this, the land may be leased for a maximum period of 35 years.[18]

Another extremely important policy move has been taken by the Government on land repurposing. In June 2024, the Ministry of Coal proposed revised guidelines for coal mine closure, under which for the first time the repurposing of mining land has been specified besides reclamation activities. More importantly this has been emphasised in the context of 'just transformation' of the local communities and addressing the social, economic, and environmental challenges associated with mine closure activities.[19]

KEY PROVISIONS ON JUST TRANSFORMATION AND LAND REPURPOSING IN DRAFT GUIDELINES (2024) ON COAL AND LIGNITE MINE PLANNING AND MINE CLOSURE

The draft guidelines of mine planning and closure of coal and lignite mines promulgated by the Ministry of Coal in 2024 has for the first time integrated the aspects of just transformation of local communities in mining areas, and opportunities of repurposing the land.

The guidelines (Para 3.2) note that just transformation is the equitable process of transitioning from traditional coal mining toward more sustainable and environmentally friendly manners, ensuring that the environment is protected, the land is restored, and affected workers, communities, and regions are supported and empowered throughout the transformation. It involves recognising and addressing the social, economic, and environmental challenges associated with mine closure activities.

It further specifies that the project proponent shall complete all activities related to technical, biological reclamation and repurposing related to just transformation before issuing the final closure certificate (Para 3.2.1).

The guidelines also emphasises the repurposing of infrastructure available with mining companies in coordination with the concerned government entities. It notes that all social amenities and infrastructure created (like hospitals, schools, community centers etc.) by the coal company should be handed over to the state government (Para 3.2.2).

Recognising the need of huge skill training in the future, the guidelines also specify that the office and other buildings of mine may also be utilised or developed as skill development centers or others. Efforts also need to be made in each progressive closure period of five years to enhance skills, livelihoods, and living conditions of communities directly or indirectly dependent within the vicinity of the mine. The project proponent will have to submit a five- yearly report, outlining of the initiatives undertaken to skill development and sustain the livelihoods of the affected communities (Para 3.2.2).

Source: Ministry of Coal, Government of India. (June 2024). Draft mining plan guidelines for coal and lignite blocks. https://coal.gov.in/sites/default/files/2024-06/18-06-2024.pdf

1.9.4 Workforce transition

While in Odisha there is no major challenge for workforce transition in the coming years, it will be important to prepare the workforce in the mining areas for the future green economy, since many of them will require a skilled workforce. Therefore, a key aspect of workforce transition will be skilling and reskilling.

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.

1.9.5 Utilisation of social welfare funds to support just transition

As Odisha plans for a just transition of the state's coal-dependent regions, it will be important to utilise some of the social welfare funds to support measures of sustainable livelihoods, skilling and reskilling, and building resilient social infrastructure. The District Mineral Foundation (DMF) funds and the coal cess, remain the most important sources of public financing for the state to support localised transition measures. The purpose of these funds is also aligned with the goal of a clean environment, supporting clean energy, and ensuring public good and social welfare. Leveraging these funds will be important to support not just immediate socioeconomic measures, but also long-term sustainable development.

A decadal assessment of potential funds available combining DMF and coal cess shows that over ₹39,764 crore can be available from DMF contribution by ongoing and planned mine expansions in the state (not accounting for allocated coal blocks).

Besides DMF, the coal cess, which is currently subsumed under the GST Compensation Cess (prospectively until 2026), can be one of the most significant sources of public financing to support just energy transition measures in the state.[20] Being levied at ₹400 per tonne of coal production (and imports), an analysis of the compensation cess collected from 2017-18 till 2022-23, shows that the state has paid over ₹39,500 crores in coal cess during the period (considering Odisha's coal production during the same period) [21]. Going ahead, the coal cess if repurposed as just an energy transition cess, can be a very significant resource to support green investments and jobs in the coal districts.

Table 1.17: Estimated funds from DMF and coal cess

Public funds	Estimated contributions (₹ crore)					
	2023-30	2031-40	2041-50	2050-60	Post 2060	Total
DMF	11,344	11,777	9,643	5,182	1,818	39,764
Coal cess	1,00,588	1,04,426	85,508	45,948	16,122	3,52,592
Total (DMF + Coal cess)	1,11,932	1,16,203	95,151	51,130	17,940	3,92,356

Source: iFOREST analysis

OPPORTUNITIES OF DISTRICT MINERAL FOUNDATION FUNDS

The Government of India (GoI), in March 2015, instituted District Mineral Foundation (DMF) through an amendment to India's central mining law, the Mines and Minerals (Development and Regulation) Act (MMDR) of 1957. As per the provisions of the law (Section 9B), DMF is a non-profit trust, developed in every mining district of India, with the precise objective to "work for the interest and benefit of persons and areas" affected by mining related operations" (Section 9B MMDR Amendment Act, 2015).

The Pradhan Mantri Khanij Kheshtra Kalyan Yojana (PMKKKY), the flagship Central Government scheme introduced in 2015, and aligned to the implementation of DMFs also upholds the spirit of DMFs. To optimise the benefits for mining-affected people and areas, the guidelines specify the need for DMFs to identify mining-affected people, and delineate the mining-affected areas (directly and indirectly affected). It also outlines mechanisms of fund use and prioritization of sectors for investments through planning, transparency, and public accountability, among others.

In essence, the MMDR Amendment Act (2015) and the PMKKKY collectively emphasize on composition, functioning, planning, and implementation aspects of DMFs in a manner that ensures that DMFs function as inclusive, effective, and publicly accountable institutions.

The contribution of DMFs comes through payment by mining companies operational within a district. The mining companies (or individuals) operating within the administrative boundaries of the district pay DMF an amount equivalent to 30% of the royalty (for leases granted before 2015) and 10% of the royalty for leases granted after that.

So far the state has received ₹25,858 crore in DMF from coal mining and other major mineral mining activities. Out of which, slightly over 23% is from coal mining, and the rest is from non-coal mining. Out of the total coal-related DMF, over 55% is from Angul district.

Table 1.18: Status of DMF funds accrual and utilisation in coal districts

District	Total collected (₹)	Total spent (₹)
Angul	**3,412.18**	**1,798.69**
Jharsuguda	**1,419.32**	**1,179.72**
Sundargarh*	**7,820.3**	**5,965.53**
Total	**12,651.8**	**8,943.94**

Source: Ministry of Mines, July 2024; *A major share of Sundargarh's DMF is from iron ore mining

Going ahead, DMF funds, can be crucial seed money for supporting just transition measures in Angul, Jharsuguda, and Sundargarh 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.

CHAPTER 2

Oil and Gas

2.1 Oil

India is the third-largest consumer and importer of crude oil in the world, and its refining capacity ranks fourth globally[22]. 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[23]. 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[24].

2.1.1 Capacity and production of refinery

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.

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[25] – with a cumulative production capacity of about 254 million metric tonne per annum (MMTPA)[26].

Paradip refinery located in Jagatsinghpur district of Odisha was commissioned in 2016 The refinery currently accounts for 5.6% of the country's refining capacity[27].

The Paradip refinery is designed to process 15 MMTPA crude including high sulphur heavy crudes[28]. It currently produces various petroleum products such as gasoline, diesel, kerosene, aviation turbine fuel, Propylene, Sulphur, and petroleum coke. It also serves as an economic stimulus for industrial development in the region by way of immediate potential growth of ancillary and auxiliary industries.

Table 2.1: Processing at Paradip refinery (2021-22)

Refinery name	Year of commencement	Petroleum refining capacity in 2022-23 (MMT)		Crude oil processed (MMT) in 2022-23		Production of petroleum products in 2022-23 (MMT)	
		In Odisha	Share of India's total (%)	In Odisha	Share of India's total (%)	In Odisha	Share of India's total (%)
IOCL-PARADIP	2016	15	5.97	13.6	5.33	12.27	4.67

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

Table 2.2: Year-wise crude oil processed by Paradip

Year	Crude Oil processed by IOC- Paradip (MMT)
2015-16	18.17
2016-17	82.30
2017-18	12.73
2018-19	14.61
2019-20	12.92
2020-21	11.73
2021-22	13.21
2022-23 (P*)	13.60

*provisional
Source: Petroleum Planning & Analysis Cell, 2023

2.1.2 Sales of petroleum products

The total annual sales of all petroleum products in Odisha have been increasing at a steady rate for the last 12 years. For the year 2022-23, Mobile Spirit (MS) and High-Speed Diesel (HSD) accounted for over 51% of the total sales (12.8 MMT).

Table 2.3: Annual industry sales of petroleum products in Odisha

Year	Total annual industry sales (MMT)	Annual industry sales of MS (MMT)	Annual industry sales of HSD (MMT)
2010-11	3.3	3.2	1.8
2011-12	3.4	3.4	1.8
2012-13	3.4	3.7	1.8
2013-14	3.7	4.1	2.0
2014-15	3.9	4.7	1.9
2015-16	4.5	5.5	2.2
2016-17	5.2	6.1	2.3
2017-18	5.7	7.0	2.5
2018-19	5.9	7.8	2.6
2019-20	6.0	8.3	2.7
2020-21	5.9	7.8	2.5
2021-22	6.2	8.6	2.6
2022-23	6.6	9.9	2.9

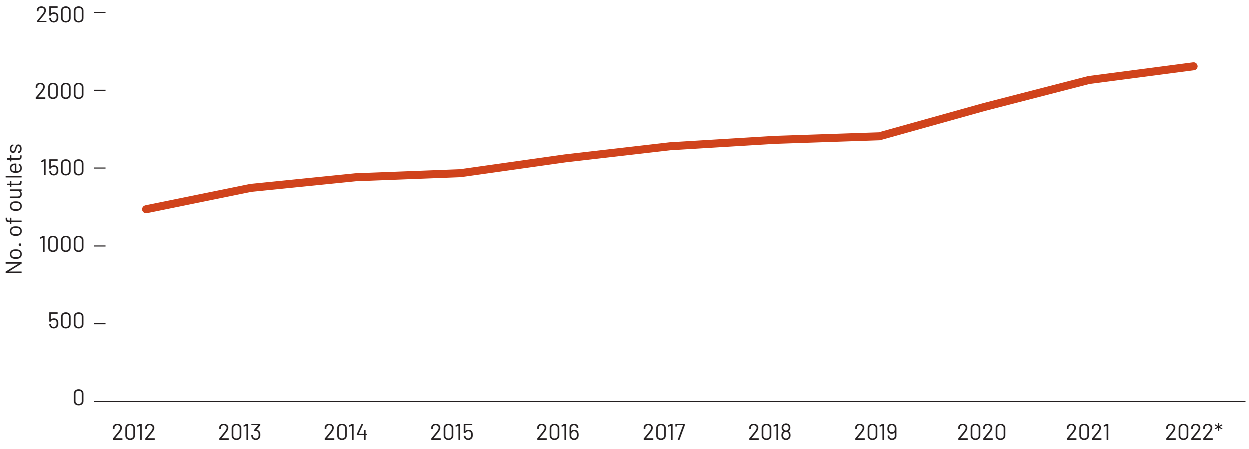
Source: Petroleum Planning & Analysis Cell, 2023

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 significant for a just transition because this is where the most immediate impacts of the oil transition will be experienced in India[29].

The marketing and distribution segment of the oil sector has been evaluated in terms of the impact on retail outlets. The evaluation shows that the number of retail outlets in Odisha has registered an increase to 2,159 outlets in 2022, compared to 1,230 in 2012 in the state.

Figure 2.1: Trend in increase in retail outlets



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

2.1.4 Employment and workforce

The employment in the oil sector has been estimated for the one refinery operating the state. The primary employment in this sector stems from the Indian Oil Corporation Limited (IOCL) refinery located in Paradip, which has a refining capacity of 15 MMTPA.

In total, the Paradip refinery provides direct employment to around 8,100 individuals. The number of permanent employees is estimated at 200 persons per MMTPA of refining capacity, while contract workers are approximately 1.7 times the number of permanent employees.

Table 2.4: Employment in oil refinery

State	District	Company	Capacity (MMTPA)	Employees		
				Permanent	Contract	Total
Odisha	Paradip	IOCL	15	3,000	5,100	8,100

Source: Manpower has been assessed at 200 persons per MMTPA of refining capacity for permanent employees, and the number of contract employees is estimated to be 1.7 times the total number of permanent employees, based on data from IOCL's All India worker statistics.

2.1.5 Just transition issue and opportunities

The key just energy transition issue for India's oil sector will be greening the refining process by using green hydrogen in the coming years[30].

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 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, the adoption of green hydrogen can help to neutralize CO_2 emissions from hydrogen production by 2050[31].

For state-run refineries, the Central Government is providing fiscal incentives for greening the sector. In the 2023 union budget, an outlay of ₹1300 billion was announced to help such refiners move toward cleaner energy[32].

At Paradip refinery, a significant step has been taken towards renewable energy (RE) adoption with the installation of 1.87 MW capacity solar panels over the roof of the warehouse. This solar power generation facility helps reduce the reliance on conventional power sources and promotes the use of clean energy[33].

Overall, IOCL has adopted various measures to reduce greenhouse gas emissions by transitioning to cleaner and RE sources. For this, the company has implemented initiatives such as rainwater harvesting, water, carbon, and waste footprint mapping, as well as the installation of solar panels and LED lights. Additionally, sapling plantations have been carried out at pipeline installations to contribute to carbon sequestration and environmental preservation[34]. The company has also recently announced to achieve net zero operational emissions by 2046. The decarbonisation plans encompass both Scope 1 and 2 emissions, with an estimated budget requirement of more ₹2.4 lakh crore[35].

Besides the use of green hydrogen, the application of carbon capture and storage (CCUS) technology is also being proposed by international expert agencies, such as the International Energy Agency (IEA)[36]. 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[37].

Concerning workforce transition, key intervention will be necessary in the marketing and distribution segment. 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. All the net-zero models project a three to fourfold increase in natural gas demand by 2050. The 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. Natural gas consumption, therefore, is projected to increase in the industrial sector, as well as in the power sector.

2.2.1 Capacity and production

Odisha's natural sector focus on import and regasification through the Dhamra LNG Terminal, located at Dhamra Port in Bhadrak district. This facility, initially developed with a capacity of 5 million tons per annum (MMTPA) and with the potential to expand up to 10 MMTPA, is critical in supplying natural gas to eastern Indian states, including Odisha. The state's integration into India's natural gas grid through key pipelines, such as the Jagdishpur-Haldia-Bokaro-Dhamra pipeline (JHBDPL), further solidifies its role in regional energy supply and distribution[38].

The natural gas sector in Odisha plays a pivotal role in supporting the state's energy transition by providing a cleaner alternative to traditional fossil fuels like coal, thus contributing to reduced emissions and a more sustainable energy mix. The state's key industries—such as steel, aluminum, and fertilizer—are significant consumers of natural gas, utilising it as a cleaner source of energy for production processes. In addition, natural gas is used for power generation and as a critical feedstock in chemical industries, showcasing its versatility and importance in fostering industrial growth.

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 Odisha, as of the latest estimates (June, 2024), there are at least 108 CNG stations in the state which is 2% of India's total[39]. For PNG, there are over 1.2 lakh connections[40], which constitutes 1% of India's total.

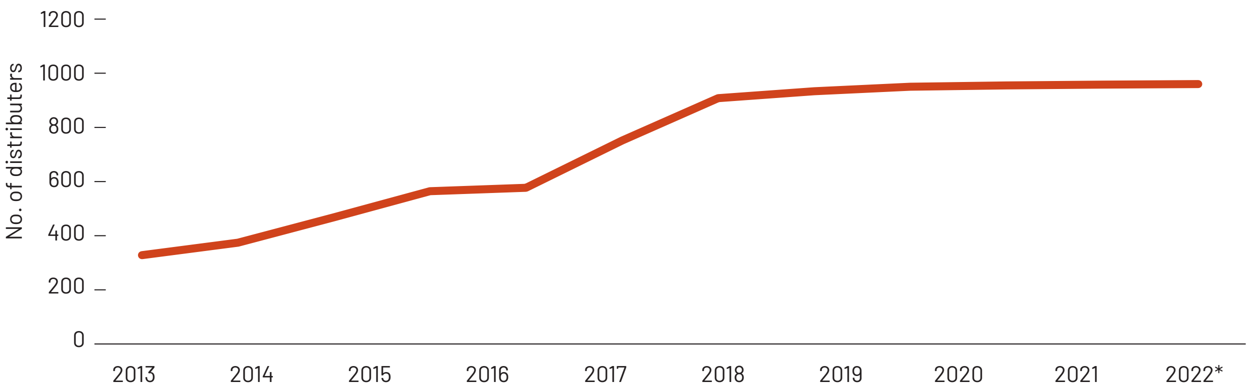
Table 2.8: PNG connections

Connection Type	No. of PNG Connections	Share of India Total (%)
Domestic	1,23,953	1
Commercial	11	0.02
Industrial	0	0

Source: Petroleum Planning & Analysis Cell, 2024

Concerning LPG distributors, as of the latest estimates (April 2024), the state has over 965 distributors, depicting a triple-fold increase over the past decade (323 in 2013). This accounts for 4% of the LPG distributors in India.

Figure 2.2: Trend in increase in LPG distributors



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

2.2.3 Employment and workforce

The employment for the gas sector could only be estimated for LPG distributors in the state. Based on the review of the letter of intent of oil marketing companies, the total employment in LPG distribution can be estimated to be about 3,860 (considering two office staff and two loaders/ unloaders who also do delivery).

2.2.4 Just transition issues and opportunities

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 MMT of CO_2 equivalent (CO_2e) is estimated to be emitted for each MMT 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 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 I120,000 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.

SECTION II

ELECTRICITY SECTOR

Chapter 3: COAL-BASED THERMAL POWER

CHAPTER 3

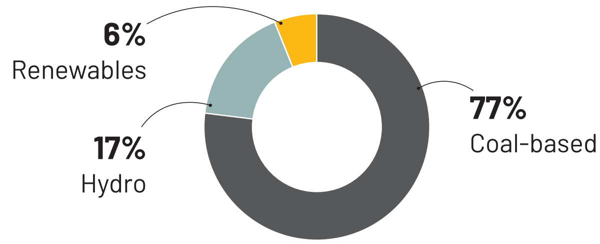
Coal-based Thermal Power

3.1 Overview

Odisha has over 21 GW of installed coal-based thermal power capacity, which is about 10% of India's total. Out of this, over 55% (11.6 GW) is captive power capacity and the rest 45% (9.4 GW) is the utility-scale capacity.[1]

As per the latest information from the Central Electricity Authority on the state's utility-scale installed capacity, it is predominantly reliant on coal with a 77% share (9,540 MW) of the state's total installed capacity of about 12,382 MW. This is followed by hydropower. The installed capacity from renewable energy sources (RES) is less than 6%.[2]

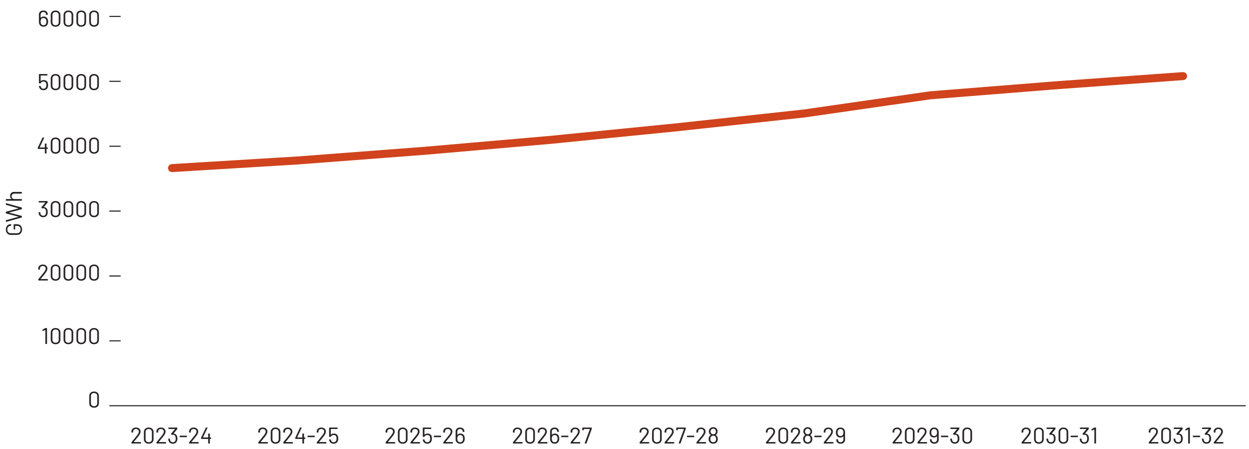
Figure 3.1: Fuel types in the electricity sector



Source: iFOREST analysis based on CEA data of August, 2024

Considering consumption, Odisha accounts for about 2.7% of the country's electricity consumption. In 2023-24, the total electricity consumption of the state was 36,453 GWh. Electricity consumption is projected to increase steadily in the coming years reaching 50,952 GWh in 2031-32 owing to the state's industrial and domestic demand.[3]

Figure 3.2: Projected electricity consumption



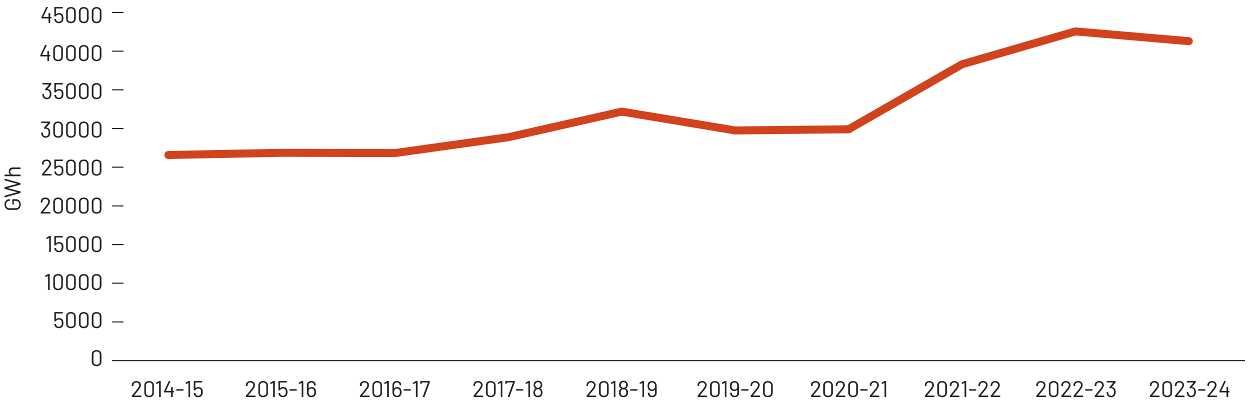
Source: iFOREST analysis based on CEA data of September 2024

Analysis of electricity consumption among various sectors shows that high voltage (HV) industrial power accounts for 39% (11,746.07 GWh) of the total energy sold. Domestic consumers represent the second-largest segment, consuming 25% (7,713.94 GWh) of the total electricity. Low voltage (LV) industrial power follows with a 12% (3,754.2 GWh) share, indicating considerable energy use by smaller industrial units.[4]

The state's Economic Survey report (2024) also indicates that the industrial sector and growing urbanisation will remain the key drivers of rising electricity demand in the state. Owing to such push factors, demand in the state has been growing steadily over the last 10 years. Overall electricity demand has increased from 26,482 GWh in 2014-15 to over 42,631 GWh in 2022-23.[5]

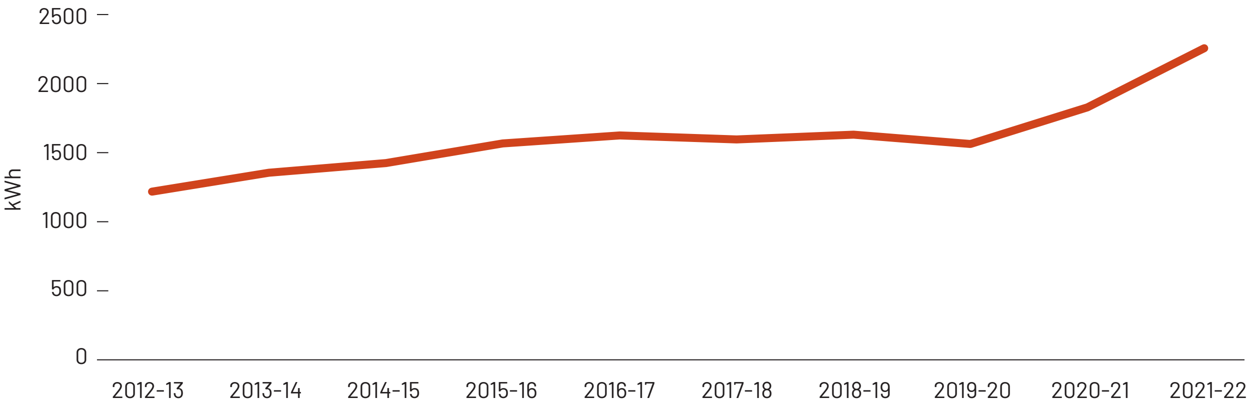
Simultaneously the per capita consumption of electricity has also increased steadily over the past 10 years.[6] The current per capita electricity consumption of the state is about 2,264 kWh, which is 1.8 times the India average of 1,255 kWh.[7]

Figure 3.3: Trend in utility demand



Source: iFOREST analysis based on CEA data of September 2024

Figure 3.4: Per capita electricity consumption



Source: iFOREST analysis based on CEA data of September 2024

Considering the growing demand for electricity in the state, with increased industrialisation and urbanisation in the future, a green energy transition becomes an absolute necessity. This requires an overall evaluation of the current status of the coal-based thermal power sector in the state (including both utility-scale and captive) to understand how a just energy transition can be planned and implemented in the coming decades.

3.2 Captive power plants

Odisha is one of the top states in terms of installed captive power capacity, accounting for 16% of India's total. Of the total 12.5 GW of captive power capacity, 11.7 GW is coal-based, which is about 93% of the total captive capacity.

Table 3.1: Installed capacity of captive power plants

Fuel type	Installed capacity (MW)	Share of total state capacity (%)
Steam (coal)	11,655	93.1
Diesel	352	2.8
Gas	399	3.2
Solar	84	0.7
Biomass	28	0.2
Total	**12,517**	**100**

Source: All India Electricity Statistics, 2024

Captive power plants (CPPs) in Odisha play a crucial role across various industries, with the aluminium sector leading in installed capacity at nearly 6 GW. This represents about 66% of the total captive capacity in the aluminium industry nationwide. The iron and steel sector follows, with around 4.8 GW of captive capacity, contributing 30% of the sector's total captive capacity in India. Other key sectors relying on CPPs include non-ferrous metals, fertilizers, petroleum and mineral oil, paper, mining and quarrying, and food processing.[8]

Currently, coal dominates captive power generation in the state, accounting for 99% of the energy mix, based on 2022-23 industry data. Renewable energy sources like solar and biomass contribute only 0.6% and 0.35%, respectively.

Given the scale of operations and the heavy reliance on coal, transitioning CPPs toward green energy will be critical for Odisha's energy transition efforts and for advancing industrial decarbonisation in the state.

Table 3.2: Industry-wise captive capacity

Type of Industry	Installed capacity (MW)
Aluminium	6,808
Automobiles	3
Cement	129
Chemical	1
Collieries	4
Fertiliser	173
Heavy Engineering	2
Iron and Steel	4,156
Mineral Oil and Petroleum	380
Mining and Quarrying	8
Miscellaneous	734
Non-industry	20
Paper	96
Plastic	2
Total	**12,517**

Source: All India Electricity Statistics, 2024

3.3 Utility-scale thermal power plants

Odisha has over 9.4 GW of coal-based utility-scale capacity.[9] Due to the state's substantial coal reserves, most of its thermal power plants (TPP) are pit-head which provide affordable electricity. The TPPs are thus concentrated in Jharsuguda, Angul, and Sundargarh districts.

Table 3.3: Operational utility-scale TPPs

District	Block	Company name	Plant name	Unit No.	Installed capacity (MW)
Jharsuguda	Lakhanpur	OPGCL	IB Valley TPS	1	210
				2	210
				3	660
				4	660
		IBPIL	Utkal TPP	1	350
	Jharsuguda	Vedanta Limited	Vedanta TPP	2	600
Dhenkanal	Odapada	GMR Energy Limited	Kamalanga TPS	1	350
				2	350
				3	350
Angul	Banarpal	JITPL	Derang TPP	1	600
				2	600
	Talcher	NTPC	Talcher STPS	1	500
				2	500
				3	500
				4	500
				5	500
				6	500
Sundargarh	Hemgir	NTPC	Darlipali STPS	1	800
				2	800
Total				**19**	**9,540**

Source: Central Electricity Authority, list of thermal power plants in India, 2024

In addition to operational TPPs, the state further plans for a capacity addition of 3,720 MW from two ultra-supercritical TPPs. The Talcher TPPS-III is expected to commence operation from the end of 2027 (September to December), and the Talabira TPP in 2028 (May to November).[10]

Table 3.4: Under construction and likely to be commissioned TPPs

District	Block	Company name	Name of TPP	Unit No.	Capacity (MW)
Jharsuguda	Rampur	NLC India Ltd.	Talabira TPP	1	800
				2	800
				3	800
Angul	Talcher	NTPC	Talcher TPPS-III	1	660
				2	660
Total				**5**	**3,720**

Source: Central Electricity Authority, broad status report of under-construction thermal power projects, July, 2024

Overall, considering the operational utility-scale TPPs, those to start operation by 2027-28, and the existing coal-based captive capacity, the total capacity of coal-based TPPs in the state by 2027-28 will be about 25 GW.

Table 3.5: Overall coal-based capacity by 2027-28

Production type	Capacity (MW)
Utility	13,260
Captive	11,655
Total	**24,915**

Source: iFOREST analysis based on Central Electricity Authority data of July 2024 and OREDA, 2024

3.4 Age assessment of power plants

The age assessment of coal-based power plants in the state has been considered for both utility-scale units, as well as the CPPs. For CPPs, the age assessment has been undertaken for units that are 100 MW capacity or above, as it is significant from the perspective of emission reduction.

The assessment shows that the thermal power fleet in the state is relatively young when considering utility-scale plants. About 1.4 GW of the installed utility-scale capacity will reach 35 years in the next 10 years (by 2035). These include two units (200*2=400 MW) of the IB Valley Thermal Power Station (TPS) in Jharsuguda district which is the oldest TPP of Odisha Power Generation Corporation Limited (OPGCL) commissioned in mid mid-1990s, and two units (500*2=1,000 MW) of Talcher power station operated by NTPC Limited.

Table 3.6: Age assessment of utility-scale TPPs

TPP reaching the age of 35 years	Company name	Plant name	Unit No.	Location	Installed capacity (MW)	Year in which reaching the age of 35 years
2025- 2030	OPGCL	IB Valley TPS	1	Jharsuguda	210	2029
			2	Jharsuguda	210	2030
	NTPC	Talcher STPS	1	Angul	500	2030
Total by 2030			**3**		**920**	
2031- 2040	NTPC	Talcher STPS	2	Angul	500	2031
			3	Angul	500	2038
			4	Angul	500	2038
			5	Angul	500	2039
			6	Angul	500	2040
Total by 2040			**5**		**2,500**	
2041-2050	Sterlite Energy Limited	Sterlite TPP	1	Jharsuguda	600	2045
			2	Jharsuguda	600	2045
	GMR Energy Limited	Kamalanga TPS	1	Dhenkanal	350	2048
			2	Dhenkanal	350	2048
			3	Dhenkanal	350	2049
	JITPL	Derang TPP	1	Angul	600	2049
			2	Angul	600	2050
Total by 2050			**7**		**3,450**	
Beyond 2050	IBPIL	Utkal TPP (Ind Barath)	1	Jharsuguda	350	2051
	OPGCL	IB Valley TPS	3	Jharsuguda	660	2054
			4	Jharsuguda	660	2054
	NTPC	Darlipali STPS	1	Sundargarh	800	2054
			2	Sundargarh	800	2056
Total beyond 2050			**5**		**3,270**	

Source: iFOREST analysis

The assessment of CPPs as per data that could be obtained for 100 MW and above capacity (10 out of 17 plants) shows that except for a few, most of the plants started operating in the early 2000s. The feedback from officials of the State Pollution Control Board (SPCB) also corroborates with the analysis. As per feedback, the captive fleet in the state is not very old and mostly started in the early to mid-2000s.

Table 3.7: Age assessment of selected CPPs (as per available data)

Company	District	2022-23 Total Capacity (MW)	Date of commissioning
Vedanta Limited	Jharsuguda	3,015	1,215 MW* in 2008
National Aluminium Company Limited (NALCO)	Angul	1,294.1	1968
Jindal Steel & Power Ltd. (JSPL)	Angul	853.5	2011
Bhushan Power & Steel Ltd. (Acquired by JSW Steel Ltd.)	Sambalpur	506	2005
Angul Energy Ltd (Acquired by TATA Steel)	Dhenkanal	465	300 MW in 2010; 165MW in 2016
Rourkela Steel Plant	Sundargarh	326.5	250 MW** - 2022
Indian Metal & Ferro Alloys Ltd.	Cuttack	200	50 MW in 1989; 30 MW in 2011; 120 MW in 2013
Bhubaneswar Power Pvt. Ltd. (Acquired by TATA Steel)	Cuttack	135	2016
Indian Farmers Fertiliser Cooperative Limited (IFFCO)	Jagatsinghpur	110	2000
Facor Power Ltd. (Acquired by Vedanta)	Bhadrak	100	50 MW in 2011; 50 in MW-2013

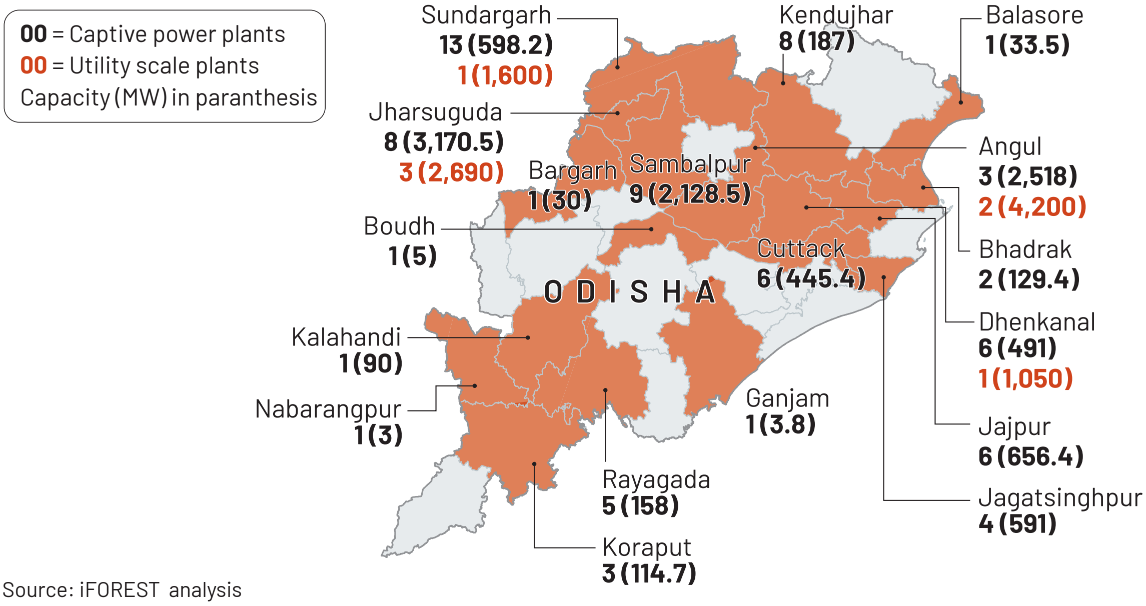
Source: iFOREST analysis based on EC letters and plant level documents; * Information obtained for 1215 MW of active capacity as per company information in the public domain. ** Data as obtained for PP-II Expansion of 250 MW capacity

3.5 Spatial distribution

The seven coal-based utility-scale TPPs in Odisha are all located in the state's coal-producing and adjoining districts, such as Jharsuguda, Angul, and adjoining Dhenkanal, and Sundargarh. Considering the distribution of the 79 CPPs, while these are located across the state, about 69% of the capacity is concentrated in Angul, Jharsuguda, and Sambalpur districts.

Overall, about 88% of the coal-based power capacity (combining utility-scale and captive plants) is concentrated in five districts- Angul, Dhenkanal, Jharsuguda, Sundargarh, and Sambalpur, which are the hubs of coal mining and industrial operations. Among these, Angul has the maximum installed capacity, about 6.7 GW. Jharsuguda is a close second with about 5.7 GW installed capacity.

Map 3.1: District-wise distribution of coal-based power plants



Source: iFOREST analysis

3.6 Land availability

There is a considerable amount of land available with the utility-scale and captive TPPs in Odisha. As per plant-related data available for utility-scale TPPs, about 4,192 ha of land is available with various plants in four districts. Of this, the maximum share of land is concentrated in Talcher block of Angul district (36%) and Lakhanpur block of Jharsuguda district (about 24%). Considering industries, the maximum amount of land is available with NTPC. The largest share of the land is available with the Talcher STPS.

Besides, an estimated 5,904 ha of land is available with the CPPs operating in various districts.[11] About 69% of this land is concentrated in just three districts, Angul, Jharsuguda, and Sambalpur, the biggest industrial districts of the state.

Table 3.8: Land availability with utility-scale TPPs

District	Block	Company name	Plant name	Total land (ha)
Angul	Talcher	NTPC	Talcher STPS	1,502
	Banarpal	JITPL	Derang TPP	384
Dhenkanal	Odapada	GMR Energy Limited	Kamalanga TPS	425
Jharsuguda	Lakhanpur	OPGCL	IB Valley TPS	755
		IBPIL	Utkal TPP (IND Bharath)	240
	Jharsuguda	Vedanta Limited	Vedanta TPP	210
Sundargarh	Hemgir	NTPC	Darlipali STPS	676
Total				**4,192**

Source: Land area as per latest available environmental clearance letters and EIA reports of TPPs

Table 3.9: Land available with CPPs

District name	Total number of CPPs	Estimated land (ha)
Angul	3	1,309.4
Balasore	1	17.4
Bargarh	1	15.6
Bhadrak	2	67.3
Boudh	1	2.6
Cuttack	6	231.6
Dhenkanal	6	255.3
Ganjam	1	2.0
Jagatsinghpur	4	307.3
Jajpur	6	341.3
Jharsuguda	8	1,648.7
Kalahandi	1	46.8
Kendujhar	8	97.2
Koraput	3	59.6
Nabarangpur	1	1.6
Rayagada	5	82.1
Sambalpur	9	1,106.8
Sundargarh	13	311.1
Total	**79**	**5,903.7**

Source: iFOREST analysis based on a factor of 1.3 acres or 0.52 ha per MW

3.7 Employment and workforce

The employment in TPPs in the state (both utility-scale and captive) has been calculated as per data provided by some of the companies, and as per the manpower requirement curve provided by CEA for permanent employees for various capacities of TPPs with varied numbers of units (Norms for manpower requirement in thermal power sector, 2022).[12] For contractual workers, employment factors have been developed based on the data of some of the TPPs in Odisha.

Considering this, the total formal workforce associated with utility-scale TPPs is over 13,247. Among them, the number of permanent workers is 3,312. The number of contractual workers can be estimated to be three times the number of permanent workers as per estimates obtained from NTPC plants.

The total number of permanent workers with CPPs is estimated to be over 4,700. For contractual workers, going by the same estimates as utility-scale TPPs, the number of workers is estimated to be about 14,284 workers. Therefore, combining permanent and contractual workers, the CPPs employ about 19,000 workers.

Overall, it can be estimated that the coal-based power plants employ about 32,300 people. As per ground assessments, the estimated informal workers is about 1.5-1.8 times the formal workforce.

Table 3.10: Total employment in TPPs

Type of plant	No of permanent workers	No of contractual workers	Total number of formal workers
Utility-scale TPP	3,312	9,935	13,247
Captive TPP	4,762	14,284	19,046
Total	**8,074**	**24,219**	**32,293**

Source: iFOREST analysis

Table 3.11: District-wise employment in coal-based power plants

District	Manpower in utility-scale plants			Manpower in CPPs			Total formal workers in the district
	Permanent	Contractual	Total formal	Permanent	Contractual	Total formal	
Angul	1,136	3,408	4,544	992	2,975	3,967	8,511
Balasore				15	45	60	60
Bargarh				16	47	62	62
Bhadrak				65	195	261	261
Boudh				3	8	10	10
Cuttack				255	766	1,021	1,021
Dhenkanal	415	1,245	1,660	210	629	838	2,498
Ganjam				8	24	32	32
Jagatsinghpur				252	757	1,010	1,010
Jajpur				429	1,288	1,718	1,718
Jharsuguda	961	2,882	3,843	1,124	3,373	4,497	8,339
Kalahandi				41	122	163	163
Kendujhar				109	327	436	436
Koraput				43	127	170	170
Nabarangpur				2	6	8	8
Rayagada				60	184	244	244
Sambalpur				872	2,617	3,490	3,490
Sundargarh	800	2,400	3,200	265	795	1,060	4,260
Total	**3,312**	**9,935**	**13,247**	**4,761**	**14,285**	**19,047**	**32,293**

Source: iFOREST analysis based on company data, manpower requirement norms of Central Electricity Authority, 2024, and district-wise CPP data as obtained from GRIDCO, 2024

3.8 Environmental performance and operational efficiency

The environmental performance and operational effectiveness of TPPs has been assessed by considering fly ash generation and utilisation, installation of Flue Gas Desulfurization (FGD) equipment, and the plant load factor (PLF). Together, these factors have significant implications for mitigating GHG emissions from TPPs.

3.8.1 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. In December 2021, the Ministry of Environment, Forests and Climate Change (MoEFCC) issued a notification on fly ash (revising the earlier notifications), that prohibited 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 embankment.[13] Following the notification the TPPs are increasing their fly ash utilisation for various activities like brick making, cement, and road construction.

In Odisha, the fly ash generation and management information for utility-scale TPPs of the CEA shows that except for Vedanta and Kamalanga TPS, the fly ash utilisation does not follow the 100% utilisation recommendation. In fact, in IB Valley TPS and Darlipali STPS is it extremely low.[14]

Table 3.12: Fly ash generation and utilisation

Plant name	Fly ash generation (MMT)	Fly ash utilization (MMT)	Proportion of fly ash used (%)
IB Valley TPS	0.5278	0.1384	26.22
Vedanta TPP	1.4488	1.6641	114.86
Kamalanga TPS	1.0866	1.2591	115.88
Derang TPP	0.9867	0.7589	76.91
Utkal TPP	NA	NA	NA
Talcher STPS	3.2324	1.6723	51.74
Darlipali STPS	1.8316	0.3379	18.45

Source: Central Electricity Authority, Report on fly ash generation at coal and lignite thermal power plants and its use in the country, 2022-23.
NA- Not available

3.8.2 Plant load factor and FGD installation status

The plant load factor (PLF) is an important parameter to understand the operational efficiency of the TPPs. An analysis of the PLF of various TPPs shows that all of the utility-scale plants have a PLF of over 76%, suggesting that the plants are operating at optimal capacity.[15]

Considering the Flue Gas Desulfurization (FGD) installation status, The Environment (Protection) Amendment Rules, 2015 mandates all TPPs to integrate units as a means to mitigate sulfur dioxide (SO_2) emissions.

As per the FGD status reviewed for various TPPs it shows that all units of both the NTPC plants in Angul[16] and Sundargarh[17] districts have installed FGD. For the OPGCL-operated plants, the older units of the IB Valley TPS in Jharsuguda have not installed FGD. However, the newer units 3 and 4 have installed FGD.[18] The other plants have not installed FGDs as per available data at the time of the evaluation.

Table 3.13: Plant-wise PLF and FGD installation status

Company name	Plant name	Unit No.	Installed capacity (MW)	Age (as of Dec 2023)	PLF (%)	FGD status
OPGCL	IB Valley TPS	1	210	29	76.9	Absent
		2	210	28		Absent
		3	660	4		Present
		4	660	4		Present
NTPC	Talcher STPS	1	500	28	88.4	Present
		2	500	27		Present
		3	500	20		Present
		4	500	20		Present
		5	500	19		Present
		6	500	18		Present
Sterlite Energy Limited	Sterlite TPP	1	600	13	Not available	Absent
		2	600	13		Absent
GMR Energy Limited	Kamalanga TPS	1	350	10	77	Absent
		2	350	10		Absent
		3	350	9		Absent
JITPL	Derang TPP	1	600	9		Absent
		2	600	8		Absent
IBPIL	Utkal TPP (IND Barath)	1	350	7		Absent
NTPC	Darlipali STPS	1	800	4	80.8	Present
		2	800	2		Present

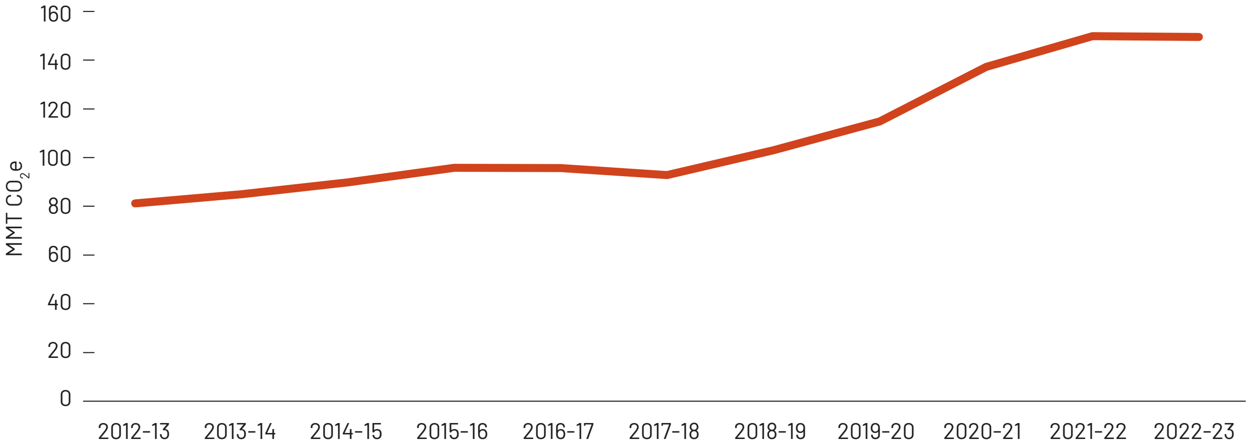
Source: Central Electricity Authority, 2023 and plant-level documents

3.9 GHG emissions

Coal-based TPPs are the single-largest source of GHG emissions in the state accounting for about 52% of total emissions. Emissions from TPPs have grown at a CAGR of 6.3% since 2012-13. As per the latest estimates, the emissions stand at over 149.7 MMT CO_2e.

This dominance reflects the state's dependence on coal for energy generation, which aligns with national trends but poses considerable challenges to climate action and energy transition efforts.

Figure 3.5: GHG emissions from TPPs



Source: iForest analysis

3.10 Just transition issues and opportunities

The transition towards a low-carbon economy presents significant challenges and opportunities for Odisha's coal-based thermal power plants. Given their critical role in the state's energy supply and employment, a planned and inclusive transition is essential to mitigate adverse socio-economic impacts while fostering sustainable development.

3.10.1 Energy transition strategy

To reduce GHG emissions, Odisha needs to plan a gradual phase-down of coal-based power generation over the coming years. However, given the state's energy demand, this transition requires a phased approach that aligns the reduction of coal-based power with the expansion of RE.

A strategic phase-down schedule for TPPs has been developed based primarily on the plants' age, assuming they will be decommissioned at the end of their average design life of 35 years. Other factors, such as operational efficiency, were not considered, as the state's TPPs generally maintain decent efficiency, as discussed earlier. Considering this, a prospective phase-down schedule in four phases is outlined for the utility-scale TPPs.

By 2030, three units, two units of OPGCL, and one unit of NTPC can be retired. The retirement of these 3 units will lead to a reduction in capacity of 920 MW. Between 2030 and 2040 five units with a cumulative capacity of 2,500 MW can be retired.

Between 2040 and 2050, there will be the maximum retirement of the TPP units. A total of seven units with a cumulative capacity of 3,450 MW can be retired. Post 2050 remaining five units with a cumulative capacity of 3,270 MW can be retired.

Overall, a phased and strategic approach to retiring TPPs in the state is essential for meeting both energy demand and achieving a just energy transition to meet the climate goals. The proposed phase-down schedule, based on the age and design life of the plants, outlines four distinct phases spread across the decades up to 2050 and beyond. As the analysis shows, given the state's relatively young fleet, there is no immediate challenge of closures in the coming years. Like the coal mining sector, the coal-based TPPs also have at least the next 10 years to plan for a transition so that there are no challenges to energy security and energy access. By gradually decommissioning units, starting with the oldest, the state can reduce its dependency on coal while ensuring a stable energy supply through the concurrent phase-in of RE sources.

3.10.2 Transition of CPPs

Odisha has a substantial number of CPPs, primarily fueled by coal. These plants help industries meet their energy demands while reducing reliance on the state's grid. However, the heavy dependence on fossil fuels for power generation in these plants contributes significantly to carbon emissions. With the state's ambition and potential for industrial growth, the number of captive plants will also increase. Therefore, it is important to plan a transition of the CPPs to green energy sources.

One of the most significant opportunities for energy transition in captive power plants is the integration of RE sources, such as solar, wind, and biomass. Odisha has considerable potential for solar energy (discussed below), which must be harnessed for the transition of CPPs.

On the policy side, the state government has developed incentives under the state's RE Policy of 2022 . Some of the key ones include:

- Fast-track approvals for captive RE projects.
- Exemption of fifty (50) paisa per unit on Electricity Duty to captive consumers on consumption of energy from RE projects set up inside the state during the policy period.
- Exemption of twenty (20) paisa per unit on STU charges to captive consumers on consumption of energy from RE projects commissioned in the state during the Policy period for 15 years. In case a project is commissioned before March 31, 2026, the exemption shall be extended for five more years.
- Exemption of 25% of wheeling charges to captive consumers on consumption of energy from RE projects commissioned in the state during the Policy period for fifteen (15) years.

Commensurate to the government policies, it will be important for the industries, including small and medium enterprises to invest in captive RE. Overall, the CPP units must accelerate RE integration to align with the Renewable Purchase Obligation (RPO) targets (43.33% overall RPO target by 2030) to support decarbonisation efforts.

3.10.3 Phasing-in RE

The development of RE infrastructure and augmenting RE investments will be crucial for Odisha's energy transition. The state currently has an installed capacity of about 628 MW. However, the state's potential for RE development is massive.

Table 3.14: Installed RE capacity

Category	Installed capacity (MW)
Solar	453.17
Small hydro	115.63
Biogas power	59.22
Total	**628.02**

Source: Central Electricity Authority General Review Report, 2024

As per estimates of the Ministry of New and Renewable Energy (MNRE), the potential for solar energy development in the state is about 25.8 GW. Besides, there is also significant potential for wind energy.

However, the potential of RE is far higher than even the MNRE estimates. As per an RE potential assessment undertaken by iFOREST, considering the modest use of wasteland and reservoirs in the state, the solar potential of the state is about 170 GW. In some districts, such as Koraput, Malkangiri, Kendujhar, and even the state's top coal district Angul, the solar potential is comparable to leading RE states like Karnataka and Gujarat.

The majority of the assessed solar potential is for ground-mounted solar projects. The potential is maximum in districts, such as Angul, Bolangir, Kendujhar, Koraput, and Malkangiri due to the higher concentration of large land patches with low socio-ecological conflict and substantially higher insolation.

For floating solar projects, large capacity projects of 1.5-3 GW can be set up at the Rengali, Tikilipada, Upper Indravati, Nabrangpur, Jalaput and Hirakund reservoirs. For solar rooftops, the potential is high in urban agglomerations. Bhubaneshwar block has the highest potential, followed by other urban blocks of Baleshwar and Jatani and the industrial blocks of Kujanga, Kuanrmunda, and Jharsuguda.

Table 3.15: RE potential

Category	MNRE estimates (MW)	iFOREST estimates (MW)
Solar	25,780	170,000
Biomass	246	3,400
Wind	8,346 (120m)	86 high-potential sites were identified with an average CUF of 22%-29% at 150 m hub height across 16 districts. Need detailed ground-level assessment

Source: iFOREST analysis

The state government is taking proactive policy measures to support green energy development. The state has developed a progressive RE Policy 2022, that aims to add about 11 GW of RE capacity by 2030.[19]

3.10.4 Repurposing retired TPPs for green energy development

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.

Odisha has six TPP units with a cumulative capacity of 0.46 GW that were retired between 2021 and 2022 for techno-economic reasons. Besides, about 1.4 GW capacity combining four TPP units can be retired by 2035. These include two units (200*2=400 MW) of the IB Valley TPS and two units (500*2=1,000 MW) of Talcher STPS. Repurposing the retired units into green energy and green industry infrastructure, such as for RE, battery energy storage systems (BSES), green hydrogen plants, etc. provides significant opportunities for supporting green energy and industry development, creating jobs, and strengthening state-level climate action.

3.10.5 Transition of the workforce

The phasing down of coal-based power plants, and particularly the phasing in of RE in Odisha will create demand for reskilling the existing workforce and developing future workforce.

Odisha is embarking on an ambitious plan to transition from coal-based energy generation to a RE-driven power system with a target of achieving 10 GW of installed RE capacity by 2030. This shift not only aligns with the state's broader decarbonisation goals but also presents significant opportunities for socio-economic development, including job creation and local enterprise growth.[20]

However, the transition also poses challenges, particularly in terms of workforce readiness and skills availability. Given that a substantial segment of the existing workforce is currently employed in coal-based industries, there is an urgent need to undertake systematic reskilling and capacity-building initiatives to ensure that the transition is both socially just and economically beneficial.

The collaboration of the State Government and industry will be essential to develop the workforce for roles in RE system. 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.

The government and the industry should undertake targeted measures to facilitate the inclusion of local communities, particularly those in coal-dependent regions, in the emerging RE value chain through targeted training, capacity building, and entrepreneurship development programs. The deployment of these measures should be aligned with the state's target of 11 GW of RE capacity by 2030.

SECTION III
FACTORIES

Factories Overview

According to the Annual Survey of Industries 2021-22, Odisha has 3,207 factories of which 2,697 were operational during the reference year 2021-22. The factories collectively employ about 3.2 lakhs (0.32 million) people.[1]

Despite a modest share of 1.2% of the total number of factories in India, the state ranks third in terms of fixed capital investment, accounting for 8.38% of the national total. This signifies the presence of large, capital-intensive industrial units in the state such as steel, aluminum, and cement.[2]

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

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

b) Sectors that will go through technological disruptions due to energy and environmental transition. From an energy transition perspective, this will include the manufacturing of electric motors, generators, batteries, wiring and wiring devices, lighting equipment, domestic appliances, etc. From an environmental transition perspective, this will include the 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.

ENERGY TRANSITION IMPACT ON FACTORIES

The energy transition will impact various fossil fuel-dependent factories in Odisha 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: Sectors including iron and steel, coke ovens, refined petroleum products, electric motors, generators, batteries, cement, bricks, refractories, automobile and automobile components, basic chemicals, fertilizer, and nitrogen compounds, among others, will be highly impacted. Also, those involved in waste treatment, disposal, and material recovery will be highly impacted.

Overall, the high-impact segment includes over 40% of total factories in the state. These factories are highly significant for the economy as they account for 90.9% of the economic output and 92.3 % of the GVA from all factories. The segment also accounts for 95.7% of total energy use in factories. Considering the workforce, they account for over 78% of the total factory employment and engage 80% of all factory workers. Besides, considering National Sample Survey estimates, about twice informal workers are engaged by these factories. This segment also has a very high share of women workers, which is about 71% of all women workers (total women workers in factories is 16,403) engaged in various factories.

Medium impact: Sectors including fabricated metals, pulp and paper, and pharmaceuticals, among others, will be moderately impacted due to the direct use of fossil fuels like coal and natural gas for process heat and electricity.

Overall, the medium-impact segment includes about 36% of the total factories. It accounts for 4.7% of the total economic output and 5.4% of the GVA from all factories. Considering the workforce, the segment accounts for about 11.5 % of the total employment and 10.7% of the total workers employed in factories. Besides, considering similar proportion of informality as per the National Sample Survey, the informal workers are nearly double.

Box continued

Low impact: Sectors including, food processing, wood-processing and product industries, tobacco, computer and electronics, consumer goods, types of machinery, etc., will have low impact from the transition.

Approximately 24% of the factories will face low impact from the energy transition as these have very low energy consumption and are responsible for about 0.8% of the total energy usage. It accounts for 4.4 % of the economic output and 2.3 % of the GVA from all factories. Considering the workforce, the segment accounts for 10.2 % of the total employment and 9.3 % of the total workers employed in factories.

Characteristics of industries likely to be impacted by the energy transition

Characteristics	All factories	High impact		Moderate impact		Low impact	
		Value	Share of total (%)	Value	Share of total (%)	Value	Share of total (%)
1. Number of factories	3,207	1,297	40.4	1,149	35.8	761	23.7
a. Number of factories in operation	2,697	1,057	39.2	941	34.9	699	25.9
2. Total output (₹ Lakh)	4,68,79,707	4,26,12,003	90.9	22,03,707	4.7	20,63,997	4.4
3. Gross Value Added (GVA) (₹ Lakh)	1,00,09,291	9,236,293	92.3	5,41,582	5.4	2,31,416	2.3
4. Number of persons engaged	3,20,649	2,51,105	78.3	36,882	11.5	32,662	10.2
5. Total number of workers	2,70,401	2,16,370	80	28,797	10.7	25,234	9.3
a. Percentage of workers employed through contractors (%)	58.4	61.7		47.8		42.2	
b. Number of directly employed women workers	16,403	11,701	71.3	589	3.6	4,113	25.1
6. Total energy use (as per cost in ₹ Lakh)	35,05,724	33,55,888	95.7	1,20,600	3.4	29,236	0.8

Source: Analysis based on Annual Survey of Industries data, 2021-22, Government of India

CHAPTER 4

Iron and Steel

4.1 Overview

India is the second largest producer of crude steel with a capacity to produce 179.5 MMT of crude steel per year. The country also has the largest production capacity of sponge iron in the world which stood at 55 MMT in 2023 -24.[3]

In 2023-24, the country produced over 144.3 MMT of crude steel, marking an increase from the 127.2 MMT produced in 2022-23. The private sector dominating the steel industry accounted for 83% share of the total crude steel production. Overall, the steel sector has grown steadily over the past years (since COVID), from 103.5 MMT in 2020-21 to 144.3 MMT in 2023-24.[4]

In terms of consumption, India is the world's second-largest consumer of finished steel after China. The domestic consumption of finished steel stood at 119.17 MMT in 2022-23.[5]

The steel sector is poised for expansion in the coming years supported by government policies, and growing demand in the domestic and international markets for construction. The National Steel Policy 2017 envisages achieving up to 300 MMT of production capacity by 2030-31, while making the Indian steel industry technologically advanced and globally competitive.[6] The policy also seeks to increase the domestic per capita consumption from the current 97.7 kg per year (which is one-third of the global average) to 158 kg per year by 2030.[7]

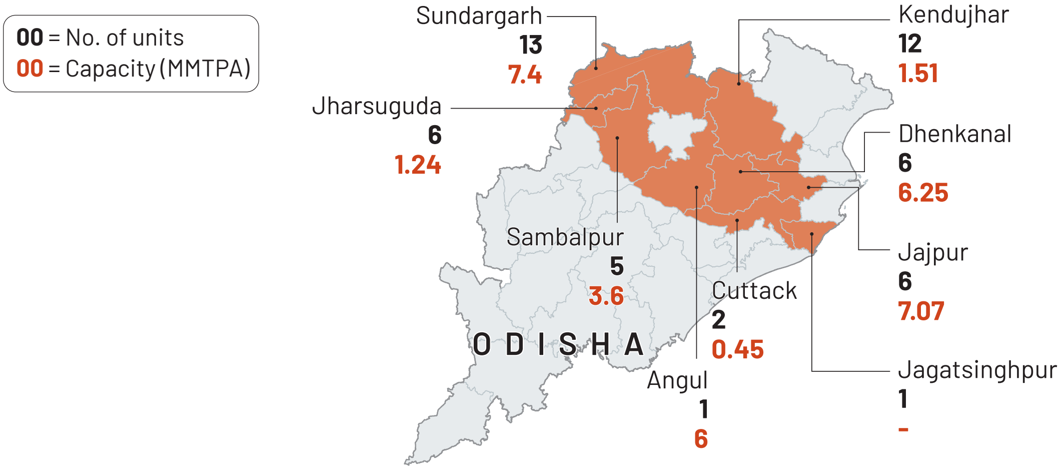
Odisha produces about half of the country's iron ore and is the largest producer of crude steel in India.[8] As per the latest information from the Department of Steel and Mines, the state has a total crude steel production capacity of 33.5 MMTPA, which is about 21% of the country's total The state is the largest producer of stainless steel in the country and has more than 20% of the steelmaking capacity.[9] Odisha's capacity of crude steel production is expected to be 100 MMTPA by 2030.[10] Major producers like TATA Steel, Jindal Stainless Steel (JSL), and Jindal Steel and Power Limited (JSPL) who have a robust presence in the state are going to lead the state's growth target. Besides, players like Arcelor Mittal Nippon Steel India are tying up with the government to establish new plants. In 2021 the company and the Odisha government signed an MoU to establish a 12 MMT integrated steel plant with an investment worth ₹50,000 crore.[11]

4.2 Production and spatial distribution

Odisha has a large number of iron and steel units (including units producing sponge iron, crude steel, and finished steel products). As noted, the state has 52 iron and steel plants with a crude steel production capacity of 33.5 MMTPA.[12]

The crude steel-making units are distributed across eight districts in the state. Sundargarh has the highest crude steel production capacity of over 7.4 MMTPA, with Rourkela, Odisha's steel capital being situated in the district. Overall, Sundargarh and adjoining Sambalpur and Jharsuguda districts constitute the largest crude steel-producing region with 24 plants and a cumulative production capacity of over 12.5 MMTPA. The other key steel production clusters include Angul and Dhenkanal districts, with about 12.25 MMTPA collective production capacity.

Map 4.1: Distribution of crude steel-producing plants



Source: Department of Steel and Mines, Government of Odisha, 2024; For Jagatsinghpur capacity not shared.

Besides crude steel units, there are 83 sponge iron units. These units are spread across various districts in Odisha with the largest concentration being in Sundargarh and Kendujhar, the two largest iron ore-producing districts of the state.

ODISHA'S SPONGE IRON INDUSTRY

Sponge iron, also known as direct reduced iron (DRI), is a cost-effective way to produce steel. Sponge iron production in Odisha is a significant industrial activity, with numerous units across nine districts. There are 83 units with a total production capacity of 13,387.7 MMTPA. Sundargarh district, a major producer of iron ore and also coal has nearly 50% of the units. The sponge iron segment is estimated to employ over 22,700 workers.

The process of producing sponge iron is energy-intensive, with coal being the major fuel. The quality of coal used in these plants also poses a significant challenge to the environment as it is low-grade (E or F grade) with high ash content and low fixed carbon. This low-grade quality contributes to both operational efficiency and local environmental pollution. Sponge iron plants emit large quantities of pollutants, including oxides of sulfur and carbon, unburnt carbon, and silica particles.

Table 4.1: District-wise sponge iron-making units

Districts	No. of units	Production capacity (MMTPA)	Estimated manpower
Angul	3	2.0	3,315
Cuttack	3	0.4	621
Dhenkanal	3	1.7	2,899
Jajpur	3	0.3	561
Jagasinghpur	Not specified	Not specified	
Jharsuguda	6	0.5	859
Kendujhar	14	1.9	3,205
Sambalpur	9	3.3	5,632
Sunderghar	41	3.3	5,525
Khordha	1	0.1	143
Total	**83**	**13.4**	**22,759**

Source: Joint Plant Committee, Indian Iron and Steel Database-2022-23; Workers estimated as employment factor derived from EC letters of sponge iron units; Bureau of Energy Efficiency, Ministry of Power, Government of India. Manual on energy conservation measures in sponge iron manufacturing cluster Orissa. 2011. https://sameeksha.org/pdf/clusterprofile/ODISHA_SPONGE_IRON_CLUSTER.pdf

IRON ORE MINING IN ODISHA

Odisha is India's top iron ore producer accounting for over 50% of India's total iron ore production. In 2023-24 the state produced 169 MMT of iron ore.

There are 67 iron ore mines operating in the state with a production capacity of 297 MMTPA. The mines are spread across four districts, including Kendujhar, Sundargarh, Mayurbhanj, and Jajpur. However, 94% of mines are concentrated in Kendujhar and Sundargarh, with both these districts accounting for 97% of the production capacity.

Overall, the mines cover an area of 22,124 ha in the state. Kendujhar district with the largest share of mines has about 13,968 ha of land under iron ore mines.

There is significant employment dependence on the iron ore mines in the state. Applying an employment factor approach based on employment estimates in iron ore mines by the Indian Bureau of Mines, it can be estimated that over 31,800 workers are formally employed by these mines.

Table 4.2: Iron ore mines

District	No. of mines	Production capacity (MMTPA)	Lease area (ha)
Kendujhar	34	175.4	13,968
Sundargarh	29	113.5	6589.1
Mayurbhanj	3	2.3	549.1
Jajpur	1	6	1018.31
Total	**67**	**297.2**	**22,124**

Source: Department of Steel and Mines, Government of Odisha, 2024; Indian Bureau of Mines. (2023). Indian Mineral Yearbook 2022. https://ibm.gov.in/writereaddata/files/17125794946613e3a6b3a5dIron_ore_2022.pdf

4.3 Employment and workforce

The iron and steel plants (crude steel producing plants) employs a large number of people formally and informally. As per information provided by the Odisha State Pollution Control Board (OSPCB), more than 1.5 lakh workers are engaged in the steel plants in the state as direct and indirect workers. The highest number of workers are in Jajpur (22.3%), Sambalpur (16.7%), Sundargarh (16.4%), Dhenkanal (16.8%) and Angul (14.7%) districts, which in total have 87% of total iron and steel sector workers of Odisha. Besides, as noted earlier, the sponge iron units are estimated to employ over 22,700 workers.

Table 4.3: District-wise workforce in crude steel-making units

District	Direct workers	Indirect workers	Total workforce
Angul	4,024	18,450	22,474
Cuttack	734	1,841	2,575
Dhenkanal	5,497	20,202	25,699
Jagasinghpur	436	1,611	2,047
Jajpur	9,707	24,317	34,024
Jharsuguda	2,840	4,328	7,168
Kendujhar	3,697	4,398	8,095
Sambalpur	8,219	17,351	25,570
Sundargarh	12,990	12,025	25,015
Total	**48,144**	**1,04,523**	**1,52,667**

Source: As per data provided by OSPCB, 2024

4.4 Production process and technology

The Indian steel industry is primarily reliant on coal-based blast furnaces. Consequently, the emission intensity of steel produced in India is 2.54 tonnes CO_2 /tonne crude steel (tCO_2 /TCS), which is significantly higher than the global average of 1.91.[13]

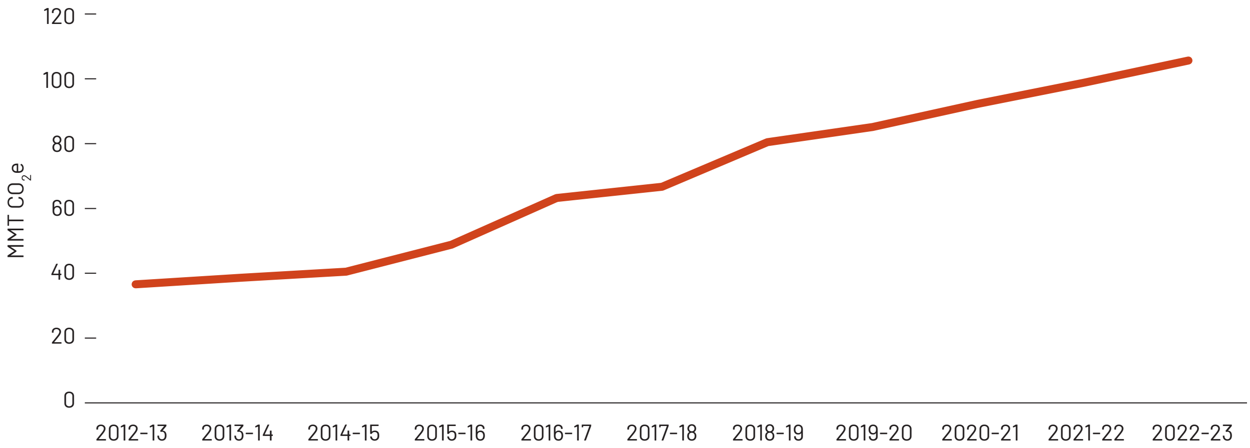
In Odisha, for the production of crude steel blast furnace and electric furnaces are used. An analysis of furnaces by various crude steel-producing units shows that most of the units (47) use electric furnaces accounting for a total production capacity of 17.1 MMTPA. The remaining five units using blast furnace account for 16.4 MMTPA production capacity, which is about half of the total capacity.

4.5 GHG emissions

The iron and steel industry is a major contributor to GHG emissions in India.[14] As of 2023, the sector accounts for approximately 5% of the country's total GHG emissions. This is significant given that India is the second-largest steel producer in the world, with production and demand expected to rise rapidly in the coming years.[15]

The GHG emissions from the steel sector in Odisha have rapidly grown over the last decade. Emissions have increased at a CAGR of 11.2% since 2012-13. As per the latest estimates for 2022-23 (undertaken by iFOREST), the GHG emissions from the sector stand at 105.7 MMT CO_2e.

Figure 4.1: Emissions from the steel industry



Source: iFOREST analysis

4.6 Just transition issues and opportunities

The Indian steel sector is a critical contributor to the nation's economic growth and infrastructure development. However, it is also one of the highest-emitting industries. To align with India's national climate targets and the global ambition of net-zero emissions, the steel sector must undergo a fundamental transformation.[16] Odisha being the country's top steel producer will have a key role in the just energy transition of the sector.

i. Greening production process and material use

The Ministry of Steel's report (August 2024) identifies six key transition levers for the steel sector. These include enhancing energy efficiency, material efficiency, RE use, process transition, green hydrogen adoption, and deployment of carbon capture, utilization, and storage (CCUS) technologies. Each of these strategies offers unique opportunities to significantly reduce the carbon footprint of the steel sector while ensuring its competitiveness and growth.[17]

For example, energy efficiency improvements can significantly reduce the emissions intensity of steel production while also cutting production costs. The Perform, Achieve, and Trade (PAT) scheme by the Bureau of Energy Efficiency (BEE) has been effective, with the steel sector achieving total energy savings of 6.137 Mtoe by Cycle V (2019-22), surpassing the target of 4.575 Mtoe.

However, the energy intensity of Indian steel production still remains high. The average specific energy consumption (SEC) for the blast furnace-basic oxygen furnace (BF-BOF) route is 6.0-6.5 Gcal/tcs, as compared to the global average is 4.5-5.0 Gcal/tcs. The application of some of the best available technologies (BAT) can help in improving energy efficiency of the steel sector and also reduce its CO_2 emissions. Some of the key technologies that can be used at integrated plants are outlined in Annexure 1.

Similarly, RE penetration in the steel industry will be a crucial decarbonisation strategy. As per the Ministry of Steel, the share of RE in the steel sector's electricity consumption was 7.2% in FY 2021-22. This can significantly improve with RE penetration targets set at 43.33% by 2030 by the Ministry of Power. The steel sector is expected to achieve up to 35% RE penetration by incorporating renewable sources in captive power generation and compliance with the Renewable Purchase Obligation (RPO).

Besides RE penetration, the use of green hydrogen by the sector will also be important. Green hydrogen can substitute coal use in blast furnaces and gas-based shaft furnaces, reducing CO_2 emissions significantly.

Besides shifting to green energy in the coming years improvements in material use and efficiency will also be important. The key measures will include beneficiation, pelletisation, and enhanced scrap utilization. These strategies can enhance resource efficiency and reduce overall emissions.

Overall, Odisha with its significant share of India's steel production holds a pivotal position in achieving India's industrial decarbonisation and energy transition goals. The state has an ambitious plan for developing green hydrogen/green ammonia hubs and developing a dedicated policy. One of the initiatives the state can take is to ensure that the future steel plants are hydrogen-ready. The steel sector's growth trajectory also needs to be aligned with the decarbonisation vision for the sector set forth by the Ministry of Steel, including enhancing energy efficiency, material efficiency, RE use, process transition, and deployment of carbon capture, utilization, and storage (CCUS) technologies.

ii. Policy support for green steel

The GoI 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. 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 PAT scheme under the National Mission for Enhanced Energy Efficiency, which incentivises the steel industry to reduce energy consumption.[18]

iii. Industry initiatives

India's steel industry is actively exploring and implementing various initiatives to promote green steel production, aligned with the country's broader decarbonization and climate commitments. Several steel companies, such as Tata Steel[19] and JSW Steel[20], are evaluating the use of green hydrogen for steelmaking. Tata Steel has also pledged to explore CCUS technologies to capture and reuse CO_2 emissions from steel plants.[21]

The Steel Authority of India Limited (SAIL) and other major players have also initiated pilot projects and collaborations to develop and scale up green steel technologies, often partnering with international agencies and technology providers.[22]

iv. Workforce transition

A key issue for the 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 the 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 decarbonisation. For this, policies by the government as well as the enterprises will be required.

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 the need to create and empower educational institutions to meet evolving skill demands.

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

Overall, for a successful workforce transition in Odisha's steel sector, it is essential for the State Government, training institutions, and industry leaders to collaborate effectively. Key institutions like the Biju Patnaik National Steel Institute and the World Skill Centre, alongside industry stakeholders, can play a pivotal role in establishing a robust skilling and workforce development ecosystem. This coordinated approach will equip the local workforce with the necessary skills to meet the demands of the emerging green steel sector, fostering job opportunities and ensuring Odisha remains competitive in a low-carbon economy.

CHAPTER 5

Aluminium

5.1 Overview

India is the second largest aluminium producer in the world accounting for about 7% of the total production in 2023-24.[23] The production of aluminium in the country was recorded at 4.16 MMT.[24] The rich bauxite reserves offer a significant competitive advantage for aluminium production in the country.

India's aluminium industry is dominated by four major primary producers, viz., National Aluminium Company Limited (NALCO), Hindalco Industries Ltd., Bharat Aluminium Company Ltd. (BALCO), and Vedanta Aluminium Ltd. These companies have a strong presence and are now expanding further. Key sectors expected to drive aluminium consumption in the country include automotive, power, electronics, railways, aerospace and defence, construction, solar energy, and aluminium packaging.[25]

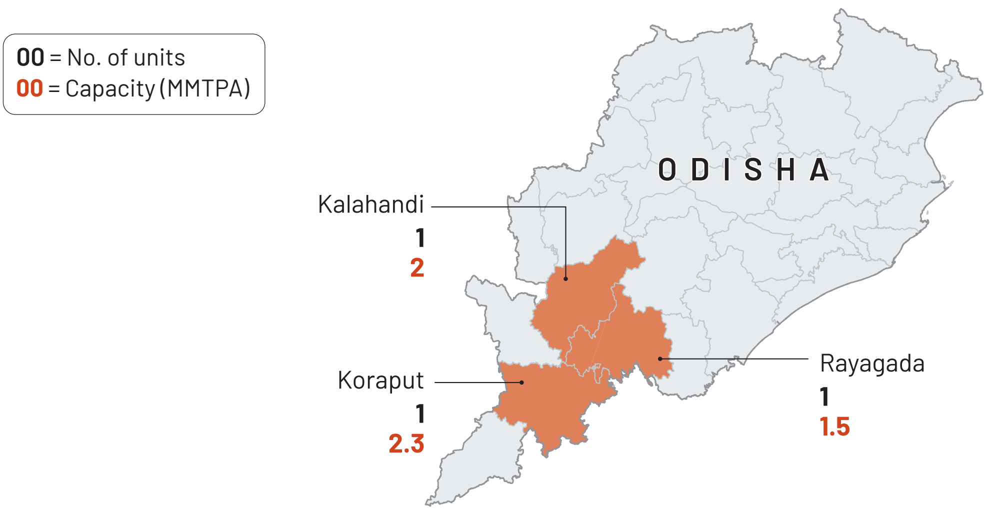
Odisha is the largest aluminium-producing state in India, accounting for 54% of the country's aluminium smelting capacity. The state also has almost 75% of India's total bauxite reserves which has supported the growth of the industry in the state.[26] Major industry players such as NALCO, Hindalco, and Vedanta have aluminium refineries and smelters in Odisha.

5.2 Production and spatial distribution

Odisha has three alumina refineries and four aluminium smelting plants. The three refineries have a combined processing capacity of about 5.8 MMTPA. These refineries are located in rural districts of the state, including Koraput, Rayagada, and Kalahandi.

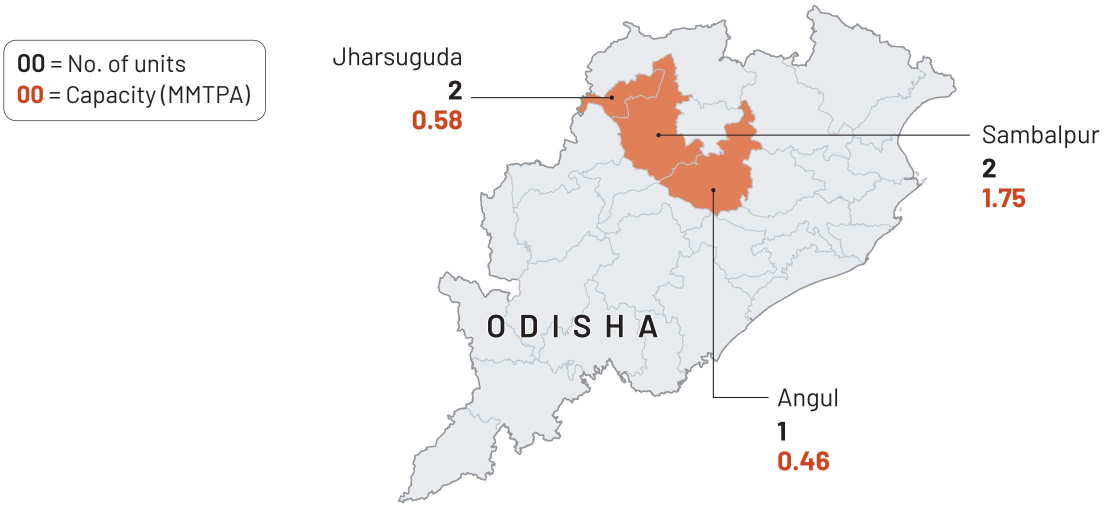
The five aluminium smelters, with a combined production capacity of about 2.8 MMTPA are primarily concentrated in the industrial districts of Angul, Jharsuguda, and Sambalpur. The NALCO integrated Bauxite-Alumina-Aluminium- Power Complex is one of the largest in the country.[27]

Map 5.1: Capacity and distribution of alumina refineries



Source: Indian Mineral Yearbook, 2022

Map 5.2: Capacity and distribution of aluminium smelters



Source: Indian Mineral Yearbook, 2022

BAUXITE MINING IN ODISHA

Odisha's bauxite reserves are some of the richest in the country, enabling the state to produce a substantial portion of India's total bauxite output, which is used for refining alumina and further producing aluminum. The state is the largest producer of bauxite in India producing about 17 MMT of bauxite in 2023-24. Bauxite is mined extensively in districts like Koraput, Kalahandi, and Rayagada.

Overall, there are five mines in Odisha with a total production capacity of 21.6 MMTPA. The mines cover an area of 3,849 ha in the state. Koraput district with the largest share of mines has about 2,272 ha of land under bauxite ore mines.

The bauxite mines are an important source of employment in districts where the mines are located. Applying an employment factor approach based on employment estimates in bauxite mines by the Indian Bureau of Mines, it can be estimated that over 4,830 workers are formally employed by these mines.

Table 5.1: Bauxite mines

District	No. of mines	Production capacity (MMTPA)	Lease area (ha)
Koraput	3	12.98	2,271.6
Sundargarh	1	0.13	188.5
Rayagada	1	8.5	1388.7
Total	**5**	**21.61**	**3,848.8**

Source: Department of Steel and Mines, Government of Odisha, 2024; Source: Indian Bureau of Mines. (2023). Indian Mineral Yearbook 2022. https://ibm.gov.in/writereaddata/files/170987945265eab09cd2f82Bauxite_2022.pdf

5.3 Employment and workforce

The aluminium smelters in Odisha employs about 15,398 workers as per official data. This includes both permanent and contractual workers.[28] The total employment numbers could be much higher owing to various informal employments in the downstream and ancillary industries in aluminium like conductors, extrusions, castings, and raw materials manufacturing.

While no employment data was shared for alumina refineries, however, from the environmental clearance letters of the companies operating in the state (such as Hindalco Industries Ltd.)[29] and by applying an employment factor approach, it can be estimated that the refineries in Odisha collectively employ about 4,300 workers (combining permanent and contractual).[30]

Therefore, overall, it can be estimated that the aluminium industry in Odisha employs about 19,698 workers formally.

Table 5.2: Employment in aluminium smelters

Smelter	District	Permanent workers	Contractual workers	Total workforce
Aditya Smelter	Sambalpur	1,314	3,559	4,873
Hirakud Smelter		1,480	2,652	4,132
Nalco Smelter	Angul	2,107	4,286	6,393
Vedanta Smelter	Jharsuguda	1,233	2,467	3,700
Total workforce		**4,901**	**10,497**	**15,398**

Source: Data as provided by SPCB, 2024

5.4 Just transition issues and opportunities

Aluminium production is an energy-intensive process and requires a constant supply of electricity.[31] Any effort to produce low-carbon aluminum has to directly address the supply of electricity required for the smelting process, in which aluminum is extracted from its oxide, alumina. About 80% of primary aluminum GHG emissions are generated from smelting.[32] In Odisha, the GHG emissions from the aluminium sector have increased at a CARG of 10% from 2012-13 to 2022-23. As per the latest estimates for 2022-23 (undertaken by iFOREST), the GHG emissions from the sector stand at 4.5 MMT CO_2e.

The following are some of the key opportunities for ensuring a just energy transition of the aluminium sector in India.

i. Use of RE and other technologies

As per global best practices, the following can be considered for decarbonising the sector. These include direct electrification using RE, using green hydrogen, and using CCUS.[33]

As most of the primary aluminum GHG emissions come from the electricity used in smelting, a direct way to reduce these emissions is to source electricity from low-carbon or RE sources such as hydroelectric, solar, or wind power.[34]

Enhancing energy efficiency in both alumina refining and aluminium smelting processes will also be important. This includes adopting advanced technologies and practices that minimise energy consumption, which currently accounts for approximately 80% of total emissions in aluminium production. Implementing energy-efficient technologies can significantly reduce the carbon footprint of the industry.[35]

Addressing these factors can help decarbonise the aluminum industry and contribute to the production of low-carbon aluminum, which is becoming increasingly important given the growing demand for sustainable materials in sectors like automotive, construction, and packaging.

ii. Industry initiatives

The industry players are also taking the initiative to use RE sources in production. For example, in 2022, Vedanta Ltd. announced long-term sourcing of 380 MW of RE for the companies aluminium smelters. Of this, 180 MW will be supplied to the smelter at Jharsuguda. This will be carried out through a Power Delivery Agreement (PDA) between Vedanta Aluminium Ltd. and Special Purpose Vehicles – affiliates of Sterlite Power Technologies Pvt. Ltd. (SPTPL), a company engaged in the business of supplying renewable power (hybrid) with solar, wind and storage solutions.[36]

iii. Workforce transition

A just energy transition for the aluminium sector should also include plans to support workers and communities that may be affected by the shift to low-carbon production methods. The primary measure will involve reskilling and upskilling the workforce to equip them for changing technologies and processes and emerging roles in the green economy.

CHAPTER 6

Cement

6.1 Overview

The cement industry in India is the second largest in the world with an annual production capacity of about 600 MMT, which is about 8% of the global capacity. In 2023-24 the country produced over 426 MMT of cement[37].

The cement industry in India is set to experience robust growth in the coming years. Cement demand is expected to increase significantly driven by a surge in infrastructure projects, urban development, and industrial capital expenditure. This demand is projected to reach between 550 and 600 MMT by 2025[38]. On the supply side, the industry is witnessing significant capacity additions. Between FY 2025 and FY 2026, around 63-70 MMT of capacity is expected to be added[39]. While the cement industry in India is primarily concentrated in the Southern and Northern states, the eastern and southern regions are expected to lead this expansion in the coming years.[40]

6.2 Production and spatial distribution

There are 20 cement plants in Odisha, including integrated units, grinding units, and clinker units. Among these, three are integrated plants, 15 are grinding units and two are clinker units.

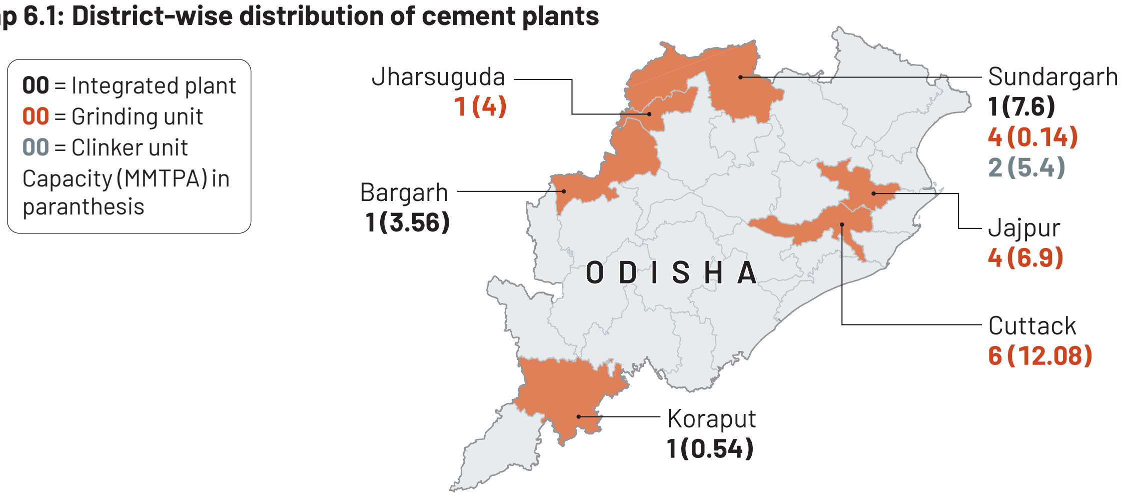
Table 6.1: Number and capacity of cement plants

Type of Unit	Number of units	Total consented capacity (MMTPA)
Integrated unit	3	11.7
Grinding unit	15	23.12
Clinker unit	2	5.4

Source: Odisha State Pollution Control Board, 2024

A district-wise assessment of the cement-producing units shows that Sundargarh has the highest number of units followed by Cuttack and Jajpur. In terms of type of cement, Portland Cement is the most commonly produced cement in Odisha.[41]

Map 6.1: District-wise distribution of cement plants



Source: Odisha State Pollution Control Board, 2024

LIMESTONE MINING IN ODISHA

Limestone mining plays a critical role in Odisha's economy, serving as a key resource for industries such as cement and construction. Odisha has six limestone mines, with a total production capacity of 17.5 MMTPA.

The mines cover an area of 2,604 ha in the state. Sundargarh district with the largest share of mines has about 1,895 ha of land under limestone ore mines.

Concerning employment, applying an employment factor approach based on employment estimates in limestone mines by the Indian Bureau of Mines, it can be estimated that over 865 workers are formally employed by these mines.

The limestone mined from these regions supports a growing industrial base in the state, with particular demand coming from the cement and steel sectors. The quality of the limestone deposits in Odisha is suitable for large-scale industrial use, which has fueled consistent production levels.

Table 6.2: Limestone mines

District	No. of mines	Production capacity (MMTPA)	Lease area (ha)
Bargarh	1	1.7	428.91
Koraput	1	0.35	280.77
Sundargarh	4	15.43	1,894.55
Total	**6**	**17.48**	**2,604.23**

Source: Indian Bureau of Mines. (2023). Indian Mineral Yearbook 2022. https://ibm.gov.in/writereaddata/files/17125769676613d9c707156Limestone_2022.pdf

6.3 Employment and workforce

The employment in the cement sector has been estimated based on the employment factor approach. The estimated employment in cement factories in Odisha is over 6,100 formal workers. The number of informal workers couldn't be estimated, but they are likely to be of the same magnitude as formal workers.

Table 6.3: Employment in cement plants

District	Integrated plant	Grinding unit	Clinker units	Total
Bargarh	875	-		875
Cuttack	-	1,208		1,208
Jajpur	-	690		690
Jharsuguda	-	400		400
Koraput	74	-		74
Sundargarh	1,505	14	1,350	2,869
Total	**2,454**	**2,312**	**1,350**	**6,116**

Source: iFOREST analysis
*The employment factor derived based on data available in EIA reports is 350 workers per MMTPA for integrated units 250 workers per MMTPA for clinker unit and 100 workers per MMTPA for grinding units were considered for calculation.

6.4 Just transition issues and opportunities

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 m2 in 2017 to 6.8 billion m2 by 2047. Reliability of primary construction materials, such as cement and steel, will be essential to meet this demand[42].

For India to meet its net zero target and to reduce the emission intensity of the country's GDP, for which the building and construction sectors are significant contributors, the energy transition of the cement industry is essential. Reduction of emissions 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. Additionally, measures need to be adopted for a transition of the workforce aligned with the technological shift in the sector.

i. Material use

Reducing the clinker content of cement will be important to reducing the process emissions in the sector. 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.[43] 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[44].

To decarbonise 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[45]. Besides, there are considerations for the use of Supplementary Cementitious Materials (SCM), such as geopolymer/alkali activated cement, calcium sulfo-aluminate (CSA) cement, magnesia binder, celitement, etc., that will help reduce the use of clinker for cement production[46]. Clinker demand can also be reduced through innovations in construction, design, and material mixes and developing low- binder cement and reusable concrete modules.

ii. Using non-conventional fuels

The cement industry currently relies heavily on coal-based energy. 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.[47]

iii. Alternative technological opportunities

Technological opportunities alongside 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.[48]

iv. 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 Odisha, it will also be important to develop the future workforce for the cement industry considering investment considerations by big players of the cement industry in the Eastern states.[49]

v. Policy support

The cement industry lacks a comprehensive decarbonisation 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[50]. 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[51].

vi. Private sector initiatives

The cement industry's energy transition is highly dependent on the engagement and initiatives of private sector players. Leading companies such as JSW Cement, Dalmia Cement, and Ramco Cements are taking significant steps to support the sector's green transformation through investments in technology, innovation, and sustainable practices. These companies are already producing green cements and have committed to reducing their carbon footprint

For example, Dalmia Cement stands out with its ambitious goal to become carbon-negative by 2040. It is also setting up the world's largest carbon capture facility in the cement sector, which demonstrates the company's leadership in adopting cutting-edge technology to address climate challenges[52].

Overall, a 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.

Overall, it will be important for Odisha to reduce the industrial production process-related emissions to reduce the state's overall emission intensity of its economy. As per estimates, given large-scale industrial activities, the Industrial Processes and Product Use (IPPU) contributes significantly to the overall GHG emissions in the state, with a share of 4.3% of the total emissions . The emissions from IPPU have increased at a CAGR of 9.7% in the last decade in the state and currently stand at about 12.5 MMT CO_2e.Therefore, developing a comprehensive industrial decarbonisation pathway in the coming years is crucial for the state.

SECTION IV

BUILDING AND CONSTRUCTION

Chapter 7: CONSTRUCTION SECTOR

CHAPTER 7

Construction Sector

7.1 Overview

The building sector is growing rapidly in India due to the rising demand for housing, commercial spaces, and infrastructure. The housing sales, for example, are estimated to rise by 30% in 2023 as compared to the previous year and reach a record of 4.74 lakh units. Considering the current rate of urbanisation and various government initiatives such as Make in India, Housing for All, and Smart Cities, the demand for major building materials is expected to grow substantially in the coming decades.[1]

The manufacturing of building and construction materials, such as cement, steel, aluminium, are resource and energy-intensive process. The foundation of construction in buildings, particularly in urban and peri-urban areas relies on reinforced concrete and steel frames. Around 60 million tonnes of cement and 14 million tonnes of steel were used for urban construction in India in 2020[2]. The production of these is energy and material-intensive (as discussed in the earlier section) and contributes to embodied emission of the sector.

Overall, buildings currently account for over 40% of the country's total energy consumption, increasing at an annual rate of 8% (including embodied plus operational). In addition to its high energy demand, the building and construction sector contributes 32% to India's total GHG emissions (with embodied emissions making up 40% and operational emissions accounting for 60%).[3]

If traditional building practices continue, buildings could be responsible for more than 70% of India's emissions by 2050[4]. Thus, transitioning this sector towards energy efficiency and sustainability is crucial for achieving India's net-zero targets and broader climate goals.

7.2 Construction sector in Odisha

The construction sector is an important component of Odisha's economy contributing 6.9% of the State GSVA and 16% of the industrial GSVA in 2023-24.[5] The sector is also a significant employment generator. As of 2022-23 estimates, 17% of the total workforce in the state is engaged in the construction. This is considerably higher than the national average of 13%.[6]

The construction sector in the state is further expected to grow in the coming years due to demographic and spatial changes from urbanisation, inter-state and intra-state migration, and the expansion of peri-urban areas. Between 2001 and 2011, the urban population in Odisha increased by 26.8%, which is double the national growth rate, reaching 70 lakh people. As per stakeholder feedback, migration into urban areas has also increased as a result of employment opportunities and the expansion of industries, especially in cities such as Bhubaneswar, Cuttack, and Rourkela. Additionally, intra-state migration, particularly from rural to urban and peri-urban areas, is largely driven by economic activities around mining and industrial hubs concentrated in regions like Angul, Jharsuguda, and Sundargarh.

The rate of urbanisation is projected to grow even more. By 2031, the projected urban population is likely to be 98.5 lakhs – motre than 40% than 2011 population.

Table 7.1: Population and urban share in India and Odisha

Year	Odisha				India			
	Population (in lakh no.)			Urban (percent)	Population (in lakh no.)			Urban (%)
	Rural	Urban	Total		Rural	Urban	Total	
1951	140.5	5.9	146.4	0	2,986.4	624.4	3,610.8	17.3
1961	164.4	11.1	175.5	0.1	3,603.0	789.4	4,392.4	18
1971	201.0	18.5	219.5	0.1	4,390.5	1,091.1	5,481.6	19.9
1981	232.6	31.1	263.7	0.1	5,238.7	1,594.6	6,833.3	23.3
1991	274.6	42.4	317.0	0.1	6,288.6	2,175.7	8,464.3	25.7
2001	31.9	54.2	86.1	0.6	7,426.2	2,861.2	10,287.4	27.8
2011	349.7	69.8	419.5	0.2	8,334.6	3,767.3	12,101.9	31.1
2021*	373.1	84.9	458.0	0.2	8,950.4	4,721.4	13,671.8	34.5
2031*	384.7	98.5	483.2	0.2	9,239.1	5,577.5	14,816.6	37.6

Source: Adopted from Census of India from 1951 to 2011; Projected population, Ministry of Housing and Family Welfare. GoI

The growing population is putting significant pressure on urban infrastructure, creating a higher demand for residential and commercial buildings. The resulting expansion of the construction sector not only addresses this demand but also presents an opportunity to integrate energy-efficient and sustainable practices into new developments.

Considering the push factors of urbanisation and growing demands for residential and commercial spaces, and other infrastructure, the energy transition of the sector remains a crucial component of the energy transition strategy of the state. Also considering the high employment dependence on the sector, the transition needs to be just and inclusive.

GREEN BUILDINGS IN ODISHA

In Odisha, the development of green buildings is gaining momentum, which include both government and private office buildings. As per available data, there are 156 certified green buildings in the state. This, however, makes up a small percentage of the total built environment in the state. It is estimated that less than 1% of Odisha's total building stock meets green building standards. This highlights a significant gap between existing non-green buildings and the urgent need for green infrastructure in the state.

Table 7.2: List of various green-certified buildings

Type of certification	No. of buildings
GRIHA Certified	47
LEEDs Certified	13
IGBC Certified	96
Total green-certified buildings	**156**

Source: Projects, Green Rating for Integrated Habitat Assesment (2024); Odisha, Leadership in Energy and Environmental Design (2024); Indian Green Building Council (2024)

7.3 Employment and workforce

The building and construction sector is one of the largest employment generators in Odisha, providing livelihoods for millions of people. The industrial sector in Odisha employed 53.3 lakh workers in 2022-23 as per the periodic labour force survey (PLFS), which was around 26% of the total workforce in the state. The construction sector constitutes about 66% of the industrial workforce[7]. A significant proportion of the workers are informal workers.

Overall, a district-wise distribution shows that 14 districts have at least one lakh registered construction workers. About 63% of construction workers are in industrial and urbanised districts, such as Cuttack, Khordha, and Sundargarh, among others.

Table 7.3: Districts with over one lakh registered construction workers

District	Total
Cuttack	2,55,315
Khorda	2,40,405
Sundargarh	1,76,613
Balasore	1,63,222
Bargarh	1,63,135
Kendrapara	1,58,972
Bhadrak	1,48,275
Jajpur	1,41,252
Kendujhar	1,22,107
Mayurbhanj	1,17,862
Subarnapur	1,14,210
Nuapada	1,10,961
Ganjam	1,09,112
Kandhamal	1,00,084

Source: Odisha Building and Other Construction Workers' Welfare Board, n.d.

7.4 Just transition issues and opportunities

The building and construction sector is a significant contributor to global greenhouse gas emissions, primarily driven by energy use in construction processes, embodied carbon in building materials, and operational energy consumption. A sustainable transition in this sector requires a multi-faceted approach that addresses material efficiency, and energy efficiency in buildings.

i. Optimisation of material and resource use

The use of construction materials—such as cement, steel, glass, and aluminum—accounts for a substantial portion of the sector's carbon footprint. Material efficiency involves the optimisation of resource use in the design, construction, and operation of buildings. This can be achieved through:

- **Design for reduced material use:** Implementing lightweight structural designs, optimising building forms, and using efficient framing techniques can reduce the volume of materials used in construction[8].
- **Use of low-carbon materials:** Promoting the use of alternative materials such as recycled aggregates, low-carbon cement, fly ash, blast furnace slag, and timber can significantly reduce the embodied carbon of buildings[9].

- **Circular-economy approaches:** Strategies like reusing building components, recycling construction waste, and designing for deconstruction support a circular economy, minimising waste and extending the lifecycle of materials[10].

ii. Decarbonization of cement, steel, and aluminium sectors

Achieving the energy transition of the building and construction sector requires a holistic approach that integrates decarbonisation strategies of the cement, steel, and aluminum sectors. While each of these sectors will have sector-specific approaches for decarbonisation (as discussed in the previous section), the following can be considered for an integrated approach with the building sector:

- **Lifecycle assessment and embodied carbon reporting:** Encouraging or mandating lifecycle assessments (LCAs) and embodied carbon reporting for building projects can help identify emission hotspots and prioritize the use of low-carbon materials[11].
- **Green procurement policies:** Establishing green procurement policies that prioritise low-carbon cement, steel, and aluminium can create a market for these products and incentivise further decarbonisation in these industries[12].
- **Collaboration across the value chain:** Collaboration between material producers, construction companies, architects, and policymakers is essential to drive innovation and implement low-carbon solutions at scale.

iii. Construction of green buildings and increasing energy efficiency

Operational energy use in buildings constitutes a major portion of energy consumption and emissions. Reducing this energy use through improved efficiency is crucial for achieving net-zero targets in the sector[13]. Key strategies include:

- **Building envelope optimisation:** High-performance building envelopes—comprising walls, windows, roofs, and insulation—can reduce energy demand for heating, ventilation, and air conditioning (HVAC). Technologies like double-glazed windows, cool roofs, and advanced insulation materials contribute to lower energy consumption[14].

- **High-efficiency HVAC and lighting systems:** Transitioning to energy-efficient HVAC systems and lighting, such as LED lights, occupancy sensors, and smart controls, can significantly cut energy use in buildings[15].
- **RE integration:** Utilizing renewable energy technologies, such as rooftop solar panels, geothermal heating, and solar water heating, can decrease reliance on conventional energy sources and contribute to the building's energy needs[16].

iv. Policy support for green buildings

To accelerate the green building transition, future policy support should focus on deeper integration of sustainability, enhanced enforcement, and innovative incentives.

- **Strengthening building codes and standards:** India's existing building codes, such as the Energy Conservation Building Code (ECBC) and Eco Niwas Samhita, offer a strong foundation for energy efficiency in new constructions. However, future policies could go further by making these codes mandatory for all new commercial and residential projects. This would not only ensure wider compliance but also help mainstream energy-efficient designs.

  The Government of Odisha's Energy Conservation Building Code Rules, 2022 also represents a significant opportunity to promote energy efficiency in commercial buildings. The Rules apply to every building, which is used or intended to be used for commercial purposes, having a connected load of 100 kilowatt (kW) or above, or a contract demand of 120 kilo-Volt-ampere (kVA) or above or a total built-up area of 1000 square meter or above (excluding stilt or basement meant for parking areas).[17]

  Overall, the state's ECBC Rules also aligns with national mandates like the Energy Conservation Act of 2001, emphasising energy-saving practices through prescriptive and performance-based compliance pathways. By setting specific requirements for building components—such as ventilation, HVAC systems, and RE integration—the code offers a structured approach toward reducing carbon footprints. It also mandates the use of certified auditors, ensuring a level of technical scrutiny that promotes accountability and adherence to the standards.

  However, so far there have not been significant strides in the implementation. As per stakeholders, one critical issue lies in the potential administrative burden, as it requires multiple approvals, certifications, and compliance checks by empanelled auditors in various phases. Additionally, the provision that deviations from energy performance goals could result in revoked permits or occupancy restrictions creates some compliance risks for small developers who may lack resources for technical adjustments. Thus, the success of the OECBC will hinge on effective coordination between stakeholders, including developers, auditors, and government agencies. Capacity-building initiatives and streamlined processes could help mitigate the bureaucratic complexity, ensuring that the code achieves its objective of sustainable urban development.
- **Incentives and financing mechanisms:** To encourage wider adoption of green buildings, financial incentives will be crucial. Future policies could introduce comprehensive subsidies, tax rebates, or reduced loan interest rates for developers and homeowners who achieve green building certifications like GRIHA or IGBC.
- **Integration with the policies:** Green building standards should not exist in isolation but be integrated with broader urban development policies. Future policies could link green building requirements with central and state initiatives like the Pradhan Mantri Awas Yojana (PMAY) and the Smart Cities Mission. By tying green building mandates to housing schemes and infrastructure development, governments can ensure that all public projects meet sustainability benchmarks[18].

v. Workforce transition

For the building and construction sector, a key aspect of the workforce transition will be massive skilling and reskilling. The following measures need to be considered.

- **Training programmes:** Develop and implement training programmes to equip the workforce with skills in energy-efficient building technologies, sustainable construction methods, and renewable energy integration.
- **Collaboration with educational institutions:** Partner with technical and vocational education institutions to design curricula that focus on green building practices, energy management, and emerging construction technologies.

- **Certification programmes:** Promote industry-recognised certification programmes that validate new skills in green construction practices, energy-efficient design, and building maintenance.
- **Promote awareness:** To facilitate workforce transition, it is also essential to promote awareness of job opportunities in green construction.

Overall, the transition of the building and construction sector will be crucial for a just energy transition in Odisha considering the sector's centrality in the state's economy and employment, especially in urban and peri-urban areas. The sector's transition will also be important to build climate resilient towns and cities, which will be an essential component of strengthening climate action.

SECTION V

JOBS AND WORFORCE

Chapter 8: GREEN JOBS AND WORKFORCE DEVELOPMENT

CHAPTER 8

Green Jobs and Workforce Development

8.1 Introduction

Fossil fuel sectors and fossil fuel-dependent industries in Odisha employ a large number of people formally and informally. As discussed in previous sections, coal mining, coal-based power plants, and factories are key employment sources. Considering sectors, such as coal mining, coal-based power plants, and only iron and steel, aluminium, and cement in the factories segment, it is estimated that these sectors collectively employ over 1.7 lakh people formally and many more informally and indirectly. Seven districts, including Angul, Dhenkanal, Jajpur, Jharsuguda, Sundargarh, Sambalpur, and Kendujhar, account for approximately 88% of the total formal workers considering employment only in these industries. Besides, other factories and the construction sector employ thousands of workers in these districts. Some of these districts, such as Sundargarh and Kendujhar also have high level of employment dependence on mining of minerals like iron ore, intricately related to these industries.

A critical challenge during the energy transition, therefore, will be to minimise job losses and support the workforce transition through targeted interventions. A specific focus should be on districts and regions that are highly dependent on these industries. This will require enhancing workforce employability in green economic sectors, such as RE, green industries, and sustainable construction.

Beyond workforce transition, job creation in green industries will be essential to avoid exacerbating unemployment challenges in fossil fuel-dependent regions. While Odisha has a Labour Force Participation Rate (LFPR) of 61.3%, higher than the national average of 57.9%, the state also faces an unemployment rate of 3.9%, slightly above the national average of 3.2%.[1] Notably, the unemployment rate among educated youth (aged 15–29) stands at 39.95%.[2] This highlights the potential for addressing unemployment through the development of emerging low-carbon/green industries in these areas.

Table 8.1: District-wise formal workers in fossil fuel industries in key districts

District	Coal mining	Coal-based power plants	Iron and steel		Aluminium	Cement	District total
			Crude steel	Sponge iron			
Angul	21,593	8,511	4,024	3,315	2,107		39,550
Dhenkanal		2,498	5,497	2,899			10,894
Jajpur		1,718	9,707	561		690	12,676
Jharsuguda	9,250	8,339	2,840	859	1.233	400	21,689
Kendujhar		436	3,697	3,205			7,338
Sambalpur	2,814	3,490	8,219	5,632	2,794		22,949
Sundargarh	6,858	4,260	12,990	5,525		2869	32,502
Sector total	**40,515**	**29,252**	**46,974**	**21,996**	**4,902**	**3,959**	**1,47,598**

Source: iFOREST analysis

8.2 Green job potential

Odisha's abundant coal and mineral reserves, along with its RE potential, present a unique opportunity to build a sustainable green industrial economy over the next three decades. However, as traditional carbon-intensive industries transition towards low-emission alternatives, the state faces the challenge of mitigating job losses and socio-economic disruptions. Proactive measures will be essential to safeguard existing jobs and generate new employment opportunities within emerging green sectors.

The state's ongoing industrial transformation is being facilitated by progressive policies, including the Industrial Policy Resolution (IPR, 2022)[3] and the Renewable Energy Policy (2022)[4] which have bolstered investor confidence. These frameworks aim to promote sustainable growth, encourage green manufacturing, and attract investments in RE and other low-carbon industries.

Over the next decade, Odisha has a strategic advantage to establish a robust green energy and industrial foundation. This can be enabled through the responsible utilisation of coal to power key industries, while simultaneously developing infrastructure necessary for future green manufacturing.

The IPR (2022) and the State Government's Economic Survey Report (2024)[5] also highlight priority sectors for promoting industrial and economic development. These include green energy, green manufacturing, and electric mobility, with a strong focus on employment generation. Additionally, the state government is committed to developing an industry-ready skilled workforce, ensuring that the workforce is equipped to support emerging industries and sustain long-term economic growth.

POLICY FOR GREEN INDUSTRY DEVELOPMENT TO SUPPORT JOBS

The IPR 2022 envisions a green and sustainable industrial base by fostering innovation, investment, infrastructure development, fiscal incentives creation, and infrastructure facilitation. The policy has specified certain thrust sectors for boosting industrial growth in the state in the coming years among which green energy, green manufacturing, and electric mobility (e-mobility) are noted as important opportunities .

The policy specifically focuses on promoting green hydrogen and ammonia production for industrial use, attracting investment in solar PV manufacturing and storage technologies (e.g., batteries), and supporting private sector-led distributed RE projects for industries to meet energy needs.

In green manufacturing, the focus is on EV manufacturing, battery production, manufacturing of energy-efficient appliances, LED lights, and green building materials, among others. The policy also focuses on promoting low-emission cement and steel production technologies.

Concerning EVs, the policy aligns itself with the Odisha Electric Vehicle Policy 2021, which promotes the use of EVs across public and private transportation. The IPR 2022 has a focus on infrastructure development to support EVs. This includes developing charging stations and battery-swapping infrastructure in collaboration with private and public partners, and earmarking industrial parks and EV zones with dedicated facilities for EV and component manufacturing, among others. The policy also mentions the establishment of EV Centers of Excellence for R&D, skilling, and testing.

The policy recognises that all of these will require skilled workforce. Overall, for skilling and workforce development, the policy has emphasised on partnerships with technical institutes to develop programs on renewable energy technologies, sustainable manufacturing, and electric mobility.

Source: Industry Department, Government of Odisha. (2022). Industrial Policy Resolution. https://investodisha.gov.in/download/industrial_policy_resolution_2022.pdf

Overall, considering the resource potential, policy environment, and growth potential of green industries, the following are some of the key sectors that will be important for boosting opportunities for green economic growth, while enhancing job opportunities in transition regions, and contributing to the state's employment outcomes.

i. Green energy: Odisha has significant potential for green energy development and boosting employment opportunities in the RE sector. As discussed, the state has set an RE target of 11 GW by 2030. Estimates indicate that meeting this target could generate at least over 32,000 full-time employment (FTE) opportunities across multiple RE segments. Among them, the solar sector dominates the employment potential, with a target to install 7.5 GW by 2030. Employment in the solar segment will increase progressively as capacity expands, reaching 6,900 FTE annually by 2029-30, accounting for a total of 25,875 FTE over the next six to seven years.

Table 8.2: Potential RE jobs

Sector		2025-26	2026-27	2027-28	2028-29	2029-30	Total
Solar	Capacity target (GW)	0.7	1.3	1.5	2	2	7.5
	Estimated FTE	2,415	4,485	5,175	6,900	6,900	25,875
Wind	Capacity target (GW)	0.2	0.8	0.5	0.25	0.25	2
	Estimated FTE	254	1016	635	317.5	317.5	2540
Small hydro	Capacity target (GW)	0.06	0.03		0.01	0.09	0.19
	Estimated FTE	240	120		40	360	760
Large hydro	Capacity target (GW)					0.06	0.06
	Estimated FTE					NA	NA
Pumped Storage Plant	Capacity target (GW)					1.2	1.2
	Estimated FTE					3,000	3,000
Total RE	**Capacity target (GW)**	**0.96**	**2.13**	**1.5**	**2.26**	**3.6**	**10.95**
	Estimated FTE	**2,969**	**5,651**	**5,810**	**7,268**	**10,668**	**32,175**

Source: iFOREST analysis based on employment factor approach for each sector.
1. For solar, the jobs have been estimated considering ground-mounted solar with an employment factor of 3.45/MW for direct jobs.[6]
2. For wind, the jobs have been estimated with an employment factor of 1.27/MW of direct jobs.[7]
3. For hydro, the jobs have been estimated with an employment factor of 4/MW for direct jobs.[8]
4. For the pumped storage plant, the employment factor is 2.5/MW for direct jobs.[9]

However, the overall potential of RE jobs is much higher considering the RE potential of the state that can be harnessed. An assessment of RE potential by iFOREST, considering the modest use of wasteland and reservoir, shows that solar potential alone is about 170 GW in the state.

In addition to RE, Odisha has set ambitious production targets for green hydrogen, green ammonia, and other derivatives by 2030—green ammonia at 5.8 MMTPA, green hydrogen 0.1 MMTPA, and other derivatives 0.5 MMTPA[10]—which are expected to play a critical role in supporting green jobs. These industries will require skilled workers for plant operations and maintenance, as well as experts in supply chain management and logistics to ensure smooth production and distribution. Additionally, there will be a growing demand for research and development (R&D) specialists focused on enhancing process efficiency. Significant investments in infrastructure development, such as for storage facilities and transportation networks will further contribute to employment generation.

ii. Green metals and mining: Odisha, with its vast reserves of minerals such as iron ore, bauxite, and manganese, holds a central role in India's green transition by enabling the growth of green metals and sustainable mining practices. This transition presents significant opportunities for Odisha to diversify its mining sector, sustainable mining technologies, and mineral recycling, while simultaneously generating green jobs.

For example, the segment will require mining engineers and geologists specialising in sustainable mining techniques, officials to ensure environmental compliance, technical workers to operate low-emission equipment and autonomous technologies, workers in ore beneficiation plants, RE technicians to manage on-site solar or wind installations in mining areas, R&D specialists, among others.

iii. Green manufacturing: The manufacturing sector in Odisha is crucial for the state's green growth and green jobs pathway with already a share of 54% of the industrial GSVA. To maintain a strong manufacturing sector, it will be essential to increase green manufacturing. The state can promote the manufacturing of electric vehicles (EVs), solar PV panels, and batteries for energy storage, which will not only drive the transition to clean energy but also boost domestic production of high-value products and create jobs.

For example, in the EV sector, new roles will arise in battery manufacturing, manufacturing of other electronic equipment, servicing and maintenance, R&D, EV charging infrastructure, supply chain logistics, among others.[11]

iv. Green construction and green infrastructure: Odisha is experiencing a rapid upbanisation with the urban population expected to reach 98.5 lakhs by 2031. Therefore, green construction will be crucial for the sector. As per feedback from stakeholders, this will involve transforming materials and practices in construction and infrastructure development. Developing a skilled workforce across the entire value chain will be critical, including expertise in sustainable building materials, energy efficiency of buildings, green utilities, and green certification, among others.

8.3 Skill ecosystem

Odisha is at the forefront of skilling initiatives in India. The State Government has placed a strong emphasis on skill development as a part of its broader strategy to enhance workforce readiness and boost economic growth. This initiative aligns with the state's vision of creating future-ready human capital capable of meeting both domestic and global market needs.

Odisha's 'Skilled in Odisha' programme stands out as a key element, focusing on improving vocational education through Industrial Training Institutes (ITI). The nodal agencies implementing skill development schemes and initiatives in Odisha are the Skill Development and Technical Education Department (SDTE) and the Odisha Skill Development Authority (OSDA). However, even with progressive schemes and investments, Odisha faces a considerable gap in the skilling ecosystem, with 10% of the youth reported to be receiving formal training.[12]

The skilling ecosystem in Odisha has been evaluated by considering the key skilling programmes, the infrastructure, and the types of skilling offered at the facilities.

i. Programmes and schemes

Odisha's skilling ecosystem leverages both central and state-level schemes, aligning with the state's development priorities and growth aspirations. The key Central Government schemes include Pradhan Mantri Kaushal Vikas Yojana (PMKVY)[13] which is a flagship scheme of the Ministry of Skill Development and Entrepreneurship (MSDE), Deen Dayal Upadhyaya Grameen Kaushalya Yojana (DDUGKY)[14], and the National Apprenticeship Promotion Scheme (NAPS)[15] among others.

The State Government has taken significant initiative in recent years to expand the skilling ecosystem in the state. Among the state schemes, the key ones include, Nutana Unnata Abhilasha (NUA) Odisha,[16] the Placement-linked Training Programmes (PLTP),[17] the Nano Unicorn scheme,[18] and Swakalpa,[19] among others, which are implemented through the State Government's World Skill Centre (WSC), OSDA, SDTE, and Directorate of Technical Education and Training (DTET), among others.

These schemes can play a crucial role in workforce skilling, upskilling, and development, aligning with the state's vision of preparing the workforce for emerging sectors and supporting a low-carbon economy.

KEY STATE SCHEMES

NUA Odisha: The Nutana Unnata Abhilasha (NUA) Odisha scheme developed in 2023, aims to address the scarcity of skilled human resources in emerging economic sectors and trades. The scheme focuses on offering high-quality training, fostering industry linkages, and enhancing employability skills. It leverages both existing and new skilling institutions while and industry partnerships to ensure impactful training across all 30 districts of Odisha, with a special focus on aspirational districts, tribal, and remote areas.

The NUA initiative recognises the need to develop high-quality infrastructure by setting up advanced laboratories and incentivising training providers. By prioritising the training of trainers and curriculum development, it emphasises long-term capacity building. In addition, the scheme's wide accessibility, offering online courses, ensures outreach to a diverse set of participants across 30 districts.

The budget allocation for the scheme is ₹385 crores over the period 2023-24 to 2025-26, which signals the government's substantial commitment to workforce development. This strategic funding suggests the ambition to generate scalable and sustainable skilling ecosystems that align with the future demand for skilled labour across multiple sectors.

The Placement-linked Training Programme (PLTP): The PLTP has been a significant initiative in Odisha since its inception in 2011-12. Designed to enhance the skills of youth, particularly targeting school and college dropouts, the programme aims to improve employability and integrate individuals into the workforce. Conducted through a network of both private and government project implementing agencies, PLTP emphasises a demand-driven approach, tailoring courses to align with the needs of various sectors.

Over the years, PLTP has trained a substantial number of participants, with a total of 1,13,901 individuals benefiting from the programme between 2011 and 2023 with very high placement records. This extensive outreach reflects the initiative's commitment to fostering skill development across all demographics, ensuring that diverse groups have access to valuable training opportunities.

Going ahead, the programme is poised to continue its trajectory by introducing additional demand-driven courses. This adaptability is crucial, as it allows PLTP to respond effectively to the evolving job market and the specific needs of employers.

Nano Unicorn: The Nano Unicorn scheme is designed to support entrepreneurship in rural areas. The scheme aims to empower skilled youth by promoting entrepreneurship as a solution to challenges such as rural migration and unemployment. Promulgated in 2024, it will support 1,200 Nano Unicorns between FY 2023-24 to 2025-26 by providing refundable seed funding up to rupees one lakh each. The scheme envisages mentoring and handholding support to the Nano Unicorns apart from the refundable seed funding to ensure sustainability. The scheme will cover all 30 districts of the state with a focus on 10 aspirational districts.

Swakalpa: Another programme Swakalpa was launched by the Odisha Skill Development Project (OSDP) with a mission to empower young individuals through self-employment opportunities and entrepreneurship skills. The primary goal of the initiative was to prepare 10,000 youth across Odisha with essential entrepreneurship skills and help establish at least 1,000 micro-businesses.

A key focus of the programme was to support sustainable economic growth while promoting gender equality and inclusivity by ensuring at least 25% representation of women at every level.

Sources:
1. Skill Development & Technical Education Department, Government of Odisha. (2023). Guidelines for NUA Odisha. https://nua.skillodisha.gov.in/download/NUA_Odisha_Guidelines_Notified.pdf
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3. Odisha Skill Development Authority. (2024). Swakalpa. https://www.swakalpa.in/about

ii. Infrastructure and courses offered

The skilling infrastructure in Odisha primarily revolves around ITIs and polytechnic institutes, which are spread across various districts of the state. As of 2024, Odisha has 72 operational ITIs and 34 polytechnics, with intake capacities of 23,512 and 8,730 students, respectively.[20] Among the ITIs, 39 have been designated as Centres of Excellence, focusing specifically on employability skills. For the academic year 2023-24, the placement rates for ITI and polytechnic graduates stood at 36% and 54%, respectively.[21]

There are 74 different courses taught at ITIs in the state. These include courses related to electrician (19%), fitter (19%), welder (9%), mechanic (5.5%), electronic mechanic (4.2%), and computer programming (5.5%). Overall, 30 ITIs have at least one course related to emerging green industrial job roles, such as solar technician and EV mechanic with a total strength of 1,008 students.[22]

Besides, the traditional ITIs and polytechnics, a key initiative in Odisha is the establishment of the World Skill Centre, a state-of-the-art facility aimed at cultivating the future workforce. Established in 2021, the center responds to the growing demand for skilled labour in emerging sectors, particularly in RE and sustainable manufacturing. By emphasising advanced technologies and digital skills, the WSC is dedicated to preparing individuals for the jobs of tomorrow.[23] The WSC primarily functions as a finishing school as of now for students coming from ITIs and polytechnics. As per official feedback, these students are enrolled in one-year courses and after that, they receive good placements. The placement record in the initial years has been about 90% with industrial salaries starting at about rupees two lakhs per year.

As a model for contemporary vocational training, the World Skill Centre prioritises practical, hands-on learning experiences that meet industry requirements. It provides specialised programmes tailored to the local economy, creating an environment where learners can acquire relevant skills that boost their employability. Additionally, the centre envisages partnering with industry stakeholders to ensure that its training remains current and aligned with the evolving job market.[24]

iii. Overall assessment of schemes and skilling infrastructure to support transition

While the above-mentioned schemes and initiatives are significant, the current skilling ecosystem yet does not adequately address the growing demand for jobs in various RE segments, and other sectors green and high-tech industrial sectors. While initiatives such as the World Skill Centre and NUA Odisha, are well positioned to accommodate the need for workforce development for RE, green manufacturing, and green construction, the courses and training modules need to be further strengthened based on in-depth skill gap assessment, potential demands, and market outlook.[25] The PLTP, which has a high placement rate,[26] should also modify the courses and training modules to incorporate emerging green sectors to leverage its outreach and employability focus. Overall, in various schemes and programmes, the existing courses need to be updated to align with future job requirements.

Besides, programmes, such as the NAPS[27] and the Nano Unicorn Scheme[28] have established good industry connections and support entrepreneurship, they lack specific modules focused on green industries. These schemes should be realigned to promote green business models and apprenticeships in emerging sectors.

In addition to redesigning existing skilling schemes, enhancing the capacity of technical education and training institutes in Odisha is essential for preparing the workforce for the emerging green economy. Specialised institutes, such as the Biju Patnaik National Steel Institute. Various National Skills Qualification Framework (NSQF) accredited institutes in the state, along the World Skill Centre will play a vital role in this expansion. By focusing on advanced technologies and digital skills, these institutes can provide targeted training that aligns with industry needs, particularly in green sectors. This will not only improve employability but also facilitate the integration of innovative practices in local industries.

Table 8.3: Strengths and gaps of skilling programmes

Schemes	Total number of people completed training in last five years in the state*	Total placed	Strengths	Gaps
PMKVY	5,01,704	1,15,391 (23%)	Large-scale reach and network.	Low placement, challenges with employability skills for green industries
DDUGKY	2,14,703	1,76,001 (81%)	Rural youth skilling, high placement.	No green job focus in rural areas.
NAPS	23,744	Not available	Strong industry linkages.	Negligible green industry apprenticeships.
NUA Odisha	95,000	Data not available	Focus on offering high-quality training, fostering industry linkages, and enhancing employability skills, including digital skills.	Lacks green skills courses.
PLTP	1,13,901 trained between 2011-2023	1,13,901 (100%)	Emphasises a demand-driven approach, tailoring courses to align with the needs of various sectors; high focus on placement.	No emphasis on emerging green sectors.
World Skill Centre	640	574 (89%)	High class modern facility with focus on future skills.	Needs broader green sector coverage.

Source: iFOREST compilation based on interactions with stakeholders from OSDA, DTET, and SDTE in May 2024. Beneficiaries and placement data derived from various state and central government dashboards relevant to the respective scheme and Apprentice performance dashboard of Skill India, 2024 . *For new schemes, training since inception year has been considered.

8.4 Strengthening skilling and workforce development

Strengthening the ecosystem for skilling and workforce development is crucial for Odisha's green transition and the creation of employability of the existing and future workforce in the low-carbon economy. As the state moves away from carbon-intensive industries, it must equip its workforce with the skills needed to thrive in emerging green industries such as RE, green manufacturing, sustainable construction, and electric mobility. Building an inclusive ecosystem to ensure this requires targeted interventions in the development of foundational skills, such as education, strengthening reskilling and upskilling programmes aligning with technological changes and emerging industries, designing industry-specific courses, and stronger partnerships between skilling institutes, agencies, and industry players. The following are some of the key aspects that can be considered in this regard.

i. Strengthening foundational skills and education: A robust workforce development ecosystem must start by strengthening foundational education. Higher education, including technical education and acquisition of digital skills should be enhanced, ensuring that workers are well-prepared for and adaptable to evolving industries. Partnerships between educational institutions and skill development centers should foster early exposure to green technologies, sustainable practices, and industrial careers.

ii. Skill mapping and skill gap assessment: To support a smooth and inclusive energy transition of the workforce, regular skill mapping and skill gap assessments are essential, especially in the state's fossil fuel-dependent industrial regions like Angul, Dhenkanal, Jharsuguda, Sundargarh, and Sambalpur, among others. These exercises will help identify the existing skills of the workforce and align them with emerging opportunities in green sectors. Mapping will also allow the state to pinpoint skill shortages and develop targeted programmes for reskilling, upskilling, and new workforce integration.

Additionally, sector-specific skill gap assessments will anticipate future workforce needs by analysing trends and labour market projections, helping industries and institutions stay ahead of the transition curve. Engaging stakeholders from government, industries, academic institutions, and local communities in these assessments will ensure a holistic approach. By institutionalising these assessments as part of Odisha's skilling ecosystem, the state can ensure that its workforce is continuously prepared to meet the evolving demands of a green economy while mitigating the risks of unemployment in transition regions.

iii. Developing sector-specific skilling courses and modules: Develop targeted skilling courses to help existing workers pivot to green sectors with minimal disruption align with industry demands, and ensure that the workforce is equipped to support Odisha's green transition. This includes short courses for workers with related skills (e.g., steel plant operators transitioning to hydrogen-based steelmaking) and intensive modules for new entrants. Lifelong learning pathways should be promoted by offering modular certifications that workers can accumulate over time to enhance their qualifications in a low-carbon economy. The integration of practical, hands-on learning and industry collaborations will enhance employability and prepare workers for emerging job roles.

iv. Green skilling centers in transition regions: Set up dedicated green skill centers in fossil fuel-dependent districts such as Angul, Dhenkanal, Jharsuguda, Sundargarh, Sambalpur, etc., to ensure access to skilling. This will be particularly important for women as they have mobility challenges. Developing skill centres in transition regions by leveraging existing infrastructure—such as repurposed office buildings from closed mines—will enable rapid deployment and reduce infrastructure costs.

v. Expanding industry-academia partnerships: The skill ecosystem must strengthen collaboration between industry and academia. This can be achieved by engaging key green industry players to co-design specialised programmes, such as battery technology, hydrogen technology, and EV-related jobs, among others. Joint programmes with green industries will also foster apprenticeships, providing on-the-job learning and enhancing employability.

vi. Developing a green jobs and skills portal: Create a state-specific 'Green Jobs and Skills Portal' to track employment opportunities, training programmes, and industry demand. This portal can function as a bridge between job seekers, skilling centers, and employers, offering real-time information on market trends and skilling requirements. Integrating career counselling services will guide workers and students toward future green careers.

vii. Social inclusion and support for vulnerable groups: Ensure that skilling programmes are inclusive by designing specific initiatives for marginalised communities, women, and informal workers. Special provisions should support the transition of workers from declining industries, with financial assistance, counselling, and targeted programmes to minimise job loss impacts and foster mobility.

By focusing on foundational education, targeted skilling, industry collaboration, and digital competency, along with access to advanced skilling for various socio-demographic groups, Odisha can create a resilient workforce prepared to thrive in the emerging green economy.

SECTION VI

WAY AHEAD

Chapter 9: AGENDA FOR ACTION

CHAPTER 9

Agenda for Action

9.1 Introduction

Odisha aims to become the industrial hub of Eastern India and a trade gateway to South and East Asia in the coming years. However, as industrial growth accelerates, the state must balance economic ambitions with its climate commitments. Odisha plays a crucial role in India's net-zero journey and just energy transition. With large-scale industrial expansion—particularly in coal, power, steel, and construction sectors—Odisha requires a climate-responsive strategy to lower the emissions intensity of its economy, adopt cleaner energy sources, and align with national and state climate and RE goals.

A well-planned, cross-sectoral strategy is essential for Odisha to accelerate climate action, achieve green growth, and ensure a just energy transition. Key components must include reducing industrial emissions through technological upgrades and adopting RE, while repurposing land and energy assets for sustainable and productive economic use. At the same time, the strategy must focus on green job creation, workforce skilling, and inclusive economic development to support communities that will be potentially affected by the transition of fossil fuel industries. Through a well-managed transition, the state can position itself as a model for balancing industrial growth with environmental responsibility, while contributing significantly to India's climate goals.

9.2 Key action agenda

State governments are at the forefront of addressing the socio-economic impacts of energy transitions on their local economies and ensuring green and inclusive growth. For Odisha, the key agenda for action, especially for the next 10 years, will include the following:

i. Repurposing land and energy assets;

ii. Setting targets for industrial sectors;

iii. Developing a state Just Transition Policy;

iv. Developing regional just transition plans;

v. Supporting workforce transition and human resource development;

vi. Mobilising financial resources; and,

vii. Building stakeholder consensus and empowering communities.

i. Repurposing land and energy assets: Repurposing land and energy assets is a crucial opportunity to support just energy transition measures because it enables the creation of sustainable economic activities, augments green energy development, revitalises local economies, and ensures environmental sustainability in the transition regions.

For Odisha, repurposing mining and industrial wastelands can help the state achieve the RE targets, diversify the local economy, and boost employment opportunities. These fragmented land parcels already possess essential infrastructure, making them ideal for RE projects and enhancing green economic opportunities.

In the next decade, a significant focus should be placed on repurposing readily available mining and industrial wasteland in Odisha. An analysis by iFOREST indicates that the state currently has 1,680 hectares of mining wasteland and 3,990 hectares of industrial wasteland.[1] Furthermore, by 2030, approximately 11,000 hectares of coal mining land can be available for repurposing.

Regarding energy assets, about 1.4 GW of capacity from four thermal power plant (TPP) units is projected for repurposing by 2035.

Overall, land repurposing is a crucial opportunity in the coming decades. More than 36,000 ha of land is available with operational and closed mines in the state. In the coming years, a planned reclamation and repurposing of mining land through a collaborative approach between the mining company(ies), the state government, and the local community will be crucial for optimising productive economic use of this valuable asset and ensuring economic continuity in mining districts and blocks.

Besides coal mining land, repurposing the land available with TPPs is an important opportunity for industries to develop green energy infrastructure. Nearly 4,200 ha of land is available with the utility-scale plants. Besides, an estimated 5,904 ha of land is available with the CPPs operating in various districts.

ii. Setting targets for industrial sectors: Setting targets for industrial sectors is essential for facilitating an energy transition and aligning with broader environmental goals. Clear and measurable targets enable industries to systematically reduce their carbon emissions, enhance energy efficiency, and adopt sustainable practices.

Odisha has already set a 11 GW RE target by 2030. As investments in the RE sector increase, the state can set more ambitious targets for the next 10 years.

Similarly, targets need to be set for the mining and steel sectors, the two other critical sectors for achieving a just energy transition.

In the mining sector, it will be important to set progressive RE adoption targets. Switching to RE sources can help reduce Scope 1 and Scope 2 emissions from the sector that is related to activities, such as extraction, processing, material movement, and transportation.

For the steel sector, which is a major contributor to GHG emissions, transitioning to green hydrogen-based production is crucial for achieving long-term sustainability. Developing a phased roadmap for hydrogen adoption will allow the sector to make a smooth transition, keeping pace with technological advancements and market demands. The government can require the establishment of greenfield 'hydrogen-ready steel plants' starting in 2025 and mandate the retrofitting of existing plants to support this transition. Following this, a phased approach to adopting green hydrogen as an energy source can be implemented. The targets can be set at 10% hydrogen adoption by 2030, 25% by 2035, 50% by 2040, 75% by 2045, and achieving 100% hydrogen utilisation by 2050.

By setting these ambitious yet attainable targets, Odisha can also enhance the Environmental, Social, and Governance (ESG) performance of its industrial sectors, attract responsible investments, and contribute to the state's green growth objectives.[2]

iii. Development of a Just Transition Policy: To manage the complex and cross-sectoral impacts of the energy transition, Odisha will require a state Just Transition Policy.

This policy will provide a strategic framework to guide the following:

- Economic diversification and innovation to maintain economic vitality in regions affected by the energy transition;
- Foster opportunities for green investments especially in districts that have traditionally relied on coal and other fossil fuel industries;
- Guide workforce transition including of formal and informal workers;
- Enhance social welfare provisions to provide targeted support for informal workers, women, and other vulnerable groups;
- Support investments in social and physical infrastructure to build community resilience and also attract businesses and investors;
- Mobilise public and private financing to support just transition measures; and,
- Establish well-designed and dedicated institutional structures.

Overall, the Just Transition Policy should provide clear guidance on embedding just transition strategies across multiple policy domains and plans, including state climate change policy and action plans, industrial policy, economic development policies, labour support, and welfare policies, among others. This comprehensive integration will ensure that the transition to a low-carbon economy is inclusive, well-coordinated, and aligned with broader state priorities.

iv. Development of regional just transition plans: While fossil fuel industries and other industries in the value are spread across various districts, seven districts are highly significant from an energy transition perspective. These include Angul, Dhenkanal, Jajpur, Jharsuguda, Sundargarh, Sambalpur and Kendujhar districts.

These seven districts account for 100% of the coal mines and utility-scale coal-based power capacity, and 88% of the coal-based captive power capacity. Besides, 97% of the crude steel capacity and 94% of sponge iron capacity are concentrated in these districts, and a majority of the iron ore mines, accounting for 99% of the production capacity are located here. They also account for 100% of the aluminium production capacity and 65% of the cement capacity (integrated plants).

Given the geographic concentration of coal mining, coal-based power, and various fossil fuel industries in these specific regions, developing regional just transition plans for these clusters is essential. These plans should primarily be designed as inclusive and outcome-oriented investment plans to support strategic planning and investments for a just energy transition in these regions.

For Odisha, the development of at least three regional just transition plans will be necessary in the next 10 years to ensure a well-planned transition in these regions in the coming years. The three clusters include:

- Angul-Dhenkanal cluster;
- Sundargarh-Sambalpur cluster; and,
- Jharsuguda cluster.

The plans should be designed with a 10-year horizon with key targets and milestones, to provide a structured approach for managing the socio-economic impacts of decarbonisation and ensuring inclusive growth. A decade-long timeline will allow sufficient scope for economic diversification, workforce transition, and infrastructure development while maintaining economic stability. The plans should undergo regular evaluations and revisions as required, to align with emerging challenges and opportunities.

v. Supporting workforce transition and human resource development: A key aspect of just energy transition and sustaining green growth in the state will be ensuring the successful transition of the workforce associated with fossil fuel industries, and developing human resources aligning with the low-carbon economy.

In Odisha, the energy transition can potentially impact an estimated 9.3 lakh workers who are engaged formally and informally in coal mines, thermal power plants and various factories that will be highly or moderately impacted by the transition. Besides, there are a large number of workers associated with the value chain of these industries. The impact will be pronounced in the districts where these industries are concentrated, such as Angul, Dhenkanal, Jharsuguda, Sundargarh, Sambalpur, Jajpur and Kendujhar.

To ensure an inclusive workforce transition and human resource development, actions will be required both at the policy front and to strengthen the skilling ecosystem, including building foundational skills.

On the policy front, labour laws can be strengthened with specific provisions aimed at ensuring job security for workers. This includes establishing clear provisions for severance pay and compensation for workers affected by the transition in various industries. In addition, it is crucial to develop provisions within state labour laws to ensure worker security in the emerging green economy. By reinforcing these protections, the government can help mitigate the impacts of economic shifts on vulnerable workers, such as informal workers, including women.

Concerning the skilling ecosystem, as discussed in earlier sections, developing and implementing targeted skilling programnes in alignment with the skill needs in the green economic sectors will be important. Aligning skilling initiatives with technological advancements will be essential for preparing the workforce to thrive in a rapidly changing industrial landscape.

Finally, strengthening education infrastructure and resources will be essential for cultivating foundational skills within the future workforce. By enhancing access to quality education and vocational training, individuals can be imparted the necessary competencies to thrive in an evolving job market and engage in decent and well-paid jobs.

vi. Mobilising financial resources: A well-structured financial strategy is critical for supporting Odisha's just energy transition. Mobilising financial resources will require innovative approaches, including the utilisation of existing public funds, incentives for private investment, and strategic alignment of national and state resources.

Two key resources for financing this transition are the coal cess and the DMF funds, both of which can be directed towards supporting green infrastructure, economic diversification, workforce development, and community resilience.

Concerning DMF funds, the state has the maximum DMF accrual amounting to over ₹25,858 crore (as per the Ministry of Mines latest data of 2024), which is nearly 30% of India's total. About 95% of the accruals are just from five districts (which are also the transition hotspots), including Angul, Jajpur, Kendujhar, Sundargarh and Jharsuguda.[3]

Besides, by 2060, an estimated ₹39,764 crore will be generated through DMF funds by 2060, considering only the ongoing and soon-to-start operations. The utilisation of the DMF funds can be aligned with local transition initiatives, particularly in key mining districts like Angul, Sundargarh, Jharsuguda, and Kendujhar, among others.

Besides DMF, the coal cess (currently subsumed under the GST compensation cess) which is levied at ₹400 per tonne on coal production and imports, could generate ₹3,52,592 crore (as discussed in Section I). Odisha should work with the central government to ensure the coal cess is allocated toward green growth initiatives and just energy transition programmes.

vii. Building stakeholder consensus and empowering communities: Achieving a just transition will require strong stakeholder consensus at both the state and district levels to ensure sustained support throughout the process. Developing an effective communication strategy will be essential to align stakeholders, foster mutual understanding, and create shared ownership of the transition efforts.

Additionally, empowering local communities through active engagement with district administrations, local institutions—such as Panchayati Raj Institutions (PRIs) and municipal wards—labour/workers organisations, women-led groups, and civil society organisations will be crucial. This participatory approach will ensure inclusive planning and allow continuous feedback on the design and implementation of just transition measures.

In conclusion, a comprehensive and strategic approach to just energy transition will be essential for Odisha to build a climate-resilient future while fostering green growth. A well-planned transition will not only reduce the carbon footprint of key industrial and economic sectors, it will also create new economic opportunities, improve livelihoods, and ensure a sustainable transformation.

Annexure 1

Best Available Technologies (BATs) for integrated steel plants

S. N.	Best available Technology (BAT)	Energy savings potential		CO2 reduction potential	Remarks
		Electrical energy	Thermal energy		
Sintering					
1.	Sinter plant heat recovery (for steam generation)	Not applicable	0.251 GJ/t-sinter	23.86 kg-CO2/t-sinter	The device recovers sensible heat in the hot air from the sinter cooler to generate steam.
2.	High efficiency burner in ignition furnace for sinter plant	Not applicable	0.010 GJ/t-sinter	0.44 kg-CO2/t-sinter	The multi-slit burner can form successive and uniform frame in the ignition furnace using coke oven gas.
Coke making					
1.	Coke Dry Quenching (CDQ)	Not applicable	1.9 GJ/t-coke	97.5 kg-CO2/ tcoke	The heat recovered by inert gas from hot coke is used to produce steam, which may be used on-site or to generate electricity
2.		150 kWh/t- coke	Not applicable	135.45 kg-CO2/ tcoke	
3.	Coal Moisture Control (CMC)	Not applicable	0.29 GJ/t-coke	27.55 kg-CO2/ tcoke	CMC uses waste heat from COG to dry the coal used for coke making. Coal moisture is reduced from 8-9% to 3-5%, which reduces fuel consumption in the coke oven
Iron making					
1.	Top Pressure Recovery Turbine (TRT)	50 kWh/t-pig iron	Not applicable	45.15 kg-CO2/t pig iron	This system generates electric power by employing blast furnace top gas to drive a turbine generator. Blast furnace gas passed through TRT is used as a fuel in iron and steel making processes.
2.	Dry gas cleaning plant with bag filter	9.26 kWh/t-pig iron	Not applicable	8.36 kg-CO2/t pig iron	This system cleans the blast furnace gas that goes into TRT power generation system through removing dust and water drops using bag filter.
3.	Pulverized Coal Injection (PCI) system	Not applicable	1.55 GJ/t-pig iron	147 kg-CO2/t pig iron	Pulverized coal is directly injected through the blast furnace tuyeres as a partial substitute for the coke used in the blast furnace.
4.	Hot stove waste heat recovery	Not applicable	83-125 MJ/t hot metal	7.89 kg-CO2/t-CS	The device recovers the sensible heat of the flue gases generated in the hot stove and the heat is used in preheating fuel and combustion air for the hot stoves.

Annexure 1 continued

S. N.	Best available Technology (BAT)	Energy savings potential		CO2 reduction potential	Remarks
		Electrical energy	Thermal energy		
Steel making					
1.	Low NOx regenerative burner system for ladle preheating	-	0.2 GJ/t-CS	12.62g-CO2/t-CS	Has high energy saving potential with automation. Fuel Direct Injection (FDI) combustion is adopted.
2.	Dry gas cleaning plant (GCP) with bag filter	9.26 kWh/t crude steel	Not applicable	8.36 kg-CO2/ t-crude steel	This system cleans the blast furnace gas that goes into TRT power generation system through removing dust and water drops using bag filter.
3.	Regenerative burner total system for reheating furnace	Not applicable	0.19 GJ/t-CS	10.66 kg-CO2/t-CS	While one of the burners is burning, the other burner will work as an exhaust outlet. The combustion air will be preheated to a super high temperature.
4.	Induction/hybrid heating for long products	Not applicable	To be established	To be established	This technology allows utilising electricity-based heating (induction heating) replacing fully or partially the existing system.

Source: Adopted from Ministry of Steel, Government of India. (2024). Greening the steel sector in India: Roadmap and action plan

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Notes

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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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