Report # 3

Energy Transition in Jharkhand

Progress, Challenges and Policy Insights

Jayashree Parida | Amarendra Das | Pranay Kumar Swain

विज्ञान एवं प्रौद्योगिकी विभाग
भारत सरकार
DEPARTMENT OF SCIENCE & TECHNOLOGY
GOVERNMENT OF INDIA

DST
Centre for Policy Research (CPR)
National Institute of Science Education and Research (NISER) Bhubaneswar

DST- Centre for Policy Research

NISER, Bhubaneswar

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Jayashree Parida

Amarendra Das

Pranay Kumar Swain

DST- Centre for Policy Research

National Institute of Science Education and Research (NISER), Bhubaneswar

DST- Centre for Policy Research,
National Institute of Science Education and Research,
Bhubaneswar, Odisha

In December 2021, the Ministry of Science and Technology, Department of Science and Technology (Policy Research Programme) made an open call for the submission of Expressions of Interest in STI Policy Research towards the Establishment of the Centre for Policy Research (CPR) by the academic and research Institutes in India. After multiple rounds of consultations and review, the DST-CPR at NISER received the final sanction order from the Government of India, Ministry of Science & Technology, Department of Science & Technology, bearing the letter No DST/PRC/CPR/NISERBhubaneswar-2023 (G)(PCPM) dated 29/03/2023.

The primary focus of the DST-CPR at NISER is to study the Energy Transition and the secondary focus is to study the Tribal Education, and Innovations for Tribal Education in Eastern India covering Odisha, Bihar, Chhattisgarh, Jharkhand and West Bengal.

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Principal Investigator: Amarendra Das

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List of Abbreviations

APNRL	Adhunik Power & Natural Resources Limited
BEE	Bureau of Energy Efficiency
CAGR	Compound Annual Growth Rate
CEA	Central Electricity Authority
CFA	Central Financial Assistance
CGPs	Captive Generating Plants
DDUGJY	Deendayal Upadhyaya Gram Jyoti Yojana
DISCOMs	Distribution Companies
DVC	Damodar Valley Corporation
EV	Electric Vehicle
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic Information System
GSDP	Gross State Domestic Product
GW	Gigawatt
GWh	Gigawatt-hour
IPL	Inland Power Limited
IPPs	Independent Power Producers
JBVNL	Jharkhand Bijli Vitran Nigam Limited
JREDA	Jharkhand Renewable Energy Development Agency
JSBAY	Jharkhand Sampoorn Bijli Achadan Yojana
JSEB	Jharkhand State Electricity Board
JSERC	Jharkhand State Electricity Regulatory Commission
JSPTCL	Jharkhand State Power Transmission Company Limited
JUSNL	Jharkhand Urja Sancharan Nigam Limited
JUUNL	Jharkhand Urja Utpadan Nigam Limited
MNRE	Ministry of New and Renewable Energy
MU	Mega Unit
MW	Megawatt
NBP	National Biogas Programme
NTPC	National Thermal Power Corporation
PEUM	Partial End Use Method
PGCIL	Power Grid Corporation of India Limited
PM-KUSUM	Pradhan Mantri Kisan Urja Suraksha Evam Utahan Mahabhiyan
PPAs	Power Purchase Agreements
RDSS	Revamped Distribution Sector Scheme
RPOs	Renewable Purchase Obligations
RTS	Rooftop Solar
SEEI	State Energy Efficiency Index
SHP	Small Hydro Power
T&D	Transmission and Distribution
TPCL	Tata Power Company Limited
TSL	Tata Steel Limited
TSUISL	Tata Steel Utilities and Infrastructure Services Limited
TVNL	Tenughat Vidyut Nigam Limited
UMPP	Ultra Mega Power Projects
UNIDO	United Nations Industrial Development Organization

Executive Summary

The energy transition in Jharkhand illustrates an evolving landscape where economic development is being increasingly aligned with environmental sustainability and social equity. Traditionally dependent on sectors like mining and heavy industry, the state is now gradually moving toward cleaner and more sustainable energy sources. This shift is being propelled by policy initiatives, technological progress, and shifting market forces.

Energy plays a crucial role in driving a state's economic growth, and in Jharkhand, this has led to a rising demand for power in recent years. During 2021–2022 and 2022–2023, power demand outpaced supply, resulting in a deficit of 201 MW in 2021–2022, which further widened to 229 MW by August 2022. In the financial year 2020–21, transmission and distribution (T&D) losses in Jharkhand increased by 12.31%, reflecting a decline in the operational efficiency of the state's DISCOMs responsible for electricity transmission.

Jharkhand's energy mix remains heavily skewed toward thermal power, which accounts for 93.59% of the total electricity generation. This is followed by hydropower (4%) and solar power (2.25%), while bio-power and small hydropower contribute a minimal 0.8%. The state's energy intensity is relatively low, at approximately 0.004, suggesting that Jharkhand is efficient in generating economic output with comparatively low energy consumption. Notably, solar power has consistently contributed to the state's renewable energy capacity, whereas small hydropower generation has shown irregular output, making it an unreliable energy source.

Renewable energy has become a central pillar in Jharkhand's energy transition strategy, given the state's substantial potential for harnessing solar, wind, and biomass energy. To accelerate the adoption of renewables, Jharkhand has introduced a range of policies and programs, including financial incentives for renewable energy projects, investments in solar parks, and targeted initiatives to expand renewable energy capacity.

However, despite this progress, the state continues to face notable challenges. These include infrastructural bottlenecks, financial limitations, and the absence of a comprehensive and robust regulatory framework. Overcoming these hurdles will require sustained investment in renewable energy infrastructure, strategic policy reforms to encourage sustainable energy practices, and concerted efforts to build institutional and community-level capacity.

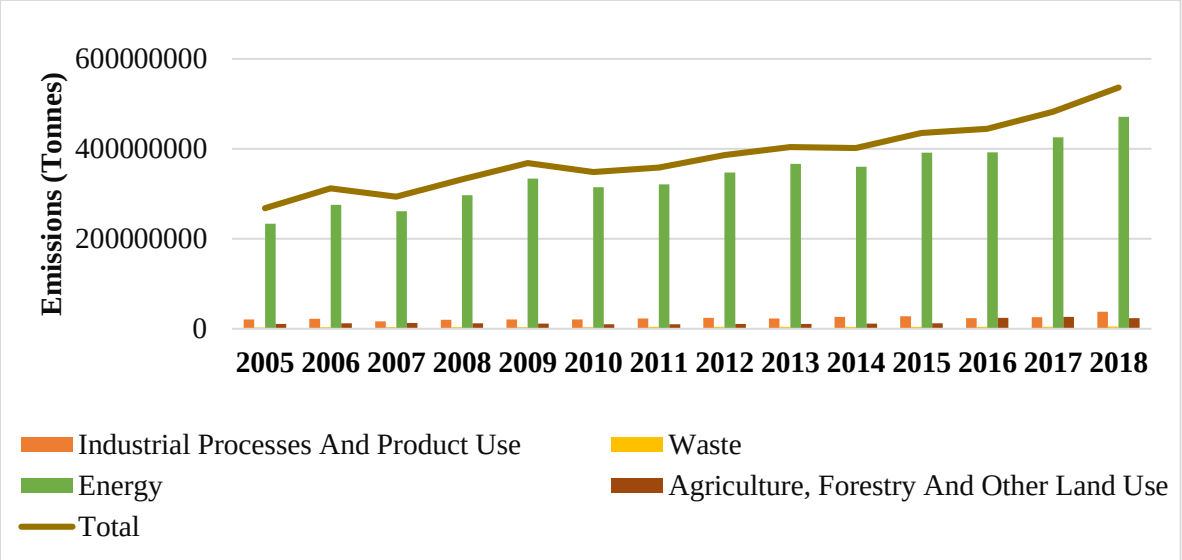
1. Introduction

India, as one of the world's fastest-growing economies, is undergoing a significant transformation in its energy sector. The national energy transition involves a strategic shift from conventional fossil fuels to cleaner and renewable energy sources, driven by the imperatives of climate change mitigation, energy security, and sustainable development (Ordonez et al., 2023). As the third-largest emitter of greenhouse gases globally, accounting for 2.8 Gt CO_2 annually, India has pledged to achieve net-zero emissions by 2070 (International Energy Agency, 2024). This commitment, articulated through the Panchamrit strategy announced by Prime Minister Narendra Modi at COP26 in Glasgow, includes increasing non-fossil fuel energy capacity to 500 GW and meeting 50% of the country's energy demand from renewable sources by 2030 (UNFCCC, 2022). Achieving these targets will require coordinated action at the national and subnational levels, particularly through effective state-level strategies and implementation.

Situated in eastern India, Jharkhand is well known for its rich mineral reserves, cultural diversity, and substantial development potential. According to the 2011 Census, Jharkhand had a population of approximately 32.96 million, constituting 2.79% of India's total population, with tribal communities accounting for nearly 26%. The state's vast mineral wealth, including coal, iron ore, copper, uranium, and mica, has long underpinned its industrial and economic development. Mining remains a cornerstone of Jharkhand's economy, significantly contributing to gross state domestic product (GSDP) and export revenues. The state has experienced rapid industrialisation, particularly in steel, power, and manufacturing sectors. Prominent steel producers like Tata Steel and JSW Steel have established major operations in Jharkhand, boosting local employment and contributing to national industrial output. Moreover, the development of industrial parks and special economic zones has further spurred investment and economic growth.

However, this industrial expansion comes with considerable environmental costs. Jharkhand is among the leading contributors to India's greenhouse gas (GHG) emissions, releasing approximately 115.20 Mt CO_2e annually, about 3.9% of the national total (GHG Platform India, 2022). The energy sector is the dominant source of these emissions, largely due to the state's dependence on coal-fired thermal power plants for electricity generation (**Fig.1**). Between 2005 and 2018, both the number and capacity of such plants increased significantly, resulting in a marked rise in CO_2 emissions from coal combustion.

Figure 1: Sector-wise GHG emissions in Jharkhand (2005-2018)



Source: GHG Platform India, 2022

This report aims to present a comprehensive overview of the current state of the energy sector in Jharkhand, with a focus on key areas including electricity generation, distribution, renewable energy initiatives, and the challenges associated with transitioning to cleaner energy sources.

2. Research Methodology

The present report draws upon secondary data sources, including peer-reviewed research articles, annual reports from various government departments, and policy documents related to energy transition, renewable energy deployment, and sustainable development in Jharkhand. These sources include data from agencies such as the Central Electricity Authority (CEA), Jharkhand Renewable Energy Development Agency (JREDA), and the Ministry of New and Renewable Energy (MNRE). This comprehensive review aims to analyse the current status of energy transition initiatives, identify economic, infrastructural, and social challenges, and assess the effectiveness of existing policies and programmes. The report also highlights gaps in implementation and offers evidence-based insights for policy reform.

3. The Economy of Jharkhand

Jharkhand is one of India's most mineral-rich states, endowed with substantial reserves of coal, iron ore, bauxite, copper, limestone, and other valuable minerals. The mining sector plays a pivotal role in the state's economy, attracting significant investment from both domestic and international

stakeholders. In addition to mining, the industrial, agricultural, and service sectors contribute notably to employment generation and overall economic development.

Between the financial years 2011–12 and 2018–19, Jharkhand's economy, measured by Gross State Domestic Product (GSDP), grew at a compound annual growth rate (CAGR) of 6.2% at constant prices and 10.6% at current prices. However, in 2019–20, the state's economic growth experienced a slowdown, with the real GSDP growing by only 1.1% at constant prices and the nominal GSDP increasing by just 1.5% at current prices (**Table 1**).

Table 1: GSDP at Constant and Current Prices from 2011-12 to 2024-25 FY.

Year	GSDP in Crore		Growth Rate in GSDP	
	Constant Prices	**Current Prices**	**Constant Prices**	**Current Prices**
2011-12	150918	150918		
2012-13	163250	174724	8.2	15.8
2013-14	165816	188567	1.6	7.9
2014-15	186534	218525	12.5	15.9
2015-16	174881	206613	-6.2	-5.5
2016-17	193174	236250	10.5	14.3
2017-18	210587	269816	9.0	14.2
2018-19	229274	305695	8.9	13.3
2019-20	231755	310305	1.1	1.5
2020-21	219483	296664	-5.3	-4.4
2021-22 (P.)	243348	358863	10.9	21.0
2022-23 (Pr.)	259800	393722	6.8	9.7
2023-24 (Pr.)	278316	428155	7.1	8.7
2024-25 (Pr.)	299843	470104	7.7	9.8

(P-Provisional, Pr. -Projection)

Source: Jharkhand Economic Survey, 2023-24, Govt. of Jharkhand.

The COVID-19 pandemic had a profound impact on economies across the globe, including India. The nationwide lockdowns and restrictions imposed to control the spread of the virus significantly disrupted economic activity. Industries, businesses, and commercial establishments were forced to shut down temporarily, resulting in production losses and a sharp decline in revenue. In Jharkhand, the economic impact of the pandemic was substantial. According to the Jharkhand Economic Survey 2023–24, the Gross State Domestic Product (GSDP) growth rate declined to 5.3% at constant prices and 4.4% at current prices between the financial years 2019–20 and 2020–21. In 2020–21, the state's GSDP was estimated at ₹2,96,664 crore at current prices and ₹2,19,483 crore

at constant prices. Despite the initial setback, the economy rebounded in subsequent years, with real GDP projected to grow by 10.9% between 2020–21 and 2021–22, and by 6.8% between 2021–22 and 2022–23. Overall, from 2020–21 to 2022–23, Jharkhand's economy grew at an average annual rate of 8.8%, slightly higher than the national average of 8.1% (Times of India, February 28, 2024). Projections for the state indicate a growth rate of 7.1% for the fiscal year 2023–24, with further improvement to 7.7% expected in 2024–25.

Table 2 : Growth Rate of the Sectors of Economy at Constant Prices from 2012-13 to 2024-25 FY.

Sectors	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P.)	2022-23(Pr.)	CAGR (2011-23)
Agriculture, Forestry and Fishing	5.9	-1.8	30.7	-28.4	23.4	2.2	-6.8	0	6.3	5	10.1	3.1
Mining and Quarrying	6.8	-0.6	17.3	-2.6	-14.2	0.6	9.7	0.5	-16.8	19.4	2.4	1.5
Manufacturing	19.8	-7.2	9.4	-25.8	34.1	14	22.4	-9.5	1.5	13.7	2.9	5.6
Electricity, Gas, Water supply and Other Utilities	18.7	1.6	-6.9	14.5	-53.9	44.1	50.8	23.1	-7.2	35.6	12.9	7.7
Construction	-6.6	10.4	0.4	1.6	5.6	5.7	6.8	1.5	-6.7	16.2	7.9	3.7
Trade, Repair, Hotels and Restaurants	11.7	8.8	10.6	14.7	13.5	12.8	16.7	10.2	-17.3	10.4	5.5	8.5
Transport, Storage and Communication	10.3	9.7	9.4	8.1	0.4	2.7	4.6	4.5	-15	23.2	6.7	5.2
Financial Services	9.4	2.9	5.7	23.3	-1.4	4.4	-0.2	6.1	3	-3	8.5	5.1
Real estate, dwelling and professional services	8	5	12.6	7.4	8.7	6.4	5.5	4.1	-2.8	11.6	9.7	6.9
Public administration	-12.5	-6.8	17	-9.7	3.5	53.2	-6.6	-10.1	-1.6	8.8	7.6	2.6
Other services	11.9	9.3	6.9	-1.7	1.3	-15.1	40.7	24	-5.6	3.9	12.1	7.1

(P-Provisional, Pr. -Projection)

Source: Jharkhand Economic Survey, 2023-24, Govt. of Jharkhand.

Similarly, the per capita income in Jharkhand also declined during the pandemic period. It fell by 7.7% at constant prices and 5.3% at current prices between 2019–20 and 2020–21. However, a recovery followed, with per capita income rising from ₹51,365 to ₹55,126 at constant prices and

from ₹71,071 to ₹78,660 at current prices between 2020–21 and 2021–22. For 2023–24, per capita income is projected to grow by 6.7% at constant prices and 9.4% at current prices. Additionally, the state's poverty intensity showed signs of improvement, with the poverty rate declining from 47.91% in 2015–16 to 43.8% in 2019–21 (Jharkhand Economic Survey, 2023–24).

An analysis of sectoral growth in Jharkhand from 2012–13 to 2024–25 reveals key trends across various segments of the economy. Agriculture, forestry, and fishing remain vital to Jharkhand's economy, supporting a large share of the rural population. This sector, which includes crop production, livestock, forestry, and fisheries, grew at a modest average annual rate of 3.1% between 2012–13 and 2022–23, primarily due to fluctuating monsoon patterns. In contrast, the tertiary sector, comprising trade, repair, hotels and restaurants, transport, storage and communication, financial services, and real estate, performed significantly better than the primary and secondary sectors. Over the same period, these sectors grew at an average annual rate of 8.5%, 5.2%, 5.1% and 6.9% respectively. Overall, the service sector has emerged as a key driver of economic growth in the state (**Table 2**).

4. The Energy Sector of Jharkhand

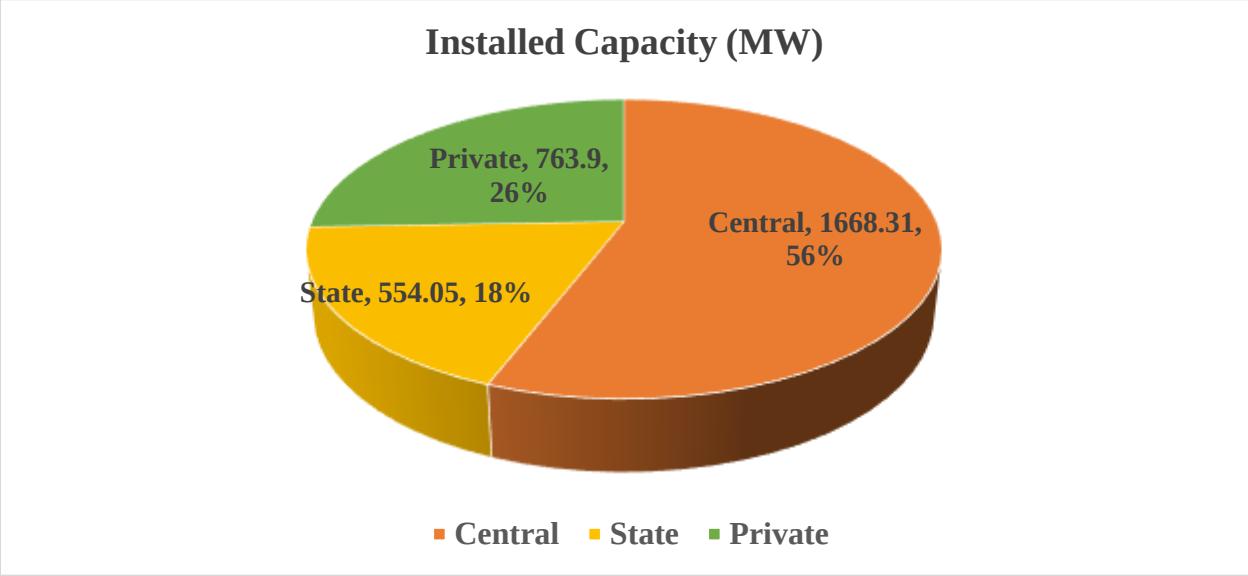
Jharkhand, endowed with abundant mineral wealth, holds a prominent position in India's energy landscape. The state's energy sector is diversified, encompassing coal, thermal power, hydropower, and renewable energy sources. As one of the country's leading coal-producing states, Jharkhand possesses substantial reserves of high-grade coal, which plays a crucial role in both its economy and the national power supply. The coal mining industry is a major economic driver for the state, supporting energy generation and industrial activity. Key coal-producing regions include Dhanbad, Bokaro, and Ramgarh, which are central to Jharkhand's energy infrastructure.

4.1 Installed capacity

Jharkhand's installed power generation capacity is predominantly reliant on coal-based thermal power plants, a reflection of the state's abundant coal reserves. However, there is a growing emphasis on transitioning to a more diversified and sustainable energy portfolio. The state has initiated several projects aimed at enhancing generation capacity, improving efficiency, and promoting the adoption of renewable energy sources. The composition of Jharkhand's installed power capacity highlights a collaborative framework involving the central government, state authorities, and private sector stakeholders. Notably, the central government accounts for the largest

share of this capacity, approximately 56%, while the state government and private entities also contribute significantly (**Fig. 2**).

Figure 2: Sector-wise installed capacity (in MW) of power utilities in Jharkhand



Source: Central Electricity Authority (CEA) Report, as on 31st May, 2024

4.2 Production and Consumption of Power in Jharkhand

According to the Jharkhand Economic Survey 2023-24, the total power consumption in Jharkhand reached 9,098.93 million units (MU) in 2022–23, while power availability for Jharkhand Bijli Vitran Nigam Limited (JBVNL) stood at 16,510 MU during the same period (**Table 3**). Power statistics indicate that JBVNL's power availability increased by 2,729.66 MU between 2020–21 and 2021–22. Analysing data from FY 2014–15 to FY 2023–24, this represents the highest level of power availability, accompanied by a steady year-on-year growth rate of 4.2%.

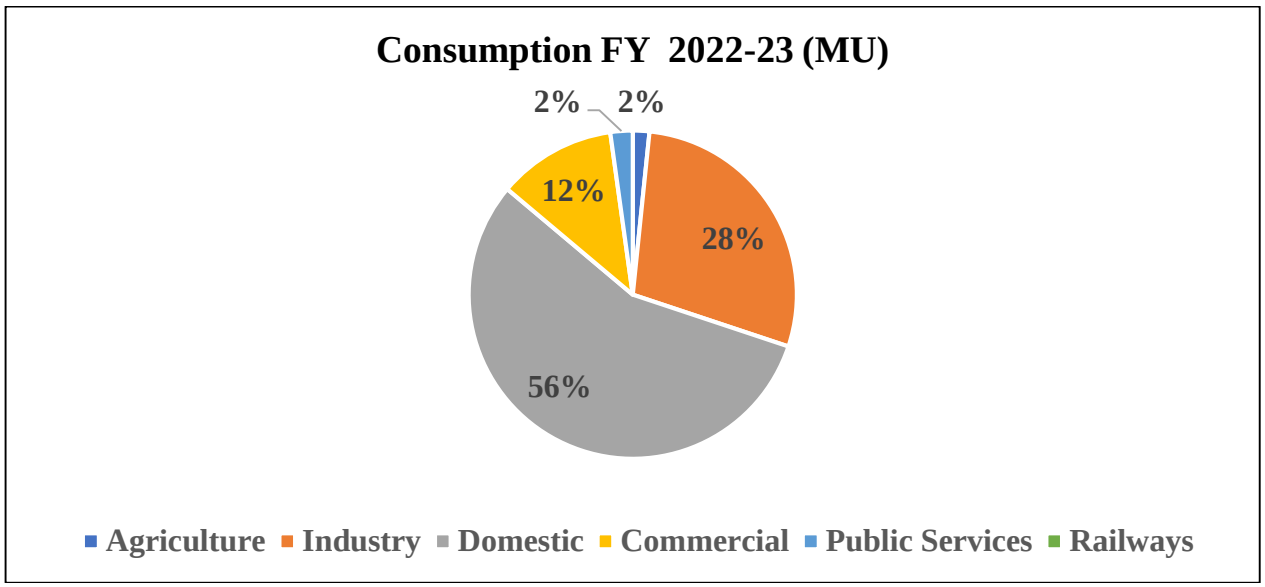
Table 3: Power Statistics for Jharkhand (in MU)

Year	Availability of power for JBVNL
2014-15	10859.61
2015-16	13062.67
2016-17	12864.97
2017-18	13319.79
2018-19	13820.2
2019-20	11437.12
2020-21	13177.34
2021-22	15907
2022-23	16510
2023-24 (Up to September 23)	9350

Source: Jharkhand Economic Survey, 2023-24, Govt. of Jharkhand.

When we look into the sector-wise consumption, we have seen that domestic power consumption (56%) has been consistently high followed by industrial power consumption (28%) (**Fig.3**).

Figure 3: Sector-wise Power Consumption for FY 2022-23



Source: Jharkhand Economic Survey, 2022-23, Govt. of Jharkhand.

The domestic sector constitutes a significant share of power consumption in Jharkhand, with households relying on electricity for lighting, cooking, heating, and various appliances. The growth of urban areas and expanding household electrification have driven increased electricity demand in residential zones. Industrial consumers, particularly in the steel, mining, and manufacturing sectors, are among the largest power users in the state, requiring a reliable and continuous supply to operate machinery and production processes. However, power consumption across most sectors declined in FY 2022–23 compared to previous years, except the commercial and public service sectors. Power usage in the commercial sector rose by 149.97 million units (MU), from 911.85 MU in FY 2021–22 to 1,061.82 MU in FY 2022–23. Although the public services sector consumes the least electricity, it witnessed substantial growth, increasing from just 21.43 MU in FY 2019–20 to 200.17 MU in FY 2022–23, a nearly tenfold rise (**Table 4**). While the agricultural sector's electricity consumption remains relatively low compared to industrial and commercial sectors, it still represents an important portion of Jharkhand's overall power use.

Table 4: Sector wise power consumption in the years from FY 2019-20 to FY 2022-23

Sector	Consumption FY 2019-20(MU)	Consumption FY 2020-21(MU)	Consumption FY 2021-22 (MU)	Consumption FY 2022-23 (MU)
Agriculture	234.42	255.66	178.05	148.68
Industry	2716.27	2730.38	2067.29	2591.24
Domestic	5660.08	5886.49	5629.96	5097.02
Commercial	798.87	894.74	911.85	1061.82
Public Services	21.43	22.08	90.04	200.17
Railways	100.42	104.44	13.02	-
Total	**9531.49**	**9893.79**	**8890.21**	**9098.93**

Source: Jharkhand Economic Survey, 2023-24, Govt. of Jharkhand.

4.3 Demand and Supply of Electricity in Jharkhand

The state has recovered from the economic setbacks experienced during the COVID-19 pandemic. Given the crucial role of energy in driving economic growth, power demand in Jharkhand has consistently outpaced supply during FY 2021-22, FY 2022-23, and FY 2023-24. Consequently, the gap between peak power demand and supply has widened from 281 MW in FY 2021-22 to 514 MW in FY 2022-23, and further increased to 535 MW as of September 2023 in FY 2023-24. Detailed data on electricity demand and availability in Jharkhand from FY 2014-15 through FY 2023-24 (up to September 2023) are presented in **Table 5**.

Table 5: Peak Power Demand and Supply (MW)

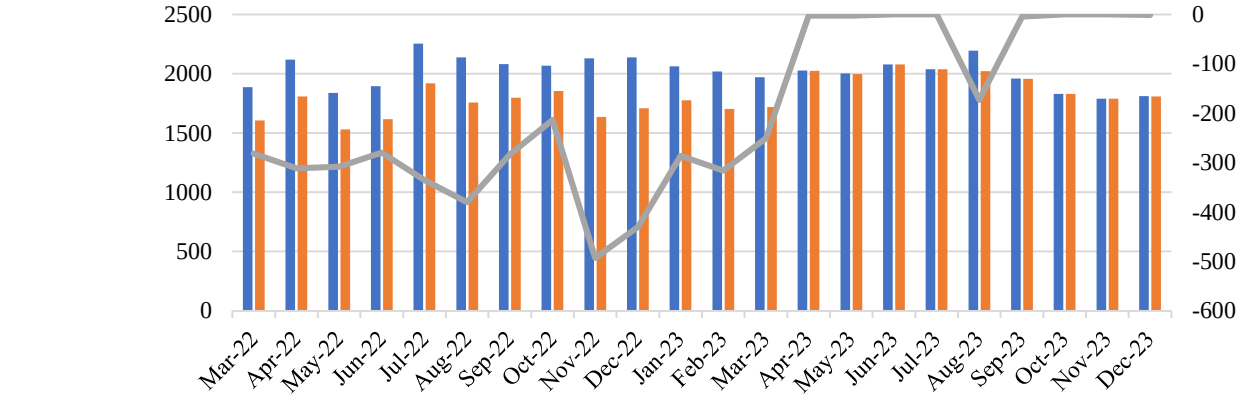
Year	Peak Demand	Peak Availability	Shortage
2014-15	1850	1764	86
2015-16	1970	1827	143
2016-17	2051	1933	118
2017-18	2113	1994	119
2018-19	2169	2210	-41
2019-20	1396	1389	7
2020-21	1619	1566	53
2021-22	2358	2197	281
2022-23	2636	2429	514
2023-24 (Up to September 2023)	2715	2792	535

Source: Jharkhand Economic Survey, 2023-24, Govt. of Jharkhand.

In FY 2018-19, electricity demand in Jharkhand was 41 MW lower than the available supply. However, statistics reveal that peak demand has been rising more rapidly than peak availability, indicating an increasing overall load factor in the state.

Monthly power supply data for FY 2022-23 and FY 2023-24 (up to December) show a recurring power deficit relative to demand. The highest shortfall occurred in November 2022, with a deficit of 493 MW, followed by a similar shortage in December. Notably, the deficit sharply decreased in April 2023, dropping from -251 MW in March to just -2.8 MW in April. Moreover, Jharkhand was able to fully meet its power demand during June, July, October, and December 2023 (**Fig. 4**). This trend indicates that the state is now capable of satisfying its peak power demand in 2023.

Figure 4: Peak Demand vs Peak met in Jharkhand in the financial years 2022-23 and 2023-24 (Up to December 2023)



	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23
Peak Demand	1887	2118	1837	1895	2253	2138	2081	2068	2128	2138	2061	2019	1970	2026	2001	2077	2036	2193	1960	1830	1788	1810
Peak Met	1605	1807	1528	1615	1918	1757	1797	1854	1635	1708	1775	1703	1719	2023	1998	2077	2036	2020	1955	1830	1788	1809
Shortage	-282	-311	-308	-280	-336	-381	-284	-214	-493	-430	-287	-316	-251	-2.8	-2.8	0	0	-173	-4.3	0	0	-1.1

Source: Central Electricity Authority (CEA) Dashboard

4.4 Transmission and Distribution (T&D) Loss in Energy

Energy losses during supply and delivery occur due to both technical and commercial factors. The efficiency of Distribution Companies (DISCOMs) is often assessed by analysing these energy losses over a given period. In Jharkhand, Transmission and Distribution (T&D) losses increased by 11.94 per cent in 2020–21, signalling a decline in the efficiency of DISCOMs responsible for electricity transmission in the state (**Table 6**).

4.5 Energy Intensity

Energy intensity refers to the amount of energy required to generate a unit of economic output, such as Gross Domestic Product (GDP) or industrial production, and serves as a key indicator of energy efficiency within an economy (Filipović et al., 2015). A high energy intensity means that more energy is needed to produce a given level of output, whereas low energy intensity signifies greater

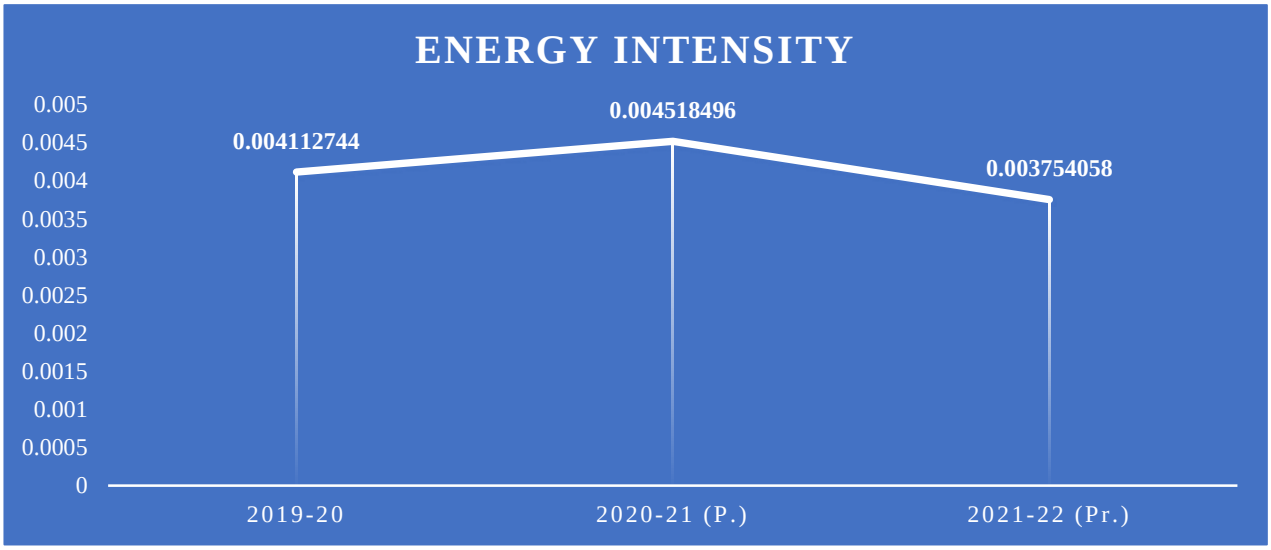
efficiency, with less energy consumed for the same output level (Hajiyev et al., 2023). Jharkhand's energy intensity is low, approximately 0.004, indicating that the state efficiently produces goods and services while consuming relatively less energy (**Fig. 5**).

Table 6: Year-wise Transmission and Distribution Loss of Energy

Year	T & D Loss (%)
2014-15	29.71
2015-16	28.00
2016-17	24.20
2017-18	20.40
2018-19	22.89
2019-20	23.03
2020-21	34.97
2021-22	27.45
2022-23	30.28

Source: Jharkhand Economic Survey, 2023-24, Govt. of Jharkhand.

Figure 5: Energy Intensity of Jharkhand



Years	GSDP (in crore)	Consumption (in MU)	Consumption (in crore)	Energy Intensity
2019-20	231755	9531.49	953.149	0.004113
2020-21 (P.)	218962	9893.79	989.379	0.004518
2021-22 (Pr.)	236816	8890.21	889.021	0.003754

Source: Computed by the author

4.6 Forecasting of Electrical Energy Consumption in Jharkhand

Forecasting electricity demand is essential for utilities, policymakers, and energy planners to effectively manage power generation, transmission, and distribution infrastructure. Multiple factors

influence electricity demand, including population growth, economic development, technological advancements, weather patterns, and the implementation of energy efficiency measures.

To project electricity consumption in Jharkhand, the Central Electricity Authority of India (CEA, 2022) employed the Partial End Use Method (PEUM**)**. The PEUM is a detailed forecasting approach that estimates electricity consumption by disaggregating total demand into specific end-use categories or applications. Unlike aggregate forecasting methods that analyse total energy use at a regional or sectoral level, PEUM offers granular insights by breaking down consumption across distinct end-uses.

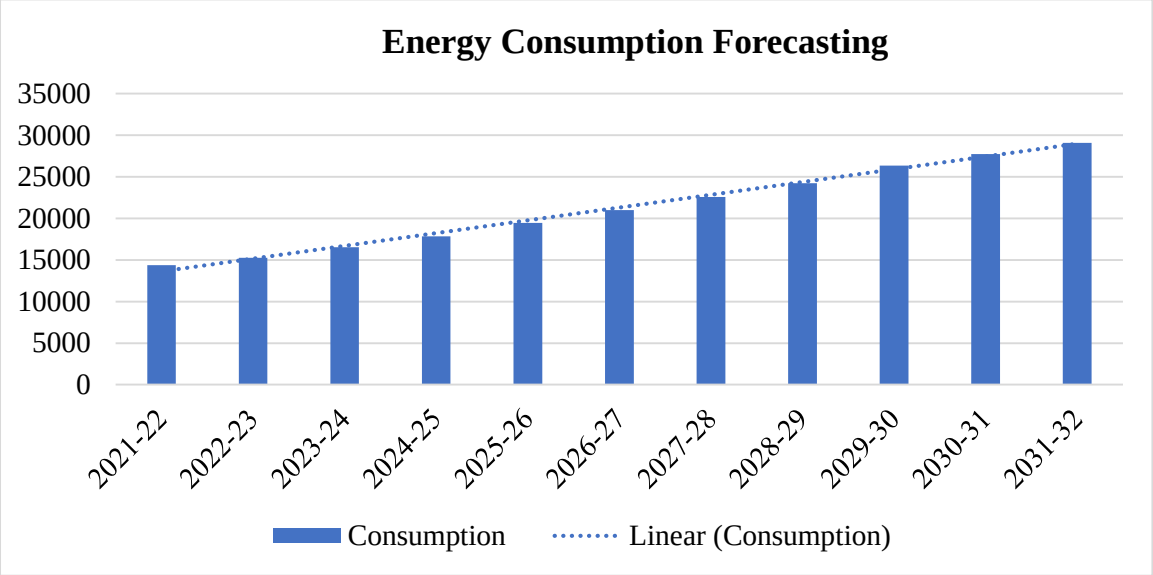
The first step in the PEUM involves identifying the key end-use categories, such as lighting, space heating and cooling, water heating, appliances, industrial processes, and commercial activities. Subsequently, in the second step, relevant data are collected for each category, including historical electricity consumption, demographic trends, economic indicators, building characteristics, weather patterns, and technological variables. In the third step, statistical regression techniques are applied to model the relationship between electricity consumption and its influencing variables for each end-use category. These regression models, developed using historical and contextual data, serve as the basis for forecasting future electricity consumption. Based on the analysis presented in **Table 7**, electricity consumption in Jharkhand is projected to grow steadily from FY 2021–22 to FY 2031–32. As industrial activities expand and urbanization continues, demand across residential, commercial, and industrial sectors is expected to rise correspondingly. The consumption trend over the forecasted period follows a linear growth pattern (**Fig. 6**), reflecting the state's evolving socio-economic dynamics, industrial development, and increasing emphasis on sustainable energy practices.

Table 7: Forecasting of Energy Consumption (in MU)

Year	Consumption (in MU)
2021-22	14361
2022-23	15259
2023-24	16512
2024-25	17842
2025-26	19472
2026-27	20984
2027-28	22571
2028-29	24224
2029-30	26346
2030-31	27732
2031-32	29068

Source:20th Electric Power Survey of India, Central Electricity Authority, 2022

Figure 6: Trend of Forecasting of Energy Consumption



Source: 20th Electric Power Survey of India, Central Electricity Authority, 2022

Table 8 presents the Compound Annual Growth Rate (CAGR) of electrical energy sales in Jharkhand from the financial year (FY) 2012–13 to FY 2020–21. The data indicate a general upward trend in energy sales over the period, with a CAGR of 3.42 per cent. Electrical energy sales increased from 22,737.74 GWh in FY 2012–13 to 28,789.96 GWh in FY 2019–20. However, there was a decline in sales in FY 2020–21, when the total dropped to 27,673.21 GWh, primarily due to the disruptions caused by the COVID-19 pandemic, which led to reduced industrial and commercial activities across the state.

Table 8: Compound Annual Growth Rate (CAGR) of Electrical Energy Sales

Year	Total Energy Sold (GWh)	CAGR (in %)
2012-13	22737.74	**3.42**
2013-14	23845.47	
2014-15	22150.97	
2017-18	24788.80	
2018-19	26814.80	
2019-20	28789.96	
2020-21	27673.21	

Source: Central Electricity Authority (CEA) Dashboard, from the FY 2012-13 to 2020-21

An analysis of the Compound Annual Growth Rate (CAGR) of electrical energy sales across various sectors in Jharkhand from FY 2012–13 to FY 2020–21 reveals significant sectoral variations (**Table 9**). The agricultural sector recorded the highest CAGR at 11.7 per cent, followed by the commercial

sector at 10.87 per cent and the domestic sector at 6.95 per cent, indicating robust growth in electricity consumption in these areas. In contrast, the industrial sector (low and medium voltage) exhibited the slowest growth rate among the major sectors. Notably, there was a negative CAGR in public lighting (-12.4 per cent) and traction (-3.25 per cent), reflecting a consistent decline in energy sales in these categories over the review period.

Table 9: Compound Annual Growth Rate of Electrical Energy Sales Sector-Wise

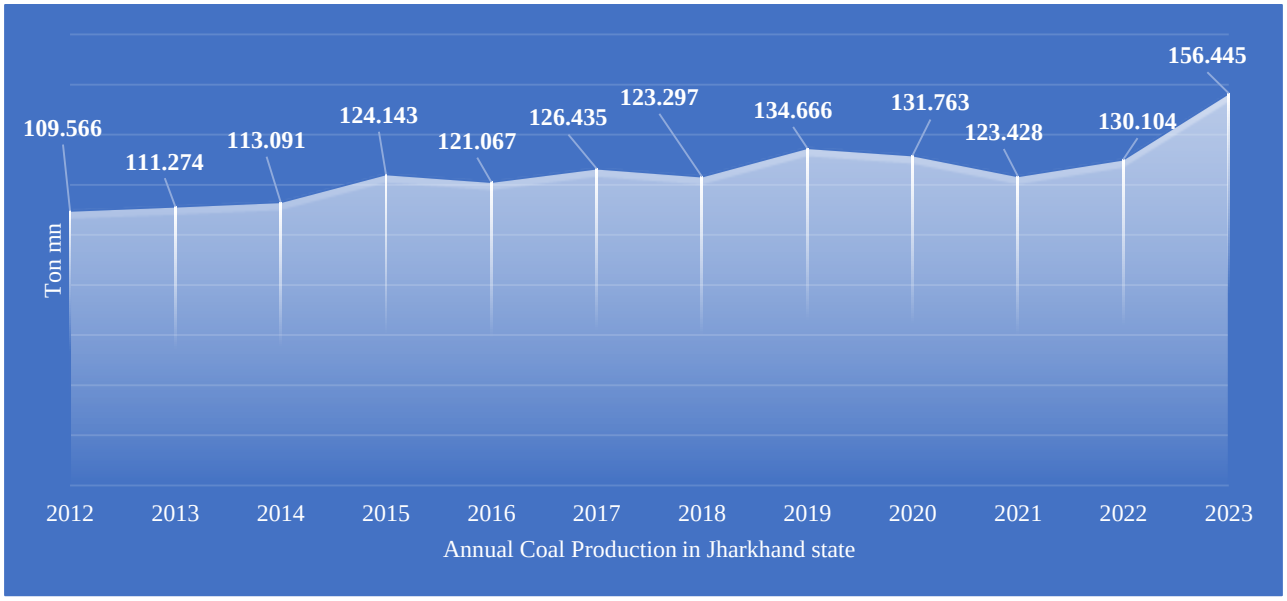
Category	CAGR (in %)
Domestic	6.95
Commercial	10.87
Industrial (Low & Med. Voltage)	6.89
Public Lighting	-12.40
Traction	-3.25
Agriculture	11.70
Public Water Works & Sewage Pumping	-
Miscellaneous	4.20

Source: Central Electricity Authority (CEA) Dashboard, from the FY 2012-13 to 2020-21

5. Energy Mix in Jharkhand

Jharkhand's industrial sector, particularly its mining and manufacturing industries, is a major consumer of electricity, accounting for approximately 46 per cent of total energy consumption in the state (ISEP, 2021). The presence of large-scale steel plants, coal mines, and other heavy industries significantly contributes to this high energy demand. To meet its energy requirements, Jharkhand relies on a mix of conventional and non-conventional energy sources. Among these, thermal energy production plays a dominant role, primarily driven by the state's abundant coal reserves. As of April 2023, Jharkhand held an estimated 86,660 million tonnes of coal, constituting about 23.98 per cent of India’s total coal reserves (Government of India, 2024). This vast resource base supports the operation of several coal-based thermal power plants across the state, operated by both public and private entities. These plants generate electricity by burning coal to produce steam, which in turn drives turbines (**Fig. 7**).

Figure 7: Coal production in Jharkhand

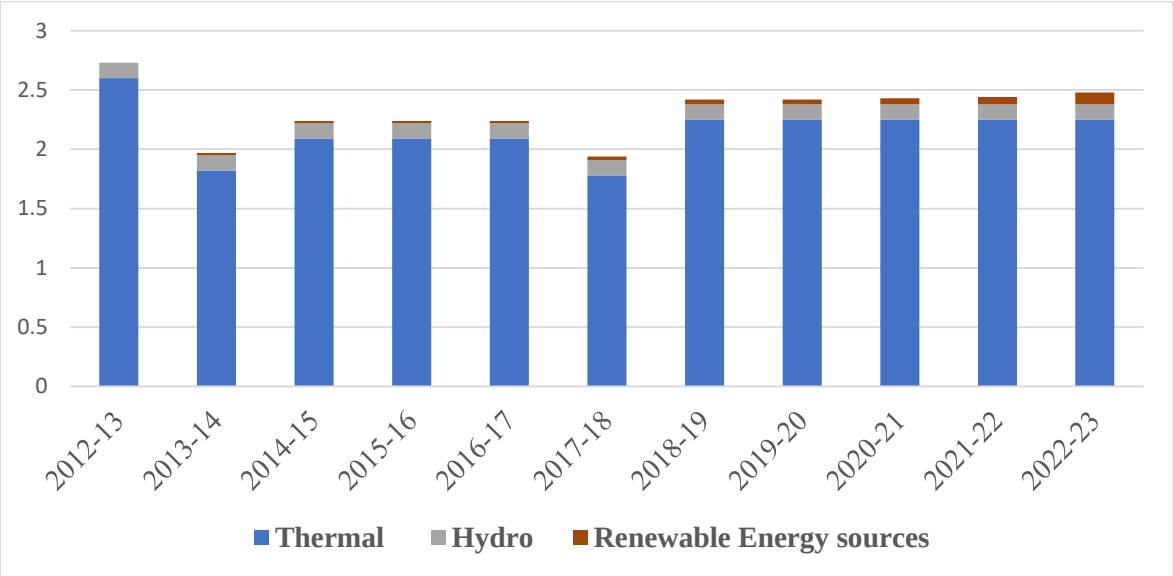


Source: Central Electricity Authority (CEA) Dashboard, from the FY 2012-13 to 2022-23

Alongside thermal power generation, Jharkhand is increasingly focusing on integrating renewable energy sources, notably solar and hydro, into its energy mix. This transition aims to diversify the state's energy portfolio, reduce greenhouse gas emissions, and enhance energy security. **Figure 8** illustrates a rising trend in the adoption of renewable energy sources, complementing the growth in thermal power generation. In terms of renewable energy potential, Jharkhand has a significant estimated solar energy potential of 18,180 MW, followed by 300 MW of large hydropower capacity (**Table 10**). However, despite this potential, the actual capacity utilisation remains limited. As per the Central Electricity Authority (CEA), as of January 2024, Jharkhand's total installed power generation capacity stood at 2,773.53 MW, of which renewable energy contributed just 332.87 MW, including 191 MW from hydropower, while the remaining 2,440.66 MW was derived from thermal sources (Renewable Watch, March 1, 2024). Notably, there is no operational wind power capacity in the state.

The state government has taken active steps to promote solar energy, introducing a range of policies, incentives, and subsidies to encourage the uptake of rooftop solar installations, utility-scale solar projects, and the development of solar parks. Moreover, hydroelectric power, though limited in potential, has historically played a supplementary role in meeting the state's energy requirements.

Figure 8: Energy Generation Category Wise Installed Capacity in Jharkhand from 2012-13 to 2022-23



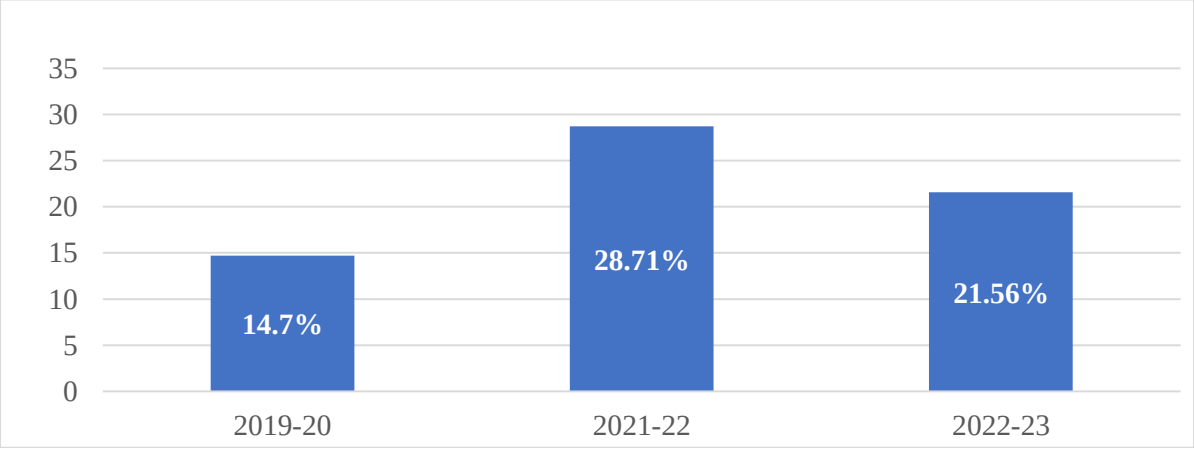
Source: Energy Statistics from the year 2013 to 2023, Ministry of Statistics and Programme Implementation, GOI

Table 10: Source-wise Estimated Potential of Renewable Energy in Jharkhand as of 23.03.2023

Source	**Potential (in MW)**
Wind Power @150m	16
Small Hydro Power	228
Biomass Power	146
Solar Energy	18180
Large Hydro	300
Total	**18870**

Source: Energy Statistics 2024, Ministry of Statistics and Programme Implementation, GOI

Figure 9: Trend of Solar Power Generated from FY 2019-20 to FY 2022-23



Source: Central Electricity Authority (CEA) Dashboard, from the FY 2019-20 to 2022-23

5.1 State Energy Efficiency Index 2020

The State Energy Efficiency Index (SEEI) is an evaluative framework developed by the Bureau of Energy Efficiency (BEE), Government of India, designed to assess and compare the energy efficiency performance of all Indian states and union territories (UTs) across multiple sectors. The SEEI serves as a critical tool for policymakers, energy planners, and stakeholders, enabling them to track progress, identify areas for improvement, and benchmark performance in the realm of energy efficiency. The index incorporates a comprehensive set of 68 indicators, which include qualitative, quantitative, and outcome-based metrics. These indicators span six key sectors: Buildings, Industry, Municipalities, Transport, Agriculture & DISCOMs and Cross Sector. The maximum attainable score under the SEEI 2020 framework is 100, providing a standardised metric to evaluate and rank states based on their implementation of energy efficiency policies, programs, and outcomes (**Table 11**).

Jharkhand scored 17 out of 100 in SEEI 2020.

- Jharkhand experiences a longer period of power outages, i.e. an interrupted supply of electricity.
- Jharkhand has greater scope for improvement in clean energy initiatives, energy efficiency, environmental sustainability, and new initiatives such as energy storage for the power and transport sectors.
- Among the larger states, Jharkhand's category rank is 18, and it is 26th in overall ranking and is amongst the bottom three states in this respect.

Table 11: SECI (State Energy and Climate Index) Round I scorecard for Jharkhand

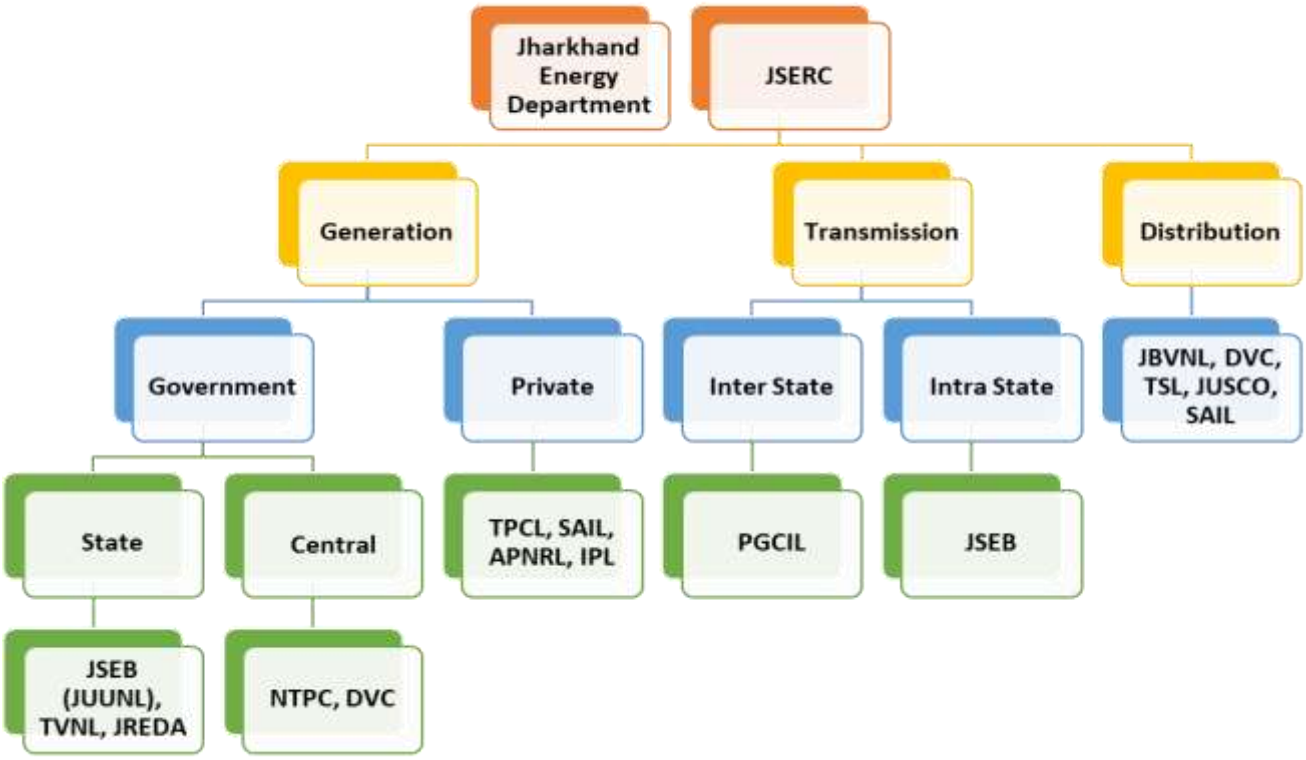
Sl. No.	Category	Score (out of 100)
1	DISCOM's Performance	58.3
2	Access, affordability and reliability	46.5
3	Clean Energy Initiatives	2.9
4	Energy Efficiency	17.2
5	Environment Sustainability	19
6	New Initiatives	9.3
7	SECI Score	35.2

Source: State Energy &Climate Index Round -1, NITI Aayog (April 2022)

6. The Institutional and Administrative Structure of Jharkhand Power System

The power sector in Jharkhand operates within a well-defined administrative and institutional framework, encompassing multiple entities that oversee the generation, transmission, distribution, and regulation of electricity. This structure facilitates coordination among stakeholders and promotes the efficient and reliable delivery of power across the state. The framework is designed to ensure that responsibilities are delineated among the various agencies involved, thereby enhancing the overall governance and performance of the state's power sector (**Fig. 10**).

Figure 10: Jharkhand Power System Structure



The *Jharkhand State Electricity Regulatory Commission (JSERC)* serves as a pivotal institution in the governance of the power sector in Jharkhand. Established under the provisions of the Electricity Act, 2003, JSERC is tasked with ensuring the regulated, balanced, and sustainable development of the electricity market in the state. It functions as an independent statutory body that safeguards the interests of consumers while promoting efficiency, competition, and investment in the sector. One of its core responsibilities is the determination and regulation of electricity tariffs across the value

chain—including generation, transmission, distribution, and supply. In addition to tariff regulation, JSERC plays a proactive role in mainstreaming renewable energy by formulating enabling regulations, setting Renewable Purchase Obligations (RPOs) for distribution licensees, and encouraging the adoption of clean energy technologies. Through these interventions, JSERC contributes to building a more resilient and sustainable power ecosystem in Jharkhand.

6.1 Power Generators in Jharkhand

The state has a diverse mix of power generation sources, including thermal (coal-based), hydroelectric, and renewable energy plants. These facilities are operated by state-owned entities, central government agencies, and private sector companies (**Table 12**).

Table 12: Power Generating Companies in Jharkhand

Generating Company	Power plants	Type	Installed capacity (MW)
State-owned Agencies			
1. **Jharkhand Urja Utpadan Nigam Limited (JUUNL)**	Subarnarekha Hydro Power Station (SHPS)	Hydro	130
2. **Tenughat Vidyut Nigam Limited (TVNL)**	Tenughat Thermal Power Station (TTPS)	Thermal	420
Central Government Agencies			
3. **National Thermal Power Corporation (NTPC)**	NTPC Kahalgaon	Thermal	2340
4. **Damodar Valley Corporation (DVC)**	Bokaro Thermal Power Station (BTPS)	Thermal	630
	Chandrapura Thermal Power Station	Thermal	750
	Koderma Thermal Power Station	Thermal	1000
	Maithon Hydel Power station	Hydro	63.2
Private Sector (IPP)			
5. **Tata Power Company Limited (TPCL)**	Jojobera Thermal Power Station	Thermal	240
6. **Adhunik Power & Natural Resources Limited (APNRL)**	Mahadev Prasad Super Thermal Power Plant	Thermal	540
7. **Inland Power Limited (IPL)**	NA	Thermal	63
8. **Tata Power and Damodar Valley Corporation (Joint venture)**	Maithan Thermal Power Station	Thermal	1050

Source: *Central Electricity Authority (CEA) Annual Report, 2022-23*

The *Jharkhand Renewable Energy Development Agency (JREDA*) plays a pivotal role in advancing the renewable energy agenda in Jharkhand. As the state nodal agency for renewable energy, JREDA is responsible for the planning, promotion, coordination, and implementation of various renewable energy projects. Its mandate encompasses the development of solar, wind, biomass, and small hydro power initiatives through a mix of policy interventions, project facilitation, capacity building, and public-private partnerships. JREDA has been particularly instrumental in the expansion of solar energy infrastructure across the state. This includes the development of grid-connected solar power plants, off-grid solar solutions, and rooftop solar systems in both urban and rural areas. These initiatives have significantly enhanced the installed solar capacity in Jharkhand and helped reduce the state's reliance on conventional energy sources. Furthermore, JREDA has led the establishment of solar parks, providing large-scale, pre-approved infrastructure for solar developers, thereby attracting private investment and accelerating project execution. Through its sustained efforts, JREDA has positioned renewable energy as a key pillar of Jharkhand's energy transition strategy. The agency's impact is evident in **Table 13**, which outlines its major achievements and contributions to the state's renewable energy landscape.

Table 13: Achievements of Jharkhand Renewable Energy Development Programme (JREDA)

Achievement of works under JREDA Scheme till March 2023			
Sl. No.	**Component/Scheme**	**Unit**	**Achievement**
1	Installation of Solar water Pumping System with a capacity of up to 7.5 HP under PM-KUSUM Component – B	No's	8922
2	Distribution of 200Wp Standalone Home lightening System	No's	14634
3	Grid-Connected Rooftop Solar Power Plants installed at various government buildings in the state	kWp	38953
4	Solar Mini/micro plant installed	kWp	1885.5
5	Installation of Street Lightening System	No's	22546
6	Solarization of Various Airport in the state	MW	1.2
7	Installation of Solar High mast System	No's	175

Source: Jharkhand Economic Survey, 2023-24, Govt. of Jharkhand

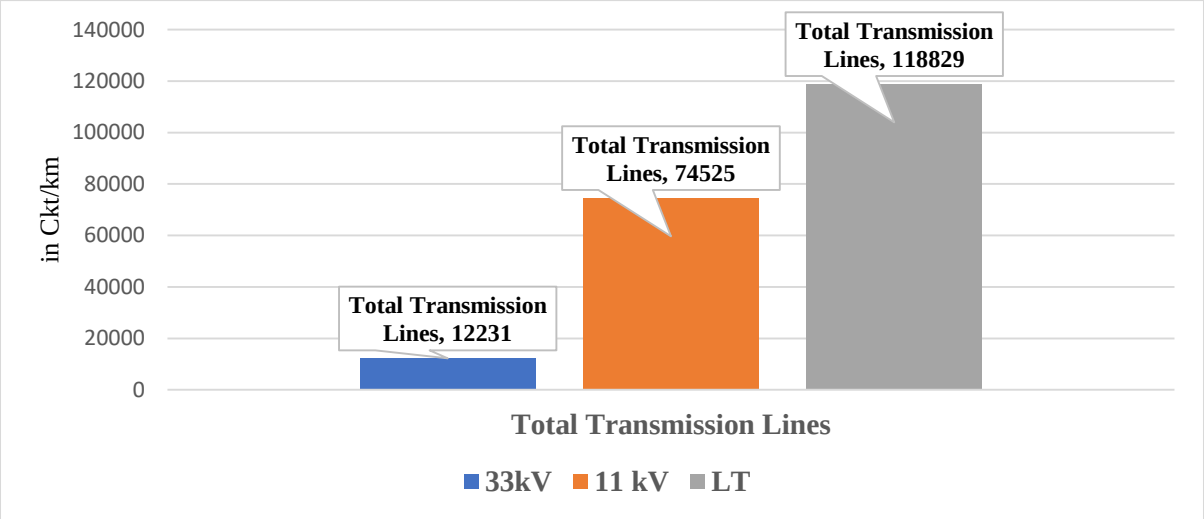
6.2 Power Transmission in Jharkhand

Power transmission forms a vital component of Jharkhand's electrical infrastructure, enabling the seamless transfer of electricity from generation sources to distribution networks and ultimately to end consumers. The state's transmission system is managed through a collaborative framework

involving both state and central agencies, which ensures the efficient, secure, and reliable flow of power across urban and rural areas.

At the forefront of Jharkhand's transmission infrastructure is the Jharkhand Urja Sancharan Nigam Limited (JUSNL), the state-owned transmission utility. JUSNL is entrusted with the responsibility of planning, developing, operating, and maintaining the intra-state transmission network. Its role is central to maintaining the stability of the power system by transmitting electricity at high voltage levels from generating stations to load centres. To meet the increasing energy demand, JUSNL manages an expanding network of transmission lines and substations that are strategically located throughout the state. Among the most critical infrastructure facilities under its purview are the Chandil Substation, Patratu Substation, and Dhanbad Substation—which play essential roles in voltage transformation, grid stability, and load balancing (**Fig. 11**). The continued development and strengthening of JUSNL's infrastructure are key to supporting Jharkhand's goals of industrial growth, rural electrification, and renewable energy integration, ensuring that transmission bottlenecks do not hinder the state's overall energy development.

Figure 11: Total Transmission Lines in Jharkhand (Up to September 2023)



Source: Jharkhand Economic Survey, 2023-24, Govt. of Jharkhand

The *Power Grid Corporation of India Limited (PGCIL)*, a central government enterprise, plays a pivotal role in Jharkhand's power transmission infrastructure by integrating the state's transmission network with the national grid. PGCIL's involvement ensures the efficient transfer of electricity across state borders, facilitating the balancing of supply and demand at both regional and national levels. In Jharkhand, PGCIL is responsible for the development, operation, and maintenance of

high-voltage transmission lines and substations that form the backbone for long-distance electricity transmission and inter-state connectivity. Its operations complement those of the Jharkhand State Power Transmission Company Limited (JSPTCL), the state transmission utility, creating a collaborative framework for managing and strengthening the transmission network. Through the operation of several critical high-voltage transmission corridors in Jharkhand, PGCIL plays an essential role in supporting the state's growing energy requirements, enabling power flow from generating stations within and outside the state, and ensuring grid stability. This partnership between the central and state agencies is vital to Jharkhand's ability to meet its expanding industrial, commercial, and residential power demands while maintaining the reliability and resilience of the power supply system.

6.3 Distribution Companies (DISCOMs) in Jharkhand

In Jharkhand, the distribution of electricity is managed by various entities, both public and private. These companies are responsible for delivering electricity from the transmission network to end consumers, ensuring reliable and efficient power supply across the state. The twenty-four districts of Jharkhand are supplied by five DISCOMs: **Jharkhand Bijli Vitran Nigam Limited (JBVNL),** Damodar **Valley Corporation (DVC), SAIL/Bokaro Steel Plant, Tata Steel Limited, Jamshedpur (TSL)** and **Tata Steel Utilities and Infrastructure Services Limited (TSUISL/JUSCO).** Both JBVNL and DVC are public sector utilities, that serve more than 90 per cent of consumers in Jharkhand. SAIL/Bokaro Steel Plant distributes power for plant operation as well as the township of Bokaro Steel City. Private Distributing Companies are, Tata Steel Limited, Jamshedpur (TSL) and Tata Steel Utilities and Infrastructure Services Limited (TSUISL/JUSCO). JUSCO and TSL operate in two areas of Jharkhand state, Jamshedpur city and Seraikela-Kharsawan district. Jharkhand Bijli Vitran Nigam Limited (JBVNL) is the state-owned electricity distribution utility responsible for distributing electricity to consumers throughout Jharkhand. It works towards improving energy access and reliability, integrating renewable energy sources into the distribution network, and implementing demand-side management initiatives. JBVNL had a revenue of 6948 crores rupees, profit after tax had increased from -2,200 crores rupees in FY 2020-21 to -2,088 crores in FY 2021-22 and it sold 9,491 million units of energy. JBVNL facilitates the integration of renewable energy sources such as solar, wind, and biomass into the distribution network. It procures renewable energy under power purchase agreements (PPAs) and ensures the seamless integration of renewable energy generation into the grid. In FY 2021-22, the solar Renewable Purchase Obligation (RPO) component was fixed at 10.5 per cent, but JBVNL managed only 128.9 MUs against the target of 1317.83 MUs (Govt of Jharkhand, 2024). Besides JBVNL, **Damodar Valley**

Corporation (DVC) is a central government organization that operates in the distribution sector. It has a significant role in distributing electricity in seven districts of Jharkhand (Dhandbad, Koderma, Bokaro, Giridih, Hazaribagh, Ramghar and Chatra). The consumer details of JBVNL and DVC are given in **Table 14**.

Table 14: Number of Electricity Consumers of DISCOMs by category

Consumer Category	JBVNL	DVC
Domestic	3,850,029	1282
Commercial	237,536	461
Agriculture	63,420	-
Industrial	17,309	145
Others	538	13
Total	4,168,832	1,901

Source: Jharkhand State Electricity Regulatory Commission (FY 2019-20)

7. Energy Transition in Jharkhand: Policy Actions and Achievements

Jharkhand has proactively implemented several policies and initiatives aimed at promoting renewable energy and fostering sustainable energy practices across the state. These measures are designed to encourage investment, ease project execution, and accelerate the shift towards cleaner and more sustainable energy sources. The Jharkhand Energy Policy of 2012 marked a significant milestone as the state's first comprehensive framework addressing energy generation, distribution, and consumption. This policy placed strong emphasis on the development and integration of renewable energy sources such as solar, wind, biomass, and small hydropower. It set ambitious targets for renewable energy capacity addition, outlining strategies to attract investment and participation from both the public and private sectors. A key focus of the policy was on decentralized energy generation, aimed at expanding energy access in rural and remote areas while reducing dependency on conventional fossil fuels. By fostering a conducive environment for renewable energy development, the policy paved the way for Jharkhand's ongoing energy transition, supporting its goals of environmental sustainability and energy security.

7.1 Solar Energy Policies

7.1.1 Jharkhand State Solar Power Policy, 2015

In 2015, Jharkhand introduced the State Solar Power Policy with the goal of accelerating the adoption of solar energy and boosting solar power generation within the state. The policy set an ambitious target to achieve 2,650 MW of solar power capacity by 2020, aiming to significantly increase the share of solar energy in Jharkhand's overall energy mix. Key objectives of the policy included promoting local solar manufacturing units, generating employment opportunities, and encouraging the development of solar parks and designated solar development zones to attract investments and streamline project implementation. Despite these goals, Jharkhand's current solar power installed capacity remains below 5 per cent of the target, standing at 123.72 MW. This capacity is distributed across ground-mounted solar installations (21 MW), rooftop solar systems (53.19 MW), and off-grid solar applications (49.53 MW), reflecting significant potential for scaling up solar energy adoption in the state.

7.1.2 Jharkhand State Solar Rooftop Policy, 2018

The Jharkhand State Solar Rooftop Policy, 2018 was formulated with the objective of promoting the installation of 500 MW of solar rooftop systems over five years, from FY 2018-19 to FY 2022-23. This policy aimed to encourage renewable energy generation at the consumer level by harnessing solar power on the rooftops of residential, commercial, institutional, and industrial buildings across the state. Key goals of the policy included reducing reliance on conventional electricity sources, promoting clean energy adoption, and lowering greenhouse gas emissions. A significant feature of the policy was the incorporation of net metering provisions, which allowed consumers to export surplus solar energy to the grid, thereby offsetting their electricity bills and incentivizing greater solar rooftop adoption.

7.1.3 Jharkhand State Solar Policy, 2022

The Jharkhand State Solar Policy, 2022 marks a pivotal advancement in the state's commitment to sustainable development, energy security, and climate change mitigation through the expanded use of solar power. The policy sets an ambitious target of 4,000 MW of solar energy capacity by 2027, aiming to significantly increase solar power's share in Jharkhand's overall energy mix. The policy delineates three key project categories with specific capacity targets: Utility-scale solar projects (3000 MW), Distributed solar projects (720 MW) and Off-grid solar projects (280 MW) including park and non-park solar installations, distributed grid-connected, rooftop solar systems and off-grid systems. These categories include solar parks and non-park installations, distributed grid-connected rooftop solar systems, and off-grid solutions. The policy actively promotes the development of solar

parks and designated solar zones to facilitate large-scale solar power projects, ensuring robust grid connectivity and reinforcing transmission and distribution infrastructure. In addition to grid-connected initiatives, the policy emphasizes off-grid solar solutions—such as solar microgrids, solar home systems, and mini-grids—to improve electricity access in rural and remote communities, thereby fostering energy equity and reliability. To support sustainable growth of the solar sector, the policy includes provisions for training programs, vocational education, and skill development initiatives. These efforts aim to build a skilled workforce capable of deploying, operating, and maintaining solar technologies, thereby nurturing local industry growth, generating employment opportunities, and driving economic development in Jharkhand.

7.1.4 Other Initiatives for Green Energy Access

To advance the adoption of renewable energy and ensure greater consumer access, the Jharkhand State Electricity Regulatory Commission (JSERC) has introduced a series of progressive regulations. These aim to facilitate green energy integration, encourage private sector participation, and promote distributed renewable energy generation across the state. The *JSERC (Terms and Conditions for Green Energy Open-access) Regulations* were introduced to streamline the transmission and distribution of renewable energy generated by Independent Power Producers (IPPs) and Captive Power Producers (CPPs). Under this regulation, consumers, particularly commercial and industrial users, with a contract demand or sanctioned load of 100 kW and above are eligible to qualify as Green Energy Open Access (GEOA) consumers. These regulations aim to promote the adoption of renewable energy, encourage private investment in green power projects, and support energy diversification and sustainability. Green energy open access regulations typically focus on facilitating the transmission and distribution of renewable energy, such as solar, wind, and biomass power, through open access mechanisms. The regulations can streamline the process for consumers to procure renewable energy directly from green energy generators, including solar, wind, biomass, and hydropower projects. The commission determines the tariff for green energy access which includes reductions in cross-subsidy surcharges for consumers opting for green energy open access, transparent and non-discriminatory wheeling charges for the transmission and distribution of renewable energy from generators to consumers.

To ensure accountability and integrity in the electricity market, the *Verification of Captive Generating Plants (CGPs) and Captive Consumers Regulations, 2024* was implemented. These regulations aim to establish a transparent and accountable mechanism for the verification and monitoring of CGPs and captive consumers to uphold the integrity of the electricity market and

safeguard the interests of all stakeholders involved. The regulations define captive generating plants and captive consumers, outlining the criteria and parameters for their classification. This includes defining the capacity threshold for CGPs and specifying the eligibility criteria for captive consumers. It encourages the adoption of renewable energy sources by captive generating plants and captive consumers through appropriate incentives, exemptions, or subsidies.

To further promote decentralized renewable energy systems, JSERC introduced the *Group Net Metering and Virtual Net Metering Regulations, 2024*. These regulations aim to democratize solar and other renewable energy benefits by enabling collective or offsite energy usage models. The regulations define group net metering and virtual net metering arrangements, outlining the scope, applicability, and eligibility criteria for participating entities, including consumers, generators, and distribution utilities. It establishes a framework for group net metering, allowing multiple consumers or stakeholders to share the benefits and costs of a renewable energy system interconnected to the distribution grid. Group net metering enables consumers to collectively offset their electricity bills with the electricity generated from a shared renewable energy facility and virtual net metering allows consumers to offset their electricity consumption with renewable energy generated elsewhere, promoting the use of clean energy sources.

Apart from the policies and regulations, the state has implemented several schemes and programmes for energy transition.

7.1.5 Pradhan Mantri Kisan Urja Suraksha Evam Utahan Mahabhiyan (PM-KUSUM)

The Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyan (PM-KUSUM), launched by the Government of India in 2019, is a flagship initiative aimed at integrating solar energy into the agricultural sector. The scheme seeks to reduce farmers' reliance on diesel-powered irrigation, enhance energy access in rural areas, and increase farmer incomes through surplus solar power generation. Under the scheme, the government provides substantial financial assistance to farmers for the installation of solar-powered agricultural pumps. These solar pumps serve as a clean, cost-effective alternative to conventional diesel and grid-powered pumps, offering a sustainable solution for irrigation, particularly in remote and off-grid regions. The scheme also supports the solarization of existing grid-connected pumps, enabling farmers to offset their electricity consumption and even supply excess power to the grid—thereby contributing to both their financial wellbeing and the broader green energy transition.

As per the Jharkhand Economic Survey 2023–24, a total of 16,717 standalone solar pumps (each with a capacity of up to 7.5 HP) were sanctioned for individual farmers in the financial year 2022. Of these, 8,922 pumps were successfully installed across the state (Government of Jharkhand, 2024). This reflects a significant step forward in enabling clean irrigation technologies and reducing the carbon footprint of agriculture in Jharkhand.

7.1.6 Deen Dayal Upadhyay Gram Jyoti Yojana (DDUGJY)

The Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY), launched in 2015 by the Government of India, is a key initiative aimed at ensuring reliable and quality electricity supply to rural households and agricultural consumers. The scheme forms part of the national agenda for universal electrification and plays a vital role in promoting inclusive socio-economic development in rural areas. The primary objective of DDUGJY is to achieve 100% electrification of villages, particularly through the extension of the electricity grid to all un-electrified villages and habitations. In addition to grid expansion, the programme strongly emphasizes the integration of renewable energy technologies, such as solar mini-grids and standalone systems, to ensure sustainable and decentralized power access in areas where grid connectivity is not feasible or reliable.

In Jharkhand, DDUGJY has contributed significantly to rural electrification efforts by promoting clean energy deployment. As part of the scheme, a solar mini-grid capacity of 3,480 kWp was installed across 216 villages, and an additional 119.2 kWp of standalone solar systems were implemented in 30 villages. These installations have not only improved electricity access but also enhanced the resilience of rural energy systems, reduced dependence on fossil fuels, and supported rural livelihoods.

7.1.7 Ultra Mega Power Projects (UMPP)

The Ultra Mega Power Projects (UMPPs) initiative was launched in 2005 by the Government of India to develop large-scale, high-capacity power generation plants, primarily based on coal and other conventional fuel sources. These projects were conceived to meet the escalating electricity demand across the country and to enhance energy availability through economies of scale and improved generation efficiency. UMPPs are among the largest power generation undertakings in India, typically designed with a capacity of 4,000 MW or more, making them critical to the national energy infrastructure. The initiative aims to centralize and streamline power generation using state-of-the-art technology while ensuring a balance between energy needs and environmental considerations. While UMPPs predominantly rely on coal-based thermal generation, efforts are made to minimize their environmental footprint. These include the adoption of advanced emission control technologies such as flue gas desulfurization (FGD), electrostatic precipitators (ESP), and

ash disposal systems. Moreover, the environmental compliance framework governing UMPPs mandates adherence to stringent national standards, ensuring that these projects are aligned with the country's sustainable development goals.

7.1.8 Jharkhand Sampoorn Bijli Achadan Yojana (JSBAY)

The Jharkhand Sampoorn Bijli Achadan Yojana (JSBAY) is a flagship initiative launched by the Government of Jharkhand aimed at achieving universal electricity access across the state. This comprehensive scheme is designed to provide reliable and affordable electricity to all households, with a particular focus on rural, tribal, and remote areas where grid connectivity has historically been inadequate. The primary objective of JSBAY is to bridge the gap in electricity access by expanding the electricity distribution infrastructure, enabling last-mile connectivity, and ensuring that no household is left in the dark. The scheme complements national initiatives such as Saubhagya (Pradhan Mantri Sahaj Bijli Har Ghar Yojana) by addressing state-specific challenges and prioritizing inclusion and equity in energy access. The achievements of JSBAY are detailed in **Table 15**, reflecting the state's commitment to ensuring energy inclusion and socio-economic development through electrification.

Table 15: Progress of JSBAY Scheme in Jharkhand

Achievement of work under JSBAY Scheme from July 2018 to Aug 2022				
Sl. No.	**Component/Scheme**	**Unit**	**Scope**	**Achievement**
1	PSS- New	No's	111	99
2	PSS- R and M and augmentation of old PSS	No's	196	196
3	33 kV Line (New)	Ckm	2203.68	2112.71
4	33 kV Line re-conductoring	Ckm	1602.80	1583.30
5	11 kV Line (New)	Ckm	3601.38	3175.08
6	11 kV Line re-conductoring/ conversion	Ckm	4436.92	4261.65
7	New DTR	No's	6100	5226
8	Replacement/ Augumentation of 10/16 kVA DTR to 25 kVA DTR	No's	1221	1040
9	New LT Line and conversion (Bare to AB Cable)	Ckm	8183.23	7536.02
10	PE Village	No's	948	807
11	Existing unmetered to metered connections	No's	892943	690718
12	Existing agriculture unmetered to metered connections	No's	23045	13946

Source: Jharkhand Economic Survey, 2022-23, Govt. of Jharkhand.

7.1.9 Suryamitras

The Suryamitra Skill Development Program, launched by the Ministry of New and Renewable Energy (MNRE), Government of India in 2015, is a pivotal initiative aimed at creating a skilled workforce to support the expansion of the solar energy sector in India. The program focuses on training solar energy technicians, commonly referred to as Suryamitras, who are proficient in the installation, operation, and maintenance of solar power systems. The primary objective of the Suryamitra program is to enhance employability in the renewable energy sector by equipping youth with technical skills aligned with industry standards. The training curriculum covers various aspects of solar power technology, including photovoltaic (PV) systems, solar panel installation, system design, operation, and maintenance. Under this program, 846 suryamitras were trained in Jharkhand from 2015-16 to 2022-23 (Government of Jharkhand, 2024).

7.1.10 GEF-MNRE-UNIDO Project

The GEF-MNRE-UNIDO Project is a collaborative initiative led by the Global Environment Facility (GEF), the Ministry of New and Renewable Energy (MNRE), Government of India, and the United Nations Industrial Development Organization (UNIDO). This project aims to address the growing challenges of industrial and organic waste management through the promotion of renewable energy solutions and sustainable practices, particularly in states like Jharkhand.

A core component of the project focuses on the deployment of decentralized biogas plants, especially for organic and industrial waste management. By leveraging waste-to-energy technologies, the project facilitates the conversion of municipal solid waste (MSW), industrial effluents, and agricultural residues into clean energy, such as biogas and Bio-CNG. These efforts serve dual objectives: i) Improved waste management and ii) Enhanced renewable energy generation. The project also emphasizes capacity building through structured training programs, technical assistance, and stakeholder engagement. These programs target government officials, industry professionals, and local communities, enabling them to adopt and sustain energy-efficient and environmentally responsible waste management practices.

One of the notable tools introduced under the project is a Geographic Information System (GIS)-based waste-mapping platform, which aids in identifying waste generation hotspots, estimating Bio-CNG potential, and mapping energy generation capacities across various sectors. This tool enhances data-driven planning and facilitates evidence-based policy formulation. **Table 16** presents the estimates of waste generation, Bio-CNG potential, and energy potential from selected sectors in Jharkhand, providing critical insights into the state's capacity for expanding waste-to-energy infrastructure.

Table 16: Waste Generation, Bio CNG Potential, and Energy Potential Estimate of Selected Sectors in Jharkhand (as of December 2022)

Sl. No.	Components	Quantity
1	Poultry Waste Generation (000 TPA)	363
2	Poultry Energy Potential (MW)	5
3	Poultry Bio-CNG Potential (TPD)	25
4	Cattle Waste Generation (000 TPA)	13580
5	Cattle Energy Potential (MW)	116
6	Cattle Bio-GNG Potential (TPD)	555
7	Urban Liquid Waste Sewage Generation (MLD)	1055
8	Urban Liquid Waste Energy Potential (MW)	10
9	Urban Liquid Waste Bio-CNG Potential (TPD)	50
10	Urban Solid Waste Generation (000 TPA)	1317
11	Urban Solid Waste Energy Potential (MW)	20
12	Urban Solid Waste Bio-CNG Potential (TPD)	95
13	Total Solid Waste Generation (000 TPA)	15260
14	Total Liquid Waste Generation (MLD)	1055
15	Total Energy Potential (MW)	151
16	Total Bio-CNG Potential (TPD)	725

Source: GIS Waste Mapping Tool, GEF-MNREUNIDO (https://bio-energy.isid4india.org/

7.1.11 Solar Park Scheme

The primary objective of the solar park scheme in Jharkhand is to increase the installed capacity of solar power generation by establishing 50 solar parks by the year 2021-22 with a capacity of 40,000 MW in the state. Solar parks enable the development of utility-scale solar projects, facilitating the integration of large amounts of solar energy into the grid. According to the Annual report 2022-23 of MNRE, 1149 MW capacity of solar parks were installed in Jharkhand state (MNRE, 2023). The development of solar parks generates employment opportunities during the construction and operation phases, benefiting local communities and stimulating economic growth and it also enhances the state's energy infrastructure, strengthening grid connectivity and promoting energy access and reliability.

7.1.12 Grid Connected Rooftop and Small Solar Power Plants Programme: Phase I and Phase II

The Grid Connected Rooftop and Small Solar Power Plants Programme: Phase I was launched by the Ministry of New and Renewable Energy (MNRE), Government of India, to establish rooftop solar PV systems among residential, commercial, industrial, and institutional consumers. The program aimed to leverage the vast rooftop space available in urban and rural areas for solar power generation. The phase II programme was launched in the year 2019 by the Ministry of New and Renewable Energy (MNRE), Government of India, to promote the installation of rooftop solar systems and small solar power plants across the country with a capacity of 40,000 MW by the year 2022. Due to the COVID-19 pandemic, the programme period has been extended till 2026. The primary objective of Phase II is to accelerate the adoption of rooftop solar photovoltaic (PV) systems among residential, commercial, industrial, and institutional consumers. This includes both grid-connected and off-grid systems. For residential households, the financial incentive up to 40 percent up to 3 KW capacity and 20 per cent up to 10 KW capacity is provided. Under the programme, the net allocated capacity for the state was 28.38 MW, out of which 0.97 MW capacity was installed in residential sectors with Central Financial Assistance (CFA) and overall rooftop solar system installed in all sectors with and without CFA was 35.29 MW (as of 31/12/2022) (MNRE, 2023).

7.1.13 Off-grid and Decentralised Solar PV Applications Programme

The Off-grid and Decentralised Solar PV Applications Programme is an initiative led by the Ministry of New and Renewable Energy (MNRE), Government of India, aimed at promoting the deployment of solar street lights, solar study lamps, solar power packs to the local communities and institutions. Under the off-grid SPV phase-I programme, 9450 solar home lights, 790515 solar lamps, 14344 solar street lights, 13592 solar pumps, and 3769.9 KW capacity of solar power plants were installed in Jharkhand state till the year 2022 (MNRE, 2023).

7.2 National Biogas Programme (NBP)

The primary objective of the National Biogas Programme (NBP) is to promote the adoption of biogas technology for decentralized energy generation, primarily in rural and semi-urban areas for the period of 2021-26. NBP aims to enhance energy access and energy security by providing clean and renewable biogas as a cooking fuel for households, institutions, and small-scale industries. Biogas can replace traditional cooking fuels such as firewood, charcoal, and LPG, thereby reducing indoor air pollution and deforestation. The program focuses on promoting the sustainable management of organic waste by converting it into valuable biogas and organic manure. Under the

New National Biogas and Organic Manure Programme, 7890 small biogas plants were installed in Jharkhand by the year 2022 (MNRE, 2023).

7.3 Small Hydro Power (SHP) Programme

Jharkhand has significant potential for hydropower development due to its numerous rivers and favourable topography. The Small Hydro Power (SHP) Programme is an initiative launched by the Ministry of New and Renewable Energy (MNRE), Government of India, to promote the development of small-scale hydroelectric projects for decentralized power generation. The primary objective of the SHP Programme is to promote the development of micro, mini and small hydroelectric projects with capacities typically ranging from 0.1 megawatts to 25 megawatts. **Table 17** provides the list of potential sites, installed projects and ongoing projects under SHP in Jharkhand state.

Table 17: List of potential sites, installed projects, and on-going projects in the SHP (as of 31/12/2022)

Sl. No.	Components		Quantity
1	Total potential	Nos. (Total capacity in MW)	121 (227.96 MW)
2	Projects installed up to 2022-23	Nos. (Total capacity in MW)	06 (4.05 MW)
3	Projects under implementation	Nos. (Total capacity in MW)	0

Source: Annual Report 2022-23, MNRE, Govt. of India

7.4 National Electric Mobility Mission Plan

The plan is a comprehensive initiative launched by the Government of India in 2018 to promote the adoption of electric vehicles (EVs) and accelerate the transition towards clean and sustainable transportation. The programme aims to reduce India's dependency on fossil fuels for transportation by promoting the use of electric vehicles powered by clean and renewable energy sources such as electricity. Under this programme, the target of completing 5,00,00,000 green kilometres were set to be achieved by July 2021 (**Table 18**).

7.5 Street Lighting National Programme

This programme was launched on January 5, 2015, to replace conventional streetlights with smart and energy-efficient ones across India. In Jharkhand, 554091 streetlights have been installed through state and gram panchayat projects under this programme (as on 18/04/2024).

Table 18: Status of National E-Mobility Scheme

Sl. No.	Parameter	Jharkhand	
		2021(as in October 2021)	2022 (as in December 2022)
1	Total E kilometre covered (km)	20,94,420	29,27,416
2	Number of Electric Vehicle Deployed	51	51
3	Savings in fuel consumption	0.14	0.20
4	Monetary Saving on Fuel (MINR)	11.87	16.59
5	Reduction in CO2 Emissions (tCO2)	374.21	523.03
6	Reduction in Particulate Matter (Kg)	52.36	73.19

Source: Energy Efficiency Service Limited dashboard, govt. of India

8. Challenges to Just Transition in Jharkhand

Transitioning to a more sustainable and inclusive energy landscape in Jharkhand presents several social, economic, environmental and technological challenges, particularly in ensuring transition for all stakeholders involved.

8.1 Economic Dependence on Coal and Extractive Industries

Jharkhand's energy sector is heavily reliant on conventional sources such as coal and thermal power. According to a 2021 study by the United States-based Centre for Strategic and International Studies (CSIS), Jharkhand has 144 mines employing around 300,000 people directly and around one million people indirectly (Kumar, 2022). Transitioning away from coal while ensuring the livelihoods of workers and communities dependent on the coal industry is a significant challenge (Nandan and Panigrahi, 2022). The decline of the coal industry can lead to job losses and economic dislocation, particularly in regions where coal mining is a primary source of employment. Many communities in Jharkhand, especially indigenous and tribal communities, rely on extractive industries like coal mining for their livelihoods (Pelz et al., 2024). A just transition requires addressing the potential economic dislocation and loss of livelihoods resulting from the shift away from fossil fuels (Cha, 2020). Providing alternative sources of employment, skills training, and social safety nets is essential to mitigate the impact on affected communities.

8.2 Energy Poverty and Inequitable Access

Despite being a significant producer of coal and other energy resources, large sections of the population in Jharkhand still lack access to reliable and affordable electricity. Ensuring universal access to clean and sustainable energy is crucial for addressing energy poverty and promoting social equity in the transition process. However, expanding energy access to remote and underserved areas poses infrastructure and financing challenges.

8.3 Environmental Degradation from Conventional Energy Sources

Decades of coal mining and thermal power generation have resulted in severe environmental degradation, including deforestation, land erosion, and water contamination. While transitioning to renewable energy is essential for mitigating environmental and climate impacts, it requires substantial investment and planning to build sustainable infrastructure that restores rather than exploits ecosystems.

8.4 Inadequate Infrastructure and Institutional Capacity

Another challenge is the lack of adequate infrastructure and institutional capacity to support the scale-up of renewable energy projects and decentralized energy solutions. Limited access to finance, technical expertise, and regulatory support constrains the development of renewable energy markets and impedes the integration of clean energy technologies into the grid. Strengthening institutional frameworks, enhancing policy coherence, and promoting public-private partnerships are essential to overcome these challenges and unlock the full potential of renewable energy in Jharkhand.

8.5 Social Justice and Community Participation

Jharkhand is home to adivasi (indigenous) communities who often bear the brunt of environmental degradation and displacement due to mining and industrial activities. A just transition must prioritize the rights and interests of marginalized communities, ensuring their meaningful participation in decision-making processes and equitable distribution of benefits (Lee et al., 2023). However, historical injustices and power imbalances may impede efforts to achieve social justice and equity.

8.6 Challenges in Land Acquisition

Land acquisition for solar park development is a major challenge related to land availability, ownership disputes, and environmental concerns (Sati, Powell and Tomar, 2022). Land acquisition processes are often governed by complex legal frameworks, including land acquisition laws, environmental regulations, and tribal land rights protections, which pose administrative hurdles and delays. Local communities sometimes resist land acquisition efforts due to concerns about displacement, loss of livelihoods (particularly for agricultural communities), and perceived impacts on their way of life, cultural heritage, or access to natural resources.

8.7 Grid Integration and Technical Limitations

Concerning the technological challenges, integrating intermittent renewable energy sources such as solar energy into the existing grid infrastructure poses technical challenges related to grid stability, balancing supply and demand, and managing variability. Upgrading and modernizing the grid infrastructure is essential to ensure reliable and efficient energy transition. Transitioning to a sustainable energy system requires significant investments in renewable energy infrastructure, grid modernization, energy efficiency measures, and skill development.

8.8 Financial Barriers and Low Investment

Mobilizing financial resources and attracting private sector investments in clean energy projects can be challenging, particularly in rural and underserved areas where the potential for returns on investment is lower.

8.9 Low Awareness and Acceptance of Renewable Energy

Low awareness and limited acceptance of renewable energy technology such as solar, biogas among rural communities and stakeholders pose challenges to program implementation and adoption. Awareness campaigns and community engagement efforts are needed to overcome misconceptions and promote biogas as a viable energy option.

8.10 Biogas Feedstock Supply Chain Issues

Related to biogas technology, the availability and quality of organic waste feedstock for biogas production vary seasonally and regionally, posing challenges to consistent biogas production and plant operation. Strategies for feedstock collection, storage, and management need to be developed to ensure uninterrupted biogas supply.

8.11 Policy Gaps and Regulatory Fragmentation

The absence of clear and coherent policies and regulations for renewable energy development and sustainable land use planning hinders the transition process (Kumar and Majid, 2020). Strengthening policy frameworks, incentivizing renewable energy deployment, multisectoral collaboration and promoting sustainable land management practices are essential for facilitating the transition.

9. Policy Recommendations

Transitioning Jharkhand towards a sustainable energy future requires a comprehensive and integrated approach that addresses the unique challenges and opportunities in the state. Following are certain recommendations to facilitate the energy transition in Jharkhand state.

- The development of green industries and sustainable manufacturing practices that rely on clean energy sources and prioritize resource efficiency and environmental sustainability should be supported, particularly by encouraging investment in sectors such as renewable energy manufacturing, eco-friendly products, and green technology innovation.
- There should be decentralized energy planning frameworks that empower local communities and stakeholders to participate in decision-making processes related to energy infrastructure development and promote community-owned renewable energy projects and micro-grids in rural and remote areas.
- Proper awareness about the benefits of renewable energy, environmental stewardship, and climate change mitigation should be provided to all the stakeholders
- The state should ensure coherence and alignment between energy transition policies and other relevant policy areas such as land use planning, environmental protection, and economic development. There is a need for multi-sectoral collaboration among all the stakeholders.
- The state should prioritize universal energy access and equity by targeting the marginalised communities with off-grid and decentralised energy solutions.
- Transitioning to green industries such as renewable energy, sustainable agriculture, and eco-tourism can diversify the economy and reduce its reliance on polluting sectors. Jharkhand is endowed with rich biodiversity and natural resources, including forests, rivers, and wildlife. Green jobs should be created in sectors such as conservation, reforestation, and sustainable land management to protect and preserve these ecosystems, ensuring their long-term sustainability and resilience to climate change. By creating employment opportunities in clean energy deployment, Jharkhand can enhance energy resilience and reduce reliance on fossil fuels.
- Jharkhand has abundant agricultural and forest resources that can be utilized for the production of biofuels such as biodiesel, bioethanol, and biogas. Biogas-powered generators and micro-turbines can produce electricity from biogas, providing reliable and sustainable energy access to off-grid areas.
- The green hydrogen sector and nuclear power plants can also be a promising opportunity for Jharkhand to advance its energy transition efforts and contribute to sustainable development.

- Increasing the number of electric vehicle (EV) charging points in Jharkhand can significantly boost the adoption of EVs and contribute to environmental sustainability.

10. Conclusion

Jharkhand's energy sector is pivotal in supporting the state's industrialization, urbanization, and socio-economic development. With a mix of conventional and renewable energy sources, the state has the opportunity to chart a path that ensures energy security, sustainability, and affordability for both residents and industries. In recent years, Jharkhand has made notable progress in advancing its renewable energy agenda, particularly in solar power deployment. The state has adopted progressive renewable energy policies, promoted clean energy technologies, and begun diversifying its energy mix. While hydropower and biomass energy projects are also being explored, their growth remains modest. However, despite these advancements, Jharkhand's energy transition remains at a nascent stage, with several critical challenges impeding the pace and scale of transformation. A key concern is the continued reliance on fossil fuels, especially coal, which dominates power generation and industrial activities. This dependence contributes to environmental degradation, air pollution, and greenhouse gas emissions. The shift towards a cleaner energy future is hindered by a combination of factors such as entrenched interests and institutional inertia within the fossil fuel sector, financial and technical barriers to scaling renewable energy infrastructure and infrastructural deficits, particularly in grid capacity, rural connectivity, and decentralized energy systems. For Jharkhand to achieve a resilient, low-carbon energy future, these challenges must be addressed through coherent policy action, inclusive governance, and sustained investment in renewable energy and green infrastructure.

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