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TRENDS AND PATTERNS IN THERMAL POWER GENERATION IN JHARKHAND: A COMPREHENSIVE STUDY

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ABSTRACT

This research shows the trend & pattern of thermal power industries in Jharkhand for the year of 2015 to 2023, with fluctuation as the focal point in installed capacity, electricity generation production, and industry trends. This state has 27% of coal holding in all India, so it's a major contributor in the world's power generation, especially through coal thermal power industries. The study examines the past data to investigate the Thermal power plant's trend and identify the effect of policy shifts, innovation and environmental factors. The result clearly shows that continuous increase in installed capacity which is from 1,543.74MW to 2,466.5MW, in 2019 to 2022 respectively with a CAGR of 11.21%. Although electricity generation reduces from 30,472.78MU to 8,662.96MU in 2022 to 2023, respectively, with a negative CAGR of -25.68% showing operational inefficiencies. The finding shows the need for planned initiatives to upgrade operational efficiency, shifting towards renewable energy for sustainable growth.

Keywords: Conventional Thermal electricity generation, Thermal electricity production, Compound Annual Growth Rate (CAGR), Percentage changes.

INTRODUCTION

Widely, coal is the only important source of electricity, especially in India, where Jharkhand is the one who holds 26.4% of the country's total coal resources. Its coal deposits are continuously growing from 86.217 billion tonnes to 86.660 billion tonnes, respectively, from 2021 to 2022 (CEIC, 2024). In Dhanbad, the Jharia coalfield is situated; this state contains the biggest coal resources in this country, which is the estimated reserve of 19 billion tonnes of the cooking coal. This dependency emphasizes how crucial the state is to supplying the country's 1,257,388 MU of power per year (CEA, 2020). Also, Jharkhand's electricity production capacity increased from 554MW to 4,495.87 MW from 2000, including 2,660MW coming from thermal energy (Deogharia, 2024). This state is improving ecological responsibility and operational efficiency with coal-based thermal power plants.

"As Coal is the biggest supplier of electricity, there is only a moderate change to sustainable energy; therefore, it remains fourth place in East India". This allows an eco-friendlier electricity balance (Kumar et al., 2021). Electricity production is an important aspect of advanced economies, and it is significant for emerging economies due to its promotion of capital accumulation, inventions, and career prospects. The eastern states of Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, and West Bengal produce more than 85% of the

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country's coal. The nation's electricity industry depends on these regions (Sen et al., 2023). Jharkhand has the highest coal resources in India (26.16%), then comes Odisha (24.52%). The nation's coal holdings increased by 2.05% between 2016 and 2017, with Maharashtra experiencing a 7.15% rise (Ali et al., 2022).

As of January 2024, Jharkhand had a total electricity capacity of 2,773.53 MW. Of this, 2,440.66 MW, or 92.8% of its energy infrastructure, was generated from thermal energy, with the remaining balance coming from renewable sources; similarly, the nearby states depend on thermal power to satisfy rising needs. Similarly, 12,545.32 MW, or nearly 76.5% of Odisha's total energy capacity, comes from thermal power (CEA, 2024). The border-based Bhartiya Rail Bijlee Company Limited (BRBCL) power station heavily pollutes the region, while efficiency gains sustain thermal power’s 70% dominance in Odisha, which plans to add 2,000 MW by 2030 (CEA, 2022). This regional interdependence is mirrored by Uttar Pradesh importing coal from Jharkhand. Aligning with national trends (Ministry of Power, 2023), coal plants leverage 29% of India's reserves to meet 75% of Jharkhand's demand, while the state aims to deploy 4,000 MW of solar power by 2027 (Government of Jharkhand, 2022). To enhance sustainability, Jharkhand is integrating ANNs and supercritical technologies under the BEE's PAT scheme (CEA, 2024; JSERC, 2024; Ministry of Power, 2023). While standing fourth in Eastern India with 434.06 MW of renewable energy, Jharkhand has huge development possibilities (Agarwal, 2025). Resource Adequacy Plan for Jharkhand projects that the state's contractual capability will be 7,069 MW by 2025–2026 and 13,366 MW by 2033–2034 (CEA, 2024). To understand how economic reasons, new regulations, and technological advancements have impacted the current state of the business, this study closely studies trends in thermal power generating patterns over a certain time period.

METHODOLOGY

This research uses a descriptive research design to investigate the trend and pattern of the thermal power industries of Jharkhand during 2015 to 2023. Also, the methodology depends on a quantitative analysis of the secondary data, which is collected in two phases:

- **Data Collection by Secondary data sources:** So, the data was taken from the industry’s reports such as the Ministry of Power, Central Electricity Authority (CEA), the Jharkhand State Regulatory Commission, and major thermal power industries (like DVC, MPL and APNRL) and official government reports.
- **Data & frameworks:** Data from 2015 to 2023 was taken to analyze installed capacity, electricity generation as an output, contribution through resource –wise (coal, hydro and nuclear) and sector-wise.

These statistical methodologies were employed:

a. **Compound Annual Growth Rate (CAGR):** According to Fisher (1930), CAGR evaluates the variable’s average annual growth by smoothing out short–term fluctuation over a time period. While Prajneshu and Chandran (2005) show its drawbacks when measured against nonlinear models. Even if it still proves very useful for evaluating long-term financial and economic patterns, the following equation is used to measure CAGR:

$$\boldsymbol{CAGR = \left(\frac{Ending\ Value}{Beginning\ Value}\right)^{\frac{1}{n}-1}}$$

Where,

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Ending Value – Value at the ending period of Jharkhand's thermal power plants installed capacity 2023.

Beginning Value – Value at the starting period of Jharkhand's thermal power industries installed capacity in 2015.

n -Number of years (e.g., 2023 - 2015 = 8 years).

The CAGR provides insights into long-term trends, highlighting whether the capacity and generation are growing or declining.

b. Percentage Change Calculation

According to Törnqvist, Vartia, and Vartia (1985), Percentage change measures a variable's rate of change over time relative to its original value, establishing a conceptual basis. Although Vickers (2001) notes its statistical inefficiency compared to adjusted methods like ANOVA, it remains a valuable tool for descriptive statistical analysis. The formula for percentage change is as follows:

$$\boldsymbol{percentage\ Change} = \left(\frac{\boldsymbol{Current\ year\ value - previous\ year\ value}}{\boldsymbol{previous\ year\ value}}\right) \times \mathbf{100}$$

Where,

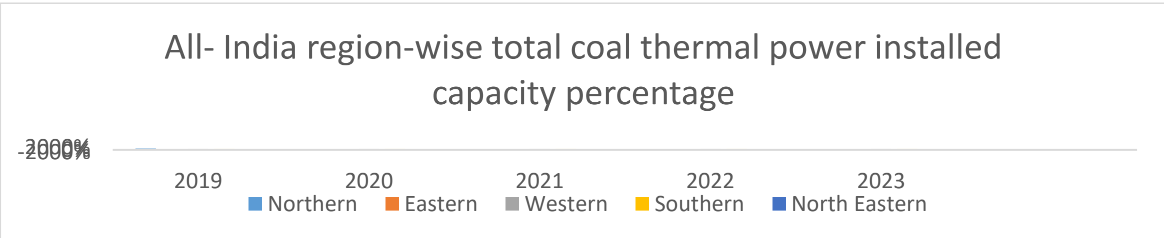
Current Year Value - Data point for the current year (e.g., generation output in 2023).

Previous Year Value -Data point for the previous year (e.g., generation output in 2022).

This formula helps determine the annual growth or decline rate, providing a clear picture of short-term fluctuations. This methodology outlines the statistical techniques used, including formulas for CAGR and percentage change, and provides a comprehensive data analysis approach.

DATA ANALYSIS

Figure 1: All India region total coal thermal installed capacity by percentage



Source: CEA (National Power Portal)

Figure 1 shows India's regional thermal power installed capacity across five areas defined by the CEA (Rallapalli et al., 2012). Driven by industrial demand, mine access, and infrastructure investment, the Western and Southern regions hold the largest capacities, followed by the Eastern and Northern zones (Chikkatur et al., 2009). Conversely, the Northern region saw a steep downfall between 2019 and 2023 due to legal sustainability commitments, renewable transformation, and eliminating older, inefficient units during modernization (Gunavathi, R., & Karthikey, 2023). Lastly, the North Eastern region remains lowest due to harsh landscapes, natural calamities, and low industrialization creating problematic situations for large-scale development (Instanes A et al., 2016).

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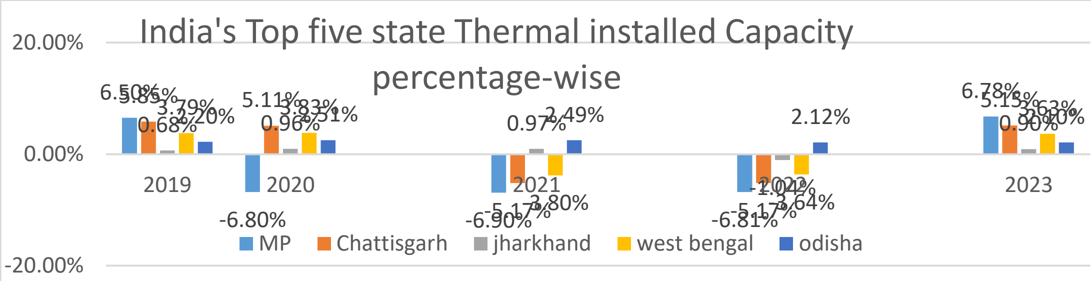
Figure 2: "Thermal Power Installed Capacities of India's Top 5 States (2019-2023)"



Source: Official site of all state power portal

In Figure 2, the thermal power shares of the top five states from 2019 to 2023 are displayed, where growth plans, policy shifts, and abundant coal deposits caused Madhya Pradesh to rise to 6.78% and Jharkhand to rise to 0.9% (MPERC, 2023; CEA, 2023; Ministry of Power, 2023; The Economic Times, 2023). On the other hand, Chhattisgarh, which is ranked second, witnessed a decrease from 5.85% to 5.15% as a result of the shutdown of outdated, incompatible companies and move into more environmentally friendly options under India's National Electricity Plan (Central Electricity Authority, 2022). While, West Bengal's percentage dropped to 3.63% as a result of slow standardization of infrastructure. Both states improved their current industries to extraordinary innovations rather than raising their capacity (Kulkarni, A.R., 2022; Ministry of Power, 2023). In general, states having asset advantages and prudent investment practices increased their percentage, whereas other states saw declines as a result of ageing infrastructure or policy changes.

TABLE 1: Jharkhand Coal Thermal Installed and Generation Capacity

Jharkhand coal thermal installed & generation capacity		
years	**Installed capacity (MW)**	**Generation (MU)**
2019	1543.74	28391
2020	2276.46	28715
2021	2296.46	28338.72
2022	2466.5	30472.78
2023	2361.25	8662.96
CAGR	11.21%	-25.68%

Source: CEA (ministry of power) & PIB, 10 Aug 2023

According to Table 1, Jharkhand's coal thermal installed capacity grew by 52.91% to 2361.25 MW (11.21% CAGR), reaching a high in 2022 as a result of Ultra Mega Power Project (UMPP) policies and industrial demand, utilizing coal reserves that account for 25% of the nation's total (CEA, 2022; Business Standard, 2022; Nandan & Pagrahi, 2022; Ministry of Coal, 2023). However, following a peak in 2022, production decreased dramatically to 8,662.96 MU in 2023, resulting in a CAGR of -25.68% caused by coal limitations, old infrastructure, economic pressures, and policy modifications to sustainable energy (Economic Times, 2023; Pratirodh, 2022). Significantly, operational failures within the state's thermal sector are revealed by this imbalance between increasing capacity and decreasing generation. So, targeted government initiatives are needed to reduce these performance disparities, including the National Electricity Plan 2023, RDSS, UDAY program, and generating flexibility regulations (Ministry of Power, 2023; CEA, 2023).

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TABLE2: Sector –Wise Thermal Power Installed Capacity (MW) With Their Share of Jharkhand

Jharkhand Sector-wise Thermal Power Installed Capacity				
Years	**Central (MW)**	**Private (MW)**	**State (MW)**	**Total installed capacity (MW)**
2019	393.74 (25.5%)	730 (47.2%)	420 (27.2%)	1543.74
2020	1276.46 (56%)	580 (25.4%)	420 (18.4%)	2276.46
2021	1296.46 (56.4%)	580 (25.2%)	420 (18.2%)	2296.46
2022	1466.5 (59.4%)	580 (23.5%)	420 (17%)	2466.5
2023	1361.25 (57.6%)	580 (24.5%)	420 (17.7%)	2361.25

Source: Central Electricity Authority

In Table 2, considering the importance of Jharkhand's coal thermal power sector-wise performance, the contribution analysis from 2019 to 2023 reveals that the overall installed capacity increased by 817.51 MW, reaching 2361.25 MW. With huge developments by DVC and NTPC, such as the North Karanpura Super Thermal Power Station, supported by initiatives from the government, long-term Power Purchase Agreements (PPAs), and assured coal connections, the Central sector became the dominating player (CEA, 2022; Ministry of Power, 2021). On the other hand, private sector which comes in second place shows a decrease in capacity as a result of growing financial expenses, unpredictability in the coal supply, and a general shift in investment toward renewable energy sources (Financial Express, 2022; TERI, 2021). Last but not least, the State sector made a miserable contribution that was entirely unchanged for five years due to antiquated plants run by JBVNL, inadequate infrastructure, and financial limitations.

TABLE: Jharkhand's Yearly Total Thermal Power Installed Capacity and Resource –Wise Thermal Power Installed Capacity with their share

Years	**Coal Thermal Power Installed Capacity (MW)**	**Nuclear Power Installed Capacity (MW)**	**Hydro Power Installed Capacity (MW)**	**Total Power Installed Capacity (MW)**
2019	1543.74 (88.90%)	0	191 (11%)	1734.74 (11%)
2020	2276.46 (92.20%)	0	191 (7.70%)	2467.46 (7.70%)
2021	2296.46 (92.30%)	0	191 (7.60%)	2487.46 (7.60%)
2022	2466.5 (92.80%)	0	191 (7.18%)	2657.5 (7.18%)
2023	2361.25 (92.50%)	0	191 (7.48%)	2552.25 (7.48%)

Source: CEA (Ministry of Power)

Table 3 shows Jharkhand's resource-wise installed power generation capacity, where the state's total potential rose by 47.2% to 2,552.25 MW. In part to central sector initiatives such NTPC's North Karanpura and Patratu facilities, which are situated close to conventional coal mines for a consistent fuel supply, coal-powered thermal capacity has increased by 52.95% to account for 92.50% of the total (CEA, 2022). On the other side, Jharkhand's 191 MW hydro power potential saw its proportion share drop from 11% to 7.48% over a period of the five years because of this strong coal priority. Simultaneously, nuclear capacity remained

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stationary at 0 MW, due to a reliance on uranium alone, reflecting a narrower focus on hydro and nuclear options brought on by site limitations, difficult projects, and large capital needs (JREDA, 2022).

TABLE 4: Jharkhand's important thermal power industries with their yearly installed (MW) and generation capacity (MU)

Year	Koderma (DVC) Installed capacity (MW)/ Electricity generation capacity (MU)	Bokaro A Exp (DVC) Installed capacity (MW)/ Electricity generation capacity (MU)	Bokaro B (DVC) Installed capacity (MW)/ Electricity generation capacity (MU)	PVUNL Installed capacity (MW)/ Electricity generation capacity (MU)	Adhunik Power Installed capacity (MW)/ Electricity generation capacity (MU)	MPL Installed capacity (MW)/ Electricity generation capacity (MU)
2015	1000/ 3326.80	500/ 0	500/1859.85	NA	540/ 0	1050/ 6684
2016	1000/ 3801.80	500/ 365.57	500/ 1456.68	NA	540/ 3249.61	1050/ 7172
2017	1000/ 5911.25	500/ 2924.20	500/ 573.94	NA	540/ 2211	1050/ 7357
2018	1000/ 6279.16	500/ 2920.01	500/ 688.44	NA	540/ 2877	1050/ 7406
2019	1000/ 6459.72	500/2690.01	500/ 94.03	NA	540/ 2959	1050/ 7268
2020	1000/ 7508.96	500/3271.48	500/ 18.50	NA	540/ NA	1050/ 6488
2021	1000/ 6930.25	500/ 2996.85	500/ 0	2400/NA	540/ NA	1050/ 6383
2022	NA	NA	NA	2400/NA	540/ NA	1050/ 7489
2023	NA	NA	NA	2400/NA	540/ NA	1050/ 7555

Note: "NA" denotes that data is not available.

Source: Official site of all thermal power plants of Jharkhand DVC, APNRL, MPL, PUVRNL, Jharkhand State Regulatory Commission

In Table 4, we can see two sectors are listed, the central and private thermal plants in Jharkhand, with DVC Koderma carrying 1,000 MW and PVUNL sustaining 2,400 MW since 2021 with unnoticed generation because of phased installation or organizational delay. Adhunik Power with 540 MW generating statistics became unavailable after 2019, however Maithon Power Limited (MPL) was steady at 1,050 MW with consistent output increases indicating long-term PPAs, both companies belong to private sectors. The government run DVC Koderma (highest at 7,508.96 MU) and the privately run MPL (reaching 7,555 MU) are the most successful operating assets, driven by active electricity delivery. In the end, these structure patterns indicate the functional differences resulting from policy changes and delays in the coal supplies (CEA, 2023; Ministry of Power, 2022), which are crucial for enhancing industry effectiveness and guaranteeing availability of electricity.

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CONCLUSION

Jharkhand is rapidly required to upgrade its infrastructure and comply with environmental regulations due to its heavy reliance on coal-based thermal generation. (PVUNL, 2017). The best-performing assets driving active state generation are the independently owned Maithon Power Limited and the centrally run DVC Koderma. The result shows that long-term sector involvement and investment can significantly enhance performance through innovative technology (Tata Power, 2022). To ensure long-term sustainability, Jharkhand ultimately has to find a balance between investing in renewable energy and modernising its current thermal facilities (Ministry of Power, 2021).

IMPLICATIONS OF THE STUDY

Maithon Power's rise illustrates that steady investment significantly boosts performance (Tata Power, 2022), even though Jharkhand's coal-based power needs urgent upgrading (PVUNL, 2017). Ultimately, the state must balance upgrading thermal facilities with renewable investments for long-term sustainability (Ministry of Power, 2021).

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