Report # 4

Energy Transition in Chhattisgarh:
Progress, Challenges, and Policy Insights

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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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Disclaimer:

Opinions and recommendations in the report are exclusively of the author(s) and not of any other individual or institution including DST-CPR, NISER, Bhubaneswar. This report has been prepared in good faith on the basis of information available at the date of publication.

DST-CPR, National Institute of science Education and Research, Bhubaneswar

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List of Abbreviations

BEE	Bureau of Energy Efficiency
CAGR	Compound Annual Growth Rate
CEA	Central Electricity Authority
CMERI	Central Mechanical Engineering Research Institute
COP26	26th Conference of the Parties (UN Climate Conference)
CPR	Centre for Policy Research
DDUGJY	Deen Dayal Upadhyaya Gram Jyoti Yojana
DRE	Decentralized Renewable Energy
DVC	Damodar Valley Corporation
EC	Energy Conservation
ECBC	Energy Conservation Building Code
EEFP	Energy Efficiency Financing Platform
EV	Electric Vehicle
FDG	Flue Gas Desulphurization
FEEED	Framework for Energy Efficient Economic Development
GHG	Greenhouse Gas
GSDP	Gross State Domestic Product
HT	High Tech
ICED	India Climate Energy Dashboard
MNRE	Ministry of New and Renewable Energy
MSME	Micro, Small and Medium Enterprises
MTEE	Market Transformation for Energy Efficiency
NABARD	National Bank for Agriculture and Rural Development
NAPCC	National Action Plan on Climate Change
NFI	National Foundation for India
NIWE	National Institute of Wind Energy
NMEEE	National Mission for Enhanced Energy Efficiency
NSM	National Solar Mission
NSDP	Net State Domestic Product
NREMPP	New and Renewable Energy Manufacturing Promotion Policy
NRES	Non-Conventional and Renewable Energy Sources

PAT	Perform, Achieve, and Trade
PCGERSE	Policy on Co-generation and Generation of Electricity from Renewable Sources of Energy
PEUM	Partial End Use Methodology
RPO	Renewable Purchase Obligation
SPI	Smart Power India
STPS	Super Thermal Power Station
T&D	Transmission and Distribution
TPS	Thermal Power Station
UNFCCC	United Nations Framework Convention on Climate Change
WBGEDCL	West Bengal Green Energy Development Corporation Limited
WBREDA	West Bengal Renewable Energy Development Agency
WBREP	West Bengal Rural Electrification Programme
WBSEDCL	West Bengal State Electricity Distribution Company Limited
WBSDA	West Bengal State Forest Development Agency

Executive Summary

This report evaluates the current energy landscape of Chhattisgarh by examining recent government reports and energy dashboard data. Findings indicate that the state remains heavily dependent on thermal power, with coal contributing approximately 86.2% of its electricity generation capacity as of 2024. The remaining 13.8% is derived from renewable sources, including nuclear energy. Chhattisgarh holds the largest number of operational coal-field units in India and is home to some of the world's largest coal mines. This deep reliance on coal presents significant challenges for the energy transition, particularly for the large workforce employed in the coal sector.

Currently, the state is grappling with an energy deficit, as demand exceeds supply. Projections suggest a substantial rise in energy consumption by 2032, driven largely by high-tech industries and domestic usage. This surge, coupled with population growth, necessitates urgent action to address the mounting energy demand.

Renewable energy emerges as the most viable, sustainable, and cost-effective solution. The state has already initiated efforts in this direction, primarily through solar energy, which is growing at a compound annual growth rate of 43%, outpacing other energy sources. Moreover, Chhattisgarh holds considerable potential for wind energy development, though this remains underutilized due to insufficient investment and infrastructure. Strategic focus on solar and wind power through targeted investment and policy support can unlock significant opportunities for economic growth and employment in the renewable energy sector.

Introduction

India stands at a critical point in its pursuit of energy security and sustainability, with a strong emphasis on transitioning toward renewable energy sources. The nation has set an ambitious goal of achieving 500 GW of non-fossil fuel-based power capacity by 2030, as outlined in the National Policy on Energy Conservation (NPEC). This shift is vital not only to combat the effects of climate change but also to support sustainable economic growth and reduce the country's reliance on fossil fuels.

Under the framework of cooperative federalism, Indian states play a central role in implementing the country's energy efficiency agenda. State Designated Agencies (SDAs), established under the Energy Conservation Act of 2001, are responsible for overseeing, regulating, and executing energy efficiency policies at the state level. These agencies are instrumental in ensuring that national energy conservation initiatives are effectively translated into actionable state-level strategies. Achieving meaningful progress in India's climate goals demands close coordination between central and state governments to drive energy transitions across all key economic sectors.

Chhattisgarh, a mineral-rich state and a significant contributor to India's energy output, plays a pivotal role in this national transition. It holds around 18% of India's total coal production, as reported by the Ministry of Coal, significantly bolstering the national power supply. However, despite this energy surplus, the need to diversify the state's energy portfolio and adopt more renewable sources has become increasingly urgent. According to the Central Electricity Authority's *National Electricity Plan (NEP) 2021*, Chhattisgarh's electricity demand is expected to grow at a compound annual growth rate (CAGR) of 7.1% between 2023–24 and 2029–30. This anticipated growth highlights the importance of strategic investments and planning to expand renewable energy capacity.

The State Energy Efficiency Index (EEI) 2018 categorized Indian states based on their performance in implementing energy efficiency initiatives into four groups: 'Frontrunner,' 'Achiever,' 'Contender,' and 'Aspirant.' Chhattisgarh initially ranked as an 'Aspirant' in 2018 with a score of 27.50. Encouragingly, by the 2021–22 assessment, the state advanced to the 'Contender' category with an improved score of 47.5. However, this progress was not sustained; in 2023, the state's score dropped back to 27.25—nearly the same as its 2018 level (Ministry of Power, 2018, 2022, 2023).

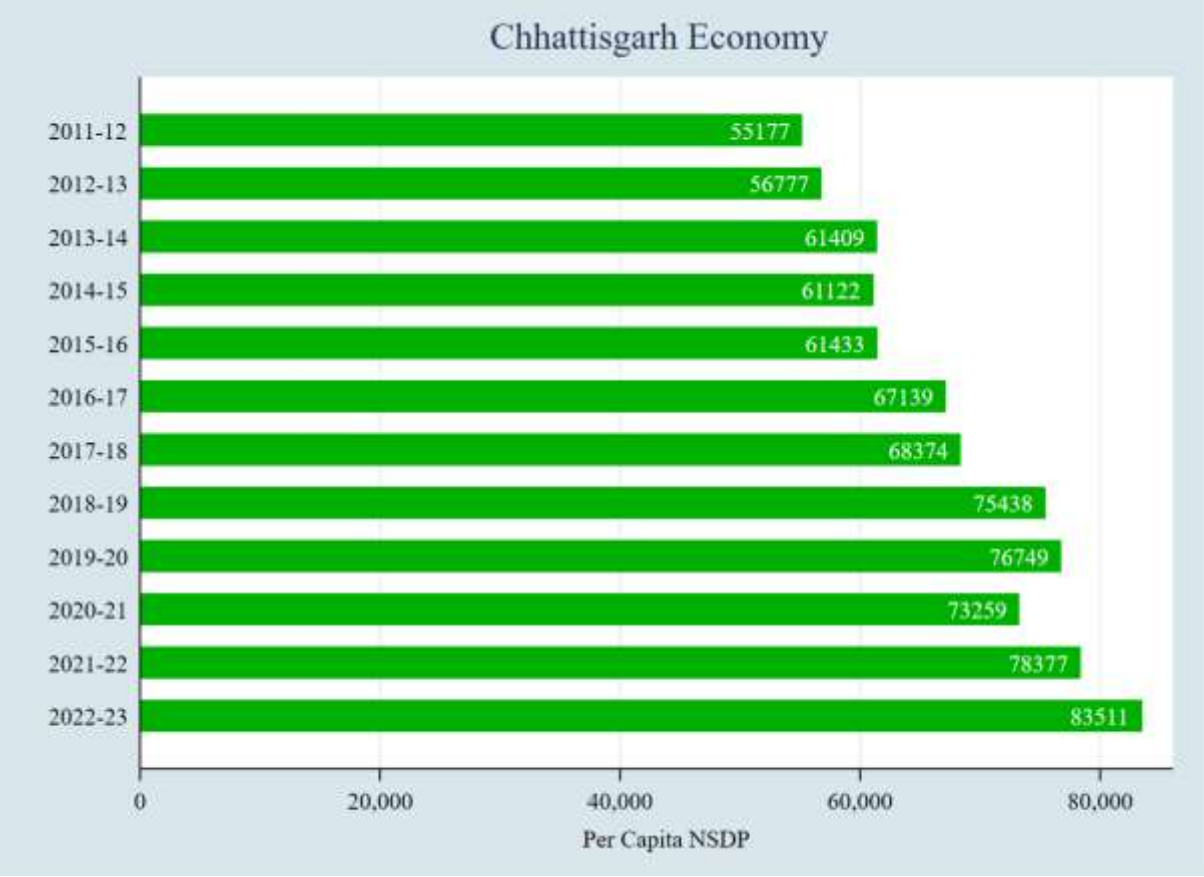
This chapter investigates Chhattisgarh's evolving energy transition by analyzing diverse government reports and datasets. It provides a comprehensive assessment of the state's progress in diversifying its energy sources and enhancing its energy infrastructure. The chapter also explores future opportunities and challenges, offering strategic insights for sustained development. The analysis relies on trend evaluation and descriptive statistics, with a primary focus on the compound annual growth rate (CAGR) to assess the effectiveness of current policies and initiatives.

Economic Scenario of Chhattisgarh

Per capita income of the state has continuously increased from 2011-12 from ₹ 55177 to 2019-20 ₹ 76749, and later slightly declined, reaching 2020-21 due to the adverse effect of COVID-19 and its impact on the economy. But, later on, the economy revived to become a

normal and start progress as Indian economy grows progressively. The upward trend in per capita income reflects Chhattisgarh's economic development, offering its residents better financial stability and access to an improved quality of life The NSDP of Chhattisgarh (₹ 83511) is the second highest in 2022-23 just behind Odisha (₹ 87361) among the eastern states including Bihar, West Bengal and Jharkhand.

Figure 1: Per Capita Net State Domestic Product in Chhattisgarh



Source: Reserve Bank of India, 2023; Notes: Per Capita Net State Domestic Product (NSDP) (₹) at constant price with the base: 2011-12.

Energy Scenario in Chhattisgarh

Table 1: Installed Capacity (in MW) of Power Utilities in Chhattisgarh

Ownership /Sector	Thermal					Nuclear	Renewable			Grand Total
	Coal	Lignite	Gas	Diesel	Total		Hydro	RES* (MNRE)	Total	
State	1840.00 (93.4%)	0.00	0.00	0.00	1840.00 (93.4%)	0.00	120.00 (6.1%)	11.05 (0.6%)	131.05 (6.6%)	1971.05
Private	7667.50 (82.9%)	0.00	0.00	0.00	7667.50 (82.9%)	0.00	0.00	1582.65 (17.1%)	1582.65 (17.1%)	9250.15
Central	2714.35 (91.6%)	0.00	0.00	0.00	2714.35 (91.6%)	135.57 (4.6%)	113.00 (3.8%)	0.00	113.00 (3.8%)	2962.92
Sub-Total	12221.85 (86.2%)	0.00	0.00	0.00	12221.85 (86.2%)	135.57 (1%)	233.00 (1.6%)	1593.70 (11.2%)	1826.70 (12.8%)	14184.12

Source: Central Electricity Authority Dashboard, Government of India, 2024, (As on 31.07.2024); * Renewable Energy Sources

Table 1 demonstrates the electricity produced from renewable and non-renewable sources in Chhattisgarh. The state predominantly relies on non-renewable energy source, with around 86.2 percent of its total installed capacity sourced from thermal power. Notably, coal constitutes a predominant share, representing 86.2 percent of the installed capacity, contributed by state, central, and private sectors. Both state and central sectors account for over 90 percent of thermal power plants, but the private sector's share is marginally lower at 82.9 percent. The central sector significantly supplies 4.6 percent to the state's electricity utility via nuclear power.

The state derives 12.8 percent of its installed capacity from renewable energy sources. The private sector accounts for the highest share, at 17.1 percent. The contributions from both the state and central sectors are 6.6 percent and 3.8 percent, respectively. Within the category of residual renewable energy sources (RES), the private sector possesses the largest part at 17.7 percent, whilst the public sector's contribution is far lower, at merely 2 percent.

Table 2: Installed capacity by sector in Chhattisgarh (2019-2024) (MW)

Year	Central	Private	State	Total
2019	6880	13633.13	3327.717	23840.85
2020	7280	13709.38	3211.05	24200.43
2021	7680	13872.33	2971.05	24523.38
2022	7680	14158.46	2971.05	24809.52
2023	7680	14484.02	2971.05	25135.07
2024®	7680	14658.27	2971.05	25309.31
CAGR	0.022244	0.014606	-0.02242	0.012026
2019-2024	2.2	1.5	-2.2	1.2

Source: CEA dashboard, 2024. https://cea.nic.in/dashboard/?lang=en; Note: ® data provided until Feb 2024.

Table 2 provides an overview of the installed energy capacity (in MW) in Chhattisgarh from 2019 to 2024, divided into three key sectors: central, private, and state. The central sector's installed capacity shows consistent growth, starting at 6,880 MW in 2019 and rising to 7,680 MW by 2024, reflecting a compound annual growth rate (CAGR) of 2.22%. This indicates that the central government is steadily increasing its contribution to Chhattisgarh's energy capacity. Similarly, the private sector has also increased its contribution, albeit at a more modest rate, from 13,633.13 MW in 2019 to 14,658.27 MW by 2024, exhibiting a CAGR of 1.46%, indicating a slow but stable growth. In contrast, the state sector's installed capacity has decreased over the years, from 3,327.71 MW in 2019 to 2,971.05 MW in 2024, showing a negative CAGR of -2.24% and signalling a reduction in state-funded energy capacity. Overall, the total installed capacity in the state has grown from 23,840.85 MW in 2019 to 25,309.31 MW in 2024, with a modest overall CAGR of 1.2%, indicating incremental progress in the state's energy capacity expansion. The increase in energy capacity from the central and private sectors highlights growing external contributions, while the decline in the state sector's capacity suggests possible fiscal challenges or a shift in focus. This trend underscores the need for the state to possibly explore alternative energy initiatives or partnerships to maintain a balanced energy infrastructure. Additionally, the slow growth in

private sector capacity suggests that there may be further opportunities to incentivize private investment in energy development.

Table 3: Energy generation from different parameters

Parameter	Hydro (in MU)	Coal (in MU)	Bio Power (in MU)	Small Hydro (in MU)	Solar (in MU)	Wind (in MU)	Total
2012-13	302	67813.63	-	-	-	-	68115.63
2013-14	252	70564.97	-	-	-	-	70816.97
2014-15	258	79019.09	-	-	-	-	79277.09
2015-16	323	87049.55	1119.33	30.43	52.7	-	88575.01
2016-17	154	103576.77	1281.12	44.23	110.93	9.97	105177.02
2017-18	178	100204.23	909.72	22.94	136.54	-	101451.43
2018-19	243.08	114997.19	529.89	80.08	335.15	-	116185.39
2019-20	236.79	113444.25	679.7	101.62	326.42	-	114788.78
2020-21	419.19	134659.99	1117.57	145.51	370.8	-	136713.06
2021-22	404.13	140524.04	1315.98	185.66	436.56	-	142866.37
2022-23	237.37	142489.58	1211.69	155.93	635.42	-	144729.99
2023-24	321.77	162372.5	1388.15	145.55	943.75	-	165171.72
CAGR	-0.0005	0.0810	0.0273	0.2161	0.4343		0.0810
2015-2024	-0.05%	8.1%	2.7%	21.6%	43.4%	0.0	8.1%

Source: CEA dashboard, 2024. https://cea.nic.in/dashboard/?lang=en

Table 3 presents data on Chhattisgarh's electricity generation from various sources—coal, hydro, biopower, small hydro, solar, and wind—over the period from 2012–13 to 2023–24. Throughout this period, coal has remained the dominant source of energy, accounting for the largest share of power generation. In 2012–13, coal-based power generation stood at 67,813.63 million units (MU) and increased steadily to 162,372.5 MU by 2023–24, reflecting a compound annual growth rate (CAGR) of 8.1%.

While renewable energy sources have shown notable growth, solar energy has witnessed the most significant expansion. Solar generation increased from negligible levels to 943.75 MU in 2023–24, marking a remarkable CAGR of 43.4%—the highest among all energy sources in the state during the period 2015–2024. Small hydro and biopower also recorded positive, though comparatively modest, growth rates of 21.6% and 2.7% respectively. In contrast, wind energy production remains largely undocumented across most of the observed years.

Overall, Chhattisgarh's total electricity generation increased from 68,115.63 MU in 2012–13 to 165,171.72 MU in 2023–24, corresponding to a CAGR of 8.1%. This reflects growth in both conventional and renewable sectors, although the energy mix remains heavily skewed toward coal.

These findings underscore Chhattisgarh's continued reliance on coal, even as the state increasingly prioritizes renewable energy development. The rapid growth in solar power generation signals a strategic commitment to diversifying the energy mix and reducing carbon emissions. However, accelerating the transition from coal to renewables will require significant investment in infrastructure, technology, and policy support to scale renewable capacity and ensure long-term energy sustainability.

Table 4: The trend of Energy requirements and availability (GWh)

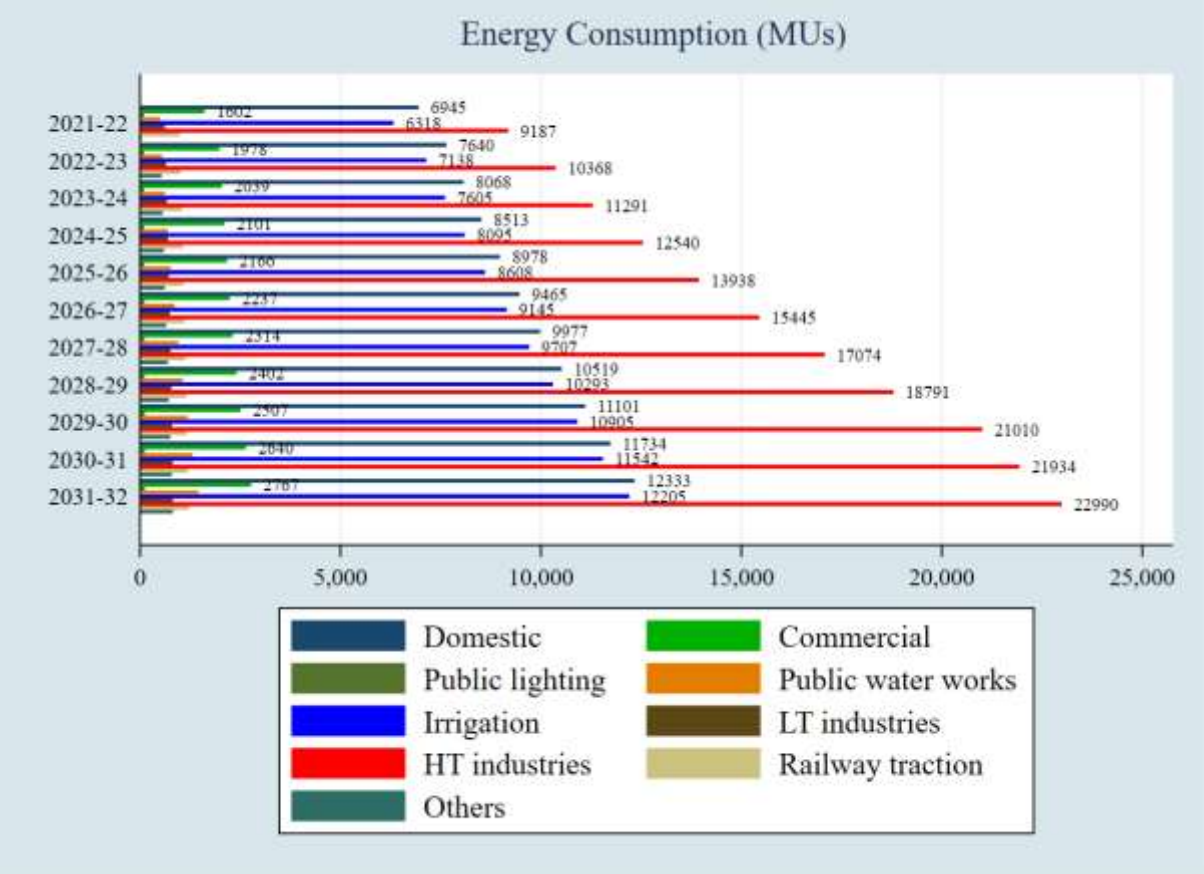
Year	Energy requirement	Energy availability	Gap
2020	2440.017	2439.952	-0.0650
2021	2649.473	2644.828	-4.6450
2022	3110.088	3109.583	-0.5050
2023	3300.969	3294.773	-6.1960
2024	3654.093	3651.883	-2.2100

Source: CEA dashboard, 2024. https://cea.nic.in/dashboard/?lang=en

Table 4 outlines the average energy requirement and availability in Chhattisgarh from 2020 to 2024, along with the resulting energy gap, measured in gigawatt-hours (GWh). Over the years, the energy requirement has shown a consistent upward trend, increasing from 2,440.017 GWh in 2020 to 3,654.093 GWh in 2024. This growth reflects the rising demand for electricity in the state, driven by factors such as population growth, industrial expansion, and increased consumption across residential and commercial sectors. In contrast, energy availability, while also increasing, lags behind the requirement, rising from 2,439.952 GWh in 2020 to 3,651.883 GWh in 2024. The energy gap, which represents the difference between energy requirements and availability, fluctuates over the years, starting at a slight deficit of -0.065 GWh in 2020 and widening significantly to -6.196 GWh in 2023 before narrowing slightly to -2.210 GWh in 2024. This increasing negative gap indicates that the state is experiencing a shortfall in energy supply relative to its needs, highlighting challenges in meeting the energy demands of its population and industries. The persistent energy gap underscores a critical issue for Chhattisgarh, necessitating investments in infrastructure, renewable energy sources, and efficiency improvements to enhance generation capacity. Addressing this gap will be essential for ensuring reliable electricity availability and supporting sustainable growth in the state.

Forecast for the Energy Demand of the State

Figure 2: Energy Consumption forecast (2021-2032)



Source: 20th Electric Power Survey of India, 2022; **Note**: The projection has been made using the Partial End Use Methodology (PEUM), which combines time series analysis with the End Use Method. T&D – Transmission and Distribution. LT: Low Tech; H T: High Tech

Figure 2 depicts a detailed analysis of Chhattisgarh's energy consumption from 2021-22 to 2031-32, encompassing sectors like home, commercial, public lighting, irrigation, industries, and railway traction. During this decade, the state's energy consumption is anticipated to increase substantially, propelled by expansion in all sectors, especially residential and industrial. Domestic energy consumption, the predominant category, is anticipated to rise from 6,945 MU in 2021-22 to 12,333 MU by 2031-32, indicative of expanding electrical access and population expansion. Correspondingly, commercial energy consumption will increase progressively from 1,602 MU to 2,767 MU, signifying the growth of business operations throughout the state. Industrial consumption, particularly in high-tension sectors, is projected to rise significantly from 9,187 MU in 2021-22 to 22,990 MU in 2031-32, reflecting the state's industrial expansion and growing dependence on energy-intensive operations.

Transmission and distribution (T&D) losses, initially recorded at 16.94% in 2021-22, are anticipated to decrease to 12.92% by 2031-32, indicating enhancements in the efficiency of the state's energy distribution networks. This likely arises from technical advancements and infrastructure improvements designed to minimise energy waste. The state's total energy

requirement is projected to increase from 31,641 MU in 2021-22 to 62,827 MU by 2031-32, while the "ex-bus" requirement (energy needed post-losses) is anticipated to rise from 31,948 MU to 63,436 MU. This increase in demand underscores the necessity for substantial capacity expansions in the forthcoming years.

The annual load factor, which measures the efficiency of installed capacity, remains largely consistent but shows a modest decline from 71.82% in 2021-22 to 73.84% in 2031-32. Projections suggest an increase in peak energy consumption from 5,029 MW to 9,713 MW over the same timeframe, requiring a substantial enhancement of Chhattisgarh's generation capacity to satisfy the elevated demand during peak periods. The data indicates a persistent increase in energy consumption in Chhattisgarh, especially in the residential and industrial sectors, highlighting the necessity for ongoing investment in energy infrastructure and generation capacity. The consistent decrease in T&D losses signifies enhanced distribution efficiency; nonetheless, further efforts are necessary to conform to national and worldwide norms. The increasing energy demand and peak consumption indicate a necessity for proactive planning to guarantee that the energy supply can satisfy future requirements. Moreover, investment in renewable energy and infrastructure modernisation will be essential for sustainably managing the growing energy demand.

Table 5: Energy Consumption, Requirement, and Peak Demand forecast (2021-2032)

Year	Energy Requirement - MU	Annual Load Factor - %	Peak Demand - MW	Energy Requirement (Ex-Bus) - MU	T&D losses (Ex- Bus) - in %
2021-22	31641	71.82	5029	31948	17.74
2022-23	35911	76.52	5358	36260	17.36
2023-24	38159	76.31	5708	38528	16.98
2024-25	40828	76.00	6132	41223	16.59
2025-26	43707	75.69	6592	44130	16.20
2026-27	46755	75.38	7081	47208	15.80
2027-28	49991	75.07	7602	50475	15.39
2028-29	53382	74.76	8152	53900	14.99
2029-30	57426	74.45	8805	57983	14.58
2030-31	60067	74.14	9248	60649	14.16
2031-32	62827	73.84	9713	63436	13.75

Source: Same as in Figure 2; **Note**: T&D – Transmission and Distribution.

The forecasts in Table 5 show a substantial rise in Chhattisgarh's energy demand and peak power requirements from 2021 to 2032, with energy needs virtually tripling from 31,641 million units (MU) in 2021-22 to 62,827 MU by 2031-32. Industrialisation, urbanisation, and population growth are the driving factors behind this expansion. Peak demand will increase from 5,029 MW to 9,713 MW, requiring substantial investments in power generation and infrastructure to accommodate the heightened load during peak periods. The annual load factor displays a minor decrease, suggesting possible inefficiencies in energy use throughout the year, while the transmission and distribution (T&D) losses are anticipated to decrease from 17.74% to 13.75%. This decrease signifies initiatives to improve grid efficiency and reduce losses.

The rising energy demand and peak load will necessitate substantial investments in power generation and grid infrastructure, including renewable energy initiatives, to provide a reliable supply. The marginal decrease in the load factor indicates the necessity for programs that enhance energy efficiency, such as demand-side management, to equilibrate consumption annually and alleviate the strain on the grid during peak periods. The reduction in T&D losses signifies continuous enhancements; nonetheless, additional modernisation of transmission systems, grid automation, and smart meters will be essential to guarantee that a greater amount of electricity is delivered to consumers efficiently. To satisfy increasing demand while minimising carbon emissions, Chhattisgarh must concentrate on switching to cleaner energy sources rapidly. Government initiatives that promote renewable energy and better energy systems will be crucial in sustainably fulfilling projected demand. With the rising energy demand, it is imperative to provide energy stability through a varied energy portfolio and strategic reserves to prevent disruptions and maintain long-term economic stability.

Chhattisgarh's readiness for energy transition

The Government of India expressed and represented the concerns of developing nations at the Conference of the Parties (COP26) to the United Nations Framework Convention on Climate Change (UNFCCC) in Glasgow, United Kingdom. India also presented the five key components (Panchamrit) of India's climate action, which are outlined below:

1. Achieve a 500 GWN capacity for non-fossil energy by 2030.
2. By 2030, renewable energy will meet 50% of the country's energy needs.
3. An anticipated reduction of one billion metric tonnes in global carbon emissions between now and 2030.
4. A reduction of 45% from 2005 levels in the economy's carbon intensity by 2030.
5. Reaching the goal of having no emissions by 2070.

In line with the nation's energy transition objectives, each state should develop its own energy policy and actively participate in it. Before delving into the specifics of the state-level energy policy, it is crucial to consider the national objectives and their intended direction for the state's involvement in the energy sector.

National Action Plan on Climate Change (NAPCC) 2008

India's climate change strategies have predominantly emphasised fostering synergies between developmental and climatic outcomes. India was among the few nations that enacted the Energy Conservation Act in 2001, which was amended in August 2022.

The formulation of eight national missions on climate change has taken place. The first two missions are pertinent to the energy sector.

1. National Solar Mission

2. National Mission for Enhanced Energy Efficiency

National Solar Mission (NSM) 2010

The aim of the National Solar Mission is to position India as a global leader in solar energy by facilitating the rapid dissemination of policy conditions nationwide. The Mission has a tripartite strategy: Phase 1 (up to 2012-13), Phase 2 (2013-17), and Phase 3 (2017-22).

The primary objective of NSM was to implement 20 GW of solar electricity by 2022. This was raised to 100 GW in early 2015. Various facilitative programs and initiatives under the Mission have propelled the grid-connected solar power installed capacity from 25 MW in 2010-11 to around 36.32 GW as of 31st October 2020. An extra 58.31 GW of solar generating capacity is presently undergoing installation or tendering procedures.

National Mission for Enhanced Energy Efficiency (NMEEE) 2011

NMEEE aims to enhance the energy efficiency market by establishing a supportive regulatory and policy framework, while promoting innovative and sustainable business models within the sector.

NMEEE comprises four initiatives aimed at enhancing energy efficiency in energy-intensive industries.

- Perform, Achieve and Trade (PAT)
- Market Transformation for Energy Efficiency (MTEE)
- Energy Efficiency Financing Platform (EEFP)
- Framework for Energy Efficient Economic Development (FEEED)

Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) 2014

The Government of India launched DDUGJY in December 2014 for various rural electrification works, including separation of agriculture and non-agriculture feeders, strengthening and augmentation of sub-transmission & distribution infrastructure, metering at distribution transformers/feeders/consumers, and electrification of villages across the country. The scheme has completed its works and now stands closed.

States' Policies for Energy Transition and Achievement

Chhattisgarh Solar Energy Policy 2017-2027

The State Government executes the "Chhattisgarh Solar Energy Policy 2017-2027" with the following goals:

1. To encourage solar energy-based power generation to address the growing demand for electricity while considering environmental and economic factors within a comprehensive long-term strategy.
2. Encouraging involvement from the private sector in solar power generation.
3. To establish a supportive environment for enhancing solar generation capacities in the state.
4. To fulfil the state's long-term energy needs and enhance energy security by gradually decreasing reliance on traditional thermal energy sources like coal.

5. To address the energy requirements of villagers residing in remote and inaccessible regions of the state. To promote stand-alone off-grid solar applications.
6. Guaranteeing access to clean energy for various uses.
7. To promote decentralized production and distribution within the state.

The **Chhattisgarh State Renewable Energy Development Agency (CREDA)** serves as the nodal agency responsible for implementing and overseeing all activities under the state's solar energy policy. This policy is effective from **April 1, 2017, to March 31, 2027**, or until a new solar policy is introduced—whichever comes first.

Projects commissioned between **2012 and 2017** are eligible to receive benefits as outlined in the current policy. All stakeholders—including individuals, private companies, government power utilities, captive power plants, and solar energy developers—must comply with the provisions of the **Electricity Act, 2003**, and its subsequent amendments, regardless of whether the electricity generated is intended for self-consumption or commercial sale.

In Chhattisgarh, **energy banking charges** are determined based on both the **season** and **time of day**. From **January and July to December**, off-peak hour banking incurs a **2% charge**, while peak hours are charged at **10%**. During the **February to June** period, off-peak charges rise to **5%**, and peak hour charges increase to **15%**.

At the end of each financial year, the **state DISCOM** settles the banked energy accounts by compensating producers at the prevailing market rate, after deducting any energy withdrawn from the grid. This mechanism allows solar power producers to store excess electricity in the grid and retrieve it later, with deductions based on the defined banking charges. The differentiated rate structure encourages energy banking during off-peak hours—when grid demand is lower—and discourages banking during peak periods, thereby promoting efficient energy distribution and grid stability.

Chhattisgarh State Electric Vehicle (EV) Policy 2022

Major Objectives

Drive widespread adoption of Battery Electric Vehicles (BEVs), aiming for them to represent 15% of all new vehicle registrations by 2027, leading to a substantial reduction in transport-related emissions and enhancing Chhattisgarh's environmental quality.

Speed up the transition to electric vehicles across all segments, with a focus on two-wheelers, public/shared transport, and goods carriers in the mass market.

Position Chhattisgarh as a leading manufacturing hub for electric vehicles and related components, creating extensive job opportunities for the state's youth.

Build a skilled talent pool of engineers, designers, technicians, and researchers to meet industry needs and promote sustainable development

Policy Period

This policy will be effective for a duration of five years starting from April 1, 2022, with the possibility of extension up to 10 years at the discretion of the State Government.

All the aggregator service providers to mandatorily have at-least 30% of e-vehicles in their fleet

Table 6: Targets under Chhattisgarh State Electric (EV) Policy 2022

classification of EVs	2022-23	2023-24	2024-25	2025-26	2026-27	Total
2 Wheelers	2,000	8,000	20,000	54,000	85,000	1,69,000
3 Wheelers	200	800	2,000	4,000	10,000	17,000
4 Wheelers (non-commercial)	200	400	1,400	3,000	7,000	12,000
4 Wheelers (commercial)	10	40	100	300	650	1,100
Buses	10	25	65	200	600	900
Total						2,00,000

Source: Chhattisgarh State Electric (EV) Policy 2022.

Actual attainment of electric vehicles penetration in Chhattisgarh

Table 10 provides the electric vehicle (EV) penetration in Chhattisgarh, highlighting the impact of the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) schemes. When FAME-I began in 2015-16, the adoption of electric vehicles was relatively low, with only 100 units recorded. The launch of FAME-I (2015-2019) led to a gradual increase, with 1,195 EVs by 2017-18 and a significant jump to 2,568 by 2018-19, showing a CAGR of 195%. However, a slight decline occurred in 2019-20, with 2,272 EVs registered, marking the end of FAME-I. The introduction of FAME-II in 2019-20 (2019-2024) spurred even more significant growth. Specifically, by 2021-22, the number of EVs surged to 6,529, and in 2022-23, the adoption rise steeply to 27,711 EVs, indicating an increase of CAGR at 107%. By 2023-24, this number reached 42,167, contributing to a grand total of 85,565 EVs. The FAME-I policy laid the foundation for EV adoption in Chhattisgarh, but the real acceleration registered in the first phase, which provided more substantial incentives, infrastructure development, and a clearer policy framework. When it comes to the FAME-II the CAGR of EVs penetration is recorded a CAGR at 107.6% in the state which is lower growth rate than in FAME-I (190%). This reduction may be due to the reduction of incentives in the FAME-II. But still the adoption of EVs is increasing and it is anticipated to increasing faster. This faster adoption of EVs and its future market will impact the state's energy transition in the transport sector, reducing its reliance on conventional fossil fuels and encouraging a shift toward cleaner, electric-powered mobility.

Chhatisgarh attains the grand total of EVs 85565 by the year 2023-24 which is 42% of their total target 2 lakh of EVs in the total vehicles in the state level EV policy 2022. This achievement is the simultaneous impact of both national and state-level EV policies.

Table 7: Number and CAGR of total EVs in Chhattisgarh

Year	EVs	Cumulative	CAGR
2000-01	1		

2001-02	3		
2002-03	2		
2003-04	1		
2004-05	8		
2005-06	8		
2006-07	9		
2007-08	33		
2008-09	90		
2009-10	96		
2010-11	201		
2011-12	281		
2012-13	130		
2013-14	84		
2014-15	115		
2015-16	100	**FAME - I**	**FAME - I**
2016-17	276	(2015-2019)	(2015-2019)
2017-18	1195	4139	1.950
2018-19	2568		195.0%
2019-20	2272	**FAME - II**	**FAME - II**
2020-21	1685	(2019-2024)	(2019-2024)
2021-22	6529	80364	1.076
2022-23	27711		107.6%
2023-24	42167		
Grand Total	**85565**		

Source: Author’s estimation using data from NITI Aayog | India's Climate and Energy Dashboard (2024)

Chhattisgarh Industrial Policy 2019-24: Energy-related objectives

Non-Conventional Energy Generation: The policy promotes industries involved in non-conventional energy generation, including solar, wind, and biofuel sectors, to foster renewable energy development. The state provides special incentives for the production of biofuels and ethanol, particularly from surplus paddy. This contributes to the state's push for cleaner energy sources and reducing dependency on fossil fuels. Electric Vehicles and Battery Manufacturing: The policy focuses on the production of electric vehicles (two-wheelers, three-wheelers, and four-wheelers) and their components, as well as batteries and equipment for electric vehicle charging stations.

Renewable Energy Equipment Manufacturing: It encourages the manufacturing of plants, machinery, and accessories used for generating power from renewable energy sources. This includes equipment for the generation, transmission, and distribution of electricity from renewable sources. Mega and Ultra Mega Projects in Renewable Energy: Ultra-mega projects in sectors like renewable energy and electric vehicle manufacturing are provided with customised incentive packages to attract large-scale investments in clean energy sectors. Electricity Duty Exemption: Depending on their size and location, new industries engaged in renewable energy are eligible for exemptions from electricity duty for a specific period.

These points align with the state's broader commitment to promoting sustainable industrial growth while meeting renewable energy targets, supporting India's national green energy transition goals.

State-level Institutions on directing energy transition

The Chhattisgarh Renewable Energy Development Agency

On May 25, 2001, the Department of Energy, Government of Chhattisgarh, established the Chhattisgarh State Renewable Energy Development Agency (CREDA) to implement various schemes focused on renewable energy sources and energy conservation initiatives. Registered under the Society Act of 1973, CREDA serves as the State Nodal Agency, tasked with promoting and developing non-conventional and renewable energy. The Ministry of Non-Conventional and Renewable Energy Sources (MNRE) of the Government of India sponsors numerous programs, including the National Program on Biogas Development and Solar Thermal Initiatives, which CREDA effectively implements.

Additionally, Chhattisgarh has designated CREDA as the State Designated Agency (SDA) to oversee, regulate, and enforce the provisions of the Energy Conservation Act of 2001. This designation expands CREDA's responsibilities to include promoting energy efficiency and developing conservation projects alongside renewable energy development. Since its inception, the agency has made significant strides toward enhancing energy efficiency, particularly in rural areas, and has successfully executed various projects focussing on power generation from renewable and environmentally friendly sources. The CREDA has established a professional organizational structure that is fully equipped with the necessary financial and human resources to fulfil its mandates. This structure includes extensive human resource development activities, which foster a modern working environment for its staff.

Chhattisgarh Biofuel Development Authority (CBDA)

Recognizing the state’s significant potential for cultivating tree-borne oilseeds (TBOs) such as Pongamia pinnata (Karanj) and Jatropha curcas (Ratanjot), the Chhattisgarh government established the Chhattisgarh Biofuel Development Authority (CBDA) in January 2005. The primary aim of the CBDA is to facilitate effective management and coordination of activities related to the promotion of TBO plantation, seed collection, biofuel extraction, and marketing of biofuel derived from these tree-borne oilseeds.

Chhattisgarh Environment Conservation Board (CECB)

The Chhattisgarh Environment Conservation Board (CECB) plays a vital role in providing recommendations and regulatory oversight within the power sector. The board has implemented measures to ensure that all new large-scale power plants in the state adopt super-critical technology, which enhances fuel combustion efficiency by 1-3%. Additionally, since 2010, the CECB has mandated the use of high-concentration slurry disposal systems for fly ash to minimize pollution and reduce fugitive emissions from thermal power plants. The CECB also advocates for the use of 'beneficiated' or washed coal in thermal power generation to maximize energy output and improve overall efficiency. Furthermore, the board promotes reforestation efforts and the utilization of alternative fuels in power generation.

The Chhattisgarh State Electricity Regulatory Commission (CSERC)

It holds the role as both a regulator and a promoter of the state's power sector. Its goal is to foster growth through increased investment, ensuring reasonable returns for the electricity industry while providing a competitive environment. This will help Chhattisgarh realize its potential as a power hub in the country. The CSERC aims to enhance the efficiency of electricity generation, transmission, and distribution, ensuring that consumers receive electricity at fair rates. To achieve these objectives, the Commission will employ transparent processes that encourage stakeholder participation.

Renewable Energy: A Potential Future

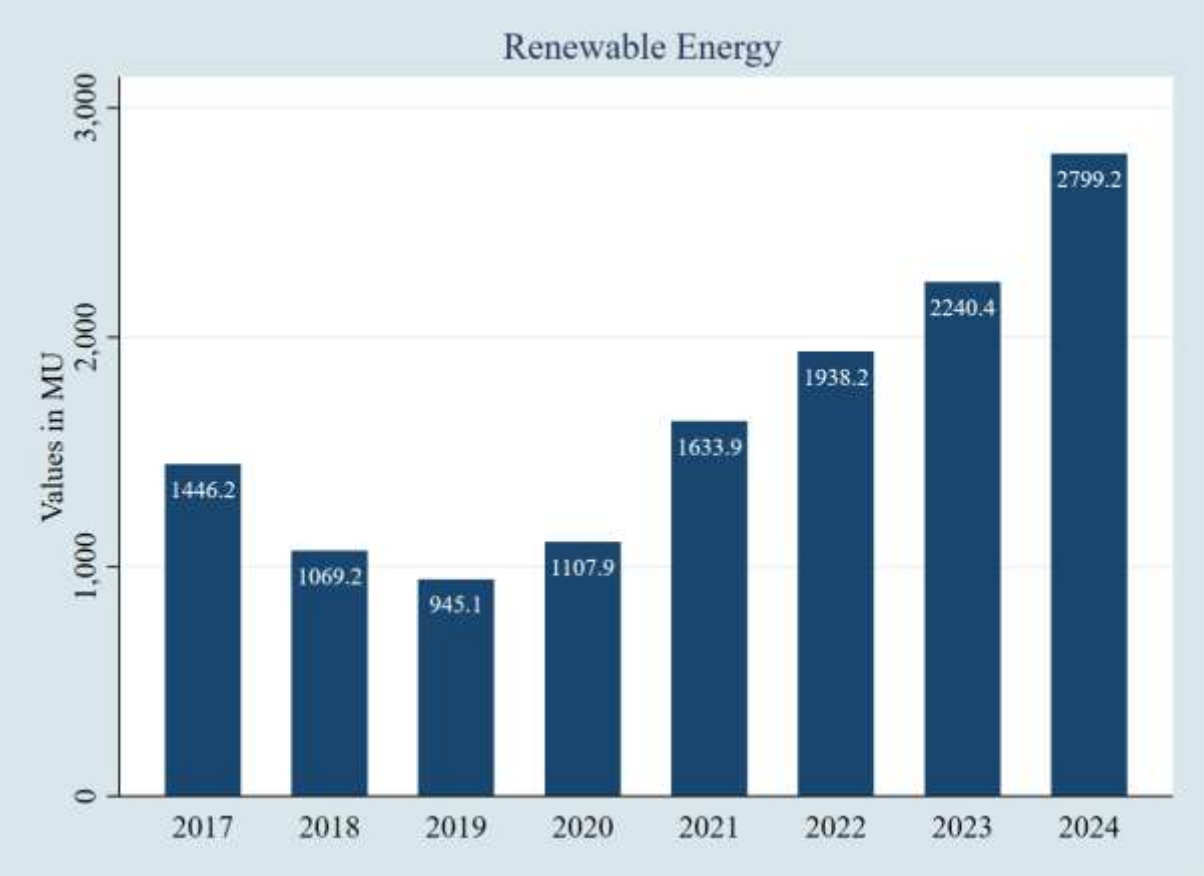
Table 8: Estimated Potential of Renewable Power in Chhattisgarh among Eastern states (as on 31.03.2023) (MW)

States/ UTs	Wind Power @ 150m	Small Hydro Power	Biomass Power	Cogeneration-bagasse	Solar Energy	Large Hydro	Total	Distribution (%)
Bihar	4023	527	964	347	11200	130	17191	15.40
Chhattisgarh	**2749**	**1098**	**354**	**0**	**18270**	**1311**	**23782**	**21.30**
Jharkhand	16	228	146	0	18180	300	18870	16.90
Odisha	12129	286	299	0	25780	2825	41318	37.01
West Bengal	1281	392	1742	0	6260	809	10484	9.39
Eastern states	20198	2531	3505	347	79690	5375	111645	100.00

Source: Author's own estimation using data from the Energy Statistics Report 2024 (NSO, 2024).

Chhattisgarh holds significant renewable energy potential, particularly in comparison to other eastern states like Bihar, Jharkhand, Odisha, and West Bengal. Notably, the state leads in small hydropower capacity among these states, as shown in Table 7. Chhattisgarh also ranks third in wind power potential with 2,749 MW, following Odisha (12,129 MW) and Bihar (4,023 MW). In terms of biomass energy, the state secures the third highest potential. Furthermore, Chhattisgarh has the second-largest solar energy potential in the region, with 18,270 MW, just behind Odisha's 25,780 MW. Additionally, the state possesses a substantial capacity for large hydropower. With a total capacity of 23,782 MW, Chhattisgarh ranks second among eastern states in terms of renewable energy potential, accounting for 21.30% of the regional energy distribution, as shown in Table 7. In the national level comparison, Chhattisgarh accounts for 1.13% of the total renewable energy potential (NSO, 2024).

Figure 3: Renewable Energy trend in Chhattisgarh



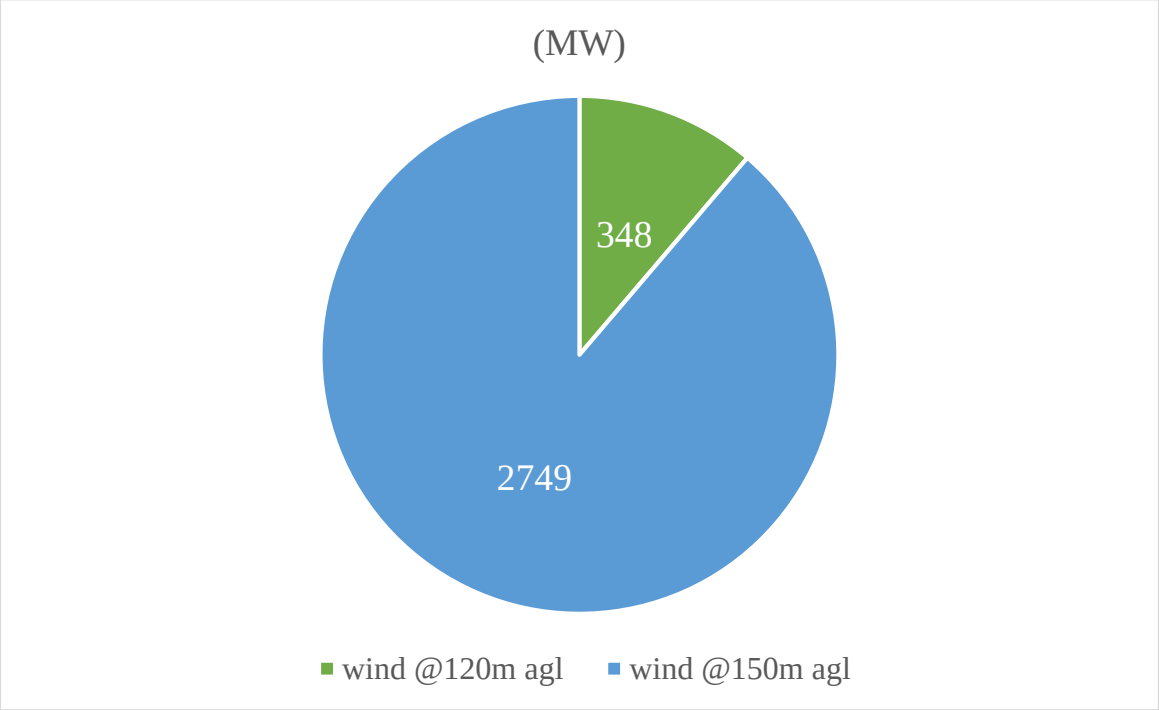
Source: Author's calculation based on data from the CEA dashboard. RE generation in MU April – March.

The renewable energy generation in Chhattisgarh in Figure 3 has shown varying trends from 2017 to 2024, but overall, it displays a substantial growth. In 2017, the renewable energy output was 1,446.22 MU, which dipped to 1,069.21 MU in 2018 and further to 945.1 MU in 2019. However, from 2020 onwards, renewable generation rebounded, reaching 1,107.87 MU in 2020 and climbing steadily each year to 2,799.2 MU by 2024.

This increase can be attributed to several factors, including policy shifts promoting renewable energy, improved incentives for solar and wind projects, and the adoption of advanced technologies that have made renewable generation more efficient. Additionally, government initiatives aimed at meeting national clean energy targets, along with rising investments from both public and private sectors, have played a key role in this expansion.

This upward trajectory indicates Chhattisgarh's increasing reliance on renewable sources, such as solar and wind, to meet its energy demands. The implications of this rise are significant, as they reflect the state's efforts to transition to cleaner energy sources, reduce greenhouse gas emissions, and improve energy sustainability. To sustain this growth, further investments in grid infrastructure and energy storage systems will be crucial for efficiently integrating the increasing renewable capacity into the state's energy mix.

Figure 4: Wind Potential in Chhattisgarh



Source: NITI Aayog | India's Climate and Energy Dashboard (2024). https://iced.niti.gov.in/energy/fuel-sources/wind/potential.

Wind Power Potential

Figure 4 illustrates the forecast for Chhattisgarh's wind energy potential. Chhattisgarh's wind energy potential, as shown in the projection, varies significantly based on turbine height. At 150 meters above ground level, the state has a much higher potential capacity of 2,749 MW, compared to just 348 MW at 120 meters. This substantial difference implies that installing taller wind turbines can dramatically enhance the state's capacity for generating wind power. It suggests that by investing in taller turbines, Chhattisgarh could better harness its wind resources, contributing more significantly to renewable energy targets and reducing reliance on fossil fuels. Additionally, it highlights the importance of technological and infrastructure improvements in maximizing renewable energy output.

Major Challenges for the energy transition in Chhattisgarh

Thermal Power Dependency

The state has totally 26 operational coal units (Table 9) which is the highest number than any other states in India. According to the statistics from the India Climate Energy Dashboard (ICED) in 2024, Chhattisgarh has the highest number of operational coal power stations among the eastern states (ICED, 2024). The Gevra and Kusmunda megaprojects, operated by South Eastern Coalfields Limited (SECL) in Chhattisgarh, have ranked 2nd and 4th among the world's 10 largest coal mines, according to WorldAtlas.com. These two mines, located in the Korba district, contribute over 100 million tonnes of coal annually, accounting for

roughly 10% of India’s total coal output. The Gevra opencast mine, which began operations in 1981, has a production capacity of 70 million tonnes per year, producing 59 million tonnes in FY 2023-24. Expected to meet India's energy needs for the next decade, Gevra holds ample reserves. Meanwhile, the Kusmunda opencast mine surpassed 50 million tonnes of production in FY 2023-24, making it the second Indian mine, after Gevra, to reach this milestone. Both mines use cutting-edge technology, including the "Surface Miner," which enables coal extraction without blasting, promoting more environmentally friendly mining practices (Ministry of Coal, 2024).

Table 9: Operational capacity of the coal in Chhattisgarh

Plant Name	Implementing Agency	Operational Units	Operational Capacity (MW)
O.P. Jindal or Tamnar I TPS/ Raigarh TPP	Jindal Power Ltd. (JPL)	1, 2, 3, 4	1000
Dr. Shyama Prasad Mukherjee TPS	Chhattisgarh State Power Generation Co. Ltd.	1, 2	500
Sipat STPS	NTPC Ltd.	1, 2, 3, 4, 5	2980
Pathadi TPP	Lanco Amarkantak Power Pvt.Ltd.	1, 2	600
Salora TPP	Vandana Vidyut Ltd.	1	135
Balco Korba TPP	BALCO Pvt Ltd.	1, 2	600
Korba STPS	NTPC Ltd.	1, 2, 3, 4, 5, 6, 7	2600
SVPL TPP	S V Power Private Limited (ACB India Ltd.)	1	63
Chakabura TPP	ACB India Ltd.	2	30
Bhilai TPS	NTPC- SAIL Power Company Limited (NSPCL)	1, 2	500
Tamnar TPP	Jindal Power Ltd. (JPL)	1, 2, 3, 4	2400
Akaltara TPS	Wardha Power Co. Ltd.	1, 2, 3	1800
Swastik Korba TPP	ACB India Ltd.	1	25
Marwa TPS	Chhattisgarh State Power Generation Co. Ltd.	1, 2	1000
Ratija TPS	Spectrum Coal and Power Limited (ACB India Ltd.)	1, 2	100
Korba West or Hasdeo TPS	Chhattisgarh State Power Generation Co. Ltd.	1, 2, 3, 4, 5	1340
Raikheda TPP	GMR Chhattisgarh Energy (GCEL)	1, 2	1370
Avantha Bhandar TPS	Korba West Power Company Limited (KWPCL) (Adani Power)	1	600
Katghora TPP	Vandana Energy & Steel Pvt. Ltd.	1	35
Nawapara TPP	TRN Energy Private Limited (ACB India Ltd.)	1, 2	600
Binjkote TPP	SKS Power Generation Ltd.	1, 2	600
Baradarha TPS	Dainik Bhaskar Power Limited (DBPL)	1, 2	1200
Kasaipalli TPP	ACB India Ltd.	1, 2	270
Uchpinda TPP	R.K.M. PowerGen Pvt. Ltd.	1, 2, 3, 4	1440
Lara STPS	NTPC Ltd.	1, 2	1600
Bandakhar TPP	Maruti Clean Coal and Power Ltd. (associates of ACB India Ltd.)	1	300

Source: NITI Aayog | India's Climate and Energy Dashboard (2024)

Chhattisgarh's energy transition faces several significant challenges. The state has long relied on coal as its primary energy source, accounting for 86.2% of its installed capacity. This dependency poses a critical hurdle in the shift toward renewable energy, as it necessitates a substantial reduction in coal consumption to meet national carbon emission targets. Infrastructure Limitations is another challenge. Particularly, the state has the more potential wind energy capacity at the 150m height which requires large wind turbines installation with

latest technological upgradation. The advanced technology and infrastructure development brings additional cost for the new wind mill installations.

The heavy reliance on coal exacerbates the challenge, particularly due to the informal workforce dependent on this sector. As the state aims to enhance its renewable energy portfolio, the transition poses risks of job losses and economic displacement for workers in the coal industry. Seasonal variations in electricity demand, particularly higher loads, complicate the resource adequacy challenge, further necessitating a diversified energy mix. The absence of sufficient strategic investment in renewable energy projects limits the state's ability to tap into its considerable potential for solar and wind energy. The existing energy infrastructure is largely outdated, which hampers the integration of renewable energy sources into the grid. Insufficient transmission and distribution networks exacerbate the energy gap, which has widened from a minor deficit to a substantial negative figure in recent years. Although investments in renewable energy have increased, the state still needs significant financial resources to modernize infrastructure and technology. While the state has established various policies aimed at promoting renewable energy, bureaucratic delays and regulatory hurdles can impede project development. A cohesive and streamlined regulatory framework is essential to facilitate renewable energy projects. The transition to renewable energy also requires public awareness and acceptance. The adoption of electric vehicles (EVs) and renewable energy sources may face resistance from communities accustomed to traditional energy systems. Initiatives to educate the public about the benefits of renewable energy and EVs will be vital for successful implementation.

Recommendations and Conclusion

To ensure a successful energy transition, **Chhattisgarh must adopt a comprehensive, multi-pronged strategy** that addresses current challenges while harnessing its significant renewable energy potential. A key priority is the **diversification of the state's energy portfolio**, with targeted investments in solar, wind, and biomass energy. Given Chhattisgarh's high solar irradiance and untapped wind capacity, expanding renewable infrastructure, supported by incentives and subsidies, can substantially increase the share of clean energy in the overall mix. In particular, strengthening policies for wind energy development and offering financial support for solar installations will be critical drivers of growth.

Upgrading the state's **energy infrastructure** is equally essential. Investments in **smart grid technologies** can enhance energy efficiency, minimize transmission losses, and support the seamless integration of renewable sources. Furthermore, the deployment of **energy storage solutions** will play a vital role in stabilizing the grid by balancing fluctuations between energy supply and demand.

Public-Private Partnerships (PPPs) are vital to unlocking investment and innovation in the renewable sector. The government should establish clear regulatory frameworks and offer attractive financial incentives to encourage private sector participation in renewable energy development.

In addition, **public awareness and education campaigns** are necessary to build community support and encourage the adoption of renewable energy technologies and electric vehicles. By promoting the benefits of clean energy and sustainable practices, these initiatives can foster a culture of environmental responsibility and local engagement.

A **strategic, long-term energy policy** that aligns with national climate targets while addressing state-specific needs will be essential for a resilient and inclusive transition. By focusing on renewable energy expansion and improved energy efficiency, Chhattisgarh can not only meet its climate commitments but also stimulate **economic development**, generate employment, and enhance **energy access and environmental quality** for its citizens.

In conclusion, while the road ahead presents significant challenges, **Chhattisgarh has the resources and potential to lead a successful energy transition**. Through coordinated efforts in policy, investment, technology, and public engagement, the state can pave the way for a cleaner, more sustainable, and prosperous energy future.

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राष्ट्रीय विज्ञान शिक्षा एवं अनुसंधान संस्थान
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