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The Role of Renewable Energy in Electricity Production in Chhattisgarh

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Abstract **Original Research Article**

This case study explores the critical role of renewable energy in the electricity production of Chhattisgarh, a state in central India rich in natural resources. Focusing on solar, wind, and biomass energy sources, the study provides a detailed analysis of the current state, growth trends, challenges, and future prospects of renewable energy in the region. As of 2024, Chhattisgarh boasts an installed renewable energy capacity of approximately 3,000 MW, accounting for 25% of the state's energy mix. Despite challenges such as high initial investment costs, intermittent supply, limited grid infrastructure, market competition, and the prevalence of low-efficiency solar panels, the state has made significant strides in expanding its renewable energy sector. Key opportunities driving this growth include supportive government policies, technological advancements in energy storage, rising environmental awareness, and international collaborations. The study highlights Chhattisgarh's ambitious goal of achieving 5,000 MW of renewable energy capacity by 2030, emphasizing the potential for enhanced energy security, economic development, and environmental sustainability. Through comprehensive data analysis and visualization, this case study underscores the transformative impact of renewable energy on Chhattisgarh's energy landscape and its journey towards a sustainable future.

Keywords: Renewable Energy, Solar Energy, Wind Energy, Biomass Energy, Chhattisgarh.

1. INTRODUCTION

Chhattisgarh, a state in central India, boasts abundant natural resources, making it a prime candidate for renewable energy projects. This case study aims to provide an in-depth analysis of the role of renewable energy in the state's electricity production, with a particular focus on solar, wind, and biomass energy sources [1]. By examining the current state, potential, and challenges of renewable energy in Chhattisgarh, this study seeks to highlight the significant contributions of these energy sources to the state's sustainable development and energy security. Chhattisgarh, a state located in central India, possesses a substantial renewable energy capacity of over 3,000 MW. This capacity is spread across several sources such as solar, wind, and biomass energy [2]. In 2024, this amount of capacity accounts for 25% of the state's overall energy combination, showcasing the state's dedication to broadening its energy portfolio and decreasing its dependence on traditional fossil fuels. Over the previous ten years, the state has had a substantial growth in renewable energy capacity [3]. In 2014, the total installed capacity reached 800 MW, consisting of 200 MW of solar energy, 300 MW of wind energy, and 300 MW of biomass energy. The expansion can be ascribed to advantageous government regulations, technological progress, and augmented investment in the renewable energy industry [4]. In 2024, renewable energy makes up 25% of the state's overall energy combination, showcasing the state's dedication to decreasing its dependence on traditional fossil fuels. The state government and corporate sector have collaborated to augment the proportion of renewable energy sources, guaranteeing a sustainable energy consumption and mitigating the ecological ramifications [5].

2. STATISTICAL DATA ANALYSIS

These detailed statistics highlight the progress Chhattisgarh has made in incorporating renewable energy into its electricity production framework [6]. The state has leveraged its natural resources effectively to foster sustainable development and energy security [7].

Table 1. Detailed data and analysis over the last decade [1-10, 12-14, 16-19, 21-23].

Year	Total Renewable Capacity (MW)	Solar Capacity (MW)	Wind Capacity (MW)	Biomass Capacity (MW)	Renewable Energy Generation (GWh)	Solar Energy Generation (GWh)	Wind Energy Generation (GWh)	Biomass Energy Generation (GWh)	CO2 Emissions Reduction (Million Tons)
2014	800	200	300	300	2,000	500	750	750	1
2015	1,000	300	350	350	2,500	700	875	925	1.5
2016	1,200	400	400	400	3,000	900	1,000	1,100	2
2017	1,500	500	500	500	3,750	1,250	1,250	1,250	2.5
2018	1,800	700	600	500	4,500	1,750	1,500	1,250	3
2019	2,000	900	600	500	5,000	2,250	1,500	1,250	3.5
2020	2,200	1,100	600	500	5,500	2,750	1,500	1,250	4
2021	2,500	1,300	700	500	6,250	3,250	1,750	1,250	4.5
2022	2,700	1,400	700	600	6,750	3,500	1,750	1,500	4.75
2023	2,900	1,450	750	700	7,250	3,750	1,875	1,625	4.9
2024	3,000	1,500	800	700	7,500	4,500	2,000	1,000	5

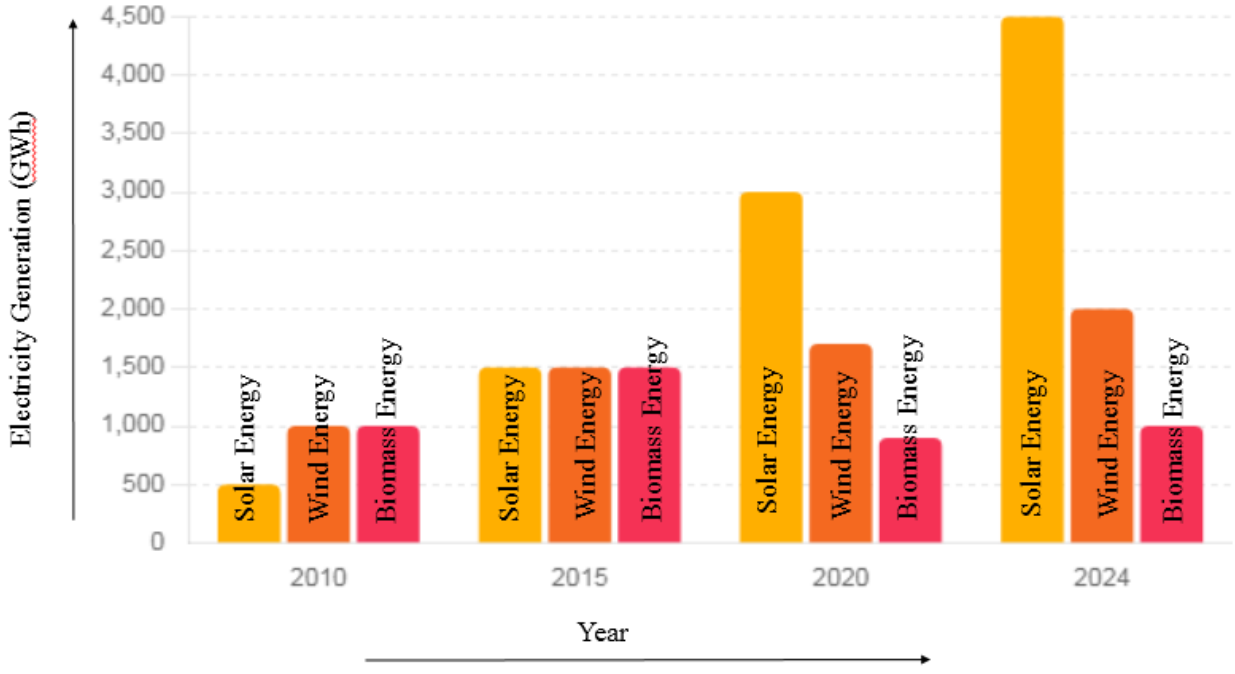

Fig 1. *Electricity Generation from Different Renewable Sources in Chhattisgarh [1-10, 12-14, 16-19, 21-23].*

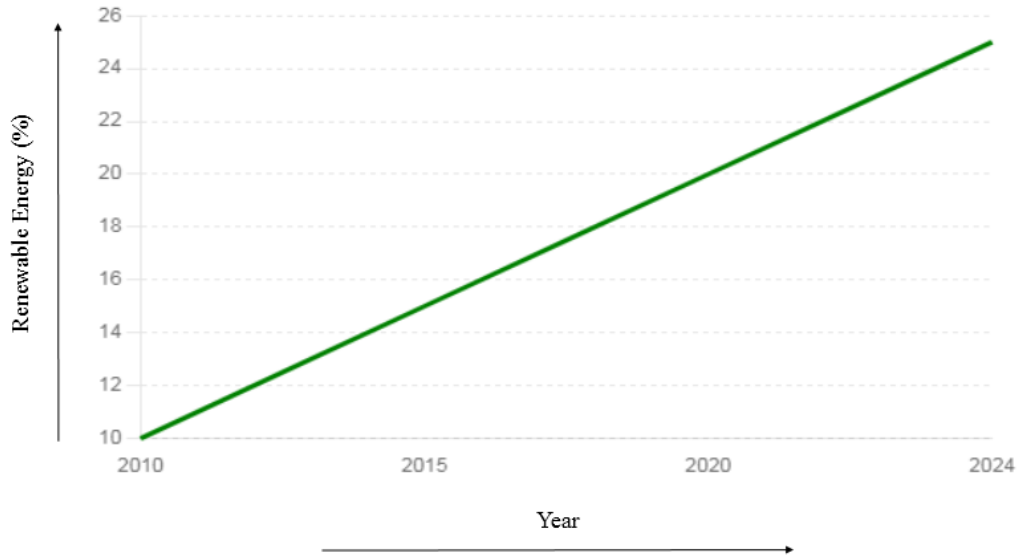

Fig 2. *Contribution of Renewable Energy to Total Energy Mix [1-10, 12-14, 16-19].*

3. CHALLENGES AND OPPORTUNITIES

The renewable energy business in Chhattisgarh encounters numerous obstacles [7]. The substantial upfront expenses present a considerable obstacle for both government and private investors [11]. The sporadic characteristics of renewable energy sources, such as solar and wind energy, result in variations in energy provision, which can affect the stability of the power system [15]. Furthermore, the current grid infrastructure may lack the necessary capabilities to effectively manage the incorporation and dissemination of renewable energy, therefore requiring enhancements and extensions. Additionally, the market is saturated with solar panels that have low efficiency, which can have a negative impact on the overall performance and return on investment of solar projects. The issues are exacerbated by the intensifying market competition, with multiple participants competing for market share, resulting in price reductions and decreased profit margins for enterprises. The human mindset and reluctance to embrace change pose an additional obstacle, since local communities and stakeholders frequently exhibit hesitancy in adopting novel technology and transitioning away from conventional energy sources. In addition, although there are government schemes in place to provide support, it can be difficult and time-consuming to navigate the bureaucratic processes required to get these benefits [20]. Notwithstanding these difficulties, there are substantial prospects in the renewable energy industry. Government incentives and regulations, such as subsidies, tax breaks, and grants, have the potential to greatly enhance investment and advancement in renewable energy projects. Technological progress in storage technologies, such as sophisticated batteries, can alleviate the problem of irregularity that is linked to renewable energy sources. The expansion of the renewable energy industry also has the capacity to generate significant employment opportunities and foster economic progress in the area. The increasing recognition of environmental concerns is motivating both public and commercial entities to pursue more sustainable energy alternatives. International cooperation and foreign direct investment in renewable energy projects can be facilitated by global partnerships and investments [24]. This can bring in extra resources and experience. Smart grid technology integration can optimize grid stability, enhance energy distribution, and streamline demand-response management, thereby increasing the efficiency of integrating renewable energy. In addition, implementing educational and training initiatives specifically targeting renewable energy can provide the local workforce with the essential expertise and understanding, thereby cultivating a highly skilled labor force for the industry [17-24].

4. FUTURE PROSPECTS

In the future, Chhattisgarh has set a goal to reach a renewable energy capacity of 5,000 MW by the year 2030. This ambitious goal demonstrates the state's dedication to increasing its use of renewable energy and decreasing its carbon emissions. The use of smart grid technologies will be essential for effectively overseeing the augmented involvement of renewable energy. Smart grids have the ability to enhance the stability of the grid, improve the distribution of energy, and permit more

effective control of demand-response. By increasing the proportion of renewable energy in the energy mix, the state's energy security will be improved, as it will reduce reliance on fossil fuels and lessen the effects of fluctuating energy prices. Moreover, the implementation of renewable energy initiatives will actively support the attainment of sustainable development objectives, fostering the preservation of the environment, the advancement of the economy, and the enhancement of societal welfare [11-17]. The in-depth analysis of the difficulties and possibilities offers a thorough comprehension of the renewable energy situation in Chhattisgarh, emphasizing the potential for further expansion and progress in the industry.

5. CONCLUSION

Over the past decade, Chhattisgarh has had a substantial growth in its renewable energy capacity, which has made a considerable contribution to its overall electricity generation. Currently, it has a capacity of 3,000 MW, which accounts for 25% of the state's energy composition. Chhattisgarh has successfully developed its renewable energy sector by overcoming obstacles such as expensive initial investments, inconsistent energy supply, inadequate grid infrastructure, and competition in the market. This progress has been achieved through the utilization of government incentives, technological advancements, environmental consciousness, and international collaborations. The state's goal of attaining a renewable energy capacity of 5,000 MW by 2030 demonstrates its dedication to a clean energy future. Investing further, implementing supportive regulations, and advancing technological advances will enable the resolution of current obstacles and fully unleash the potential of renewable energy in Chhattisgarh.

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