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INDUSTRY OUTLOOK

NAVIGATING THE FUTURE: INDIA'S RENEWABLE ENERGY INDUSTRY OUTLOOK

02 February 2024

'Climate change is more than statistics, it's more than data points. It's more than net-zero targets. It's about the people, it's about the people who are being impacted right now'. ~Vanessa Nakate

Introduction

India's power sector has undergone a remarkable transformation, aimed at providing reliable, affordable, and sustainable energy to its people. Over the last nine years, significant strides have been taken in enhancing power generation capacity, expanding access to electricity, promoting renewable energy, and implementing innovative policies. The country's commitment to renewable energy sources has played a pivotal role in achieving milestones in the power sector.

The remarkable growth of solar and wind energy capacity has cemented India's position as a global leader in renewable energy adoption. Today, India stands 4th globally in Renewable Energy Installed Capacity, with 43 per cent of its total installed electricity capacity coming from non-fossil energy sources (as of July 2023).

India is the fourth largest renewable energy market in the world, with ranks of four in renewable energy installed capacity (including large hydro), wind power capacity, and solar power capacity, according to the REN21 Renewables 2022 Global Status Report.[1]

Between 2005 and 2022, per capita electricity consumption in India doubled from 631 units to 1255 units, making it the third largest electricity market in the world. India is the only G20 nation on track to achieve the targets of the Paris Agreement, which came into effect on November 4, 2016, after 55 countries representing at least 55 per cent of global emissions met the minimum threshold. The Paris Agreement aims to contain global temperature increases well below 2°C, and if possible 1.5°C, compared to pre-industrial levels.[2]

Market Size and Growth of Renewable Energy in India

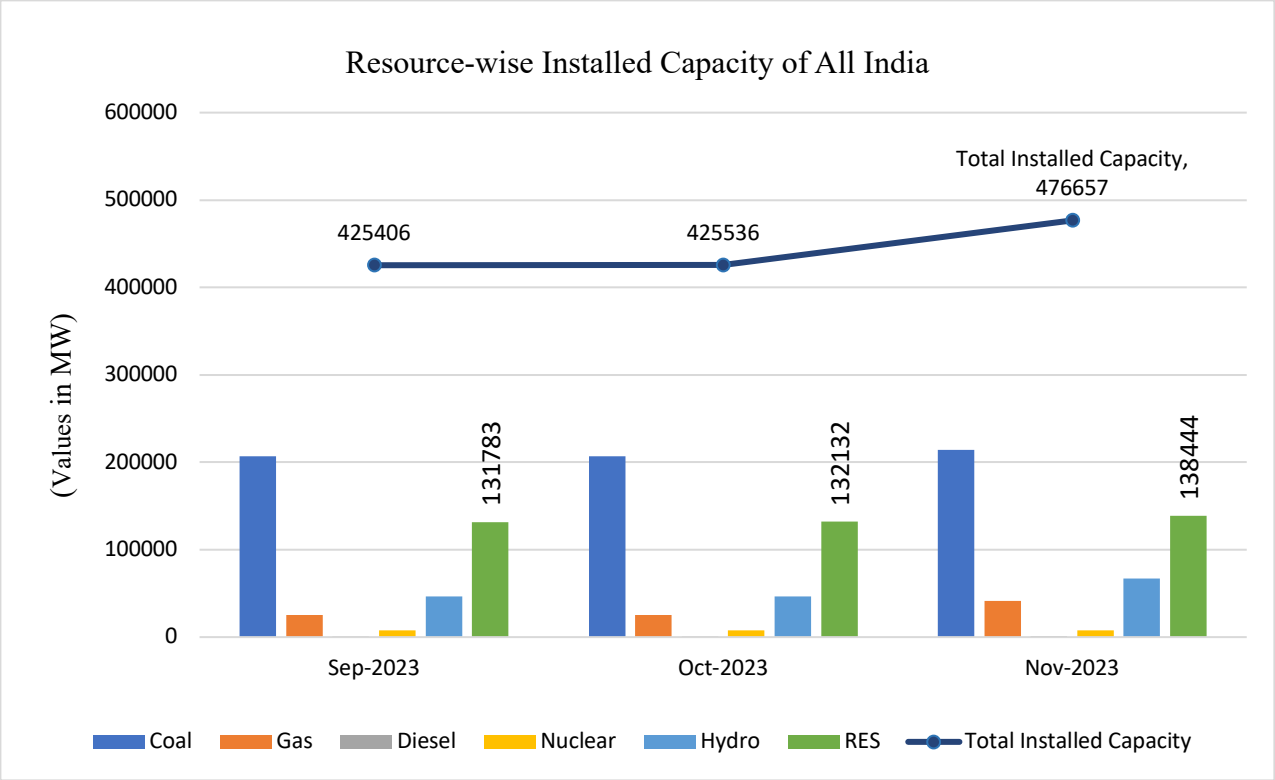
India's ambitious target of achieving 500 GW of renewable energy capacity by 2030 as part of its commitment under the Paris accord has been partially met with renewable energy capacity reaching over 170 GW in 2023.

The sources of renewable energy in India are small hydro power, wind power, biomass-based electricity, and solar power. Data for renewable power generation is available starting from the fiscal year 2015-16. Over this period, there is a clear increase in electricity generation from these sources, demonstrating the growth of renewable energy in India. India's installed non-fossil fuel capacity increased 396 per cent in the last 8.5 years and stands at more than 179.322 Giga Watts (including large Hydro and nuclear). India saw the highest year-on-year growth in renewable energy additions of 9.83 per cent in 2022.The installed solar energy capacity has increased by 24.4 times in the last 9 years and stands at 67.07 GW as of July 2023. The installed Renewable energy capacity (including large hydro) has increased by around 128 per cent since 2014.[3]

Installed Capacity

During the period from September to November 2023, India exhibited a steady increase in the installed capacity of renewable energy sources, marking a significant contribution to the overall power generation landscape. In September, the installed capacity of renewable energy sources stood at 131,783 MW, constituting approximately 31 per cent of the total installed capacity, which was 425,406 MW. October witnessed a marginal rise, reaching 132,132 MW, while the overall installed capacity of power slightly increased to 425,536 MW. In November 2023, a significant surge in renewable energy capacity can be witnessed, reaching 138,444 MW, indicating a consistent growth trend. Despite this commendable rise in renewable energy, it still represents around 29 per cent of the total installed capacity, which concurrently increased to 476,657 MW. The data emphasizes a positive trajectory for renewable energy, but there remains ample room for further expansion to enhance the share of sustainable sources in India's power generation mix (see Chart 1).

Chart 1: Installed Capacity of Renewable Sources in India from September to November 2023.



Source: Dashboard, CEA, Ministry of Power, GoI.

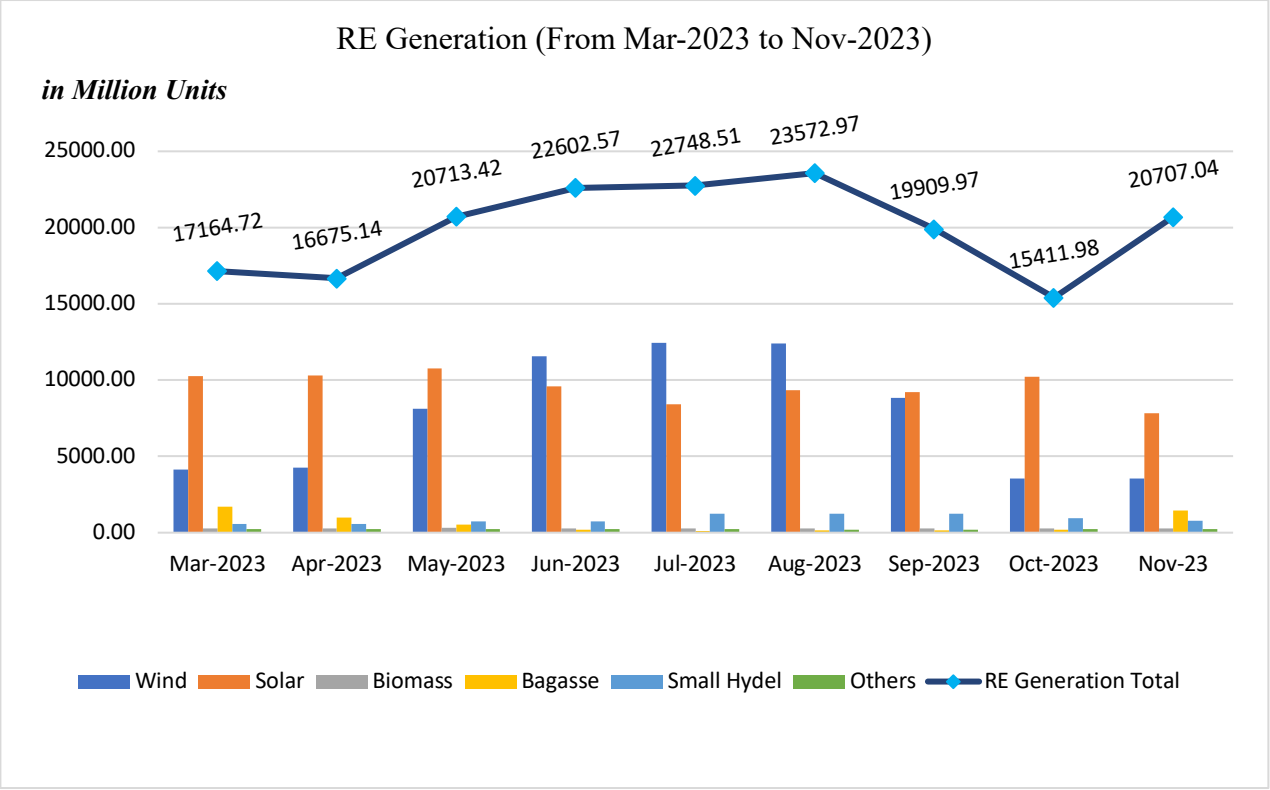
Renewable Energy Generation

Monthly Trend

The monthly trend of renewable energy generation in India steadily reveals a dynamic mix of renewable sources, demonstrating the country's commitment to a multifaceted approach in achieving sustainable energy goals.

From March to November 2023, India witnessed a substantial contribution to its renewable energy generation from various sources. Wind energy consistently played a significant role, ranging from 3544.27 MW in November to 12449.42 MW in July. Solar energy demonstrated a steady increase, peaking at 10776.14 MW in May. Biomass and bagasse contributed consistently, with biomass ranging from 257.34 MW in August to 317.04 MW in May, and bagasse ranging from 1000.32 MW in April to 1683.65 MW in March. Small hydel power maintained a relatively stable contribution, while other sources collectively added to the overall renewable energy generation. In November, the total renewable energy generation reached 20707.04 MW, reflecting a diverse and growing portfolio in India's pursuit of sustainable energy (see Chart 2).

Chart 2: Renewable Energy Generation Monthly Trend from March to October 2023

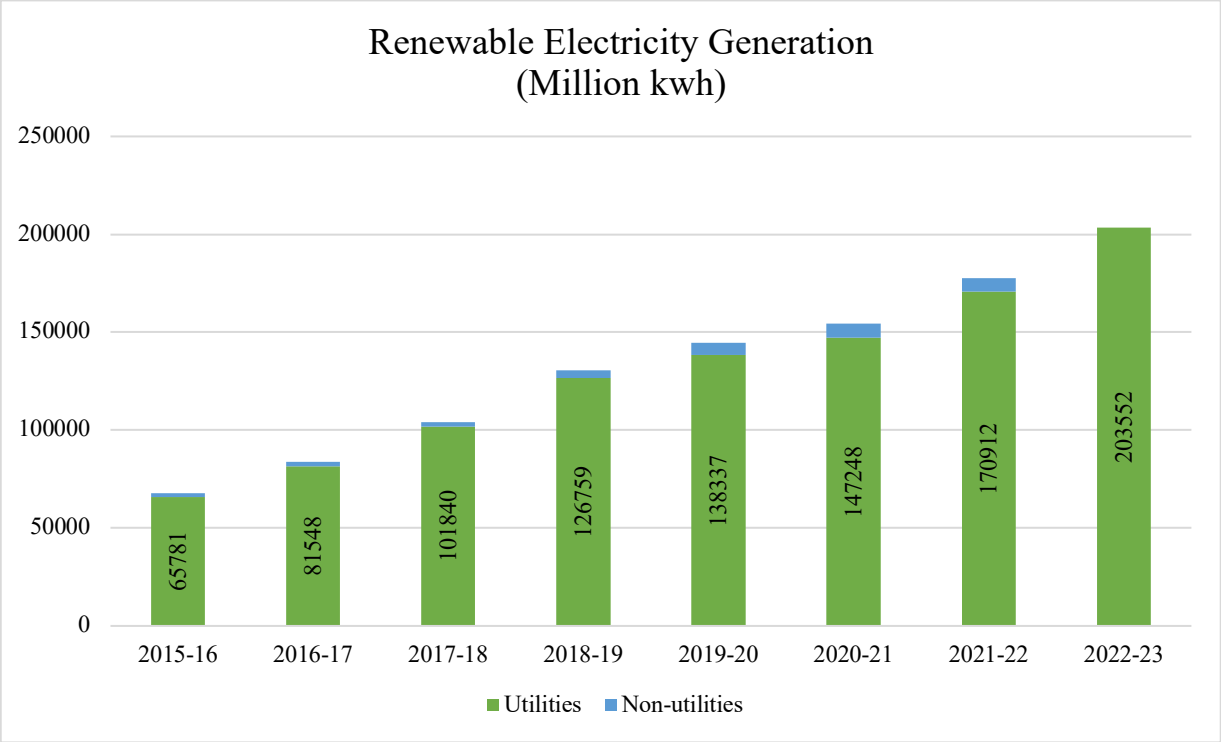


Source: Dashboard, CEA, Ministry of Power, GoI. | Infomerics Economic Research

Annual Trend

India's renewable energy journey in the last nine years has been a remarkable story of growth and ambition. The ambitious targets, coupled with the government's commitment and strong support from the private sector, make India a promising leader in the global transition to clean energy. In the utilities segment, the renewable energy generation has shown a consistent upward trend, increasing from 65,781 KWh in 2015-16 to 170,912 KWh in 2021-22. Further, non-utilities renewable energy generation has also witnessed substantial growth, rising from 2,046.10 KWh in 2015-16 to 6,813.00 KWh in 2021-22 (see Chart 3).

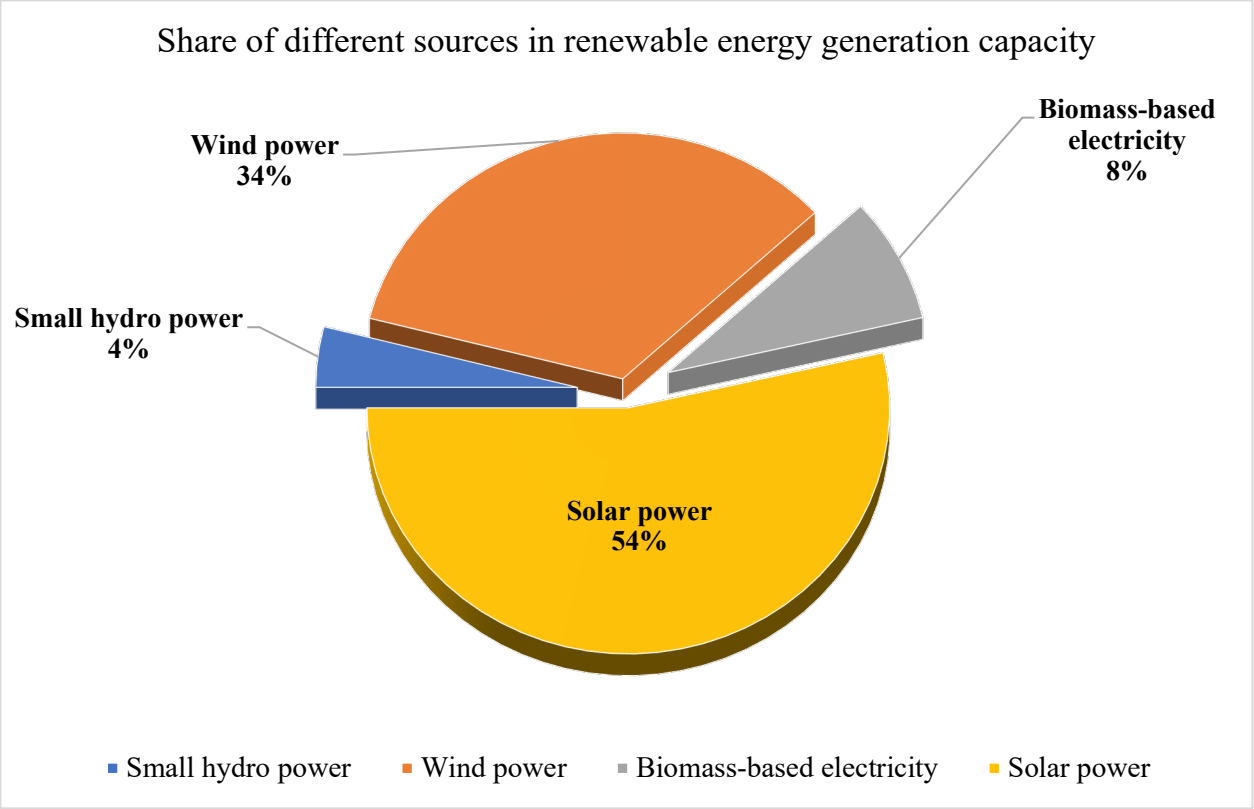
Chart 3: Renewable Electricity Generation: Utilities and Non-utilities



Source: CMIE | Infomerics Economic Research

In the fiscal year 2015-16, renewable electricity accounted for only 5.5 per cent of the total electricity generated, but by the fiscal year 2022-23, it had expanded to 12.5 per cent of the total generation. The compound annual growth rate (CAGR) for renewable electricity generation during this period was a robust 17.5 per cent.[4] When examining the segment-wise breakdown of renewable electricity generation capacity, solar power holds the largest share of the total generation in 2023, followed by wind power, biomass-based electricity, and small hydro power (see Chart 4).

Chart 4: Share of various sources in Renewable Energy generation Capacity Mix in 2023



Source: CMIE | Infomerics Economic Research

In 2022-23, solar power accounts for the largest share at 53.36 per cent, indicating a substantial focus on solar energy development. Wind power follows with a significant share of 34.06 per cent, showing a substantial presence in the renewable energy mix. Small hydro power and biomass-based electricity contribute 3.95 per cent and 8.19 per cent, respectively, to the overall renewable energy generation capacity, demonstrating their relatively smaller but still valuable roles in the country's renewable energy landscape.

State-wise Renewable Electricity Generation

The states with the highest renewable electricity generation are Tamil Nadu, Karnataka, and Gujarat. Tamil Nadu generated over 27,626.5 million Kwh of renewable electricity in 2022-23, Karnataka generated over 29,575.4 million Kwh, and Gujarat generated over 29,762.6 million Kwh. These states have all made significant investments in renewable energy, and they have also benefited from favourable geographical conditions, such as strong sunshine and wind resources (see Table 1).

Table 1: State-wise Renewable Electricity Generation: Utilities

(*in million Kwh*)

Year	2018-19	2019-20	2020-21	2021-22	2022-23
Karnataka	21,657.50	25,648.40	27,850.30	28,634.30	29,575.40
Maharashtra	14,974.90	13,985.80	14,232.50	15,845.70	17,206.60
Tamil Nadu	16,898.50	19,763.90	21,659.00	24,061.30	27,626.50
Andhra Pradesh	14,550.50	13,993.20	14,133.80	15,662.60	16,411.90
Uttar Pradesh	5,694.80	5,143.20	5,747.80	6,328.90	7,217.20
Gujarat	13,976.90	17,716.90	17,977.00	24,839.50	29,762.60
Rajasthan	11,863.40	14,332.10	16,516.40	24,099.30	40,990.10
Telangana	7,046.00	6,794.20	6,933.10	7,345.90	7,429.90
Madhya Pradesh	8,246.50	8,297.90	8,517.90	8,716.70	8,872.70
Punjab	2,445.20	2,739.40	2,864.50	3,242.20	4,169.60
West Bengal	1,486.20	1,475.00	1,530.70	1,845.10	1,959.10
Uttarakhand	1,105.00	1,194.00	1,236.90	872.3	933.7
Chhattisgarh	945.1	1,107.90	1,633.90	1,938.20	2,003.10
Bihar	488.1	358.7	226.6	239.8	288.9
Kerala	770.3	804.8	1,092.10	1,614.60	1,946.30
Himachal Pradesh	2,287.90	2,167.20	2,160.30	2,043.80	2,913.00
Haryana	662.4	733.5	760.8	1,135.40	1,419.70
Odisha	653.5	783.2	877.8	1,081.10	1,192.10
NCT of Delhi	287.7	423.7	426.7	458.7	530.2
Jammu & Kashmir	312.2		439.3	415.8	393.2
Meghalaya	50.5	62.7	56.8	44.7	71.6
Nagaland	87.5	75.9	70.8	63.5	112
Tripura	82.1	28.1	15.6	7.6	6.6
Mizoram	40.1	50	33.5	28.1	62.3
Jharkhand	19.1	22.9	24.5	28.7	19.7
Daman & Diu	18.9	21.8	40	47.7	
Assam	20.7	58.8	51.5	122.1	279
Andaman & Nicobar	30.4	17.3	41.5	34.8	37.9
Chandigarh	13.5	13.3	10.2	14.2	12.6
Sikkim	28.1	60.6	56	12.4	12.4
Multi States	2.6	0	0	0	
Dadra & Nagar Haveli	5.8	6.2	12	49.2	
Lakshadweep	1.1	0.7	0.5	0.3	0.1
Puducherry	2.6	4.2	6.4	12.2	12.2
Arunachal Pradesh	1.8	2.2	2.1	2.1	24.9
Manipur	1.9	4.2	7.7	6.7	8.8

Source: CEA | Infomerics Economic Research

The states with the lowest renewable electricity generation are Tripura, Mizoram, and Jharkhand. Tripura generated just 6.6 million Kwh of renewable electricity in 2022-23, Mizoram generated just 62.3 million Kwh, and Jharkhand generated just 19.7 million Kwh. These states have all faced challenges in developing renewable energy, such as limited financial resources, lack of infrastructure, and regulatory hurdles.

Global Market for Renewable Energy

Global renewable capacity additions are set to soar by 107 gigawatts (GW), the largest absolute increase ever, to more than 440 GW in 2023. This is equivalent of more than the entire installed power capacity of Germany and Spain combined. This unprecedented growth is being driven by expanding policy support, growing energy security concerns, and improving competitiveness against fossil fuel alternatives. These factors are rising interest rates, higher investment costs and persistent supply chain challenges.[5]

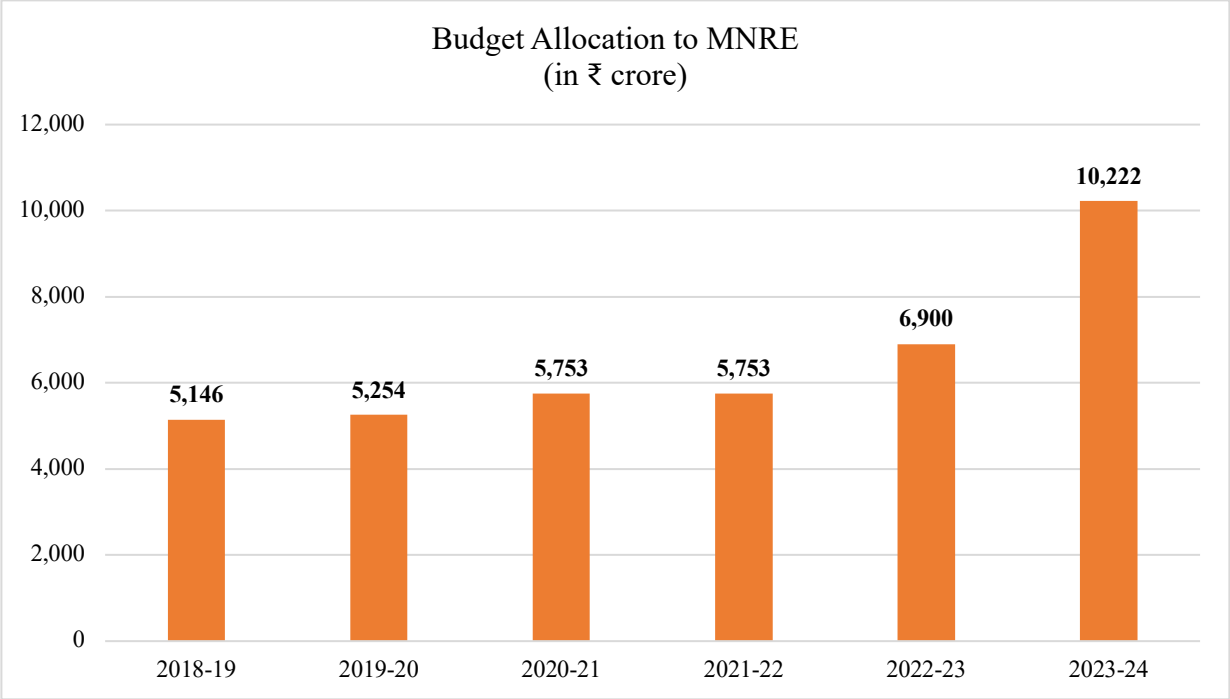
Renewable energy companies, spanning wind, solar, hydrogen, hydro, and ethanol, are expected to sustain their growth momentum in 2024 following a successful 2023. Anticipating robust capacity additions in the renewable energy sector, various entities within the value chain, including engineering firms, solar panel manufacturers, and logistics companies, are poised to benefit from the slew of initiatives now underway. Projections suggest a significant increase in renewable energy capacity in India, with an estimated investment of ₹137,500 crore (approximately USD 16.5 billion) in 2024, surpassing the figures of 2023.[6] Solar energy will continue to be a focal point, while wind power is poised for a comeback. The emphasis on green hydrogen, supported by the Green Hydrogen Mission, adds another dimension to the sector's growth. Consistent policies at both central and state levels contribute to a positive outlook, promising strong auctions and sustained expansion in the renewable energy sector.

Institutional Initiatives

The government is proactively promoting the use of renewable energy sources in the country. In this regard, several flagship missions and programmes have been launched so far. The National Solar Mission, one of the flagship missions of the central government, was launched in 2010 with an objective of installing 100 GW of solar power by 2022, later which has been extended to produce 450 GW by 2030.[7]

The Central government allocated ₹10,222 crore to the Ministry of New and Renewable Energy in the Union Budget 2023-24, marking an increase from the previous allocations (see Chart 5).

Chart 5: Union Budget Allocations to the Ministry of New and Renewable in the last six years



Source: India Budget, https://www.indiabudget.gov.in/doc/eb/sbe71.pdf

Climate action and sustainability have gained prominence globally and within the country, with government emphasizing green initiatives. During the Union Budget speech, the Minister of Finance outlined the Green Hydrogen Mission, aiming for an annual production of 5 MMT by 2030. Also, an additional amount of ₹5,331.5 crore has been allocated for the solar power sector, witnessing a significant increase. The National Hydrogen Mission and solar energy projects, including the PM-KUSUM scheme, received attention. The government's focus on renewable energy includes plans for over 65 per cent power generation from non-fossil fuels by 2030. The Budget also addressed funding for hydro power and the National Institute of Solar Energy. While green bonds were emphasized, no specific target was set in the Budget, but recent sovereign green bond auctions underscored government commitment to environmentally sustainable projects.[8]

The Government of India has been actively promoting the use of various forms of renewable energy to achieve the goal of 50 per cent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030. In pursuit of this objective, the Ministry of Power, in consultation with the Ministry of New and Renewable Energy (MNRE), has issued an advisory stating that the states must fulfil a certain percentage of their energy consumption from sources such as Wind, Hydro, or Other Renewable Power. They have prescribed the Renewable Purchase Obligations (RPOs) for the states, applicable from 2022-23 to 2029-30.[9]

In 2023, India implemented crucial policy initiatives to enhance its renewable energy sector. These initiatives included a structured annual bidding trajectory of 50 GW, a Renewable Purchase Obligation trajectory until 2030, and the introduction of a Uniform Renewable Energy Tariff. The establishment of Ultra Mega Renewable Energy Parks facilitated development, and infrastructure enhancements involved laying new transmission lines, along with waiving ISTS (Inter-State Transmission Charges) charges for

solar and wind power. A Production Linked Incentive Scheme aimed at boosting local manufacturing, coupled with the launch of the National Green Hydrogen Mission, aimed to position India as a global hub. State-level policies in Gujarat and Rajasthan targeted significant investments and ambitious renewable energy capacity goals. These comprehensive measures signify India's holistic approach to drive renewable energy growth and global competitiveness. Also, improvements in technology, including higher wattage solar panels and wind turbines, were highlighted as key elements to reduce installation costs and enhance self-reliance across the supply chain.[10]

Green Bonds

Green bonds are financial instruments, such as, debt and equity that deliver both returns and environmentally positive outcomes, particularly in the light of the Paris Agreement and SDG. Green bonds are based on use of projects, project evaluation and selection, management of proceeds and reporting. Given that most growth in developing regions stems from non-green, traditional, carbon-intensive activities, the aspect of ESG issuance must acquire center-stage in developing countries[11][12][13][14][15] (AIIB, 2014; Alexander, 2014; Banga, 2018; Berensmann, et al 2016; Economist 2020). This is, however, a work in progress and this innovative modality has yet to gain a fair measure of consensus across the development spectrum. The world needs an '*absolute transformation*' of the global financial system to reach net-zero emissions and to help developing countries deal with the impact of the climate crisis in an equitable and sustainable manner.

Table 2: Yearly Green Bond Volume by Currency (US$)

Year	Total Green Bond Volume (USD billion)	Europe	US	China
2007	0.807	0.807	-	-
2008	0.414	-	-	-
2009	0.909	-	0.48	-
2010	4.3	0.003	0.29	-
2011	1.3	0.051	0.665	-
2012	3.5	0.748	0.585	-
2013	11.3	4.3	5.3	-
2014	36.8	16.8	11.2	0.208
2015	44.5	15.0	22.5	0.095
2016	84.5	20.6	38.0	17.7
2017	158.0	56.1	71.2	15.6
2018	171.2	66.4	55.3	22.0
2019	258.9	108.0	82.4	19.9

Source: Climate Bond Initiative

Table 3: Yearly Green Bond Volume Issued in Asia (in million USD)

	2015	2016	2017	2018	2019
China	1,295	21,211	22,245	31,030	31,400
Hong Kong (China)	0	1,206	618	2,692	2,550
India	1,151	1,570	3,804	700	3,073
Indonesia	0	0	0	1,975	750
Japan	840	1,098	3,338	4,174	7,216
Malaysia	0	0	755	223	660
Philippines	0	226	150	150	1,498
Singapore	0	0	571	1,341	2,649
South Korea	0	900	650	2,077	3,576
Taiwan	0	0	172	447	1,018
Thailand	0	0	0	213	734
Vietnam	0	27	0	0	0

Source: Moody's

Simply kicking the can down the road with the myopic view that climate-related and environmental (C&E) risks are immaterial is neither valid nor acceptable. Banks must clearly make C&E risks an integral part of their governance, strategy and risk management[16] .

Carbon Pricing

The world faces multiple challenges of sustainable development in general and climate change in particular. Of late, carbon pricing has emerged as an important instrument of addressing these challenges with pricing mechanisms now in place in at least 70 national and subnational jurisdictions. However, carbon pricing alone is grossly inadequate to significantly slash carbon emissions despite its widespread growth and adoption. We need to put a price on carbon, to incentivize polluters to invest in these solutions. But pricing carbon requires policy change.

In view of the fact that this is a new and evolving area, we need to examine how successful implementations of carbon pricing have encouraged a reduction in carbon emissions, where carbon pricing has been inadequate and why policies that target the supply of carbon emissions have become imperative and the interplay between the voluntary carbon markets and corporate decarbonization, government regulation, and compliance markets. While pricing carbon emissions and creating incentives for renewable energy and reduced consumption, we must ensure that we are not oblivious to the needs of marginalized communities, particularly vulnerable to climate impacts.

Box 8.1: The Impacts of Energy Transition

A recent BIS paper 'The energy transition and its macroeconomic effects' (Americo et al, 2023):

- assesses the evolution of clean technology (mainly wind, solar, electric vehicles),
- inventorizes the challenges and opportunities the transition poses for fossil fuel, metals and minerals producers in the short and long term,
- describes the likely macroeconomic consequences of the energy transition, and identifies the countries that are most positively or negatively exposed.

Broad, Qualitative Overview of the Energy Transition

In order to draft a view of how the transition may evolve in the future, the paper:

- brings together research from a variety of disciplines (economics, finance, energy systems, environmental science), and
- aims both to complement quantitative macroeconomic scenarios (e.g., NGFS) and to give a more targeted, sector-specific description. Consequently, it may also inspire future research that more narrowly focuses on specific aspects (e.g., quantifying the effects on inflation, trade flows, financial flows).

Main Conclusions

1. ***Unequal impacts on various countries***

Although fossil fuel producing regions will suffer from the transition, most of the world will benefit from the lower, less volatile energy prices and reduced air pollution, and metals and minerals producers will enjoy an important increase in demand for their products.

2. ***Preparation is urgently needed***

All countries should immediately start building resiliency and making the appropriate preparations in order to get prepared to the wide range of possible transition paths.

- Fossil fuel exporters: building buffers, implementing structural reforms needed to manage the long-term decline of their primary industries (e.g., transitioning to a less volatile tax base or to market-based exchange rates).
- Fossil fuel importers: introducing structural reforms by reducing the regulatory and/or financial barriers, thereby protecting themselves against volatile global energy markets, enhancing domestic energy security, improving public health.
- Metals and minerals producers: reforming their budgeting practices to mitigate increased exposure to volatile commodity prices, taking measures to reduce potential labour market displacement from higher exchange rates, modernizing mining regulations to ensure that

economic development does not come at the cost of environmental sustainability.

3. ***No one should be left behind***

The provision of accessible low-cost financing and technical assistance needs to accelerate, in order to provide support where most needed.

Reference:

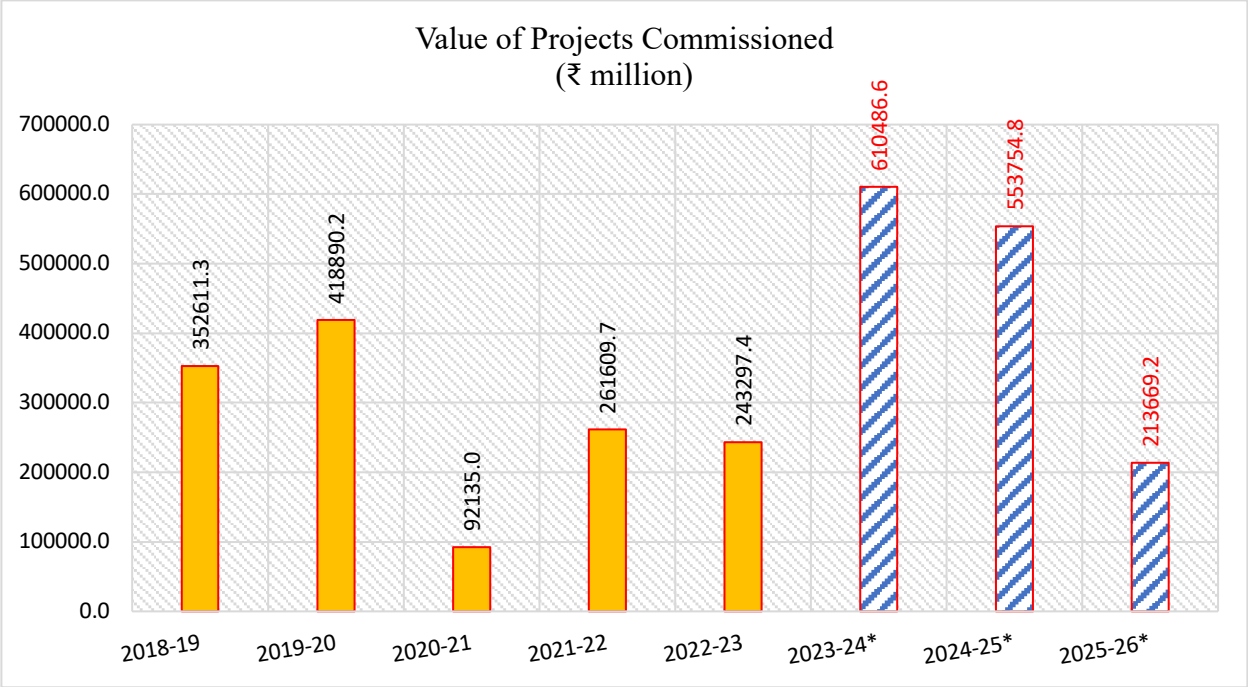
Alberto Americo, Jesse Johal and Christian Upper (2023). 'The energy transition and its macroeconomic effects'. *BIS Papers No 135*

Investment Trend

The renewable electricity industry in India has witnessed substantial growth in investment, particularly following the country's commitment to the Paris Climate Agreement in 2015. With a focus on reducing fossil fuel consumption and carbon emissions, India pledged to achieve 175 GW of renewable energy capacity by the end of 2022, encompassing 100 GW of solar energy, 60 GW of wind energy, 10 GW of biomass power, and 5 GW of small hydropower. India aims to further increase the installed green power generation capacity to 450 GW by 2030, with a breakdown of 280 GW in solar and 140 GW in wind power capacity.

The data on the Value of Projects Commissioned (in ₹ million) in India reveals significant fluctuations over the years. In the fiscal year 2018-19, the value of project commissioned stood at ₹352,611.3 million, experiencing a noticeable increase to ₹418,890.2 million in 2019-20. However, a substantial decline occurred in 2020-21, with the value plummeting to ₹92,135.0 million. The subsequent years witnessed a recovery, as the value rose to ₹261,609.7 million in 2021-22 and ₹243,297.4 million in 2022-23 (see Chart 6)

Chart 6: Projects Commissioned and the Forecasts



*Forecast
Source: CMIE | Infomerics Economic Research

As per the Ministry of Power and the Ministry of New & Renewable Energy, India is set to experience an over 83 per cent surge in renewable energy (RE) investments, reaching approximately $16.5 billion in 2024. This increase aligns with the nation's commitment to achieving 500 GW of renewable energy by 2030 and reducing fossil fuel-based power generation capacity to less than 50 per cent. India has also pledged to achieve net zero emissions by 2070.[17] Synchronized efforts with a sense of urgency by all stake-holders could help India to surpass the 2030 target, aiming at 65 per cent of power generation capacity to be derived from non-fossil fuels.

Risks and Challenges

The Indian renewable energy industry has experienced notable growth, but its advancement is impeded by several key challenges. Policy and regulatory instability, marked by frequent changes, delays in project approvals, and unclear guidelines, create uncertainty for investors. Financial constraints, including high financing costs, limited long-term funding options, and dependence on imported equipment, pose hurdles for project viability. Grid integration and infrastructure bottlenecks, such as inadequate transmission infrastructure, high transmission charges, and a lack of energy storage solutions, hinder the sector's competitiveness.

Other challenges include competition from subsidized fossil fuels, a shortage of skilled manpower, and the need for enhanced public awareness. Despite these obstacles, the industry displays resilience and innovation, with government initiatives and collaborative efforts addressing issues like grid integration and local manufacturing. With sustained efforts to overcome these challenges, India's renewable energy sector holds the potential to achieve its ambitious goals and emerge as a global leader in the clean energy transition.

India’s renewable capacity additions are expected to increase again in 2023 and 2024, owing to faster onshore wind, hydropower and distributed solar PV deployment. The utility-scale solar PV projects, India’s largest renewable electricity growth segment, are expected to briefly slow this year due to supply chain challenges, lower auction volumes and trade policies. While large-scale PV manufacturing is emerging in India, import tariffs are causing short-term demand and supply mismatches.[18]

The lack of required infrastructure is one of the major hurdles of the renewable energy sector. Most of the available infrastructure is suitable to produce fossil-based and thermal-based fuels. Also, most of the electric transmission and distribution lines were developed long back, and therefore, need to be renovated and reconstructed in conformity with the emerging sources of energy in power generation system.

The lack of power storage is another risk because power generation through solar energy is possible only in daytime while the peak demand of power is mostly in night. Also, there might be inconsistency in power generation through solar and wind energy because of unpredictable weather system. Therefore, there must be an affordable and efficient battery storage system to store up the surplus energy than can be used to meet peak hour demands.

The financial distress of India's power distribution companies (DisComs) poses a significant challenge to the country's renewable energy industry. DisComs incur heavy losses, struggle with cash flow problems, and delay payments to generators, creating a liquidity crisis across the sector. These challenges raise concerns about the long-term viability of renewable energy investments and hinder the sector's growth potential. Here are some of the specific challenges and risks associated with the financial distress of DisComs:

- Reduced investment in renewable energy: DisComs' financial difficulties make them less likely to invest in new renewable energy projects. This can lead to a slowdown in the growth of the renewable energy sector.
- Increased risk of project failure: Renewable energy projects are often financed by loans from DisComs. If DisComs are unable to repay these loans, it could lead to project failures.
- Job losses in the renewable energy sector: The financial distress of DisComs could lead to job losses in the renewable energy sector.
- Negative impact on the environment: The slowdown in the growth of the renewable energy sector could have a negative impact on the environment.

The Road Ahead

In the past decade, India's power sector has undergone a transformative journey, with a focus on delivering reliable, affordable, and sustainable energy. India’s significant achievements so far include a substantial increase in power generation capacity, widespread electricity access, and a strong commitment to renewable energy. The country has emerged as a global leader, ranking fourth in Renewable Energy Installed Capacity, showcasing a remarkable growth in solar and wind energy. India's progress aligns with its commitment to the Paris Agreement, setting ambitious targets, including 500 GW by 2030 and achieving net-zero by 2070.

Challenges, however, persist. Legacy infrastructure costs, transmission losses, coal-related issues, and the evolving grid's reliability pose hurdles in the pursuit of the avowed objectives of development. The government's efforts to address financial distress in the Distribution Companies (DisComs) are acknowledged, but a more comprehensive approach is needed to meet renewable energy targets. The success of India's energy transition hinges on consistent policy support, institutional strengthening, depoliticizing tariff setting, and supporting vulnerable communities through direct benefit transfers.

Given the enormity of the challenge, budgetary capex is required for augmenting transmission infrastructure for smart grids to manage intermittent supply. Emerging areas like green hydrogen and offshore wind would need further policy backing to achieve commercial viability [19].

The collaborative efforts of the government, private sector, research institutions, and civil society as partners in development are crucial to overcoming challenges, such as, land acquisition, grid integration, and affordability. As India stands at the forefront of the renewable energy revolution, achieving its goals requires streamlined processes, enhanced infrastructure, innovation in energy storage, and a diversified renewable energy mix. While the outlook is promising, focused actions in these areas will not only secure India's energy independence but also position it as a global leader in sustainable and clean energy. With ongoing technological advancements, increased investments, and growing public awareness, India's renewable energy landscape in 2024 is promising and would usher in a cleaner and greener future.

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