Industry Research Report

on

Renewable Energy, Green Technologies and Power-focused NBFCs

November 2023

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Table of Contents

List of Charts

List of Tables

Background & Executive Summary

CARE Analytics and Advisory Private Limited has been appointed by Indian Renewable Energy Development Agency Limited (IREDA) for providing the report titled "Industry Research Report on Renewable Energy, Green Technologies and Power-focused NBFCs" (the Report). IREDA is proposing to launch an initial public offering (IPO) and the Report shall be included in the regulatory documents to be filed with the stock exchanges for the purpose of the IPO. A brief summary of the key messages of the Report is as follows.

Government's thrust to drive installed renewable capacity share to 66% by FY32

India is the world's third-largest producer and second-largest user of energy. Power demand in the country has been on a rise in the past decade, with an exception during FY21 due to the Covid-19 pandemic. Peak energy demand grew at a CAGR of 4.7% from 148 GW in FY14 to 216 GW in FY23, while peak supply grew at a CAGR of 5.3% over the same time period. The peak deficit stood at 0.5% i.e. 7,582 MU in FY23.

The all India peak electricity demand projected is projected to reach 277 GW and energy requirement is projected at 1,908 BU in FY27, growing at a CAGR of 4.8% and 4.5%, respectively. During FY27 to FY32, energy requirement and peak demand are expected to grow at a faster CAGR of 5.3% and 5.7%, respectively.

As on September 2023, the total installed power generation capacity stood at 425 GW with renewable sources accounting for 42 % of the installed capacity. Driven by factors such as (i) government's thrust on the renewable energy sector to achieve India's climate targets – 500 GW of non-fossil fuel energy capacity by 2030, 50% of energy requirement to be met through renewable energy by 2030, reduction in carbon intensity of the economy by 45% by 2030 over 2005 levels, becoming energy independent by 2047 and achieving net zero by 2070, (ii) Benefits of renewable energy such as abundant availability of resources, lower tariffs and (iii) technological advancements in renewable power technology, the installed renewable power capacity is expected to increase to 336 GW by FY27, with solar, wind and hydro accounting for 55%, 22% and 16% of installed renewable power capacity, respectively. The installed renewable power capacity is expected to reach 595 GW by FY32 and account for 66% of the total power generation capacity. A total outlay of Rs 24.43 trillion is expected towards renewable capacity additions between FY23-FY32.

To further support reduction in emissions, the government has taken multiple initiatives to promote net zero and other technologies. The National Green Hydrogen Mission has been launched in August 2021 with an objective to make India a global hub for production, usage and export of green hydrogen and its derivatives with an outlay of Rs. 190 billion to help achieve an annual production target of 5 MMT by 2030. Further, India has set a target of 30% electric vehicle (EV) adoption by 2030, which will require a massive expansion of the EV charging infrastructure. The government has set a target of 46,397 public charging stations by 2030. With further focus on achieving a sustainable and eco-friendly transportation ecosystem, the government is taking steps to promote EV adoption, such as providing subsidies for EVs and the charging infrastructure is expected to expand rapidly in the coming years. Additionally, decarbonization measures are being implemented by all major industries including power, steel, fertilizers, cement, oil and gas etc. to contribute to the net zero target by 2070.

Governments thrust towards renewable energy presents lending opportunity to power focused NBFCs

Power sector financing NBFCs primarily focus on financing of power generation, transmission, distribution and other such activities. These NBFCs provide funds for various types of power projects, including thermal power plants, transmission lines and renewable energy projects such as solar power plants, wind farms, hydroelectric projects, bioenergy energy projects and clean energy generation.

Power financing NBFCs have seen significant traction supported by increase in demand for funds from power sector, and government's push towards growth of power sector. In FY23, the outstanding credit of key power financing NBFCs

witnessed a CAGR of nearly 10% over FY19. In FY24, power-financing NBFCs are expected to continue this growth momentum and this growth is likely to be driven by increase in power demand, rise in population, renewable integration and sustainability goals of the country. The renewable sector has been gaining significant traction over the years and power financing NBFCs have been playing a key role in funding renewable projects.

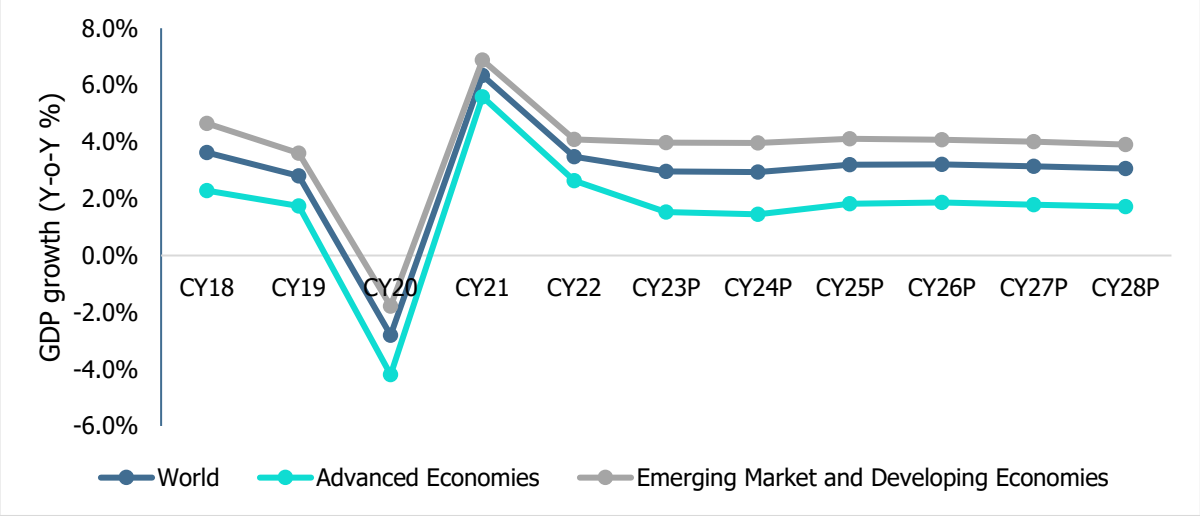
Over the years, asset quality for this set of NBFCs have seen significant improvement with gross NPAs coming down. The decline in gross NPAs is largely supported by restructuring of stressed assets, write-offs, decline in slippages and increased provisioning.

1. Economic Outlook

1.1 Global Economic Outlook

As per the International Monetary Fund (IMF)'s World Economic Outlook growth projections released in October 2023, the global economic growth for CY22[1] stood at 3.5% on a year-on-year (y-o-y) basis, down from 6.3% in CY21 due to disruptions resulting from the Russia-Ukraine conflict and higher-than-expected inflation worldwide. On the other hand, the global economic growth for CY23 is projected to slow down further to 3.0% and 2.9% in CY24, attributed to compressing global financial conditions, expectant steeper interest rate hikes by major central banks to fight inflation, and spill-over effects from the Russia-Ukraine conflict, with gas supplies from Russia to Europe expected to remain tightened. For the next 4 years, the IMF projects world economic growth in the range of 3.0%-3.2% on a y-o-y basis.

Chart 1: Global Growth Outlook Projections (Real GDP, Y-o-Y change in %)



Notes: P-Projection;
Source: IMF – World Economic Outlook, October 2023

Advanced Economies Group

The major advanced economies registered GDP growth of 2.6% in CY22, down from 5.5% in CY21, which is further projected to decline to 1.5% in CY23. This forecast of low growth reflects increased central bank interest rates to fight inflation and the impact of the Russia-Ukraine war. About 90% of advanced economies are projected to witness decline in GDP growth in CY23 compared to CY22. In addition, this is further expected to decline to 1.4% in CY24.

One of the major countries from this group is the **United States**. The United States registered GDP growth of 2.1% in CY22 compared to 5.9% in CY21. Whereas, growth for CY23 and CY24 is projected at 2.1% and 1.5%, respectively. Among advanced economies group, private consumption has been stronger in the United States than in the euro area. The business investments have also been robust in the second quarter, in addition, the general government fiscal stance of United States is expected to be expansionary in CY23. However, the unemployment rate is expected to rise coupled with declining wages and savings. With this, the GDP growth is expected to soften in near term.

Further, the **Euro Area** registered GDP growth of 3.3% in CY22 compared to 5.6% in CY21. For CY23 and CY24, the growth is projected at 0.7% and 1.2%, respectively. There is divergence in GDP growth across the euro area. Wherein, Germany is expected to witnesses slight contraction in growth due to weak interest rate sensitive sector like banking and

[1] CY – Calendar Year

financial services and slow trading demand. On the other hand, the GDP growth for France has been revised upwards on account of growing industrial production and external demand.

Emerging Market and Developing Economies Group

For the emerging market and developing economies group, GDP growth stood at 4.1% in CY22, compared to 6.8% in CY21. This growth is further projected at 4.0% in CY23 and CY24. About 90% of the emerging economies are projected to make positive growth. While the remaining economies, including the low-income countries, are expected to progress slower.

Further, in **China**, growth is expected to pick up to 5.0% with the full reopening in CY23 and subsequently moderate in CY24 to 4.2%. The property market crisis and lower investment are key factors leading to this moderation. Whereas, India is projected to remain strong at 6.3% for both CY23 and CY24 backed by resilient domestic demands despite external headwinds.

Table 1: GDP growth trend comparison - India v/s Other Emerging and Developing Economies (Real GDP, Y-o-Y change in %)

	Real GDP (Y-o-Y change in %)									
	CY19	CY20	CY21	CY22	CY23P	CY24P	CY25P	CY26P	CY27P	CY28P
India	3.9	-5.8	9.1	7.2	6.3	6.3	6.3	6.3	6.3	6.3
China	6.0	2.2	8.5	3.0	5.0	4.2	4.1	4.1	3.7	3.4
Indonesia	5.0	-2.1	3.7	5.3	5.0	5.0	5.0	5.0	5.0	5.0
Saudi Arabia	0.8	-4.3	3.9	8.7	0.8	4.0	4.2	3.3	3.3	3.1
Brazil	1.2	-3.3	5.0	2.9	3.1	1.5	1.9	1.9	2.0	2.0

P- Projections; Source: IMF- World Economic Outlook Database (October 2023)

The **Indonesian** economy is expected to register growth of 5% both in CY23 and CY24 with a strong recovery in domestic demands, a healthy export performance, policy measures, and normalization in commodity prices. In CY22, **Saudi Arabia** was the fastest-growing economy in this peer set with 8.7% growth. The growth is accredited to robust oil production, non-oil private investments encompassing wholesale and retail trade, construction and transport, and surging private consumption. Saudi Arabia is expected to grow at 0.8% and 4.0% in CY23 and CY24, respectively. On the other hand, **Brazil** is expected to project growth of 3.1% in CY23 driven by buoyant agriculture and resilient services in the first half of CY23.

Despite the turmoil in the last 2-3 years, India bears good tidings to become a USD 5 trillion economy by CY27. According to the IMF dataset on Gross Domestic Product (GDP) at current prices, the GDP has been estimated to be at USD 3.4 trillion for CY22 and is projected to reach USD 5.2 trillion by CY27. India's expected GDP growth rate for coming years of 6.3% is almost double compared to the world economy's projected growth of 3.0-3.2% over CY23-CY28.

Besides, India stands out as the fastest-growing economy among the major economies. The country is expected to grow at more than 6% in the period of CY24-CY28, outshining China's growth rate. By CY27, the Indian economy is estimated to emerge as the third-largest economy globally, hopping over Japan and Germany. Currently, it is the third-largest economy globally in terms of Purchasing Power Parity (PPP) with a ~7% share in the global economy, with China [~18%] on the top followed by the United States [~15%]. Purchasing Power Parity is an economic performance indicator denoting the relative price of an average basket of goods and services that a household needs for livelihood in each country.

Despite Covid-19's impact, high inflationary and interest rates globally, and the geopolitical tensions in Europe, India has been a major contributor to world economic growth. India is increasingly becoming an open economy as well through

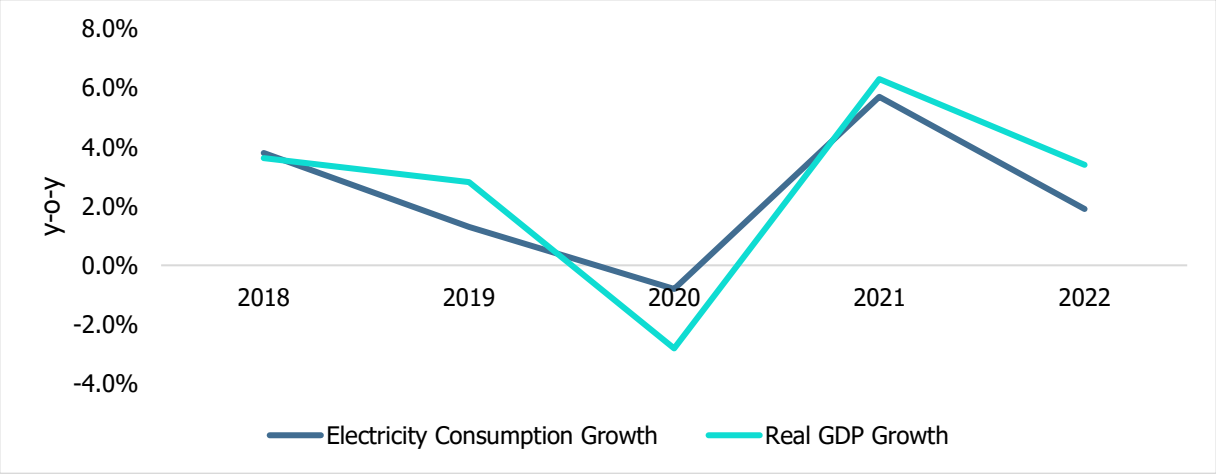
growing foreign trade. Despite the global inflation and uncertainties, Indian economy continues to show resilience. This resilience is mainly supported stable financial sector backed by well-capitalized banks and export of services in trade balance. With this, the growth of Indian economy is expected to fare better than other economies majorly on account of strong investment activity bolstered by the government's capex push and buoyant private consumption, particularly among higher income earners.

Global electricity consumption growth is closely linked to GDP Growth

Economic growth and electricity demand are positively correlated – if the economy grows, the electricity demand rises and vice-versa. Continuous supply of electricity is critical factor for growth of key economic drivers such as industrial activity, services sector, agriculture etc.

As depicted in chart below, the electricity demand was growing in line with the real GDP growth in 2018 and 2019. During 2020, the GDP declined by 2.8% y-o-y due to the impact of lockdowns and movement restrictions imposed by several countries due to the Covid-19 pandemic. During this year, the global electricity demand shrank by 0.8%. In 2021, as the global GDP bounced back from the impact of pandemic with 6.3% growth, electricity demand also followed the trend with 5.7% y-o-y growth.

Chart 2: World Electricity Demand vs. GDP Growth Rate

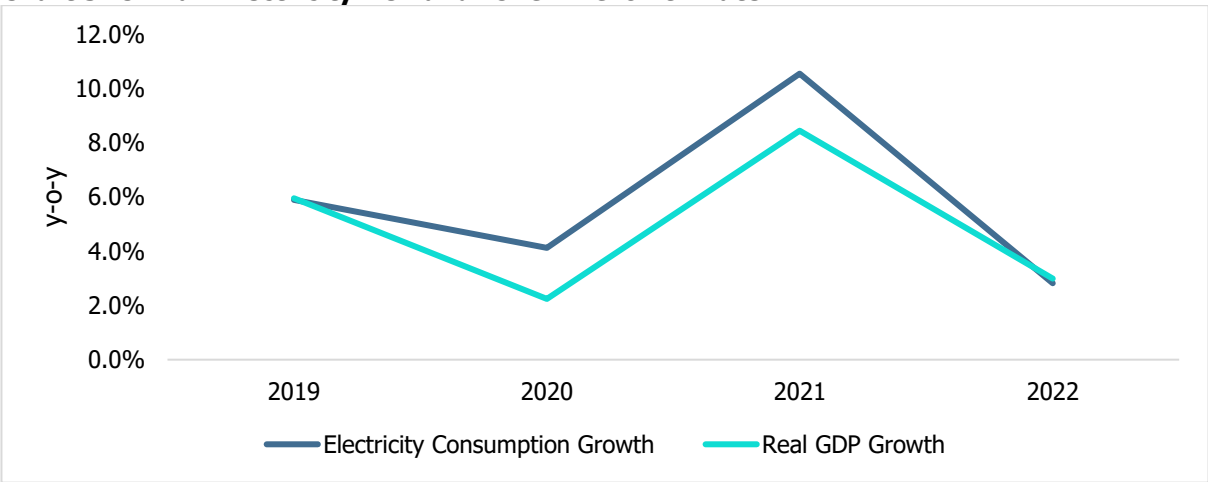


Source: International Energy Agency (IEA), IMF, World Economic Outlook Database (April 2023)

Global electricity demand growth moderated to 1.9% in CY22 amidst the global energy crisis on account of Russia-Ukraine war. The high energy prices and prices of linked commodities such as coal and natural gas in turn sharply increased power generation costs and electricity prices in most economies of the world. Furthermore, high inflationary environment and high electricity prices led to lower electricity growth in most economies around the world.

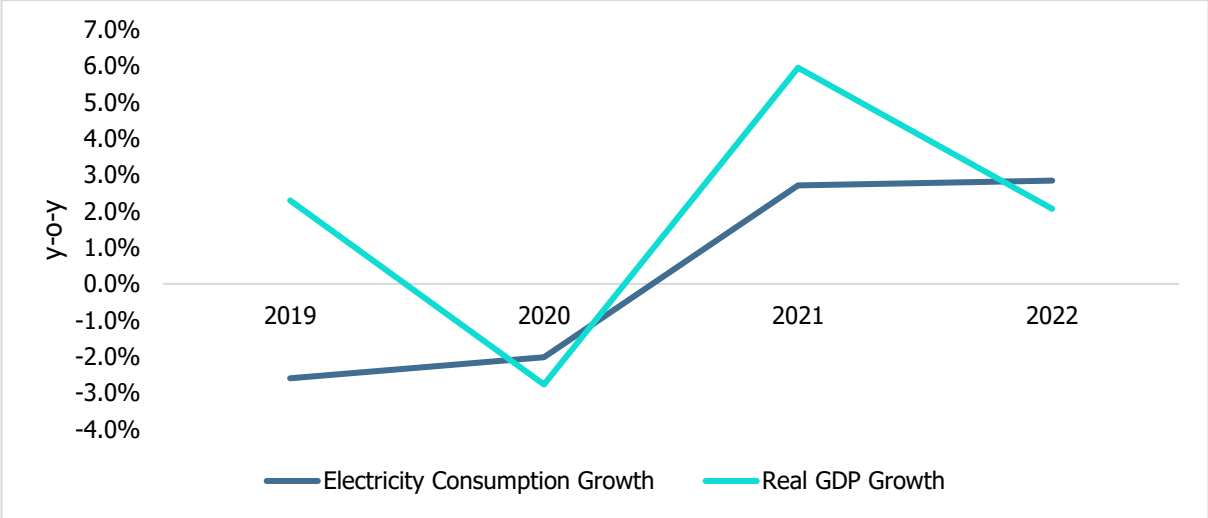
A similar trend was observed in the electricity demand of China, the United States and India, the top 3 consumers of electricity, where-in the electricity demand mapped the GDP growth for respective years.

Chart 3: China - Electricity Demand vs. GDP Growth Rate



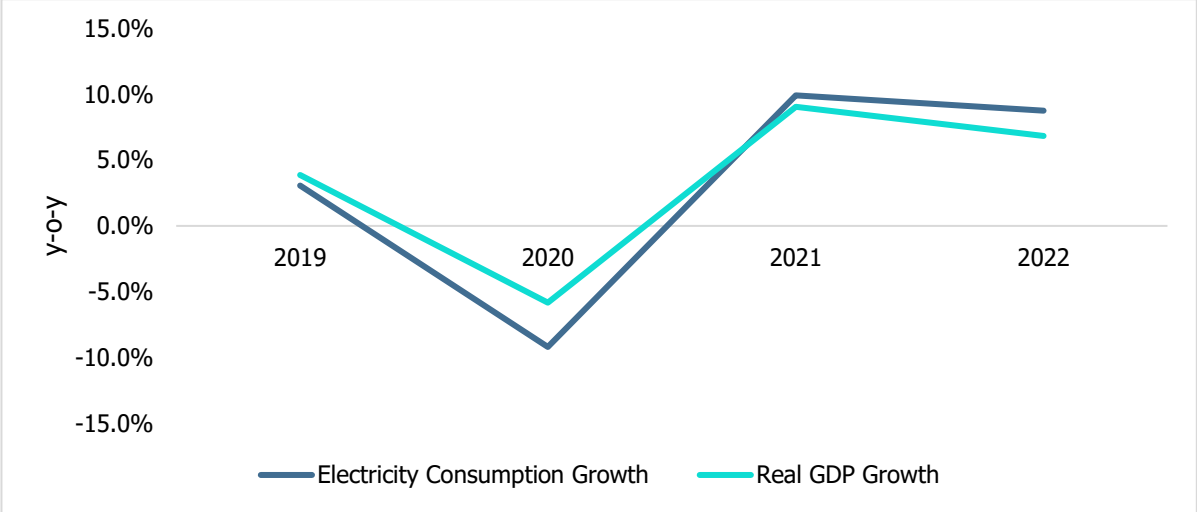
Source: International Energy Agency (IEA), IMF, World Economic Outlook Database (April 2023)

Chart 4: US - Electricity Demand vs. GDP Growth Rate



Source: International Energy Agency (IEA), IMF, World Economic Outlook Database (April 2023)
Note: Electricity demand contracted in 2019 despite GDP growth due to milder summer and winter weather

Chart 5: India - Electricity Demand vs. GDP Growth Rate



Source: International Energy Agency (IEA), IMF, World Economic Outlook Database (April 2023)

1.2 Indian Economic Outlook

1.2.1 GDP growth and Outlook

Resilience to External Shocks remains Critical for Near-Term Outlook

According to the estimates released by Ministry of Statistics and Programme Implementation (MOSPI), India's GDP grew by 9.1% in FY22 and stood at Rs. 149.3 trillion despite the pandemic and geopolitical Russia-Ukraine spill overs. In Q1FY23, India recorded 13.2% y-o-y growth in GDP, largely attributed to improved performance by the agriculture and services sectors. Following this double-digit growth, Q2FY23 witnessed 6.3% y-o-y growth, while Q3FY23 registered 4.5% y-o-y growth. The slowdown during Q2FY23 and Q3FY23 compared to Q1FY23 can be attributed to the normalization of the base and a contraction in the manufacturing sector's output.

Subsequently, Q4FY23 registered broad-based improvement across sectors compared to Q3FY23 with a growth of 6.1% y-o-y. The investments, as announced in the Union Budget 2022-23 on boosting public infrastructure through enhanced capital expenditure, have augmented growth and encouraged private investment through large multiplier effects in FY23. Supported by fixed investment and higher net exports, GDP for full-year FY23 was valued at Rs. 160.1 trillion registering an increase of 7.2% y-o-y.

Furthermore, in Q1FY24, the economic growth accelerated to 7.8%. The manufacturing sector maintained an encouraging pace of growth, given the favourable demand conditions and lower input prices. The growth was supplemented by a supportive base alongside robust services and construction activities.

GDP Growth Outlook

- During FY24, strong agricultural and allied activity prospects are likely to boost rural demands. However, a rebound in contact-intensive sectors and discretionary spending is expected to support urban consumption.
- Strong credit growth, resilient financial markets, and the government's continual push for capital spending and infrastructure are likely to create a compatible environment for investments.
- External demand is likely to remain subdued with a slowdown in global activities, thereby indicating adverse implications for exports. Additionally, heightened inflationary pressures and resultant policy tightening may pose a risk to the growth potential.

Taking all these factors into consideration, in October 2023, the RBI in its bi-monthly monetary policy meeting estimated a real GDP growth of 6.5% y-o-y for FY24.

Table 2: RBI's GDP Growth Outlook (Y-o-Y %)

FY24 (complete year)	Q2FY24	Q3FY24	Q4FY24	Q1FY25
6.5%	6.5%	6.0%	5.7%	6.6%

Source: Reserve Bank of India

1.2.2 Gross Value Added (GVA)

Gross Value Added (GVA) is the measure of the value of goods and services produced in an economy. GVA gives a picture of the supply side whereas GDP represents consumption.

Industry and Services sector leading the recovery charge

• The gap between GDP and GVA growth turned positive in FY22 (after a gap of two years) due to robust tax collections. Of the three major sector heads, the service sector has been the fastest-growing sector in the last 5 years.

• The **agriculture sector** was holding growth momentum till FY18. In FY19, the acreage for the rabi crop was marginally lower than the previous year which affected the agricultural performance. Whereas FY20 witnessed growth on account of improved production. During the pandemic-impacted period of FY21, the agriculture sector was largely insulated as timely and proactive exemptions from COVID-induced lockdowns to the sector facilitated uninterrupted harvesting of rabi crops and sowing of kharif crops. However, supply chain disruptions impacted the flow of agricultural goods leading to high food inflation and adverse initial impact on some major agricultural exports. However, performance remained steady in FY22.

Further, in Q1FY23 and Q2FY23, the agriculture sector recorded a growth of 2.4% and 2.5%, respectively, on a y-o-y basis. Due to uneven rains in the financial year, the production of some major Kharif crops, such as rice and pulses, was adversely impacted thereby impacting the agriculture sector's output. In Q3FY23 and Q4FY23, the sector recorded a growth of 4.7% and 5.5%, respectively, on a y-o-y basis.

Overall, the agriculture sector performed well despite weather-related disruptions, such as uneven monsoon and unseasonal rainfall, impacting yields of some major crops and clocked a growth of 4% y-o-y in FY23, garnering Rs. 22.3 trillion. In Q1FY24, this sector expanded at a slower pace of 3.1% compared to a quarter ago. Going forward, rising bank credit to the sector and increased exports will be the drivers for the agriculture sector. However, a deficient rainfall may impact the reservoir level weighing on prospects of rabi sowing. A downside risk exists in case the intensity of El Nino is significantly strong.

• The **industrial sector** witnessed a CAGR of 4.7% for the period FY16 to FY19. From March 2020 onwards, the nationwide lockdown due to the pandemic significantly impacted industrial activities. In FY20 and FY21, this sector felt turbulence due to the pandemic and recorded a decline of 1.4% and 0.9%, respectively, on a y-o-y basis. With the opening up of the economy and resumption of industrial activities, it registered 11.6% y-o-y growth in FY22, albeit on a lower base.

The industrial output in Q1FY23 jumped 9.4% on a y-o-y basis. However, in the subsequent quarter, the sector witnessed a sharp contraction of 0.5% due to lower output across the mining, manufacturing, and construction sectors. This was mainly because of the poor performance of the manufacturing sector, which was marred by high input costs. In Q3FY23, the sector grew modestly by 2.3% y-o-y. The growth picked up in Q4FY23 to 6.3% y-o-y owing to a rebound in manufacturing activities and healthy growth in the construction sector. Overall, the industrial sector is estimated to be valued at Rs. 45.2 trillion registering 4.4% growth in FY23.

The industrial sector grew by 5.5% in Q1FY24. The industrial growth was mainly supported by sustained momentum in the manufacturing and construction sectors. Within manufacturing (as captured by IIP numbers), industries such as pharma, non-metallic mineral products, rubber, plastic, metals, etc., witnessed higher production growth during the quarter.

• The **services sector** recorded a CAGR of 7.1% for the period FY16 to FY20, which was led by trade, hotels, transport, communication, and services related to broadcasting, finance, real estate, and professional services. This sector was the hardest hit by the pandemic and registered an 8.2% y-o-y decline in FY21. The easing of restrictions aided a fast rebound in this sector, with 8.8% y-o-y growth witnessed in FY22.

In Q1FY23 and Q2FY23, this sector registered a y-o-y growth of 16.3% and 9.4%, respectively, on a lower base and supported by a revival in contact-intensive industries. Further, the services sector continued to witness buoyant demand and recorded a growth of 6.1% y-o-y in Q3FY23. Supported by robust discretionary demands, Q4FY23 registered 6.9% growth largely driven by the trade, hotel, and transportation industries. Overall, benefitting from the pent-up demand, the service sector was valued at Rs. 20.6 trillion and registered growth of 9.5% y-o-y in FY23.

Whereas in Q1FY24, the services sector growth jumped to 10.3%. Within services, there was a broad-based improvement in growth across different sub-sectors. However, the sharpest jump was seen in financial, real estate, and professional services. Trade, hotels, and transport sub-sectors expanded at a healthy pace gaining from strength in discretionary demand. Accordingly, steady growth in various service sector indicators like air passenger traffic, port cargo traffic, GST collections, and retail credit are expected to support the services sector.

Table 3: Sectoral Growth (Y-o-Y % Growth) - at Constant Prices

At constant Prices	FY18	FY19	FY20 (3RE)	FY21 (2RE)	FY22 (1RE)	FY23 (PE)	Q1FY23	Q1FY24
Agriculture, Forestry & Fishing	**6.6**	**2.1**	**6.2**	**4.1**	**3.5**	**4**	**2.4**	**3.5**
Industry	**5.9**	**5.3**	**-1.4**	**-0.9**	**11.6**	**4.4**	**9.4**	**5.5**
Mining & Quarrying	-5.6	-0.8	-3	-8.6	7.1	4.6	9.5	5.8
Manufacturing	7.5	5.4	-3	2.9	11.1	1.3	6.1	4.7
Electricity, Gas, Water Supply & Other Utility Services	10.6	7.9	2.3	-4.3	9.9	9	14.9	2.9
Construction	5.2	6.5	1.6	-5.7	14.8	10	16	7.9
Services	**6.3**	**7.2**	**6.4**	**-8.2**	**8.8**	**9.5**	**9.4**	**10.3**
Trade, Hotels, Transport, Communication & Broadcasting	10.3	7.2	6	-19.7	13.8	14	25.7	9.2
Financial, Real Estate & Professional Services	1.8	7	6.8	2.1	4.7	7.1	8.5	12.2
Public Administration, Defence and Other Services	8.3	7.5	6.6	-7.6	9.7	7.2	21.3	7.9
GVA at Basic Price	**6.2**	**5.8**	**3.9**	**-4.2**	**8.8**	**7**	**11.9**	**7.8**

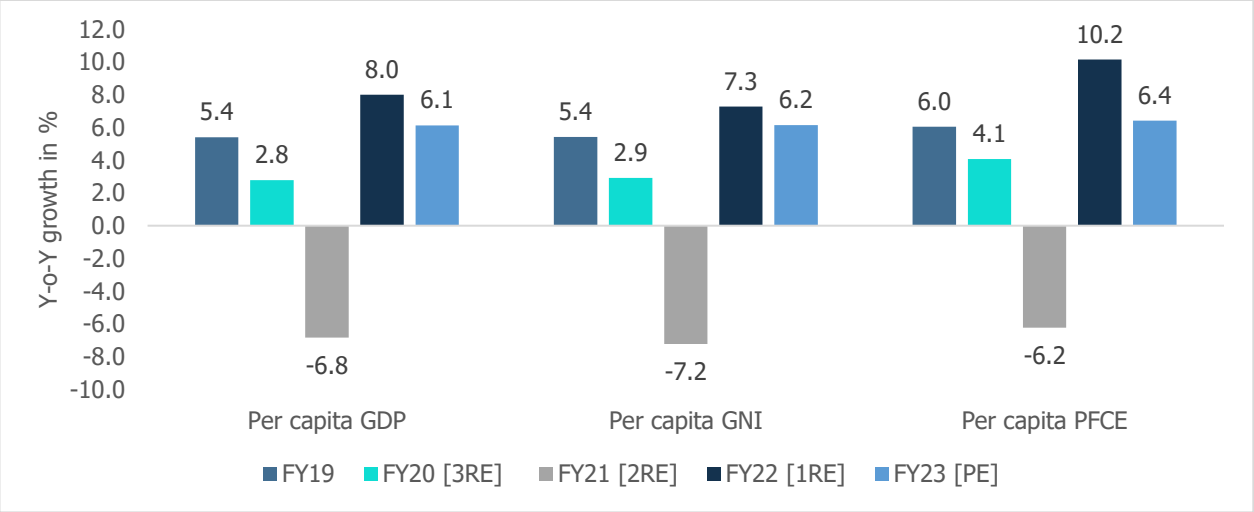
Note: 3RE – Third Revised Estimate, 2RE – Second Revised Estimates, 1RE – First Revised Estimates, PE – Provisional Estimate; Source: MOSPI

Per capita GDP, Per Capita GNI and Per Capita PFCE

India has a population of about 1.3 billion with a young demographic profile. The advantages associated with this demographic dividend are better economic growth, rapid industrialization and urbanization.

Gross Domestic Product (GDP) per capita is a measure of a country's economic output per person. FY21 witnessed significant de-growth due to the pandemic. However, in FY22 the economy paved its way towards recovery and the per capita GDP grew by 8.0%. This growth was moderated to 6.1% due to the correction of base effect in FY23. The Gross national income (GNI) also increased by 7.3% in FY22 and 6.2% in FY23. The per capita private final consumption expenditure (PFCE), which represents consumer spending, increased by 10.2% in FY22 and 6.4% in FY23.

Chart 6: Growth in Per Capita GDP, Income and Final Consumption (Y-o-Y growth in %)

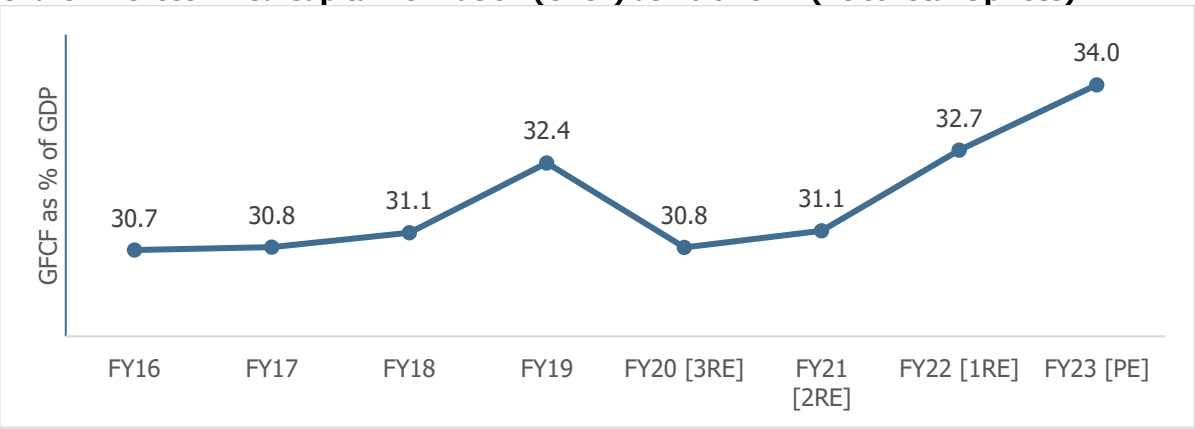


Note: 3RE – Third Revised Estimate, 2RE – Second Revised Estimates, 1RE – First Revised Estimates, PE – Provisional Estimate; Source: MOSPI

1.2.3 Investment Trend in Infrastructure

Gross Fixed Capital Formation (GFCF), which is a measure of the net increase in physical assets, witnessed an improvement in FY22. As a proportion of GDP, it is estimated to be at 32.7%, which is the second-highest level in 7 years (since FY15). In FY23, the ratio of investment (GFCE) to GDP climbed up to its highest in the last decade at 34%, as per the advanced estimate released by the Ministry of Statistics and Programme Implementation (MOSPI).

Chart 7: Gross Fixed Capital Formation (GFCF) as % of GDP (At constant prices):



RE: Revised Estimate; Source: MOSPI

Overall, the support of public investment in infrastructure is likely to gain traction due to initiatives such as Atmanirbhar Bharat, Make in India, and Production-linked Incentive (PLI) scheme announced across various sectors.

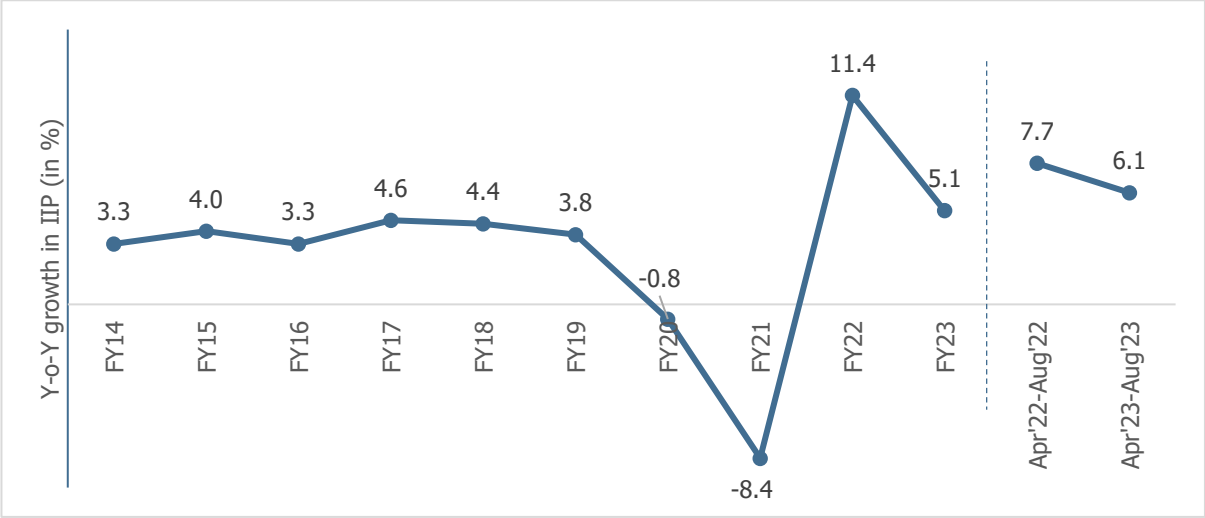
1.2.4 Industrial Growth

Improved Core and Capital Goods Sectors helped IIP Growth Momentum

The Index of Industrial Production (IIP) is an index to track manufacturing activity in an economy. On a cumulative basis, IIP grew by 11.4% y-o-y in FY22 post declining by 0.8% y-o-y and 8.4% y-o-y, respectively, in FY20 and FY21. This high growth was mainly backed by a low base of FY21. FY22 IIP was higher by 2.0% when compared with the pre-pandemic level of FY20, indicating that while economic recovery was underway, it was still at very nascent stages.

During FY23, the industrial output recorded a growth of 5.1% y-o-y supported by a favourable base and a rebound in economic activities. During April 2023 and May 2023, IIP grew by 4.2% y-o-y and 5.3% y-o-y growth, respectively. This growth in April and May 2023 was aided by encouraging performance of the mining and manufacturing sectors. However, in June 2023, the industrial output slowed to 3.7% mainly due to moderation in the manufacturing sector's output. This industrial growth rebounded to 5.7% in July 2023 with improvement in the manufacturing segment and further accelerated to 10.3% in August 2023 with improvement in the manufacturing segment. Sectors like mining and electricity as well aided this performance.

Chart 8: Y-o-Y growth in IIP (in %)



Source: MOSPI

The rebound in industrial activity in July 2023 is encouraging. The healthy momentum recorded in the infrastructure and construction sector is likely to continue aided by the Government's focus on this segment. The consumption demand is likely to see an improvement in the upcoming festive season. However, the elevated food inflation and monsoon-related vagaries could pose a risk to consumption demand. Over a longer period of time, the unfolding of the domestic demand scenario remains critical for industrial activity. External demand is likely to remain weak and that will continue to cast a shadow on export-dependent sectors.

1.2.5 Consumer Price Index

India's consumer price index (CPI), which tracks retail price inflation, stood at an average of 5.5% in FY22 which was within RBI's targeted tolerance band of 6%. However, consumer inflation started to upswing from October 2021 onwards and reached a tolerance level of 6% in January 2022. Following this, CPI reached 6.9% in March 2022.

CPI remained elevated at an average of 6.7% in FY23, above the RBI's tolerance level. However, there was some respite toward the end of the fiscal wherein the retail inflation stood at 5.7% in March 2023, tracing back to the RBI's tolerance band. Apart from a favourable base effect, the relief in retail inflation came from a moderation in food inflation.

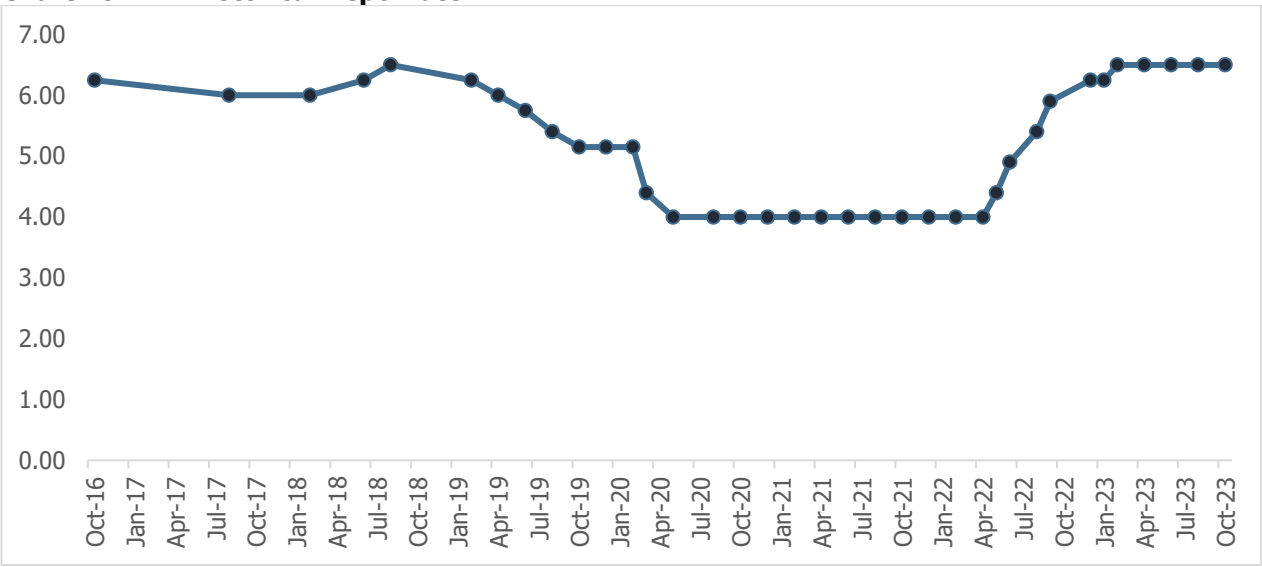
In the current fiscal FY24, the CPI moderated for two consecutive months to 4.7% in April 2023 and 4.3% in May 2023. This trend snapped in June 2023 with CPI rising to 4.9% and 7.4% in July 2023 largely due to increased food inflation. The CPI has breached the RBI's target range for the first time since February 2023. This marks the highest reading observed since the peak in April 2022 at 7.8%. The notable surge in vegetable prices and elevated inflation in other food categories such as cereals, pulses, spices, and milk have driven this increase. Further, the contribution of food and beverage to the overall inflation has risen significantly to 65%, surpassing their weight in the CPI basket. This was moderated for second consecutibe month in In September 2023 by 5% helped by a sharp correction in vegetables prices and lower LPG prices.

Chart 9: Retail Price Inflation in terms of index and Y-o-Y Growth in % (Base: 2011-12=100)

Source: MOSPI

The CPI is primarily factored in by RBI while preparing their bi-monthly monetory policy. The repo rate increased from 4.00 as of March 2021 and March 2022 to 5.90% as of September 2022 and further to 6.25% as of March 2023 and 6.50% as of September 2023.

Chart 10: RBI historical Repo Rate



Source: RBI

However, with the inflation easing over the last few months, RBI has kept the repo rate unchanged at 6.5% in the last four meetings of the Monetary Policy Committee. At the bi-monthly meeting held in October2023, RBI projected inflation at 5.4% for FY24 with inflation during Q2FY24 at 6.4%, Q3FY24 at 5.6%, Q4FY24 at 5.2% and Q1FY25 at 5.2%

In a meeting held in October 2023, RBI also maintained the liquidity adjustment facility (LAF) corridor by adjusting the standing deposit facility (SDF) rate of 6.25% as the floor and the marginal standing facility (MSF) at the upper end of the band at 6.75%.

Further, the central bank continued to remain focused on the withdrawal of its accommodative stance. With domestic economic activities gaining traction, RBI has shifted gears to prioritize controlling inflation. While RBI has paused on the policy rate front, it has also strongly reiterated its commitment to bringing down inflation close to its medium-term target of 4%. Given the uncertain global environment and lingering risks to inflation, the Central Bank has kept the window open for further monetary policy tightening in the future, if required.

1.2.6 Fiscal Deficit, Current Account Deficit

Fiscal Deficit

In FY23, the Central government finances remained fairly comfortable despite several challenges. During the fiscal, the Centre undertook targeted fiscal measures to curb domestic inflation as global food and energy prices soared following the Russia-Ukraine crisis. However, healthy tax collections had supported government finances thereby offseting the impact of several fiscal measures and weak disinvestment receipts. The quantum of fiscal deficit in FY23 at Rs 17.3 trillion was better compared to the revised estimate of Rs 17.6 trillion. With this, the Centre stayed on the path of fiscal consolidation with the fiscal deficit as a percentage of GDP at 6.4%, down from 6.7% in FY22.

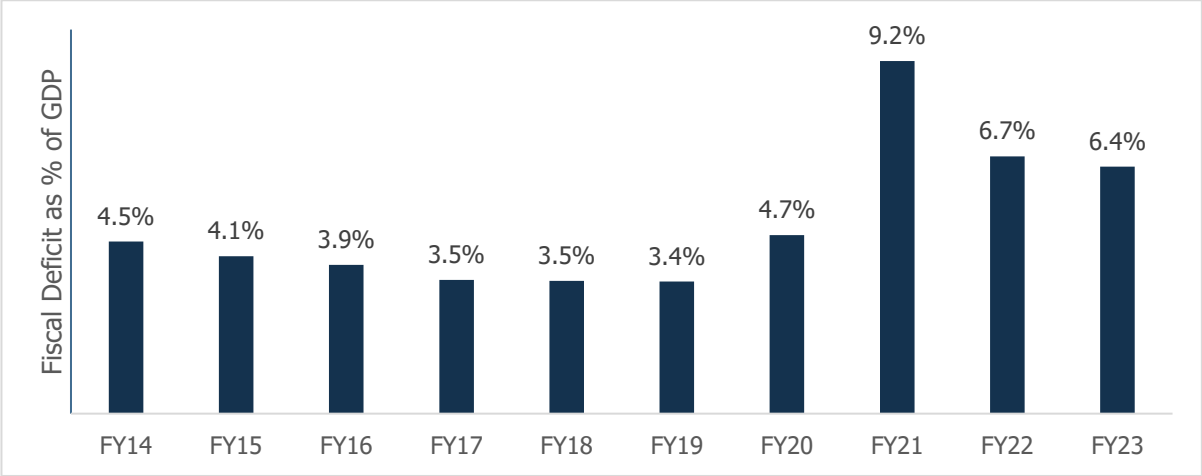
Table 4: Snapshot of Central Government Finances in FY23 (Rs trillion)

	FY22	FY23(P)	% Change
Total Receipts	**22.1**	**24.6**	**11.2**
Revenue Receipts	21.7	23.8	9.8
Capital Receipts	0.4	0.7	83.3
Total Expenditure	**37.9**	**41.9**	**10.4**

Revenue Expenditure	32.0	34.5	7.8
Capital Expenditure	5.9	7.4	24.4
Fiscal Deficit	**15.8**	**17.3**	**9.4**
Fiscal Deficit (As % of GDP)	6.7	6.4	

Source: CGA, CareEdge Research

Chart 11: Historical trend in Fiscal Deficit as % of GDP

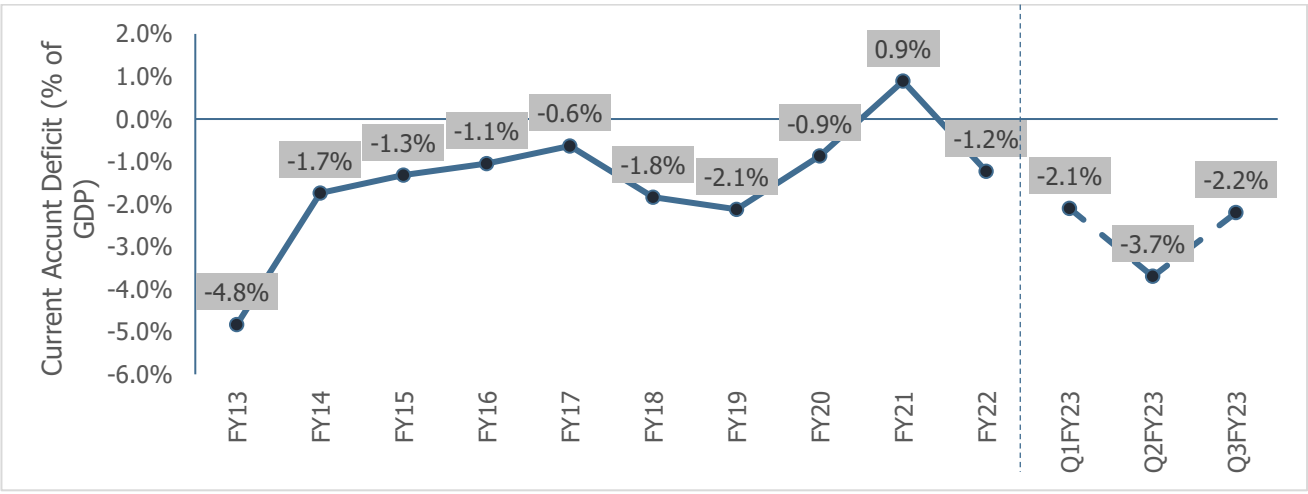


Source: CMIE, CGA, CareEdge Research

Current Account Deficit

On the current account front, upbeat services exports and healthy remittances helped cushion the impact of an elevated merchandise trade deficit. The capital account gained from foreign investments and inflows from banking capital, translating into an overall balance of payment. India recorded a current account deficit as percentage of GDP at 2.1% and 3.7% in Q1FY23 and Q2FY23, respectively, on the back of a sharp increase in the merchandise trade deficit as compared to the last year. However, it narrowed down to 2.2% of GDP in Q3FY23. In the final quarter of FY23, while merchandise exports remained weak, imports also declined further, moderation in the merchandise trade deficit is likely to be seen. Moreover, buoyancy in the services trade surplus and remittances are likely to continue. This service trade surplus signals some relief for India's external sector scenario with the current account deficit for the overall fiscal year FY23.

Chart 12: Historical trend in Current Account Deficit as % of GDP

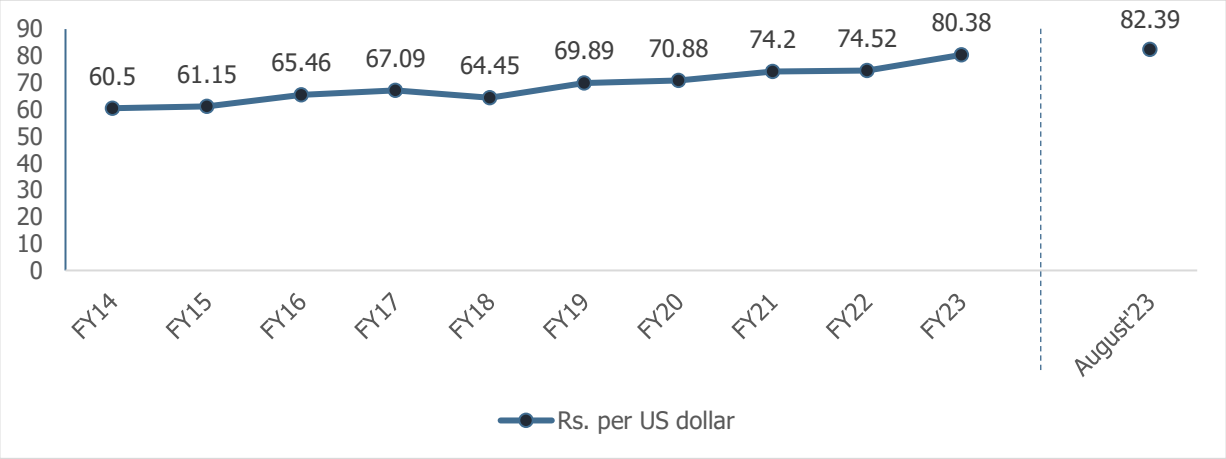


Source: CMIE, CareEdge Research

Rupee-Dollar Exchange Rate

The Indian rupee has traded within a tight range of Rs. 81-83 per USD since late 2022 on active RBI interventions. The Indian currency was also supported by overseas inflows and moderation in oil prices. Rupee was one of the better-performing currencies amongst emerging market peers during this period. Rupee's expected volatility also fell to multi-decade lows, reflective of RBI's active interventions. During August 2023, the average rupee-dollar exchange rate stood at Rs. 82.39 per USD. Overall, the rupee is expected to remain in the 81-83 range by end-FY24, with an improving CAD, capital inflows, lower oil prices and positive real rates contributing to a positive bias.

Chart 13: Exchange Rate of Indian Rupee against US Dollar



Source: CMIE, CareEdge Research

1.2.7 Key Demographic drivers for Economic Growth

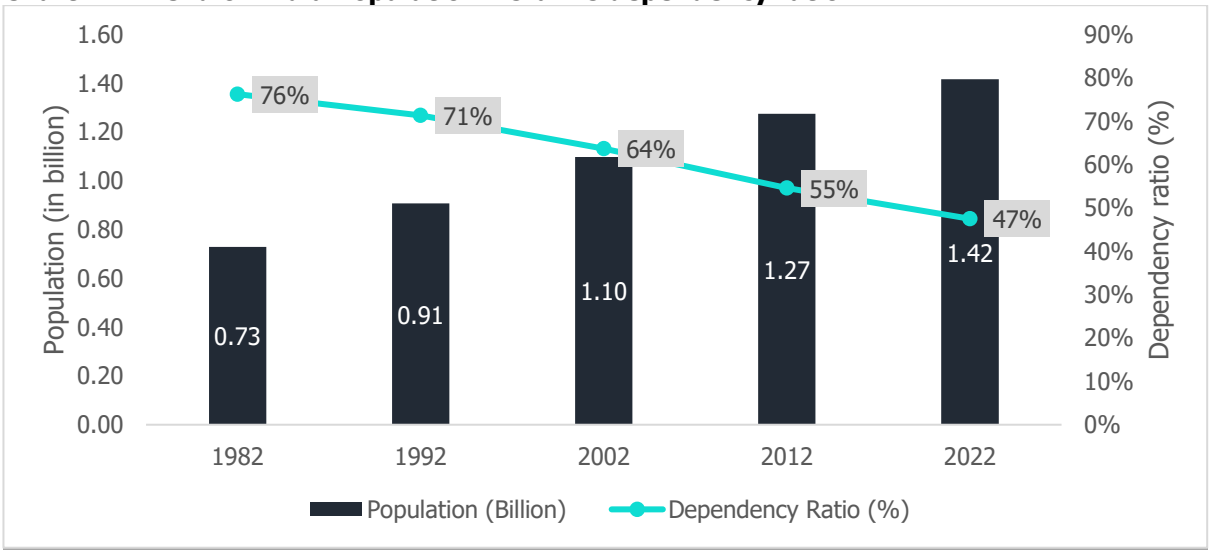
The trajectory of economic growth of India and private consumption is driven by socio-economic factors such as demographics and urbanization. Some of the key demographic drivers are as under:

- **Growing Population and Declining Dependency Ratio**

With 1.41 billion people, India is the second-most populous country in the world, with the population witnessing significant growth in the past few decades.

Age Dependency Ratio is the ratio of dependents to the working age population, i.e., 15 to 64 years, wherein dependents are population younger than 15 and older than 64. This ratio has been on a declining trend. It was as high as 76% in 1982, which has reduced to 47% in 2022. Declining dependency means the country has an improving share of working-age population generating income, which is a good sign for the economy.

Chart 14: Trend of India Population vis-à-vis dependency ratio

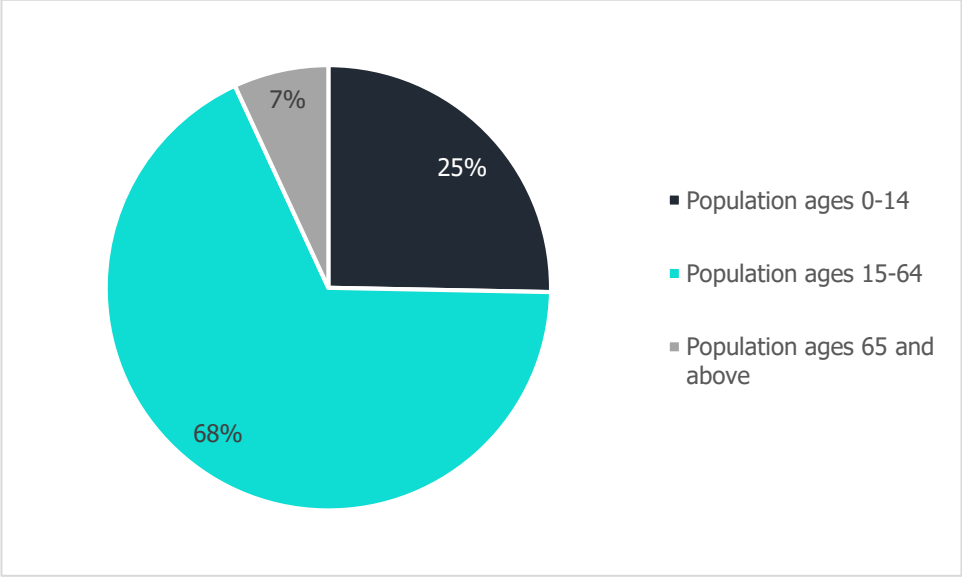


Source: World Bank Database

- **Young Population**

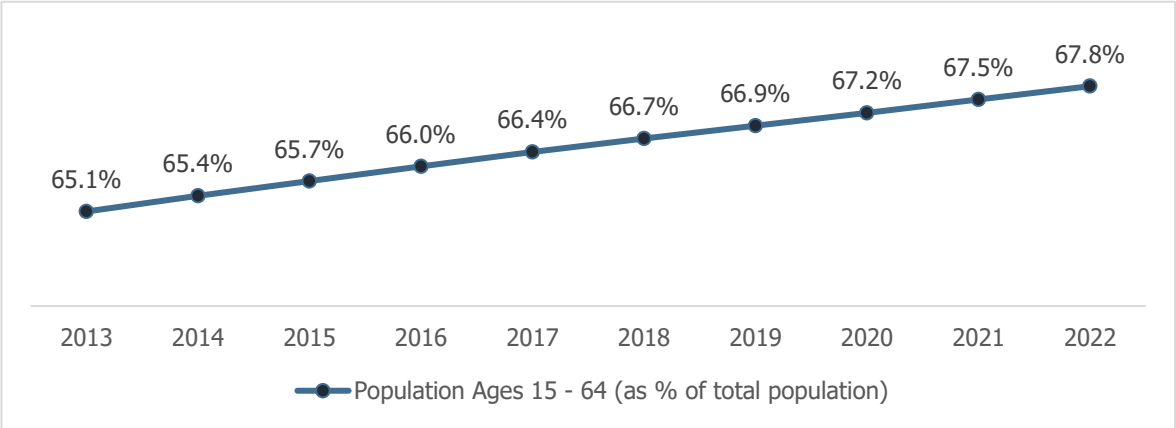
With an average age of 29, India has one of the youngest populations globally. With vast resources of young citizens entering the workforce every year, it is expected to create a 'demographic dividend'. India is home to a fifth of the world's youth demographic and this population advantage will play a critical role in economic growth.

Chart 15: Age-Wise Break Up of Indian population



Source: World Bank Database

Chart 16: Yearly Trend - Young Population as % of Total Population

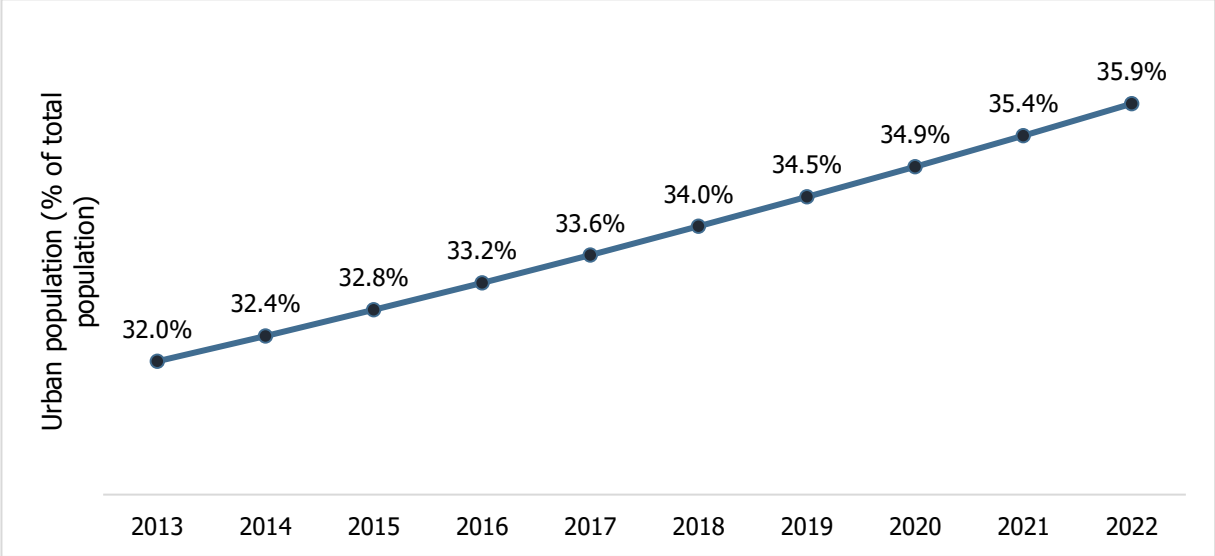


Source: World Bank database

- **Urbanization**

The urban population is significantly growing in India. The urban population in India is estimated to have increased from 403 million (31.6% of total population) in the year 2012 to 508 million (35.9% of total population) in the year 2022. People living in Tier-2 and Tier-3 cities have greater purchasing power.

Chart 17: Urbanization Trend in India



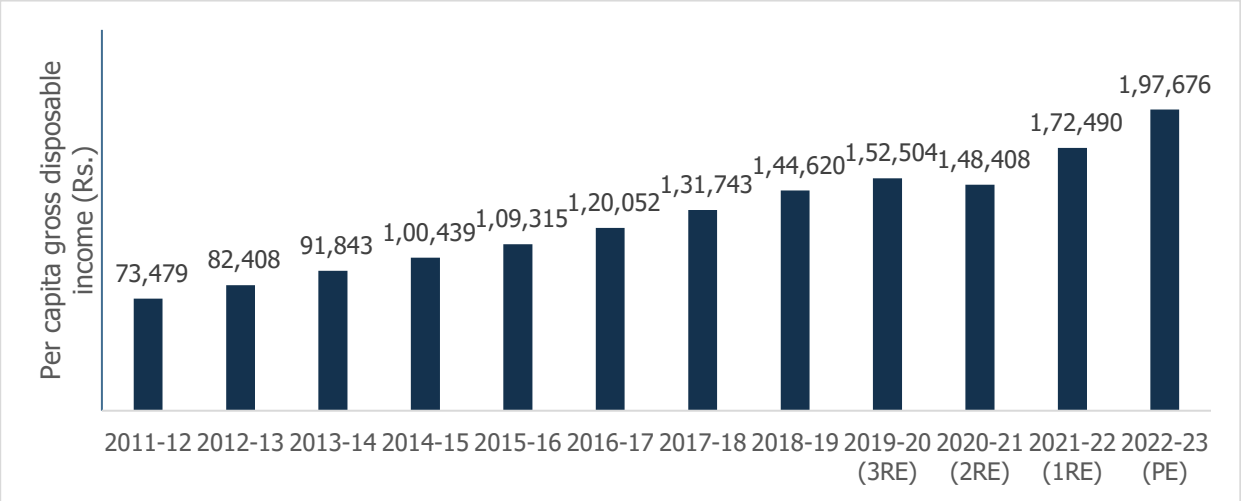
Source: World Bank Database

- **Increasing Per Capita Disposable Income**

Gross National Disposable Income (GNDI) is a measure of the income available to the nation for final consumption and gross savings. Between the period fiscal 2012 to fiscal 2023, per capita GNDI registered a CAGR of 9.4%. More disposable income drives more consumption, thereby driving economic growth.

The chart below depicts the trend of per capita GNDI in the past 12 years:

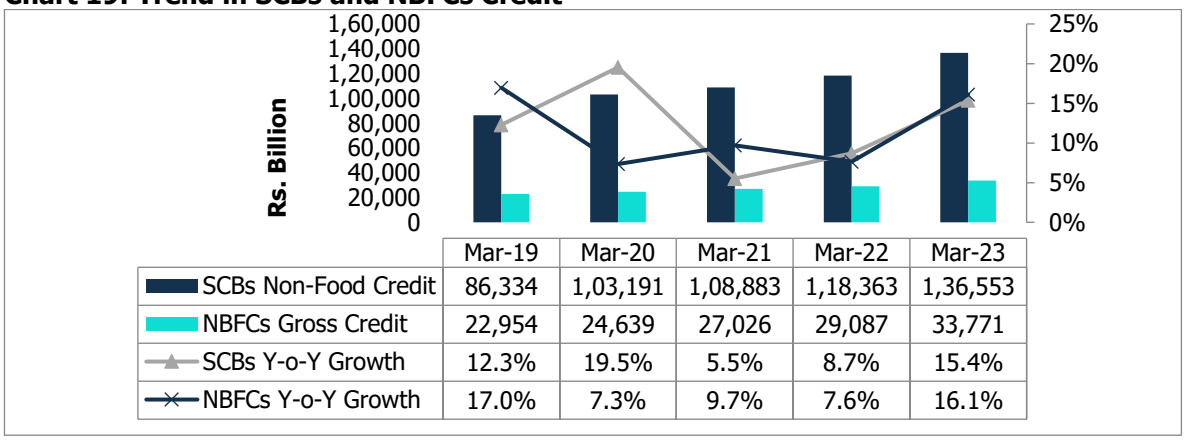
Chart 18: Trend of Per Capita Gross National Disposable Income



Note: 3RE – Third Revised Estimate, 2RE – Second Revised Estimates, 1RE – First Revised Estimates, PE – Provisional Estimate
Source: MOSPI

1.2.8 Overview of Indian Financial Services

Chart 19: Trend in SCBs and NBFCs Credit



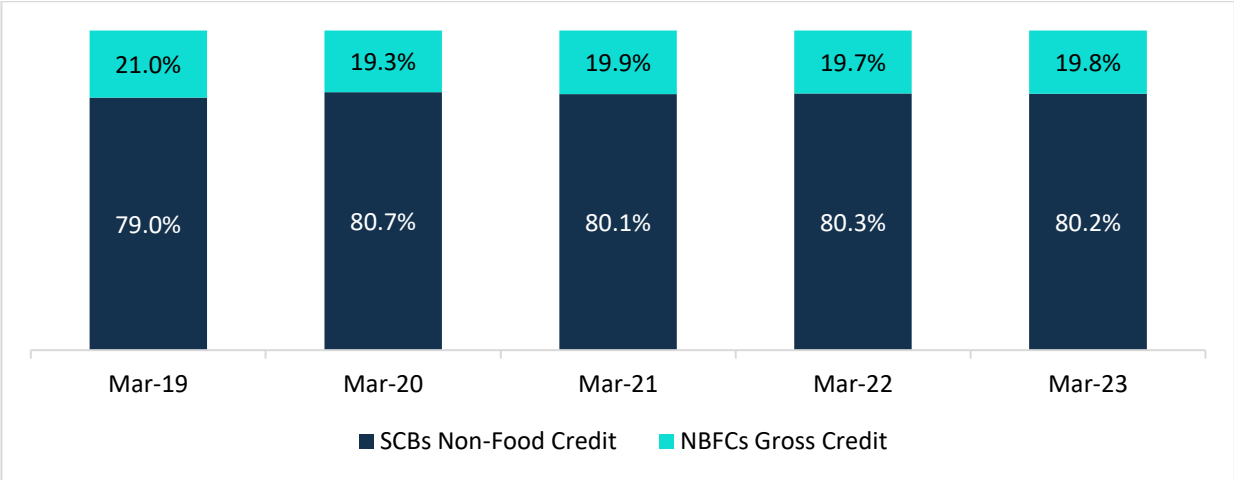
	Mar-19	Mar-20	Mar-21	Mar-22	Mar-23
SCBs Non-Food Credit	86,334	1,03,191	1,08,883	1,18,363	1,36,553
NBFCs Gross Credit	22,954	24,639	27,026	29,087	33,771
SCBs Y-o-Y Growth	12.3%	19.5%	5.5%	8.7%	15.4%
NBFCs Y-o-Y Growth	17.0%	7.3%	9.7%	7.6%	16.1%

Source: RBI, CareEdge Research
Note: Data are provisional, SCBs- Scheduled Commercial Banks, NBFCs- Non-banking financial companies

Over the years, there has been significant growth in credit deployed by SCBs and NBFCs. Despite the hike in interest rates in 2022, global uncertainties related to geo-political and supply chain issues, the credit offtake has remained robust. During FY23, the credit growth continued to be driven by a lower base of previous year, higher lending to NBFCs, growth in retail segments of unsecured personal loans, housing loans, auto loans while growth in MSME and corporate lending was on account of increase in working capital requirements.

During FY23, NBFCs have also seen significant ramp-up in credit deployed, with its growth surpassing y-o-y growth of bank credit. NBFCs growth is driven by increase in demand for retail credit and working capital loans.

Chart 20: Share in Overall credit



Source: RBI, CareEdge Research
Note: Data are provisional

While SCBs share in total credit deployed has marginally declined, they continue to be the largest lenders of credit with their share in overall credit hovering in the range of 79%-81%, followed by NBFCs at 19%-21% share in overall credit in the last five financial years.

In general sense, bank credit growth is a key indicator of economic growth. The domestic credit to private sector (as % GDP) was on an average ~51% during the period 2017-2021. In the financial sector, credit conditions remain strong even as the cost of funds tightens. As on July 28, 2023, bank credit grew by 14.7% y-o-y as compared to 15.4% on May 19, 2023. With indications of healthy GDP growth in the medium term, private investments which remained subdued has started to pick up which is visible in the current credit growth which have remained above 14% in the last few quarters. With private investments gaining full momentum, the credit growth will continue to remain healthy benefiting banks and NBFCs in the medium term.

1.2.9 Concluding Remarks

The major headwinds to global economic growth are escalating geopolitical tensions, volatile global commodity prices, and a shortage of key inputs. Despite the global economic growth uncertainties, the Indian economy is relatively better placed in terms of GDP growth compared to other emerging economies. It is expected to grow at 6.3% in CY24 compared to the world GDP growth projection of 3%. The bright spots for the economy are continued healthy domestic demand, support from the government towards capital expenditure, moderating inflation, and improving business confidence.

Likewise, several high-frequency growth indicators including the purchasing managers index, auto sales, bank credit, and GST collections have shown improvement in FY23. Moreover, normalizing the employment situation after the opening up of the economy is expected to improve and provide support to consumption expenditure.

Further, in line with the latest India Meteorological Department (IMD) projection, the rainfall activity has been muted during June 1, 2023 to September 20, 2023, with cumulative rainfall falling back to a 7% deficit. Also, weak-to-moderate El Nino conditions are expected to lead to a prolonged dry spell. A drop-in yield due to irregular monsoon and a lower acreage can lead to a demand-supply mismatch, further increasing the inflationary pressures on the food basket. Going ahead, consumption demand is expected to pick up during the festive season, but the quantum of rise in demand will be dependent on the extent of the impact of the irregular monsoon.

At the same time, public investment is expected to exhibit healthy growth as the government has allocated a strong capital expenditure of about Rs. 10 lakh crores for FY24. The private sector's intent to invest is also showing improvement

as per the data announced on new project investments. However, volatile commodity prices and economic uncertainties emanating from global turbulence may slow down the improvement in private CapEx and investment cycle.

Furthermore, the industrial sector is expected to perform better among all sectors, as input costs are now moderating. With flagship programmes like 'Make in India' and the PLI schemes, the government is continuing to provide the necessary support to boost the industry sector. Similarly, the service sector is expected to see continued growth in FY24. However, some segments in the service sector, like information technology, are likely to be impacted by the slowdown in the US and European economies.

2. Power Industry in India

Power is one of the most critical components for infrastructure development and crucial for the economic growth and well-being of any country. The existence and development of adequate power infrastructure is essential for the sustained growth of the Indian economy.

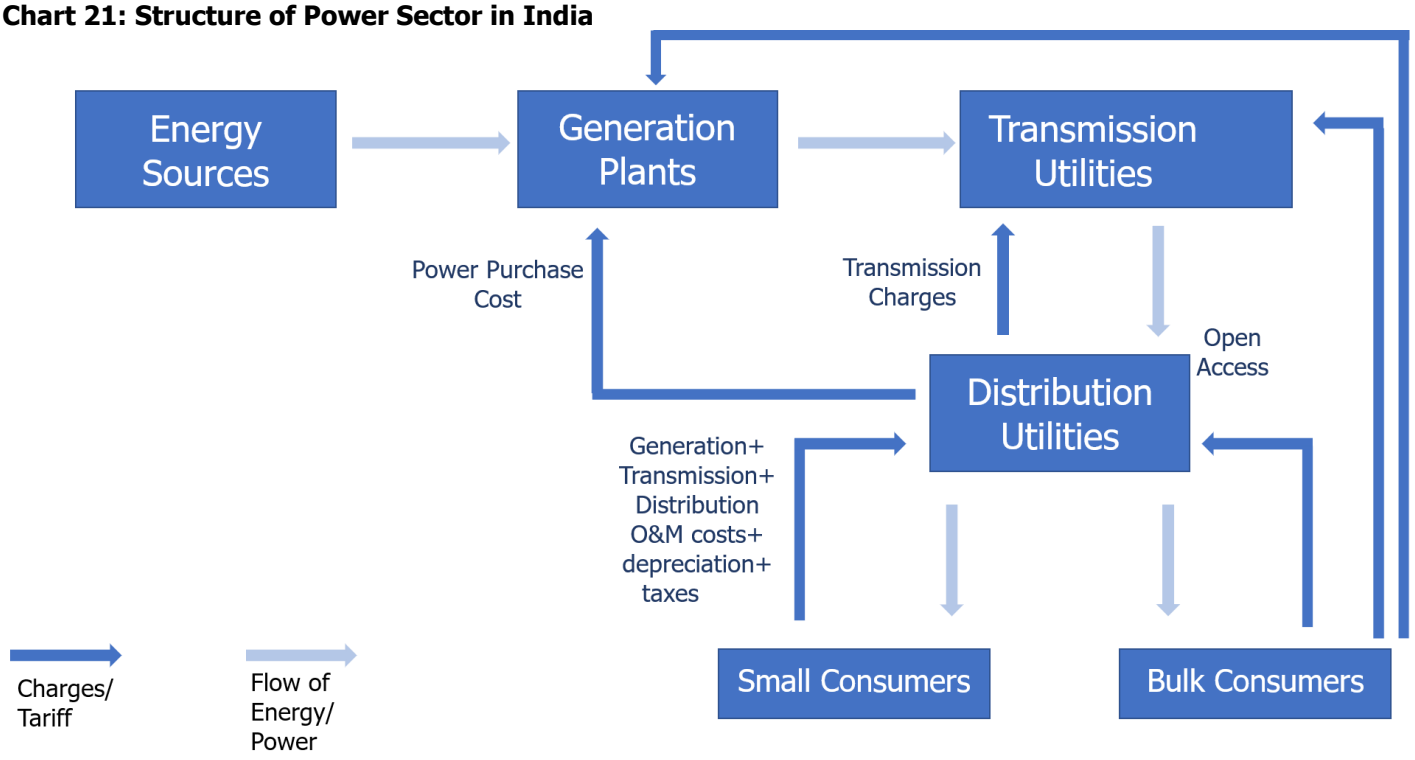
The power industry is divided into three segments:

- Generation
- Transmission
- Distribution

Generation is the process of producing electricity from different sources like thermal energy (coal, diesel etc.), nuclear and renewable sources such as sunlight and wind, natural gas, etc. in generating stations or power generation plants. Transmission utilities transport large amount of electricity from power plants to distribution substations via a grid at high voltages. The retail electricity distribution, which is the distribution of electricity to consumers at lower voltages, forms part of the distribution segment.

The structure of the power industry is depicted in the figure below.

Chart 21: Structure of Power Sector in India



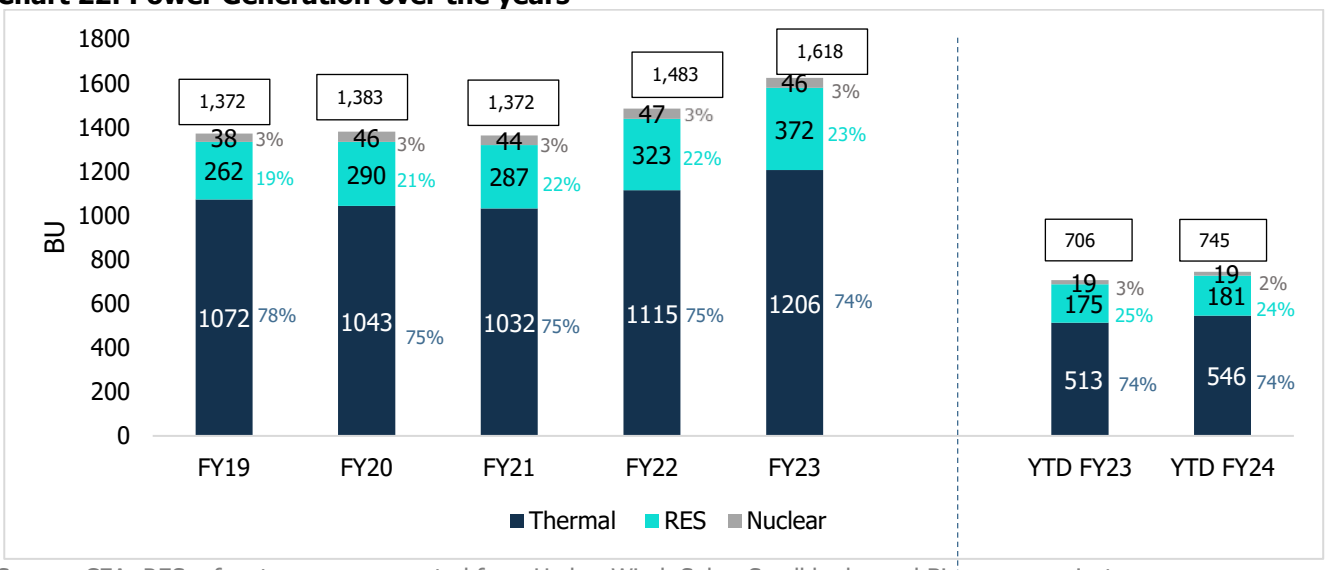
Source: CareEdge Research

2.1 Overview of Indian Power Generation Industry

Indian power generation sector is one of the most diversified in the world. Power generation sources in India range from conventional sources such as coal, lignite, natural gas, oil, and nuclear to viable unconventional sources such as wind, solar, hydro, agricultural and household waste.

Electricity generation in India increased from 1,372 BU in FY19 to 1,618 BU in FY23, implying a compounded annual growth rate (CAGR) of 4.2%. Electricity generation increased by about 6% y-o-y to 745 BU during April 2023 to August 2023. Thermal power forms the largest source of power in the country with about 75% of the electricity consumed being generated from thermal power plants. There are different types of thermal power plants, out of which coal based thermal power plants account for highest amount of electricity followed by gas and diesel. Renewable Energy Sources (RES) including solar, wind and hydro are quickly increasing their share and their contribution has increased from 19.1% in FY19 to 23% in FY23.

Chart 22: Power Generation over the years

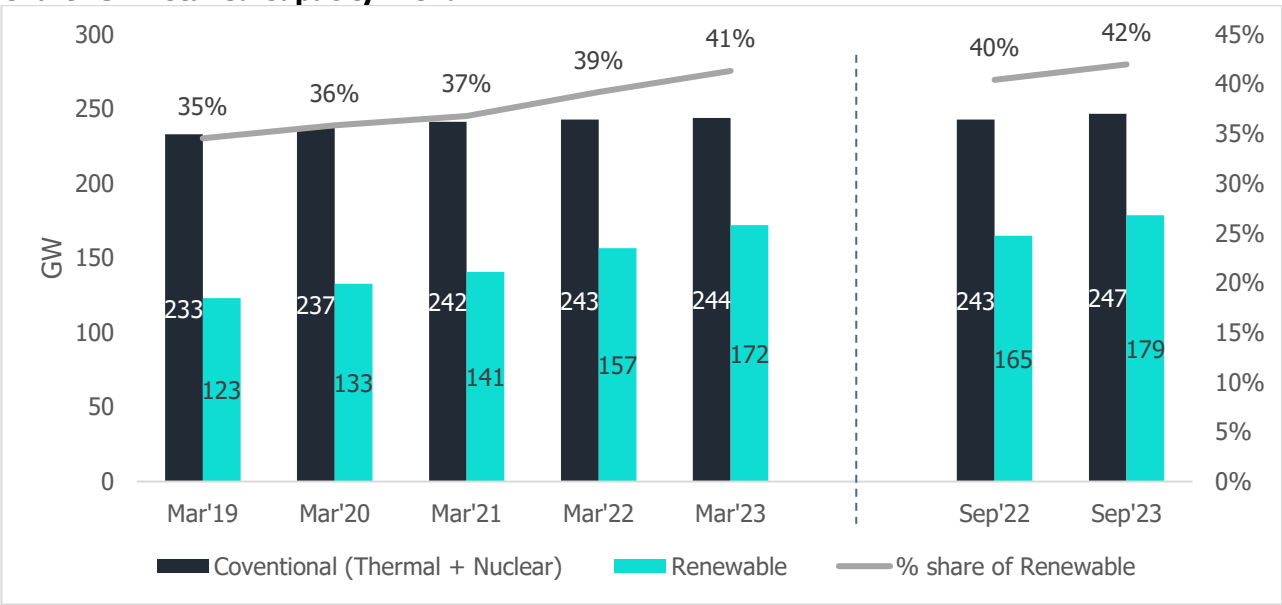


Source: CEA; RES refers to power generated from Hydro, Wind, Solar, Small hydro and Bioenergy projects;
Note: YTD FY23/FY24 indicates April to August

Installed capacity

The installed power capacity in India has increased from 356 GW in FY19 to 416 GW in FY23; it increased by 4% y-o-y as on September 2023 to 425 GW; India is the world's third-largest producer and second-largest user of energy.

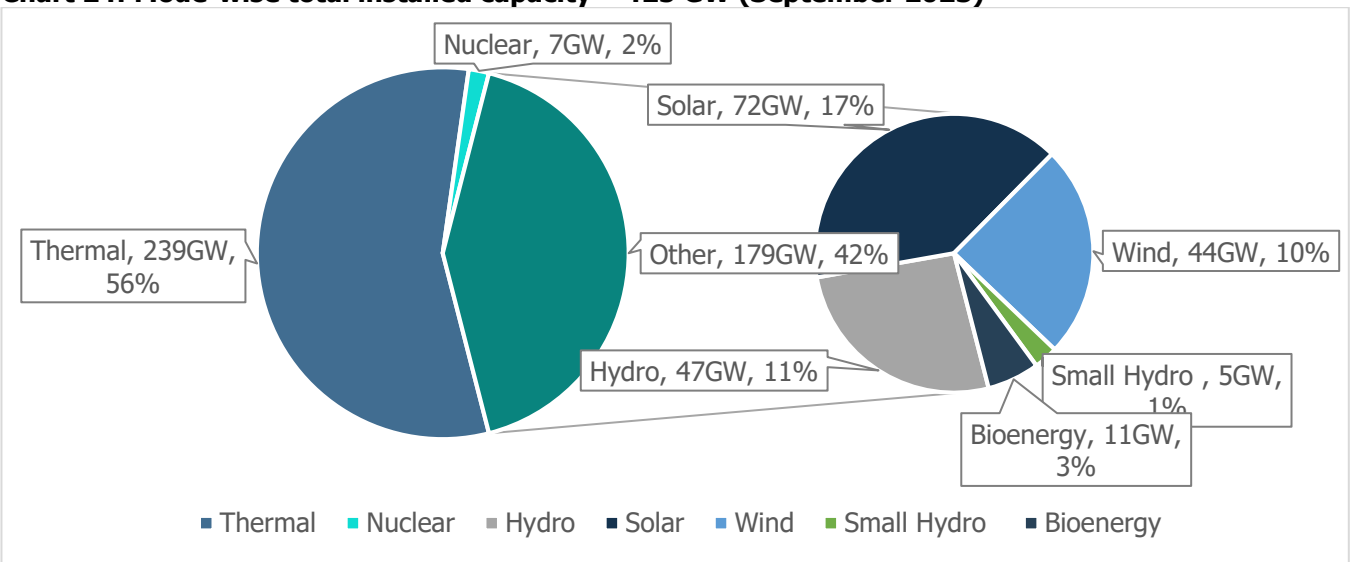
Chart 23: Installed Capacity Trend



Source: CEA, CareEdge Research

While conventional sources currently account for 58% of installed capacity, with the Government of India's ambitious projects and targets, power generated from RES including hydro, which currently accounts for 42%, is expected to have nearly equal in contribution compared to conventional sources in the medium term. With consistent focus on renewable sector, the percentage share of installed capacity is expected to shift towards renewable energy.

Chart 24: Mode-wise total installed capacity – 425 GW (September 2023)



Source: CEA, CareEdge Research

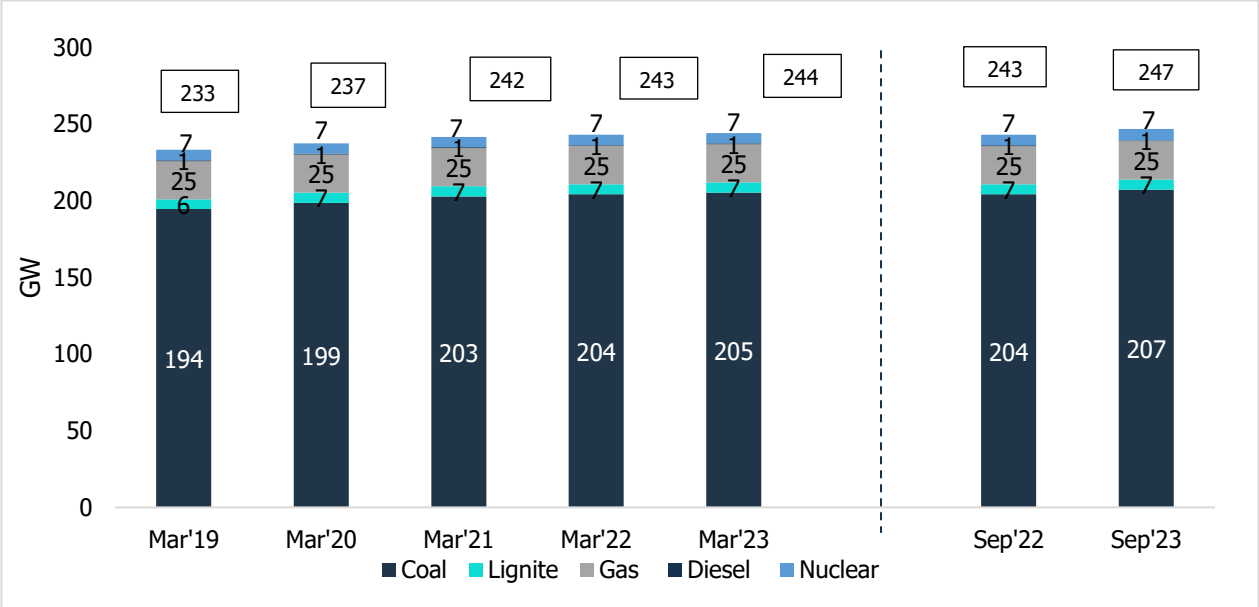
Renewable accounts for 42% of the total power generation capacity of which solar accounts for the largest share of 17% followed by hydro at 11% and wind at 10%.

Conventional Power

Conventional power includes power generated from thermal sources i.e. coal, lignite, gas, diesel and nuclear energy. The conventional power generation capacity has increased from 233 GW in FY19 to 244 GW in FY23, and 247 GW in September 2023.

India is majorly dependent on fossil fuels for power generation even as the installed and generation capacity of renewables is increasing. Coal continues to be the backbone of India's energy sector, accounting for 69% as on September 2023 of the country's energy mix, the third largest among Group of 20 (G20) countries. With abundant local reserves, India has the world's fifth largest proven coal reserves.

Chart 25: Installed Capacity in India- Conventional (Thermal + Nuclear)



Source: CEA, CareEdge Research

Thermal:

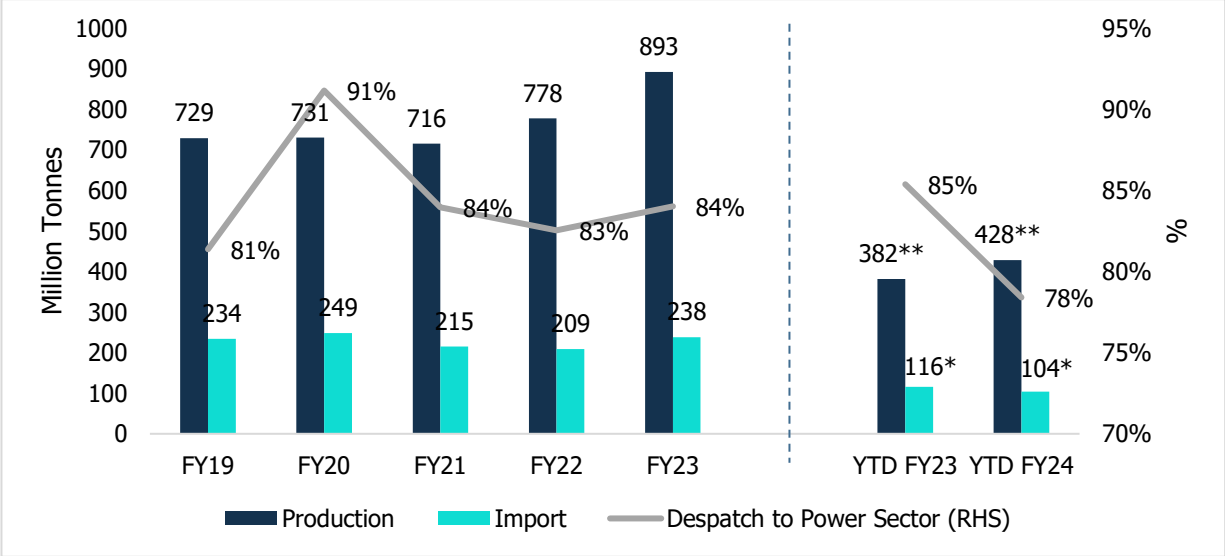
- **Coal**

India has the world's fifth largest known coal reserves of 361,411 million tonnes as on April 2022, however, coal production has lagged behind demand. This has resulted in a dependence on imports. Coal is primarily provided by public-sector enterprises at prices specified under fuel supply agreements (FSAs), can be purchased through e-auctions conducted by the public sector coal miners or procured from captive coal mines.

India's coal production has been on an increasing trend due to sustained investments and greater thrust on use of modern technologies. The all India coal production stood at 893 million tonnes in FY23 and 293 million tonnes between April 2023-July 2023, with a y-o-y growth of around 14.8% and 10%, respectively.

The dispatch of coal to the power sector was at its peak of 91% during FY20. Since then there has been a shift and decrease in the dispatch of coal to power sector.

Chart 26: Coal production, import and despatch to power sector trend in India

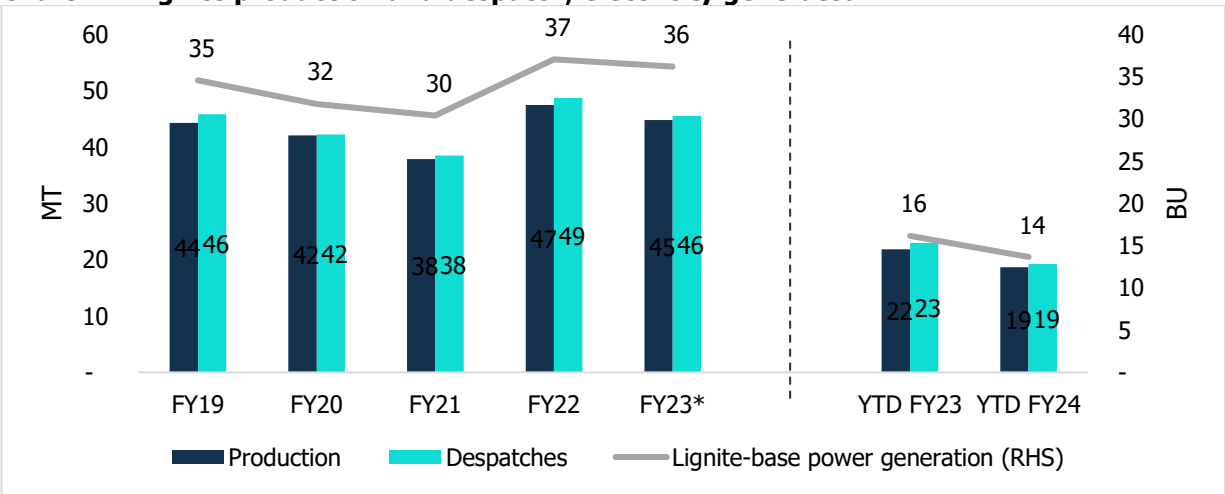


*Indicates numbers upto August; **Indicates numbers from April'23 - September'23
Source: Ministry of Coal, CareEdge Research

- **Lignite**

India has around 40.9 billion tonnes of lignite reserves which are mainly found in Tamil Nadu. Currently, only a small percentage of lignite reserves are exploited and there is considerable scope of use of lignite in thermal power stations. As on September 2023, India has around 6,620 MW of lignite-based installed power generation capacity.

Chart 27: Lignite production and despatch, electricity generated



Source: CMIE, National Power Portal, Ministry of Coal, CareEdge Research, YTD denotes April-September

- **Natural Gas**

While natural gas' proportion in India's primary energy mix has remained relatively stable at approximately 6% in recent years, overall energy demand has increased quickly, with substantial swings in natural gas consumption in certain sectors of the economy. There has been a shortage of natural gas availability as most of the wells have aged and become less productive over time and producers would now have to invest heavily in extracting gas from more difficult fields using technologically intensive means. The shortage has impacted natural gas-based power generation.

India has announced its target to raise the natural gas portion of its primary energy mix to 15% by 2030, up from 6% in 2019. The government has taken a number of steps to promote this goal, including increasing domestic production, facilitating imports, and encouraging demand.

- **Diesel**

A diesel power plant consists of two or more diesel generators that operate in parallel. Diesel power generation is used in areas that are not connected to the power grid or are isolated like islands. The installed capacity for grid connected diesel-based power plant was 589 MW as on May 2023.

- **Nuclear**

India has 23 nuclear reactors in operation at seven nuclear power facilities, with a total installed capacity of 7 GW as on March 2023. Nuclear power plants generated 46 BU in FY23, accounting for 3% of India's total electricity output. A total of ten additional reactors with a combined generation capacity of 8,000 MW are now under development.

Renewable Power

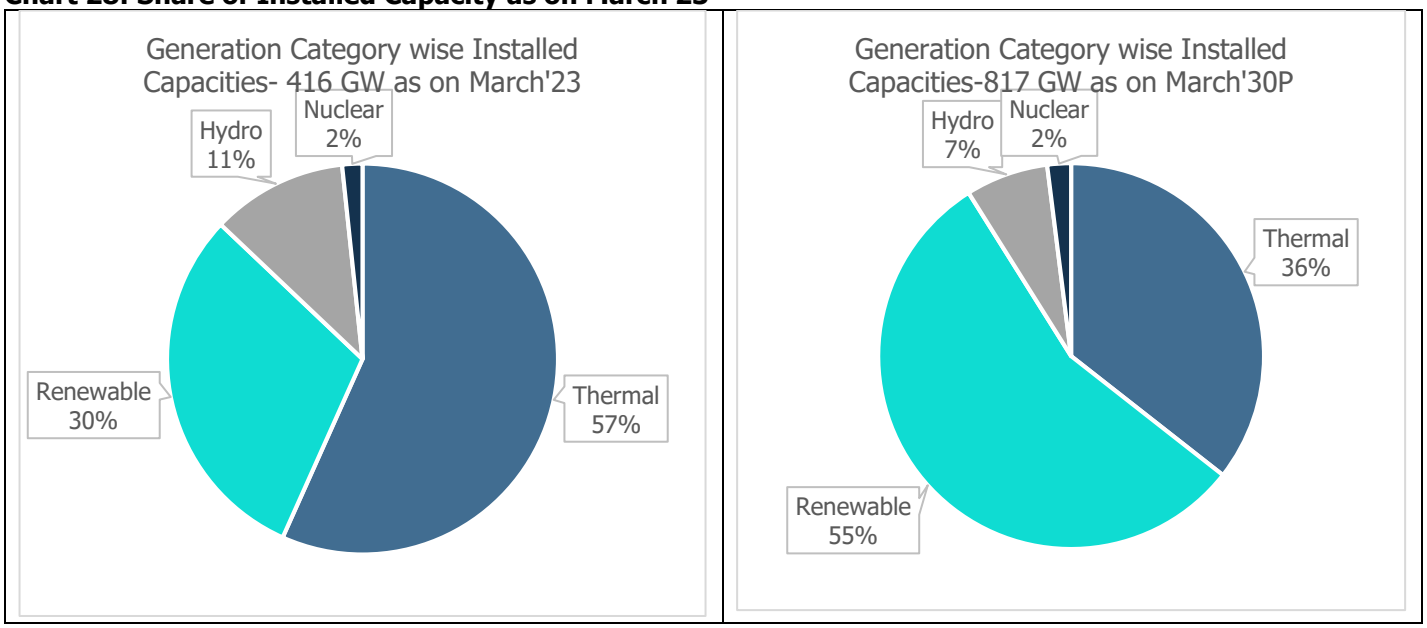
Installed capacity of renewable energy including hydro power has increased from 123 GW in FY19 to 172 GW in FY23. The total potential of renewable power in India is estimated to be 1,639 GW.

India's renewable installed capacity has increased due to increased support from the government and increased economies. The sector has also become attractive for the investors.

India has made a commitment to decrease the emissions intensity of its Gross Domestic Product (GDP) by 45% by 2030, compared to 2005 levels. Additionally, India aims to attain a non-fossil fuel-based installed power generation capacity of approximately 50% (500 GW) by 2030. These targets were proposed at the 26th session of the Conference of the Parties (COP26) to the United Nations Framework Convention on Climate Change (UNFCCC), which took place in Glasgow, United Kingdom, in November 2021. The ultimate objective is to achieve a net-zero emissions target by the year 2070. This further reiterates India's commitment and focus towards renewable energy additions in the future.

The Government of India has highlighted priority areas for Renewable Energy (RE) generation, including RE component manufacturing (solar modules, hydrogen electrolysers, battery storage, among others), green energy corridor, green hydrogen production, utility-scale battery storage, pumped storage hydro and rooftop solar power. Further with the announcement of 500 GW RE capacity installation by 2030 and Net-Zero emissions by 2070, India has set itself on one of the most accelerated energy transition trajectories in the world.

Chart 28: Share of Installed Capacity as on March'23



P-Projected
Source: CEA, CareEdge Research

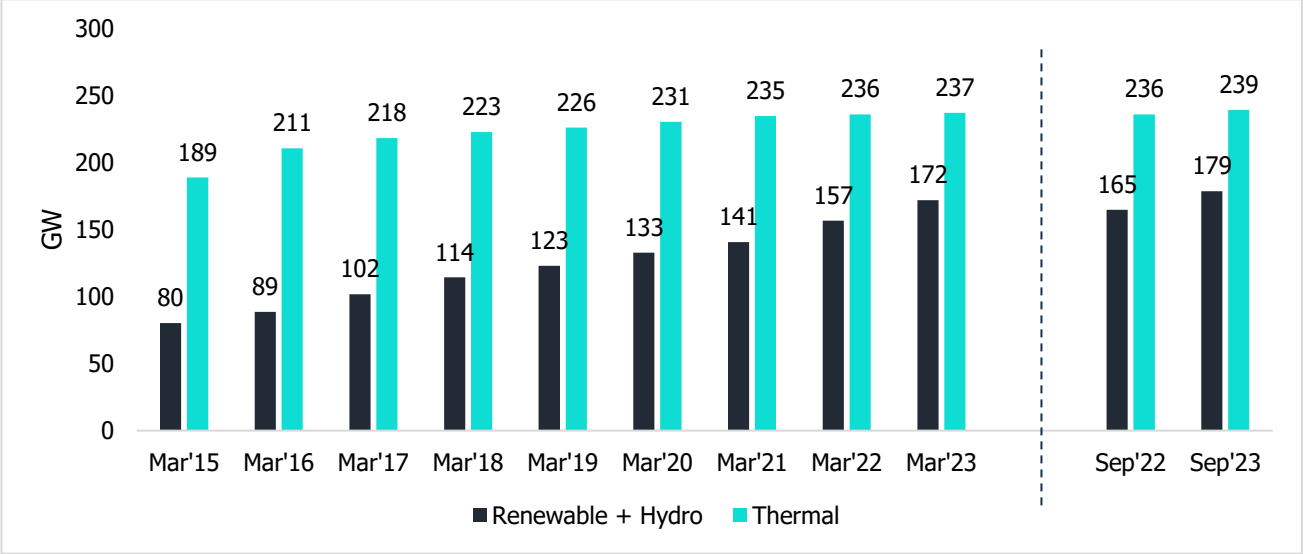
The total installed power generation capacity is expected to reach 817 GW as on March 2030. The share of renewable energy (excluding Hydropower) is expected to increase from 30% as on March 2023 to 55% in March 2030 while the share of thermal power is expected to reduce from 57% to 36% over the same period.

2.2 Renewable sources v/s Conventional Sources

Thermal power has traditionally been the preferred source of power over the years, but strong government focus on renewable energy, combined with lower tariffs (due to lower capital costs and improved efficiency), increased adoption of renewable energy sources and technological advancements have aided the expansion of renewable energy capacity.

Share of renewable energy in the total power generation increased from 17% in FY15 to 23% in FY23. The CAGR in thermal installed capacity for the last five years was 2.9% whereas for renewables it was 10%, indicating a shift in trend from thermal to renewables.

Chart 29: Installed Capacity- Renewable v/s Thermal



Source: CEA, CareEdge Research
Note: Thermal excludes Nuclear Power

India's current electricity generation is highly reliant on non-renewable natural resources like coal. Renewable energy mainly solar and wind, backed by batteries and other green technologies like electric vehicles and green hydrogen are recognized by the government as necessary alternatives to high-emitting fossil fuel generation plants. Renewable energy market of India is one of the most attractive market globally due to its large targeted capacity additions, strong government support and favourable policies.

The support and implementation of policies by the government has been playing a vital role in aiding India's renewable sector and has led the sector becoming attractive for investors. The policies include National Solar Mission, International Solar Alliance, Pradhan Mantri Kisan Urja Suraksha Evam Utthan Mahabhiyan (PM KUSUM), Green Energy Corridor, National Solar-Wind Hybrid Policy, National Offshore Wind Energy Policy, Hydro Policy Notification, Renewable Purchase Obligation (RPO) Trajectory. Other special measures include Round-The-Clock Power (RTC) from RE power plants, Hybrid Projects, Solar cities, waiver of Inter State Transmission System Charges, enhancing domestic manufacturing, must run status for renewable projects, concessional open access charges etc.

Benefits of Renewable over Conventional Sources:

- **Fewer environmental concerns unlike thermal power plants**

One of the biggest challenges involved with the conventional source is the environmental contamination. Coal combustion at thermal power plants emits carbon dioxide (CO_2), Sulphur oxides (SO_x), nitrogen oxide (NO_x), Chlorofluorocarbon (CFCs) and other gases, and inorganic pollutants like fly ash.

As per the UN Human Development Report 2021/22, the per capita carbon dioxide emission of India is around 1.8 metric tonnes as compared to the world average of 4.3 tonnes.

About half of the total carbon dioxide emission of India is estimated to be generated by the power sector while other sectors contributing to it are transport and industrial sector. As per a report by International Energy Agency (IEA) around 30% of the carbon emission is by the industrial sector and 13% can be attributed to transport sector.

Chart 30: Evolution of India's CO2 emissions

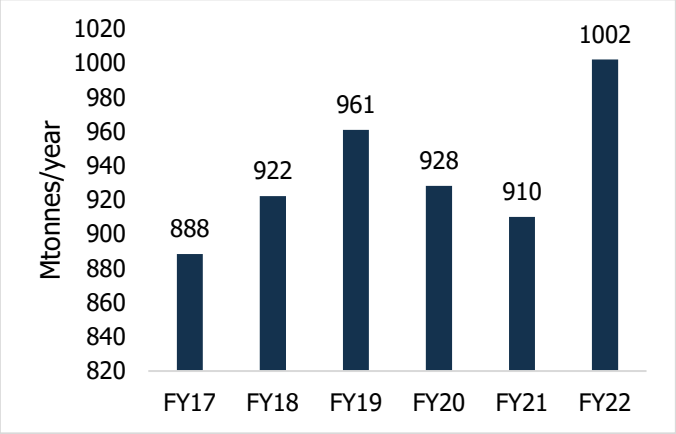
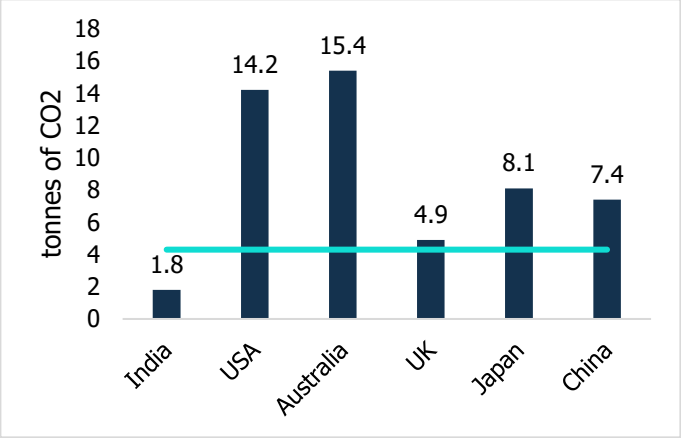


Chart 31: India's per capita CO2 emission v/s other countries



Source: National Electricity Plan Vol 1 (March 2023), UNDP Human Development report 2021/22, CareEdge Research

Majority of the coal-fired power plants are inefficient and run on older subcritical technologies. These technologies utilize more coal per MWh of electricity generated. Air pollution, water pollution, noise pollution and land degradation are some of the environmental and health risk posed by the thermal power plants.

Table 5: Weighted average specific emissions for fossil fuel fired stations for 2020-21

	Coal	Diesel	Gas	Lignite
tCO2/MWh (net)	0.975	-	0.465	1.28

Source: National Electricity Plan Vol 1 (March 2023), CareEdge Research

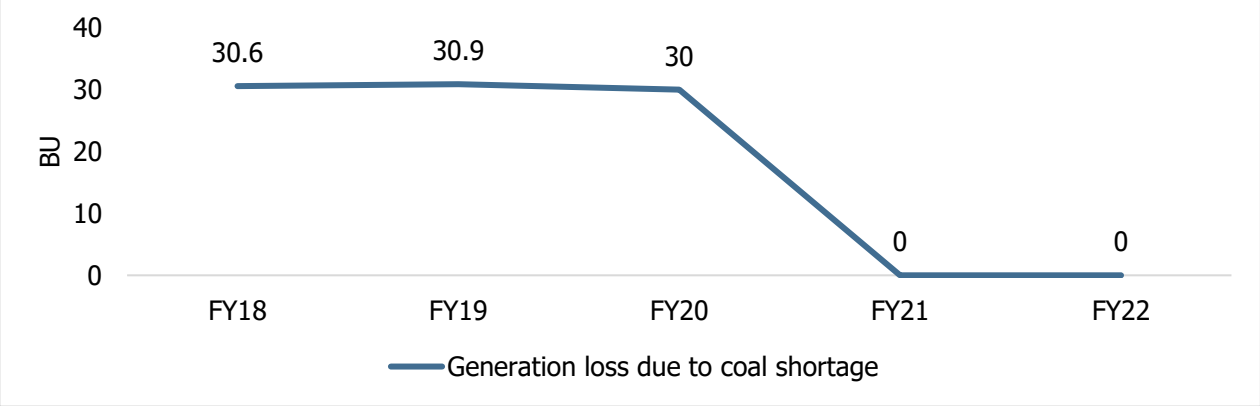
The Government of India has taken various measure to reduce the environmental emission which include improving the efficiency of power generation, notification of stricter environmental norms and retiring old thermal plants, etc.

- **Abundant availability of resources**

While the traditional thermal power generation requires fuels like coal, lignite, gas and diesel which are available in limited quantity and the resources deplete on usage, renewable power sources are abundantly available in nature and do not deplete.

From FY18 to FY20, there was around 30 BU of loss in generation due to coal shortage which has reduced to zero in FY21 and FY22 due to import of coal to meet the increasing demand. The loss of generation due to coal shortage as reported by the power utilities between FY18 to FY22 is given as below:

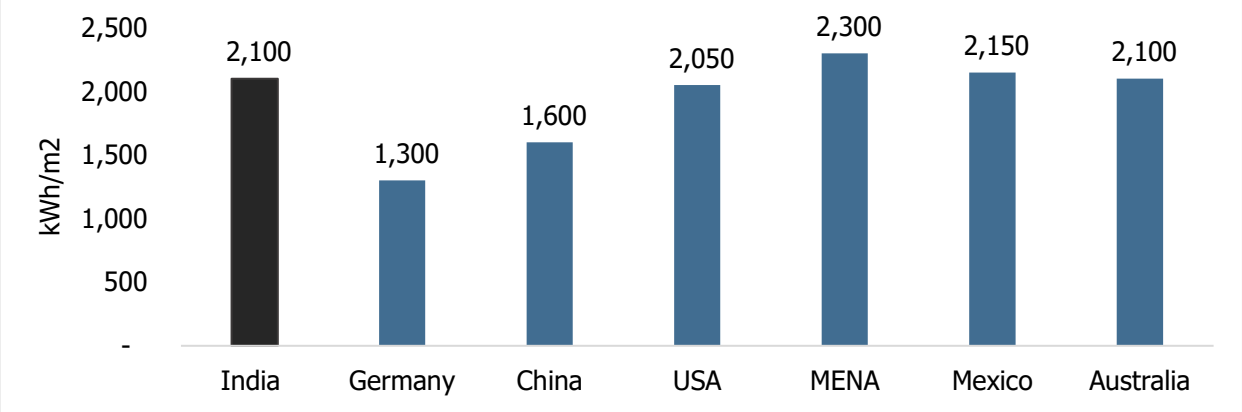
Chart 32: Generation loss due to coal shortage



Source: National Electricity Plan Vol 1 (March 2023), CareEdge Research

India has a large amount of solar energy potential with incidence of approximately 5,000 trillion kWh of energy over India's geographical area each year. Among various countries like Germany, China, USA, etc. India has the highest solar irradiance. The abundance of solar irradiance and availability of solar energy throughout the year has created enormous opportunities to exploit solar energy especially in states like Rajasthan, Gujarat, and Andhra Pradesh.

Chart 33: Solar Irradiance data – India and World (kWh/m2)



Source: Solargis, CareEdge Research

Wind is an intermittent and site-specific resource of energy and therefore, an extensive Wind Resource Assessment is essential for the selection of potential sites. The Government, through National Institute of Wind Energy (NIWE), has installed over 800 wind-monitoring stations all over country and issued wind potential maps at 50m, 80m, 100m and 120m above ground level. The recent assessment indicates a gross wind power potential of 302 GW in the country at 100 meter and 696 GW at 120 meter above ground level.

Most of this potential exists in seven windy states including Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Rajasthan, Tamil Nadu and Telangana.

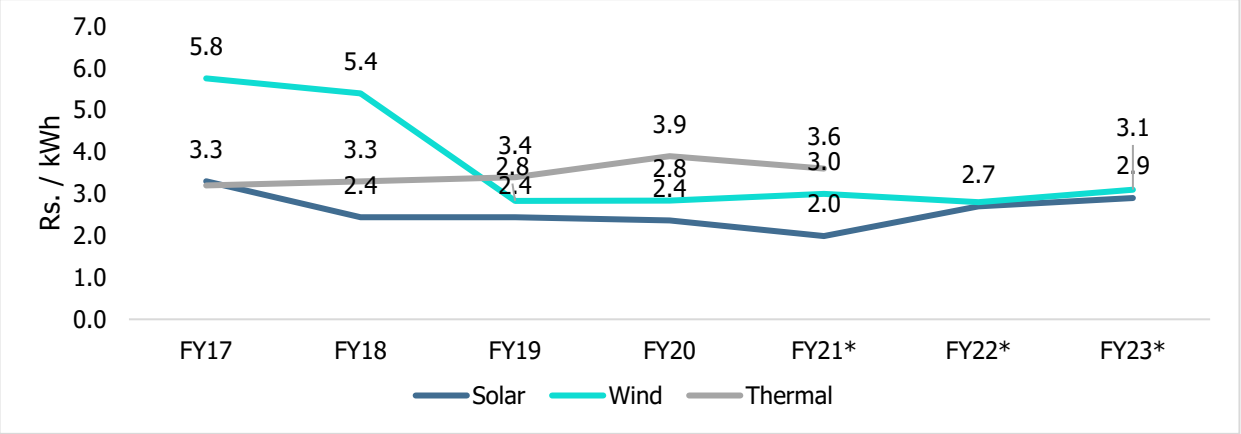
- **Lower Tariffs as compared to thermal power plants**

Clean generation technologies like solar and wind are becoming increasingly cost competitive compared to the traditional technologies.

The tariffs of wind and solar projects have declined sharply in comparison with thermal power projects in the past few years. Solar tariffs have reduced from Rs. 6.47/ Kwh in FY14 to Rs. 2.9/ Kwh in FY23, driven by declining solar panel prices, supportive government policies, technological advancements and intense competition resulting in significantly lower tariffs than the thermal power tariffs.

A similar drop was observed in wind power when the procurement process was changed from Feed in Tariff to bidding in 2017.

Chart 34: Trend in Tariff of Solar and Wind as compared to thermal power projects (Rs. /kWh)



* Tariff represents average of bids during the respective periods
Note: Thermal tariffs for FY22 and FY23 are not available
Source: MNRE Annual Report, CareEdge Research

- **Lower offtake risk**

DISCOMs purchase power from multiple power producers, across various generation types and under different contractual frameworks. Since renewable energy have the must run status, the electricity from these renewable plants cannot be curtailed for any commercial reasons. This reduces the offtake risk since in case of excess supply or availability of cheaper power, the DISCOMs cannot curtail the RE power or refrain the power producers from generating or dispatching power.

- **Low Risk of completion compared to thermal projects**

Renewable energy (solar and wind) plants are easier to construct in terms of complexity and take less time as compared to the coal and gas fired plants. Further, they are easier to maintain. Hence the risk of completion in solar and wind projects are lower compared to thermal and nuclear projects.

Table 6: Construction time for various type of power projects

Sr. No.	Resource	Construction Time (in years)
1.	Coal	4
2.	Solar	0.5
3.	Wind (Onshore)	1.5
4.	Wind (Offshore)	1.5

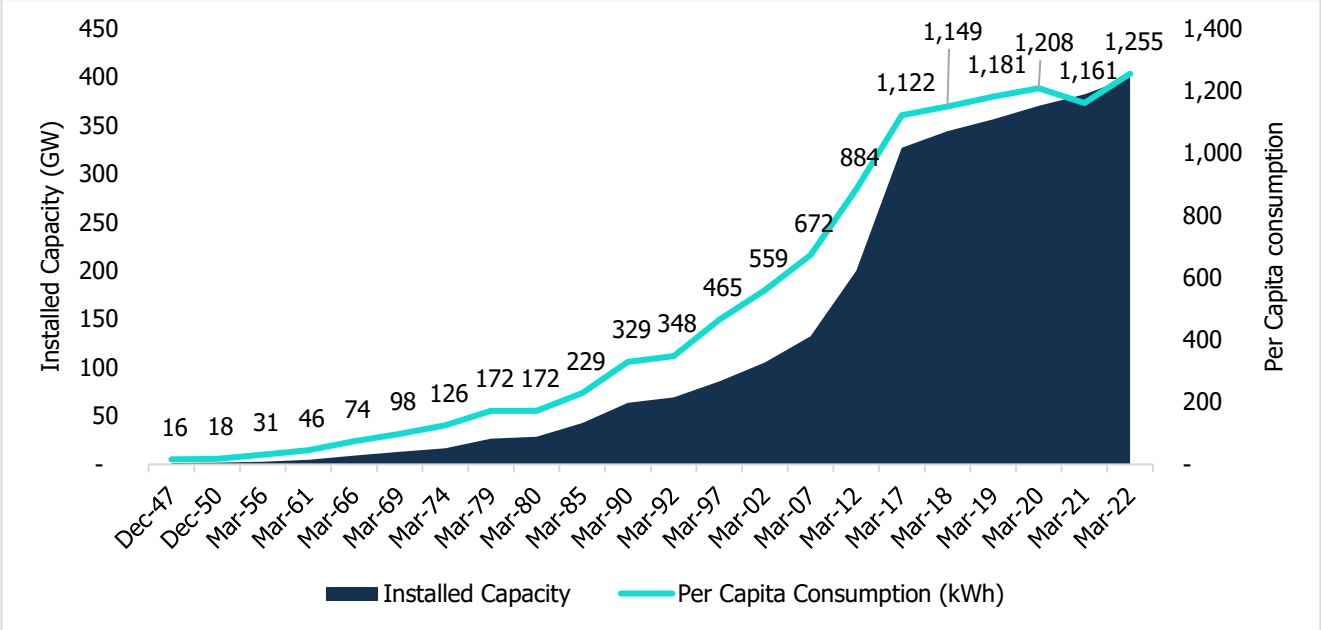
Source: National Electricity Plan Vol 1 (March 2023), CEA, CareEdge Research

2.3 India's per capita power consumption

India's per capita power consumption

India's per capita power consumption has been on a consistent rise with the government focusing more and more on electrification of villages and families across the country. It has risen steadily over the last nine years, from 884 kWh per capita in 2011-12 to 1,255 kWh per capita in 2021-22. At the time of India's independence in 1947, demand was only 16 kWh per capita.

Chart 35: Growth of Electricity Sector in India - Installed Capacity and Per Capita Consumption*



Source: CEA, CareEdge Research
(*) Per Capita Consumption= Gross Electricity availability/ Mid-year Population

Developed countries such as Japan and the United States have the world's highest per capita electricity consumption. India's per capita consumption has remained low as compared to even the emerging countries like Brazil and Mexico, implying significant room for growth.

Table 7: Global Per Capita Consumption Comparison (MWh/Capita)

Year	World	India	Nigeria	Mexico	Thailand	Brazil	China	Japan	USA
1990	2.06	0.32	0.11	1.14	0.70	1.46	0.53	6.71	11.69
1995	2.14	0.46	0.11	1.38	1.25	1.63	0.79	7.53	12.64
2000	2.32	0.51	0.09	1.76	1.45	1.90	1.02	8.05	13.66
2005	2.58	0.61	0.13	1.98	1.91	2.02	1.81	8.30	13.68
2010	2.87	0.77	0.14	2.02	2.31	2.37	2.96	8.78	13.38
2015	3.06	1.01	0.15	2.23	2.58	2.56	4.05	8.01	12.86
2019	3.30	1.18	0.10	2.40	2.90	2.60	5.10	7.90	12.70

Source: IEA, CEA (For India), CareEdge Research
Data for India is as per FY-Financial Year while for others it is CY-Current Year

Sector wise Power Consumption in India

The Industrial sector accounts for majority of the power consumption in India followed by the domestic sector. The industrial sector consumption recorded a CAGR of 4.3% between FY13 and FY22 whereas the domestic sector recorded 7% over the same period, thereby indicating an increase in power consumption by the domestic sector as more and more household got access to electricity. The commercial and agricultural sectors' consumption recorded a CAGR of 4.4% and 5%, respectively, between FY13 and FY22.

Table 8: Sector wise Power Consumption in India

	Year	FY13	FY18	FY19	FY20	FY21	FY22*
Domestic	GWh	183,700	273,545	288,243	308,745	330,809	334,000
	As % of total	22.3%	24.3%	23.8%	24.7%	26.9%	25.8%
Commercial	GWh	72,794	93,755	98,228	106,047	86,950	107,500
	As % of total	8.8%	8.3%	8.1%	8.5%	7.1%	8.3%
Industrial	GWh	365,989	468,613	519,196	532,820	508,776	533,500
	As % of total	44.4%	41.7%	42.9%	42.7%	41.4%	41.2%
Traction & Railway	GWh	14,100	17,433	18,837	19,148	14,668	19,800
	As % of total	1.7%	1.6%	1.6%	1.5%	1.2%	1.5%
Agriculture	GWh	147,462	199,247	213,409	211,295	221,303	229,000
	As % of total	17.9%	17.7%	17.6%	16.9%	18.0%	17.7%
Misc.	GWh	40,256	70,834	72,058	70,031	67,701	72,500
	As % of total	4.9%	6.3%	6.0%	5.6%	5.5%	5.6%
Total	GWh	824,301	1,123,427	1,209,972	1,248,086	1,230,208	1,296,300

*Provisional

Source: Energy Statistics India-2023, Ministry of Statistics and Programme Implementation, CareEdge Research

India is among the top nations in the world which are leading the global renewable energy growth. On technology specific installed capacity, India ranks 3th in onshore wind, 5th in Solar, 4th in Bioenergy and 6th in Hydro as per International Renewable Energy Agency (IRENA) renewable capacity statistics 2023.

Table 9: List of top 10 countries – Installed Capacity Statistics 2023 (As on Dec 2022)

Ranking	Technology Specific Ranking by Installed Capacity					Ranking - Total Renewable Installed Capacity
	Onshore Wind	Offshore Wind	Solar	Bioenergy	Hydro	
1	China	China	China	China	China	China
2	USA	UK	USA	Brazil	Brazil	USA
3	Germany	Germany	Japan	USA	USA	Brazil
4	India	Netherlands	Germany	India	Canada	India
5	Spain	Denmark	India	Germany	Russia	Germany
6	Brazil	Belgium	Australia	UK	India	Japan
7	France	Vietnam	Italy	Japan	Japan	Canada
8	Canada	Chinese Taipei	Brazil	Thailand	Norway	Spain
9	UK	France	Netherlands	Sweden	Turkey	France
10	Sweden	Sweden	Korea	Italy	France	Italy

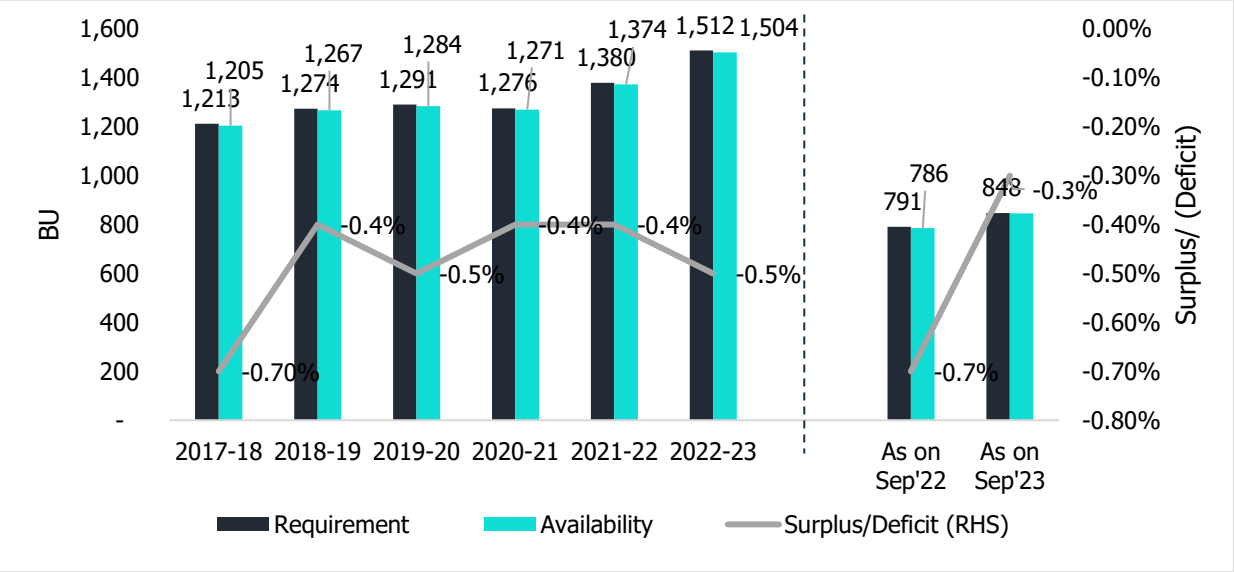
Source: IRENA Renewable Capacity Statistics 2023, CareEdge Research

2.4 Power Demand, supply and deficit in India

Power demand in the country has been on a rise in the past decade, with an exception during FY21 due to the Covid-19 pandemic. Peak energy demand grew at a CAGR of 4.7% from 148 GW in FY14 to 216 GW in FY23, while peak supply grew at a CAGR of 5.3% over the same time period. There has also been a decrease in the peak shortage from 6.1 GW in FY14 to 2.4 GW in FY22, and decline in the power deficit of the country supported by improving supply. However, in previous year i.e. FY23, there was a significant increase in peak shortage to 8.6 GW.

Covid-19 induced lockdown and restrictions had led to lower demand and generation of electricity since the pandemic had curtailed commercial and business activity. As a result, the first half of FY21 witnessed a decline in power demand. However, with the gradual reopening of the economy despite localized lockdowns, the power demand has continued to gradually rise over the past 2 years.

Chart 36: Power Supply Position in India



Source: Power Ministry, CEA, CareEdge Research

The electricity requirement has grown from 1,274 BU in FY19 to 1,512 BU in FY23. There has been a continuous deficit between electricity requirement and availability of around 0.4%-0.5% between FY19 and FY23. During April-September 2023, the electricity demand stood at 848 BU, an increase of 7% y-o-y, while the deficit was 0.3%.

The peak demand not met was around 3.31 GW in FY18 and the average energy not supplied was around 8,629 MU. The peak demand not met and energy not supplied has been on a downward trend and has substantially decreased to 2,475 MW and 5,787 MU, respectively, in FY22. However, in FY23, due to very high demand of power, the peak demand not met was 8.6 GW and energy not supplied increased to 7,582 MU. In April-September 2023, the peak demand not met was 731 MW and the energy not supplied was 2,444 MU.

There was a 9.6% y-o-y increase in the power requirement by the country in FY23. The power consumption and demand were highest in months of March and April due to higher temperatures during the summer season compared to last year.

2.5 Outlook and Growth Drivers

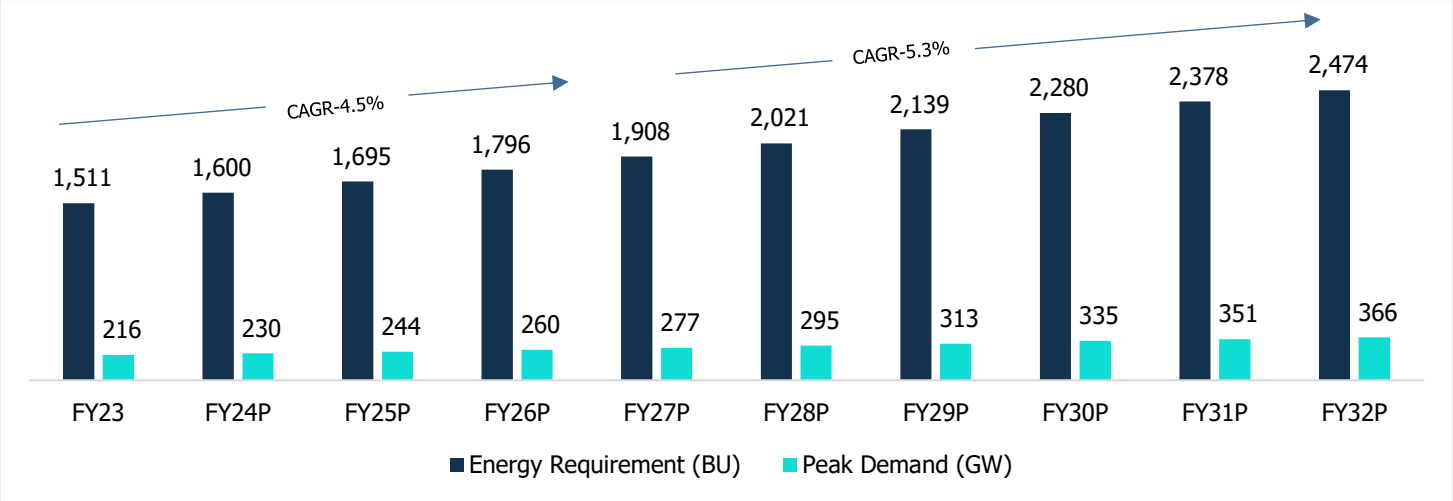
According to the 20th Electric Power Survey of India, the all India peak electricity demand projected for FY27 is 277 GW and energy requirement is projected at 1,908 BU. Going forward, the power demand is further expected to rise with rise in population and increased economic activity.

The CAGR between FY24 and FY27 is expected to be around 4.5% for energy requirement while for peak demand it is expected to be around 4.8%. For FY27 to FY32, the CAGR is on a higher side at 5.3% for energy requirement and 5.7% for peak demand.

The government has taken various steps to meet the peak demand of power such as:

- 175 GW of power generation capacity, 17,33,459 ckt kms of transmission lines and 6,21,176 MVA of transformation capacity has been added to the grid from 2014 till 31.12.2022.
- Schemes like Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY)/ Pradhan Mantri Sahaj Bijli Har Ghar Yojana (SAUBHAGYA) / Integrated Power Development Scheme (IPDS) have strengthened the distribution system.
- 100% FDI through automatic route for power generation projects
- Private sector participation in generation and transmission through notification of revised Tariff Policy on 28.01.2016
- For promoting generation, purchase, consumption of green energy the Green Open Access Rules, 2022 have been notified on 06.06.22
- Revamped Distribution Sector Scheme (RDSS) launched in 2021 for improving the financial sustainability and make operationally efficient distribution sector.
- The Electricity Amendment Rules, 2022 has been notified on 29.12.2022 which mandate preparation of resource adequacy plan so as to successfully meet the power demand of the consumers.

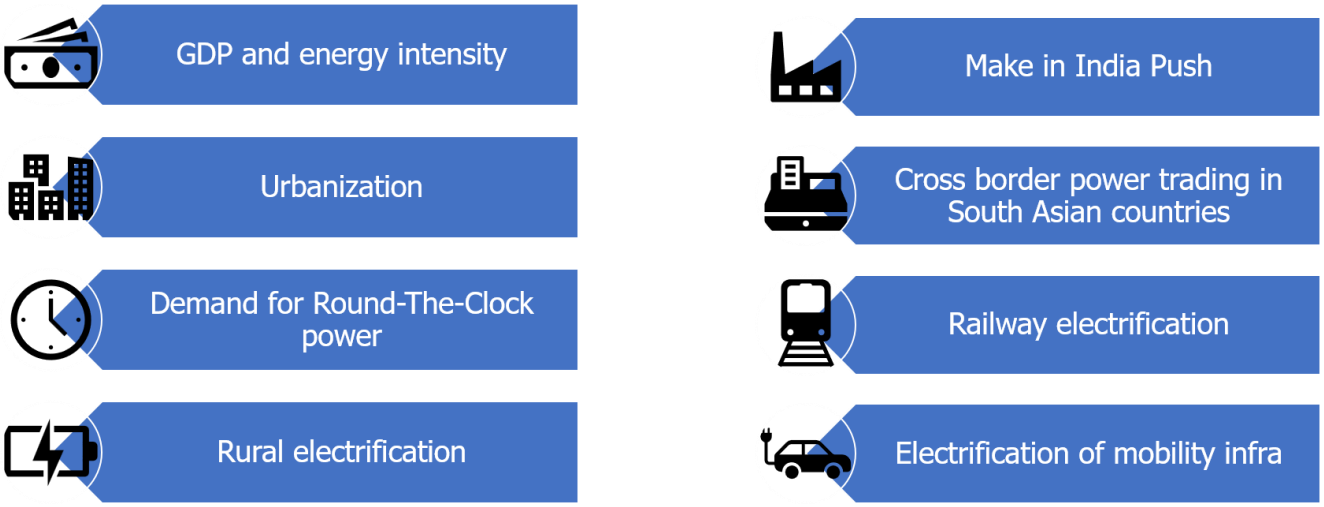
Chart 37: Projected All India Peak Demand and Energy Requirement



*Projected
Source:20TH Electric Power Survey of India, CareEdge Research

The growth drivers for the increasing power demand are mentioned as below.

Chart 38: Growth Drivers for power demand



Source: CareEdge Research

- **GDP and energy intensity**

India has latent power demand because of its low per capita power consumption, strong GDP outlook and growing population. India is likely to emerge as one of the world's fastest growing economy as per IMF which is expected to lead to an increase in the power demand of the country.

- **Urbanization**

Urbanization leads to faster infrastructure development, job creation, development of the consumer and services sectors, and hence is a major driver for the growing power demand. The urban consumption is increasing due to rising disposable income, favourable demographics and the trend is likely to continue.

- **Demand for Round-The-Clock power**

Recently, there has been a significant focus on blending two or more energy sources like wind-solar hybrid to achieve better synergies, higher plant load factor and better energy gains. The wind and solar energy have complementary generation patterns and hence provide smooth output. Round-The-Clock ensures quality clean power is made available round the clock, mixing renewable with conventional energy sources for stable power and utilization of existing coal-based plants.

- **Rural Electrification**

The government of India has taken joint initiative with the state governments for providing Power for All (PFA) to all households/homes, industrial and commercial consumers including supply of power to agricultural consumers. PFA initiative along with rural electrification across various states aims to ensure 24X7 electricity access, enhance the satisfaction levels of the consumers, improve quality of life of people and increase economic activities resulting in development. This is one of the key drivers for the growing power demand.

Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) was launched in December 2014 with the objective of electrification of all un-electrified villages as per Census 2011 by the Government of India. Similarly, Pradhan Mantri Sahak Bijli Har Ghar Yojana- SAUBHAGYA was launched in October 2017 for electrification of rural and urban poor households in the country.

Following have been achieved so far:

1. All 5,97,464 (Census 2011) inhabited villages stood electrified as on 28.04.2018
2. SAUBHAGYA Scheme:
   a. Under this scheme, projects worth Rs. 140.82 billion were sanctioned with a closure cost of Rs. 92.46 billion. Against this central grant of Rs. 63.05 billion were released up to March 2022.
   b. Under the SAUBHAGYA scheme as on March 2019, all households were reported electrified by the states except 18,734 households in Left Wing Extremists (LWE) affected areas of Chhattisgarh.
   c. Subsequently the seven states namely Assam, Chhattisgarh, Jharkhand, Karnataka, Manipur, Rajasthan and Uttar Pradesh had reported 1.909 million unelectrified household that were unwilling, later as on March 2021 these households expressed willingness and the states reported 100% electrification.
   d. Post March 2021, around 1.184 million households remain to be electrified as reported by the states against which 0.443 million households have been electrified.
   e. Under the SAUBHAGYA scheme, a total of 28.17 million households were electrified as on March 2021 and as on March 2022, the schemes stand closed.
3. For 24X7 power supply:
   - In Urban areas, 20 states comprising of 24 DISCOMs having more than 20 average hours of power supply in a day has been achieved.
   - In Rural areas, 17 states and 1 union territory (UT) comprising of 35 DISCOMs having more than 20 hours of power supply in a day has been achieved.
4. The present status of power availability has reached 22 ½ hours on average in rural areas and 23 ½ hours in urban areas.

Schemes like Integrated Power Development Scheme (IPDS) with an outlay of Rs. 326.12 billion including a budgetary support of Rs. 253.54 billion from the Government of India have been approved. Other schemes like Deendayal Upadhyaya Gram Jyoti Yojana, Pradhan Mantri Sahaj Har Ghar Yojana, etc. have also been announced.

Table 10: State-wise details of electrification of households since launch of SAUBHAGYA Scheme / Additional sanctions and achievements under DDUGJY – as on March 2022

Sr. No.	States	Original households sanctioned under SAUBHAGYA	Additional households sanctioned under SAUBHAGYA		Additional Households sanctioned under DDUGJY		Grand Total
		From 11.10.2017 to 31.03.2019	From 01.04.2019 to 31.03.2021	As on 31.03.2021	Additional Sanctioned	Electrified as on 31.03.2022	
1.	Andhra Pradesh*	1,81,930	0	1,81,930			1,81,930
2.	Arunachal Pradesh	47,089	0	47,089	7,859	0	47,089
3.	Assam	17,45,149	2,00,000	19,45,149	4,80,249	3,81,507	23,26,656
4.	Bihar	32,59,041	0	32,59,041			32,59,041
5.	Chhattisgarh	7,49,397	40,394	7,89,791	21,981	2,577	7,29,368
6.	Gujarat*	41,317	0	41,317			41,317
7.	Haryana	54,681	0	54,681			54,681
8.	Himachal Pradesh	12,891	0	12,891			12,891
9.	Jammu & Kashmir	3,77,045	0	3,77,045			3,77,045
10.	Jharkhand	15,30,708	2,00,000	17,30,708			17,30,708
11.	Karnataka	3,56,974	26,824	3,83,798			3,83,798
12.	Ladakh	10,456	0	10,456			10,456
13.	Madhya Pradesh	19,84,264	0	19,84,264	99,722	0	19,84,264
14.	Maharashtra	15,17,922	0	15,17,922			15,17,922
15.	Manipur	1,02,748	5,367	1,08,115	21,135	0	1,08,115
16.	Meghalaya	1,99,839	0	1,99,839	420	401	2,00,240
17.	Mizoram	27,970	0	27,970			27,970
18.	Nagaland	1,32,507	0	1,32,507			1,32,507
19.	Odisha	24,52,444		24,52,444			24,52,444
20.	Puducherry*	912		912			912
21.	Punjab	3,477	0	3,477			3,477
22.	Rajasthan	18,62,736	2,12,786	20,75,522	2,10,843	52,206	21,27,728
23.	Sikkim	14,900	0	14,900			14,900
24.	Tamil Nadu*	2,170	0	2,170			2,170
25.	Telangana	5,15,084	0	5,15,084			5,15,084
26.	Tripura	1,39,090	0	1,39,090			1,39,090
27.	Uttar Pradesh	79,80,568	12,00,003	91,80,571	3,34,652	0	91,80,571
28.	Uttarakhand	2,48,751	0	2,48,751			2,48,751
29.	West Bengal	7,32,290	0	7,32,290			7,32,290
TOTAL		2,62,84,350	18,85,374	2,81,69,724	11,83,870	4,43,700	2,86,13,424

* Electrified prior to SAUBHAGYA and not funded under SAUBHAGYA

Source: PIB, CareEdge Research

- **Make in India push**

The Make in India Initiative which aims to boost manufacturing's share in the GDP would lead to substantial growth in electricity demand.

- **Cross border power trading in South Asian countries**:

Power deficit in India has been on a declining trajectory and India is expected to further expand its generation capacity. India is also evaluating opportunities with neighbouring countries such as Nepal, Bangladesh, Sri Lanka, Maldives and Bhutan for better integration and synergies by interlinking electricity transmission systems and allowing surplus power to be exported to other grids.

- **Railway Electrification**

A lot of emphasis is given to railway electrification with the view to reduce the nation's dependence on the imported coal and petroleum-based energy and with a vision of providing eco-friendly, faster and energy-efficient mode of transportation. In the past 9 years, the pace of electrification has increased significantly with a record breaking 37,011 route kms (RKM) of tracks being electrified.

A total of 58,424 RKMs have been electrified, nearly 50% was completed in the last 5 years alone. 100% railway electrification in 14 states/UTs has been achieved making significant strides. Electrification of 6,542 RKMs has been achieved in Indian railways history during FY23, registering an increase of 2.76% over last year. Government plans to fully electrify railway network by 2024. To support the electrified railway network, close to 30 billion units of electricity shall be required on an annual basis by 2024.

- **Electrification of Mobility Infra**

The global market for electric vehicles (EVs) is growing. As per the International Energy Agency (IEA), the global EV fleet will reach about 130 million by 2030, a sharp rise from just more than 5.1 million in 2018.

The growth of EV segment in India has also been on an increasing trend. The penetration of EVs has increased to 5% of the total vehicle sales in FY23. The EV sales have witnessed massive growth in FY23 on account of favourable government policies for EVs supporting reduction in upfront cost and expansion of charging infrastructure, rising fuel prices and shifting consumer preferences**.**

The 2-wheeler and 3-wheeler segments dominate the electric vehicles market in India, comprising of around 62% and 34%, respectively, of total EV sales in year FY23. Electric two-wheelers (E2Ws) are a key segment of the electric vehicle market in India, with growing interest among consumers and increasing government support for electric mobility. On the other hand, Electric three-wheelers (E3Ws) are also an important mode of public transportation in India, particularly for last-mile connectivity and intra-city transportation. The historical trends of sales of EVs in each segment are depicted in the table below:

Table 11: Sale of EV Units in India (in units)

EV Sales Units	FY18	FY19	FY20	FY21	FY22	FY23
Two-wheeler	1,897	25,393	24,839	40,837	2,52,547	7,27,434
Three-wheeler	92,395	1,18,944	1,40,683	88,378	1,82,587	4,04,231
Four-wheeler	1,362	1,632	2,727	4,588	18,565	47,383
Goods vehicle	993	517	50	28	2,452	3,049
Total EV sales units	**96,647**	**1,46,486**	**1,68,299**	**1,33,831**	**4,56,151**	**11,82,097**

Source: Council of Energy & Environment & Water (CEEW), CareEdge Research

The Government of India has targeted 30% EV penetration by 2030. NITI Aayog projects EV sales penetration of 80% for two and three wheelers, 50% for four wheelers, and 40% for buses by 2030.

As EV adoption grows, there will be additional power demand for EVs and hence readiness of the electricity grid to EV charging demand is critical to achieve rapid and large-scale transition to EVs.

The total electricity demand for EVs, at 33% EV penetration rate by 2030, is projected to be 37 TWh as per NITI Aayog 2021 report. This constitutes less than 2% of the total electricity demand across the country by 2030. Therefore, meeting the overall energy demand for EVs in India can be met going forward. The charging demand by vehicle segment is depicted below in the table:

Table 12: Charging demand by vehicle segment

Vehicle segments	Total daily charging demand in kWh - 2025	Total daily charging demand in kWh – 2030
E – 2W	1,25,596	7,65,442
E-3W (passenger / cargo)	2,55,162	9,72,757
E-car (personal)	17,498	1,64,786
E-car (commercial)	55,931	4,91,838
Total	**4,54,187**	**23,94,823**

Source: Handbook of electric vehicle charging infrastructure implementation by NITI Aayog – Version 1

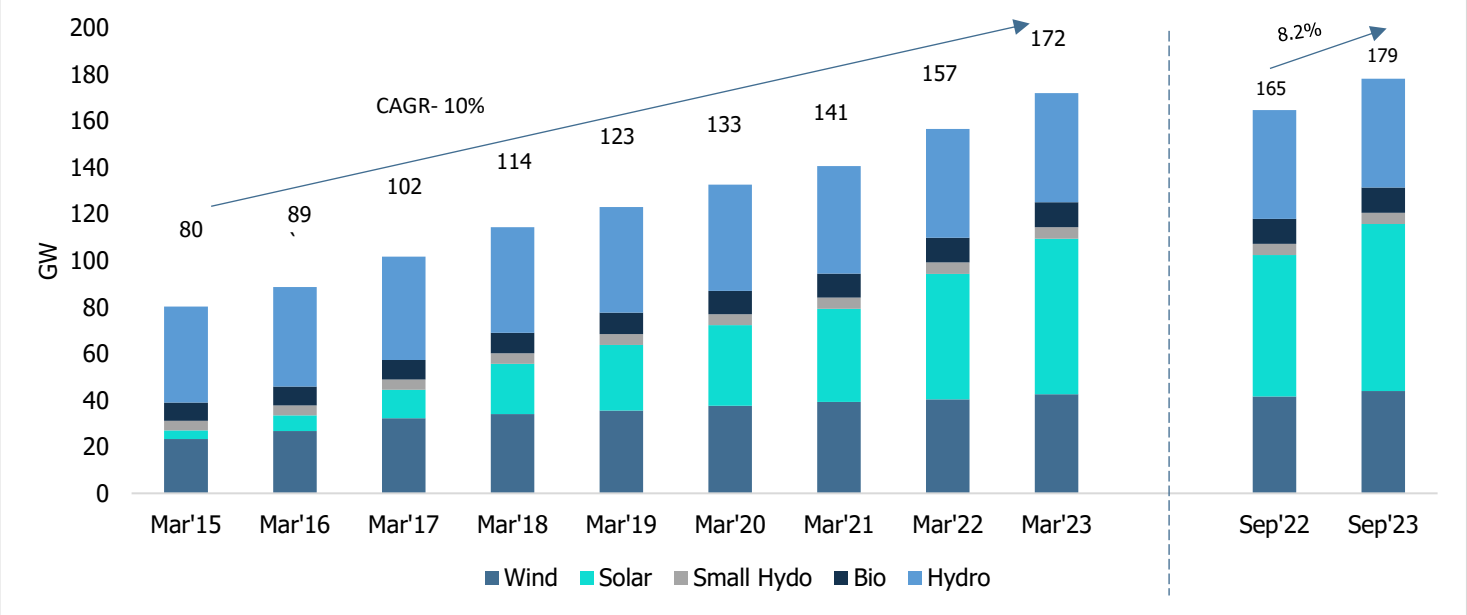
3. Renewable Energy

3.1 Overview

There has been a significant shift globally in the generation capacity mix due to the growing concerns towards the environment and climate change. India is an active participant and has taken initiatives towards sustainable development and cleaner environment including significant additions of renewable energy generation capacity.

As per REN21 Renewables 2022 Global Status Report, India currently ranks 4th globally in total renewable energy installed capacity, wind power capacity and solar power capacity with generation from non-fossil fuel sources being 41% of the total installed generation capacity in 2022. The total potential of renewable power in India is estimated to be 1,639 GW as compared to installed capacity of 179 GW as on September 2023. The installed capacity of renewable energy has grown by 92 GW over FY15-FY23, implying a CAGR of around 10%.

Chart 39: Renewable Energy – Trend in Installed Capacity



Note: Small Hydro denotes projects up to 25 MW, Hydro Power Plants denotes projects more than 25 MW
Source: CEA, CareEdge Research

- **Solar:**

In the last nine years, solar power capacity has risen manifold, from 4 GW in Mar 2015 to 72 GW as on September 2023, supported by MNRE. Solar tariffs in India are now highly competitive and have reached grid parity. Along with large scale grid connected solar PV, there is development of off-grid solar projects for local needs in India.

Solar energy in India has emerged as a significant player in the grid connected power generation capacity over the years and various initiatives by the government like National Solar Mission, Solar Park Scheme, VGF Schemes, CPSU Scheme, Canal and Canal top Scheme, Grid Connected Solar Rooftop Scheme, etc. have helped solar to grow fastest among other renewable energy sources.

As per Central Electricity Authority (CEA), as on July 2023, solar projects aggregating 36.27 GW are under construction.

- **Wind:**
  With a total installed capacity of 44 GW (as of September 2023), the country has the fourth largest wind installed capacity in the world. The pace of capacity additions in wind has slowed down in the past few years due to non-availability of favourable wind sites, policy structure moving away from feed-in-tariff mechanism to competitive bidding, removal of generation-based incentives (GBI) and accelerated depreciation (AD) benefits etc. These factors are expected to continue to affect future capacity additions in wind.

  As per Central Electricity Authority (CEA), as on July 2023, wind projects aggregating to 17.23 GW are under construction.

- **Hydro:**
  India has the fifth-largest installed hydroelectric power capacity in the world. India's installed utility-scale hydroelectric capacity was 47 GW as on September 2023, accounting for 11% of the country's total utility power generating capacity. Hydro projects aggregating to 10.9 GW are under construction and are likely to be completed between FY24 and FY27.

- **Small Hydro**
  The Ministry of New and Renewable Energy (MNRE) is in charge of constructing Small Hydro Power (SHP) Projects, i.e. hydro power projects with a capacity of up to 25MW. As on September 2023 the total installed capacity is 4,982 MW while another 277 MW are under construction.

- **Bioenergy:**
  Power generation from bioenergy and waste to energy offers good potential in rural areas especially if they are far from the grid. The total power generating capacity is 10,835 MW as on September 2023. Gasification based (bioenergy) power projects of aggregate capacity of 59.25 MW are under construction along with 227.25 MW of waste to energy and co-generation projects.

Table 13: Physical Progress cumulative up to September'23 (GW):

Sector	Cumulative up to September 2023	Under Construction As on July 2023	Tendered As on July 2023	Potential (GW)
Hydro Power	46.9	10.9	0	148
Wind Power	44.2	17.23	1.2	695
Solar Power	71.8	36.27	20.3	750
Small Hydro Power	4.9	0.3	0	21
Bioenergy- Biomass (Bagasse) Cogeneration	9.4	0	0	22
Bioenergy- Biomass (Non-Bagasse) (Cogeneration/ Captive Power)	0.8	0	0	
Waste to Power	0.2	0	0	3
Waste to Energy (Off-grid)	0.3	0	0	
Hybrid/ Round the clock/ Thermal + RE bundling	-	-	11.0	0
Total	**178.6**	**64.7**	**33**	**1,639**

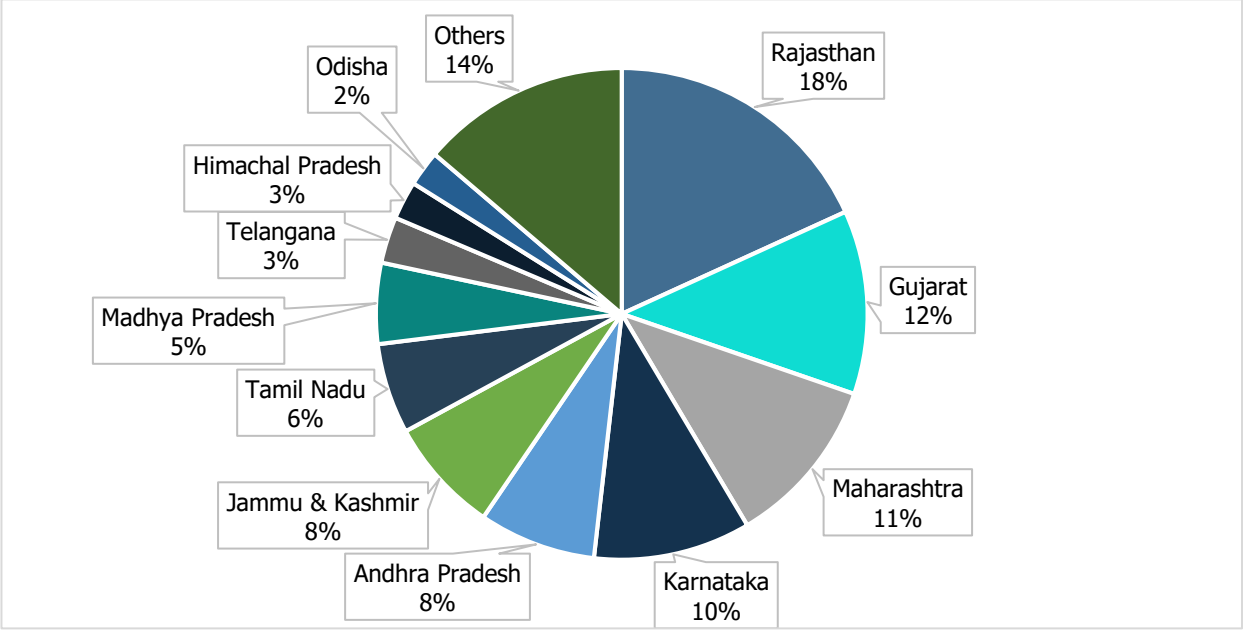
Source: MNRE, Energy Statistics India 2023, CareEdge Research

The MNRE has declared a quarterly plan for bids for FY24, which includes bids of around 15 GW of renewable energy in first and second quarter of FY24 and around 10 GW of renewable energy in third and fourth quarters of FY24. The targeted capacity for FY24 will be allocated among the four Renewable Energy Implementing Agency (REIA) i.e. Satluj

Jal Vidyut Nigam (SJVN), Solar Energy Corporation of India Ltd. (SECI), National Thermal Power Corporation (NTPC) and National Hydro Electric Power Corporation (NHPC).

The state-wise potential of renewable energy is as below. Rajasthan, Gujarat, Maharashtra, Karnataka and Andhra Pradesh are top 5 renewable energy potential states.

Chart 40: State-wise estimated potential of renewable power in India



*Excluding Hydro power

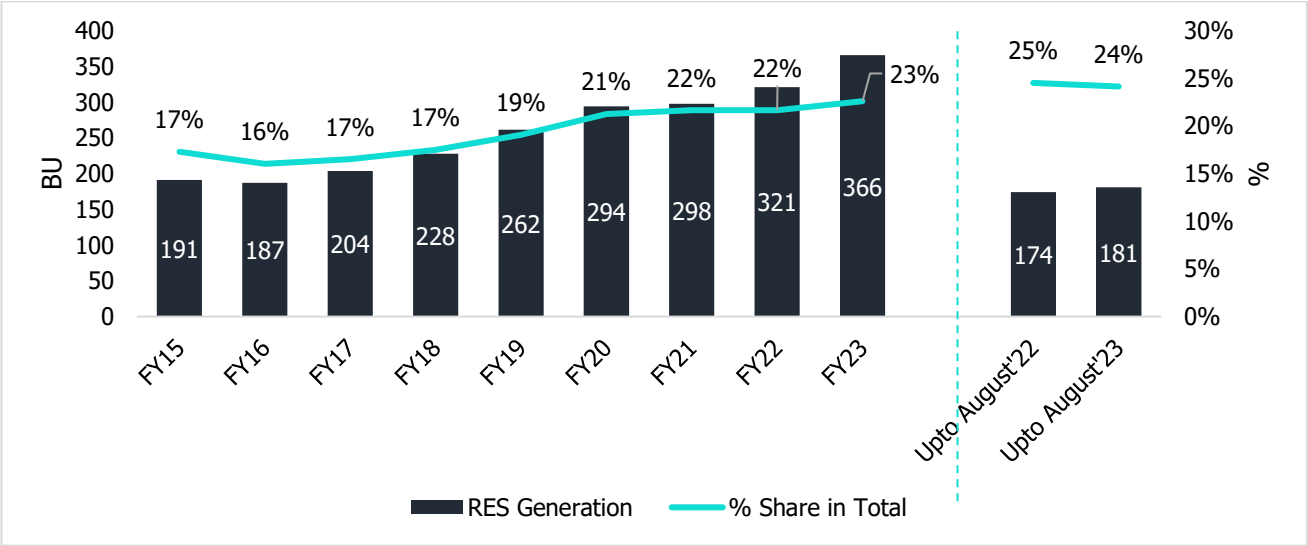
Source: Energy Statistics India 2023, CareEdge Research

3.2 Trend in Renewable Generation

India is the world's third-largest producer of energy and is also the second largest consumer of electricity.

While conventional sources (thermal power comprising of coal, lignite, gas and diesel-based power plants) currently account for 58% of installed capacity, installed capacity of RES, which currently accounts for 42%, is expected to contribute equally as the conventional sources in the long term supported by Government of India's ambitious projects and targets.

Chart 41: Share of Renewables in total power generation



RES includes Solar, Wind, Hydro, Small Hydro and Bioenergy.
Source: CEA, CareEdge Research

In FY15, the power generated from renewable sources including hydro was 191 BU which has increased to 366 BU in FY23, growing at a compounded annual growth rate of 8.5%. The share of renewable also increased from 17% in FY15 to around 23% in FY23.

In FY15, hydro power had the largest share in renewable energy generation at 68% followed by wind at 9%. In FY23, while hydro continues to have the largest share, it has decreased from 68% to 44%, and solar has emerged as the second largest with a share of 28% followed by wind.

Chart 42: Breakup of renewable energy generation FY15

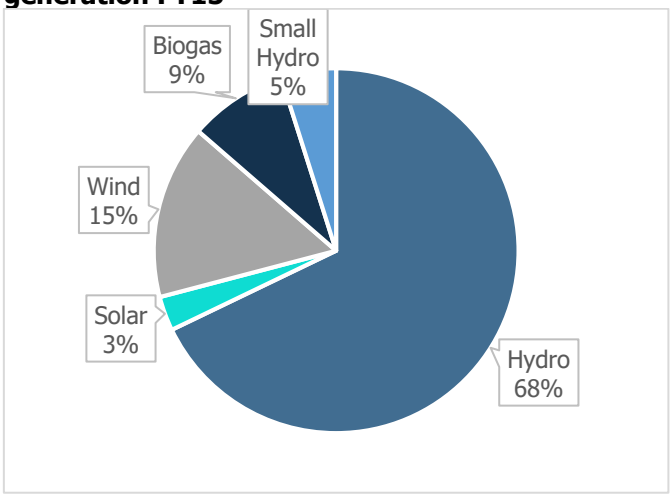
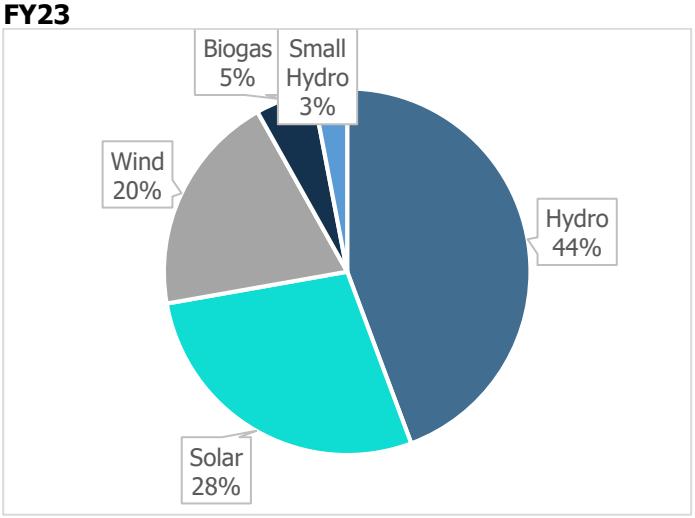


Chart 43: Breakup of renewable energy generation FY23



Source: CEA, CareEdge Research

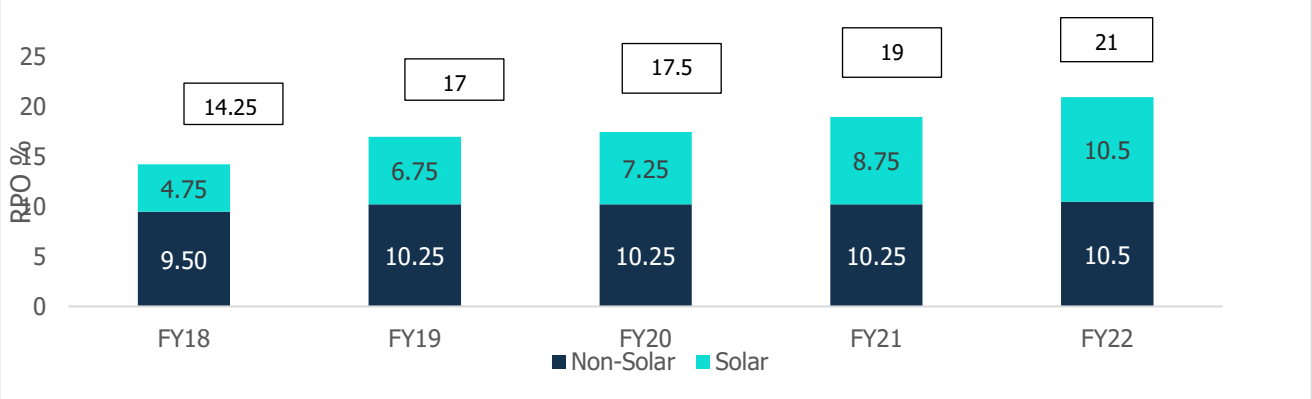
3.3 Renewable Purchase Obligation (RPO)

Under Section 86(1) (e) of the Electricity Act 2003 and the National Tariff Policy 2006, Renewable Purchase Obligation (RPO), is a mechanism by which the obligated entities are obliged to purchase certain percentage of electricity from renewable energy sources, as a percentage of the total consumption of electricity or buy, in lieu of that, renewable energy certificates (REC) from the market.

RPOs were earlier categorised as solar and non-solar RPOs. However, as per the latest targets, RPOs are categorized as Wind RPO, Hydro RPO, Distributed RPO and Others. Obligated entities (which includes distribution companies (or DISCOMs), open access consumers and captive power producers) are obligated to purchase a minimum share of their electricity from renewable energy sources as per RPO targets.

The RPO target set for FY18 was 14.25% which was gradually increased to 21% for FY22.

Chart 44: Long term RPO Trajectory



Source: National Portal for Renewable Power Obligations, MNRE, CareEdge Research

The Central Electricity Regulatory Commission has taken a position that it does not have the jurisdiction to enforce RPOs in the relevant states and that the responsibility of setting RPO targets and implementation rests with the State Electricity Regulatory Commissions (SERCs). However, some of the SERCs have not enforced RPOs and the market for RECs has not matured as originally expected when the legislation was adopted. However, revenue from REC sales has increased following the order of the Appellate Tribunal for Electricity to resume REC trading from November 24, 2021 after a ban on REC trading since July 2020.

The state-wise RPO targets for various states from FY18 to FY22 is given as below:

Table 14: State-wise RPO targets from FY17 to FY22

Sr. No.	State	RE Technology	2017-18	2018-19	2019-20	2020-21	2021-22
1.	Andhra Pradesh	Non-Solar	6%	7%	8%	9%	10%
		Solar	3%	4%	5%	6%	7%
		Total	9%	11%	13%	15%	17%
2.	Arunachal Pradesh	Non-Solar	9.5%	10.25%	NA	NA	NA
		Solar	4.75%	6.75%	NA	NA	NA
		Total	14.3%	17%	0%	0%	0%
3.	Assam	Non-Solar	5%	6%	7%	8%	9%
		Solar	4%	5%	6%	7%	8%
		Total	9%	11%	13%	15%	17%
4.	Bihar	Non-Solar	5.5%	6%	6.75%	7.5%	9%
		Solar	2.25%	3.25%	4.75%	6.75%	8%
		Total	7.75%	9.25%	11.5%	14.25%	17%

Sr. No.	State	RE Technology	2017-18	2018-19	2019-20	2020-21	2021-22
5.	Chhattisgarh	Non-Solar	7%	7.5%	8%	8.5%	NA
		Solar	2%	3.5%	5%	6.5%	NA
		Total	9%	11%	13%	15%	NA
6.	Delhi	Non-Solar	9.5%	10.25%	11%	NA	NA
		Solar	4.75%	6.75%	8.75%	NA	NA
		Total	14.25%	17%	19.75%	NA	NA
7.	JERC (Goa & UT)	Non-Solar	4.2%	5.4%	6.8%	8%	9%
		Solar	2.5%	3.6%	4.7%	6.1%	8%
		Total	6.7%	9%	11.5%	14.1%	17%
8.	Gujarat	Non-Solar	8.25%	8.45%	8.8%	8.9%	9%
		Solar	1.75%	4.25%	5.5%	6.75%	8%
		Total	10%	12.7%	14.3%	15.65%	17%
9.	Himachal Pradesh	Non-Solar	9.5%	10.25%	10.25%	10.25%	10.5%
		Solar	4.75%	6.75%	7.25%	8.75%	10.5%
		Total	14.25%	17%	18%	19%	21%
10.	Jammu and Kashmir	Non-Solar	7.25%	8%	8.75%	9.5%	9.5%
		Solar	1.25%	1.5%	1.75%	2%	3%
		Total	8.5%	9.5%	10.5%	11.5%	12.5%
11.	Jharkhand	Non-Solar	4%	4.5%	5%	NA	NA
		Solar	3.75%	5.5%	6.55%	NA	NA
		Total	7.75%	10%	11.55%	NA	NA
12.	Karnataka	Non-Solar	NA	NA	NA	NA	NA
		Solar	NA	NA	NA	NA	NA
		Total	NA	NA	NA	NA	NA
13.	Kerala	Non-Solar	6%	7%	5.75%	6.05%	6.35%
		Solar	1.5%	2.75%	0.25%	0.25%	0.25%
		Total	7.5%	9.75%	6%	6.3%	6.6%
14.	Madhya Pradesh	Non-Solar	7%	7.5%	8%	8.5%	9%
		Solar	1.5%	1.75%	4%	6%	8%
		Total	8.5%	9.25%	12%	14.5%	17%
15.	Maharashtra	Non-Solar	10.5%	11%	11.5%	NA	NA
		Solar	2%	2.75%	3.5%	NA	NA
		Total	12.5%	13.75%	15%	NA	NA
16.	Manipur	Non-Solar	2%	2.5%	3%	3%	3%
		Solar	5.5%	8%	9%	10%	10.5%
		Total	10%	12.7%	14.3%	15.65%	17%
17.	Mizoram	Non-Solar	NA	NA	NA	NA	NA
		Solar	NA	NA	NA	NA	NA
		Total	NA	NA	NA	NA	NA
18.	Meghalaya	Non-Solar	2.07%	3.25%	4%	4.75%	NA
		Solar	0.43%	0.75%	1%	1.25%	NA
		Total	2.5%	4%	5%	6%	NA
19.	Nagaland	Non-Solar	NA	NA	NA	NA	NA
		Solar	NA	NA	NA	NA	NA
		Total	NA	NA	NA	NA	NA
20.	Orissa	Non-Solar	4.5%	5%	5.5%	NA	NA
		Solar	3%	4.5%	5.5%	NA	NA
		Total	7.5%	9.5%	11%	NA	NA
21.	Punjab	Non-Solar	4.2%	4.3%	5.5%	6.5%	8%

Sr. No.	State	RE Technology	2017-18	2018-19	2019-20	2020-21	2021-22
		Solar	1.8%	2.2%	4%	5%	6.5%
		Total	6%	6.5%	9.5%	11.5%	14.5%
22.	Rajasthan	Wind	8.2%	8.75%	8.75%	8.75%	8.9%
		Bioenergy	1.3%	1.5%	1.5%	1.5%	1.6%
		Non-Solar	9.5%	10.25%	10.25%	10.25%	10.5%
		Solar	4.75%	6.75%	7.25%	8.75%	10.5%
		Total	14.25%	17%	17.5%	19%	21%
23.	Tamil Nadu	Non-Solar	9%	NA	NA	NA	NA
		Solar	5%	NA	NA	NA	NA
		Total	14%	NA	NA	NA	NA
24.	Tripura	Non-Solar	11.5%	12.25%	13%	NA	NA
		Solar	1.5%	1.75%	2%	NA	NA
		Total	13%	14%	15%	NA	NA
25.	Uttarakhand	Non-Solar	9.5%	10.25%	11%	11.75%	12.5%
		Solar	4.75%	6.75%	7%	7.5%	8%
		Total	14.25%	17%	18%	19.25%	20.5%
26.	Uttar Pradesh	Non-Solar	NA	NA	NA	NA	NA
		Solar	NA	NA	NA	NA	NA
		Total	NA	NA	NA	NA	NA
27.	West Bengal	Non-Solar	7.4%	NA	NA	NA	NA
		Solar	0.6%	NA	NA	NA	NA
		Total	8%	NA	NA	NA	NA
28.	Sikkim	Non-Solar	9.5%	10.25%	NA	NA	NA
		Solar	4.75%	6.75%	NA	NA	NA
		Total	14.25%	17%	NA	NA	NA

Source: MNRE, CareEdge Research

The actual RPO compliance of various states for the year 2019-20 is given below:

Table 15: State/ UT wise RPO Compliance (2019-20)

States/UTs	Energy Supplied excl. Hydro (MU)	Solar Obligation (MU)	Non-Solar Obligation (MU)	Total RE Obligation (MU)	Solar Consumption (MU)	Non-Solar Consumption (MU)	Total RE Consumption (MU)	RPO Compliance (%)	Bracket of RPO compliance
Karnataka	59,537	4,316	6,102	10,419	11,948	14,103	26,052	250%	>100%
Andhra Pradesh	62,143	4,505	6,369	10,875	5,974	7,486	13,460	123.8%	
Rajasthan	77,139	5,592	7,907	13,499	7,572	6,500	14,072	104.2%	
Tamil Nadu	103,617	7,512	10,621	18,133	4,769	13,559	18,328	101.1%	
Gujarat	112,504	8,156	11,531	19,688	3,771	14,134	17,906	90.9%	55% - 100%
Mizoram	488	35	50	85.5	20	49	69	81.2%	
Nagaland	565	41	57	98.9	0	76	76	76.7%	
Madhya Pradesh	68,552	4,970	7,026	11,996	4,213	4,988	9,202	76.7%	
Telangana	65,150	4,723	6,677	11,401	6,325	513	6,838	60%	
Dadar & Nagar Haveli	6,528	473	669	1,142	116	561	677	59.3%	
Maharashtra	148,395	10,758	15,210	25,969	3,184	11,791	14,976	57.7%	
Jharkhand	7,941	575	814	1,389	290	453	743	53.5%	<55%

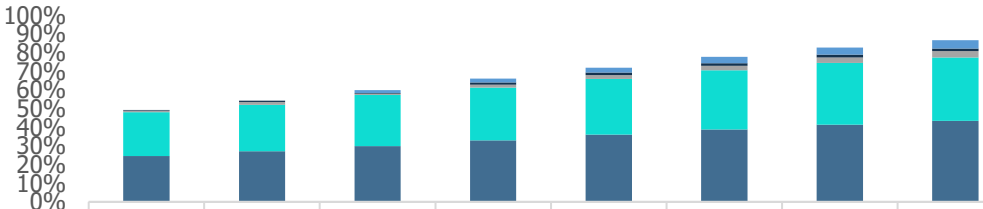
Punjab	45,742	3,316	4,688	8,005	1,358	2,151	3,509	43.8%	
Meghalaya	961	69	98	168	3	68	71	42.6%	
Delhi	30,045	2,178	3,079	5,258	868	1,209	2,077	39.5%	
Assam	7,825	567	802	1,369	206	285	491	35.9%	
Uttar Pradesh	112,873	8,183	11,569	19,752	2,496	4,470	6,967	35.3%	
Andaman & Nicobar	323	23	33	56	11	5	17	30.6%	
West Bengal	48,032	3,482	4,923	8,405	72	2,128	2,200	26.2%	
Puducherry	2,846	206	291	498	4	122	127	25.5%	
Kerala	19,056	1,381	1,953	3,334	157	677	835	25%	
Odisha	22,916	1,661	2,349	4,010	434	683	1,118	27.9%	
Chhattisgarh	29,786	2,159	3,053	5,212	340	720	1,061	20.4%	
Daman & Diu	2,574	186	264	450	23	49	72.	16.1%	
Bihar	29,792	2,160	3,053	5,213	516	266	783	15%	
Goa	4,350	315	446	761	1	103	104	13.6%	
Haryana	50,189	3,638	5,144	8,783	207	902	1,109	12.6%	
Tripura	1,300	94	133	227	2	25	27	12.2%	
Chandigarh	845	61	86	147	12	0	12	8.1%	
Lakshadweep	46	3	4	8	1	0	1	8.1%	
Manipur	646	47	66	113	2	1	4	3.7%	

Source: Report by Standing Committee (2020-21), MNRE

RE-rich states of Karnataka, Andhra Pradesh, Rajasthan and Tamil Nadu had RPO compliance more than 100% i.e. they fulfilled their compliance. Other states which have lower RE potential were unable to fulfil their RPO compliance. While majority of the states lie in the bracket of less than 55% which shows that the states are unable to comply with the RPO.

A joint committee under the Co-chairmanship of Secretary, Ministry of Power and Secretary, Ministry of New and Renewable Energy was constituted on 17th December 2020 and based on the recommendations, Ministry of Power has specified the RPO trajectory beyond FY22. As per the targets set, RPO of 43.33% is proposed to be achieved by FY30.

Chart 45: RPO Trajectory from FY23 to FY30



	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30
Distributed RPO	0.0%	0.0%	1.5%	2.1%	2.7%	3.3%	3.9%	4.5%
HPO	0.4%	0.7%	0.4%	1.2%	1.3%	1.4%	1.4%	1.3%
Wind RPO	0.8%	1.6%	0.7%	1.5%	2.0%	2.5%	3.0%	3.5%
Other RPO	23.5%	24.8%	27.4%	28.2%	29.9%	31.6%	33.1%	34.0%
Total RPO	24.6%	27.1%	29.9%	33.0%	36.0%	38.8%	41.4%	43.3%

Source: Renewable Purchase Obligation and Energy Storage Obligation Trajectory Report dated 22nd July, 2023
Renewable Purchase Obligation and Energy Storage Obligation Trajectory Report dated 20th October, 2023, Ministry of Power, CareEdge Research

Note: Distributed RPO is not available for FY23 and FY24

- Wind RPO shall be met only through energy generated from wind power projects commissioned after 31st March 2024.
- Hydro purchase obligation (HPO) shall be met only by energy generated from hydro-power projects, Pumped Storage Plants (PSPs) and Small Hydro Projects commissioned after 31th March 2024
- Distributed renewable energy target shall be met from capacities of less than 10 MW, including various solar installation configurations such as net metering, gross metering, virtual net metering etc.
- Other RPO targets shall be met by energy produced from any RE power projects not included above including all wind and hydropower projects commissioned before 1st April 2024.

The RPO trajectory for energy storage obligation is as follows:

Table 16: Energy Storage Obligation from FY24 to FY30

Year	Storage (on Energy basis)
FY24	1.0%
FY25	1.5%
FY26	2.0%
FY27	2.5%
FY28	3.0%
FY29	3.5%
FY30	4.0%

Source: MNRE, CareEdge Research

The energy storage obligation shall be calculated in energy terms as a percentage of total consumption of electricity and shall be treated as fulfilled only when at least 85% of the total energy stored in the Energy Storage System (ESS) is procured from renewable energy sources on an annual basis.

Renewable Energy Certificates (RECs)

Renewable energy sources are not evenly spread across the country and hence this inhibits the State Electricity Regulatory Commissions (SERCs) from specifying higher RPOs. In this context, RECs assume significance as it addresses the mismatch between availability of RE sources and the requirement of the obligated entities to meet their RPO. RECs are issued to eligible RE generators, distribution licensee, open access consumers and Captive generating stations based on renewable energy. On January 14, 2010, CERC issued the Central Electricity Regulatory Commission Terms for recognition and issuance of RECs for enabling states to meet their RPO targets.

The framework of REC is expected to give push to RE capacity additions in the country.

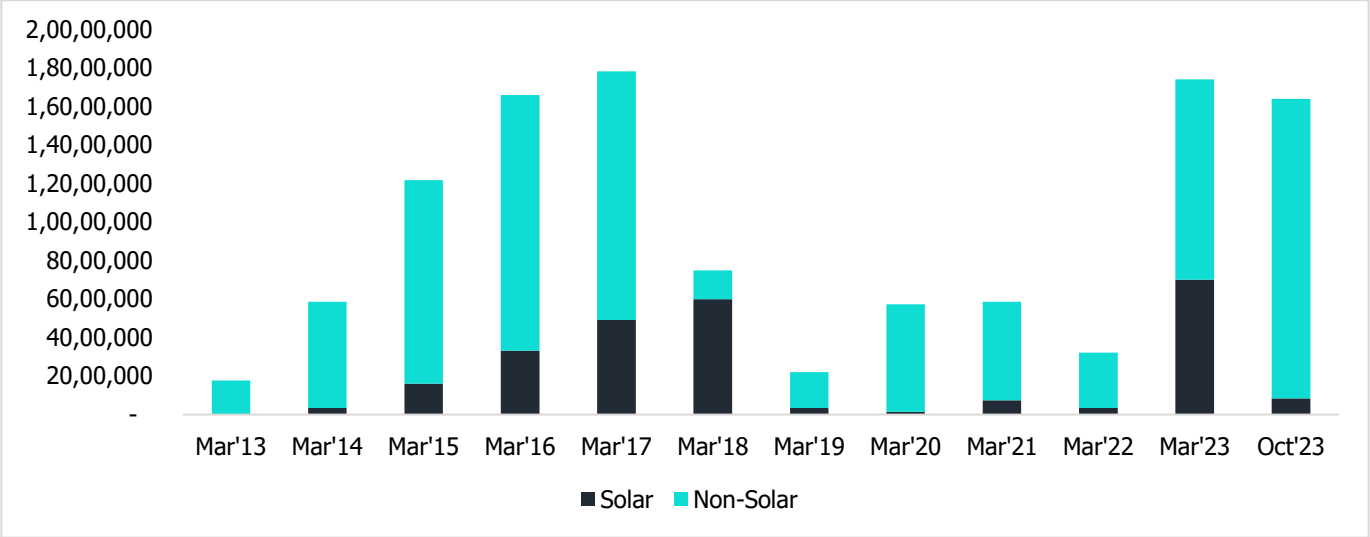
REC mechanism has provided an extra avenue for sale of renewable energy, the renewable energy generators may use either of the following ways for sale of energy:

- Sale of electricity to obligated entities which include DISCOMs, captive power plants, open access consumers, etc. wherein the buyer uses the purchased electricity for compliance of RPO.
- The renewable energy generator can set up the project under REC mechanism. Here the renewable energy generators sell the generated electricity to the local DISCOM at Average Power Purchase Cost (APPC) or to the open access consumers at a mutually agreed rate. In this case, the buyer is not allowed to use the purchased renewable electricity for compliance of RPO but the energy sold to the purchaser is eligible for issuance of REC.

RECs can be exchanged in CERC approved power exchanges and through electricity traders. The price of REC would be determined in power exchange. RECs are traded in power exchange within the forbearance price and floor price determined by CERC from time to time.

The chart below gives the annual trend in closing balance[2] of RECs.

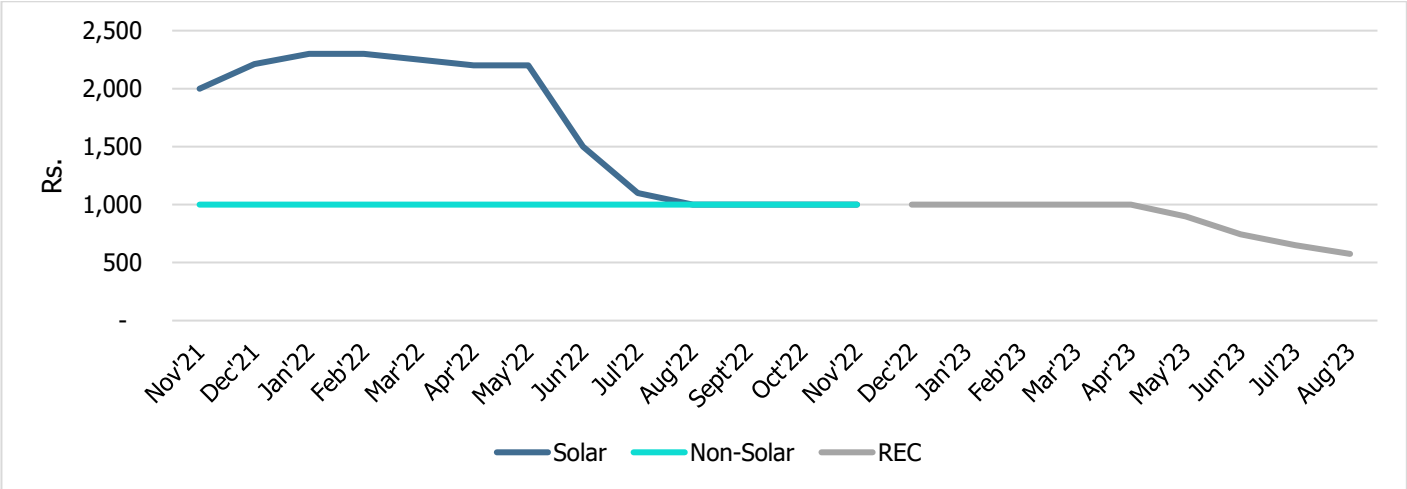
Chart 46: Status of RECs



Source: REC Registry India, CareEdge Research

The prices below indicate REC cleared prices as traded at Indian Energy Exchange (IEX).

Chart 47: Price trend of RECs



*Prices till Nov'22 are bifurcated as Solar and Non-Solar
Starting Dec'22 the REC prices (includes solar and non-solar) have been declared by IEX
Source: Indian Energy Exchange (IEX)

3.4 India's Renewable Energy Targets

India's installed renewable power capacity as on September 2023 stood at 179 GW, as per the break-up given in following table.

[2] The closing balance is calculated as RECs issued less (i) RECs redeemed through power exchanges, traders, (ii) RECs retained by the generators and (iii) RECs revoked/deleted.

Table 17: Renewable Energy Capacity as on September 2023 (GW)

	Capacity
Solar	71.7
Wind	44
Bioenergy	10.7
Large Hydro	46.8
Small Hydro-power	4.9
Total	**178.6**

Source: CEA, CareEdge Research

As India is committed to meet 50% of its energy requirements from renewable energy by 2030, non-fossil fuel based installed capacity target of 500 GW by 2030 has been set, with highest target for solar power.

Table 18: Renewable Energy Capacity - Target for CY30 (GW)

	Target
Solar	270
Wind	117
Bioenergy	15
Small Hydro-power	5
Sub-Total	**407**
Large Hydro	72
Nuclear	21
Total	**500**

Source: Thirty-Fourth Report of the Standing Committee on Energy on Demands for Grants (2023-24) (17th Lok Sabha) of the MNRE, CareEdge Research

3.5 Solar Power in India

3.5.1 Overview

India has a significant amount of solar energy potential. Approximately 5,000 trillion kWh of energy is incident over India's geographical area each year incident over India's land area with most parts receiving 4-7 kWh per square meter per day. Further, solar PV power can effectively be harnessed, providing huge scalability in India and at the same time, has the ability to generate power on a distributed basis and enables rapid capacity addition with short lead times.

India's solar energy sector has emerged as a key participant in grid-connected power generation capacity over the past decade. It contributes significantly to the government's objective of sustainable growth while emerging as a key anchor in meeting the nation's energy demands and ensuring energy security. Due to its abundant availability, solar energy is the most secure among all sources from an energy security perspective.

India has a solar potential of 749 GW, assuming that solar PV modules cover 3% of the waste land area. Comparatively, India had an installed capacity of 72 GW of as on September 2023. The top ten states, which account for around 75% of the total solar potential, have an installed capacity of 65 GW, which is only around 9% of their potential and hence there is a significant untapped solar potential across India.

Table 19: Top 10 states by potential

States	Potential (MW)
Rajasthan	1,42,310
Jammu & Kashmir	1,11,050
Maharashtra	64,320
Madhya Pradesh	61,660
Andhra Pradesh	38,440

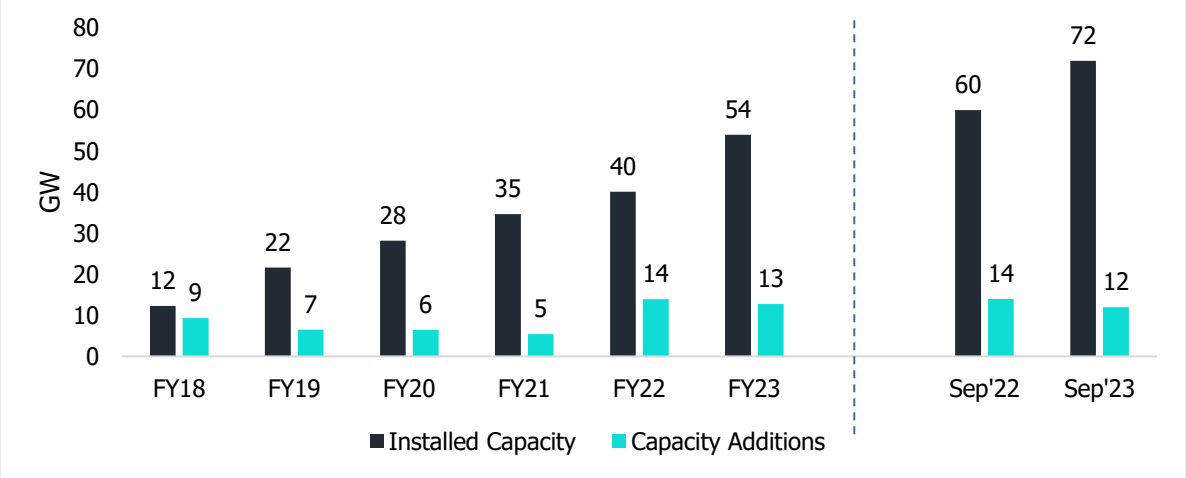
States	Potential (MW)
Himachal Pradesh	33,840
Gujarat	35,770
Odisha	25,780
Karnataka	24,700
Uttar Pradesh	22,830
Sub-total Top 10 States	5,60,700
Other states	1,88,280
Total	**7,48,980**

Source: Annual Report 2022-23, MNRE, CEA, CareEdge Research

3.5.2 Capacity Addition Trends

Solar energy accounted for 54% of the renewable energy basket (excluding Hydro Power) as of September 2023. Over the previous nine years, the solar power industry has experienced strong growth. Over FY15 to FY23, the segment added 63 GW of capacity, registering a CAGR of 44%, albeit on a low base. Despite suffering from supply chain constraints, increasing shipping costs, and rising prices of key commodities, the capacity installations have been high due to rapid technological improvements, increased competitiveness, faster completion of projects in pipeline during COVID-19 period, consistent focus of Government of India, greater demand from the commercial and industrial segment increasing maturing of the renewable energy market etc.

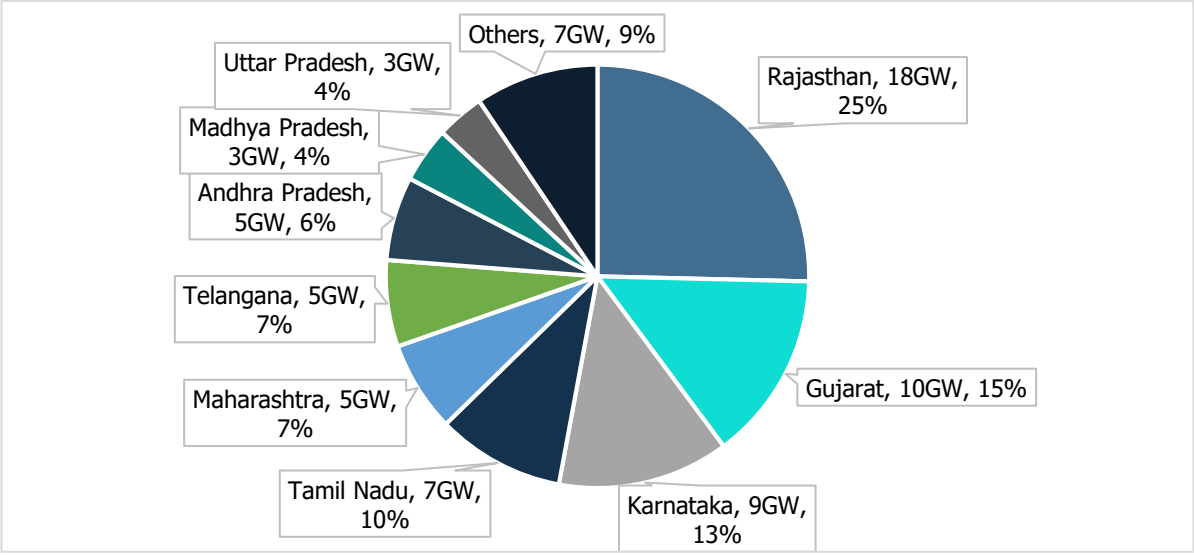
Chart 48: Trend in Solar Installations



Source: MNRE, CareEdge Research

Out of the total installed capacity of 72 GW, Rajasthan has the highest installed capacity of 18 GW constituting a 25% share followed by Gujarat at 10 GW and Karnataka at 9 GW. Other states which hold major share in the installed capacity of solar power are Tamil Nadu, Maharashtra, Telangana, Andhra Pradesh, Madhya Pradesh and Uttar Pradesh. While the other states together hold only 9% share in installed capacity which is around only 7 GW.

Chart 49: State-wise installed capacity of solar as on September 2023



Source: MNRE, CareEdge Research

The capacity under construction or in advance stages of development that are likely to be commissioned during 2022-23 to 2026-27 is around 92.6 GW for Solar while the capacity under construction as on March 2023 is around 36,270 MW.

Table 20: Solar Capacity awarded and under construction as on March 2023

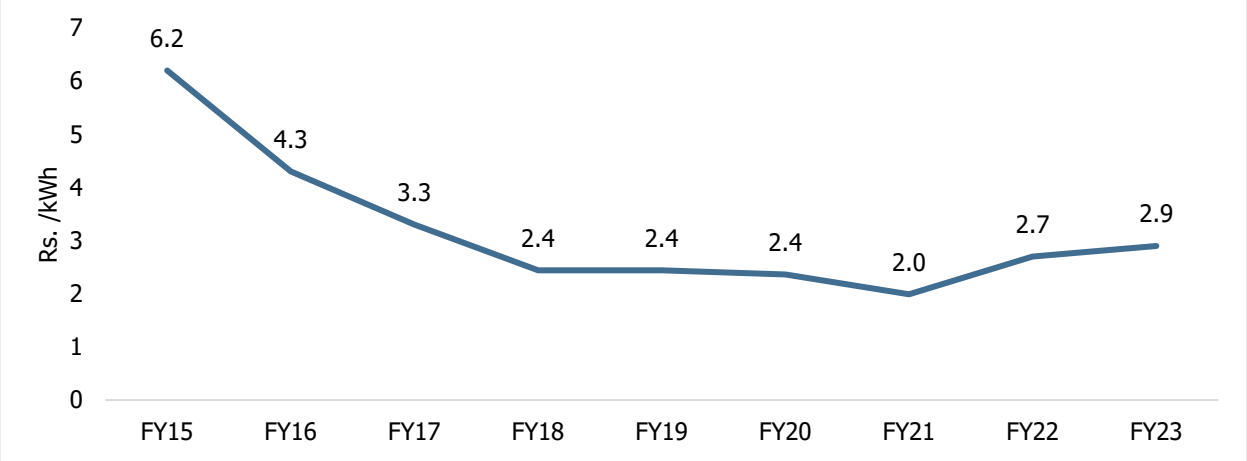
Sr. No	Scheme	Total Capacity Awarded (MW)	Under Construction Capacity (MW)
1	Solar Energy Corporation of India Limited	26,311	19,860
2	National Thermal Power Corporation Limited	1,218	1,208
3	Narmada Hydroelectric Development Corporation Limited	96	96
4	Satluj Jal Vidyut Nigam Limited	1,385	1,385
5	National Hydro Power Corporation	1,040	1,040
6	Other Projects (various states Maharashtra, Chhattisgarh, Bihar, Madhya Pradesh, Uttar Pradesh, Himachal Pradesh, Andhra Pradesh, Rajasthan, Karnataka, Gujarat) and Ultra Mega Renewable Energy Power projects (various states Maharashtra, Chhattisgarh, Bihar, Madhya Pradesh, Uttar Pradesh, Himachal Pradesh, Andhra Pradesh, Rajasthan, Karnataka, Gujarat) and Ultra Mega Renewable Energy Power projects	6,220	6,220
	Total		**36,270**

Source: CEA, CareEdge Research

3.5.3 Trend in Solar Tariffs

The solar tariffs in India are now competitive and have achieved grid parity due to technological improvements, economy of scale and reduction in solar cells/module prices. There has been a steep decrease in solar tariffs in India from Rs. 6.2 kWh in FY15 to Rs. 2.9 in FY23.

Chart 50: Trend in Solar tariff



Source: MNRE, CareEdge Research
Note: For FY22 and FY23, tariffs represent average of projects bid during the resp. periods.

The bid tariff rates during FY23 was around Rs 2.7 - 3 per unit. While in FY22, the bid tariff rates were around Rs. 2.7 per unit, which is 36% higher than FY21 primarily due to the rise in equipment pricing, raw material cost, government duties and interest rates. Despite this the bid tariff rates remained lower than that of FY15 levels.

3.5.4 Demand Drivers and Challenges

Demand Drivers

- Significant untapped solar potential in India
- Fewer environmental concerns unlike thermal power
- Falling RE costs
- GOI's focus towards green energy
- Adoption of ongoing technology innovations
- Interest from international investors

Challenges

- Counterparty risk in payment and signing PPAs
- Dependency on imports for modules
- Increase in capital costs due to material cost escalation
- Grid Integration
- Non-avaliability of round the clock/ intermittent avaliability

Demand Drivers:

- **Significant untapped solar potential in India**

India has a solar potential of 749 GW with installed capacity of 72 GW as on Sep'23. The installed capacity is only around 9% of that of the potential indicating a significant untapped potential.

Chart 51: State-wise estimated solar power potential

Note: Solar Potential of Union Territories: 0.79 GW

Source: Annual Report 2022-23, MNRE, CareEdge Research

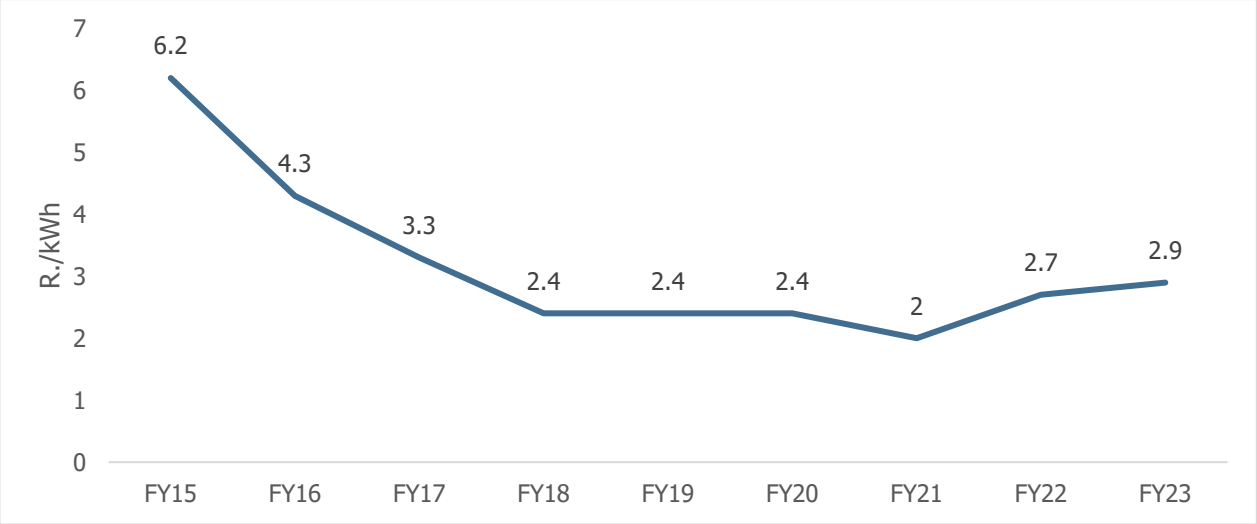
- **Fewer environmental concerns unlike thermal power**

There are no significant emissions during the generation of solar power. Therefore, there are fewer environmental concerns with solar power generation, unlike thermal power.

- **Falling RE Tariffs**

The solar tariffs in India are now competitive and have achieved grid parity due to technological improvements, economies of scale and reduction in solar cells/module prices. There has been a steep decrease in solar tariffs in India from Rs. 6.2 kWh in FY15 to Rs. 2.9 in FY23.

Chart 52: Trend in Solar tariff



Source: MNRE, CareEdge Research
Note: For FY22 and FY23, tariffs represent average of projects bid during the resp. periods.

The bid tariff rates during FY23 was around Rs 2.7 - 3 per unit. While in FY22, the bid tariff rates were around Rs. 2.7 per unit, which is 36% higher than FY21 primarily due to the rise in equipment pricing, raw material cost, government duties and interest rates. Despite this the bid tariff rates remained lower than that of FY15 levels.

- **GOI's focus towards green energy and subsidy support**

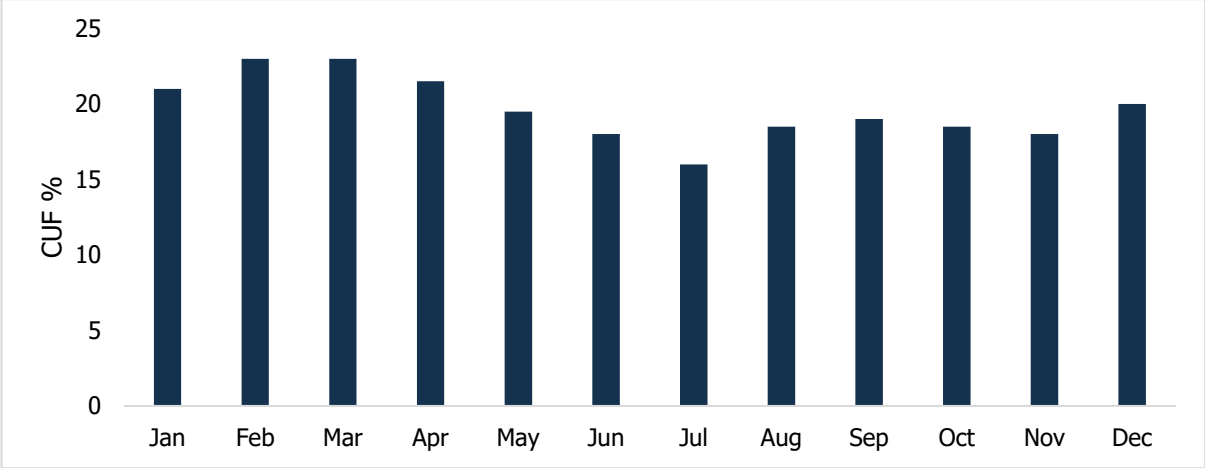
India's present electricity generation is highly reliant on non-renewable natural resources like coal. Government initiatives such as subsidy programmes and laws, are pushing power production firms to engage in this industry. Various government schemes like Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan Yojana (PM-KUSUM), Rooftop Phase-II, Atmanirbhar Bharat- PLI scheme in Solar PV manufacturing, imposition of Basic Customs Duty of 25% on solar cells and 40% on solar modules, 100% FDI, waiver of ISTS charges, setting up ultra-mega RE parks, grid connected rooftop solar scheme. To ensure timely payment to the RE generators, government has issued orders that power shall be dispatched against letter of credit (LC) or advance payment.

Details of other government schemes and subsidies are mentioned in section 4.

- **Adoption of ongoing technology innovations**

The performance of solar power plants is defined by the Capacity Utilization Factor (CUF), which is the ratio of the actual electricity output from the plant to the maximum possible output during the year. There has been improvement in performance of the technology with more projects achieving projected PLF levels. In addition, innovations such as wind-solar hybrid, floating PV Projects and storage technologies, etc. are key drivers supporting the improvement in CUF.

Chart 53: Typical month wise CUF variation of Solar



Source: National Electricity Plan Vol 1 (March 2023), CareEdge Research

India has been experimenting with new techniques to place solar power in agricultural lands, canals, and other bodies of water. These new and novel technologies, such as agrivoltaics, canal top PV, and floating PV, are still in their early stages of development and have higher installation prices, however, they present significant opportunities for future growth.

- **Interest from international investors**

Government's thrust on the sector, ambitious renewable energy targets and consistently growing power demand coupled with the security of government-backed 25-year power purchase agreements (PPAs) are key factors which are attracting the interest of global investors to the renewable energy sector in India.

There have been investments worth USD 15 billion in FY22, largely for generation assets in the renewable energy sector. It includes green bonds worth USD 4.7 billion and debt worth USD 1.8 billion from domestic and foreign lenders.

Challenges:

- **Counterparty risk in payment and signing of PPAs**

The weak financial health of DISCOMs remains the biggest challenge for the Indian power sector. As the ultimate customers for solar power producers, their financial situation continues to be dire in most cases, and hence there have been consistent delays in payments. As of May 2023, the DISCOMs collectively owe Rs. 983.18 billion to various power generators.

While the DISCOMs have faced several issues in the past including increasing debt levels, poor collection efficiency, high Aggregate Technical & Commercial (AT&C) losses and high ACS-ARR gap[3], the government has taken multiple initiatives over the past few years to improve the sector. DISCOMs have begun clearing the overdue amounts to generation company post government's imposition of late payment surcharge. The government also expects that the DISCOMs will be able to clear all their outstanding dues by 2026.

The Union Budget 2023-24 permitted the states to have a fiscal deficit of 3.5% of Gross State Domestic Product (GSDP) out of which 0.5% will be on account of power sector reforms. Such fiscal reforms will help the state undertake power distribution reforms, which will lead to upgradation of the DISCOMs.

[3] ACS- Average Cost of Supply; ARR-Average Revenue Realized

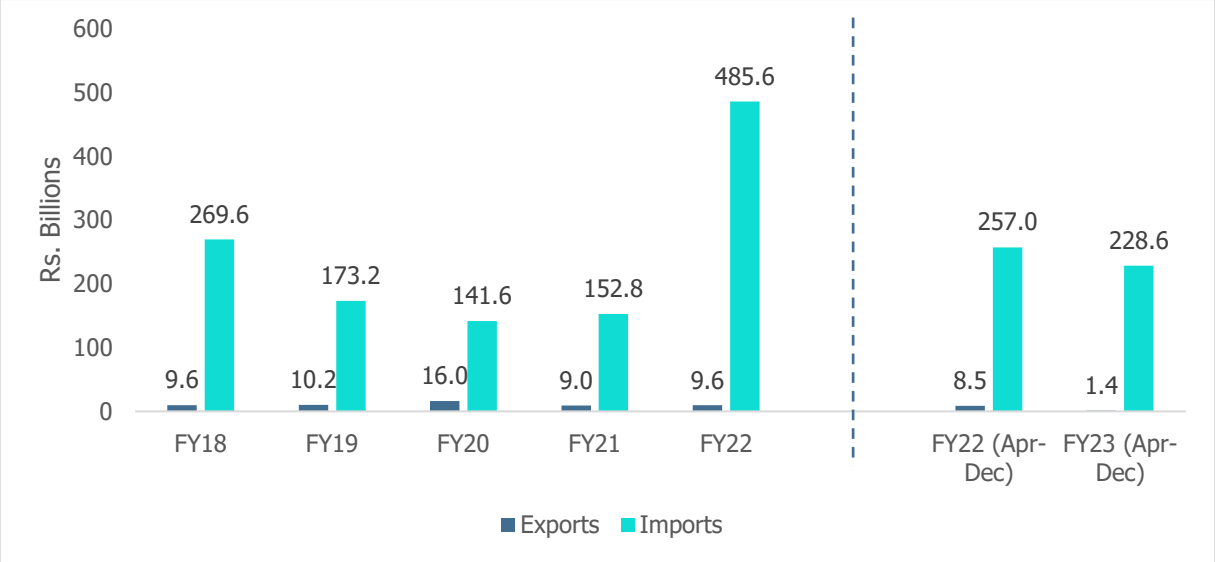
- **High dependency on imports**

Important components such as solar cells, modules, and inverters are largely imported by India's solar sector. The government has taken a number of efforts to boost indigenous industry, including raising import duties. The present installed solar PV Cells manufacturing capacity in India is around 3 GW/year and around 10 GW/year in case of Solar PV Modules capacity. The government has issued the scheme guidelines for implementation of the Production Linked Incentive Scheme on National Programme on High Efficiency Solar PV Modules.

In FY22, solar cells and modules exports have increased by 9% compared to FY21 whereas the imports have increased by 218% during the same period. The growth in imports has been significant because of imposition of BCD[4] as manufacturers tried to stock up on their raw material inventory. The imports reduced by 11% in FY23 (9 months) y-o-y while the exports declined by 84% in the same period after the BCD was imposed.

Indian solar power producers are still dependent on imports of solar modules mainly from China which accounts for about 90% of the total imports, followed by Hong Kong and Malaysia, assessed based on to the value of imports.

Chart 54: Import and Export of Solar Cells and Modules (HSN Code-854140)



Source: Ministry of Commerce and Industry, CareEdge Research; Note: No data available after Dec'22

India is well positioned by way of its geographical location and abundance of resources to become global hub for solar cells manufacturing. However, China's strong position and low-cost manufacturing base poses a challenge for domestic manufacturers to achieve self-reliance in solar energy sector.

- **Increase in capital costs due to material costs**

The solar power generation is capital intensive as a lot of equipment used in solar power are imported. The high module prices coupled with other problems such as land issues are factors impacting the growth of the solar power industry.

[4] Basic Custom Duty (BCD) was imposed from effect on April 1,2022 according to which custom duty of 25% on import of solar PV cells and 40% on import of solar PV modules has been implemented. This was done to improve the indigenous manufacturing of solar panels and modules.

Continued shortage of polysilicon, increased commodity prices and rupee depreciation have led to an increase in the module prices in Q4FY23. However, it is expected that in FY24 the downward trajectory in solar modules prices will return with increase in supply of polysilicon and reduction in input costs.

The Approved List of Models and Manufacturers (ALMM) mandate[5] introduced in 2021 to boost the domestic manufacturing, has led to disruption in the completion of the solar projects. The intention behind the ALMM mandate was to reduce the import of solar equipment from China. However, it turned out to be a barrier in ongoing projects as the demand for solar modules exceeded its indigenous supply.

After the announcement of the ALMM mandate and BCD, the manufacturers have either pushed their projects to the latter half of the year or postponed the timeline. This was because of the unavailability of solar modules due to increased demand.

Hence, the ALMM mandate is suspended for a year to prioritize solar capacity expansion to meet the targets. This temporary relief has helped the manufacturers and project developers in completion of the projects and in bringing down the project cost. Apart from this, the Government is expected to continue focus on conducive environment to increase domestic production and improve the local supply chain.

- **Grid Integration**

While the government has planned grid integration in line with renewable capacity additions, any delays in grid integration due to land acquisition, project execution delays, etc. For the additional solar capacity will impact the offtake of the projects.

- **Not availability round the clock**

Solar energy is intermittent in nature and is available only for certain hours during the day. Intensity of solar energy is also seasonal. Therefore, the power generated from solar energy is not available round the clock due to the seasonal nature and variations.

3.5.5 Outlook

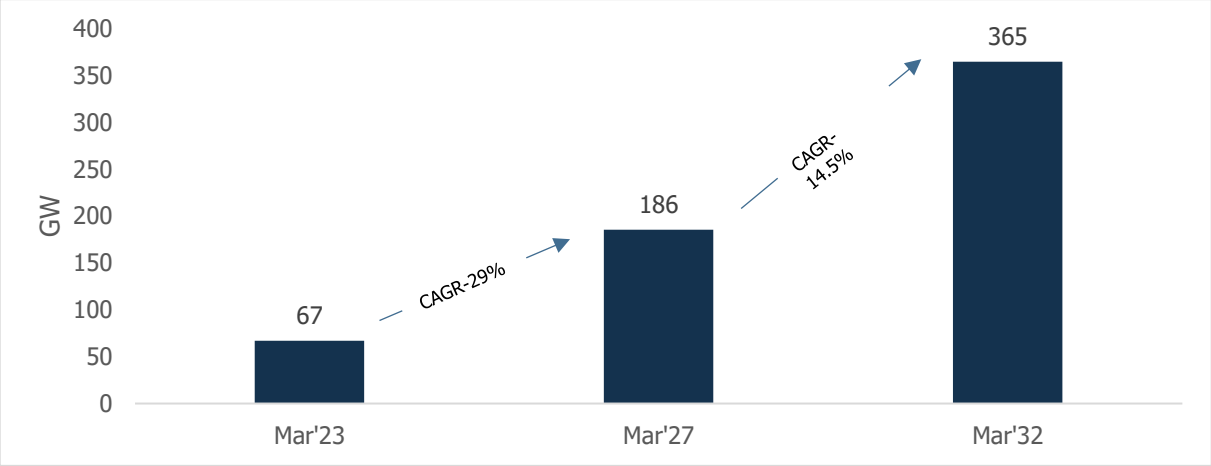
There has been a substantial increase in the installed solar power capacity because of the government's push in a bid to achieve COP26 targets[6]. The pace of bidding has also remained strong all along. MNRE has announced plans to invite bids for 50 GW of renewable energy capacity annually from FY24 to FY28 with an objective to achieve the targeted 500 GW installed capacity by 2030. Further, the domestic production of solar modules is also expected to increase driven by government initiatives such as the PLI scheme, which will lower the dependence on imports for critical components thereby addressing supply chain challenges and lowering the capital cost of solar power projects.

As per the National Electricity Plan Vol-1 (March 2023) 186 GW of installed solar power capacity is expected to be achieved by FY27 and 365 GW by FY32.

[5] ALMM mandate consists of a list of manufacturers who are eligible to manufacture solar cell and modules types which are Bureau of Indian Standard certified.

[6]The COP 26 target by Government of India states that by 2030, the non-fossil fuel energy capacity would be 500 GW, and 50% of the energy requirement would be fulfilled by renewable sources. Also, the aim is to reduce the carbon intensity of the economy by 45% and reduce the total projected carbon emission by 1 billion tonnes.

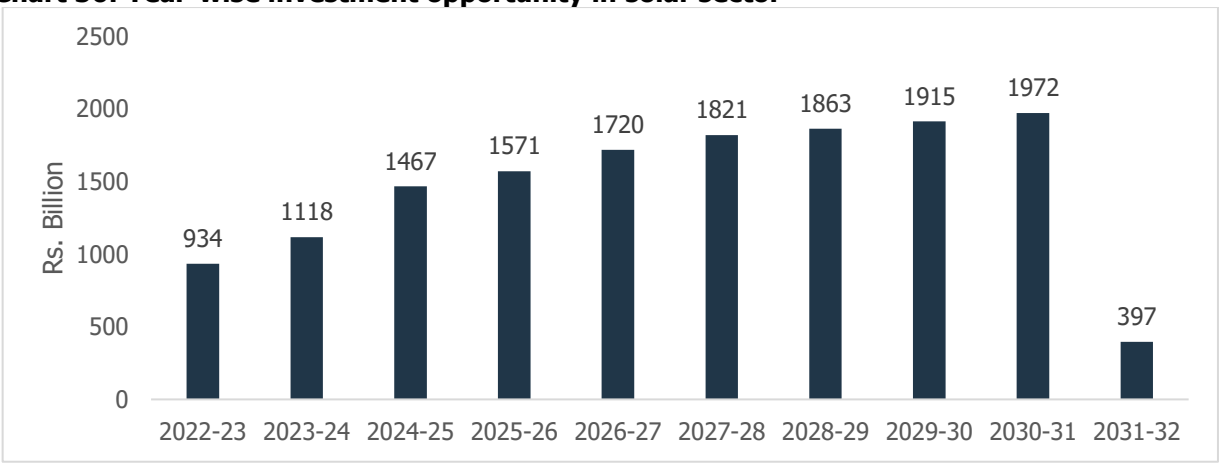
Chart 55: Solar Power – Trend in Future Installed Capacity Additions



Source: National Electricity Plan Vol-1 (March 2023), CareEdge Research

This represents an investment opportunity of Rs. 6.81 trillion FY23-27 and Rs. 7.97 trillion between FY28-32. The year-wise expected investment opportunity in the solar sector to achieve the targeted installed capacity is given below.

Chart 56: Year-wise investment opportunity in solar sector



Source: National Electricity Plan Vol-2 (March 2023), CareEdge Research
Note: Investments pertain to capacity additions targeted up to FY32. Investments towards capacities which will be commissioned beyond FY32 are not included.

3.6 Wind Power in India

3.6.1 Overview

With a total installed capacity of 44 GW (as on September 2023), India currently ranks fourth in the world in terms of installed capacity of wind power. The wind power industry's growth has resulted in a robust ecosystem, project operating capabilities, and a domestic manufacturing base of around 10,000 megawatts per year as per MNRE.

Wind is an intermittent and site-specific resource of energy and therefore, an extensive wind resource assessment is essential for the selection of potential sites. The government, through National Institute of Wind Energy (NIWE), has installed over 800 wind-monitoring stations all over country and issued wind potential maps at 50m, 80m, 100m and 120m above ground level. The recent assessment indicates a gross wind power potential of 302 GW in the country at 100 meter and 696 GW at 120 meter above ground level. Most of this potential exists in seven windy states.

Table 21: Wind Power Potential in India and Installed Capacities.

Sr. No.	States	Potential at 100 m (MW)	Potential at 120 m (MW)	Installed Capacity (MW) as on Sep'23
1	Andhra Pradesh	44,230	75,900	4,097
2	Gujarat	84,430	1,42,560	11,094
3	Karnataka	55,860	1,24,150	5,313
4	Madhya Pradesh	10,480	15,400	2,844
5	Maharashtra	45,390	98,210	5,147
6	Rajasthan	18,770	1,27,750	5,193
7	Tamil Nadu	33,800	68,750	10,300
	Total (7 Windy States)	2,92,970	6,51,720	43,740
	Other States	9,280	43,780	197
	All India Total	**3,02,250**	**6,95,500**	**44,185**

Source: Annual Report 2022-23, MNRE, CEA, CareEdge Research

Offshore Wind Energy

India has a coastline of about 7,600 kms surrounded by seawater on three sides and has tremendous power generation potential from off shore wind energy.

As per MNRE, based on early analysis of satellite data and data from other sources, eight zones in Gujarat and Tamil Nadu have been identified as possible offshore wind energy exploitation zones. The potential for off-shore wind energy is estimated to be 174 GW (technical resources) across fixed bottom and floating potential mainly off the coast of Gujarat and Tamil Nadu[7].

Ministry has set a target of 30 GW by 2030 which has been issued to give confidence to the project developers in India.

Benefits:

- The wind speed over water bodies is high and the direction is constant. Offshore wind farms generate more power per installed capacity as a result.
- Because offshore wind is stronger during the day, it provides more constant and efficient energy generation during peak consumer demand. Wind power on land, on the other hand, performs better at night when electricity demand is lower.
- The CUF of offshore wind farms is greater than that of onshore wind farms. As a result, offshore wind power may operate for extended periods of time.

Challenges:

- Local substructure manufacturers, installations vessels and trained workers are lacking in India.
- Offshore wind turbines require stronger structures and foundations than onshore wind farms. This can cause higher installation costs.
- The action of waves and even high winds, particularly during storms or hurricanes, can damage wind turbines. Eventually, offshore wind farms require maintenance that is costlier and more difficult to undertake.

[7] Source: India Outlook 2026- Global Wind Energy Council (GWEC) June 2022

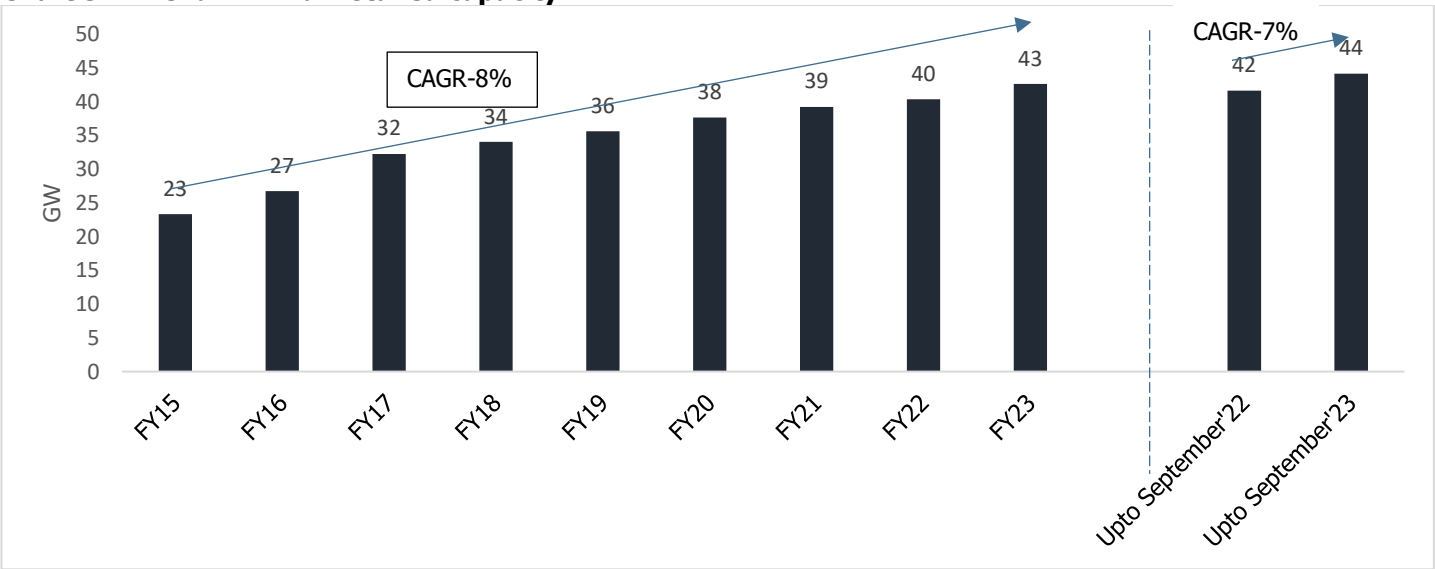
3.6.2 Capacity Additions Trends

Capacity additions in the wind power have benefited from accelerated depreciation and the GBI Scheme available for wind projects that were completed before March 31, 2017, which supported robust capacity additions in the past, apart from the presence of feed-in-tariff. Hence the capacity additions were healthy between FY15 and FY17.

The transition to competitive bidding from feed-in-tariff mechanism affected wind capacity additions leading to a drop since FY18. In addition, the highly competitive tariffs in wind power sector and unavailability of favourable wind sites has led to a slowdown in capacity additions for wind sector.

Wind installed capacity has increased from 23 GW in FY15 to about 43 GW in FY23 and to 44GW as on September 2023, with majority of the capacity additions during FY15-FY17.

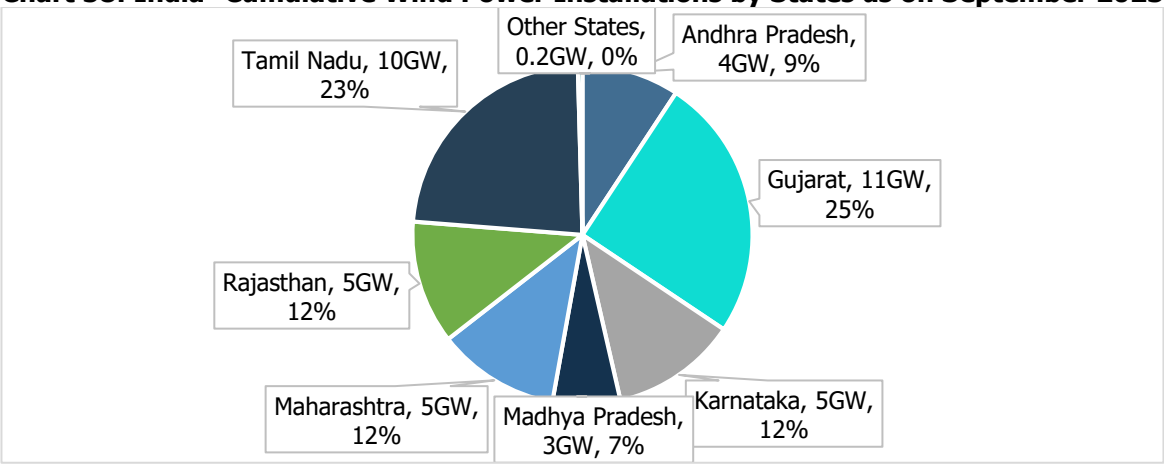
Chart 57: Trend in wind installed capacity



Source: CEA, CareEdge Research

Out of around 44 GW of wind projects installed to date, Gujarat remained the leader in cumulative installations with installed capacity of 11 GW as on September 2023, followed by Tamil Nadu, Karnataka and Maharashtra.

Chart 58: India- Cumulative Wind Power Installations by States as on September 2023



Source: MNRE, CareEdge Research

As on March 2023, wind projects aggregating to around 10,769 MW are under construction while 6,300 MW of hybrid projects are under construction. Details of the same are mentioned below:

Table 22: Wind and hybrid capacity under construction as on March 2023

Sr. No	Scheme	Total Capacity Awarded (MW)	Under Construction Capacity (MW)
	Wind		
1	Solar Energy Corporation of India Limited	15,031	6,743
2	Other Projects (various states of Andhra Pradesh, Karnataka and Gujarat)	4025.35	4,025.35
	Total	19,056.35	10,768.35
	Hybrid		
1	Solar Energy Corporation of India Limited	5,110	5,080
2	Other Projects (Karnataka and Gujarat)	1,220.375	1,220.375
	Total	6,330.375	6,300.375

Source: CEA, CareEdge Research

Wind-solar hybrid projects of 5,420 MW capacity have been awarded through e- reverse auction of which 1440 MW has been commissioned till December, 2022.

Table 23: Details of tenders auctioned for Wind-Solar Hybrid

Sr. No.	BID	Capacity Awarded (MW)	Capacity Commissioned (MW)	Min Tariff (Rs. /kwh)
1.	SECI Hybrid-I	840	840	2.67
2.	SECI Hybrid-II	600	600	2.69
3.	SECI Hybrid-III	1,110	0	2.41
4.	SECI Hybrid-IV	1,200	0	2.34
5.	MSEDCL Maharashtra	500	0	2.62
6.	SECI Hybrid-V	1,170	0	2.53
	Total	**5,420**	**1,440**	

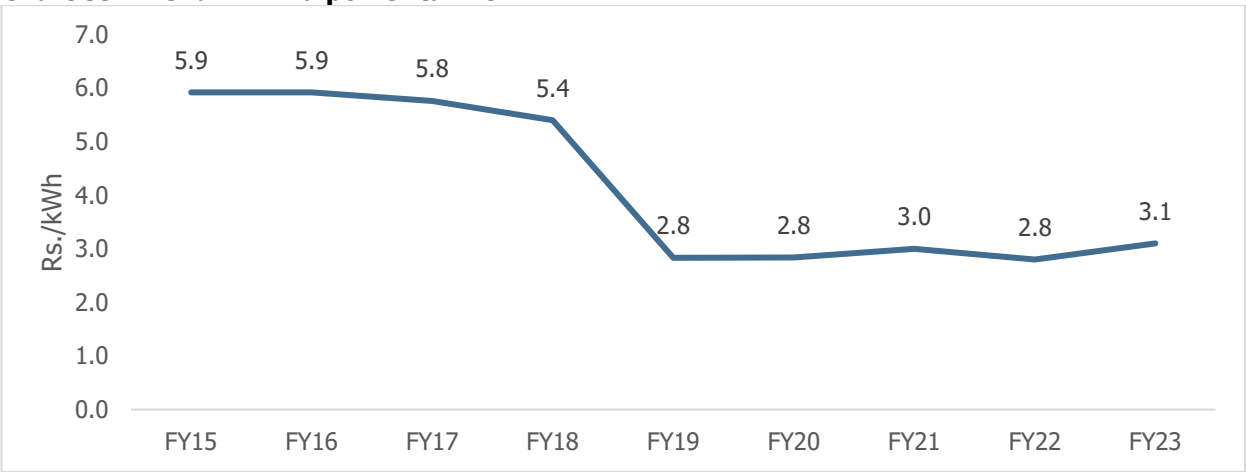
Source: MNRE, CareEdge Research

3.6.3 Trend in Wind Power Tariff

The wind tariffs have been on a downward trend, from Rs. 5.9 in FY15 to Rs. 3.1 in FY23. This drop was observed in wind power tariffs when the procurement process was changed from feed-in-tariff to bidding in 2017. The tariffs discovered in the auctions are highly competitive and much lower than coal and thermal tariffs.

Currently the bidding process has changed from reverse auctions to closed bidding where the bidder who offers the lowest tariff will win the project if the technical criteria is met. While in reverse auctions, bidders would continue quoting lower competitive tariffs after the opening of bids. The change in bidding is expected to stop the aggressive bidding by the developers and lead to higher tariffs.

Chart 59: Trend in wind power tariffs



Source: MNRE, CareEdge Research
Note: For FY22 and FY23, these are the average of projects bid during the resp. periods.

3.4.3 Demand Drivers and Challenges

Demand Drivers

- Strong wind potential
- Government support for green energy
- Wind-Solar Hybrid Plants
- Offshore wind energy
- Repowering of old wind farms
- Improved turbine technologies

Challenges

- Scarce wind sites-Land limitations
- High Capital cost affecting cost-competitiveness
- Seasonal in nature

Demand Drivers:

- **Strong wind potential**

India has strong wind potential of around 302 GW at 100m and around 695 GW at 120m. The wind potential is mainly concentrated in top 7 windy states that include Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Tamil Nadu. Comparing the installed capacity of wind to the potential, it is only 14% and India has huge untapped potential. Refer table 21.

The country also has repowering potential of around 25.406 GW considering wind turbines below capacity of 2 MW as per National Institute of Wind Energy.

- **Government schemes and initiatives**

The government of India is promoting wind projects by way of encouraging private sector investments and providing various fiscal and financial incentives like custom duty exemption on certain components of wind electric generators,

generation based incentive scheme for wind projects commissioned before 31st March 2017, technical support including wind resource assessment and identification of potential sites, issuance of guidelines for competitive bidding process for procurement of power, etc. The concessional custom duty benefit (CCDC) for several wind turbine components have also been extended till 31st March 2025 by Ministry of Finance.

Details of other government schemes and initiatives are mentioned in section 4.

- **Hybrid Plants**

SECI began conducting solar/wind hybrid auctions in 2018 to enhance the dependability of renewable energy. In May 2018, the MNRE released the National Wind-Solar Hybrid Policy. The policy's major goal is to create a framework for the development of large-scale grid-connected wind-solar PV hybrid systems that make most efficient use of wind and solar resources, transmission infrastructure, and land. Hybrid plants provide good potential for future growth of wind capacities as they provide relatively less intermittent and more stable power supply and don't solely depend on wind for power generation.

As on March 2023, 6,475.475 MW of hybrid projects are under construction by SECI and other projects in the state of Karnataka and Gujarat. While the total capacity awarded is around 6,505.475 MW.

Table 24: Hybrid power plants under development

Sr. No	Scheme	Total Capacity Awarded (MW)	Under Construction Capacity (MW)
1	Solar Energy Corporation of India Limited	5,110	5,080
2	Other Projects (Karnataka and Gujarat)	1,395.475	1,395.475
	Total	**6,505.475**	**6,475.475**

Source: CEA, CareEdge Research

- **Offshore wind energy**

In 2018, the Indian government set the target to achieve 30 GW of installed offshore wind energy capacity by 2030. Light detection and ranging (LiDAR) measurements and geotechnical/geophysical investigations for a 1 GW offshore project in Gujarat have been completed, and preliminary licenses have been obtained. According to National Institute of Wind Energy (NIWE), a total of 71 GW offshore wind potential exists in India out of which 35 GW exists off the coast of Gujarat and nearly 35 GW off the Tamil Nadu.

The critical land resources required for onshore wind projects are gradually becoming a major constraint. Offshore wind power offers a plausible alternative in such a scenario. Absence of any obstruction in the sea offers much better quality of wind and its conversion to electrical energy. Offshore wind turbines are much larger in size (in range of 5 to 10 MW per turbine) as against 2-3 MW of an onshore wind turbine. While, the cost per MW for offshore turbines are higher because of stronger structures and foundations needed in marine environment, the desirable tariffs can be achieved on account of higher efficiencies of these turbines after development of the eco system.

The MNRE has taken several steps to kick start the offshore wind sector in India. The steps taken by the ministry are as follows:

- Strategy paper for offshore wind energy was issued showing the offshore wind auction trajectory of 37 GW by 2030.
- Ministry sought approval from the Department of Expenditure, Ministry of Finance for a Viability Gap Funding scheme of Rs. 156.09 billion for initial 3 GW of offshore wind energy projects.
- Draft Offshore Wind Energy Lease Rules 2022 have been finalized and legally vetted by Ministry of Law & Justice and is under notification.

- **Repowering of old wind farms**

The wind power industry has been looking at the prospect of repowering existing wind farms, which might help to speed up capacity expansion.

The repowering potential of India is estimated to be around 25.406 GW considering wind turbines below capacity 2 MW as per National Institute of Wind Energy. The state wise details of repowering potential are as follows:

Table 25: State-wise repowering potential

Sr. No.	State	Total Capacity below 2 MW
1.	Tamil Nadu	4,100
2.	Maharashtra	1,311
3.	Karnataka	954
4.	Gujarat	1,508
5.	Rajasthan	1,231
6.	Madhya Pradesh	290
7.	Kerala	18
8.	Andhra Pradesh	470
	TOTAL	**25,406**

Source: Circular, MNRE, CareEdge Research

The latest wind turbine technology of 3+ MW capacity is being manufactured in India and hence the repowering of wind turbines below 2 MW capacity should be considered.

Improved turbine technologies

Wind turbine generator technology is evolving, and the country now possesses state-of-the-art wind turbine manufacturing technology. With significant domestic manufacturing capability for wind energy turbines and their components, the country has been able to attain around 75% localization. The unit size of the largest machine has gone up to 3.46 MW.

Wind turbine models earlier available in the Indian market were suitable mainly for class III and IV sites; they could not be used for class I sites of older wind farms.

Wind turbine technology has advanced in the last decade with improved rotor diameters, turbine sizes and pole length (hub heights). Rotor diameters of modern wind turbines are up to 140 m compared to 80-100 m for the older turbines. Hub heights have also increased to up to 160 m from 60-100 m. Modern turbines would provide better availability of about 98%. Combining all these advancements in technology would improve capacity utilization rates to 35-40%, doubling wind generation compared to older turbines.

Challenges:

- **Scarce wind sites, land limitations**

The availability of land with good wind potential is a huge constraint in the development of wind power. Most of the good wind sites (Class I sites) have been exhausted, hence the new projects have to explore the potential in Class 3 and above sites with higher turbine efficiency.

The Indian wind sector has faced challenges due to land availability, regulatory approvals and transmission-related difficulties. Unlike the solar industry, which commissions projects on continuous land, wind projects require scattered property on a footprint basis, resulting in greater land acquisition costs and challenges, and transmission issues like upgradation of transmission infrastructure.

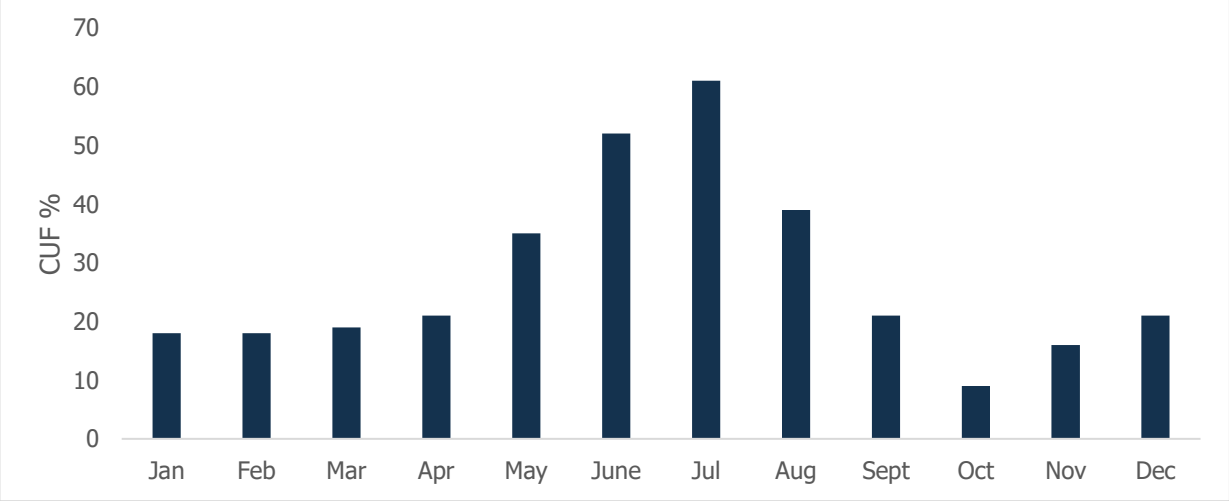
- **High capital costs, competitive tariffs have impacted project viability**

For a wind farm, the capital cost ranges between Rs. 70 million to Rs. 80 million per MW, depending up on the type of turbine, technology, size and location as per National Electricity Plan Vol-1 (March 2023), CEA. With competitive bidding, wind tariffs have fallen from an average of Rs. 5.4 per unit in FY18 to Rs. 3.1 per unit in FY23 while the capital costs have remained high. The capital cost increases with increase in hub height and rotor diameter, which is necessitated by the lack of favourable wind sites. The operational and maintenance expenses also rise as the turbine ages, considering the wear and tear and harsh environment in which these machines operate. Hence, the viability of the wind projects has been impacted.

- **Seasonality in wind availability**

Wind plant's performance varies throughout the year as a result of highly seasonal wind patterns. Nationally, wind plant performance tends to be highest during the monsoon and lowest during the mid- to late summer, while performance during the winter (November through February) is around the annual median. Because seasonal wind patterns vary by location, seasonal capacity factor patterns also vary across regions. Unlike other parts of the world where the wind blows in fairly regular patterns all year round, India gets 70% of its wind between May and September, coinciding with the south-west monsoon. Post this season, solar power largely replaces wind in supplying renewable energy.

Chart 60: Month wise CUF variation of Wind



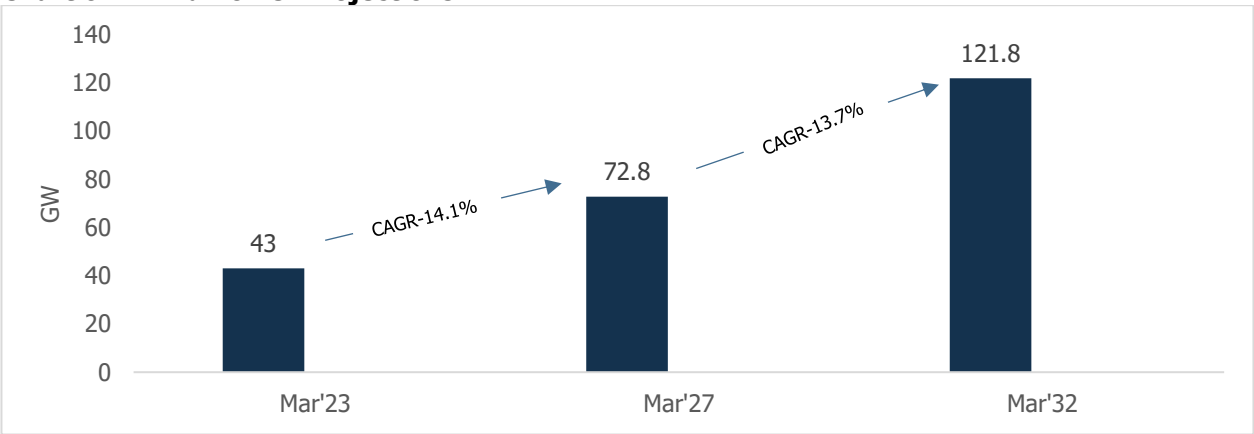
Source: CEA, CareEdge Research

3.4.4 Outlook

Wind capacity additions have slowed down in the recent past, due to challenges in pricing, grid availability, scarce availability of windy sites, land availability and payment delays. While the cost competitiveness of wind continues to be strong when compared to conventional power and government is pushing capacity additions through wind-solar hybrids, storage, round the clock supply, constraints on land and transmission infrastructure is likely to continue to impact near term capacity additions. Also, the declaration by governments of ultra-mega power parks for wind might alter the wind deployment strategy in the future.

As per the National Electricity Plan Vol-1 (March 2023), 72.8 GW of installed wind power capacity is expected to be achieved by FY27 and 121.8 GW by FY32.

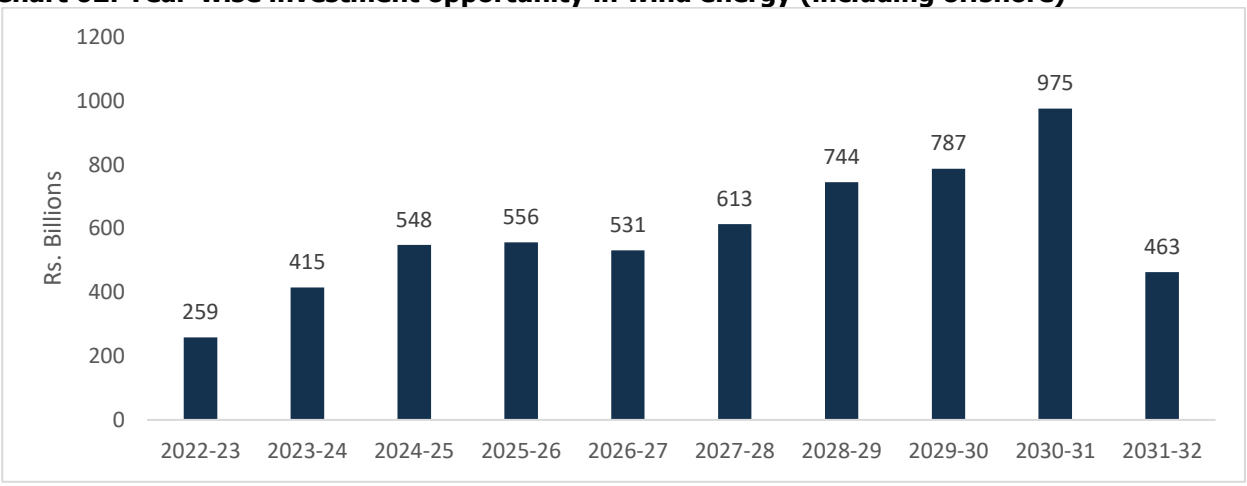
Chart 61: Wind Power Projections



Source: National Electricity Plan Vol-1 (March 2023), CareEdge Research

This target translates into an investment opportunity of Rs. 2.309 trillion between FY23-FY27 and Rs. 3.309 trillion between FY28-FY32 for onshore wind plants. Additionally, Rs. 274.01 billion would be required for offshore wind plants between FY28-32. The year-wise investment opportunity for wind energy including offshore wind is given below.

Chart 62: Year-wise investment opportunity in wind energy (including offshore)



Source: National Electricity Plan Vol-1 (March 2023), CareEdge Research

Investments pertain to capacity additions targeted up to FY32. Investments towards capacities which will be commissioned beyond FY32 are not included.

Note: The above investments have been calculated based on capex (excluding soft cost, interest during construction), contingency) of Rs 60 million per MW for 2022-23 and suitably escalated thereon

3.7 Hydro Power in India (including PSP)

3.7.1 Overview

Hydroelectric power is electricity produced from generators driven by turbines that convert the potential energy of falling water from rivers, rivulets, artificially created storage dams or canal drops into mechanical energy. Hydro power projects are classified as large and small hydro projects based on their sizes and in India, hydro power plants of 25MW or below capacity are classified as small hydro and comes under purview of Ministry of New and renewable energy.

India has the fifth-largest installed hydroelectric power capacity in the world. India's installed utility-scale hydroelectric capacity was 47 GW as on September 2023, accounting for 11% of the country's total power generating capacity. At a 60% load factor, India's hydroelectric power potential is projected to be 148 GW.

Government-owned companies produce 92.5% of hydropower generated in India including National Hydroelectric Power Corporation (NHPC), Northeast Electric Power Company (NEEPCO), Satluj Jal Vidyut Nigam (SJVNL), THDC India, and NTPC. With the growth of hydroelectric power in the Himalayan mountain ranges and Northeast India, the private sector participation is projected to increase as well. Hydropower plants have also been built by Indian firms in Bhutan, Nepal, Afghanistan, etc.

The energy generated from hydropower was around 10% of the total power generated in the country in FY23. The share of overall hydro power generation has been declining over the years, from 12% in FY15 to around 10% in FY23.

Small Hydro

MNRE is in charge of constructing Small Hydro Power (SHP) Projects, which are hydro power projects with a capacity of up to 25 MW. These projects have the ability to satisfy the electricity needs of rural and inaccessible locations in a decentralized way while also generating jobs for locals.

The projected potential of small, mini, and micro hydel projects in India is 21,135 MW[8] as on June, 2021, with 7,135 locations around the nation. Around half of this potential is in the hilly states of India mainly Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir and Uttarakhand. As on September 2023 the total installed capacity of small hydro power is 4,983 MW.

Pumped Storage Power Plants (PSPs)

Pumped hydro storage is where water is pumped uphill into a reservoir and released to power turbines when needed. They play an important part in meeting peak power requirement and maintain system stability in the power system. The pumped storage technology is long term technically proven, cost effective, highly efficient, and flexible way of energy storage large scale.

In India, the Purulia project which was set up in West Bengal in 2009 with a capacity of 900 MW, has been running successfully. As on March 31, 2022, there are 8 PSP announced projects with an aggregate capacity of 4,746 MW, out of which projects with the capacity of 3,306 MW are working in pumped mode while the balance is not commissioned due to delay in construction.

The PSP potential in India has been identified of 96,529 MW as per Central Electricity Authority. The Western region has the highest PSP potential of 37,845 MW. The following projects are under construction as on March 31, 2022:

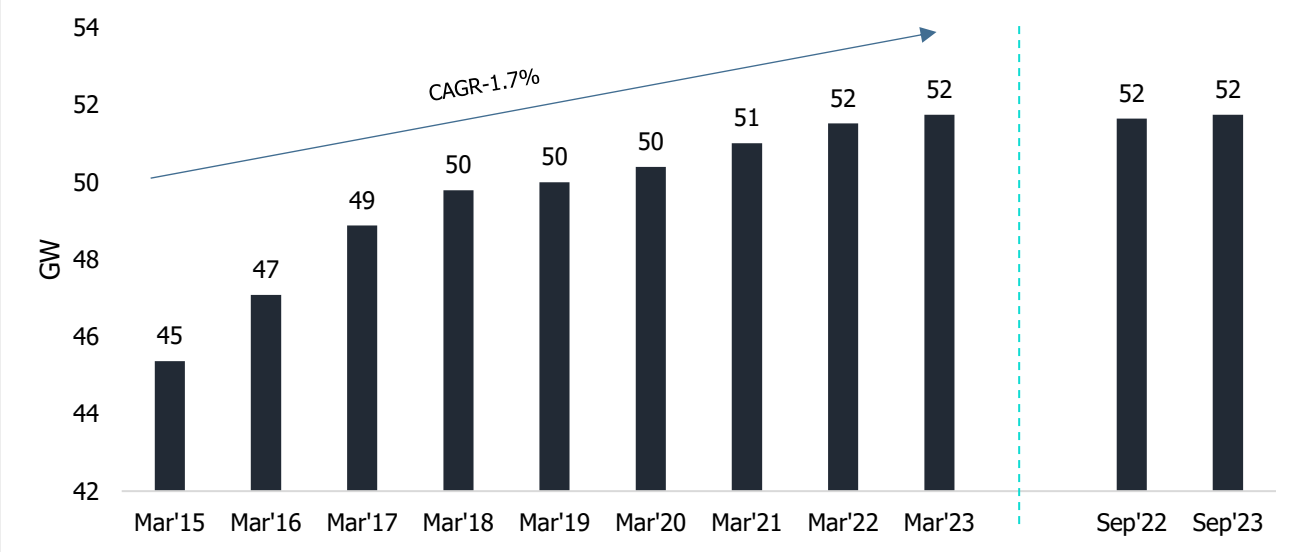
- Tehri Stage II: 1,000 MW located in Uttarakhand implemented by THDC limited
- Koyna Left Bank: 80 MW in Maharashtra being implemented by the Water Resources Department of Maharashtra
- Kundah Pump Storage Project Stages I, II, III and IV (500 MW) in Tamil Nadu being implemented by TANGEDCO

[8] Source: MNRE

3.7.2 Capacity Additions Trend

Over the FY15 to FY23, only 6.4 GW of hydro power capacity has been added, representing a CAGR of mere 1.7%. The sector has been suffering from project delays caused by complex planning procedures, land acquisition and settlement problems, long term financing, etc. Government has been providing support to hydro power with the help of budgetary support towards cost of enabling infrastructure along with significant reforms like Hydro Project Policy 2008 for encouraging private sector participation.

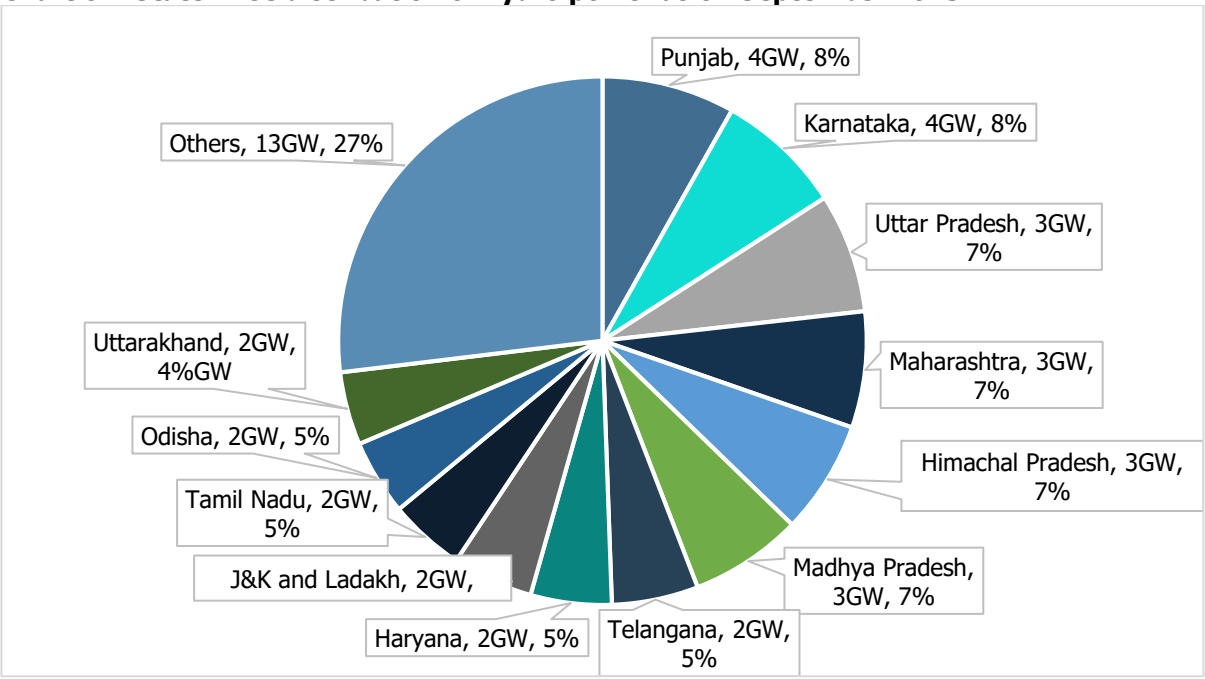
Chart 63: Trend in Hydro Power Installations



Source: CEA, CareEdge Research

The state-wise distribution of hydro power is shown below. The states of Punjab, Karnataka and Uttar Pradesh have the highest share of installed capacity at 8%, 8% and 7%, respectively, followed by others states like Maharashtra, Himachal Pradesh, Madhya Pradesh, Telangana, Haryana, Jammu and Kashmir, Tamil Nadu, etc.

Chart 64: State-wise distribution of hydro power as on September 2023



Source: CEA, CareEdge Research
Note: The above data excludes small hydro

There are various hydropower projects at early development stages in the country. Details of the projects under construction are as follows:

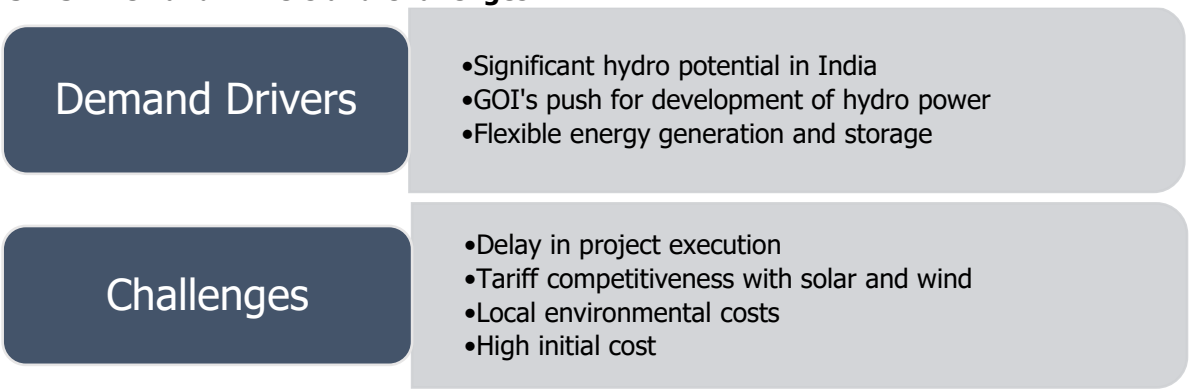
Table 26: List of Under construction Hydro Projects

Sr. No.	Name of the Project	State	Sector	Organization	Total Capacity (MW)
1	VYASI UNIT 1,2	Uttarakhand	CENTRAL	UJVNL	120
2	SUBANSIRI LOWER UNIT 1-8	Arunachal Pradesh	CENTRAL	NHPC	2,000
3	PAKAL DUL UNIT 1-4	Jammu and Kashmir	CENTRAL	CVPPPL	1,000
4	RATLE UNIT 1-5	Jammu and Kashmir	CENTRAL	RHEPPL/NHPC	850
5	PARBATI ST. II UNIT 1-4	Himachal Pradesh	CENTRAL	NHPC	800
6	KIRU UNIT 1-4	Jammu and Kashmir	CENTRAL	CVPPPL	624
7	KWAR UNIT 1-4	Jammu and Kashmir	CENTRAL	CVPPPL	540
8	TAPOVAN VISHNUGAD UNIT 1-4	Uttarakhand	CENTRAL	NTPC	520
9	TEESTA- VI UNIT 1-4	Sikkim	CENTRAL	NHPC	500
10	VISHNUGAD PIPALKOTI UNIT 1-4	Uttarakhand	CENTRAL	THDC	444
11	LUHRI STAGE-I UNIT 1-4	Himachal Pradesh	CENTRAL	SJVNL	210
12	RAMMAM - III UNIT 1-3	West Bengal	CENTRAL	NTPC	120
13	RANGIT-IV UNIT 1-3	Sikkim	CENTRAL	NHPC	120
14	DHAULASIDH U1,2	Himachal Pradesh	CENTRAL	SJVNL	66
15	NAITWAR MORI UNIT 1,2	Uttarakhand	CENTRAL	SJVNL	60
16	LATA TAPOVAN UNIT 1-3	Uttarakhand	CENTRAL	NTPC	171
17	POLAVARAM UNIT 1-12	Andhra Pradesh	STATE	Polavaram Project Authority	960
18	SHONGTONG KARCHAM UNIT 1-3	Himachal Pradesh	STATE	HPPCL	450
19	SHAHPURKANDI UNIT 1-7	Punjab	STATE	PSPCL	206
20	LOWER KOPILI UNIT 1-5	Assam	STATE	APGCL	120

21	UHL-III UNIT 1-3	Himachal Pradesh	STATE	BVPCL	100
22	PALLAIVASAL XT UNIT 1,2	Kerala	STATE	KSEB	60
23	THOTTIYAR UNIT 1,2	Kerala	STATE	KSEB	40
24	PARNAI UNIT 1-3	Jammu and Kashmir	STATE	JKSDPC	38
25	LOWER KALNAI UNIT 1,2	Jammu and Kashmir	STATE	JKSPDC	48
26	KUTEHR UNIT 1-3	Himachal Pradesh	PRIVATE	JSW Energy Ltd	240
27	TIDONG-I UNIT 1-3	Himachal Pradesh	PRIVATE	M/S Statkraft India Pvt. Ltd.	150
28	MAHESHWAR UNIT 1-10	Madhya Pradesh	PRIVATE	SMHPCL	400
29	PANAN UNIT 1-4	Sikkim	PRIVATE	Himgiri Hydro Energy Pvt. Ltd.	300
30	PHATA BYUNG UNIT 1,2	Uttarakhand	PRIVATE	LANCO	76
31	RANGIT-II UNIT 1,2	Sikkim	PRIVATE	Sikkim Hydro Power Ventures Ltd.	66
32	BHASMEY UNIT 1-2	Sikkim	PRIVATE	Gati Infrastructure	51
33	TANGNU ROMAI- I UNIT 1,2	Himachal Pradesh	PRIVATE	TRPG	44
		TOTAL			**11,494**

Source: National Electricity Plan Vol-1 (March 2023), CareEdge Research

3.7.3 Demand Drivers and Challenges



Demand Drivers:

- **Significant hydro potential in India**

India has a considerable hydro potential and hence it can play a key role in reducing carbon footprint of the power sector. As per the assessment carried out by Central Electricity Authority in 1978-87, the total potential of hydro power is 84,044 MW at 60% load factor, from a total of 845 identified hydro-electric schemes which would result in an installed capacity of 1,48,701 MW.

From the total potential of 1,48,701 MW, above 25 MW installed capacity potential is around 1,45,320 MW. As on May 2023, hydroelectric potential of the country is given below:

Table 27: Status of Hydro Electric Potential (Above 25 MW)

		Indus	Ganga	Central Indian River System	West Flowing Rivers of Peninsular India	East Flowing Rivers of Peninsular India	Brahmaputra	All India
Identified Capacity as per	1978-87	33,028	20,252	3,868	8,997	13,775	65,400	145,320
	2017-23	32,322	15,591	4,498.5	7,002	11,269	62,727	133,410
Capacity in Operation	MW	14,637	5,687	3,160	5,684	8,249	4,687	42,105
	%	45	36	70	81	73	7.5	32
Under Constructio n	MW	5,703	1,324	0	140	960	5,740	13,867
	%	18	9	0	2	9	9	10
Constructio n held up	MW	48	291	400	0	0	417	1156
	%	0	2	9	0	0	0.6	1
Yet to be taken up	MW	11,933	8,289	939	1,177	2,060	51,883	76,282
	%	37	53	21	17	18	83	57

Source: CEA, CareEdge Research

- **Government of India's push for development of hydro power**

Previously, the government had considered hydro projects up to 25 MW as renewable but now the government of India has formally recognized large hydropower as renewable in 2019.

The Ministry of Power has constituted several committees to suggest ways and means to promote pumped storage hydropower (PSH) and form framework for development, policy and regulatory aspects. The Draft Guidelines to Promote Development of Pumped Storage Projects was issued on February 2023 which recognized PSPs invaluable for the grid.

Details of other government schemes and initiatives are mentioned in section 4.

- **Flexible energy generation and storage**

Hydro power is flexible source of power generation and storage, they can go from zero power to maximum output. Hydropower plants provide backup power during major electricity outages or disruptions as they can generate power to the grid immediately.

Challenges:

- **Delay in project execution**

The growth of the hydro power sector has been slow due to delay in project execution. This involves problems like long gestation period of hydroelectric power plants, remote locations, unpredictable geology, delay in environmental clearances, local resistance.

- **Tariff competitiveness with solar and wind**

The tariff for hydro power is higher than that of other renewable like solar and wind and hence it becomes a challenge for the hydro power sector. The cost of building roads and bridges and to ferry the construction equipment can be quite high as most of projects are locate on hills, hence bringing the tariff of the hydro projects on upward trajectory.

- **Local environmental costs**

Most of the hydro projects in India are in the north and north eastern of the country barring a few small projects in central and southern India. Projects on the Himalayan rivers have been damaged by floods and landslides. This had led to huge losses of lives and infrastructure. There has been critique on construction of hydro projects in the Himalayan mountains highlighting environmental damage.
Massive floods in Uttarakhand in 2013 caused 5000 deaths, damaged homes and hydropower projects. There have been many similar incidents since then.

- **High Initial Cost**

Even though hydroelectricity generation is considered to be economical compared to other power sources, the upfront cost of setting up a hydro power plant is very high along with considerable requirement of resources, time and effort to build. According to National Electricity Plan Vol -1 by CEA, the capex of hydro power projects is Rs. 60 million to 200 million per MW with a construction time require of 5-8 years which is the highest among all other renewable power. The O&M fixed cost is also high at 2.5% of capex per MW.

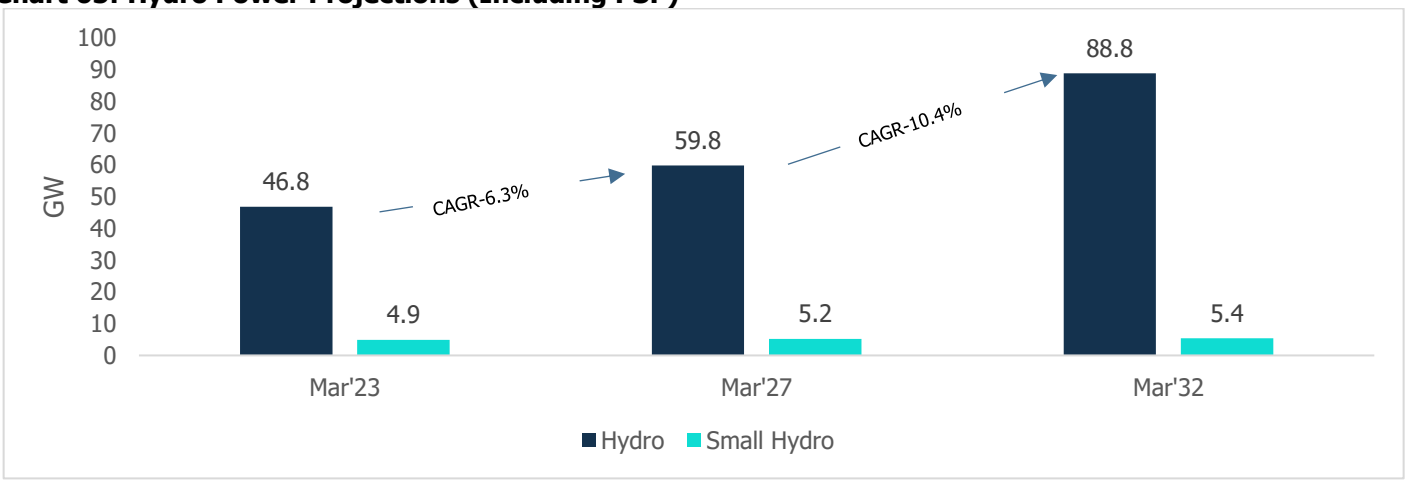
3.7.4 Outlook

There has been a subdued increase in the installed hydro power capacity because of various challenges like hydro power projects being site specific, lengthy process for detailed project report and environmental clearances, geological surprises, etc.

To meet the country's energy demand at a faster pace and achieve the targeted 500 GW of non-renewable energy, there needs to be an increase and shift of dependence on hydro power. The development of Mega hydro projects is essential.

The hydro power capacity is expected to grow at a CAGR of 6.3% from FY23 to FY27, reaching 59.8 GW while in FY32, the installed capacity is expected to reach 88.8 GW. For small hydro, the installed capacity is expected to remain in the range of 4.8 GW to 5.4 GW.

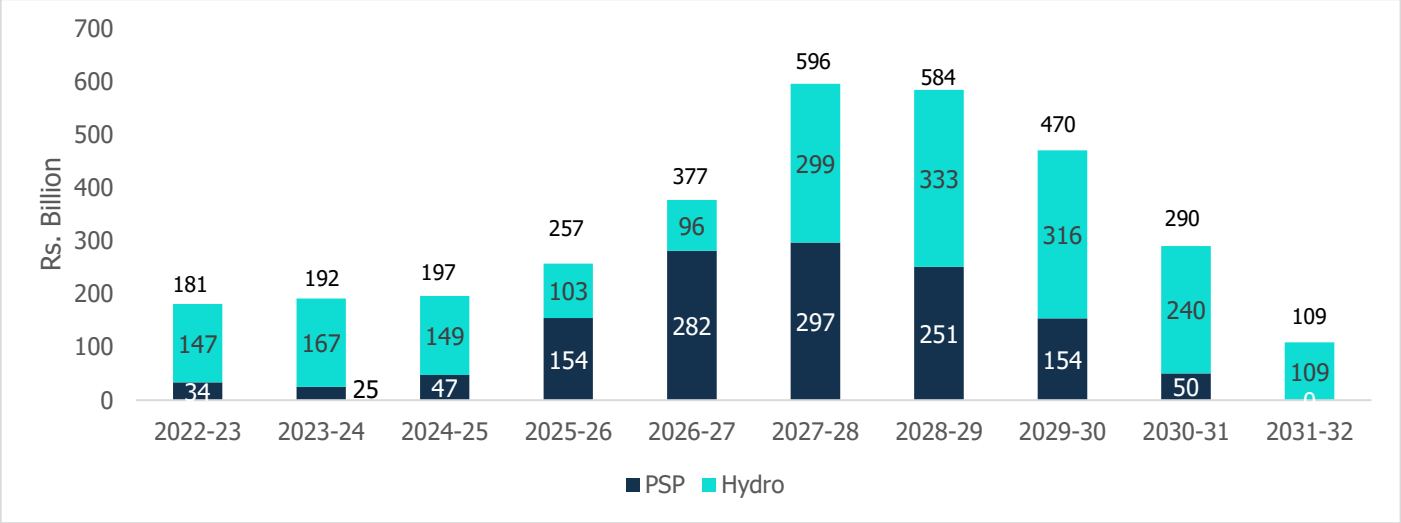
Chart 65: Hydro Power Projections (Including PSP)



Source: National Electricity Plan Vol-1 (March 2023), CareEdge Research

The capacity addition targets translate into an investment opportunity of Rs. 542.03 billion and Rs. 661.5 billion between FY23-27 and Rs. 752.4 billion and Rs. 1,297.77 billion between FY28-32 for PSP and Hydro power, respectively. The year-wise investment opportunity for hydro power including pumped hydro storage is given below.

Chart 66: Investment opportunity in hydro power projects (including pumped hydro storage)



Source: National Electricity Plan Vol-1 (March 2023), CareEdge Research

Note: Investments pertain to capacity additions targeted up to FY32. Investments towards capacities which will be commissioned beyond FY32 are not included.

3.8 Bioenergy Power in India

Biomass is the process by which agricultural waste is used for power generation or for biogas generation, where biomass includes rice husk, straw, cotton stalk, coconut shells, soya husk, de-oiled cakes, coffee waste, jute wastes, groundnut shells, saw dust, among others.

The current availability of biomass in India is 750 million metric tonnes, with an estimated surplus biomass availability of 230 million metric tonnes per annum corresponding to a potential of 28 GW. An additional power of 14 GW could be generated through bagasse-based cogeneration in the 550 sugar mills in the country.

Waste to Energy technologies like bio methanation, incineration, gasification, pyrolysis is used to recover the energy from waste in form of electricity and biogas/syngas. Waste-to-energy projects use agricultural, industrial and urban wastes of renewable nature such as municipal solid wastes, vegetable and other market wastes, slaughterhouse waste, agricultural residues and industrial and sewage treatment plant wastes and effluent, animal waste for power generation or for biogas generation.

Sector-wise waste to energy potential covering urban and industrial sectors is given below:

Table 28: Sector-wise waste to energy potential

Sr. No.	Sectors	Energy Potential-MW
1	Urban Solid Waste	1,247
2	Urban Liquid Waste	375
3	Paper	254
4	Processing and preserving of meat (liquid waste)	182
5	Processing and preserving of meat (solid waste)	13
6	Processing and preserving of fish, crustaceans and molluscs	17
7	Vegetable Processing	3
8	Vegetable Raw	579
9	Fruit Processing	8
10	Fruit Raw	203

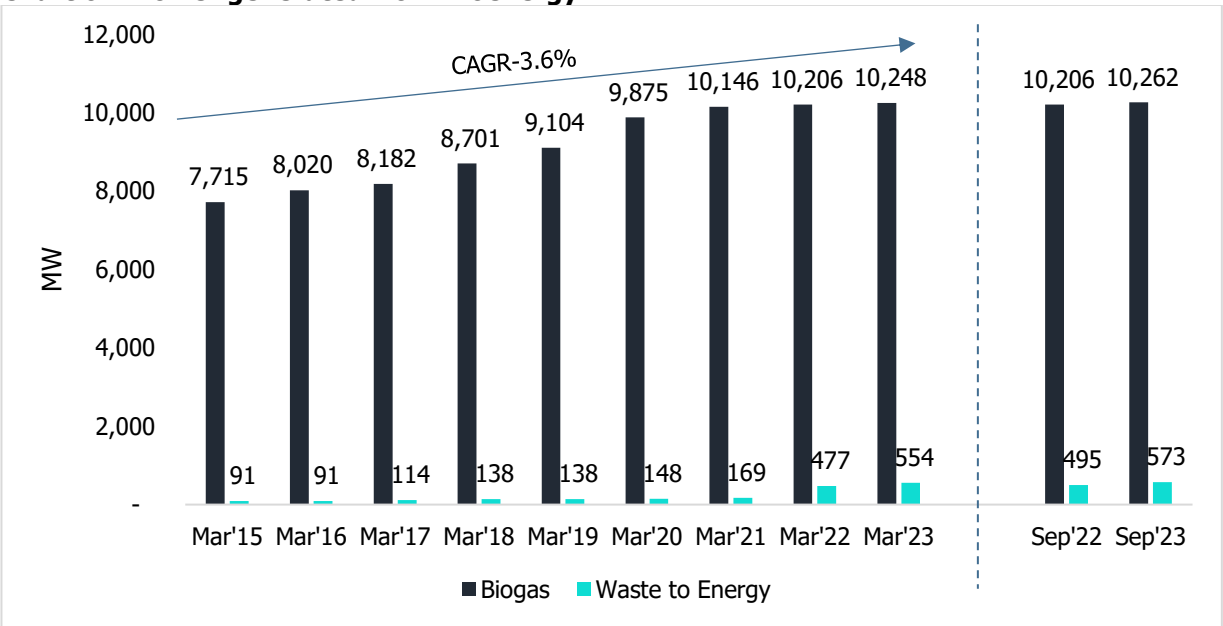
11	Palm Oil	2
12	Milk Processing/ Dairy Products	24
13	Maize Starch	47
14	Tapioca Starch (liquid waste)	36
15	Tapioca Starch (solid waste)	15
16	Sugar (liquid waste)	49
17	Sugar press mud (solid waste)	200
18	Distillery (liquid waste)	781
19	Wine Industry	NA
20	Slaughterhouse (solid waste)	48
21	Slaughterhouse (liquid waste)	263
22	Cattle farm	862
23	Poultry	462
24	Chicory	1
25	Tanneries (liquid waste)	9
25	Tanneries (solid waste)	10
	TOTAL (MW equivalent)	**5,690**

Source: MNRE, CareEdge Research

Power Generation from bioenergy offers a good potential in rural areas especially if they are far from the grid. Bioenergy uses biogas which is produced when bio-degradable waste such as cattle dung, biomass from farms, gardens, kitchen, poultry, municipal waste, etc. are subjected to scientific process in a biogas plant.

The total installed capacity of bioenergy power as on September 2023 is 10,262 MW while waste to energy is 573 MW. The bioenergy capacity has been stagnant, growing at a CAGR of 3% between FY15 to FY23. A total of 2,318 MW of bioenergy capacity is under construction.

Chart 67: Power generated from Bioenergy



Source: CEA, CareEdge Research

Drivers and Challenges

The major driver for bioenergy is that it an efficient way of utilization of waste and there are variety of feedstock used for bioenergy.

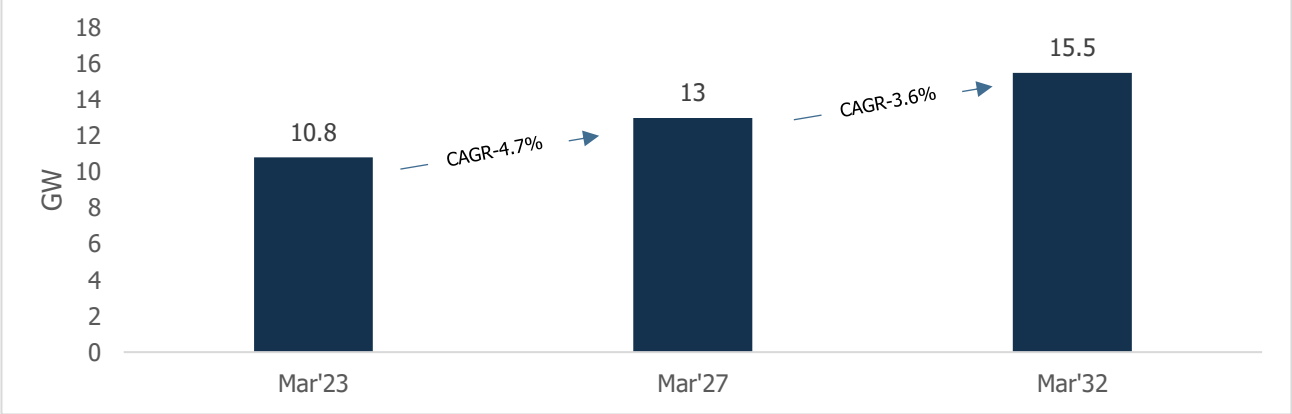
In metropolitan region, the bioenergy market is still developing, and strict governmental measures are needed to boost bioenergy generation from municipal and industrial waste. Municipal corporations are generally responsible for waste management in metropolitan areas, but they have limited financial resources. As a result, public-private partnerships should be promoted to boost private investment in India's waste-to-energy sector. However, considerations such as expensive upfront technology costs and the difficulty of obtaining finance from banks are some of the reasons for the low level of private sector participation in this area. As a result, financial assistance from the central and state governments is required to close the viability gap and make bioenergy projects financially viable. Financial incentives such as expedited depreciation and tax breaks would also aid in attracting major private sector companies.

Details of government schemes and subsidies are mentioned in section 4.

Outlook

In 2022, India's bioenergy potential was assessed to be 25 GW with the Government of India persistently promoting the Biomass Power and Bagasse Co-generation initiative. According to National Electricity Plan Vol-1 (March 2023), the estimated installed capacity as on Mar 2027 is 13 GW and 15.5 GW as on Mar 2032.

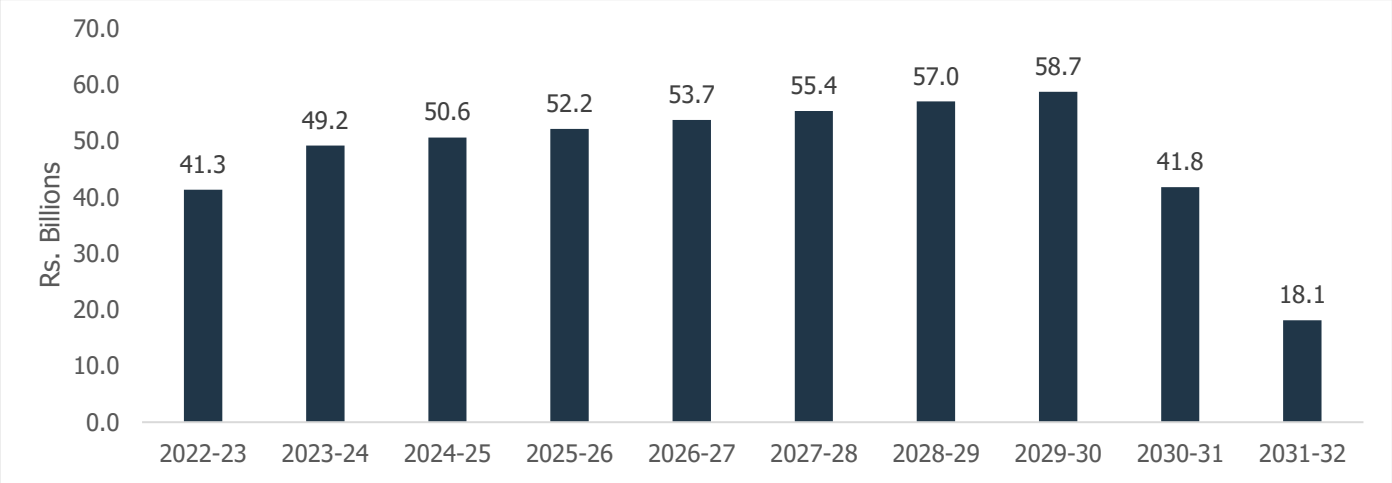
Chart 68: Bioenergy Power Projections



Source: National Electricity Plan Vol-1 (March 2023), CareEdge Research

The investment opportunity in bioenergy projects up to FY27 is around Rs. 247 billion and between FY28-FY32 is Rs. 231 billion. Year-wise fund requirement to achieve the targeted installed capacity is given below.

Chart 69: Year-wise investment opportunity in bioenergy-based power plants



Source: National Electricity Plan Vol-1 (March 2023), CareEdge Research

Note: Investments pertain to capacity additions targeted up to FY32. Investments towards capacities which will be commissioned beyond FY32 are not included.

3.9 Capital cost of renewable (solar and wind) v/s. conventional

Amongst the renewable power sources, solar is the least expensive technology on per MW basis. This is followed by wind and hydro power projects. In comparison with the coal based thermal power plants, capital cost for most of the renewable power plants is lower. Further the construction timeline of renewable capacities (excluding hydro based plants) is significantly lower compared to coal-based plants, thereby resulting in relatively earlier project completion and commencement of cashflows as well as returns.

Table 29: Cost Parameters for Thermal and Renewable Power

Resource	Capex* (Rs. Million MW)	O&M Fixed Cost (Rs. MW)	Construction Time (Years)	Life (Years)
Coal	83.4	1.954 million	4	25
Renewable				
Hydro	60-200	2.5% of Capex	5-8	40
Solar	45- 41	1% of Capex	0.5	25
Wind (Onshore)	60^	1% of Capex	1.5	25
Wind (Offshore)	137	1% of Capex	1.5	25
Bioenergy	90	2% of Capex	3	20

Source: National Electricity Plan Vol-1 (March 2023), CareEdge Research

*Capex figures are considered on actual basis at cost level of 2021-22

^ Excludes soft cost, interest during construction, contingencies etc.

4. Government Schemes and Subsidies for Renewables

As part of its Nationally Determined Contribution (NDC) for the Paris Agreement obligations, the government stated that by 2030, reduction of the emissions intensity of GDP by 45% below 2005 levels, and raise the percentage of non-fossil fuels in total capacity to 50% and increase share of non-fossil power capacity to 50%. Hence the government has pushed towards renewable capacity additions through policies initiatives like JNNSM, obligations of RPO, setting up of SECI, etc.

- **Green Energy Corridor**

The Green Energy Corridor scheme was launched in 2015 for setting up of transmission and evacuation infrastructure to facilitate evacuation of electricity from renewable energy projects. The Intra state transmission system (ISTS) projects has been sanctioned to eight renewable energy states i.e. Tamil Nadu, Rajasthan, Karnataka, Andhra Pradesh, Maharashtra, Gujarat, Himachal Pradesh and Madhya Pradesh for evacuation of over 20,000 MW of renewable energy.

As on 31.12.2022, 8759 ckm of intra-state transmission lines have been constructed and 19868 MVA intrastate substations have been charged. Under the second phase of Intra-State Transmission System Green Energy Corridor Scheme (InSTS GEC-II) approved on 6th January, 2022, the 7 states of Gujarat, Himachal Pradesh, Karnataka, Kerala, Rajasthan, Tamil Nadu and Uttar Pradesh, are currently in the process of issuing tenders to implement projects for evacuation of 20 GW renewable capacity. The project cost is Rs. 120.31 billion with central financial assistance (CFA) @33% of the project cost i.e. Rs. 39.70 billion.

Table 30: State-wise Project cost and approved CFA

State	Project Cost without IDC (Rs. Billion)	Central Financial Assistance (Rs. Billion)
Gujarat	36.36	12.00
Himachal Pradesh	4.89	1.61
Karnataka	10.36	3.41
Kerala	4.20	1.38
Rajasthan	8.80	2.90
Tamil Nadu	7.19	2.37
Uttar Pradesh	48.47	15.99
Total	**120.31**	**39.70**

Source: MNRE, CareEdge Research

- **Round-the-Clock-Power (RTC) for RE projects**

The round-the-clock power mechanism is bundling of power has been bought by the government in order to overcome the issues of intermittency and low capacity utilization of transmission infrastructure. Here the RE power is bundled with other sources and/or storage.

- **Competitive Bidding Guidelines for solar and wind projects**

The bidding guidelines have been issued for long term procurement of power to promote competitive procurement from solar and wind and also to protect the consumer interests. The guidelines for tariff based competitive bidding process for procurement of power from grid connected solar PV power projects were issued vide resolution 3rd August 2017 while the guidelines for tariff based competitive bidding process for procurement of power from grid connected wind power projects issued vide resolution dated 8th Dec 2017.

- **Waiver of ISTS Charges**

Ministry of Power has issued order for an extension to the inter-state transmission system (ISTS) charges waiver on solar and wind energy projects commissioned up to 30 June 2025. Waiver of ISTS charges shall also be allowed for hydro pumped storage plant and battery energy storage system projects to be commissioned up to 30th June 2025 following some conditions.

ISTS waiver would be allowed for trading electricity generated and supplied from solar, wind, pumped hydro, and Battery Energy Storage Systems (BESS) in the green term ahead market (GTAM) till 30th June 2023 and the arrangement would be reviewed on annual basis depending on future development in the power market.

As per the notification issued by Ministry of Power, a complete waiver of ISTS charges has been given for off-shore wind power projects commissioned on or before 31st December, 2032 for a period of 25 years from the date of commissioning of the Project.

- **Must Run Status**

In line with the Electricity Act 2003 and the Electricity Grid Code 2010, wind and solar power have the 'must-run status'. The term 'must run status' refers to the notion that electricity evacuation from solar and wind power facilities should not be limited for reasons other than grid safety, equipment or people safety, merit order dispatch, or other commercial concerns.

- **Incentives including AD and GBI**

  - Indian renewable energy companies were entitled to take 80.0% accelerated depreciation on assets employed in renewable energy power generation and benefit from a 10-year tax holiday. Until March 31, 2017, the accelerated depreciation advantage was set at 80%. The accelerated depreciation tax was reduced to 40% on April 1, 2017 as part of the Union Budget 2016-2017.

  - GBI of 50 paisa (half an Indian rupee) per unit was launched in December 2009. The purpose of this subsidy/incentive was to shift the mechanism of payment from installation-based to generation-based methods of rewarding wind farms. GBI was a way to encourage development of more efficient wind farms.

  - AD and GBI benefits enabled an improvement in installed capacities in the last decade. GBI was later discontinued in 2017.

  - Solar GBI- There are two schemes under Solar GBI, the Solar Demonstration GBI scheme and the Rooftop PV and Small Solar Power Generation Programme (the "RPSSGP") Scheme. The Solar Demonstration GBI Scheme was introduced in 2008 with the objective to develop and demonstrate the technical performance of grid interactive solar power generation and to achieve reduction in the cost of solar systems and the cost of solar generation in the country. The RPSSGP Scheme was introduced in 2010 with the objective to increase the capacity addition of Rooftop PV and small solar power plants with voltage level up to 33kV. Under this scheme, 72 solar projects with total capacity of 91.8 MW were set up across 13 states, as of March 31, 2023.

  - Wind GBI- The wind GBI scheme was introduced with the objective to promote efficient technology by incentivizing the actual generation, broaden investor base, facilitate entry of large IPPs and FDI. It was introduced with a demonstration scheme in which total of 48.9 MW wind projects were registered for GBI against target of 49MW. With the success of this scheme, Wind GBI-I scheme and Wind GBI-II scheme were introduced by MNRE in 2009 and 2013 respectively with total commissioned capacity of 13,624.88 MW and 704 wind power projects registered under the schemes. A budget of Rs. 12.14 billion have been allocated for 2023-24 under the GBI scheme which will utilized to clear past liabilities.

4.1 Solar

- **Jawaharlal Nehru National Solar Mission**

Jawaharlal Nehru National Solar Mission (JNNSM) is one of the primary missions under India's National Action Plan on Climate Change. JNNSM is a major initiative by the Indian government to encourage environmentally sustainable growth while addressing India's energy security issues. To meet this goal, the Indian Government has implemented a number of policies, including the Solar Park Scheme, Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhian (PM KUSUM), Central Public Sector Undertaking (CPSU), Grid Connected Solar Rooftop Schemes, Domestic modules production, REC, RPO, waiver of ISTS charges etc.

Table 31: Targets of National Solar Mission

Application Segment	Phase 1 2010-13	Phase 2 2013-17	Phase 3 2017-22
Utility grid power	1,000-2,000 MW	4,000-10,000 MW	100,000 MW
Off grid Applications	200 MW	1000 MW	2000 MW
Solar Thermal Collectors Area	7 million sqm	15 million sqm	20 million sqm
Manufacturing Base	-	-	4000-5000 MW
Solar Lighting Systems	-	-	20 million
Solar RPO	0.25%	-	3 %

Source: MNRE, CareEdge Research

- **International Solar Alliance**

The International Solar Alliance (ISA) is a treaty based inter-governmental organization working to create a global market system to tap the benefits of solar power and create clean energy applications. The aim of ISA is to pave the way for future solar generation, storage and technologies for the member countries by mobilizing over USD 1000 billion by 2030. The achievement of ISA's objective will help the member countries fulfil the Nationally Determined Contributions (NSC) commitments.

- **Pradhan Mantri Kisan Urja Suraksha Evam Utthan Mahabhiyan (PM KUSUM):**

The PM-KUSUM programme is to supply renewable energy to over 3.5 million farmers by solarizing their agriculture pumps. The PM-KUSUM programme intends to build grid-connected ground mounted solar power plants (up to 2 MW) totalling 10 GW under Component A; and 2 million freestanding solar pumps under Component B; and solarize 1.5 million grid connected agricultural pumps under Component C. All components combined would support installation of additional solar capacity of 30.80 GW.

As on Dec 2022, 88.45 MW capacity solar power plants were installed under scheme's Component-A, about 0.181 million stand-alone solar pumps were installed under Component-B and 1174 pumps were reported solarised under individual pump solarisation variant of Component-C.

- **Roof Top Solar (RTS) Programme:**

Rooftop solar power (RTS) is a rooftop solar system that generates electricity for Kenyan households and public buildings. Rooftop Phase-I of this initiative began on December 30, 2015, with incentives and subsidies offered for the residential, institutional, and social sectors. Achievement-based incentives were also offered for the government sector. Rooftop Phase-II began in February 2019 with the goal of reaching a total capacity of 40,000 MW by 2022. RTS has built approximately 3.7 GW of capacity so far, with another 2.6 GW under construction in the residential market. Central

Financial Assistance is given at 40% for RTS systems up to 3 kW capacity and 20% for systems with capacities more than 3 kW.

Against the target of 4 GW RTS in Residential sector under the programme, around 1.66 GW capacity was reported installed as on 31.12.2022. Overall, nearly 7.6 GW capacity of grid-connected RTS plants were reported installed in the country as on 31.12.2022. Phase II of the Rooftop Solar Programme timelines have been extended up to 31.03.2026.

- **Solar Parks:**

The Ministry of Power has introduced the Solar Parks programme with the objective of facilitating solar project developers to set up projects in a plug-and-play model. The scheme for development of solar parks has a target capacity of 40 GW and all States and Union Territories are eligible for getting benefit under the scheme.

Under this scheme, 57 Solar Parks with a cumulative capacity of 39.28 GW in 13 states were approved, as on 31.12.2022.

- **Solar Cities**

Under this scheme, at least one city in each state of India is being developed as a solar city. Here, all the electricity needs of the city will be met through RE sources primarily from solar energy and all houses will have roof-top solar energy plants along with solar street lights and waste to energy plants.

The aim of the programme is to enable and empower urban local government to address the energy challenges at city level, provide a framework and support to prepare a master plan including assessment of current energy situation, future demand and action plans.

- **Greening of Islands:**

The government plans to entirely convert the islands of Andaman and Nicobar and Lakshadweep to Green Electricity, with RE sources meeting all energy demands. The Ministry grants a capital subsidy of 40% for projects under the plan.

- **Off Grid Solar PV Applications Programme Phase III:**

The North-Eastern States' participation in Phase 3 of the Off-Grid Solar PV Applications Programme for Solar Street Lights, Solar Study Lamps, and Solar Power Packs was extended. The Scheme has sanctioned 0.174 million solar street lights, 1.35 million solar study lamps, and 4 MW solar power packs, all of which are now being implemented by state nodal agencies at various levels.

- **Public Sector Undertaking (CPSU) Scheme:**

The Cabinet Committee on Economic Affairs ("CCEA") has approved the MNRE's proposal for implementation of the CPSU Scheme Phase-II for setting up 12,000 MW grid-connected solar PV power projects with VGF support of Rs. 858 million for self-use or use by Government or Government entities, of both Central and State Governments. The scheme mandates the use of both solar PV cells and modules manufactured domestically as per specifications and testing requirements fixed by the MNRE.

Under this scheme, around 8.2 GW of projects have been awarded, as on 31.12.2022, out of which around 1.5 GW has been commissioned as on 31.12.2022 and balance are under implementation.

4.2 Wind

Duty exemption certificate for manufacturing of wind turbines

Ministry is issuing concessional custom duty exemption certificates (CCDC) to the manufacturers of wind operated electricity generators. For this purpose, the eligible turbine and component manufacturers need to get the bill of material for Revised List of Models and Manufacturers (RLMM) listed turbine models approved and then apply in prescribed formats to Ministry for a CCDC certificate for their import consignments.

Based on MNRE's recommendation, CCDC for several wind turbine components has been extended till 31.03.2025 by Ministry of Finance (Notification No. 02/2023-Customs dated 01.02.2023).

Repowering potential

In India, the wind power industry has been looking at the prospect of repowering existing wind farms, which might help to speed up capacity expansion. Repowering, which means the installation of newer, higher-capacity turbines in older wind farms, can be partial or complete. Full repowering entails the decommissioning of outdated wind turbines and the installation of new, more efficient wind turbines.

According to the NIWE, all windmills with a CUF of 15% are technically suitable for repowering, and their CUF may be quadrupled, or tripled in wind-intensive areas. If solar is also added, leading to hybrid renewable energy projects, the annual energy production can go up by more than six times.

It's worth noting that these older wind turbines are situated in some of India's most wind-friendly locations (class I sites). However, they have low plant load factors (PLF) of 10-15%, more opposed to the greater than 30% PLF of contemporary wind turbines.

Provisions of the Repowering Policy:

Draft National Repowering Policy for Wind Power Projects was issued for stakeholder's consultation in October, 2022, with the objective for optimum utilization of wind energy resources by maximizing energy (kWh) yield per km2 of the project area and utilizing the latest state-of-the-art onshore wind turbine technologies.

Offshore Wind Project

In light of potential from off-shore wind due to the abundant 7600-kilometer coastline, the Government published the National Offshore Wind Energy Policy in the Gazette on October 6, 2015.

According to the policy, the Ministry of New and Renewable Energy will serve as the nodal ministry for the development of off-shore wind energy in India, working in close collaboration with other government entities to effectively develop and use Maritime Space within the country's Exclusive Economic Zone (EEZ) for the production of massive amounts of grid-quality electrical power for national cohesion.

4.3 Wind-Solar Hybrid

- **National Wind- Solar Hybrid Policy**

On May 14, 2018, the Ministry of New and Renewable Energy released the National Wind-Solar Hybrid Policy. The policy's major goal is to create a framework for the development of large-scale grid-connected wind-solar PV hybrid systems for the most efficient and effective use of wind and solar resources, transmission infrastructure, and land. Wind-solar PV hybrid systems will aid in decreasing renewable power output unpredictability and improving grid stability. The strategy also intends to promote innovative technologies, techniques, and workarounds incorporating wind and solar PV plant co-operation.

The major highlights of the policy are as below:

- A wind-solar plant will be recognized as hybrid plant if the rated power capacity of one resource is at least 25% of the rated power capacity of other resource.
- Both AC and DC integration of wind-solar hybrid project are allowed.
- The power procured from the hybrid project may be used for fulfilment of solar RPO and non-solar RPO in the proportion of rated capacity of solar and wind power in the hybrid plant respectively.
- Existing wind or solar power projects, willing to install solar PV plant or Wind Turbine Generators (WTGs) respectively, to avail benefit of hybrid project, may be allowed.
- All fiscal and financial incentives available to wind and solar power projects will also be made available to hybrid projects.
- The Central Electricity Authority (CEA) and Central Electricity Regulatory Commission (CERC) shall formulate necessary standards and regulations including metering methodology and standards, forecasting and scheduling regulations, REC mechanism, grant of connectivity and sharing of transmission lines, etc., for wind-solar hybrid systems.
- Storage may be added to the hybrid project to ensure availability of firm power for a particular period.

4.4 Hydro (including PSP)

The Hydro Policy was notified by the government on March 2019, the salient features of the policy are as follows:

- Declaring Large Hydro Projects as renewable energy sources

The large hydro projects with the capacity more than 25 MW were earlier not recognized as renewable energy, but through the Hydro Policy, it was recognized as renewable in 2019. The large hydro projects would however not be eligible for any differential treatment for statutory clearances like forest clearances, environmental clearances, National Board of Wildlife clearance, any related assessment and study, etc. available for small hydro projects.

- Hydro Power Obligation (HPO)

Hydro Power Obligation was given separate category within the non-solar RPO and these would cover all large hydro projects commissioned after the notification as well as untied capacity of the commissioned projects. The non-solar RPO for other renewable sources have remained unchanged by the introduction of HPO.

- Tariff rationalization measures

Tariff rationalization measures were introduced to bring down the hydropower tariffs. The measures include providing flexibility to the developers to determine the tariff by back loading of tariff after increasing project life to 40 years, increasing the debt repayment period to 18 years and introducing escalating tariff of 2%.

- Budgetary support for funding flood moderation component of hydropower in case-to-case basis
- Budgetary support for cost funding for infrastructure i.e. roads and bridges limited to Rs. 15 million per MW for up to 200 MW projects and Rs. 10 million per MW for above 200 MW projects.

- **Hydro Pumped Storage Guidelines**

To achieve government of India's commitment of 500 GW of installed capacity from non-fossil fuel sources by 2030, become energy independent by 2047 and achieve net zero emissions by the year 2070, hydro pumped storage projects are necessary. Hence 39 Hydro PSPs of 47 GW are being pursued to be commissioned by 2029-30.

Various steps have been taken by the government in order to ensure that Pumped Storage Projects (PSPs) get commissioned on a fast track for accelerating the growth of renewable energy sector of India. The steps include:

- Revamped process for approval of pumped storage projects
- Single window clearance
- Speeding up environmental clearance
- Compressed timelines for approval of DPRs

The Central government had issued waiver of ISTS charges for PSP and BESS projects in order to promote commissioning and optimum utilization of storage projects on 21.06.2021. The scheme also waiver of transmission charges for trading of electricity generated/supplied from Solar, Wind, PSP and BESS in Green Term Ahead Market (GTAM) and Green Day Ahead Market (GDAM) for till 30.06.2023.

The ISTS charges for power supplied from Hydro PSP or BESS projects shall be levied gradually as follows:
i. 25% of STOA charges for initial 5 years of operation.
ii. After 5 years, the charges will be increased in steps of 25% every 3rd year to reach 100% of STOA charges from 12th year onwards.

4.5 Bioenergy

- **National Bioenergy Programme**

The National Bioenergy Programme was launched by the MNRE in November 2022 for the period from Fiscal 2022 to Fiscal 2026. The programme has been recommended for implementation in two phases. Phase-I of the programme has been approved with a budget outlay of Rs. 8.58 billion. The National Bioenergy Programme comprises the following sub-schemes:

(i) Waste to Energy Programme (Programme on Energy from Urban, Industrial and Agricultural Wastes/Residues)
(ii) Biomass Programme (Scheme to Support Manufacturing of Briquettes and Pellets and Promotion of Biomass (non-bagasse) based cogeneration in Industries); and
(iii) Bio-gas programme.

The total outlay of the programme under Phase-1 is Rs. 8.58 billion, out of which IREDA has been designated as the implementing agency for Programme on Energy from Urban, Industrial and Agricultural Wastes and Residues and the Scheme to Support Manufacturing of Briquettes and Pellets and Promotion of Biomass (non-bagasse) based cogeneration in Industries for Rs. 7.58 billion.

- **Biomass Co-firing**

Biomass co-firing is a practice where a part of fuel is substituted with biomass in thermal plants. This helps cut down the emissions from combustion of fossil fuels and reduces waste burden creating jobs in rural areas. While presenting the Union Budget 2022-23, the finance minister said that 5-7% of biomass pallets will be co-fired in every thermal power plant in the country. This will annually reduce the carbon emissions by 38 million tonnes.

13 NTPC plants have been retrofitted completely to run this scheme as of now. This retrofitting has allowed the company to co-fire 10% of biomass at maximum.

Biomass co-firing has emerged the most economical way of utilizing the biomass and reducing the carbon footprints of coal power plants.

4.6 National Green Hydrogen Mission

The National Green Hydrogen Mission was approved by the Government of India in Jan 2023, with an objective to make India a global hub for production, usage and export of green hydrogen and its derivatives and approved an outlay of Rs. 190 billion to help achieve an annual production target of 5 MMT by 2030 for facilitating the net-zero target. The mission is also expected to generate Rs. 8 trillion in total investments by 2030 and around 50 MMT per annum of CO_2 emissions are expected to be averted.

The policy provides the following:

i. Green Hydrogen / Ammonia manufacturers may purchase renewable power from the power exchange or set up renewable energy capacity themselves or through any other, developer, anywhere.
ii. Open access will be granted within 15 days of receipt of application.
iii. The Green Hydrogen / Ammonia manufacturer can bank his unconsumed renewable power, up to 30 days, with Distribution Company and take it back when required.
iv. Distribution licensees can also procure and supply Renewable Energy to the manufacturers of Green Hydrogen / Green Ammonia in their States at concessional prices which will only include the cost of procurement, wheeling charges and a small margin as determined by the State Commission.
v. Waiver of inter-state transmission charges for a period of 25 years will be allowed to the manufacturers of Green Hydrogen and Green Ammonia for the projects commissioned before 30th June 2025.
vi. The manufacturers of Green Hydrogen / Ammonia and the renewable energy plant shall be given connectivity to the grid on priority basis to avoid any procedural delays.
vii. The benefit of Renewable Purchase Obligation (RPO) will be granted incentive to the hydrogen/Ammonia manufacturer and the Distribution licensee for consumption of renewable power.
viii. To ensure ease of doing business a single portal for carrying out all the activities including statutory clearances in a time bound manner will be set up by MNRE.
ix. Connectivity, at the generation end and the Green Hydrogen / Green Ammonia manufacturing end, to the ISTS for Renewable Energy capacity set up for the purpose of manufacturing Green Hydrogen / Green Ammonia shall be granted on priority.
x. Manufacturers of Green Hydrogen / Green Ammonia shall be allowed to set up bunkers near Ports for storage of Green Ammonia for export / use by shipping. The land for the storage for this purpose shall be provided by the respective Port Authorities at applicable charges.

The mission defines green hydrogen as the hydrogen produced using renewable energy, including but not limited to production through electrolysis or conversion of biomass.

When green hydrogen is produced through electrolysis, the non-biogenic greenhouse gas emissions arising from water treatment, electrolysis, gas purification and drying and compression of hydrogen shall not be greater than 2 kilogram of carbon di-oxide equivalent per kilogram of hydrogen (kg CO_2 eq./kg hydrogen), taken as an average over last 12-month period.

For green hydrogen produced through conversion of biomass, the non-biogenic greenhouse gas emissions arising from biomass processing, heat/steam generation, conversion of biomass to hydrogen, gas purification and drying and compression of hydrogen shall not be greater than 2 kilogram of carbon dioxide equivalent per kilogram of hydrogen (kg CO_2 eq./kg hydrogen) taken as an average over last 12-month period.

The mission is proposed to be implemented in phased manner since the sector is at nascent stage and rapidly evolving.

Phase	Timeline	Activities to be undertaken
Phase I	2022-23 to 2025-26	Focus on creating demand while enabling adequate supply by increasing the domestic electrolyser manufacturing capacity
Phase II	2026-27 to 2029-30	Build on the foundational activities and undertake green hydrogen initiatives in new sectors.

The pilot projects of the mission includes outlay of Rs. 4.55 billion up to FY30 for low carbon steel projects, Rs. 4.96 billion up to FY26 for mobility pilot projects, Rs. 1.15 billion up to FY26 for shipping pilot projects and other target areas including decentralized energy applications, hydrogen production from biomass, hydrogen storage technologies, etc.

Under the Green Hydrogen Mission, the sub schemes are Strategic Interventions for Green Hydrogen Transition Programme and Green Hydrogen Hubs where, states and regions capable of supporting large scale production and/or utilization of hydrogen will be identified and developed as hubs,

The Strategic Interventions for Green Hydrogen Transition (SIGHT) program is a major financial measure under the Green Hydrogen Mission with an outlay of Rs. 174.90 billion. The programme has two distinct financial initiative mechanisms to support domestic manufacturing of electrolyser and production of green hydrogen with an aim to enable rapid scale-up, technology development and cost reduction.

4.7 Green Transmission

India has a target of 500 GW of non-fossil fuel capacity by 2030 and hence significant investments have commenced towards increasing and upgrading the transmission infrastructure. Transmission system has been planned for following RE capacity to be commission by 2030:

Table 32: Transmission System planned for Renewable Energy

Sr. No.	Category	Capacity (MW)
1.	RE capacity already commissioned (As on 31.10.2022)	1,65,943
2.	66.5 GW RE capacity to be integrated to Inter State Transmission System (ISTS) network (8.861 GW already commissioned)	57,639
3.	Additional RE capacity totalling to 236.58 GW to be integrated to ISTS network	2,36,580
4.	Margin already available in ISTS sub-station which can be used for integration of RE capacity	33,658
5.	Balance RE capacity to be integrated to intra-state system under Green Energy Corridor-I Scheme	7,000
6.	RE capacity to be integrated to intra-state system under Green Energy Corridor -II Scheme	19,431
7.	Additional Hydro Capacity likely by 2030	16,673
	Total (RE)	**5,36,924**

Source: CEA Report- Transmission System Integration of over 500GW RE Capacity by 2030, CareEdge Research

For integration of additional wind and solar capacity by 2030, the estimated length of transmission line and sub-station capacity planned is around 50,890 ckm and 4,33,575 MVA, respectively. The investment required for the green transmission is estimated to be around Rs. 2,440 billion as per the Ministry of Power. Out of this, Rs. 281 billion will be required for integration of offshore wind capacities while Rs. 2,160 billion will be required for new solar and wind (onshore) plants.

Table 33: Tentative cost of additional transmission system

	RE Capacity (GW)	BESS (GW)	Requirement of Transmission system (GW)	Tentative cost of transmission system (Rs. billion)	Average cost of Transmission system (Rs. Million/MW)
On-shore RE Capacity (Solar & Wind)	268.68	51.5	217.18	2,161	9.95
Offshore RE capacity (Wind)	10	0	10	281	28.1
Total RE capacity	**278.68**	**51.5**	**227.18**	**2,442**	**10.75**

The tentative cost includes the cost of ISTS transmission schemes for (i) 66.5 GW RE capacity (excluding commissioned transmission schemes and associated RE capacity) (ii) 55.08 GW RE capacity and (iii) 181.5 GW RE capacity

Source: CEA Report- Transmission System Integration of over 500GW RE Capacity by 2030, CareEdge Research

Table 34: Summary of government schemes with defined targets/ financial outlay

Sr. No.	Scheme/ Policy	Financial Outlay	Target
1.	Green Energy Corridor	Rs. 120.31 billion	
2.	Green Transmission	Rs. 2,440 billion	
	Solar		
3	Solar GBI	NA	91.8 MW
4.	National Solar Mission	NA	100 GW by 2022
5.	PM KUSUM	Rs. 340 billion	30.8 MW
6.	RTS Programme	Rs. 350 billion	7.6 MW
7.	Solar Parks	NA	40 GW by Mar'24
8.	Solar Cities	NA	60 solar cities
9.	CPSU Scheme	Rs. 858 million	8.2 GW
10.	PLI Scheme for Solar Module	Rs. 195 billion	NA
	Wind		
11.	Wind GBI	Rs. 12.14 billion	NA
12.	Offshore Wind Policy	Rs. 156.08 billion	37 GW by 2030
	Hydro		
	Hydro Pumped Storage	NA	47 GW by 2030
	Bioenergy		
13.	National Bioenergy Programme	Rs. 8.58 billion	NA
	Green Hydrogen		
14.	Green Hydrogen Mission	Rs. 197.4 billion	NA

Note: Timelines of the policies and proposed financial outlay are provided in the earlier sections

5. Net Zero and Other Key Technologies

5.1 Fuels from Bioenergy Sources

Bioenergy fuels or Biofuels are derived from renewable biomass resources and wastes such as Plastic, Municipal Solid Waste (MSW), waste gases etc. and used in place of or in blend with, diesel, petrol or other fossil fuels for transport, stationary, portable and other applications. These fuels have low CO_2 emissions compared to fossil fuels.

The government of India is focusing on increasing the usage of biofuel in India with the following objectives:

- Increase energy security
- Reduce dependence on imported crude oil leading to foreign exchange savings
- Address environmental issues due to vehicular emissions, burning of biomass waste
- Provide opportunities to local entrepreneurs and local farmers to participate in the energy economy, thereby supplementing their income
- Address challenges arising in waste and agricultural residue management

Table 35: Type of Biofuels

Type	Description	Products
First Generation	Produced from edible energy crops such as sugarcane, corn, wheat, barley, sunflower, canola etc.	Bioethanol and biodiesel
Second Generation	Produced from non-food feedstock such as wood, forest waste, food crop waste, waste vegetable oil, animal waste etc.	Bio-oil, FT oil, lignocellulosic ethanol, butanol, mixed alcohol etc.
Third Generation	Produced from microorganisms such as bacteria and algae	All types of biofuels with higher yield compared to earlier generations can be produced under third generation techniques.

Source: CareEdge Research

India is one of the leading producers of biofuels in the world[9]. The Public Sector Oil Marketing Companies (OMCs) have procured ethanol from domestic producers and thereafter blended 4.336 billion litres of ethanol in petrol during the Ethanol Supply Year (ESY)[10] 2021-22 and procured 58.3 million litres of bio-diesel till November 2022 for blending with diesel during FY23. The Oil and Gas Marketing Companies (OGMCs) have issued 3,694 Letters of Intents (LoIs) to potential entrepreneurs for procurement of Compressed Bio Gas (CBG) up to 31st October, 2022. Further, Oil CPSEs are setting up 2nd generation ethanol bio-refineries in the country at Panipat (Haryana), Bathinda (Punjab), Numaligarh (Assam), Bargarh (Odisha) and one demonstration project at Panipat.[11]

As on June 2022, the OMCs achieved 10% ethanol blending target ahead of the November 2022 deadline which was set under the Roadmap for Ethanol Blending in India 2020-25. As per government sources, this achievement has translated into a forex impact of over Rs.415 billion, reduced greenhouse gas (GHG) emissions of 2.7 million MT and also led to the expeditious payment of over Rs.406 billion to farmers since 2014.

Further, as on June 11, 2023, ESY 2022-23 recorded 11.70% blending. The blending target for current ESY is 12%.

[9] Source: PIB Dated 22nd December 2022
[10] ESY: 1st December to 30th November
[11] https://pib.gov.in/PressReleasePage.aspx?PRID=1885827

Compressed Bio-Gas (CBG)

Compressed Bio gas is similar to the commercially available natural gas in its composition and energy potential and can be used as an alternative renewable automotive fuel. CBG is produced after purification and compression of bio gas which is produced naturally from waste or biomass sources like agriculture residue, cattle dung, sugarcane press mud, municipal waste, etc.

The Ministry of Road Transport and Highways, Government of India had permitted usage of bio-compressed natural gas for motor vehicles as an alternate to CNG in 2015 via Vide Gazette Notification no. 395 dated 16th June 2015.

The CBG potential from various sources in India is estimated to be around 62 MMT with bio-manure generation capacity of 370 MMT[12]. There are various biofuels projects undertaken including Compressed Biogas (CBG) projects under SATAT (Sustainable Alternative Towards Affordable Transportation) initiative by the government. The initiative envisages production target of 15 million metric tonnes of CBG by 2023-24 from 5,000 CBG Plants. Investment of around Rs. 30,000 crores is envisaged for 900 plants.

Key Government Policies

1. National Policy on Biofuel

The government notified the National Policy on Biofuels (NBP) in June 2018 to promote the use of biofuels in the country and ensure availability of the same from indigenous feedstock. This policy envisaged an indicative target of 20% blending of ethanol in petrol by 2030 and 5% blending of biodiesel in diesel by 2030.

National Biofuel Coordination Committee (NBCC) headed by the Minister, Petroleum and Natural Gas and representatives of concerned Ministries was set up under the NBP to provide overall coordination, effective end-to-end implementation and monitoring of biofuel programmes.

Subsequently in May 2022, the following amendments were carried out to the NBP.

- To allow more feedstocks for production of biofuels
- To advance the ethanol blending target of 20% blending of ethanol in petrol to ESY 2025-26 from 2030
- To promote the production of biofuels in the country, under the Make in India program, by units located in Special Economic Zones (SEZ)/ Export Oriented Units (EoUs)
- To grant permission for export of biofuels in specific cases, and
- To delete/amend certain phrases in the Policy in line with decisions taken during the meetings of National Biofuel Coordination Committee (NBCC).
- To add new members to the NBCC

2. Restriction on import and exports of biofuels

In 2018, the government had imposed restrictions on imports and exports of biofuels from India under the NBP to encourage domestic manufacturing and consumption of biofuels. Subsequently, under the 2022 amendment to the NBP, the export of biofuels was permitted subject to certain conditions and with prior approval of the NBCC.

In March 2023, the Directorate General of Foreign Trade has permitted exports of biofuels for fuel as well as non-fuel purpose without any restrictions, to the extent that biofuels exported from special economic zones/export-oriented units are produced using only imported feed stock.

[12] Source: White Paper on Compressed CBG- The fuel of future by Indian Oil

3. Pradhan Mantri JI-VAN (Jaiv Indhan - Vatavaran Anukool fasal awashesh Nivaran) Yojana

In March 2019, the government notified the Pradhan Mantri Ji-Van Yojana to provide financial support to integrated bio-ethanol projects or setting up Second Generation (2G) ethanol projects in the country using lignocellulosic biomass and other renewable feedstock. The total financial outlay for the scheme is Rs. 19.695 billion for the period FY19 to FY24.

Under this scheme, financial assistance of Rs. 1.5 billion per project for commercial projects, and Rs.150 million per project for demonstration projects was prescribed for improving commercial viability as well as promoting R&D for development and adoption of technologies in the field of production of second-generation ethanol.

As on July 2022, financial assistance of Rs. 1.5 billion each to the four commercial second generation bio-ethanol projects at Bathinda in Punjab, Panipat in Haryana, Bargarh in Odisha and Numaligarh in Assam and Rs. 150 million to one demonstration project at Panipat in Haryana has been approved under the scheme and Rs. 1.51 billion was released based on the milestones achieved as per the scheme.

Apart from financial support through PM JI-VAN Yojana, other steps taken to promote 2G Ethanol Plants include imposition of additional excise duty on non-blended fuels, encouraging studies on various aspects including identifying areas having the potential of surplus Biofuels feedstocks, policy interventions to mainstream biofuels, separate price for 2G ethanol, etc.

4. Global Biofuel Alliance

The Global Biofuel Alliance was announced in February 2023 under which Brazil, India, and the United States, which are leading producers and consumers of biofuels along with other interested countries, will work towards establishing an alliance for facilitating cooperation and intensifying the use of sustainable biofuels, including in the transportation sector. The alliance aims to strengthen markets, facilitate global biofuels trade, develop concrete policy lesson-sharing and provide technical support for national biofuels programs worldwide. It will also emphasize the already implemented best practices and success cases.

The alliance shall work in collaboration with and complement the relevant existing regional and international agencies as well as initiatives in the bioenergy, bio economy, and energy transition fields more broadly, including the Clean Energy Ministerial Biofuture Platform, the Mission Innovation Bioenergy initiatives, and the Global Bioenergy Partnership (GBEP).

5. Government Support Schemes for CBG

The MNRE has been supporting installations of biogas plants in the country through the following schemes:

- Small size biogas plants under New National Biogas and Organic Manure Programme (NNBOMP)
- Medium size biogas plants (30-2500 m3 biogas per day) under the Biogas based Power Generation (Off-Grid) and Thermal Energy Applications Programme (BPGTP)
- Large size biogas plants (above 2500 m3 biogas per day) biogas plants under Programme on Energy from Urban, Industrial, Agricultural Wastes/ Residues and Municipal Solid Waste (Waste to Energy Scheme).

The Central Financial Assistance (CFA) which was being provided under the above schemes when they were being implemented was as follows: -

- Rs. 7500/- to Rs. 35,000/- per plant based on size of the plant in cubic meter under NNBOMP;
- Rs. 25,000 /- to Rs. 40,000 /- per kilowatt for power generation and Rs. 12,500 /- to Rs. 20,000/- per kilowatt equivalent for thermal applications under BPGTP; and
- Rs 1.0 crore per 12000 m3 per day for biogas generation and Rs 4.0 Crore per 4800 Kg/day for Bio-CNG generation under Waste to Energy Scheme.

Under the Sustainable Alternative Towards Affordable Transportation (SATAT), Government of India is promoting the production of Compressed Bio Gas (CBG) as an alternative green transport fuel wherein Oil and Gas Marketing Companies (OGMCs) are procuring the produced CBG.

5.2 Low Carbon Synthetic Fuels

Large scale integration of RE beyond the scope of meeting India's basic power sector requirement demands integration of clean energy usage in the industry and transport sector, necessitating the use of synthetic fuels, which are carbon neutral alternatives of conventional fuels. These fuels have the same physiochemical properties similar to fossil fuels and are produced using renewable energy. These fuels are made by chemically hydrogenating CO_2 which is either captured from the air or captured from power plant exhausts etc. The hydrogen used in the process is obtained through electrolysis of water using renewable energy.

Green Hydrogen

Hydrogen is the most abundant element on earth and it doesn't exist by itself, it is produced from compounds that contain it. Currently, it is primarily produced from fossil fuels and can also be produced from biomass and water. Hydrogen can also be produced directly from sunlight and biomass. Electrolytic hydrogen produced from green power, instead of conventional grid electricity, and hydrogen produced from other cleaner mechanisms have been termed as "Green Hydrogen".

Based on sources and processes, hydrogen can be classified into various colours

Table 36: Classification of Hydrogen

Sr. No.	Type	Sources
1.	Black/ Brown/ Grey Hydrogen	Black or brown type of hydrogen is produced via coal or lignite gasification while grey hydrogen through a process called steam methane reformation (SMR) of natural gas or methane
2.	Blue Hydrogen	Blue hydrogen is produced through natural gas or coal gasification combined with carbon capture storage (CSS) or carbon capture use (CCU) technologies to reduce carbon emission.
3.	Green Hydrogen	The green hydrogen is produced by using electrolysis of water with electricity generated by renewable energy. The more renewable energy there is in the electricity fuel mix, the greener the hydrogen produced.

Source: CareEdge Research

Hydrogen can be used for various energy solutions like electricity production from fuel cell, energy storage, etc. Owning to its clean combustion characteristics and zero carbon footprint, it has potential to be the fuel of future. India has also launched the National Hydrogen Energy Mission to enable cost competitive green hydrogen production. India would be conducting competitive bids for green hydrogen to pave the road for viable usage of hydrogen as a fuel.

Even though green hydrogen is a promising source of clean energy, there are number of risks involved which are listed below:

- High Cost- The cost of green hydrogen is relatively high due to cost of electrolyser and renewable energy. The sector also requires significant amount of investment in setting up domestic manufacturing capacities of electrolyser equipment and distribution network.
- Uncertain Demand- The green hydrogen technologies across various sectors such as power, steel, and oil & gas are still in development stages, and the demand of green hydrogen uncertain since it is dependent on the

commercialization of these technologies. India may face challenges in adopting and scaling up these technologies to be able to utilize sizable quantities of green hydrogen.

- Supply chain Challenge- The availability and cost of raw materials required for green hydrogen production, such as renewable energy sources and suitable quality of water, can influence the viability and competitiveness of the technology. Supply chain disruptions can also impact the availability of critical components needed for hydrogen production.

Green Hydrogen Mission

The Government of India has also announced National Green Hydrogen Mission with an objective to make India a global hub for production, usage and export of green hydrogen and its derivatives and approved an outlay of Rs. 190 billion to help achieve an annual production target of 5 MMT by 2030 for facilitating the net-zero target. The policy promotes Renewable Energy (RE) generation as RE will be the basic ingredient in making green hydrogen. This in turn will help in meeting the international commitments for clean energy.

Hydrogen and Ammonia are envisaged to be the future fuels to replace fossil fuels. Production of these fuels by using power from renewable energy, termed as green hydrogen and green ammonia, is one of the major requirements towards environmentally sustainable energy security of the nation. Government of India is taking various measures to facilitate the transition from fossil fuel / fossil fuel-based feed stocks to green hydrogen / green ammonia. The notification of this policy is one of the major steps in this endeavour.

The details of the Green Hydrogen Mission are mentioned in section 4.6.

The National Green Hydrogen Mission with an initial outlay of Rs. 197.44 billion was approved in January 2023 with the overall objective to develop at least 5 million metric tons of green hydrogen production capacity per annum with an associated renewable energy capacity addition of about 125 GW in the country by 2030.

Based on the report 'Investment Landscape of Green Hydrogen in India' dated May 2023 released by United States Agency for International Development (USAID) and MNRE, it is estimated that India will require an investment of Rs.3,030[13] billion towards ammonia infrastructure and electrolyser capacity to cater to the targeted annual green hydrogen demand of 5 MMT by 2030 under the National Green Hydrogen Mission.

5.3 Transmission (Including Green Transmission)

A transmission line is used for the transmission of electrical power from generating substation to the various distribution units. With the current growth trajectory of RE in last few years, coupled with Government of India's target of integrating 500 GW non-fossil based installed capacity by 2030, transmission planning has become even more essential to integrate and evacuate RE power.

India's power transmission system has expanded at a significant pace driven by growing demand, government's focus on providing electricity in rural areas and requirement for connecting the generation stations including integration of RE sources from the RE rich states. Further, with the implementation of two Central Sector Schemes namely, North Eastern Regional Power System Improvement Project (NERPSIP) and Comprehensive Scheme for strengthening of Transmission and Distribution in Arunachal Pradesh and Sikkim, the transmission and distribution infrastructure of North Eastern states are also being strengthened.

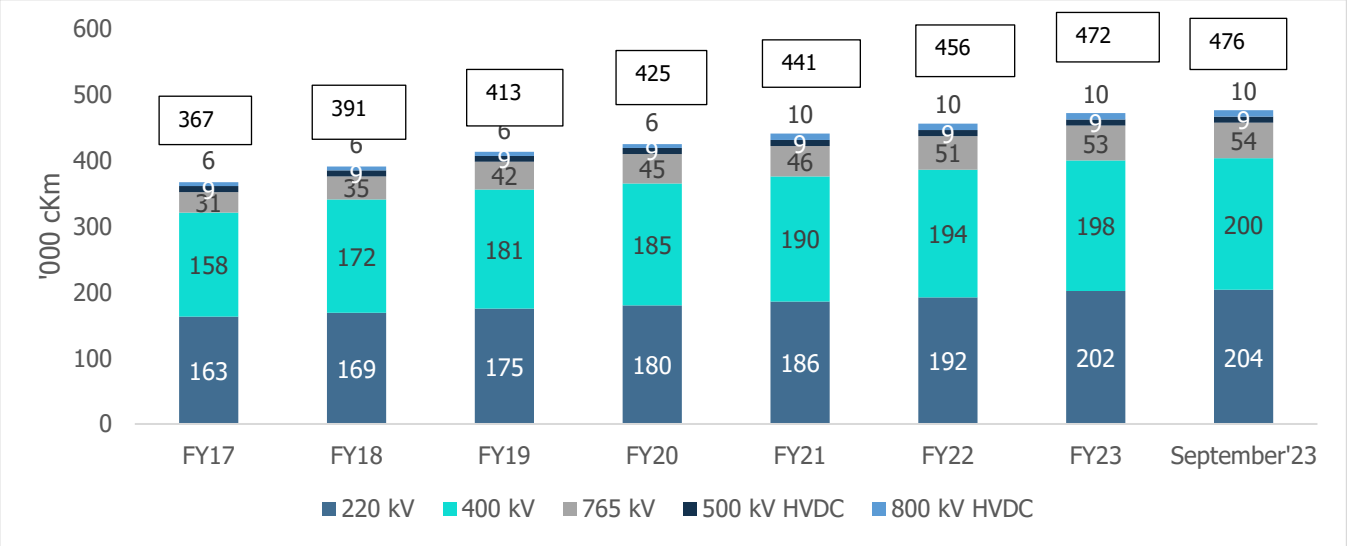
Government owned Power Grid Corporation of India Ltd (PGCIL) is the industry leader that owns and operates most of the inter-state and inter-regional transmission lines in the country facilitating transfer of power between different regions. While PGCIL and other state transmission utilities remain major players in the sector, the private sector participation has

[13] Exchange Rate 1 USD= Rs. 81.9 as on 25th July 2023

seen a healthy growth with the introduction of Tariff-based Competitive Bidding (TBCB) and viability gap funding scheme for the inter-state projects.

The transmission line network grew at a CAGR of approximately 3.7% to 4,56,428 cKM[14] as on March 2022 from 3,67,000 cKM as on March 2017. During FY23, 14,625 cKM of transmission lines were added taking the total network to 4,71,341 cKM. The transmission line network stood at 4,76,547 as on September 2023. The transmission line capacity is at 12,02,478 MVA as on September 2023.

Chart 70: Transmission line network (220 kV & above)



Source: Central Electricity Authority, CareEdge Research

As on March 2023, there are 24 transmission projects which are under construction. These include various projects of transmission system associated with renewable projects along with conventional projects in Rajasthan, Karnataka, Maharashtra, etc. These projects are being executed mainly by PGCIL along with private players like Sterlite Power Transmission Limited, Adani Transmission Limited, ReNew Transmission Ventures Private Limited, etc.

The Substation line network grew at a CAGR of approximately 6.6% to 1.13 million MVA as on March 2022 from 0.741 million MVA as on March 2017. During FY23, substation line network grew to 1.18 million MVA.

India has a target of 500 GW of non-fossil fuel capacity by 2030 and hence significant investments have commenced towards increasing and upgrading the transmission infrastructure. Transmission system has been planned for following RE capacity to be commission by 2030:

Table 37: Transmission System planned for Renewable Energy

Sr. No.	Category	Capacity (MW)
1.	RE capacity already commissioned (As on 31.10.2022)	1,65,943
2.	66.5 GW RE capacity to be integrated to Inter State Transmission System (ISTS) network (8.861 GW already commissioned)	57,639
3.	Additional RE capacity totalling to 236.58 GW to be integrated to ISTS network	2,36,580

[14] Circuit Kilometre

4.	Margin already available in ISTS sub-station which can be used for integration of RE capacity	33,658
5.	Balance RE capacity to be integrated to intra-state system under Green Energy Corridor-I Scheme	7,000
6.	RE capacity to be integrated to intra-state system under Green Energy Corridor -II Scheme	19,431
7.	Additional Hydro Capacity likely by 2030	16,673
	Total (RE)	**5,36,924**

Source: CEA Report- Transmission System Integration of over 500GW RE Capacity by 2030, CareEdge Research

As per PGCIL, investment opportunity of around Rs. 1,900 billion is expected in interstate transmission system, Rs. 1,960 billion in intrastate transmission system and around Rs. 200 billion in cross border interconnection up to 2030.

For integration of additional wind and solar capacity by 2030, the estimated length of transmission line and sub-station capacity planned is around 50,890 ckm and 4,33,575 MVA, respectively. The investment required for the green transmission is estimated to be around Rs. 2,440 billion as per the Ministry of Power. Out of this, Rs. 281 billion will be required for integration of offshore wind capacities while Rs. 2,160 billion will be required for new solar and wind (onshore) plants.

Table 38: Tentative cost of additional transmission system

	RE Capacity (GW)	BESS (GW)	Requirement of Transmission system (GW)	Tentative cost of transmission system (Rs. billion)	Average cost of Transmission system (Rs. Million/MW)
On-shore RE Capacity (Solar & Wind)	268.68	51.5	217.18	2,161	9.95
Offshore RE capacity (Wind)	10	0	10	281	28.1
Total RE capacity	**278.68**	**51.5**	**227.18**	**2,442**	**10.75**

The tentative cost includes the cost of ISTS transmission schemes for (i) 66.5 GW RE capacity (excluding commissioned transmission schemes and associated RE capacity) (ii) 55.08 GW RE capacity and (iii) 181.5 GW RE capacity
Source: CEA Report- Transmission System Integration of over 500GW RE Capacity by 2030, CareEdge Research

Green Energy Corridor (GEC)

Green Energy Corridor Project aims at synchronizing electricity produced from renewable sources, such as solar and wind, with conventional power stations in the grid. GEC comprises of both Inter State Transmission System (ISTS) and Intra State Transmission System (InSTS) along with the setting up of Renewable Energy Management Centre (REMC) and the control infrastructure like, reactive compensation, storage systems, etc.

- Inter-State Transmission System Green Energy Corridor Phase-I

The ISTS GEC project with total 3,200 ckm inter-state transmission lines and 17,000 MVA substations was implemented by PGCIL between 2015 to 2020. The project cost is Rs. 113.69 billion with funding mechanism consisting of 30% equity by PGCIL and 70% loan from KfW (EUR 500 Million) & ADB (approx. Rs. 28 billion). The project was implemented to evacuate approx. 6 GW of RE power and included transmission system for 8 solar parks including Ananthapur (1,500 MW), Pavagada (2,000 MW), Rewa (750 MW), Bhadla-III (500 MW), Bhadla-IV (250 MW), Essel (750 MW), Banaskantha (700 MW) and Fatehgarh (1000 MW).

REMC have been installed at the following 11 locations:

a. REMC-SR (Tamil Nadu, Andhra Pradesh, Karnataka SLDCs & SRLDC).
b. REMC-WR (Gujarat, Maharashtra, Madhya Pradesh SLDCs and WRLDC),

c. REMC-NR (Rajasthan SLDC, NRLDC and NLDC)

The InSTS GEC scheme with total target of 9,700 ckm intra-state transmission lines and 22,600 MVA sub-stations was approved by the Cabinet Committee on Economic Affairs (CCEA) in 2015. The InSTS GEC scheme is currently under implementation by the State Transmission Utilities (STUs) of 8 RE rich states, i.e. Andhra Pradesh, Gujarat, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan & Tamil Nadu. The project cost is Rs. 101.41 billion with funding mechanism consisting of 40% central grant by MNRE, 40% loan from KfW Germany and 20% equity by the STUs.

The projects are being set up for evacuation of about 24 GW of RE power in the above 8 States, of which about 16.4 GW RE has been commissioned and connected to the grid through the project's setup under InSTS GEC. As on November 30, 2022, the status of the project is a below:

Table 39: Status of Intra-State Transmission System Green Energy Corridor Phase-I

State	Lines Target (ckm)	Lines Constructed (ckm)	Substations Target (MVA)	Substations Charged (MVA)
Tamil Nadu	1,068	1,068	2,250	1,910
Rajasthan	1,054	984	1,915	1,915
Andhra Pradesh	1,073	739	2,157	950
Himachal Pradesh	502	470	937	653
Gujarat	1,908	1,429	7,980	6,980
Karnataka	618	609	2,702	2,490
Madhya Pradesh	2,773	2,773	4,748	4,748
Maharashtra	771	625	-	-
Total	**9,767**	**8,697**	**22,689**	**19,858**

Source: MNRE, CareEdge Research

- Intra-State Transmission System Green Energy Corridor Phase-II

The InSTS GEC-II scheme with total target of 10,750 ckm intra-state transmission lines and 27,500 MVA sub-stations was approved by the CCEA in January 2022.

The project cost is Rs. 120.31 billion with central financial assistance from MNRE of Rs. 39.7 billion (i.e. 33% of project cost). The balance 67% of the project cost is available as loan from KfW/REC/PFC. The transmission schemes would be implemented by the STUs of seven states, i.e. Gujarat, Himachal Pradesh, Karnataka, Kerala, Rajasthan, Tamil Nadu and Uttar Pradesh for evacuation of approx. 20 GW of RE power in the seven States. Currently, the STUs are preparing the packages and are in process of issuing tenders for implementing the projects. The scheduled commissioning for the projects under this scheme is March 2026.

The State-wise brief of the projects under the scheme is as under:

Table 40: Target under of Intra-State Transmission System Green Energy Corridor Phase-II

State	Estimated Project Cost (Rs Cr)	Length of Transmission Lines (ckm)	Capacity of Substations (MVA)	RE Addition (MW)
Gujarat	3,637	5,138	5,880	4,000
Himachal Pradesh	489	62	761	317
Karnataka	1,036	938	1,225	2,639
Kerala	420	224	620	452
Rajasthan	881	1,170	1,580	4,023
Tamil Nadu	720	624	2,200	4,000
Uttar Pradesh	4,848	2,597	15,280	4,000

State	Estimated Project Cost (Rs Cr)	Length of Transmission Lines (ckm)	Capacity of Substations (MVA)	RE Addition (MW)
Total	**12,031**	**10,753**	**27,546**	**19,431**

Source: Ministry of Power, CareEdge Research

5.4 Energy Storage Technologies

The demand of electricity fluctuates throughout the day while the amount of electricity generated is relatively fixed. A major breakthrough in electricity system is developing technology for storage of electricity so that it can be available to meet demand whenever it arises. Electricity storage devices can also help balance micro-grids to achieve frequency regulation to maintain the balance between generation and load and can also achieve a more reliable power supply for high tech industrial facilities.

A major driver for early market growth for energy storage generation will be renewable energy integration, replacement of diesel generators on island grids, industrial backup applications, and use of remote equipment. India has committed to increase its share of non-fossil fuel-based generation sources to 50% by 2030, which requires flexibility in power systems. The 'Power for All' target of 24X7 electricity for all had created an increased power requirement and the need to balance the supply and demand of electricity. Hence, Energy storage solutions plays a crucial role in increasing the system's overall flexibility.

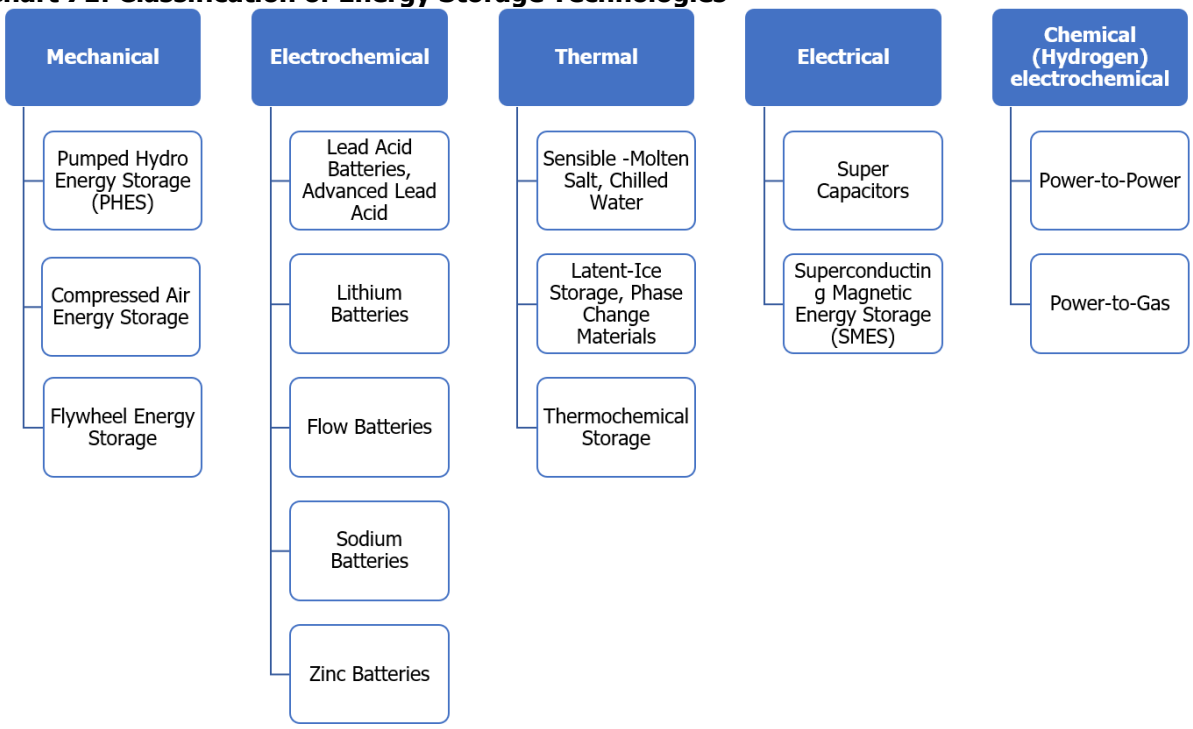
Energy Storage Systems (ESS) is emerging as an essential part of the evolving clean energy in 21st century. Energy storage is going to play an important part in grid integration and management of Renewable Energy as the share of renewable energy in the grid increases.

Greater utilization of the available grid capacity and renewable energy sources can be achieved through the energy storage systems.

Energy storage solutions are a set of methods and technologies that are used to store energy. This stored energy is later drawn upon for a number of operations.

There are various methods to store different forms of energy and hence various types of storage technologies depend on application, economics, integration within the system and availability of resource. Energy storage technologies vary depending upon on the type of energy used for storage. The different technologies based on the type of energy are as follows:

Chart 71: Classification of Energy Storage Technologies



Source: CareEdge Research

Energy storage ranges from pumped hydro storage, flywheel, super capacitors, compressed air, flywheels, super capacitors, thermal energy storage, batteries including lithium, etc. depending on the type of technology used. Dispatching electricity within seconds and providing back-up ranging from minutes to many hours are some of the features of advanced energy storage technologies.

The Union Budget 2023-24 proposed Viability Gap Funding for Battery Energy Storage Systems with a capacity of 4,000 MWH. Further, a detailed framework for pumped storage projects will be formulated. This proposal is expected to incentivize the setting up of utility-scale storage projects as the VGF shall improve its cost competitiveness. Further, focus on pumped storage projects shall ensure smoother integration of renewables in the grid.

5.4.1 Battery Energy Storage

A battery is device with one or more electrochemical cells and majorly works on the principle of electromotive force. Based on battery type, their market is divided into lithium-ion batteries, lead-acid batteries, nickel batteries, flow batteries and others. Even though lead-acid batteries are the most common type of battery, lithium-ion batteries are gaining popularity due to various applications in end user industries such as renewable, telecommunication, and power generation industries. It also has the benefit of being rechargeable battery and hence is used for portable electronics and electric vehicles. The Li-ion battery market is majorly dominated by the electric vehicle sector which consumes 60% of the Li-ion batteries.

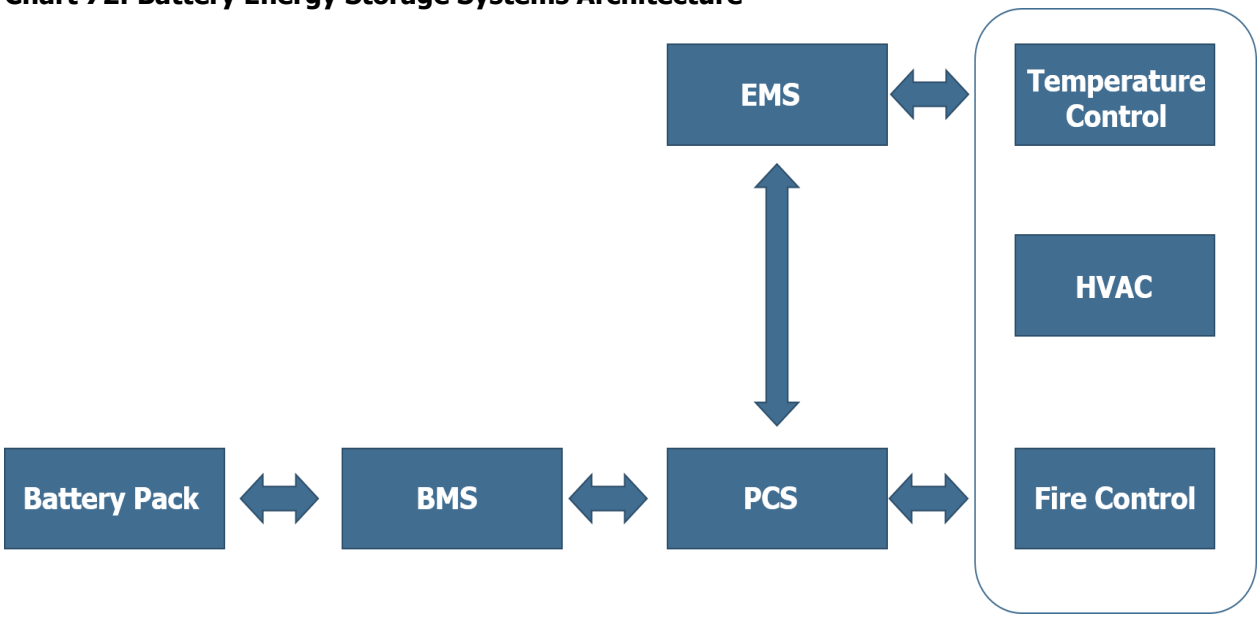
Battery Energy Storage Systems

Energy storage systems collects energy from different sources including solar arrays and electric grid, accumulates and stores this energy in rechargeable batteries for later use. A battery energy storage system (BESS) is a compound system that contains various hardware and software components. The main components of the battery energy storage system (BESS) are as follows:

- Battery system- A battery system contains individual batteries that are arranged in modules and that in turn is in form of battery packs. These batteries convert chemical energy into electrical energy.
- Battery Management System (BMS) - The battery management system ensures the safety of the battery system. Monitoring the condition of battery cells, measuring the state-of-charge (SOC) and state-of-health (SOH), protecting the batteries from fires and hazards are the functions of the battery management system.
- Power Conversion System (PCS) - The power conversion system (PCS) converts the direct current by batteries into alternating current supplied to the facilities. The bi-directional inverters are present in the battery energy storage systems to allow the charging and discharging.
- Energy Management System (EMS) - The energy management system is responsible for the monitoring and control of the energy flow within a battery storage system. The coordination between the work of BMS, PCS and other components of a BESS is done by the energy management system by collecting and analysing energy data.

There are other components of the BESS like safety systems such as fire control system, smoke detector, temperature control system, cooling, heating, ventilation and air-cooling systems depending on the functionality and operating conditions. These safety systems have their own monitoring and control units for the purpose of safe operations of the BESS.

Chart 72: Battery Energy Storage Systems Architecture



Source: CareEdge Research

BESS collects energy from an electricity grid or renewable energy and stores it using battery storage technology. Batteries then discharge and release the energy when necessary in variety of other applications. BESS require robust software solutions along with electronics. BESSs can accommodate various kinds of batteries ranging from lithium-ion, lead-acid, nickel-cadmium and others. Each type of batteries has certain technical specifications that BESS uses and hence the efficiency of battery energy storage varies depending upon the battery type.

BESSs vary depending on the electrochemistry or battery technology. The main type of BESS battery types is as below:

- Lithium-Ion (Li-Ion) Batteries
- Lead-Acid (PbA) Batteries
- Nickel-Cadmium (Ni-Cd) Batteries
- Sodium-Sulfur (Na-S) Batteries

- Flow Batteries

Table 41: Battery Technologies and their characteristics

Technology	Round-Trip efficiency	Life Span	Advantages
Lithium-Ion	88-90%	10-15 years	High specific energy and high load capabilities with power cells
Lead Acid	60-70%	3-6 years	Low-cost and simple manufacture Low cost per watt-hour
Nickel-Cadmium	60-80%	10-15 years	Rugged, high cycle count with proper maintenance
Sodium-Sulphur	75-85%	10-15 years	Low cost potential; inexpensive raw materials and sealed; no maintenance config

Source: National Electricity Plan Vol-1 (March 2023), CareEdge Research

The table shows the annual targets for storing the renewable energy between 2022-23 to 2029-30. Ministry of Power's Energy Storage Obligations 2029-30 are used for estimating the utility-scale storage requirements. 19th Electric Power Survey (CEA 2022) to get India's peak energy demand (GWh) during the period is used to estimate the obligated stored energy (GWh) and corresponding batter requirement.

Table 42: Projections for utility-scale energy storage requirement

Year	India's projected peak demand (BU)	Energy Storage Obligation (%)	Energy from storage (GWh)	Battery Requirement (GWh)
2023-24	1,600	1.0%	16,002	57
2024-25	1,695	1.5%	25,420	91
2025-26	1,796	2.0%	35,933	129
2026-27	1,908	2.5%	47,696	171
2027-28	2,021	3.0%	60,632	217
2028-29	2,139	3.5%	74,869	268
2029-30	2,280	4.0%	91,187	327

Source: CEEW Study based on CEA 2022 and MoP 2022

*Assumptions for battery capacity: 1 cycle/day with 85% roundtrip efficiency and 90% depth of discharge.

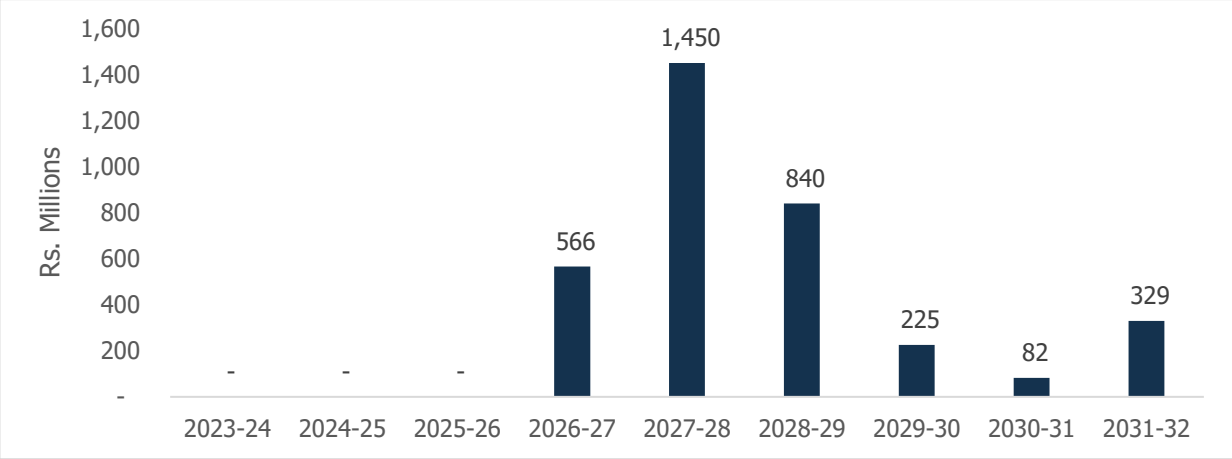
The cumulative energy storage demand from grid applications comes about 327 GWh by 2030.

India can capture significant value within local economy with the help of successful local battery manufacturing industry and supportive local supply chain. NITI Aayog estimates the market size of battery sector to be around Rs. 163.8[15] billion in FY22 and in the accelerated case scenario, the market size for stationery and mobile batteries could surpass Rs. 491.4[15] billion by 2026 and Rs. 1,228[15] billion by 2030.

An investment of Rs 3,493 million will be required between FY24-32 to achieve the above battery storage requirement. Year-wise investment is given below.

[15] Exchange Rate 1 USD= Rs. 81.9 as on 25th July 2023

Chart 73: Fund requirement for BESS



Source: National Electricity Plan Vol-1 (March 2023), CareEdge Research

In order to meet the demand for battery with domestic supply, India will require rapid buildout of battery manufacturing. To increase the development for advanced cell batteries, policy push and demand-supply incentives is required. The PLI scheme promises to put India in strong global position and realize its full value from its technology.

Budget 2023-24- Focus on Green Growth for Sustainable Development

- Reduction in basic custom duty on import of capital goods required for Li-ion battery manufacture to Nil till March 2024. Also, customs duty exemption is extended for import of capital goods and machinery required for manufacturing lithium-ion cells for batteries used in electric vehicles. Also, the concessional duty on lithium-ion cells for batteries would continue for another year. This in turn would support lithium ion cell supply in India, which is widely used across power storage, power management and battery industries.
- Focus on Green Growth, emphasis on Hydrogen energy and battery storage.
- Under the "Panchamrit" goal set up by COP26 forum, Battery Energy Storage Systems (BESS) with a capacity of 4000 Mwh will be supported by viability gap fund. Further, a detailed framework for pumped storage projects will be formulated. This proposal is expected to incentivize the setting up of utility-scale storage projects as the VGF shall improve its cost competitiveness.

Some of the key challenges and risks involved in setting up battery storage systems are as below:

- Cost Competitiveness: The BESS technology needs to be cost competitive to increase its adoption in India. For the reduction in cost of power management and storage technologies, extensive engineering research and development for new storage concepts and requisite materials is required.
- Dependence on imports for raw materials: Since there are no significant proven reserve in India for most critical elements like lithium, cobalt and nickel required for semi-conductors, it is highly dependent on imports.
- Technology Risk: There are a number of new technologies currently in research and development stage and even though the technologies in process have great potential, they have not reached the viability and commercialization yet. As there is demand uncertainty and high investment are required for setting up of the power management and storage manufacturing units, the investment is considered risky due to evolving technology changes in the storage, power management and battery sectors.

There have been significant barriers in the adoption of energy storage, electric mobility and green hydrogen. Hence to boost the industry, reduction in custom duty, tax holidays and focus on green growth was seen in the Budget 2023-24.

The reduction in duties and credit guarantee scheme for manufacturers of intermediate materials used in battery cells would support exporting businesses in the country. Sector such as battery storage, power management systems, EVs, etc. would be benefit from such schemes.

5.4.2 Pumped Hydro Storage

Pumped Hydro Storage plays an important role among all forms of storage systems as it is important in providing peaking power and maintain system stability in the power system. It improves the overall economy of power system operation and reduces the operational problems of thermal stations during period of low load. The pumped storage technology is cost effective, highly effective and flexible way of energy storage on a large scale to store intermittent and variable energy since they provide large storage capacity compared to other storage technologies.

The life cycle of pumped storage is same as hydro projects i.e. 40 years and the efficiency are in the range of 70 to 80%. The technology has advanced since and now includes adjustable speed pumped turbines which can quickly shift from motor to generator to synchronous condenser modes for easier and flexible operations of the grid.

Another new approach for pumped hydro storage called closed loop where the reservoir located in the areas that are physically separated from the existing river system. They have minimal impact to no impact on existing river systems. These types of projects can greatly reduce the most significant aquatic impacts associated with project development by avoiding the existing complex aquatic systems entirely.

Development of PSPs in India

According to Central Electricity Authority, India has a potential of around 96,530 MW in different parts of the country. The western region has the highest potential totalling to 37,845 MW because of the topographical features.

West Bengal is the frontrunner for promotion of pumped hydro storage India because of the Purulia project in West Bengal with a capacity of 900 MW which was set up in 2007.

As on March 2022, there are 8 PSP projects in the country totalling to 4,546 MW. Out of this around 3,306 MW of capacity is working in the pumped mode currently while the balance is not operating due to construction of tail reservoir or due to vibration issues in the system.

Table 43: Under Construction PSP projects as on March 2022

Sr. No.	Name of the Projects	State	Developing Authority	Capacity (MW)
1.	Tehri Stage II	Uttarakhand	THDC Limited	1,000
2.	Koyna Left Bank	Maharashtra	Water Resources Department of Maharashtra	80
3.	Kundah Pump Storage Project Stages I, II, III and IV	Tamil Nadu	TANFEDCO	500
4.	Pinnapuram Pump Storage Project	Andhra Pradesh	Greenko	1200
	Total			**2,780**

Source: National Electricity Plan Vol-1 (March 2023), CareEdge Research

Government Schemes and Policies

- Waiver of inter-state transmission charges

The Central government had issued waiver of ISTS charges for PSP and BESS projects in order to promote commissioning and optimum utilization of storage projects on 21.06. 2021.The scheme also waiver of transmission charges for trading of electricity generated/supplied from Solar, Wind, PSP and BESS in Green Term Ahead Market (GTAM) and Green Day Ahead Market (GDAM) for till 30.06.2023.

The ISTS charges excluding losses were waived for transmission of electricity supplied by Hydro PSP and BESS projects commissioned till 30.06.2025 provided that the following conditions are met:

- At least 70% of the annual electricity generation requirement of pumping of water of the PSP plant is met by use of solar and wind-based generation.
- At least 70% of the annual electricity generation requirement of charging of the BESS system is met by use of solar and wind-based generation.

The ISTS charges for power supplied from Hydro PSP or BESS projects shall be levied gradually as follows: -
i. 25% of STOA charges for initial 5 years of operation.
ii. After 5 years, the charges will be increased in steps of 25% every 3rd year to reach 100% of STOA charges from 12th year onwards.

Table 44: Summary of status of Hydro Pumped Storage

	Nos.	Capacity (MW)	%
Total Potential	63	96,530	
Schemes under operation	8	4,746	4.9%
Schemes under construction	2	1,500	1.5%
Schemes in which construction is held up	1	80	0.08
DPRs Concurred by CEA & yet to be taken up for construction	2	2,200	2.3%
Under S&I for preparation of DPRs	17	16,770	17.4%
Schemes under S&I- Held up	1	660	0.7%
Total Developed	8	4,746	5%
Total Under Development	23	21,210	22%

Source: National Electricity Plan Vol-1 (March 2023), CareEdge Research

5.5 Smart Grid and DER Management Solutions and Software

- **Smart Grid**

As per the National Smart Grid Mission (NSGM), Ministry of Power, smart grid is an electrical grid with automation, communication and IT systems that can monitor power flows from points of generation to points of consumption (down to appliances level) and control the power flow or curtail the load to match generation in real time or near real time. Smart grids can be achieved by implementing efficient transmission & distribution systems, system operations, consumer integration and renewable integration. Smart grid solutions help to monitor, measure and control power flows in real time that can contribute to identification of losses and thereby appropriate technical and managerial actions can be taken to arrest the losses.

Smart grid solutions can contribute to reduction of transmission and distribution losses, peak load management, improved quality of service, increased reliability, better asset management, renewable integration, better accessibility to electricity etc. and also lead to self-healing grids.

NSGM was established by Government of India in 2015 to plan and monitor implementation of policies and programmes related to Smart Grid activities in India. The primary aim of the smart grids is to improve reliability of the electricity networks and make the grid amenable to renewable energy inputs through distributed generation. Further, increased efficiencies with smart grid and smart meters empower the consumers to manage their electricity consumption in a better manner and help them in reducing their bills. In addition, the NSGM also envisages capacity building initiatives for distribution sector personnel in the field of smart grids.

Smart meters are digital meters which are similar to conventional meters and record data on energy consumption. However, there meters are also capable of transmitting the energy consumption data to utilities at specific intervals which

permits more frequent monitoring of consumption and can assist in reduction of T&D losses. Smart meters are beings installed under various government schemes including NSGM and Integrated Power Development Scheme (IPDS) wherein the government is providing funding to the states for implementation of smart metering projects being launched by DISCOMs. Energy Efficiency Services Limited (EESL) is also implementing projects being launched by various DISCOMs in Uttar Pradesh, Haryana, Bihar, Rajasthan, Andaman & Nicobar Islands, Delhi etc. wherein EESL is infusing the initial capital expenditure and DISCOMs are paying back to EESL on monthly rental basis.

Government of India launched the Revamped Distribution Sector Scheme (RDSS) with an outlay of Rs. 3,037.58 billion and estimated support from Central Government of Rs. 976.31 billion for the duration of 5 years (FY22-FY27). As on February 2023, 204.6 million pre-paid smart consumers meters, 5.4 million smart Distribution Transformer (DT) meters and 0.198 million smart feeder meters have been sanctioned under this scheme for 46 DISCOMs located in 28 states and union territories.

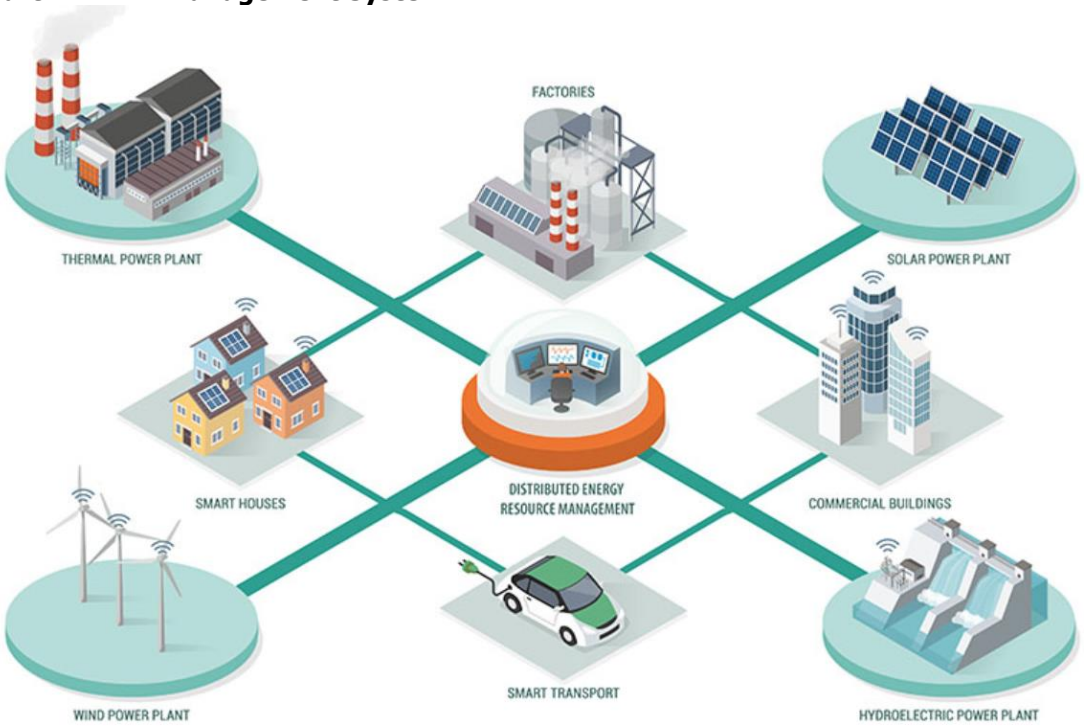
The government is implementing a nationwide Smart Meter Program under RDSS Scheme. There are 2 parts under the scheme - Part A includes upgradation of distribution infrastructure and pre-paid smart metering & system metering while Part B covers training and capacity building and other supporting activities.

Under Part A of the scheme, 25 crore smart meters are envisaged to be installed across the country. The implementation model of smart metering is TOTEX (CAPEX + OPEX) under Design, Built, Finance, Own, Operate and Transfer (DBFOOT) model and OPEX payments to Advanced Metering Infrastructure Service Provider (AMISP) are linked with Service Level Agreement (SLA).

- **Distributed Energy Resources (DER) Management Solutions and Software**

A DER management solution is an IT enabled platform that helps the DISCOMs manage their grids which are based on distributed energy resources which are small scale generation units such as rooftop solar panels, battery storage etc. located at consumer site or near the consumer.

Chart 74: DER Management System



Source: National Renewable Energy Laboratory, CareEdge Research

5.6 Electric Vehicles and Charging Infrastructure

India has been actively promoting the adoption of electric vehicles (EVs) as part of its efforts to reduce greenhouse gas emissions, improve air quality, and decrease dependence on fossil fuels. The EV market in India has been witnessing steady growth. The sales of electric cars, two-wheelers, and three-wheelers have been increasing in recent years, driven by government incentives, decreasing battery costs, and the introduction of new EV models by domestic and international manufacturers. The following table depicts total EV sales: -

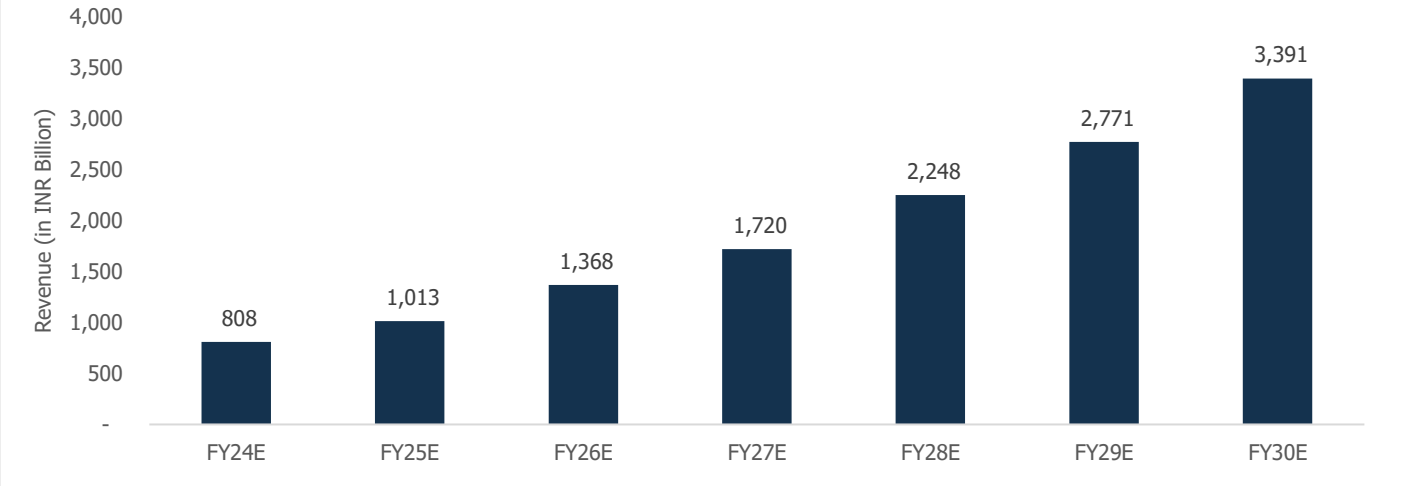
Table 45: Total EV Sales

EV Sales (in Units)	FY18	FY19	FY20	FY21	FY22	FY23	H1FY24
Two-wheeler	1,897	25,393	24,839	40,837	2,52,547	7,27,434	4,27,844
Three-wheeler	92,395	1,18,944	1,40,683	88,378	1,82,587	4,04,231	8,28,836
Four-wheeler	1,362	1,632	2,727	4,588	18,565	47,383	47,726
Goods vehicle	993	517	50	28	2,452	3,049	2,979
Total EV sales units	**96,647**	**1,46,486**	**1,68,299**	**1,33,831**	**4,56,151**	**11,82,097**	13,07,385

Source: Centre of Energy Finance, CareEdge Research

The Indian government has implemented several policies and incentives to promote EV adoption. Additionally, the government has set a target to achieve 100% electric mobility for public transport and 40% electrification of private vehicles by 2030. As per NITI Aayog estimates, India's EV sales is estimated to be at 70% for commercial car, 30% for private cars, 40% for buses, and 80% for two-wheelers and three-wheelers respectively by 2030. The current market size of electric two-wheelers (E2Ws largest segment in EV), electric three-wheelers (E3Ws) and electric four-wheelers (E4Ws) is estimated to be around ~ INR 90 Billion, ~ INR 100 Billion, and ~ INR 85 Billion respectively. The expected revenue generation from overall EV sales is estimated to reach approximately ~ INR 4,000 Billion (Bn) around 2030 in India. The sales across each EV vehicle segment is expected to clock strong growth going forward owing to governments push towards green mobility.

Chart 75: Annual Revenue forecast from EV sales



Source: Centre of Energy Finance, CareEdge Research

The development of charging infrastructure is essential for the growth of the EV market in India. The government's investment in charging infrastructure is a positive step towards making EVs more accessible to Indian consumers. India

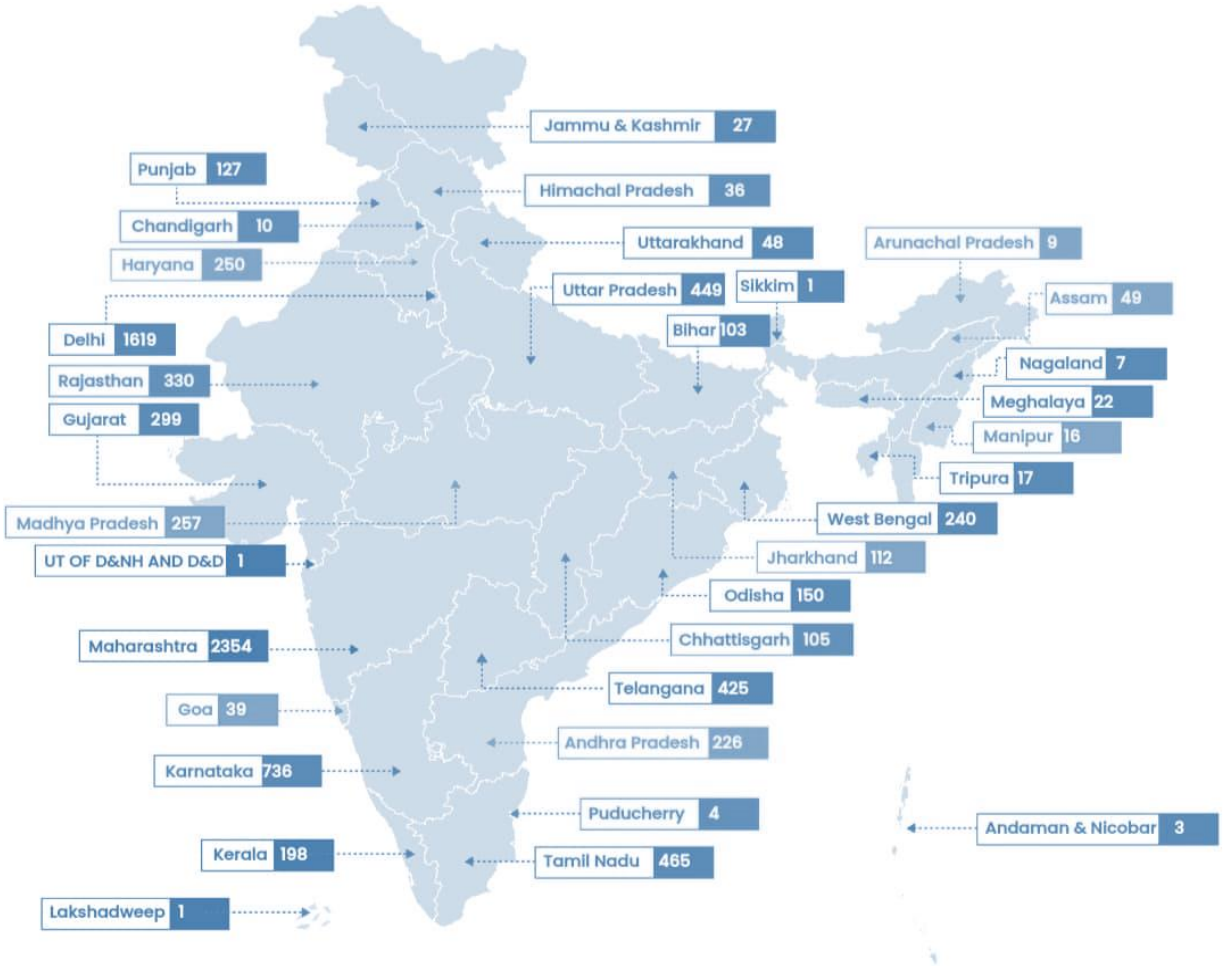
is working on the expansion of its EV charging infrastructure to support the growing number of electric vehicles. Both public and private entities are investing in the establishment of charging stations across cities, highways, commercial complexes, and parking areas.

Several public and private players are involved in setting up and operating EV charging infrastructure in India. Some prominent charging network operators include Tata Power, EV Motors India, Fortum India, and Bharat Power Solutions. State-run oil marketing companies, such as Indian Oil Corporation and Bharat Petroleum, are also expanding into EV charging infrastructure. The government has introduced guidelines and standards to enable compatibility between different EV models and charging stations.

As per the data of Bureau of Energy Efficiency, there are 8,735 public charging stations and 84 charge point operators across India. Maharashtra has emerged as the frontrunner in supporting electric vehicles (EVs), with 2,354 public charging station, followed by Delhi with 1,619 charging stations, while Karnataka boasts of 736. Tamil Nadu, Uttar Pradesh, and Telangana have 465, 449, and 425 charging stations, respectively. The government is also providing incentives for businesses to set up private charging stations.

The following figure depicts total number of charging stations as of March 2023:

Chart 76:Total number of charging stations as of March 2023



Source: Bureau of Energy Efficiency, CareEdge Research

The government plans to have 500,000 public charging stations by 2025. While India is making significant progress in developing its EV charging infrastructure, there are still challenges to address, such as the need for more widespread and reliable charging stations, grid infrastructure upgrades, and ensuring affordability and accessibility for all segments of the population. Continued government support, private investments, and collaborations between stakeholders will be crucial for the rapid expansion of EV charging infrastructure in the country.

Latest Developments

- In March 2023, the government announced that it will invest Rs. 1,064.7[16] billion to promote the manufacturing of EVs in the country. The investment will be used to set up new manufacturing facilities, to develop new technologies, and to create a skilled workforce.
- In April 2023, the government announced that it will increase the blending of ethanol in petrol from 10% to 20% by 2025. This blending program is known as E20, and it is expected to help reduce India's oil imports by 1.2 billion litres per year.
- In May 2023, the government announced that it will set up a network of 500,000 electric vehicle charging stations across the country by 2025. The charging stations will be located at public places, such as malls, parking lots, and bus stops.
- In June 2023, the government announced that it will invest Rs. 40,950[17] million in research and development for ethanol production. The investment will be used to develop new technologies for ethanol production, such as the use of non-food crops and waste materials.

India has witnessed a significant expansion of its EV charging infrastructure. These are some recent developments in EV charging infrastructure in India:

- In March 2023, the company Tata Power announced that it will set up 100,000 electric vehicle charging stations across India by 2025.
- In April 2023, the company ABB announced that it will set up 20,000 electric vehicle charging stations across India by 2025.
- In May 2023, the company Bharat Petroleum Corporation Limited (BPCL) announced that it will set up 7,000 electric vehicle charging stations across India by 2025.

The government's policies and the investments made by private companies are helping to accelerate the growth of the EV market in India.

- Public and private entities are investing in the development of charging stations across cities, highways, commercial areas, and public parking spaces. The number of charging stations has grown rapidly, and various companies are actively deploying charging infrastructure to meet the increasing demand.
- Ultra-fast charging networks are gaining traction in India. Companies like Tata Power and Magenta Power have announced plans to set up high-power charging stations capable of charging EVs to 80% capacity in under 30 minutes. These ultra-fast charging stations are being strategically deployed along major highways and key travel corridors.
- Battery swapping solutions have emerged as an innovative approach to address EV charging challenges, especially for electric two-wheelers and three-wheelers. Start-ups like SUN Mobility and GOGORO are piloting battery swapping stations, allowing users to exchange depleted batteries for fully charged ones, reducing charging time and range anxiety. The government in order to meet the ambitious target of 30% EV penetration

[16] Exchange Rate 1 USD= Rs. 81.9 as on 25th July 2023
[17] Exchange Rate 1 USD= Rs. 81.9 as on 25th July 2023

by 2030, has announced battery swapping policy along with inter-operability standards to improve efficiency in the EV ecosystem while battery energy storage systems with a capacity of 4 GWh will be supported with viability gap funding to encourage investment.

- Several collaborations have been formed to accelerate the deployment of charging infrastructure in India. Public and private entities are partnering with OEMs, charging network operators, and other stakeholders to establish charging stations at strategic locations. For example, Tata Power partnered with HPCL to set up charging stations at fuel stations, expanding the charging network reach.
- Green energy integration of renewable energy sources with EV charging infrastructure is gaining importance. Solar-powered charging stations are being set up to promote clean and sustainable charging options. Grid integration and smart charging solutions are explored to optimize the use of renewable energy & minimize the environmental impact of charging EVs.

Government Policies

The government of India has implemented a number of policies to promote the adoption of electric vehicles (EVs) and the development of charging infrastructure in the country. These policies include:

- **The Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME India) scheme:** This scheme provides subsidies for the purchase of EVs and for the development of charging infrastructure.
- **The National Electric Mobility Mission Plan (NEMMP):** This plan aims to achieve 100% electric public transportation by 2030.
- **The Production Linked Incentive (PLI) scheme for manufacturing of Advanced Chemistry Cell (ACC) batteries:** This scheme provides financial incentives to companies that set up manufacturing facilities for ACC batteries in India.
- **The Ethanol Blended Petrol (EBP) Programme:** This programme mandates the blending of ethanol with petrol at a minimum of 10%. The government has set a target of increasing the blending ratio to 20% by 2025.
- **The Interest Subvention Scheme for enhancement and augmentation of the ethanol production capacity:** This scheme provides financial assistance to ethanol producers to help them expand their production capacity.

Risk Perspective

The electric vehicle (EV) segment in India is growing rapidly, but there are still some risks that need to be addressed. One of the biggest challenges for the EV segment in India is the lack of charging infrastructure. There are simply not enough charging stations available. This makes it difficult for EV owners to travel long distances without having to worry about running out of battery power. Also, EVs are still more expensive than traditional gasoline-powered vehicles. This is due to the high cost of batteries, which are a major component of EVs. There are still some technological challenges that need to be addressed before EVs can become mainstream. In addition to that, range anxiety and safety concerns are other challenges involved in the adoption of EV. There are some safety concerns associated with EVs, such as the risk of fires or explosions if the battery is damaged. Range anxiety is the fear that an EV will run out of battery power before reaching its destination. This is a real concern for EV owners, especially those who live in areas with limited charging infrastructure. The public needs to be more accepting of EVs before the segment can reach its full potential. Some people are still hesitant to buy an EV because they are not familiar with the technology or they are concerned about the range and safety of EVs.

5.6.1 Models for deployment of E Vehicles:

EVs are getting promoted as they will help in reducing the overall CO2 emissions of a country at a global level. They are getting major support from the governments across the globe. Policies like purchase subsidy, registration tax rebates are designed to make the EV segment more attractive to the consumers.

Convenient and affordable publicly available chargers are a very crucial part of promoting EVs. The Governments across the world are supporting this measure by directly investment in EV charging or by providing subsidies to EV owners to install the charging stations.

Following models that are being used by other countries for deployment of e vehicles:

United States: The US introduced significant fiscal incentives that encouraged the uptake of electric light duty vehicles (LDVs) and supported the scale of the manufacturing of the EVs and battery industry. Measures such as purchase subsidies and vehicle purchase registration were implemented in the US as early as 2008.

European union: The European Union has introduced a law that will require all new cars sold to have zero CO_2 emissions from the year 2035, and 55% lower CO_2 emissions from the year 2030, versus year 2021 levels. The EU states propose to end the sales of new CO_2 emitting cars in 2035.

The EU member states are using policy measures to promote deployment of electric Heavy-Duty Vehicles. Countries like Germany, Spain, Italy and France have provided incentives for commercial Zero Emission Vehicle purchases with amounts ranging from EUR 9,000 to EUR 50,000 in few of the cases since 2017. The Netherlands plans to implement zero-emission zones in the year 2025 for up to 40 of its large cities, which will encourage the use of commercial EV.

China: The Zero Emission Vehicle (ZEV) policy and programmes that include charging infrastructure, battery reuse and recycling and FCEV deployment were rolled out in 2020. The local governments took measures specifically aimed at supporting the ZEV sales by offering subsidies and charging rebates. The China Society of Automotive Engineers have set a goal of over 50% EV sales by 2035.

5.6.2 EV Manufacturing

The rise of electric vehicles is having a significant impact on the transportation industry. India is actively promoting EV manufacturing as part of its sustainable transportation goals. The government's initiatives like localization combined with the participation of domestic and international stakeholders, are expected to drive the EV manufacturing in the country.

Some of the latest developments in EV manufacturing in India are: -

- **Incentives and Subsidies:** The Indian government continues to provide incentives and subsidies to promote EV manufacturing and adoption. In 2021, the government announced a PLI (Production-Linked Incentive) scheme for the auto sector, including EV manufacturers. The scheme provides financial incentives based on incremental sales and manufacturing investment, aiming to boost domestic production and exports of EVs.
- **Domestic Manufacturing Investments:** Several domestic and international automakers have announced plans for EV manufacturing in India. Companies like Tata Motors, Mahindra & Mahindra, MG Motor, and Ola Electric have invested in establishing manufacturing facilities or expanding existing ones to cater to the growing demand for EVs.
- **Battery Manufacturing:** India is making efforts to enhance domestic battery manufacturing capabilities. In recent developments, leading battery manufacturers such as Exide Industries and Amara Raja Batteries have announced plans to set up lithium-ion battery manufacturing units in collaboration with international partners. This move aims to reduce dependence on imported batteries and strengthen the EV ecosystem in India.
- **Charging Infrastructure Expansion:** The Indian government, along with public and private entities, is focused on expanding the charging infrastructure across the country. Various initiatives have been undertaken

to set up charging stations in cities, highways, and public parking areas. Additionally, electric mobility platforms like BluSmart and Ola Electric are investing in establishing charging networks to support EV adoption.

Government Policies

The Indian government has also implemented several policies and initiatives to promote EV manufacturing in the country. These policies aim to support domestic production, attract investments, and accelerate the adoption of electric vehicles. Here are some key government policies related to EV manufacturing in India:

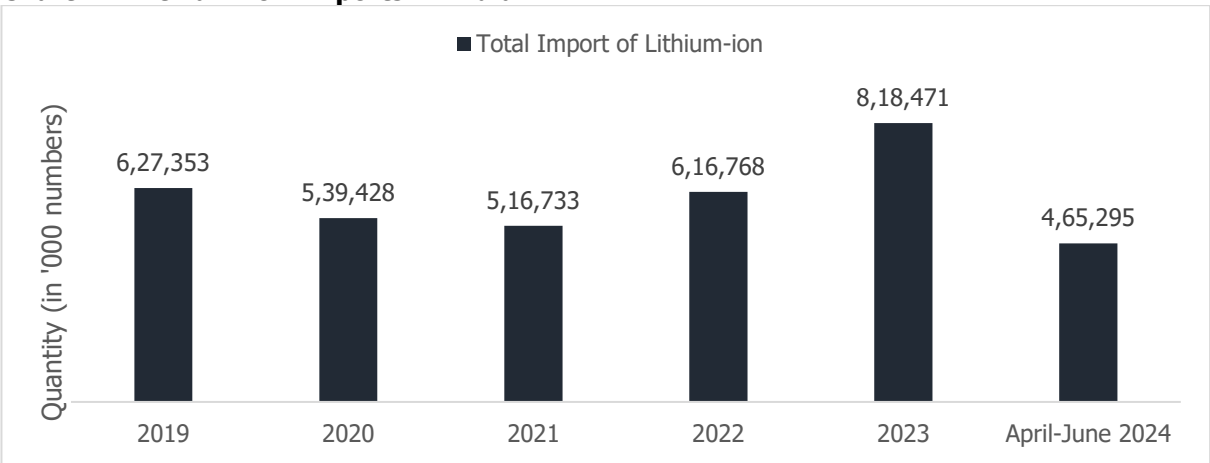
- **National Electric Mobility Mission Plan (NEMMP):** The NEMMP, launched in 2013, outlines the government's long-term vision and goals for electric mobility in India. It aims to achieve substantial EV penetration by 2030 and promote domestic manufacturing of EVs and their components.
- **Make in India Initiative:** The Make in India campaign, initiated in 2014, encourages domestic and foreign companies to establish manufacturing facilities in India. This policy aims to boost manufacturing capabilities and create employment opportunities in the EV sector.
- **Phased Manufacturing Program (PMP):** The PMP focuses on indigenization and localization of EV components and aims to reduce dependence on imports. Under this program, the government provides incentives to manufacturers for domestic production and encourages the development of a robust supply chain.
- **National Mission on Transformative Mobility and Battery Storage:** Launched in 2019, this mission focuses on promoting advanced battery manufacturing in India. It aims to attract investments, support research and development, and establish a robust ecosystem for battery manufacturing and recycling.

These government policies in India play a crucial role in encouraging EV manufacturing creating a conducive environment for growth and sustainability in the respective sectors. These policies are aimed at creating a supportive environment for the growth of the EV manufacturing in India.

5.6.3 EV Battery

The battery is one of the most important components of an electric vehicle (EV). It stores the energy that powers the vehicle's motor, and its performance has a significant impact on the vehicle's range, efficiency, and cost. The battery is the most expensive component in an EV, switching it allows companies to offer it as a service via lease or subscription models which would help in lowering the cost of owning and maintaining the EV. Due to import dependency, many EV manufacturers are importing Lithium and lithium-ion, further not complying with the Make-in-India initiatives. Lithium-ion batteries are the most popular and commonly used energy source for electric vehicles. Li-ion batteries have a high energy density and are relatively lightweight, which helps to improve the overall range of the EV. India does not have enough lithium reserves for manufacturing lithium-ion batteries and almost all-electric vehicles in the country run on batteries imported mostly from China, which is the largest producer. As a result, all manufacturers import cells and battery packs. India's heavy dependency on imports for electric vehicle batteries has resulted in exorbitant prices for these vital components, and eventually, the high cost of electric vehicles.

Chart 77: Lithium-ion Imports in India

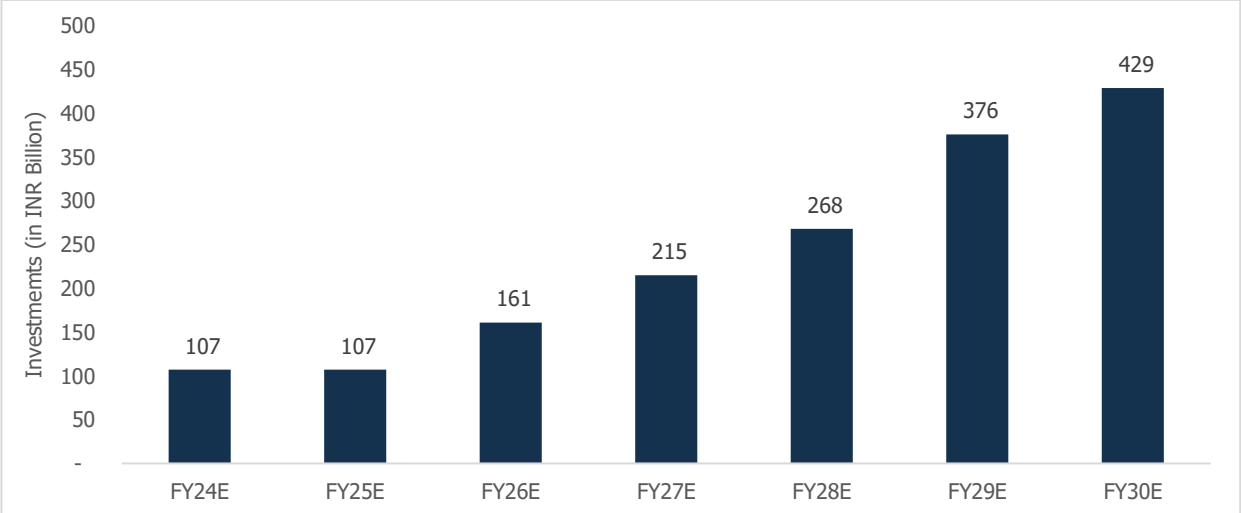


Source: Ministry of Commerce and Industry, CareEdge Research

Other types of batteries that are sometimes used in EVs in India include lead-acid batteries and nickel metal hydride (NiMH) batteries. Lead-acid batteries are the most affordable type of battery, but they have a lower energy density and a shorter lifespan than Li-ion batteries. NiMH batteries have a higher energy density than lead-acid batteries, but they are not as common as Li-ion batteries.

Battery manufacturing in India could become INR 85,900 crore (USD 12 billion) business in India by 2030. The progress of EV adoption is likely to create an unprecedented demand for batteries. The need for batteries will be driven by both new sales of EVs and the demand for replacement batteries in existing EVs.

Chart 78: Investments required for India to meet EV Battery Demand



Source: CEEW-CEF analysis, CareEdge Research

NITI Aayog estimates a demand of 100-260 GWh of lithium cells in India by 2030. The government's PLI scheme aims to establish 50 GWh of manufacturing capacity with 60% value addition over a five-year period. India market must be able to grow to mitigate the high import costs through various initiatives such as by promoting domestic lithium-ion battery cell production plants. Government is providing incentives for setting up battery manufacturing facilities with modern technologies, battery costs could significantly fall in the coming years. Initiatives like the Make in India policy, phased manufacturing plan (PMP), and Production Linked Incentive (PLI) scheme for the automotive sector and advanced chemistry cell (ACC) and electronic manufacturing are facilitating EV component localization. OEMs are mandated to

achieve 50% localization for EV components, although the extent of localization may vary across different components due to technological challenges, raw material availability, and scalability requirements. The India market for battery manufacturers is expected to grow from in a span of a decade. With the world turning towards decarbonization, these companies producing EV batteries are gaining momentum.

Some of the latest developments in EV battery are: -

The development of new battery technologies is essential for the growth of the EV market in India. As battery technology improves, EVs will become more affordable, efficient, and convenient. This will make EVs more appealing to consumers, and it will help to accelerate the growth of the EV market in India.

Significant capital expenditure has been invested in setting up lithium-ion battery manufacturing plants, with Gujarat being the primary location followed by Andhra Pradesh and Telangana. However, achieving widespread indigenization of lithium-ion battery production in the medium to long term is unlikely. The majority of lithium-ion batteries are imported, primarily from China and Vietnam. The cost of batteries constitutes the largest portion (40-50%) of EV costs. Limited access to core raw materials like lithium and the technology-intensive nature of manufacturing present challenges to localization efforts. The government needs to incentivize companies to acquire overseas lithium mines. Localization potential is high for chassis, bodies, and battery management systems (BMS), while specialized components such as batteries and motors may face limitations due to the scarcity of rare earth magnets.

In addition to these developments, there are also a number of other companies in India that are working on developing new battery technologies for EVs. These companies include Amara Raja Batteries, Exide Industries, and L&T Technology Services. The government of India is also investing in research and development (R&D) for EV batteries. This R&D is focused on developing new battery technologies that are more efficient, safer, and affordable.

Government Policies

The government of India is taking a number of steps to promote the development of the domestic battery manufacturing industry for electric vehicles (EVs). In the Union Budget 2023-24, the government has allocated INR 3,50,000 Bn to achieve the energy transition, energy security and net zero objectives, which will help the EV industry to work alongside them in addressing the issues related to Climate Crisis. The Finance Minister has announced that the customs duties exemption has been extended for the import of goods and machinery required to manufacture lithium-ion cells for EV batteries. This will ensure more local production and manufacturing of Li-On batteries, thus keeping a check on the prices of electric vehicles. The minister also proposed continuing the concessional duty on lithium-ion battery cells for another year. This would give automobile OEMs a boost to launch more EVs with high local content. Also, the Battery energy storage systems will be promoted by the government to steer the economy on the sustainable development path with the capacity of 4,000MWh.

Some of the initiatives taken by the government: -

- **Battery swapping:** Battery swapping is a new technology that allows EV owners to swap their depleted batteries for charged batteries. This can be done quickly and easily, making it a convenient way to extend the range of an EV. In the Budget 2022-23, it was announced that a Battery Swapping Policy for electric vehicle charging in congested areas will be drafted soon. The introduction of updated building by-laws has also been announced by the Finance Minister. The Indian government has plans to finalize incentives for electric cars (EVs) under its new battery exchange scheme. The policy would initially focus on battery swap services for electric scooters, motorcycles, and three-wheeled auto rickshaws, which may help in increasing deployment of EVs for last-mile delivery and ride-sharing. EV drivers can use Battery Swapping to replace discharged battery with freshly charged ones at swap stations. This is faster than charging the vehicle and relieves drivers of range anxiety. The battery is the most expensive component in an EV, switching it allows companies to offer it as a service via lease or subscription models which would help in lowering the cost of owning and maintaining the EV.

- **Production-Linked Incentive (PLI) scheme and National Programme on Advanced Chemistry Cell (ACC) Battery Storage:** The Union Budget 2023-24 has earmarked INR 80,830 Bn for production-linked incentive (PLI) schemes, the bulk of the money going to large-scale electronics manufacturing, pharma, auto and auto components, and food processing. The incentives in this scheme, is linked to turnover, with the government offering a maximum of 18% incentives depending on a company's incremental turnover. The purpose of this PLI scheme is to assist the development of technological adoption that are currently low in India, and it can be used in collaboration with other schemes like as the Faster Adoption of Manufacturing of Electric Vehicles (FAME) scheme and the PLI scheme for advanced chemistry cells (ACC). This will further encourage the development of advanced automotive products, the most prominent of which is battery electric technology. In 2022, the government launched the National Programme on Advanced Chemistry Cell (ACC) Battery Storage. This program aims to promote the development of the domestic ACC battery manufacturing industry. In 2021, the government launched a PLI scheme for the manufacture of advanced chemistry cells (ACCs) for EVs. The PLI scheme is expected to help to reduce the cost of EV batteries in India, and it is expected to boost the domestic battery manufacturing industry.

- **Standards for EV batteries:** The government has also issued a number of standards for EV batteries, such as the Bureau of Indian Standards (BIS) standard for lithium-ion batteries. These standards are designed to ensure the safety and quality of EV batteries.

- **Incentives for EV battery manufacturing:** The government also offers a number of financial incentives for EV battery manufacturing, such as capital subsidies and tax breaks. These incentives are designed to make it more attractive for companies to invest in the domestic battery manufacturing industry.

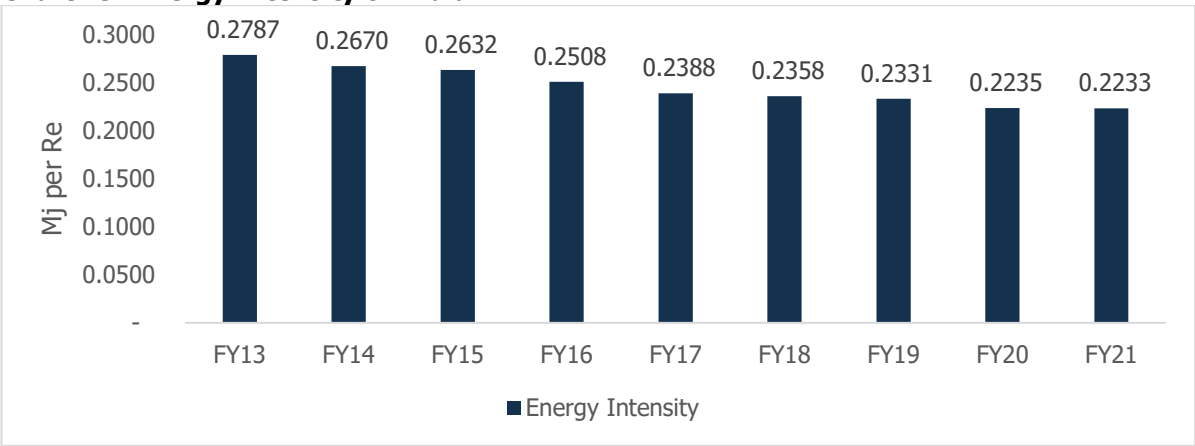
5.7 Energy Efficiency

As the primary energy demand in India is expected to be on an upward trajectory driven by rising income levels and economic growth, the government has taken multiple measures to ensure availability with minimum growth in CO_2 emissions. Energy efficiency is when specific energy consumption (units of energy consumed per unit of output) of a device or equipment is improved by changing the technology deployed. Efforts are being made to efficiently use energy through various innovative policy measures under the overall ambit of Energy Conservation Act which was enacted in 2001 with the goal of inducing energy intensity of the Indian economy.

The Government of India set up the Bureau of Energy Efficiency (BEE) in March 2002 under the provisions of the Energy Conservation Act, 2001. The mission of the BEE is to assist in developing policies and strategies with a thrust on self-regulation and market principles, within the overall framework of the Energy Conservation Act, 2001 with the primary objective of reducing the energy intensity of the Indian economy. BEE coordinates with designated consumers, designated agencies and other organizations and recognize, identifies and utilize the existing resources and infrastructure, in performing the functions assigned to it under the Energy Conservation Act. The Energy Conservation Act provides for regulatory and promotional functions. For energy conservation, the main technology of the device or equipment remain unchanged; however, the unproductive use of energy is minimized.

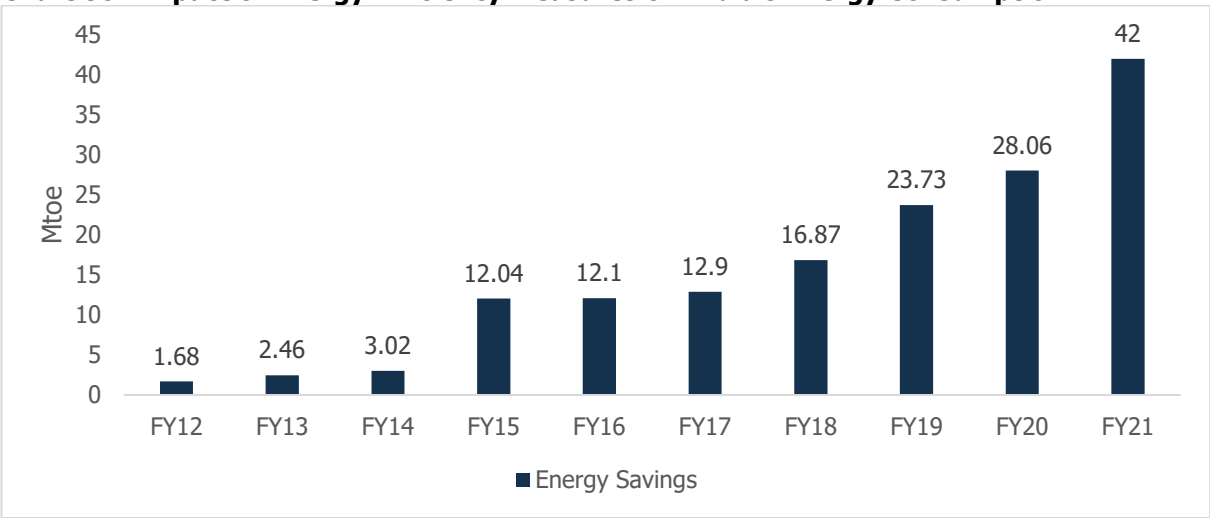
The government has taken several energy efficiency initiatives which has resulted decline of in energy intensity of the country from 0.2787 mega joule (MJ) per Re in FY13 to 0.2233 MJ per Re in FY21(P) and net savings of 210.00 BUs i.e. reduction of 9.71% of net electricity consumption, till FY21.

Chart 79: Energy Intensity of India



Source: Central Electricity Authority, National Electricity Plan 2022-2032, CareEdge Research

Chart 80: Impact of Energy Efficiency Measures on India's Energy Consumption



Source: Central Electricity Authority, National Electricity Plan 2022-2032, CareEdge Research

Government Initiatives

- Energy efficiency in appliances sector – Standards and Labelling Programme

This scheme promotes energy efficiency at the citizens' level through use of more efficient appliances like Air Conditioners, Refrigerators, Televisions, Geysers etc. by regulation of standards and increasing awareness through informative campaigns. It was launched with the objective of providing consumers an informed choice about the energy and cost saving potential of the labelled appliances/equipment being sold commercially. This scheme entails laying down minimum energy performance norms for appliances / equipment, rating the energy performance on a scale of 1 to 5, 5 stars being the most energy efficient. Energy labelling is one of the most cost-effective policy tools for improving energy efficiency and lowering associated energy cost of appliances or equipment. As on January 2023, the programme covers 30 appliances out of which 11 appliances are under the mandatory regime while as the remaining 19 appliances are under the voluntary regime.

- Expanding coverage of industrial efficiency adoption under National Mission for Enhanced Energy Efficiency (NMEEE)

National Mission for Enhanced Energy Efficiency (NMEEE) is one of the eight national missions under the National Action Plan on Climate Change (NAPCC) that was released in June 2008 by the Government of India.

One of the flagship schemes under NMEEE, the Perform, Achieve and Trade (PAT) scheme is a mechanism designed to achieve emissions reduction in energy intensive industries and it is designed on the concept of reduction in Specific Energy Consumption (SEC). It involves assessment of SEC in the baseline year and projected SEC in the target year covering different forms of net energy going into the boundary of the plant and the products leaving out of it over a particular cycle.

The PAT scheme is implemented on a rolling cycle basis and new sectors are added year. Six PAT cycles have been implemented till date. 198 Designated Consumers under PAT scheme for the period 2022-2025 has been notified. BEE has notified PAT Cycle –VII commencing from 2022-23 to 2024-2025 wherein 707 Designated Consumers from 9 sectors have been notified with total energy consumption reduction target of 8.485 Mtoe.

- Energy Conservation Building Code (ECBC)

The Energy Conservation Building Code (ECBC) of BEE sets minimum energy performance standards for commercial buildings having a connected load of 100kW or contract demand of 120 KVA and above. While the Central Government has powers under the EC Act, the State Governments have the flexibility to modify the code to suit local or regional needs and notify them.

In June 2017, BEE rolled out the updated version of ECBC which provides current as well as futuristic advancements in building technology to further reduce building energy consumption and promote low-carbon growth. ECBC 2017 sets parameters for builders, designers and architects to integrate renewable energy sources in building design with the inclusion of passive design strategies. The code aims to optimize energy savings with the comfort levels for occupants, and prefers life-cycle cost effectiveness to achieve energy neutrality in commercial buildings.

As on January 2022, 23 States and Union Territories have incorporated ECBC in Municipal Bye-laws. About 50 ULBs have been covered under these states for compliance. Energy Conservation Building Code (ECBC) Cells of BEE, housed at State Designated Agencies (SDAs), are supporting implementation of ECBC at State level. As on August 2021, 48 Urban Local Body (ULBs) from 8 States have incorporated provisions of ECBC for building approval process.

BEE developed a voluntary Star Rating Programme for commercial buildings which is based on the actual performance of a building, in terms of energy usage in the building over its area expressed in kWh/sq. m/year. This Programme rates buildings on a 1-5-star scale, with 5-Star labelled buildings being the most energy efficient. Currently the scheme is applicable to 4 categories of buildings i.e. day use office buildings, shopping malls, BPOs and hospitals. As on December 2022, more than 270 buildings have been rated under various categories.

- Demand Side Energy Efficiency

Energy Efficiency and Demand Side Management (DSM) measures in the Energy Sector is a cost-effective tool. Energy Efficiency programs encourage the installation of end-use technologies that consume less energy, thereby reducing and/ or shifting the customers' overall electric bill. Energy Efficiency and DSM programs can help utilities to reduce their peak power purchases on the wholesale market thereby lowering their overall cost of operations. Total of 62 DISCOMs have been covered under this programme which has promoted energy efficiency measure in agriculture and municipal sectors among others

- Other Initiatives

a. Programmes have also been launched for promoting energy efficiency in SMEs, transportation sector etc.
b. Fiscal Support - BEE supports Partial Risk Sharing Facility (PRSF) for energy efficiency which is implemented by World Bank through SIDBI in India. PRSF guarantee is for maximum 75% of loan amount or Rs. 150 million per project, whichever is less. Till date, SIDBI has issued 18 guarantees with project cost worth Rs. 2.75 billion (approx.) and guarantee of worth Rs. 634.5 million has been issued.

c. State Energy Efficiency Index: BEE has developed the State Energy Efficiency Index program with an objective to help drive energy efficiency policies and program implementation at the state and local level. This index promotes best practices, encourages healthy competition among states and tracks progress in managing the States' and India's energy footprint.

5.8 Waste Management, Recycling and Other Activities of Circular Economy

India, characterized by its extensive population and diverse economy, encounters noteworthy complexities in waste management and environmental sustainability. Nevertheless, the nation has undertaken proactive measures to address these challenges and foster waste management, recycling, and other circular economy activities.

- Waste Management Initiatives

Swachh Bharat Mission: The Swachh Bharat Mission, initiated in 2014, endeavours to achieve cleanliness and eliminate open defecation in India. It has garnered substantial recognition and emphasis on waste management and sanitation practices throughout the country. The mission primarily concentrates on generating awareness, constructing household and community toilets, and establishing robust systems for solid waste management.

Solid Waste Management Rules: In 2016, India implemented new solid waste management regulations to tackle the complexities associated with waste generation and disposal. These regulations place significant emphasis on waste segregation at the point of origin, decentralized waste processing, and the promotion of recycling and composting practices. Additionally, the regulations aim to integrate informal waste pickers into the formal waste management sector, recognizing their valuable role in waste collection and recycling activities.

- Recycling Initiatives

Extended Producer Responsibility (EPR): India has enacted Extended Producer Responsibility (EPR) regulations, imposing the responsibility on producers to manage the waste generated by their products throughout the entire lifecycle. This encompasses activities such as waste collection, recycling, and safe disposal. EPR serves as a mechanism to incentivize manufacturers to adopt environmentally friendly product designs, optimize packaging materials, and establish take-back systems to facilitate efficient recycling processes. By implementing EPR, India aims to enhance producer accountability and promote sustainable waste management practices in the industrial sector.

E-waste Management: Electronic waste (e-waste) represents a considerable environmental and health risk. Recognizing this concern, the Indian government introduced the E-waste Management Rules in 2016. These regulations mandate the appropriate handling, disposal, and recycling of electronic waste in order to mitigate its adverse impacts. To facilitate the implementation of these rules, authorized e-waste recyclers and collection centers have been established across the country, ensuring the adoption of safe and efficient recycling practices in the management of e-waste.

- Circular Economy Initiatives

National Plastic Waste Management Mission: Launched in 2018, has the primary objective of reducing the generation of single-use plastic waste and promoting effective recycling and waste management practices. This mission places significant emphasis on the segregation and systematic collection of plastic waste, the establishment of robust recycling infrastructure, and raising awareness about the detrimental environmental consequences of plastic pollution. Furthermore, the mission encourages the exploration and adoption of alternative materials as substitutes for plastic and actively supports research and innovation endeavours in the field of sustainable packaging.

Waste-to-Energy Projects: India has been actively engaged in promoting waste-to-energy projects as a viable solution to address the dual challenges of waste management and meeting energy demands. These projects involve the conversion of organic waste, including municipal solid waste and agricultural residues, into valuable energy resources such as

electricity or biogas. By adopting waste-to-energy technologies, India aims to alleviate the burden on landfills, minimize environmental pollution associated with waste disposal, and simultaneously harness renewable energy sources.

Organic Waste Management: Multiple initiatives have been implemented to promote decentralized composting of organic waste in India. This approach entails diverting organic waste away from landfills and instead processing it into compost rich in nutrients for agricultural use. Community-based composting programs actively engage citizens, leading to increased participation and a sense of ownership. Additionally, decentralized composting reduces transportation costs and contributes to the improvement of soil health through the application of nutrient-rich compost in agricultural activities.

Despite significant progress in waste management and recycling in India, various challenges persist. These challenges include a lack of adequate waste processing infrastructure, inadequate segregation practices at the source, and a general lack of awareness among the public regarding proper waste management practices. The informal waste sector, which plays a vital role in waste collection and recycling, requires better integration and support to enhance its efficiency and effectiveness.

To tackle these challenges, the Indian government has been actively implementing policy reforms aimed at improving waste management practices. Additionally, investments are being made to enhance waste management infrastructure, including waste processing facilities and recycling centers. Furthermore, efforts are being made to promote public participation in waste management initiatives, raising awareness about the importance of waste segregation, recycling, and responsible waste disposal practices.

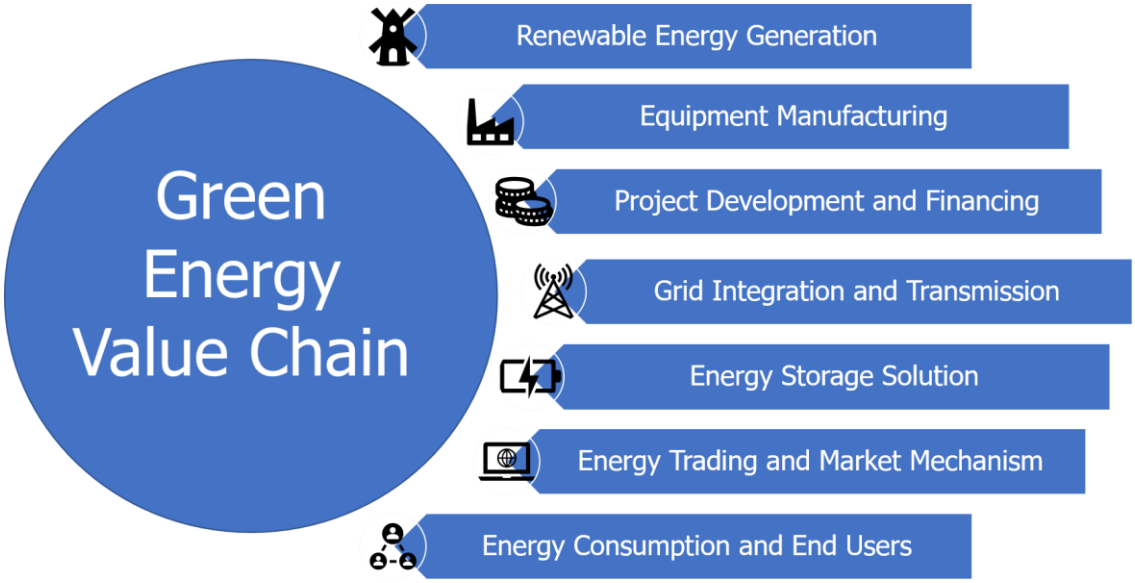
Continued efforts are necessary to build sustainable waste management systems in India. This includes improving waste segregation practices at the source, enhancing recycling capabilities, and expanding the reach of waste management infrastructure across the country. By addressing these challenges and implementing comprehensive strategies, India can further improve waste management and recycling practices, moving towards a more sustainable and environmentally conscious approach to waste management.

5.9 Green Energy Value Chains

Generation, transmission, distribution, and consumption of green energy are the interconnected processes involved in the green energy value chain. These are the various stakeholders that contribute to the development of renewable and green energy in India.

The green energy value chain is rapidly evolving driven by the government support and policies, renewable energy targets, and growing demand for green and clean energy sources.

Chart 81: Green Energy Value Chain



Source: CareEdge Research

Renewable energy generation involves generation of electricity from renewable sources i.e. solar, wind, hydro and bioenergy. It includes the installation and operation of the of the renewable power plants that are large scale and distributed.

Equipment Manufacturing is the sector that produces renewable energy equipment like solar panels, wind turbines, biomass boilers and hydroelectric turbines. This sector plans an important role in the entire green energy value chain. It includes the manufacturing of the components, assembly, and quality control.

In India, the capacity for solar equipment is around 12 GW/ year for solar module, 3 GW/ year for solar cells and around 5 GW/year for solar inverters, however, given the rapid pace of expansion, this capacity is not sufficient to meet domestic demand and India is significantly reliant on imports.

Hydro power plants require hydro-mechanical, electro-mechanical and civil works. In terms of availability, India has sufficient number of companies involved in each of these fields, however, some components like hydraulic systems for gates of hydro power plants are yet to be fully indigenization.

As for wind power projects, India has around 17 wind turbine manufacturers with annual domestic production capacity of around 10,000 MW/year. India has manufacturing base for most of the wind components in the country and they supply components to wind turbine industry and export the components to the global markets as well.

Equipment manufacturing for small hydropower equipment is in order of 1,000 MW/year and India has around 6-7 established manufacturers for the same. Most of the raw material requirement for small hydro power plants are available in India, however, 20% of the components of the generators are imported. For bioenergy, all equipment, technology and service are sourced indigenously.

Project Development and Financing involves project development by the companies and organization that include identifying suitable sites, securing necessary permits and clearances, and arranging for financing of the renewable projects. Financing can be done by investors, financial institutions, and government agencies by various means.

The equity for sourcing the financing for renewable power projects are done through initial public offering by listing in the markets, follow on public issue, convertible debentures and monetization of operational assets. Equity investments can also come directly from mutual funds, insurance companies, etc. The sources for debt funding are scheduled commercial banks, financial institutions like Power Finance Corporation (PFC), Rural Electrification Corporation (REC), Life Insurance Corporation (LIC), IREDA, commercial banks and bonds, external commercial borrowing, foreign currency in form of loans from World Bank, ADB, KfW, EXIM, etc.

Other sources include financing through various schemes like Green Climate Fund, Green bonds, etc. As per World Bank Data, Indian green bond issuances have reached a total of USD 21 billion as on February 2023 out of which private sector was responsible for 84% of the total. The largest green bond issuer in India Greenko Group for funding hydro, solar, and wind power projects in several Indian states with its green bond proceeds. Ghaziabad Nagar Nigam, a civic body in Uttar Pradesh, is the first Indian local government to have issued a green bond.

India issued its first tranche of its first sovereign green bond worth Rs 80 billion on January 25, 2023 and On February 9, 2023, the Government of India announced the issuance of another Rs 80 billion in sovereign green bonds.

Grid Integration and Transmission ensures that the green energy is efficiently integrated into the existing power grid infrastructure. Development of transmission and distribution infrastructure, grid connectivity, grid management, etc. are the various activities involved to ensure smooth and reliable integration of the green energy.

Energy storage solutions are technologies like compressed air energy storage, flywheel, thermochemical storage, supercapacitors, superconducting magnetic coil energy storage (SMES), batteries and pumped hydro storage, etc. which are essential for storing excess electricity generated from intermittent renewable sources and ensuring stable and reliable power supply when needed. Energy storage solutions help in effective utilization of the green energy and help in balancing power fluctuation and peak demands.

Energy trading and market mechanism include the trading of green energy through market mechanism by way of renewable energy certificates (RECs) and Energy Efficiency Certificates (EECs). There are energy trading platforms in India like Indian Energy Exchange (IEX) and Power Exchange India Limited (PXIL) that enable market participants to trade in RECs and EECs.

Energy Consumption and End users are the ultimate end users of the value chain that include residential, commercial, industrial, agricultural and other sectors. The ultimate aim of the green value chain is to meet the energy requirement of the end users. Increasing awareness about green energy and sustainability will increase the adoption of renewable energy among the end users and contribute to the growth of the green energy value chain of the country.

5.9.1 Manufacturing of green energy generating devices

Efforts are being taken by the India reduce the dependency on imports for power plant equipment through Make in India (MII) initiative to reduce import component in power plant equipment. The Government of India has issued Public Procurement (Preference to Make in India) Order 2017 via Department of Industrial Policy and Promotions (DIPP) to promote manufacturing and production of goods and services in India with a view to enhance income and employment. Ministry of Power issues order time to time wherein the preference shall be given by all public procuring entities to domestically manufactured products used in the Power Sector.

- **Solar Module and Cells**

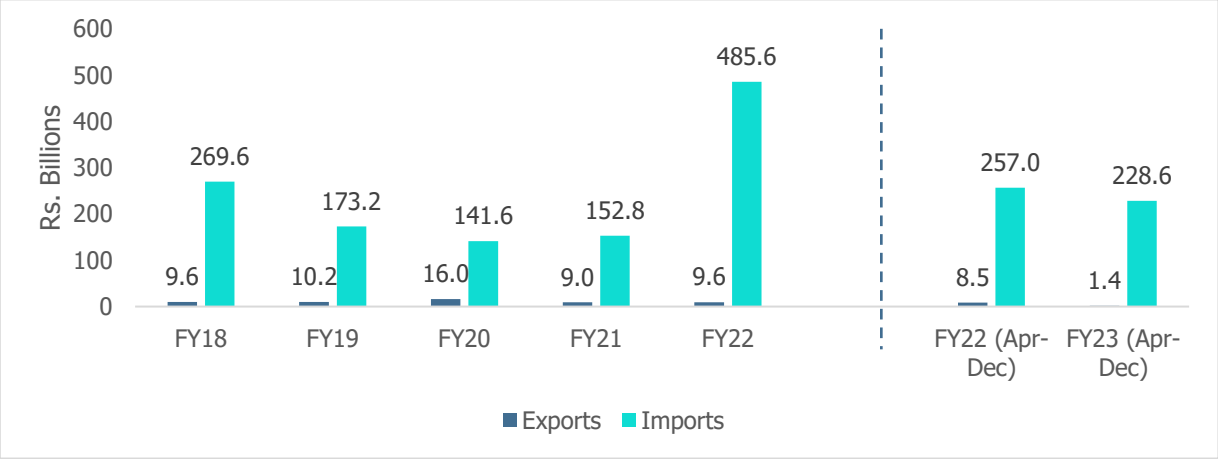
The government had introduced the PLI Scheme to promote local manufacturing in the country. Of the 13 sectors for which PLI has been approved, 'High Efficiency Solar PV Modules' has also been included with MNRE as the designated ministry. MNRE has appointed India Renewable Energy Development Agency Limited (IREDA) as the implementing agency

for the PLI Scheme 'National Programme on High Efficiency Solar PV Modules' Tranche-1. The financial outlay for PLI for 'High Efficiency Solar PV Modules' Tranche-1 over a five-year period is Rs.45 billion. Under Tranche-1 of the PLI scheme, a total integrated capacity of 8,737 MW was allocated.

The Government has further allocated a total capacity of 39,600 MW of domestic Solar PV module manufacturing across 11 companies as beneficiary under the PLI Scheme for High Efficiency Solar PV Modules (Tranche-II), with a total outlay of Rs. 140 billion. Manufacturing capacity totalling 7400 MW is expected to become operational by October 2024, 16,800 MW capacity by April 2025 and the balance 15,400 MW capacity by April 2026. The Tranche-II is expected to bring in an investment of Rs. 930 billion. The PLI scheme is expected to add 48 GW of domestic Solar Module manufacturing capacity in the next 3 years. Apart from this, the Government is expected to continue focus on conductive environment to increase domestic production and improving the local supply chain.

For solar, there is large import dependency for solar cells and modules despite significant progress being made in indigenous manufacturing. In FY22, solar cells and modules exports have increased by 9% compared to FY21 whereas the imports have increased by 218% during the same period. The growth in imports has been significant because of imposition of BCD[1] as manufacturers tried to stock up on their raw material inventory. The imports reduced by 11% in FY23 (9 months) y-o-y while the exports declined by 84% in the same period after the BCD being imposed.

Chart 82: Import and Export of Solar Cells and Modules



Source: Ministry of Commerce and Industry, CareEdge Research

Indian solar power producers are still dependent on imports of solar modules mainly from China which accounts for about 90% of the total imports, followed by Hong Kong and Malaysia, assessed based on to the value of imports. The imports consist mainly of photosensitive semiconductors, photovoltaic cells, solar modules and panels.

According to CEEW Centre for Energy Finance (CEEW-CEF), the push to improve local manufacturing could lead to domestic solar manufacturing reaching a market size of Rs. 2,457[18] billion by 2030 from selling 150 GW. To reach the 150 GW capacity of domestic solar manufacturing, investment worth Rs. 589.7[19] billion is required in the next 2-3 years in India.

[18] Exchange Rate 1 USD= Rs. 81.9 as on 25th July 2023
[19] Exchange Rate 1 USD= Rs. 81.9 as on 25th July 2023

Wind Turbines

Around 70-80% indigenization has been achieved with strong domestic manufacturing in the wind sector. There are over 17 wind turbine manufacturers available in India with domestic annual production capacity of around 10,000 MW/year. The components are domestically sourced and exported to the global wind turbine market as India has a manufacturing base for major wind components in the country.

India also has a manufacturing capacity of around 6GW/year for wind turbine gearbox which is more than requirement by the wind turbines in India. Although, the capacity is sufficient, gear box required for wind turbines are also imported due to issues related to quality, cost and delivery lead time. In addition, the manufacturing capacity for pitch and yaw drivers is also sufficient at more than 10 GW/year.

In order to encourage the manufacturing of Wind Turbine Generators (WTG) in India, Government is providing financial incentive in the form of Concessional Custom Duty Exemption on some of the critical components required to be imported for manufacturing of WTG. Ministry of Finance has provided the concessional custom duty benefit till 31.03.2025. Wind Turbine Generators/ Models which are included in the RLMM list of MNRE for OEM and component are only eligible for concessional custom duty.

Hydrogen Electrolyser

In January 2023, the government of India has approved the National Green Hydrogen Mission that targets the green hydrogen production to reach 5MT per year by 2030 with an initial outlay of Rs. 197.44 billion. The details of the mission are provided in the section 4.6.

As per a report dated May 2023 on Investment Landscape of Green Hydrogen in India released by MNRE and United States Agency International Development (USAID), India's own internal market for electrolysers could be around 29 GW by 2030 with an investment demand of Rs. 2,129[20] billion. As per Union Minister RK Singh, the government is expected to come up with a production linked incentive (PLI) scheme for investors in electrolyser manufacturing.

India's electrolyser manufacturing is at nascent stage and as per MNRE, India is already home to about 6 alkaline electrolyser manufacturers. There are a few PSUs in India that have the manufacturing capabilities for producing balance of plant (BoP) components, but the domestic production of electrochemical stacks is muted. The current demand of electrolyser is met through imports. There are indigenous solution providers who have partnered with international electrolyser manufacturers to meet the domestic demand for hydrogen.

5.9.2 Manufacturing of energy efficiency devices

For the purpose of energy efficiency, smart meters are used. Smart meters help DISCOMs reduce aggregate technical and commercial (AT&C) losses, improve their financial health, incentivize energy conservation, enhance ease of bill payments, consumer satisfaction and ensure billing accuracy by getting rid of manual errors in meter reading. There is continuous need for innovation in smart metering and advance metering infrastructure. While there are some domestic manufacturers, India imports a majority of its smart meter requirement from countries like China, Poland and Austria.

[20] Exchange Rate 1 USD= Rs. 81.9 as on 25th July 2023

5.10 Carbon Offset Solutions

- Carbon Capture Utilization and Storage

Carbon Capture Utilization and Storage (CCUS) involves capturing carbon dioxide at emission sources such as coal-based power plants and then using them for making items such as building materials, or permanently storing them at underground locations. The technology helps in capturing the carbon dioxide before it can enter the atmosphere and therefore, helps in reducing emissions. The captured CO_2 can then be utilized for production of value-added products such as green urea, building materials, polymers and chemicals etc. thereby adding to the overall circular economy. CCUS can be installed across industries including power, steel, cement, oil & gas etc.

Table 46: Types of CCUS

Types	Description
Chemical solvent-based carbon capture	This mechanism is preferred for low pressure gas steams which have low content of CO_2 such as flue gas streams from power plants, blast furnace gases in steel plants, gas streams in refineries or chemicals plants
Physical solvent-based carbon capture	This mechanism is preferred for high pressure gas stream with high concentration of CO_2
Absorption-based carbon capture	This mechanism is suitable for moderate-high pressure gas stream with moderate concentration of CO_2
Cryogenic carbon capture	This is preferred when cost of power is low

Source: NITI Aayog Report on CCUS, CareEdge Research

In order to facilitate the development of CCUS technology, the government has also launched various initiatives under the Department of Science and Technology and is also supporting CCUS initiatives by industries and PSUs. Two National Centres of Excellence in Carbon Capture and Utilization have been set up with support from the Department of Science & Technology – (i) National Centre of Excellence in Carbon Capture and Utilization (NCoE-CCU) at Indian Institute of Technology (IIT) Bombay, Mumbai and (ii) the National Centre in Carbon Capture and Utilization (NCCCU) at Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru. These centres will facilitate capturing & mapping of current R&D and innovation activities in the domain and also develop networks of researchers, industries and stakeholders with coordination and synergy between partnering groups and organizations. The Centres will act as multi-disciplinary, long-term research, design development, collaborative and capacity-building hubs for state-of-the-art research and application-oriented initiatives in the field of CCU.

Mission Innovation Challenge on CCUS has been launched with an objective to enable near zero CO_2 emissions from power plants and other carbon intensive industries. Department of Science and Technology, in collaboration with Department of Biotechnology has established a national program on CO2 storage research which supports carbon capture research and develops pilots and projects.

Thermal power generation is the biggest contributor to the carbon emissions in the country. Even with the targeted 50% renewable capacity by 2030, thermal power will remain one of the largest sources of power. Thus, CCUS in power sector is essential to achieve the CO_2 emission reduction targets. However, the capital outlay for setting up CCUS solution for a power plant is significant and some support from the government in the form of viability gap funding, tax subsidies etc. may be required for greater adoption of this technology.

- Nature-based solutions for Carbon Capture

Nature-based solutions for reducing carbon dioxide in the atmosphere include reforestation and afforestation, restoration of coastal wetlands and mangroves, using restorative agricultural practices such as cover crop, crop rotation etc. These practices help in capturing the CO2 from the atmosphere and trapping them in plants and the soil.

There are certain other nature-based solutions which have been developed such as biomass burial and biochar.

Biomass Burial: When the plants and trees decay, the trapped CO_2 returns to the atmosphere. Under biomass burial, such plants and trees and buried underground or in saline pits to lock up the carbon and avoid composting.

Biochar: Biochar is a charcoal like substance which is formed by heating biomass in limited supply of oxygen. In this process (pyrolysis), the biomass does not combust and no carbon is emitted. The process creates a stable form of carbon which can be stored in the soil.

- Carbon credit trading

Carbon trading is buying and selling the right to emit a tonne of CO_2 or CO_2 equivalent of other greenhouse gases, also referred to as carbon credits. Carbon credits have been devised as a mechanism to reduce greenhouse gases and are issued by the governments or government approved certification bodies. They are created from projects or companies that are able to remove greenhouse gasses from the atmosphere or keep emissions from being released. Companies or individuals, who are unable to adhere to their emission targets, purchase carbon credits as an offset mechanism. Carbon credits are also traded on exchanges in a number of countries.

India currently issues Energy Saving Certificates under its energy efficiency initiatives led by BEE. These certificates are issued to industrial units which save more energy than the targets allotted to them under the PAT scheme. These certificates are traded on Indian Energy Exchange and can be purchased by industrial units which did not achieve their targets.

The government has recently announced its plans to develop the Indian Carbon Market (ICM) where a national framework will be established with an objective to decarbonize the Indian economy by pricing the greenhouse gas emissions through trading of the Carbon Credit Certificates. BEE, Ministry of Power, Ministry of Environment, Forest & Climate Change are developing the Carbon Credit Trading Scheme for this purpose. For emission intensive sectors, greenhouse gas emissions intensity benchmark and targets will be developed, which will be aligned with India's emissions trajectory as per climate goals. The trading of carbon credits will take place based on the performance against these sectoral trajectories. Further, it is envisaged that there will be a development of a voluntary mechanism concurrently, to encourage greenhouse gas reduction from non-obligated sectors.

5.11 Adaptation and Resilience

5.11.1 Pollution and Sanitation

India faces significant challenges related to pollution and sanitation, which require adaptation and resilience measures to mitigate their impact on public health and the environment. Adaptation and resilience are important concepts in the context of pollution and sanitation in India. Adaptation refers to the process of adjusting to a changing environment, while resilience refers to the ability to recover from a disturbance.

By taking steps to adapt and build resilience, India can better protect its citizens from the health and environmental impacts of pollution and sanitation. Pollution and sanitation challenges in India require robust adaptation and resilience strategies. Through policy interventions, technological advancements, public participation, and international collaborations, efforts are being made to address air and water pollution, solid waste management, climate change adaptation, and promote sustainable practices for a cleaner and healthier environment.

Some of the latest developments in adaptation and resilience for pollution and sanitation in India:

- The government of India has launched the National Clean Air Programme (NCAP) 2.0. This program aims to reduce air pollution in 132 cities across India by 20% by 2024.
- In 2023, the government of India announced that it would invest Rs. 819[21] billion in research and development for climate-resilient technologies. This investment is expected to help India to adapt to the impacts of climate change and build resilience to future disasters.
- In 2023, the government of India also launched the National Adaptation Fund for Climate Change (NAFCC). This fund will provide financial assistance to states and cities to implement adaptation projects.
- In 2022, the government of India launched the National Hydrogen Mission. This mission aims to make India a global leader in the production and use of hydrogen. Hydrogen is seen as a potential fuel for the future because it produces zero emission.

Government Policies

The government of India has implemented a number of policies to promote adaptation and resilience to pollution and sanitation. These policies include:

- **National Clean Air Program (NCAP):** This program is a long-term, comprehensive strategy to tackle air pollution in India. Under the program, 122 cities have been identified as non-attainment cities with high pollution levels. This program aims to reduce air pollution in 132 cities across India by 20% by 2024. The NCAP 2.0, launched in 2022, has set more ambitious targets, aiming to reduce air pollution by 30-35% by 2030.
  During the year 2019-20 and year 2020-21, Rs. 3.75 billion were released to State Pollution Control Boards (SPCBs) for implementation of activities under clean air program, further a grant of Rs. 44 billion have been released during FY 2020-21.
- **Swachh Bharat Abhiyan (Clean India Mission):** The Swachh Bharat Abhiyan, launched in 2014, aims to achieve universal sanitation coverage and proper solid waste management. This program aims to achieve universal sanitation coverage in India by 2024.
- **National Clean Ganga Mission:** The Namami Gange program, a flagship initiative under the National Clean Ganga Mission, aims to rejuvenate the Ganga river by reducing pollution, improving wastewater treatment, and conserving river biodiversity.
- **Plastic Waste Management Rules:** The government has introduced stricter regulations for managing plastic waste. The Plastic Waste Management Rules, 2016 and the Plastic Waste Management Rules, 2018, focus on waste collection, segregation, recycling, and extended producer responsibility. The regulations aim to curb plastic pollution and promote responsible use and disposal of plastic.
- **The National Water Mission (NWM):** This mission aims to provide safe and adequate drinking water to all Indians by 2024. The NWM has made progress in improving water quality and access to drinking water, but there are still challenges to overcome, such as water scarcity and pollution.
- **The National Disaster Management Plan (NDMP):** This plan aims to reduce the impact of natural disasters on India. The NDMP includes a number of measures to improve early warning systems, disaster preparedness, and response.
- **Smart Cities Mission:** The Smart Cities Mission, launched in 2015, aims to develop 100 smart cities in India. These cities integrate technology, infrastructure, and sustainability principles to improve quality of life, including pollution and sanitation management. Smart city projects often focus on waste management, efficient transportation systems, and smart solutions for air quality monitoring and pollution control. The Smart Cities Mission promotes the development of smart cities with sustainable and resilient infrastructure.

[21] Exchange Rate 1 USD= Rs. 81.9 as on 25th July 2023

- **National Urban Sanitation Policy:** The National Urban Sanitation Policy provides guidelines and support for improving sanitation infrastructure and services in urban areas. It focuses on promoting the construction of household toilets, ensuring access to clean and safe public toilets, and implementing solid waste management practices.
- **Environmental Impact Assessment (EIA):** The government has implemented the Environmental Impact Assessment process to ensure that development projects consider the potential environmental impacts. The EIA policy requires project proponents to assess and mitigate the environmental consequences of their activities, including pollution and sanitation aspects.
- **State Pollution Control Boards:** The government has established State Pollution Control Boards (SPCBs) to enforce pollution control regulations at the state level. SPCBs monitor industrial emissions, implement pollution control measures, and undertake enforcement actions against violators.

5.11.2 Flue gas desulphurization and other technologies for thermal power fleet decarbonization in India

Flue gas desulfurization (FGD) is a technology that is used to remove sulphur dioxide (SO_2) from the flue gas of power plants. SO_2 is a pollutant that can cause acid rain and respiratory problems. FGD systems typically use limestone or dolomite to react with SO_2 to form a solid by-product, which is then collected and disposed of. However, it can be expensive to install and operate. In addition, FGD systems can produce large amounts of waste, which can pose environmental challenges.

FGD and other technologies play a crucial role in the adaptation and resilience efforts for reducing the emissions from thermal power fleet in India. As India continues to rely on thermal power generation for its energy needs, adopting cleaner technologies becomes essential to reduce greenhouse gas emissions and improve air quality. Here are key technologies and initiatives for thermal power fleet decarbonization in India:

Government Policies

The Government of India has implemented a number of policies to promote the use of flue gas desulfurization (FGD) and other technologies for thermal power fleet decarbonization. These policies include:

- **The National Clean Air Programme (NCAP):** The NCAP aims to reduce air pollution in India by 20% by 2024. The NCAP, launched in 2019, aims to tackle air pollution in India, including pollution from thermal power plants. The program focuses on city-specific action plans, including the installation of FGD systems, to reduce sulphur dioxide emissions and improve air quality.
- **The National Electricity Plan (NEP):** The NEP sets a target of reducing CO_2 emissions from India's power sector by 33-35% by 2030. The NEP includes a number of measures to promote the use of FGD and other technologies to reduce emissions from thermal power plants.
- **The Indian Emission Control Technology Centre (IECTC):** The IETCC is a government-funded organization that provides technical assistance to power plants in India to help them comply with emission standards. The IETCC also conducts research and development on new emission control technologies.
- **The National Clean Coal Technology Programme (NCCTP):** The NCCTP is a government-funded programme that supports the development and deployment of clean coal technologies in India. The NCCTP includes a number of projects to develop and deploy FGD and other technologies for thermal power plants.
- **Environment Protection Act, 1986:** The Environment Protection Act provides the legal framework for environmental protection in India. It empowers the government to take measures to control and mitigate pollution, including air pollution from thermal power plants. The act forms the basis for regulations and policies related to FGD and other emission control technologies.
- **Revised Emission Standards for Thermal Power Plants:** The Ministry of Environment, Forest and Climate Change (MoEFCC) has set revised emission standards for thermal power plants. These standards specify the

maximum permissible limits for various pollutants, including sulphur dioxide, nitrogen oxides, particulate matter, and mercury. Compliance with these standards requires the adoption of emission control technologies like FGD.

These policies are aimed at promoting the use of FGD and other technologies to reduce emissions from thermal power plants in India. The government expects that these policies will help India to achieve its emission reduction targets and improve air quality. The government is also providing technical assistance to power plants to help them comply with emission standards.

5.11.3 Water and Drought Management

Water and drought management in India is a complex and challenging issue. India is a vast country with a diverse climate, and water resources are unevenly distributed. In some areas, droughts are a regular occurrence, while in others, flooding is a major problem. Water scarcity and droughts are significant challenges in India, especially in regions that heavily rely on agriculture. Adaptation and resilience measures are crucial to ensure sustainable water management and mitigate the impacts of drought. The government of India is committed to addressing water and drought management. By implementing these policies and programs, India is working to ensure water security for its citizens and to build resilience to the impacts of climate change.

Some of the latest developments in water and drought management in India:

- The government of India has launched the Jal Jeevan Mission (JJM). The JJM is a national program that aims to provide piped water to all households in rural India by 2024.
- Advanced technologies like artificial intelligence (AI) and machine learning (ML) are being employed in water management. AI-based algorithms analyse large datasets to predict water availability, optimize water allocation, and detect anomalies in water usage patterns. ML models assist in water demand forecasting and optimize irrigation scheduling for better water efficiency.
- Smart water grids and digital platforms are being developed to monitor and manage water resources effectively. These systems provide real-time data on water supply, demand, and distribution, enabling efficient management of water networks. Digital platforms also facilitate online water billing, complaint registration, and monitoring of water quality.
- The government of India is also developing drought-resistant crops. Drought-resistant crops are crops that can withstand periods of drought. These crops are becoming increasingly important in India as the climate becomes more variable. The government is supporting research and development of drought-resistant crops and is also promoting the cultivation of these crops.
- The government of India is also strengthening early warning systems by implementing advanced technology-based systems for early detection and monitoring of drought conditions. Remote sensing, satellite imagery, and meteorological data are utilized to provide real-time information on rainfall patterns, soil moisture levels, and crop health. This enables timely interventions and proactive drought management strategies. Early warning systems can help communities to prepare for and respond to droughts. These systems can provide information on rainfall patterns, soil moisture levels, and other factors that can indicate the risk of drought. The government is investing in the development and deployment of early warning systems.
- The government of India is also working to improve disaster preparedness Disaster preparedness is the planning and preparation for natural disasters. This includes measures such as stockpiling food and water, developing evacuation plans, and training community members in disaster response. The government is running awareness campaigns and providing training to communities on disaster preparedness.

Government Policies

The Government of India has implemented a number of policies and programs to address water and drought management. These include:

- **Atal Bhujal Yojana (ABHY):** The Atal Bhujal Yojana, launched in 2020, aims to improve groundwater management and promote sustainable water resource practices. The program focuses on community participation, demand-side management, and recharge interventions in overexploited and critical groundwater areas. ABHY emphasizes the formation of Water User Associations and awareness campaigns for sustainable groundwater use.
- **Jal Jeevan Mission (JJM):** The JJM is a national program that aims to provide piped water to all households in rural India by 2024. The JJM is expected to improve access to water for drinking, cooking, and sanitation, and it is also expected to help to reduce the risk of drought. It involves the use of technology for water source mapping, demand estimation, and infrastructure planning.
- **National Water Policy:** The NWP is a comprehensive policy document that sets out the government's vision for water management in India. The policy promotes efficient water use, rainwater harvesting, groundwater recharge, and interlinking of rivers to address water scarcity and drought-related issues.
- **National Water Mission**: The NWM is a government program that aims to provide safe and adequate drinking water to all Indians by 2024. The NWM also aims to improve water quality and reduce water pollution and promoting sustainable water management practices. The mission includes initiatives like promoting rainwater harvesting, promoting efficient irrigation practices, and creating awareness about water conservation.
- **The Pradhan Mantri Krishi Sinchai Yojana (PMKSY):** The PMKSY is a government program that aims to provide irrigation to 50 million hectares of land by 2024. The scheme includes components such as the Accelerated Irrigation Benefit Program (AIBP), the Per Drop More Crop component, and the Watershed Development component. It focuses on creating water storage infrastructure, promoting micro-irrigation, and implementing efficient irrigation practices.
- **The National Disaster Management Plan (NDMP):** The NDMP is a government plan that aims to reduce the impact of natural disasters, including droughts. The NDMP includes a number of measures to improve early warning systems, disaster preparedness, and response.
- **Inter-State River Water Disputes Act:** The Inter-State River Water Disputes Act provides a legal framework to address disputes related to the sharing of river waters between states. The act facilitates the establishment of tribunals to adjudicate water disputes and ensures equitable distribution of water resources among riparian states.
- **State Water Policies:** Several states in India have formulated their own water policies to address region-specific water challenges. These policies outline strategies for water allocation, conservation, groundwater management, rainwater harvesting, and drought mitigation.
- **Watershed Development Programs:** Watershed development programs focus on soil and water conservation measures in specific regions. These programs aim to restore degraded lands, improve water infiltration, recharge groundwater, and enhance overall water availability. Watershed management practices include afforestation, contour bunding, contour trenches, and reclamation of water bodies.
- **Inter-State Water Sharing Agreements:** Water-sharing agreements between states play a crucial role in managing water resources effectively, particularly in regions with shared river basins. These agreements help in resolving conflicts, ensuring equitable distribution, and promoting coordinated water management strategies.
- **Legal and Regulatory Framework:** India has enacted laws and regulations to govern water management, including the Water (Prevention and Control of Pollution) Act, the Groundwater (Control and Regulation) Act, and the River Boards Act. These laws provide a legal framework for water conservation, pollution control, and regulation of water resources.

5.11.4 Biodiversity and Ecosystem Preservation

India is a diverse country with a wide variety of ecosystems and species including forests, wetlands, coastal areas and grasslands. However, India's biodiversity is under threat from a number of factors, including habitat loss, pollution, and climate change. The preservation of biodiversity and ecosystems is crucial for maintaining ecological balance, supporting livelihoods, and adapting to climate change. The focus on protected areas, wildlife conservation, forest conservation,

coastal and marine ecosystem management, invasive species control, wetland conservation, ecosystem-based adaptation, and legal frameworks highlight the country's efforts to promote adaptation and resilience through the preservation of biodiversity and ecosystems. The focus on Biodiversity Heritage Sites, INDC commitments, eco-sensitive zone notifications, urban greening, endangered species conservation, community-based conservation, wetland conservation, river restoration, and ecosystem-based adaptation projects demonstrates the country's dedication to adaptation and resilience through the preservation of biodiversity and ecosystems.

Some of the latest developments in biodiversity and ecosystem preservation in India:

- The government of India has announced plans to create a new national park in the Western Ghats. The park will cover an area of 1,000 square kilometres and will be home to a number of endangered species, including the Nilgiri tahr, the lion-tailed macaque, and the Malabar civet.
- The government of India has also announced plans to launch a new program to conserve wetlands. The program will focus on restoring degraded wetlands and protecting wetlands from pollution and development.
- A number of Indian states have recently passed laws to protect their own biodiversity. The state of Kerala has passed a law that prohibits the use of pesticides and herbicides in agricultural fields.
- A number of Indian organizations are working to raise awareness about biodiversity conservation. The Wildlife Trust of India runs a program called "Adopt a Tiger," which allows people to sponsor the conservation of a tiger in the wild.
- The city of Mumbai has developed a plan to plant 1 million trees by 2025.
- A number of Indian companies are working to incorporate biodiversity conservation into their business practices. The Tata Group has pledged to make its operations more sustainable by reducing its environmental impact.

Government Policies

The Government of India has implemented a number of policies and programs to address biodiversity and ecosystem preservation. These include:

- **National Biodiversity Action Plan (NBAP):** The NBAP provides a comprehensive policy framework for biodiversity conservation and sustainable use in India. It outlines strategies for preserving biodiversity, promoting sustainable livelihoods, mainstreaming biodiversity into various sectors, and ensuring equitable sharing of benefits from biodiversity resources.
- **Wildlife Protection Act:** The Wildlife Protection Act of 1972 is a key legislation that provides legal protection to wildlife and their habitats. It regulates the hunting, poaching, and trade of wildlife species, establishes protected areas, and outlines provisions for the conservation of endangered species.
- **Forest Conservation Act:** The Forest Conservation Act of 1980 regulates the diversion of forest land for non-forest purposes. It mandates the approval of the Central Government for any project that involves the diversion of forest land, ensuring that forest ecosystems are protected and sustainable use is promoted.
- **The Biological Diversity Act (2002):** The Biological Diversity Act is a comprehensive law that provides a framework for the conservation, sustainable use, and equitable sharing of biological resources in India. The Biological Diversity Act requires all users of biological resources to obtain a prior informed consent (PIC) from the government. The PIC process ensures that the benefits of using biological resources are shared equitably with the communities that own and manage these resources.
- **National Afforestation Program (NAP):** The NAP focuses on increasing forest cover, improving degraded lands, and enhancing ecosystem services. It aims to promote afforestation, reforestation, and tree planting on public and private lands, and encourages the participation of local communities and stakeholders.
- **National Mission for Green India (GIM):** The GIM, launched under the National Action Plan on Climate Change, aims to increase forest and tree cover across India, with a focus on ecological restoration, biodiversity conservation,

and improving ecosystem services. It promotes afforestation, agroforestry, and landscape restoration in both rural and urban areas.

- **Coastal Regulation Zone (CRZ) Notifications:** The CRZ notifications regulate development activities in the coastal areas to protect coastal ecosystems and biodiversity. They outline guidelines for development, conservation of marine biodiversity, and sustainable coastal zone management.
- **National Wetland Conservation Program (NWCP):** The NWCP focuses on the conservation and management of wetlands in India. It aims to identify and conserve important wetland ecosystems, restore degraded wetlands, and promote sustainable use of wetland resources. The program emphasizes community participation and collaboration among relevant stakeholders.
- **Compensatory Afforestation Fund Act (CAFA):** The CAFA, enacted in 2016, provides a mechanism for the utilization of funds collected as compensation for diversion of forest land. The funds are used for afforestation, reforestation, and biodiversity conservation activities to compensate for the loss of forest ecosystems.
- **National Mission for Himalayan Studies (NMHS):** The NMHS focuses on research, capacity building, and conservation of the fragile Himalayan ecosystem. It aims to promote sustainable development practices, protect biodiversity, and address the ecological challenges faced by the Himalayan region.
- **The National Wetland Conservation Programme (NWCP):** The NWCP is a program that is responsible for the conservation of wetlands in India.
- **The National Afforestation and Eco-Restoration Programme (NAERP):** The NAERP is a program that is responsible for the afforestation and restoration of degraded ecosystems in India.
- **Coastal and Marine Ecosystem Conservation:** India has coastal and marine ecosystems that support diverse marine life and provide essential services. The government has implemented measures to conserve coastal and marine ecosystems, including the establishment of marine protected areas, coral reef conservation programs, mangrove restoration, and sustainable fishing practices.
- **Invasive Species Management:** Invasive species pose a threat to native biodiversity and ecosystems. The government has policies and programs in place to monitor and manage invasive species. Efforts are focused on preventing the introduction of invasive species, controlling their spread, and restoring ecosystems affected by invasions.
- **National Biodiversity Authority's Biodiversity Heritage Sites:** The National Biodiversity Authority (NBA) has been designating Biodiversity Heritage Sites (BHS) to conserve areas of significant ecological importance. These sites showcase unique biodiversity and cultural heritage. NBA has designated several BHS across the country, including sacred groves, wetlands, and forests, ensuring their protection and sustainable use.
- **India's Intended Nationally Determined Contributions (INDC):** India's INDC under the United Nations Framework Convention on Climate Change (UNFCCC) includes commitments to promote sustainable land use practices, enhance forest cover, and preserve biodiversity. These commitments highlight the importance of biodiversity and ecosystem preservation in achieving climate resilience and sustainability.
- **Eco-Sensitive Zone Notifications:** The government has been issuing eco-sensitive zone notifications around protected areas to regulate activities that could impact biodiversity and ecosystems. These notifications aim to balance conservation needs with the sustainable use of resources in buffer zones around protected areas, ensuring ecological integrity and minimizing human-wildlife conflicts.
- **Urban Greening Initiatives:** Many cities in India have launched urban greening initiatives to enhance biodiversity and ecosystem services in urban areas. Projects include the development of urban parks, rooftop gardens, tree planting drives, and biodiversity conservation in urban landscapes. These initiatives promote green infrastructure, ecological connectivity, and urban biodiversity conservation.
- **Conservation of Endangered Species:** The Indian government has implemented various measures to protect endangered species and their habitats. For example, projects like Project Tiger and Project Elephant focus on

conserving these flagship species and their ecosystems. Efforts are also underway to conserve other endangered species, such as the Indian rhinoceros, snow leopard, and Great Indian Bustard.

- **Community-Based Conservation:** India has been promoting community-based conservation initiatives that involve local communities in biodiversity conservation and sustainable resource management. These initiatives recognize the role of indigenous communities and local stakeholders in preserving biodiversity and ecosystem services. Community reserves and conservation reserves are established to promote participatory conservation and sustainable livelihoods.
- **Ecosystem-Based Adaptation Projects:** The government is implementing ecosystem-based adaptation projects to enhance ecosystem resilience and climate change adaptation. These projects include landscape restoration, afforestation, and sustainable land management practices. They aim to strengthen ecosystem services and build the capacity of ecosystems to withstand climate change impacts.
- **International Conservation Collaborations:** India collaborates with international organizations and countries on biodiversity conservation and ecosystem preservation. Partnerships with organizations like the United Nations Development Programme (UNDP), Global Environment Facility (GEF), and Convention on Biological Diversity (CBD) facilitate knowledge exchange, capacity building, and financial support for conservation efforts.

As per the World Resource Institute, the country will require an investment of around Rs. 16,871.4[22] billion for the period 2015-2030 for adaption and resilience.

According to the UN Framework Convention on Climate Change (UNFCCC) Adaptation Committee's synthesis report on efforts of developing countries in assessing and meeting the costs of adaption, the following estimates were collated.

Table 47: Potential developing countries adaptation finance needs for 2021-2030 period:

Region	Annual adaptation finance needs in USD billion	
	Median	Min-Max
East Asia & Pacific	69	27-208
South Asia	59	23-177
Sub-Saharan Africa	36	14-109
Latin America & Caribbean	21	8-62
Middle East & North Africa	15	6-44
Europe & Central Asia	4	1-11
Global	**202**	**79-612**

Source: UN Environment Programme, CareEdge Research

The estimates indicate total adaptation finance needs for all developing countries in the range of USD 79 billion to USD 612 billion per year with a median estimate of USD 202 billion for the year 2021-2030 period.

5.12 Transition Fuels

Transition fuels like Compressed Natural Gas (CNG) play a role in the decarbonization of transportation by providing a cleaner alternative to conventional fossil fuels. CNG serves as a transition fuel in the decarbonization of transportation by offering cleaner burning and lower-emission characteristics compared to conventional fuels. One advantage of CNG as a transition fuel is the availability of existing infrastructure for its production, distribution, and refuelling. Many countries already have a network of CNG refuelling stations, making it a viable option for areas where other alternative fuel

[22] Exchange Rate 1 USD= Rs. 81.9 as on 25th July 2023

infrastructures are still developing. Government initiatives like tax incentives, subsidies for CNG vehicle purchases, or regulations that encourage the use of CNG in public transportation or commercial fleets.

While CNG offers certain advantages as a transition fuel, it is important to consider its limitations. It still produces emissions of greenhouse gases, such as methane. Methane is a potent greenhouse gas that is more effective at trapping heat than carbon dioxide. CNG vehicles typically have a shorter range compared to gasoline or diesel vehicles, and the refuelling infrastructure may be limited in some regions. Additionally, CNG is still a fossil fuel and does not eliminate carbon emissions entirely.

- The Indian government has set a target of increasing the share of CNG in the country's energy mix to 15% by 2030. This target is part of the government's broader plan to reduce the country's reliance on fossil fuels and transition to a cleaner energy future.
- India has been actively expanding its CNG infrastructure to promote the use of CNG as a transition fuel. This includes building new CNG refuelling stations across tier 2 and tier 3 cities, highways, and industrial areas and expanding the existing network of CNG pipelines.
- The demand for CNG vehicles in India is growing rapidly. In 2022, India registered over 4.5 million CNG vehicles, a growth of over 20% from the previous year. The automotive industry in India is also investing in CNG vehicles. A number of major automakers, such as Maruti Suzuki, Hyundai, and Tata Motors, have launched CNG-powered models in recent years.
- The adoption of CNG in public transportation has been a key focus in India. Many state transport corporations and municipalities are transitioning their bus fleets to run on CNG. Commercial fleets, such as taxis and delivery vehicles, are increasingly adopting CNG as a fuel option. Many ride-hailing platforms and logistics companies are incentivizing CNG vehicle adoption to reduce emissions from their fleets.
- India is exploring the utilization of biogas as a feedstock for producing CNG. This approach reduces the carbon footprint of CNG and aligns with India's goals of promoting clean and sustainable energy sources.

5.13 Green Infrastructure

The importance of green infrastructure in India stems from its capacity to effectively tackle environmental challenges, bolster ecological resilience, and foster sustainable development. Green infrastructure initiatives have a profound impact on climate change adaptation and mitigation, biodiversity conservation, water resource management, and the overall enhancement of community well-being. By establishing robust policy frameworks, facilitating collaborations among government entities, communities, and stakeholders, and integrating green infrastructure principles into urban and rural planning, India can unlock the full potential of green infrastructure in building a more sustainable and resilient future.

5.13.1 Green Buildings, warehouses, data centres, cooling centres

Green Buildings: Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from design, construction, operation, maintenance, renovation and deconstruction. It uses less water, optimizes energy efficiency, generates less waste and provides a healthier and sustainable space for occupants. Green buildings in India are meticulously designed to mitigate environmental impact and optimize the efficient utilization of resources. They integrate energy-efficient systems, sustainable materials, effective water management techniques, and renewable energy sources.

The Indian government has implemented several initiatives to support the development of green buildings. Notably, schemes like the Leadership in Energy and Environmental Design (LEED) certification and the Green Rating for Integrated Habitat Assessment (GRIHA) system have been introduced. These programs serve as comprehensive frameworks that establish guidelines and standards for sustainable building design, construction, and operation. By adhering to these guidelines, developers and individuals can ensure that their buildings meet the desired environmental performance criteria.

India ranked 2nd in the U.S. Green Building Council's (USGBC) list of the Top 10 Countries and Regions for LEED certification in the year 2022 behind China.

Green Warehousing: Green warehousing is concept of using sustainable practices in warehousing operations to reduce its carbon footprint. These practices include green building, automated warehouse, lean warehousing etc.

The Indian government has taken significant steps to support energy efficiency and sustainable logistics management in warehouses. These measures involve the implementation of various initiatives and policies aimed at promoting environmentally friendly practices in warehouse operations.

To encourage energy efficiency, the government provides financial assistance and incentives to warehouse operators for adopting energy-efficient technologies. These technologies include efficient lighting systems, insulation, and energy management systems that help optimize energy consumption and reduce greenhouse gas emissions.

In addition to energy efficiency, the government promotes the establishment of logistics parks with green infrastructure. These parks are designed to incorporate sustainable features such as rainwater harvesting systems, renewable energy generation, and waste management facilities. By creating such infrastructure, the government aims to reduce the environmental impact of warehouse operations and encourage the adoption of sustainable practices.

Furthermore, the government emphasizes the use of eco-friendly transportation modes, such as electric vehicles and alternative fuel vehicles, for logistics activities. It also encourages the optimization of supply chain operations to minimize carbon emissions and promote efficient transportation and distribution practices.

Indian Green Building Council (IGBC), part of the Confederation of Indian Industry (CII), has also developed a pilot version – 'IGBC Green Logistics Parks and Warehouses Rating System'.

Green Data Centers: Green data centers in India prioritize the reduction of energy consumption and carbon emissions associated with data storage and processing activities. These data centers incorporate state-of-the-art cooling systems, energy-efficient server infrastructure, virtualization technologies, and the integration of renewable energy sources. By adopting these sustainable practices, green data centers effectively mitigate the environmental impact associated with data operations, while ensuring reliable and efficient functioning of digital services.

The Indian government has taken proactive measures to promote energy efficiency in the data center sector. Recognizing the significant energy consumption associated with data centers, the Ministry of Electronics and Information Technology has published the "India Data Center Energy Efficiency Guidelines." These guidelines serve as a comprehensive framework to assist data center operators in adopting energy-efficient practices.

The guidelines provide recommendations and best practices for optimizing energy consumption throughout the data center lifecycle, including aspects such as power distribution, cooling systems, server utilization, and lighting. By following these guidelines, data center operators can significantly reduce energy consumption and enhance overall energy efficiency.

Green Cooling Centers: The Ministry of Environment, Forest and Climate Change launched the India Cooling Action Plan (ICAP) in March 2019 with an aim to provide sustainable cooling and thermal comfort for all while securing environmental and socio-economic benefits for the society. This will also help in reducing both direct and indirect emissions.

ICAP seeks to (i) reduce cooling demand across sectors by 20% to 25% by 2037-38, (ii) reduce refrigerant demand by 25% to 30% by 2037-38, (iii) Reduce cooling energy requirements by 25% to 40% by 2037-38, (iv) recognize cooling and related areas as a thrust area of research under national Science & Technology Programme, (v) training and

certification of 100,000 servicing sector technicians by 2022-23, synergizing with Skill India Mission. These actions will have significant climate benefits.

5.13.2 Green Transport

Green transport, comprising of intercity rail, metros, buses, and other sustainable modes of transportation, plays a crucial role in India's pursuit of sustainable development and environmental conservation. With the aim of reducing greenhouse gas emissions, minimizing air pollution, and enhancing urban mobility, the country has been actively implementing and expanding green transport systems.

Intercity Rail: India's intercity rail network, comprising both conventional and high-speed rail systems, holds significant importance as a green transport infrastructure. The integration of electric locomotives and the adoption of renewable energy sources for rail operations play a pivotal role in curbing carbon emissions. Moreover, the emphasis on efficient scheduling, enhanced connectivity, and improved passenger comfort in intercity trains promotes the adoption of sustainable travel options, leading to a reduction in private vehicle usage and alleviating road congestion.

Metros: The rapid expansion of metro rail systems in India's major cities has established them as a prominent and sustainable mode of urban transportation. Powered by electricity, metros significantly reduce emissions compared to conventional transport modes. With dedicated tracks and efficient signalling systems, metros provide commuters with faster and more reliable journeys, encouraging the adoption of eco-friendly transportation alternatives. As on April 2023, 860 Km of metro lines were operational across 20 cities in India. Further, the government has introduced Metro Rail Policy in 2017 to create enabling environment for metro rail system in India. Under the Make in India initiatives, metro rail coaches are now being manufactured in India, which has reduced dependence on imports.

Buses: Public bus transportation, encompassing both intracity and intercity routes, serves as a crucial catalyst for sustainable mobility in India. The deployment of compressed natural gas (CNG) and electric buses plays a vital role in curbing air pollution and lowering carbon emissions. Additionally, the implementation of dedicated bus lanes, intelligent transport systems, and user-friendly ticketing systems enhances the efficiency, reliability, and accessibility of bus services. By offering affordable and eco-friendly transportation alternatives, buses effectively reduce the reliance on private vehicles and alleviate traffic congestion, thereby improving air quality and fostering a more liveable urban environment.

Despite the advancements in promoting green transport, several challenges persist that need to be addressed. These challenges include inadequate infrastructure, limited integration between different modes of transport, and financial constraints. However, these challenges also present opportunities for innovation and collaboration. The development of sustainable transport infrastructure, such as the establishment of charging stations for electric vehicles and the creation of integrated transport hubs, can facilitate the widespread adoption of green transport. Furthermore, public-private partnerships, innovative financing models, and technological advancements offer potential solutions to overcome financial constraints and improve the efficiency and effectiveness of green transport systems.

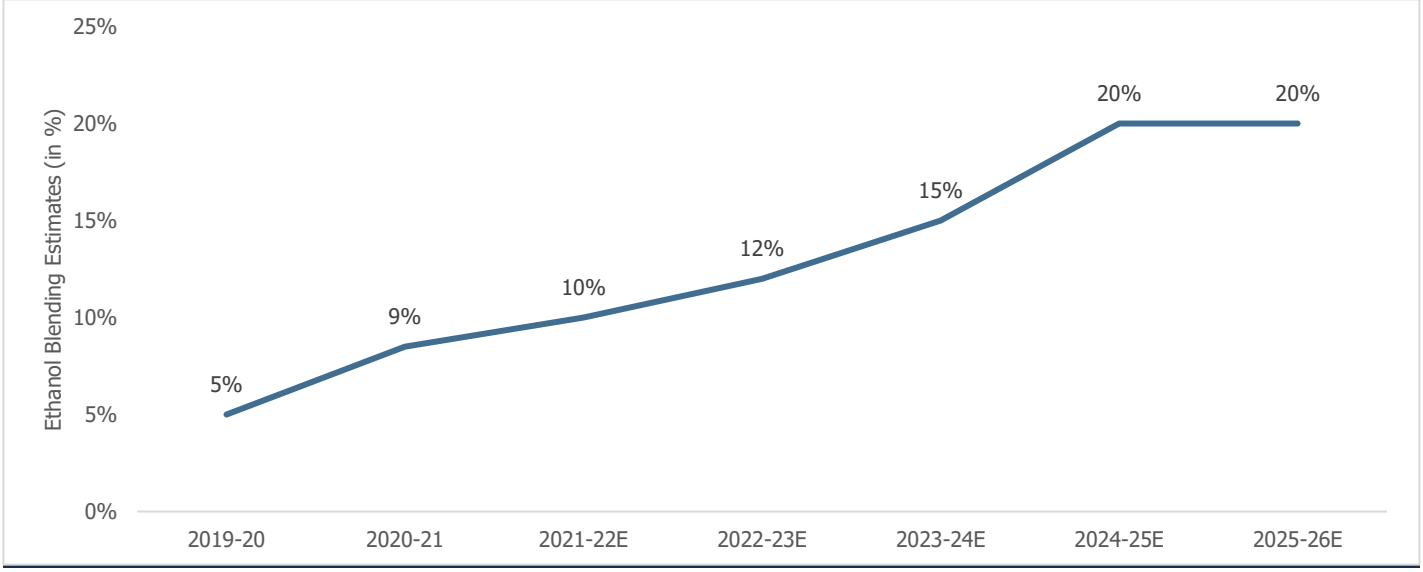
5.14 Ethanol

Ethanol is a type of biofuel derived from renewable sources such as corn, sugarcane, switchgrass, and agricultural waste. This fuel is often blended with gasoline to create ethanol-gasoline blends such as E10 (10% ethanol) or E85 (85% ethanol). These blends can be used in conventional gasoline engines or flex-fuel vehicles designed to run on higher ethanol concentrations. It offers potential benefits such as reducing dependence on fossil fuels, lowering greenhouse gas emissions, and supporting agricultural economies.

However, there are also some challenges that ethanol faces. Ethanol production involves land use, water consumption, and potential competition with food crops. Balancing these factors and ensuring sustainable sourcing of feedstocks is crucial. Another challenge is that ethanol is not as widely available as gasoline. This could make it difficult for vehicle owners to find ethanol stations, especially in rural areas.

The energy demand in our country is rising due to an expanding economy, growing population, increasing urbanization, evolving lifestyles and rising spending power. The government has advanced the target date for ethanol blended petrol from 2030 to 2025 for 20% ethanol blending to decrease the oil import burden. As per NITI Aayog, India will produce 6,660 Bn litres of ethanol/ alcohol from food grains by 2025-26, about 165 LMT of food grains would be utilized. The Ethanol Supply Year (ESY) commences from 1st December and ends on 30th November. Supply of ethanol under the EBP Programme has increased from 1,886 Bn litres in ESY 2018-19 to 4,081 Bn litres in ESY 2021-2022. Additionally, average percentage of blending has increased from 5% to 10% in the same period. The ethanol demand will be in the range of 7,220-9,210 Bn litres in 2025 to meet E20 targets. Mixing 20% ethanol in petrol can potentially reduce the auto fuel import bill by a yearly $4 billion.

Chart 83: Ethanol Production Projections



Source: Niti Aayog – Ethanol Blending in India

Some of the latest developments of ethanol in India are as below:

- **Ethanol research and development:** In June 2023, the government of India announced that it will invest Rs. 40,950[23] million in research and development for ethanol production. The investment will be used to develop new technologies for ethanol production, such as the use of non-food crops and waste materials.
- **Ethanol production capacity expansion:** In April 2023, the government of India announced that it will increase the blending of ethanol in petrol from 10% to 20% by 2025. This blending program is known as E20, and it is expected to help reduce India's oil imports by 1.2 billion litres per year. India is witnessing an expansion of ethanol production capacity to meet the growing demand. Sugar mills, in particular, are investing in distillery units to produce ethanol from sugarcane molasses. The government has also allowed the production of ethanol from surplus food grains, rice, maize, and other feedstocks, further enhancing the production potential.
- **Increased Ethanol Blending Targets:** The Indian government has been actively increasing the blending targets for ethanol in gasoline. In 2021, the blending target was raised to 10% (E10) from the previous target of 5% (E5). Additionally, the government has set a roadmap to achieve a 20% (E20) ethanol blending target by 2025.

[23] Exchange Rate 1 USD= Rs. 81.9 as on 25th July 2023

- **Ethanol Procurement and Pricing Reforms:** The Indian government has introduced reforms in the ethanol procurement and pricing mechanism to provide better remuneration to ethanol producers. The pricing formula has been revised, linking it to the prevailing price of sugarcane juice, B-heavy molasses, and other feedstocks. This move aims to incentivize ethanol production and support the agricultural sector.
- **Ethanol for Cooking Fuel:** In a recent development, the government has also encouraged the use of ethanol as a cooking fuel. Ethanol-blended cooking stoves have been introduced in select regions as a cleaner and more sustainable alternative to traditional cooking fuels like LPG and biomass.

Government Policies

The government has taken steps to promote the development of the EV and ethanol industries through research and development initiatives. The government has set up a number of research institutes and laboratories to focus on developing new technologies for EVs and ethanol production. The government is also providing funding to companies that are developing new EV and ethanol technologies. Here are some key government policies related to ethanol in India:

Some of the government policies are: -

- **The Ethanol Blended Petrol (EBP) Programme:** This program mandates the blending of ethanol with petrol at a minimum of 10%. The EBP mandates the blending of ethanol with gasoline to reduce carbon emissions. Currently, the blending target of the government is to achieve a 20% ethanol blending ratio (E20) by 2025.
- **The Interest Subvention Scheme**: This scheme is for the enhancement and augmentation of the ethanol production capacity: This scheme provides financial assistance to ethanol producers to help them expand their production capacity.
- **Flex-Fuel Vehicles:** The government has encouraged the manufacturing and adoption of flex-fuel vehicles that can run on different ethanol-gasoline blends. Incentives and concessions have been provided to promote the production and sales of such vehicles.

Risk Perspective

Ethanol has several advantages over gasoline, including its lower emissions and its ability to reduce dependence on imported oil. However, there are also some risks associated with ethanol use. The Indian government has set ethanol blending targets to promote the use of ethanol in the transport sector. However, meeting these targets may be challenging due to various factors, including feedstock availability, technical challenges, and economic considerations. Ethanol has a lower energy content than gasoline, so it can reduce fuel efficiency by up to 10%. Therefore, the vehicles that run on ethanol will need to be refuelled more often. Ethanol-blended fuels are relatively new in India, and consumer acceptance and awareness play a crucial role in their adoption. Ethanol can also damage some plastic, rubber, and aluminium components in engines. This is because ethanol is a hygroscopic material, which means that it absorbs water. The water can corrode these components and reduce the lifespan of the engine. In addition to that, the supply of ethanol can be disrupted by factors such as drought and crop failures. This could lead to shortages of ethanol, which could drive up prices and make it difficult for people to access this fuel. Also, the primary feedstock for ethanol production in India is sugarcane molasses, which is also used for sugar production. Competing demands for molasses could lead to supply constraints and price fluctuations, affecting ethanol production volumes. The production of ethanol can have a negative impact on the environment. The use of fertilizers and pesticides in sugarcane cultivation can pollute water bodies. Additionally, the burning of sugarcane residue can release greenhouse gases into the atmosphere. The price of ethanol is subject to market forces, including demand and supply dynamics, as well as government policies and regulations. Fluctuations in ethanol prices can impact the profitability of ethanol producers and create uncertainty in the market. The ongoing efforts and continuous monitoring by the Government are essential to effectively manage the risks associated with ethanol and make it a viable and sustainable alternative in India's energy mix.

5.15 Decarbonization Efforts by Other Industries

Industry	Decarbonisation Efforts
Power	• Adoption of ultra-super critical/ super-critical technology in thermal generation Ultra-supercritical & Supercritical units are designed with higher steam parameters of 280 kg/cm2 at 600/600°C and 247kg/cm2 at 565/593 °C, respectively. With the higher steam parameters of ultra-super critical/ supercritical units, the efficiency of these ultra-supercritical and supercritical units would be 9% and 5%, respectively, higher than the efficiency of present typical 500 MW sub-critical units. This would lead to corresponding savings in coal consumption and reduction in GHG emissions. In future, coal-based capacity addition would be mainly through ultra-super critical / supercritical units. Higher size units of 660-800 MW based on ultra-super critical/ supercritical technology will not only accelerate pace of capacity addition but will have lesser impact on environment due to lower CO2 & SOx emissions per unit of electricity generated. Emissions of other pollutants like NOx & SPM would also reduce with adoption of latest technologies of low NOx burners, efficient ESPs etc. Higher efficiency, besides leading to corresponding savings in coal consumption, would also lead to lower ash generation. The land requirement for ash dump areas would also correspondingly reduce and there would be reduction in auxiliary power consumption. • Renovation and Modernization (R&M) & Life Extension (LE) of existing old power stations R&M and LE works of Thermal capacity of 16,146 MW and 7202MW have been completed in 11th Plan and 12th Plan period respectively. During the years 2017-22 R&M and LE works of Thermal capacity of 14,929 MW has been considered. The R&M and LE/uprating works of Hydro capacity of 5841 MW,4149 MW and 2023 MW have been completed in 11th Plan,12th Plan and during the years 2017-22 respectively. During the years 2022-27 renovation, modernization, uprating and life extension works of Hydro Power plants of capacity of 11737 MW (tentative) are planned.
Steel	The Ministry of Steel has taken a commitment to achieve net zero by 2070 and has taken a medium-term target to reduce the emission intensity of the steel sector to 2.4 T/TCS[24] by 2030 from 2.55 T/TCS currently. Various measures as listed below, have been taken towards this target. • Steel Scrap Recycling Policy, 2019 has been introduced to enhance the availability of domestically generated scrap to reduce the consumption of coal in steel making.

[24] Tonne of CO2 equivalent per tonne of crude steel

	• The steel sector has also been made a stakeholder in the National Green Hydrogen Mission for green hydrogen production and usage which has been announced by the Ministry of New and Renewable Energy (MNRE). • Motor Vehicles (Registration and Functions of Vehicles Scrapping Facility) Rules September 2021, shall increase availability of scrap in the steel sector. • National Solar Mission launched by MNRE in January 2010 promotes the use of solar energy and also helps reduce the emission of the steel industry. • Perform, Achieve and Trade (PAT) scheme, under National Mission for Enhanced Energy Efficiency, incentivizes the steel industry to reduce energy consumption. • The steel sector has adopted the Best Available Technologies (BAT) available globally, in the modernization and expansion projects. • Japan's New Energy and Industrial Technology Development Organization (NEDO) Model Projects for Energy Efficiency Improvement have been implemented in steel plants. Since the average age of a majority of the large plants is low, it is not cost-effective for the industry to immediately move to more climate-friendly technologies. Accordingly, the steel industry is exploring multiple avenues to reduce the CO_2 emission from the existing manufacturing processes including waste hear recovery, pulverised coal injection in blast furnace process, suitable use of by-products, usage of steel scrap etc. Further, research and development are being undertaken globally on green steel (steel produced using green hydrogen) and use of CCUS. The concept of green steel is at a nascent stage in India with some of the large players having set up pilot plants to determine commercial viability. Kalyani Group, under its subsidiary Saarloha Advanced Materials, launched India's first green steel in December 2022 which is being produced at its electric arc furnace located at its plant in Pune using renewable energy. In April 2023, Tata Steel initiated trials of injecting large quantities of hydrogen gas in the blast furnace located at its Jamshedpur plant to assess the viability of hydrogen in the production process and its impact on the reduction of carbon emissions. In September 2021, Tata Steel commissioned a pilot 5 tonne per day carbon capture plant at its Jamshedpur steel plant. Jindal Steel Works (JSW) has implemented a carbon capture and storage facility with 100 tonne per day capacity at its DRI plant at Dolvi. The captured carbon is to be utilized in the food and beverages industry.
Fertilizers	Integrated fertilizer plants produce urea by reacting ammonia and CO_2. The fertilizer industry can achieve decarbonisation through adoption of green hydrogen and green ammonia.

Green ammonia is the process of making ammonia which is 100% renewable and caron-free. For this process, hydrogen is extracted from water through electroysis (green hydrogen) using renewable energy and nitrogen is separated from the air. These are then fed into the Haber Process where hydrogen and nitrogen are reacted together at high temperatures and pressures to produce ammonia.

Multiple technology providers are working to improve green ammonia technology. Nanjing Kapsom Energy Limited, a company specializing in design, engineering, and construction of chemical plants, has developed the World's First Green Ammonia Plant in Bikaner, Rajasthan.

The Ministry of Power notified the Green Hydrogen/Green Ammonia Policy in February 2022. The policy provides for the following:

- Green hydrogen / ammonia manufacturers may purchase renewable power from the power exchange or set up renewable energy capacity themselves or through any other, developer, anywhere.
- Open access will be granted within 15 days of receipt of application.
- The green hydrogen / ammonia manufacturer can bank their unconsumed renewable power, up to 30 days, with distribution company and take it back when required.
- Distribution licensees can also procure and supply renewable energy to the manufacturers of green hydrogen / green ammonia in their States at concessional prices which will only include the cost of procurement, wheeling charges and a small margin as determined by the State Commission.
- Waiver of inter-state transmission charges for a period of 25 years will be allowed to the manufacturers of green hydrogen and green ammonia for the projects commissioned before 30th June 2025.
- The manufacturers of green hydrogen / ammonia and the renewable energy plant shall be given connectivity to the grid on priority basis to avoid any procedural delays.
- The benefit of RPO will be granted incentive to the hydrogen/ammonia manufacturer and the distribution licensee for consumption of renewable power.
- To ensure ease of doing business a single portal for carrying out all the activities including statutory clearances in a time bound manner will be set up by MNRE.
- Connectivity, at the generation end and the green hydrogen / green ammonia manufacturing end, to the ISTS for Renewable Energy capacity set up for the

	purpose of manufacturing Green Hydrogen / Green Ammonia shall be granted on priority. • Manufacturers of green hydrogen / green ammonia shall be allowed to set up bunkers near ports for storage of green ammonia for export / use by shipping. The land for the storage for this purpose shall be provided by the respective Port Authorities at applicable charges.
Cement (Source: Cement Manufacturers Association)	The India Cement Industry has voluntarily devised a Low Carbon Technology Roadmap aimed at reducing its direct CO_2 emission intensity by 45% till 2050 from a 2010 baseline. Over the years, the industry has developed blended types of cement to the extent of 73% in 2017 compared to 28% in 1992. The industry has adopted best available technologies and processes to stay efficient and sustainable. Several players in the industry have also undertaken research and development on green technologies/products. Some of the key focus areas of the industry to reduce emissions are as below: • Energy Efficiency: The industry has utilized best available technologies and processes with focus on improving kiln and electricity efficiency. • Shift from Conventional to Alternative Fuels: Cement making is an energy intensive process predominantly reliant on conventional fuels. The Indian Cement Industry has successfully managed to substitute 4% of its fuel needs with alternative fuels derived after segregation, treatment and processing of municipal and industrial waste. The share of alternative fuels has gradually grown from 0.6% in 2010 to 4% in 2017. • Clinker Substitution: The industry has reduced its requirement of intermediate product clinker (made from limestone) by use of blended cement, which has resulted in mineral conservation. Indian manufacturers have been able to deliver almost 73% of their products in the form of blended cement. • Novel Cement: Novel cement has lesser dependency on limestone/clinker though process modification, and has significant potential for reduction of emissions. This variant is at R&D stage globally.
Oil and Gas	The Government of India has taken multiple initiatives towards energy transition in the upstream, midstream and downstream sectors in the oil and gas industry. • Gas pricing reforms have been brought in to encourage natural gas production in the country. The Administered Pricing Mechanism (APM), which was earlier linked to global gas prices and was determines on a semi-annual basis, is now determined monthly at 10% of the average Indian Crude Basket Prices, with a ceiling (USD 6.5/MMBTU) and floor (USD 4/MMBTU). The ceiling will remain the same for the first two years and then increase by USD 0.25/MMBTU every year, to adjust for any cost inflation. This measure will reduce sharp fluctuations in the prices of gas delivered to the consumers and will also ensure adequate compensation to the gas E&P companies. • The government has identified four drivers for clean and green energy:

	○ Diversification of supplies ○ Increase of alternate energy sources like Biofuels, Ethanol, CBG and Surya Nutan ○ Increasing E&P footprint ○ Advancing towards energy targets through EVs and green hydrogen • Following initiatives have been taken by oil refining and marketing companies towards decarbonisation: ○ Indian Oil Corporation of India (IOCL) has resolved to achieve net zero operational emission by 2046 by reducing both scope 1 and scope 2 emissions. An investment of Rs 2,000 billion is proposed to achieve this target through multiple initiatives including green hydrogen, biofuels, renewables, carbon offsetting through ecosystem restoration and CCUS. ○ Bharat Petroleum Corporation of India (BPCL) is targeting to achieve net zero by 2040. Further, it plans to boost its renewable energy portfolio to 1 GW by 2025 and 10 GW by 2040. It is also building fast charging corridors along the highways. ○ Hindustan Petroleum Corporation of India (HPCL) has set net zero targets for scope 1 and scope 2 emissions by 2040. HPCL aims to have a green hydrogen capacity of 24,000 tonnes a year, and is expecting to commission a 370-tonne per year green hydrogen plant at its Vizag refinery in 2023. ○ Reliance Industries Limited (RIL) is targeting to achieve net zero by 2020 and has announced capex of Rs 750 billion to build and end-to-end green energy ecosystem. RIL has started developing the Dhirubhai Ambani Green Energy Giga Complex on 5,000 acres in Jamnagar, Gujarat. It is planned to be among the world's largest Integrated Renewable Energy manufacturing facilities. Under the plan, the Company aims to build four giga factories to manufacture and integrate critical components of the New Energy ecosystem with the aim of bridging the green energy divide in India and globally. Reliance aims to invest in giga factories in Solar, Battery, and Hydrogen value chains.

5.16 Decarbonization Efforts by Other Countries

Industry	Decarbonisation Efforts
United States	The United States has taken a target of achieving 50-52% reduction in greenhouse gas pollution by 2030 from 2005 levels and net-zero greenhouse gas emissions by no later than 2050 and of limiting global warming to 1.5 degrees Celsius. It has also set a goal to achieve 100% carbon pollution-free electricity by 2035. The US Department of Energy has identified four pathways to reduce industrial emission. • Energy efficiency ○ Strategic energy management approaches to optimize performance of industrial processes at the system-level

	○ Systems management and optimization of thermal heat from manufacturing process heating, boiler, and combined heat and power (CHP) sources ○ Smart manufacturing and advanced data analytics to increase energy productivity in manufacturing processes • Industrial electrification ○ Electrification of process heat using induction, radiative heating, or advanced heat pumps ○ Electrification of high-temperature range processes such as those found in iron, steel, and cement making ○ Replacing thermally-driven processes with electrochemical ones • Low-Carbon Fuels, Feedstocks, and Energy Sources (LCFFES) ○ Development of fuel-flexible processes ○ Integration of hydrogen fuels and feedstocks into industrial applications ○ The use of biofuels and bio feedstocks • Carbon Capture, Utilization, and Storage (CCUS) ○ Post-combustion chemical absorption of CO_2 ○ Development and manufacturing optimization of advanced CO_2 capture materials that improve efficiency and lower cost of capture ○ Development of processes to utilize captured CO_2 to manufacture new materials The US has also identified the sector-specific initiatives that can be taken by high emission intensity sectors such as cement, petroleum refining, iron and steel, chemicals and food and beverages, to achieve net zero.
European Union	European Union has adopted target of reducing net greenhouse gas emissions at least 55% by 2030 from 2005 levels and makes climate neutrality legally binding by 2050. The EU adopted world's first emission trading system called the EU Emission Trading System (EU ETS) in 2005. The EU ETS works on a 'cap and trade' principle wherein a cap is set on the total greenhouse gases that can be emitted by all operators in the system, which reduces over time so that the emission can reduce. The operators receive emission allowances within the cap which are either consumed or traded. The EU ETS covers the following sectors and gases, focusing on emissions that can be measured, reported and verified with a high level of accuracy: • Carbon dioxide from: ○ electricity and heat generation, ○ energy-intensive industry sectors, including oil refineries, steel works, and production of iron, aluminium, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals, ○ aviation within the European Economic Area and departing flights to Switzerland and the United Kingdom; ○ maritime transport

	• nitrous oxide from production of nitric, adipic and glyoxylic acids and glyoxal; • perfluorocarbons from the production of aluminium. EU ETS limits emissions from around 10,000 installations in the energy sector and manufacturing industry, as well as aircraft operators operating between these countries and departing to Switzerland and the United Kingdom. It covers around 40% of the EU's greenhouse gas emissions. As per World Bank, greenhouse gas emissions in the EU fell by 32% between 1990 to 2020 across energy and manufacturing sectors. However, emissions from transport sector increased by 7% during this period. The EU proposes to achieve its carbon emission targets through following initiatives: • Cutting emission from transport: Emission from civil aviation, cars and vans, which accounts for over 28% of EU emissions, is proposed to be reduced with car and vans targeted to achieve net-zero by 2035. • Increasing renewable energy: The share of renewable energy is proposed to be increased from 20% in December 2022 to 42.5% by 2030 by speeding up permits for renewable energy plants, boosting renewable hydrogen and offshore renewable sources beyond wind, such as wave power. EU funding for natural gas infrastructure projects is being phased out and the money redirected to hydrogen and offshore renewable energy infrastructures. • Carbon pricing on imported goods: To avoid carbon leakage, EU proposes to operationalise Carbon Border Adjustment Mechanism by applying a carbon levy on import goods which do not adhere to specified emission standards. It will cover goods from energy-intensive industries such as iron, steel, cement, aluminium, fertilizers and hydrogen. • Carbon emission from other sectors: Sectors such as transport, agriculture, buildings and waste management are not under the purview of EU ETS. These sectors l account for about 60% of the EU's overall emissions. Emissions from these sectors are proposed to be cut 40% by 2030 compared to 2005.

6. Overview of Non-Banking Financial Institutions

6.1 Non-Banking Financial Institutions Overview

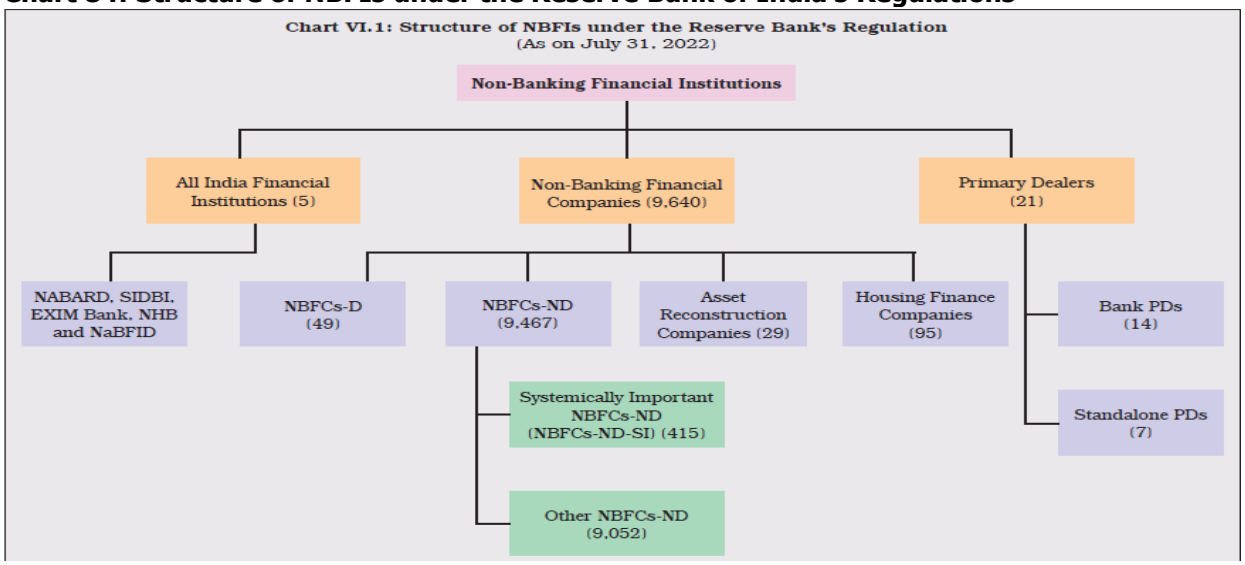
Non-banking financial institutions (NBFIs) comprise a heterogeneous group of financial intermediaries. Those under the regulatory purview of the Reserve Bank consist of

- All-India financial institutions (AIFIs) that include the National Bank for Agriculture and Rural Development (NABARD), the Export Import (EXIM) Bank of India, the Small Industries Development Bank of India (SIDBI) and the National Housing Bank (NHB) are apex financial institutions that play an important role in meeting the long-term funding requirements of agriculture and the rural sector, foreign trade, small industries, housing finance companies (HFCs), NBFCs, Micro Finance Institutions (MFIs) and other specialised segments and institutions.
- Non-banking financial institutions (NBFIs) are government/public/private limited companies that specialise in delivering credit to a wide variety of specific segments, ranging from infrastructure to consumer durables and vehicle financing. Housing finance companies (HFCs) extend housing finance to individuals, co-operative societies, and corporate bodies and lease commercial and residential premises to support housing activity in the country.
- Primary dealers (PDs) came into existence in 1995 and act as market makers in the government securities (G-secs) market, besides ensuring subscription to primary issuances.

Non-Banking Financial Institutions (NBFIs) play an important role in the Indian financial system by complementing and competing with banks, and by bringing efficiency and diversity into financial intermediation. NBFCs have evolved considerably in terms of operations, heterogeneity, asset quality and profitability, as well as regulatory architecture.

6.2 Structure of NBFIs

Chart 84: Structure of NBFIs under the Reserve Bank of India's Regulations



Source: RBI

Note: Figures in bracket indicates the number of Institutions as of July 22, NBFCs-ND – Non-deposit taking Non-banking financial companies, NBFCs-D – Deposit taking Non-banking financial companies

6.3 Classification of NBFCs

NBFCs can be classified on the basis of a) asset/liability structures; b) systemic importance; and c) the activities they undertake. In terms of liability structures, NBFCs are subdivided into deposit-taking NBFCs (NBFCs-D) - which accept and hold public deposits - and non-deposit taking NBFCs (NBFCs-ND) - which source their funding from markets and

banks. Among non-deposit taking NBFCs, those with an asset size of Rs. 5 Billion or more are classified as non-deposit taking systemically important NBFCs (NBFCs- ND-SI). As on July 31, 2022, there were 49 NBFCs-D and 415 NBFCs-ND-SI.

Since NBFCs cater to niche areas, they are also categorised on the basis of the activities they undertake. Till February 21, 2019, NBFCs were divided into 12 categories. Thereafter, these categories were harmonised in order to provide NBFCs with greater operational flexibility. As a result, asset finance companies (AFCs), loan companies (LCs) and investment companies (ICs) were merged into a new category called Investment and Credit Companies (NBFC-ICC). At present, there are 11 categories of NBFCs as per the activity-based classification.

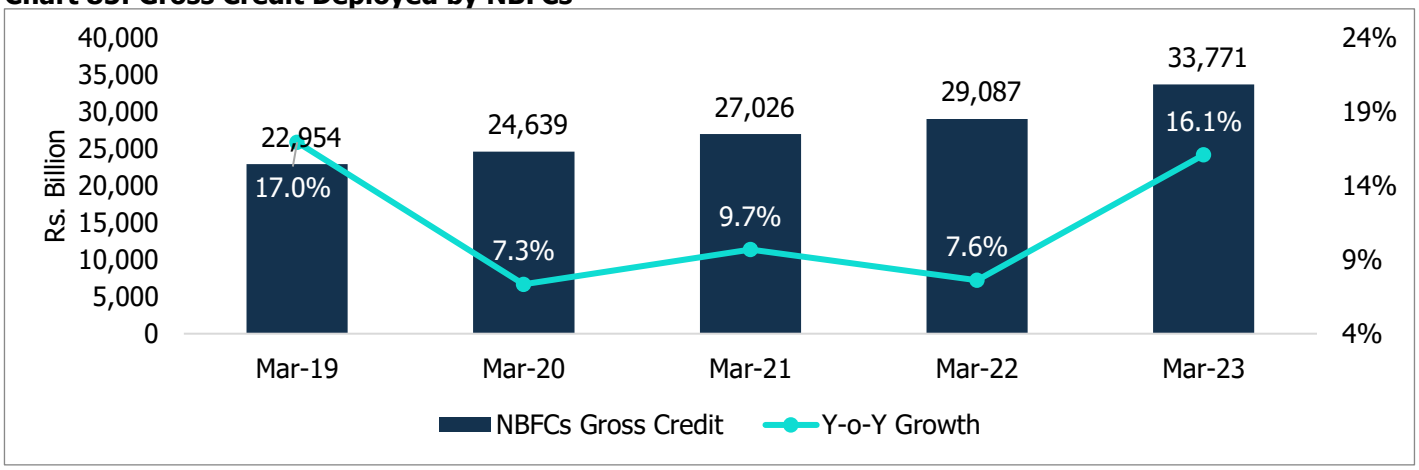
Table 48: Types of NBFCs

Type of NBFC	Activity
NBFC-Investment and Credit Company (NBFC-ICC)	Lending and investment.
NBFC-Infrastructure Finance Company (NBFC-IFC)	Financing of infrastructure sector.
Core Investment Company (CIC)	Investment in equity shares, preference shares, debt, or loans of group companies.
NBFC-Infrastructure Debt Fund (NBFC-IDF)	Facilitation of flow of long-term debt only into post commencement operations in infrastructure projects which have completed at least one year of satisfactory performance.
NBFC-Micro Finance Institution (NBFC-MFI)	Providing collateral free small ticket loans to low income households.
NBFC-Factors	Acquisition of receivables of an assignor or extending loans against the security interest of the receivables at a discount.
NBFC-Non-Operative Financial Holding Company (NBFC-NOFHC)	Facilitation of promoters/ promoter groups in setting up new banks.
NBFC-Mortgage Guarantee Company (NBFC-MGC)	Undertaking of mortgage guarantee business.
NBFC-Account Aggregator (NBFCAA)	Collecting and providing a customer's financial information in a consolidated, organized, and retrievable manner to the customer or others as specified by the customer.
NBFC–Peer to Peer Lending Platform (NBFC-P2P)	Providing an online platform to bring lenders and borrowers together to help mobilize funds.
Housing Finance Company (HFC)	Financing for purchase/ construction/ reconstruction/ renovation/ repairs of residential dwelling units.

Source: RBI, CareEdge Research

6.4 NBFC Credit Growth

Chart 85: Gross Credit Deployed by NBFCs

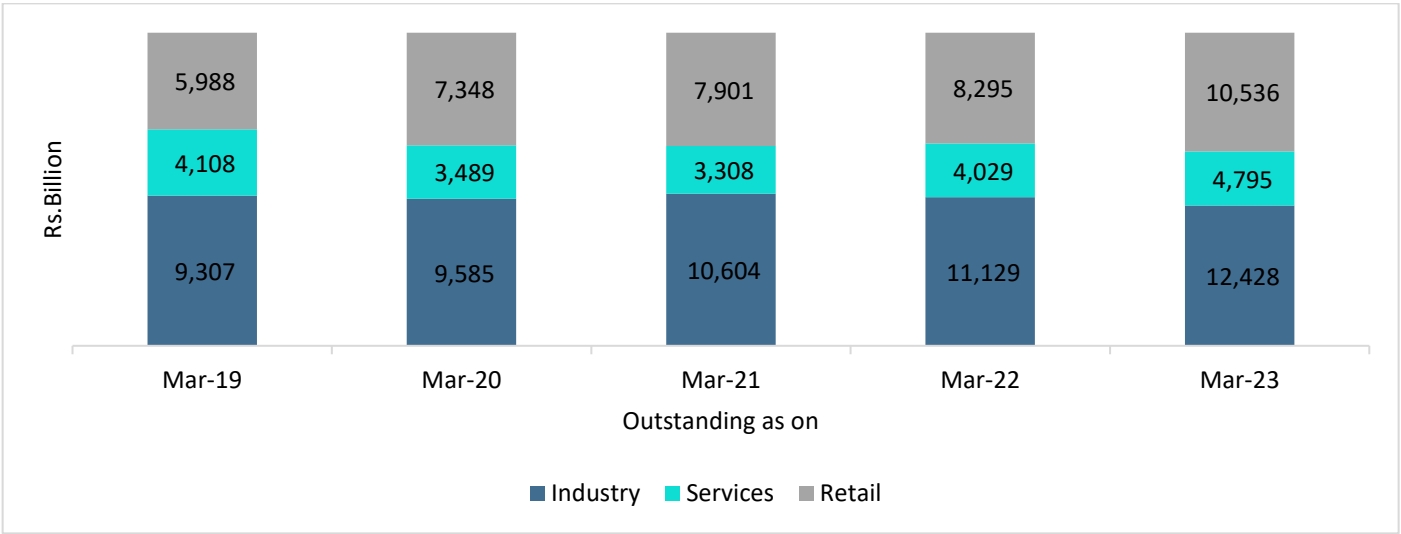


Source: RBI, CareEdge Research
Note: Data are provisional

As of Mar-23, the credit growth rate has seen an uptick of 16.1% y-o-y and reached Rs. 33,771 billion. The upward growth trajectory of NBFCs credit is indicating its importance in India's Financial System. This growth is mainly driven by increase in demand for retail credit and demand for working capital loans amid rise in commodity prices.

6.5 Sectoral Distribution of NBFC Credit

Chart 86: Sectoral distribution of NBFCs' credit



Source: RBI, CareEdge Research
Note: Others includes Food credit and Other non-food credit

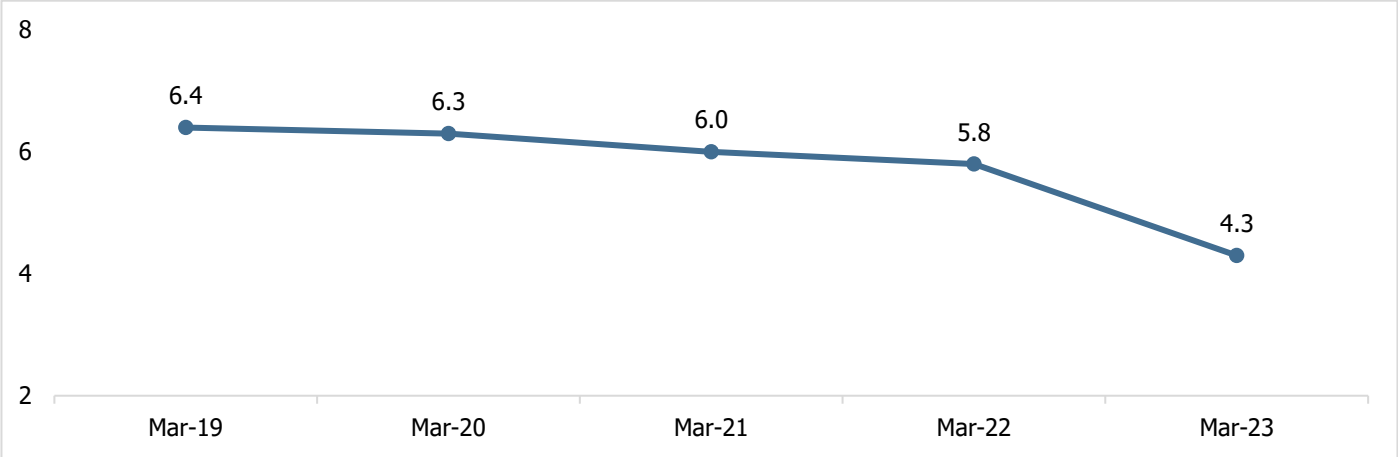
The industry sector has remained the largest recipient of credit extended by NBFCs followed by retail loans, services, other non-food credit, and agriculture & allied activities. NBFCs have increased the amount of credit deployed to industry on account of improved demand for credit mainly for working capital loans due to surge in commodity prices. As of Mar-23, industry credit contributed Rs. 12,428 billion, which is around 36.8% of NBFCs' gross credit deployed, as per the RBI.

While NBFCs' credit to the industry is growing, their credit to services has declined marginally mainly due to decline in credit to the commercial real estate sector, transport operators and other services. As of Mar-23, as per data published by RBI, credit deployed to the service sector has hovered around Rs. 4,795 billion that is around 14.2% of NBFCs gross credit deployed.

Retail loans comprise housing loans, vehicle loans, loans against gold, consumer durables loans and other such personal loans. Over the last couple of years, NBFCs have shifted their focus on retail lending in order to grow their business. And with slow demand for credit from the industry and services sector, retail lending has shown tremendous growth. As retail loans have lower delinquencies when compared to MSME / corporate lending which is also a major factor for the shift. As of Mar-23, the credit deployed to retail loans by NBFCs has increased to more than a third of their gross credit deployed, which stood at Rs. 33,771 billion for NBFCs.

6.6 Asset Quality

Chart 87: Gross Non-Performing Assets (GNPA) Ratio



Source: RBI, CareEdge Research
Note: Data is provisional

The asset quality of NBFCs has seen continued improvement on account of strong balance sheets, an increase in provisions and improved collection efficiency. Additionally, restructuring of their loan book and non-performing assets (NPA) write-offs have also aided the improvement in the asset quality of NBFCs. As of Mar-23, the GNPA of NBFCs improved to 4.3% reaching the lowest size in Mar-17. The asset quality of NBFCs is likely to be impacted on the back of refined regulations pertaining to asset classification.

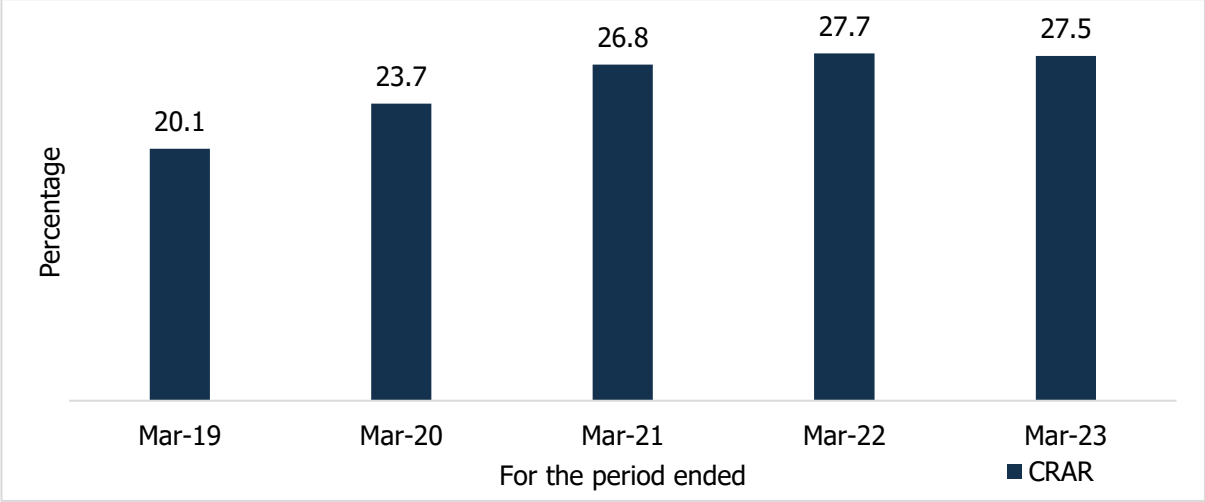
With effect from October 1, 2022, RBI has revised asset classification norms that mandate all NBFCs, requiring them to collect the entire arrears to upgrade an NPA. Asset classification would start exactly from the overdue date, unlike the present practice of starting 90 days from the end of the month in which the account becomes overdue.

Going forward asset quality is expected to remain in check owing to increased provisions, decline in fresh slippages and restructuring of the loan book.

6.7 Capital Adequacy

Over the years, NBFCs' CRARs have improved on account of increase in the level of Tier-I capital, retained earnings and moderation in NPA. NBFCs are well capitalized, with their capital to risk-weighted asset ratio (CRAR) well above the stipulated level of 15%. As per RBI data, CRAR was 27.5% as of Mar-23.

Chart 88: Capital Position of NBFCs

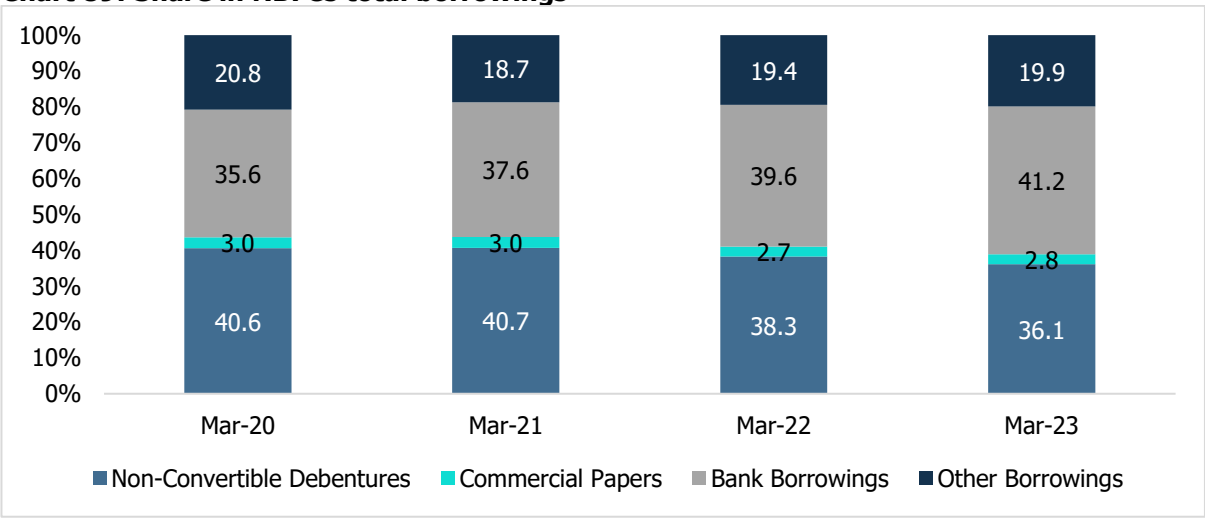


Source: Supervisory Returns, RBI
Capital to Risk- Weighted Assets Ratio (CRAR) is Tier 1+Tier 2 Capital by Risk-weighted Assets
Note: Data are provisional

6.8 Resource Profile of NBFCs

Borrowing from the markets and from banks constituted more than 75% of NBFCs total borrowings as of Mar-23. For FY23, market borrowings continue to be the largest sources of funds for NBFCs. However, their share has declined over the years. This is mainly on account of increase in spread of NBFC bonds yields over G-sec yields of corresponding maturity on the back of strict monetary policy and rising global yield. In FY23, total borrowings accelerated mainly due to increase in borrowings from banks.

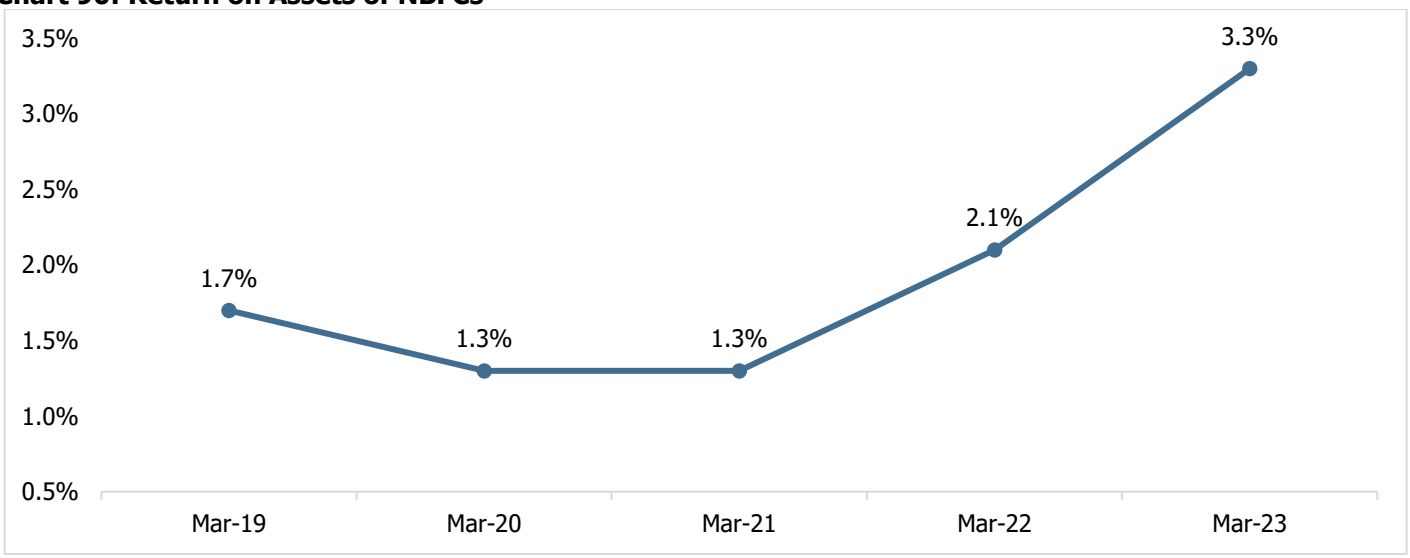
Chart 89: Share in NBFCs total borrowings



Source: RBI, CareEdge Research
Note: Market Borrowings include debentures and commercial papers, Other Borrowings include inter-corporate borrowings, subordinate debt and miscellaneous borrowings.

6.9 Profitability of NBFCs

Chart 90: Return on Assets of NBFCs



Source: RBI, CareEdge Research
Note: Data are provisional

In FY23, NBFCs return on average assets improved compared to previous years, this growth can be attributed to increase in demand for credit, low slippages and decline in non-performing assets leading to less need for extra provisioning.

6.10 Key growth drivers and challenges

Technological adoption and Co-lending arrangements:

NBFCs deploy technological solutions to develop innovative products and lower operational costs. Since NBFCs are fairly new in the financial landscape as compared to most banks, they are more agile and better positioned to leverage technology to enhance their reach while increasing efficiency.

NBFCs also collaborate with various alternative financiers and commercial banks by using the co-lending model, which enables them to diversify their income avenues and reach their targeted customer base through different channels. This co-lending model enables lenders to pool resources and distribute their risk while providing borrowers with access to diverse funding sources. Co-lending model is beneficial to banks and NBFCs as it enables them accumulate large funds while distributing the risk associate with the funds.

Government's focus on infrastructure development

Road construction is amongst the critical sub-segments of infrastructure development, economic growth as well as for employment creation. Infrastructure has been a major focus of the Government currently.

The Union Budget for 2023-24 depicted higher focus on infrastructure. The budget plan aims for multi-modal logistics facilities and connectivity systems under the PM Gati Shakti. For infra push, financial assistance of ₹1,300 Billion interest free loans for 50 years has been allocated to states from the Centre. Through this, the Government is planning to generate employment opportunities and augurs well for the Roads sector.

In addition, ₹111 Trillion of investments have been projected in infrastructure projects for FY20-FY25 by the Task Force on National Infrastructure Pipeline (NIP), with ~18% of the targeted investment expected to be made in the road sector

in India. Also, under the recently announced Asset Monetization Pipeline, around ₹1,600 Billion are to be monetized through roads.

These Government initiatives can create opportunity for NBFCs to lend towards sectors like power, construction and transportation. Infrastructure projects require substantial funds and NBFCs can participate in funding these projects.

Government's increasing efforts towards renewable power sector

The Government has been actively pursuing the growth of renewable power sector and has implemented several initiatives. These initiatives mainly focus on promoting renewable energy, strengthening distribution networks and contribute towards growth and sustainability of the power sector. In order to achieve the aim of these initiatives, power sector companies will require huge funds to set-up new renewable energy plants, upgrade the existing power plants, transmission and distribution networks and NBFCs have a significant opportunity to meet the funding requirements of power sector.

Strengthening real estate developments

Real Estate has the potential for catapulting India to the third largest construction market globally. The sector is expected to contribute 15% to the Indian economy by 2030. The recent policy reforms such as the Real Estate Act, GST and REITs are steps to reduce approval delays and are only going to strengthen the real estate and construction sector. NBFCs can play a key role in growth of real estate and construction sector by providing them adequate funds required.

6.11 Regulatory framework for NBFCs

PCA Framework

The RBI released a prompt corrective action (PCA) framework for NBFCs detailing strict action against non-banking finance companies in case their capital adequacy ratio falls or NPA levels cross a pre-defined threshold. The new framework, which earlier existed only for banks, will come into effect from 1 October 2022 based on the financial position of NBFCs on or after 31 March 2022.

Government NBFCs have been provided time up to March 31, 2022 to adhere to the capital adequacy norms provided for NBFCs (Ref. Annex I of Non-Banking Financial Company - Systemically Important Non-Deposit taking Company and Deposit taking Company (Reserve Bank) Directions, 2016). Accordingly, a separate circular would be issued in due course with regard to applicability of PCA Framework to Government NBFCs.

The PCA Framework will be reviewed after three years of being in operation.

Once an NBFC is placed under PCA, taking the NBFC out of PCA Framework and/or withdrawal of restrictions imposed under the PCA Framework will be considered basis following parameters:

a) If no breaches in risk thresholds in any of the parameters are observed as per four continuous quarterly financial statements, one of which should be Annual Audited Financial Statement (subject to assessment by RBI); and

b) Based on Supervisory comfort of the RBI, which includes sustenance of the profitability of NBFCs.

The discretionary corrective actions will be based on parameters such as strategy which would detail a recovery plan and review of the business model of the NBFC, governance related actions which would entail an engagement of RBI with the NBFC's board and recommendations and restrictions related to the same.

Along with this, the framework will require capital related actions such as restrictions on expansion of assets, reduction in exposure to high-risk sectors, board-level review of capital planning, submission of plans for raising additional capital, among others. The framework includes credit related actions such as reduction in exposure to certain sectors, individuals or industries, preparation of a time-bound plan for reduction of NPAs, higher provisioning, and loan review mechanisms.

The RBI will also look into market risk and profitability related aspects such as extent of asset liability mismatch, restrictions or reduction of borrowings from the debt market, restrictions on investment activities, limits on operating

expenses and capital expenditure. HR and operations related aspects will also come under the purview of RBI under the PCA framework.

Prudential Framework for Resolution of Stressed Assets:

Under this framework the lenders are required to recognize incipient stress in borrower accounts, immediately on default, by classifying them as special mention accounts (SMA).

Classification of SMA categories is mentioned below:

Table 49: Classification of SMA categories

Loans other than revolving facilities		Loans in the nature of revolving facilities like cash credit/overdraft	
SMA Sub-categories	Basis for classification – Principal or interest payment or any other amount wholly or partly overdue	SMA Sub-categories	Basis for classification – Outstanding balance remains continuously in excess of the sanctioned limit or drawing power, whichever is lower
SMA-0	Up to 30 days		
SMA-1	More than 30 days and up to 60 days	SMA-1	More than 30 days and up to 60 days
SMA-2	More than 60 days and up to 90 days	SMA-2	More than 60 days and up to 90 days

Table 50: Classification of NPA categories

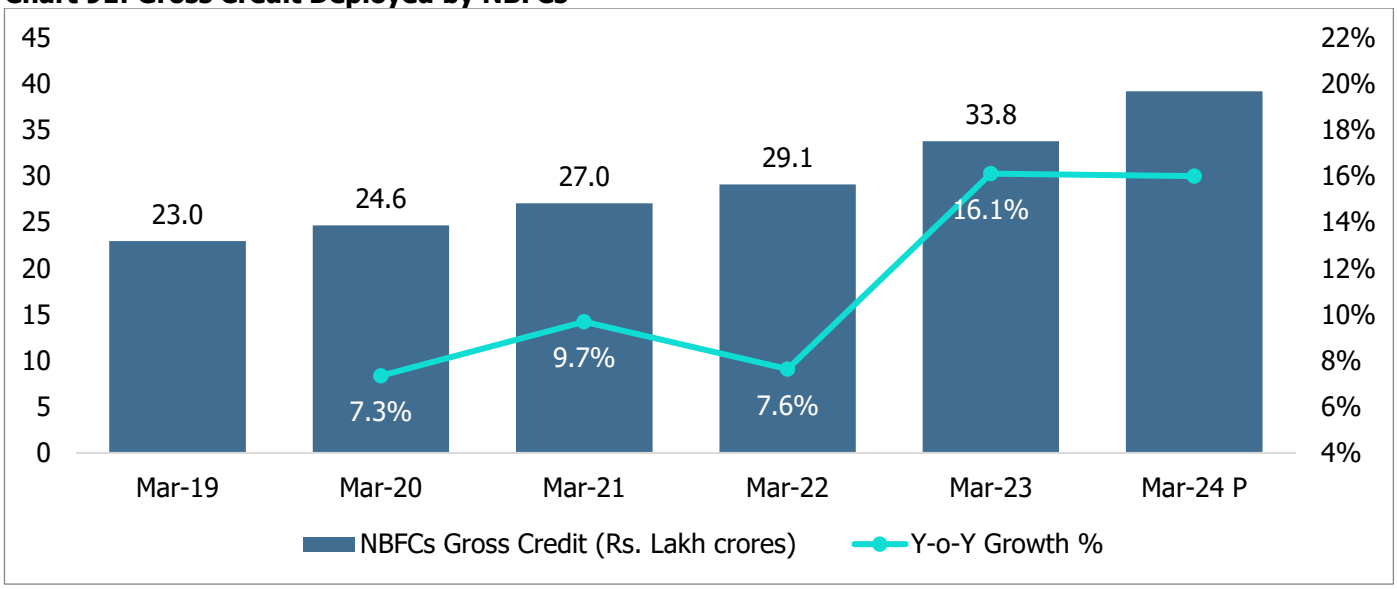
Type of loan	Identification (Account is treated as NPA)
Term Loan	Interest and/ or instalment remains overdue for a period of more than 90 days.
Cash Credit & Overdraft accounts	Account remains out of order for a period of more than 90 days An account is treated as out of order if, •The outstanding balance remains continuously in excess of sanctioned/drawing power limit or •Though the outstanding balance is less than the sanctioned limit/drawing power. •There are no credits continuously for more than 90 days in the account i.e. the account is non-operative. •The credits during the aforesaid period in accounts are not sufficient to cover the interest debited during the same period.
Bill Purchased/ Discounted	Bill remains overdue for a Discounted period of more than 90 days.
Agricultural Advances	• In case of Short duration crops, the instalment of principle or interest thereon remains overdue for two crop seasons • In case of long duration crops, the instalment of principle or interest thereon remains overdue for one crop season.
Liquidity facility	Remains outstanding for more than 90 days in respect of securitization transaction.
Derivative Transactions	Overdue receivables representing positive mark to market value of a derivative contract remaining unpaid for a period of 90 days from specified due date.

An account is classified as NPA only if interest due and charged during any quarter is not serviced fully within 90 days from the end of the quarter.

6.12 Growth Outlook

CareEdge Research estimates that NBFCs have seen good growth in FY23 in the range of 9%-13% y-o-y and FY24 is likely to bode well for NBFCs largely supported by retail loans primarily on account of steady demand and increase in middle-class spending and continued improvement in economic growth. In FY24, NBFCs gross credit deployed is expected to grow in the range of 11%-13% y-o-y on the back of improved asset quality and uptick in demand for credit from retail industry.

Chart 91: Gross Credit Deployed by NBFCs



Source: RBI, CareEdge Research
Note: Data are provisional, P - projected

The microfinance and personal loan segment are likely to see traction and significantly contribute to NBFCs' growth. These segments are likely to continue their growth momentum on the back of steady demand.

Growth in vehicle segment is also expected to see growth on the back of automotive industry's growth. In the near term, the growth is likely to be supported by improved operating environment, new model launches and sustained demand for vehicles, supported by improved availability of semi-conductors.

NBFCs' credit growth may face headwinds due to global slowdown, inflation and the amendments in the regulatory framework. In addition to this, NBFCs are expected to witness further uptick in their cost of funds as the central bank continues to be watchful of inflationary pressures. However, improved asset quality will support earnings thereby easing cost of funds.

6.13 Growing digitization in origination and appraisal

Digital technology has revolutionized the origination and appraisal process and has played a crucial role in bringing significant advancement and transformation in business operations. Digital technology streamlines origination and appraisal processes and minimizes paper work, reduces manual effort, automates recurring tasks and enables NBFCs and other organizations to handle high volume transactions effectively.

In the last decade, digital platforms have gained popularity in India due to their convenience, accessibility, and streamlined origination processes. With the help of digitization, it has become possible to quickly process a loan, enhance collections and other operational efficiencies along with ensuring customer satisfaction.

Digital tools enable collection of large amounts of data and digital platforms leverage technology, data analytics, and artificial intelligence to assess creditworthiness or eligibility of applicants and make lending decisions. These tools can gather data from multiple sources, such as financial statements, credit reports and other alternative sources such as transaction history, mobile usage patterns, and social media data, to evaluate an applicant's creditworthiness, especially for individuals who may not have extensive credit histories or formal documentation.

Digital origination platforms usually have incorporated automated underwriting systems that use algorithms to analyse the collected data and determined whether the applicant meets the predefined criteria for rejection or approval of the loan. Furthermore, client interactions throughout the origination process are managed through digital customer relationship management (CRM) systems. These system help track leads, automate communication, and provide a seamless experience for both customers and NBFCs to streamline their operation.

7. Power focused NBFCs in India

7.1 Overview

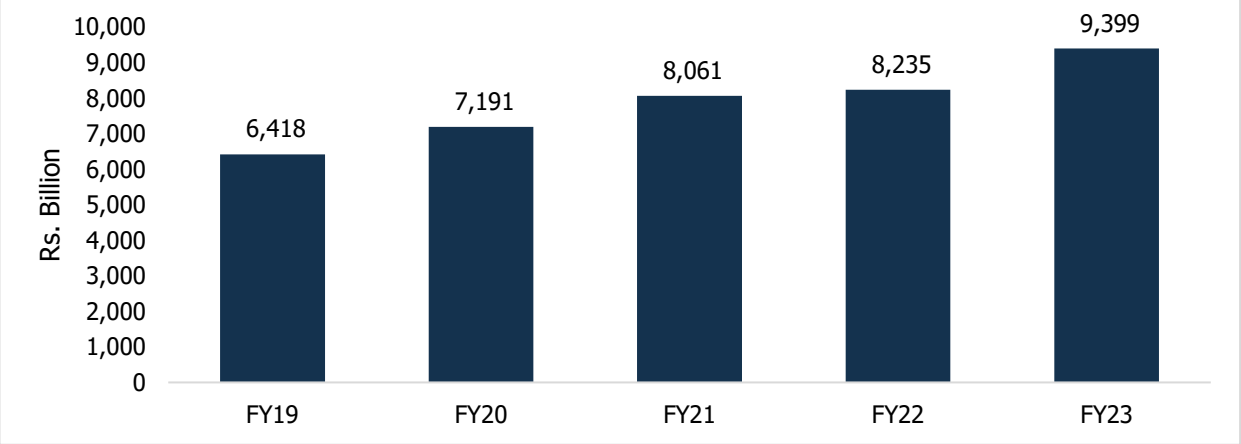
Power sector financing NBFCs primarily focus on financing of power generation, transmission, distribution and other such activities. These NBFCs provide funds for various types of power projects, including thermal power plants, transmission lines and renewable energy projects such as solar power plants, wind farms, hydroelectric projects, bioenergy energy projects and clean energy generation.

These NBFCs operate within the regulatory framework set by Reserve Bank of India (RBI), Securities and Exchange Board of India (SEBI) and National Housing Bank (NHB). NBFCs compliance with the regulation set by these regulatory bodies ensures financial stability, transparency and consumer protection.

These NBFCs have a robust risk management framework to mitigate risks such as project feasibility risks, interest rate risk, market risk, regulatory risk, etc. Power financing NBFCs provide funds to meet various requirements of power projects through products including working capital loans, term loans, equipment financing, bridge loans, project financing, refinancing, mezzanine financing and structured debt financing.

These NBFCs facilitate access to energy, uptick in power generation capacity and promote sustainable energy activities. Power financing NBFCs significantly contribute to the growth and development of the power sector by providing funding for adoption, expansion and improvement of overall power infrastructure.

Chart 92: Trend in Credit deployed by key power financing NBFCs

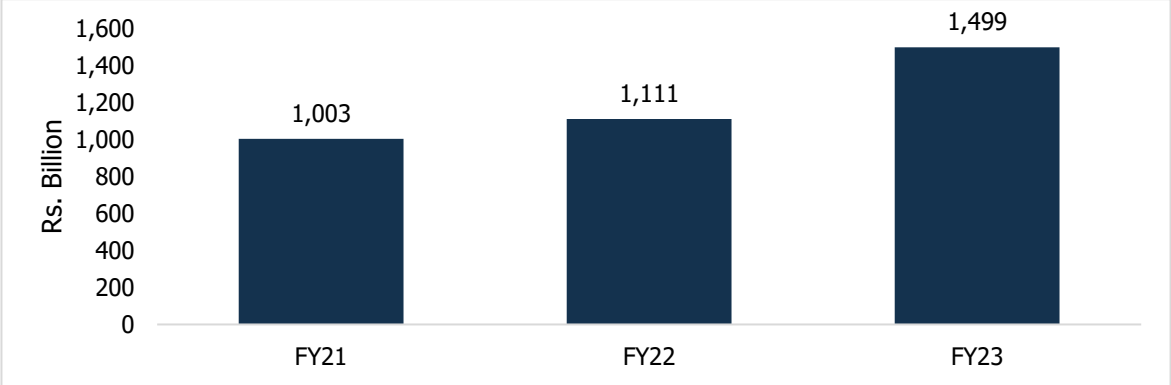


Source: CareEdge Research, Industry Reports

Note: Aggregate of outstanding credit of five key power financing NBFCs in India namely Indian Renewable Energy Development Agency Ltd (IREDA), Power Finance Corporation Ltd. (PFC), PTC India Finance Ltd. (PFS), Rural Electrification Corporation Ltd. (REC), Tata Cleantech Capital Ltd. (TCCL), India Infradebt Ltd.

Over the years, power financing NBFCs have seen significant traction supported by increase in demand for funds from power sector, and government's push towards growth of power sector. As of FY23, the outstanding credit of key power financing NBFCs reached around Rs. 9,399 billion indicating CAGR of nearly 10% over FY19. In FY24, power-financing NBFCs are expected to continue this growth momentum and this growth is likely to be driven by increase in power demand, rise in population, renewable integration and sustainability goals of the country.

Chart 93: Trend in power financing NBFCs credit towards Renewable sector



Source: CareEdge Research, Industry Reports

Note: Aggregate of outstanding credit of five key power financing NBFCs in India namely Indian Renewable Energy Development Agency Ltd (IREDA), Power Finance Corporation Ltd. (PFC), PTC India Finance Ltd. (PFS), Rural Electrification Corporation Ltd. (REC), Tata Cleantech Capital Ltd. (TCCL), India Infradebt Ltd.

The renewable sector has been gaining significant traction over the years and power financing NBFCs have been playing a key role in funding renewable projects. In FY23 based on the loan book of six major power financing NBFCs, their credit towards renewable sector reached nearly Rs. 1,500 billion.

Table 51: Share in Credit towards power financing NBFCs

Power Financing NBFCs	Share in Credit towards Renewable sector	CAGR % (FY21/FY23)
Indian renewable energy Development Agency Ltd (IREDA)	31%	30%
Power Finance Corporation Ltd. (PFC)	32%	13%
PTC India Finance Ltd. (PFS)	1%	-34%
Rural Electrification Corporation Ltd. (REC)	19%	33%
Tata Cleantech Capital Ltd. (TCCL)	7%	29%
India Infradebt Limited	9%	33%
Aggregate	100%	22%

Source: CareEdge Research, Industry Reports

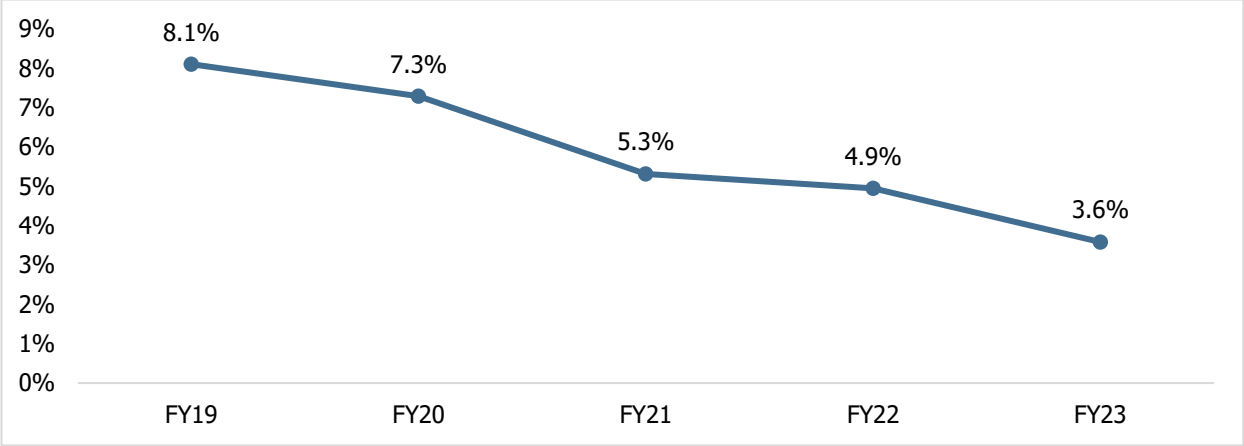
Note: Aggregate of outstanding credit of five key power financing NBFCs in India namely Indian Renewable Energy Development Agency Ltd (IREDA), Power Finance Corporation Ltd. (PFC), PTC India Finance Ltd. (PFS), Rural Electrification Corporation Ltd. (REC), Tata Cleantech Capital Ltd. (TCCL), India Infradebt Ltd.

Note: CAGR indicates growth in power financing NBFCs credit towards renewable sector, Renewable sector includes large hydro

Among these Power financing NBFCs, PFC followed by IREDA have the largest share in credit towards renewable sector with more than 30% of their loan books contributing to renewable sector. While PFC is also present in other sectors such as infrastructure, roads, mining and others, IREDA on the other hand is completely focused towards renewable sector. In the coming years, power financing NBFCs are expected to increase their focus towards renewable sector.

Asset Quality of Power Financing NBFCs

Chart 94: Gross non-performing assets of key power financing NBFCs

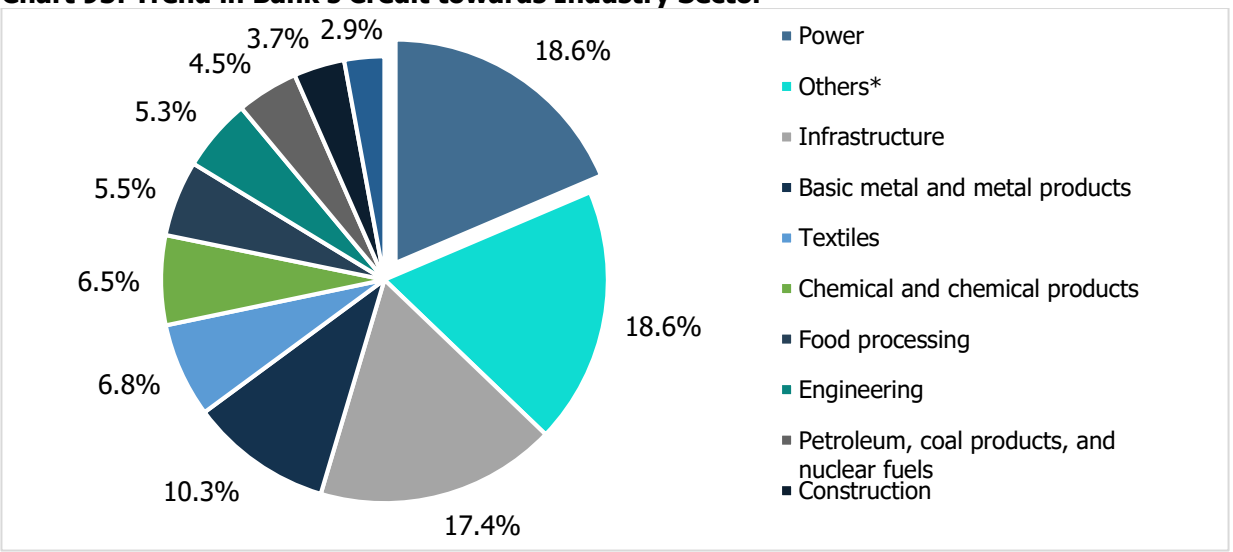


Source: CareEdge Research, Industry Reports

Note: Aggregate of GNPA of five key power financing NBFCs in India namely Indian Renewable Energy Development Agency Ltd (IREDA), Power Finance Corporation Ltd. (PFC), PTC India Finance Ltd. (PFS), Rural Electrification Corporation Ltd. (REC), Tata Cleantech Capital Ltd. (TCCL), India Infradebt.

In the last five years there has been significant improvement in the asset quality of power financing NBFCs. The gross non-performing assets (GNPA) declined from 8.1% in FY19 to 3.6% in FY23. This decline in GNPA is largely supported by restructuring of stressed assets, write-offs, decline in slippages and increased provisioning.

Chart 95: Trend in Bank's Credit towards Industry Sector



Source: RBI, CareEdge Research

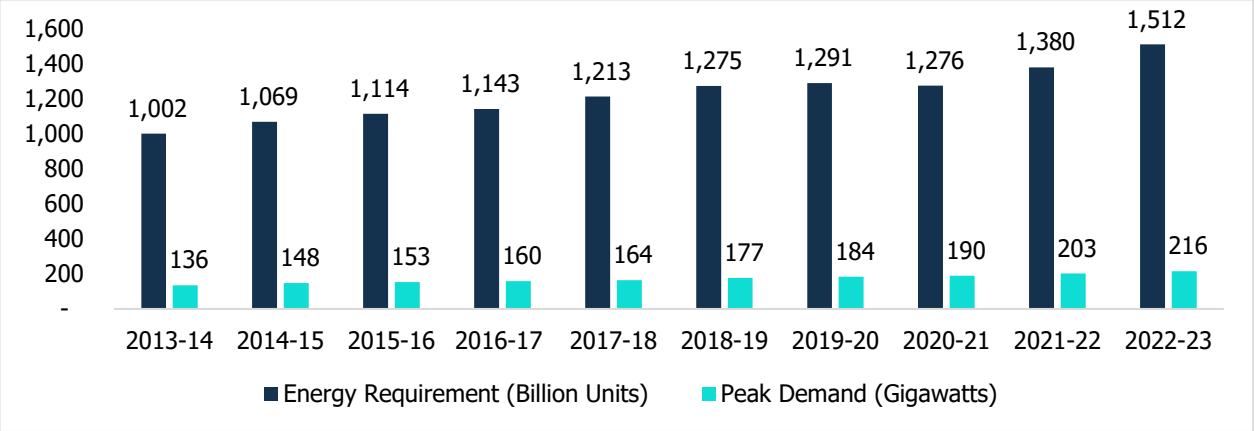
Note: Data are provisional, * indicates credit towards Rubber, plastic and their products, Gems and jewellery, Mining and quarrying (incl. coal), Cement and cement products, Paper and paper products, Beverages and tobacco, Wood and wood products, Leather and leather products, Glass and glassware.

Power sector has continued to form major chunk of bank's credit towards industry sector. In FY23, 18.6% of bank's credit towards industry sector was towards the power segment that amounted to Rs. 6,204.25 billion. The growth of credit towards power segment is largely supported by rise in demand for electricity and Government push towards the growth of power sector.

7.2 Growth Drivers

- **Growing Power Demand**

Chart 96: Power Supply Position



Source: Ministry of Power, CareEdge Research

Over the last decade, there has been significant rise in power demand on the back of growing population, rapid urbanization and ramp-up in economic activity. In FY23, country's energy requirement increased to 15,11,847 million units in FY23, indicating 4.7% CAGR over FY14. NBFCs can play a crucial role in providing funding for development of new power generation projects and expansion of transmission and distribution infrastructure to meet this uptick in power demand.

- **Enhancement and Development of Infrastructure**

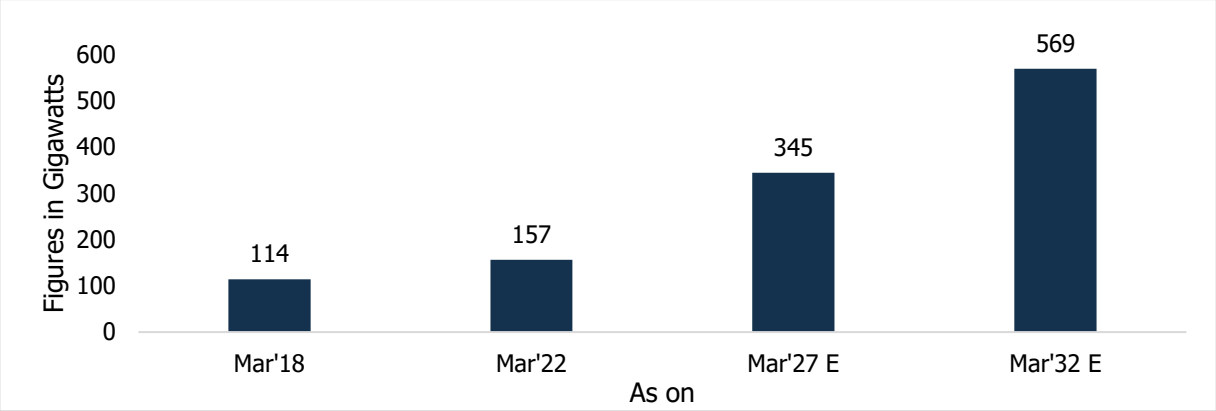
The power sector requires continuous development of existing and new power generation, transmission and distribution infrastructures to enhance the efficiency, reliability and capacity of power plants. This upgradation requires a substantial investment, this is where power financing have opportunity to fund these infrastructure projects including the refurbishment or construction of power plants, transmission lines and distribution networks and technology and equipment upgrades.

- **Expansion of Renewable Energy**

In 26th Conference of Parties, or COP26 on climate change, India announced its target to increase its non-fossil energy to 500 GW by 2030. In addition, India announced that it would meet 50% of its energy requirements by 2030 from renewable energy. India is committed towards achieving these targets and increase the contribution of renewable energy in the power generation mix to meet the rapidly growing demand for electricity.

CareEdge Research believes that financing requirement for renewable energy sectors such as solar and wind are set to expand prominently in line with the Government of India's target of 500 GW installed non-fossil fuel-based power capacity by 2030.

Chart 97: Renewable Energy Installed Capacity



Source: CEA, CareEdge Research
Note: Data includes renewable energy sources (RES) and Hydro

With support of government policies, the declining cost of many renewable energy (RE) technologies, an increase of energy demand and with more focus on sustainable development there is continuous increase in capacity of RE sources. In the coming years, renewable energy will play an important role in optimal energy mix of the country. And power financing NBFCs have a great opportunity to provide capital required for development of solar, wind, hydro and other renewable energy projects.

- **Government Initiatives**

The Government has been actively pursuing the growth of power sector and has implemented several initiatives such as the "Power for All" initiative, Ujwal DISCOM Assurance Yojana (UDAY), Atal Distribution System Improvement Yojana (ADITYA) and more. These initiatives focus on improving access to energy, promote renewable energy, strengthen distribution networks and contribute towards growth and sustainability of the power sector. The Government's push towards the growth of power sector has created conducive environment for power financing NBFCs by providing policy support, regulatory framework and incentives for investments in the power sector.

- **Rural Electricity Infrastructure**

The Government has put significant efforts towards rural electrification with initiatives such as Pradhan Mantri Sahaj Bijili Har Ghar Yojana (Saubhagya) which aims to achieve universal electrification in remote and rural households; Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) is another initiative that is focused on strengthening and augmenting rural electricity infrastructure. These initiatives have created new opportunities for power financing NBFCs to provide funding required for rural electrification projects, that can enhance electricity reach in the remote and rural regions of the country.

7.3 Rise in power demand to boost growth of power financing NBFCs

GDP and energy intensity: India is likely to emerge as one of the world's fastest-growing economies as per IMF. This growth is likely to boost economic activity and infrastructure development (including the power sector). As the GDP grows there will be an increase in power consumption as industry and households use more electricity. This rise in demand for electricity will require the expansion of power generation, transmission and distribution infrastructure. This creates a significant opportunity for power financing NBFCs that can facilitate funding power projects to meet the growing energy requirement.

Urbanization: Urbanization of India's population is growing on a larger population base. The urban population in India is estimated to have reached around 498 million (35.4% of total population) in the year 2021. Over the last decade, rapid urbanisation along with growing population, ramp-up in economic activity has been a major driver of surge in power demand. NBFCs can play a crucial role in providing funding for development of new power generation projects and expansion of transmission and distribution infrastructure to meet this uptick in power demand.

Demand for Round-The-Clock power: Recently, there has been significant demand for round-the-clock power leading to an increased focus towards renewable energy sources (such as solar and wind) that can provide continuous power supply. Round-the-clock power requires capacity expansion of existing power plants, technology upgrades and effective energy storage solutions to balance the intermittent nature of renewable energy sources and to handle peak load demands. Power-financing NBFCs can provide funding for expansion and upgradation of power plants, they can also provide funding for energy storage projects such as battery, thermal or mechanical systems, etc.

Rural electrification: The power for all (PFA) initiative of the Government of India aims to provide power supply to all households/homes, industrial, commercial and agricultural consumers. The PFA initiative and rural electrification is among the key drivers of the growing power demand. This rise in power demand necessitates expansion of existing power capacity. Power financing NBFCs can provide financing significant investment required for expansion and construction of power plants, transmission lines and distribution channels,

Railway electrification: The Government plans to fully electrify the railway network by 2024. To support the electrified railway network, close to 30 billion units of electricity shall be required on an annual basis by 2024. As railway electrification requires developed power infrastructure for supplying electricity to the electrified rail network, significant investments in the installation of electric traction systems, substations and other infrastructure. Power financing NBFCs can support the growth of railway networks by providing energy-efficient technologies, funding solar power plants, wind farms, etc.

Strong renewable energy capacity additions: Power generation in India is dominated by coal-based generation. The use of other resources, such as renewable energy, is experiencing a staggering growth due to significant additions in the installed capacity. However, renewable energy projects require large capital investments for construction, installation and commissioning of solar power plants, wind farms and hydro projects. And power financing NBFCs have great opportunity to provide the required funding for these projects.

Cross-border power trading in South Asian countries: Cross-border power trading requires the development of transmission infrastructure, including interconnectors, transmission lines and substations This will require significant investments in power generation, transmission and distribution and power financing NBFCs have the opportunity to provide project financing, equipment financing and working capital loans to developers.

Make in India push: The Atmanirbhar- Make in India movement significantly focuses on energy independence. India aims to reduce its dependence on imports for oil and coal and become self-sufficient in meeting the county's growing energy needs. Power finance NBFCs can provide financial assistant as energy independency requires significant capital in generating electricity from solar, wind and hydro which will support reducing dependency on coal-based power generation.

Electricity Mobility Infra: India's electric vehicle (EV) segment has been on an increasing trend. Country's EV sales have witnessed massive growth on account of favourable government policies for EVs supporting reduction in upfront cost and expansion of charging infrastructure, rising fuel prices and shifting consumer preferences. Power financing NBFCs have a great opportunity to provide funds required to meet these increasing energy requirements of the automobile sector.

7.4 Challenges

Power sector NBFCs face many challenges that can hamper their operations and growth prospects. Few such challenges are mentioned below:

Stringent Regulatory Framework: As power sector is highly regulated, power financing NBFCs can be significantly impacted by risks arising from change in regulations, policies and Government initiatives. Shifts in policies related to tariff such as new tariff structures or revise in existing tariffs; introduction of renewable energy incentives and obligations and regulatory clearances may create uncertainty and affect the financial viability of the project and the repayment capacity of the borrower.

Apart from this, NBFCs as an entity are also subjected to regulatory requirements and compliances, that requires significant administrative and operational efforts. This can pose a challenge for NBFCs with small asset size and limited resources.

Lack of competitive cost of borrowing: Similar to other NBFCs, power financing NBFCs rely on various external sources of funding, such as banks, financial institution bonds and commercial borrowings. These NBFCs may face difficulty in raising funds at competitive rates thereby limiting their capacity to meet the funding requirements of capital-intensive power projects.

Resource profile of NBFCs – high reliance on wholesale borrowings

Borrowing from the markets and from banks constituted more than 75% of NBFCs total borrowings as of Mar-23. For FY23, market borrowings continue to be the largest sources of funds for NBFCs. However, there share has declined over the years. This is mainly on account of increase in spread of NBFC bonds yields over G-sec yields of corresponding maturity on the back of strict monetary policy and rising global yield. In FY23, total borrowings accelerated mainly due to increase in borrowings from banks.

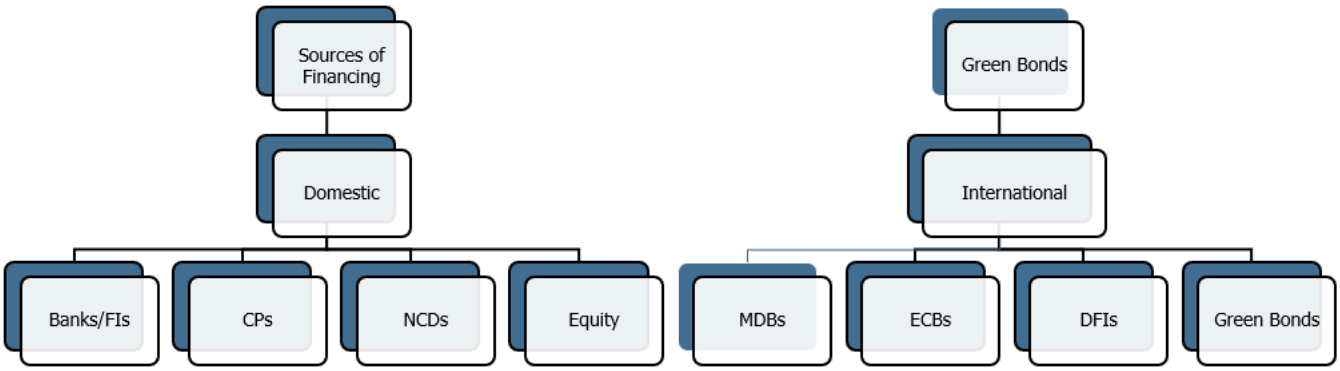
Asset-Quality: The asset quality of power financing NBFCs is mainly impacted by delayed project implementation, fuel supply and off-take risks, financial health of DISCOM and other industry specific challenges. When power projects experience delays, time and costs overruns or cash flow mismatches, it becomes difficult for borrowers to meet their obligations.

Furthermore, fuel availability issues and off-take risks can also impact the viability of the project, thereby impacting the repayment capacity of the borrower. Additional changes in the regulatory and policies create uncertainty affecting the revenue projections and loan repayment capability. The financial health of DISCOMS and economic downturn can further increase these challenges.

Interest rate volatility: Power financing NBFCs are exposed to interest rate risks due to their long-term lending activities to fund power projects. Interest rates can impact the profitability and cost of funds for NBFC's. Additionally, change in interest rate can also impact the asset-liability management of power financing NBFCs as they tend to provide long-term power project loans with short-term funding sources. This leads to asset-liability mismatch, which exposes NBFCs to the risk of refinancing their short-term obligations at a higher interest rate in case there is interest rate volatility in the market. This exposes them to potential liquidity constraints and may hamper their ability to extend credit and make repayment.

7.5 Financing Sources for Power financing NBFCs

Chart 98: Major Sources of Financing for Power financing NBFCs



Source: CareEdge Research

- **Banks and Financial Institutions (FIs):** One of the major sources of financing for NBFCs is borrowings from banks and FIs. Banks and FIs offer variety of loans such as working capital loans, term loans and other debt instruments to NBFCs. NBFCs are require to maintain a good relationship with the banks and financial institutions to get funding at competitive interest rates which are influenced by credit ratings. Lower average cost of funds enables competitive pricing by players enabling business growth, attract quality borrowers and optimise profitability.

  In March 2023, banks' outstanding credit to non-banking financial companies (NBFCs) reached Rs.13,310.97 billion, indicating 30.2% y-o-y growth. The growth in bank borrowings is supported by differentials between market yields and interest rates offered by banks and lower borrowings in the overseas market and growth in asset book of NBFCs.

- **Green Bonds:** Green Bonds are debt instruments issues specifically to raise funds for climate-suitable and environmentally sustainable projects. NBFCs can issue green bonds, the proceeds of which will exclusively be allocated to finance or refinance green projects such as renewable energy installations, energy efficient initiatives, development of sustainable infrastructure, waste management and other environmentally friendly activities. These bonds attract environmentally conscious investors who prioritize environmental, social and governance considerations and seek to support green initiatives while generating financial returns.

  So far, banks like State Bank of India, Yes Bank, power financing NBFCs including Indian Renewable Energy Development Agency (IREDA), Rural Electrification Corporation (REC), Power Finance Corporation (PFC) and companies like Greenko, Adani Green Energy and the likes have entered the green bond market. These companies have raised more than USD 21 billion in green bond market as of Feb-23.

  However, India is yet to fully explore its potential in the green bond market and Indian government's significant efforts towards making India more green, sustainable and self-sufficient is an indicator that in the coming years India's green bond market is expected to see traction.

- **Commercial paper (CP):** Commercial paper is a short-term debt instrument, cost effective and flexible source of funds that NBFCs can utilize to meet their short-term financing needs such as working capital requirements. Commercial papers are unsecured promissory notes issued by highly rated NBFCs with fixed maturity that can ranging from a few days up to a year.

- **Non-Convertible Debentures (NCDs):** NCDs are fixed income instruments with a specific coupon rate and majority date. NBFCs can you issue NCDs to raise long term capital from the bond market by attracting institutional

and retail investors looking for fixed income opportunities. Green bonds can also be issued as NCDs, specifically targeting funds for financing environmentally sustainable projects and climate suitable projects.

- **Equity:** Among other sources of financing NBFCs can raise funds through equity. This can be done through initial public offerings (IPOs), qualified institutional payments (QIPs),rights issues and private equity investments. Equity financing provides significant capital funds that can help NBFCs in improving their financial strength over time. In recent years, there has been significant increase in NBFCs raising funds through equity, this is majorly to support the growing demand for credit from borrowers and to expand their existing business.

- **Multilateral Development Banks (MDBs):** MDBs are financial institutions that provide financial support to developing countries in the form of loans and grants, with the aim to promote economic development and reduce poverty. MDBs provide financial support for various purposes such as project financing, working capital financing, debt restructuring, etc. MDBs can aid NBFCs by financing projects that promote economic development and reduce poverty and can also help NBFCs improve their operations and risk management.

- **External Commercial Borrowings (ECBs):** ECBs are foreign currency loans borrowed from non-resident lenders, international banks and financial institutions. The external commercial borrowing framework is regulated by the Reserve Bank of India that specifies eligibility criteria, borrowing limits and permitted end users. NBFCs can issue green bonds in the form of ECBs, when they are targeting international investors.

- **Development Financial Institutions (DFIs):** DFIs are specialized financial institutions that provide long-term financing and support for infrastructural and industrial development. DFIs mainly focus on project finance, term loans, and equity capital to support infrastructure projects including power plants. DFIs also offer technical assistance, advisory services and help in building capacity to facilitate project development, effective project implementation and sustained growth of infrastructure sector in India.

  DFIs are backed by Government support or public sector ownership and usually have a development mandate. They often have expertise in assessing project viability, risk management and structuring financial solutions. The Indian Government has recently established National Bank for Financing Infrastructure and Development (NaBFID) a development financial institution that aims to provide long-term debt and equity financing for infrastructure projects and attract private sector investments. Power financing NBFCs can collaborate with DFIs to access long-term funds, seek expert sector guidance and leverage policy support for financing power projects. Indian Renewable Energy Development Agency (IREDA) is among the first financial institution to raise global funds for climate financing from DFIs / Multilaterals in India.

  Funds can be also raised through private equity and venture funding. With Government's significant push towards the growth of power sector and increase in demand for renewable sources of generation, there has been increased focus of investors towards renewable energy sector thereby resulting in increased traction of private investments.

8. Business Profiling

8.1 Indian Renewable Energy Development Agency Ltd (IREDA)

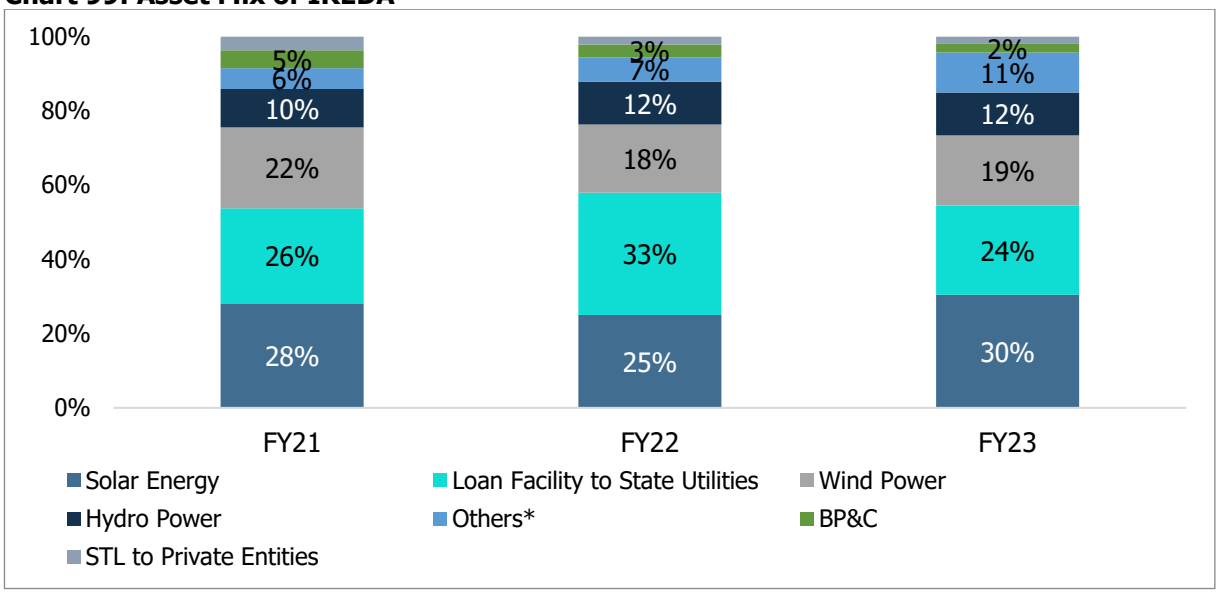
• IREDA is a NBFC established in 1987, with an objective to provide innovative financing in Renewable Energy & Energy Efficiency/Conservation and Environmental Technologies.
• IREDA provides a comprehensive range of financial products and related services from project conceptualization to the post-commissioning stage in the Renewable energy projects and equipment manufacturing.
• It provides financial assistance through both fund-based and non-fund-based facilities including project finance, short-terms loans, debt refinancing, performance guarantee and letters of comfort.
• The company mainly finances projects in the wind, hydro, solar, bio-energy sectors as well as emerging areas, such as battery-powered vehicle sectors.
• IREDA is the largest pure-play green financing NBFC in India. As per RBI, "green finance" means lending to and/or investing in the activities/projects that contributes to climate risk mitigation, climate adaptation and resilience, and other climate-related or environmental objectives - including biodiversity management and nature-based solutions.
• IREDA is the issuer of first debt security (green masala bond) in India listed on IFSC exchange.
• IREDA is the first financial institution in India to raise green masala bonds.
• IREDA is among the first financial institution to raise global funds for climate financing from DFIs / Multilaterals in India.
• IREDA is a nodal agency for MNRE schemes such as Central Public Sector Undertaking Scheme, Phase-II (Government Producer Scheme); National Bioenergy Program; National Programme on High-Efficiency Solar PV Modules under PLI scheme, Tranche-I; and Generation-Based Incentive (GBI) Scheme.
• As on Mar-23, the loan assets of the company reached at Rs. 470.7 billion.

Table 52: Key financial performance summary of IREDA

Particular	Indian Renewable Energy Development Agency Ltd (IREDA)			
	FY21	FY22	FY23	H1FY24
Loan book size or AUM (Rs.Mn.)	2,78,539	3,39,306	4,70,755	NA
Revenue from operations (Rs. Mn)	26,548	28,599	34,820	23,198
Profit after tax (Rs.Mn.)	3,464	6,335	8,646	5,793
Net Interest Income (Rs. Mn)	9,922	11,280	13,237	6,987
Total Debt (Rs.Mn.)	2,40,000	2,76,131	4,01,653	3,98,502
Net Worth (Rs.Mn.)	29,956	52,681	59,352	65,806
Return on assets (%)	1.20%	1.89%	1.98%	1.14%
Return on equity (%)	12.56%	15.33%	15.44%	9.26%
Net Interest Margin (%)	3.93%	3.75%	3.32%	NA
CRAR (%)	17.12%	21.22%	18.82%	20.92%
Gross NPA (%)	8.77%	5.21%	3.21%	3.13%
Net NPA (%)	5.61%	3.12%	1.66%	1.65%
Provision coverage ratio (%)	38.14%	41.45%	49.25%	48.11%
Basic EPS (Rs)	4.41	8.03	3.78	2.54
Diluted EPS (Rs)	4.41	8.03	3.78	2.54

Source: Company reports, CareEdge Research
Note: Net Interest Income for H1FY24 does not include other interest income.

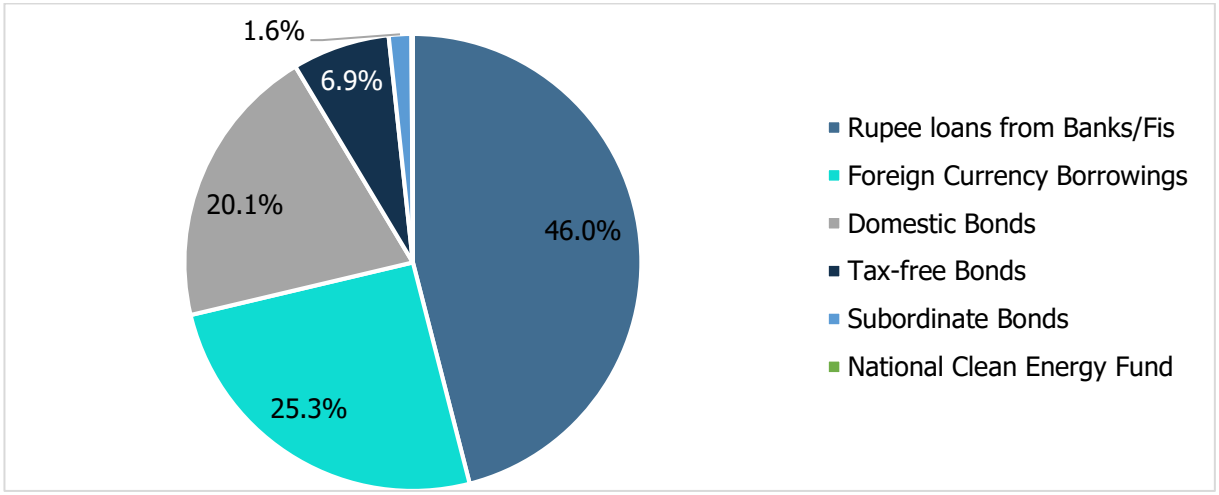
Chart 99: Asset Mix of IREDA



Source: Company reports, CareEdge Research

Note: BP&C-Biomass Power & Co-generation, STL-Short term loan, Others include Hybrid Wind and Solar, Ethanol, Manufacturing, Waste-to-energy, Electric Vehicle ("EV"), Guaranteed Emergency Credit Line, Transmission, EEC, Biomass (Briquetting, Gasification and Methanation from Industrial Effluents), National Clean Energy Fund, Bridge Loan.

Chart 100: Resource Profile of IREDA as on Mar-23



Source: Company reports, CareEdge Research

8.2 Power Finance Corporation Ltd (PFC)

• PFC is the largest NBFC with net worth of around Rs. 890 billion as on June 2023.

• The company's main business is to provide financial assistance to the power sector and offers a diverse range of products and services to different segments of the sector including generation (conventional and renewable), transmission and distribution projects as well as for related renovation and modernization projects.

• PFC provides financial support through various fund-based products and non-fund-based products. Fund based products includes long-term project finance, short-term loans, lease financing for purchase of equipment and wind power projects, corporate loan, buyer's line of credit, underwriting of debt and debt refinancing schemes whereas non-fund-based products includes deferred payment guarantee, credit enhancement guarantees and letters of comfort.

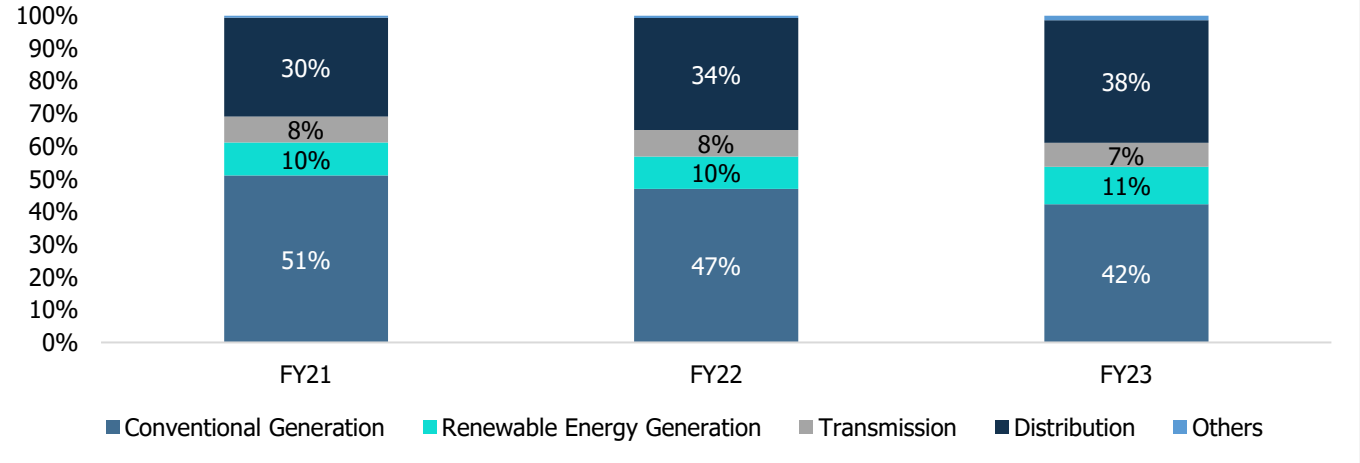
• The company also provides various fee-based technical advisory and consultancy services for power sector projects through its wholly-owned subsidiary.

Table 53: Key financial performance summary of PFC Ltd - Consolidated

Particular	Power Finance Corporation (PFC)			
	FY21	FY22	FY23	H1FY24
Loan book size or AUM (Rs.Mn.)	74,51,891	75,84,964	85,75,000	92,37,236
Revenue from operations (Rs. Mn)	7,16,561	7,62,617	7,75,683	4,33,835
Profit after tax (Rs.Mn.)	1,57,162	1,87,682	2,11,786	1,26,103
Net Interest Income (Rs. Mn)	2,59,957	2,84,737	2,63,899	1,51,613
Total Debt (Rs.Mn.)	65,96,822	66,04,762	75,11,575	81,40,647
Net Worth (Rs.Mn.)	8,17,903	9,62,752	11,19,813	12,37,030
Return on assets (%)	2.14%	2.40%	2.51%	1.35%
Return on equity (%)	23.96%	21.08%	20.34%	10.70%
Net Interest Margin (%)	3.68%	3.79%	3.27%	1.17%
CRAR (%)	18.83%	23.48%	24.37%	24.86%
Gross NPA (%)	5.29%	5.02%	3.66%	3.40%
Net NPA (%)	1.97%	1.66%	1.06%	NA
Provision coverage ratio (%)	63.97%	68.05%	71.73%	71.18%
Basic EPS (Rs)	44.50	53.08	60.19	28.51
Diluted EPS (Rs)	44.50	53.08	60.19	28.51

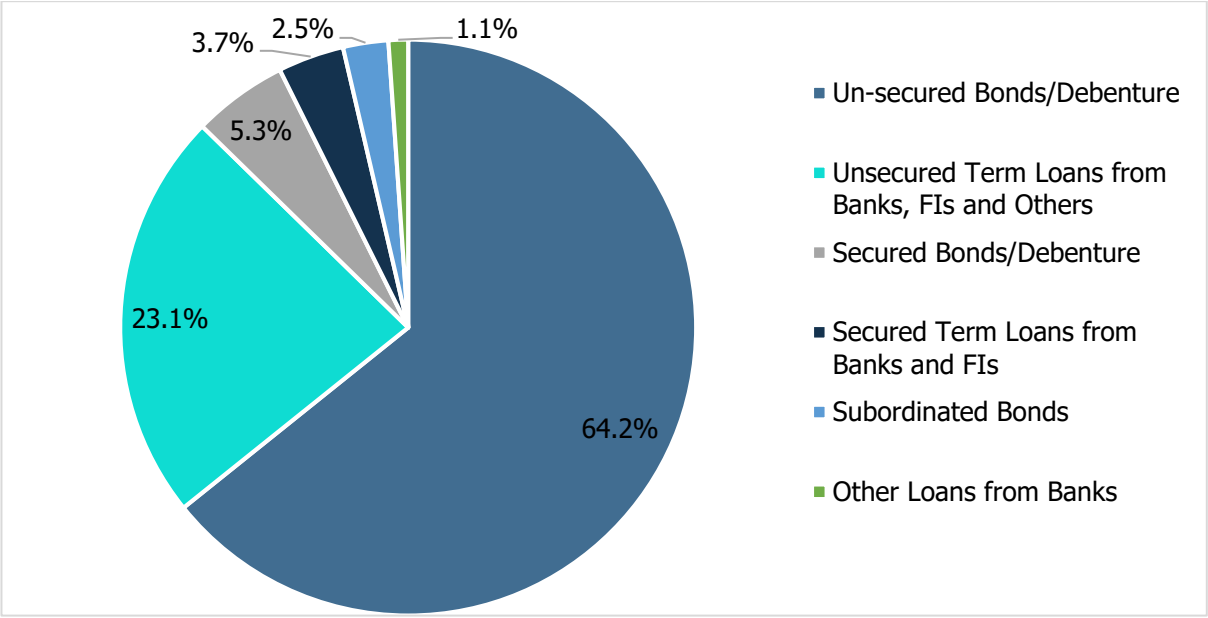
Note: Only 11% of PFCs loan book is into renewables as on March 2023
Source: Company reports, CareEdge Research

Chart 101: Asset Mix of PFC Ltd



Source: Company reports, CareEdge Research

Chart 102: Resource Profile of PFC Ltd as on Mar-23



Source: Company reports, CareEdge Research

8.3 Rural Electrification Corporation (REC) Limited

• REC Ltd is one of the leading NBFC categorized as Infrastructure Finance Company (IFC) by the RBI, servicing the financing needs of entire power sector value chain.

• The company offers a wide range of products across the value-chain and the principal products of REC Ltd are interest-bearing loans to State utilities, private-sector borrowers etc.

• The main products of the Company include long-term loans, medium-term loans, short-term loans etc. Other sources of funding include debt financing and equity financing.

• The company operates in various segments in power generation (both conventional and renewable energy), transmission, distribution, rural electrification, e-mobility, financing equipment manufacturing for power sector and activities having forward/ backward linkage with power projects.

• The number of disbursements made during FY23 amounted to Rs 968.4 billion.

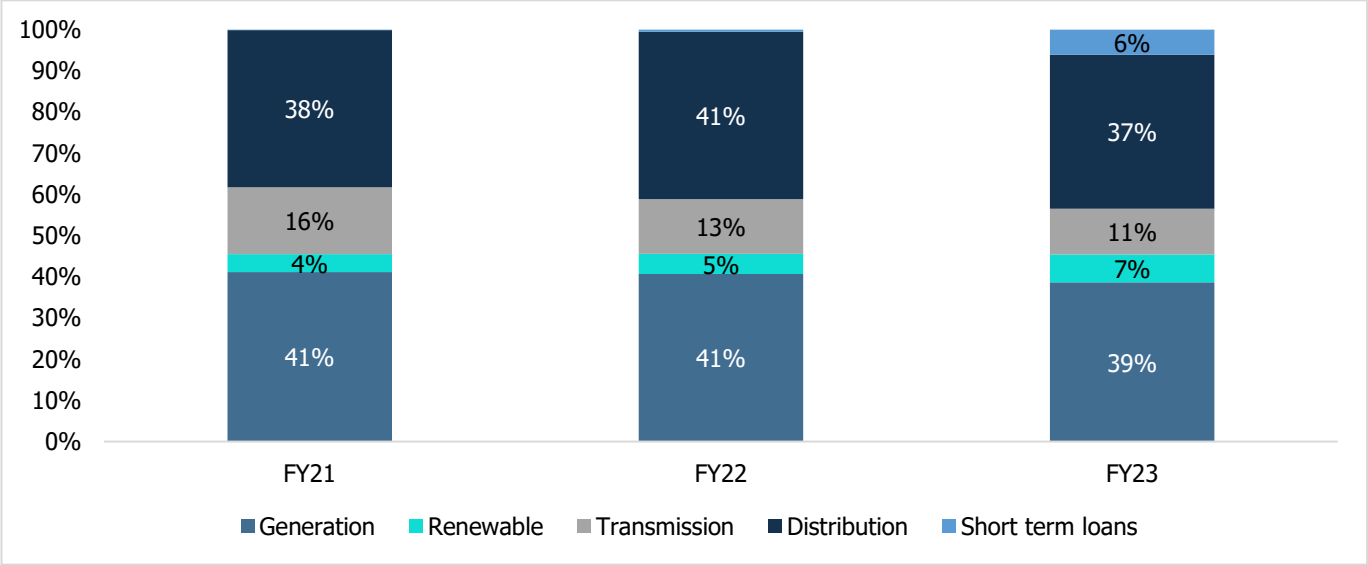
Table 54: Key financial performance summary of REC Ltd - Consolidated

Particular	Rural Electrification Corporation (REC) Limited			
	FY21	FY22	FY23	H1FY24
Loan book size or AUM (Rs.Mn.)	37,74,180	38,53,710	43,50,120	47,42,749
Revenue from operations (Rs. Mn)	3,55,528	3,92,691	3,94,783	2,27,758
Profit after tax (Rs.Mn.)	83,781	1,00,357	1,11,669	67,580
Net Interest Income (Rs. Mn)	1,28,742	1,53,445	1,39,990	75,623
Total Debt (Rs.Mn.)	32,97,234	33,30,427	38,07,898	41,95,167
Net Worth (Rs.Mn.)	4,37,639	5,13,141	5,81,205	6,35,825
Return on assets (%)	2.24%	2.47%	2.55%	1.38%
Return on equity (%)	21.17%	21.11%	20.41%	11.11%
Net Interest Margin (%)	3.68%	4.02%	3.41%	1.66%
CRAR (%)	19.72%	23.61%	25.78%	28.53%
Gross NPA (%)	4.84%	4.45%	3.42%	3.14%
Net NPA (%)	1.78%	1.51%	1.04%	NA

Particular	Rural Electrification Corporation (REC) Limited			
	FY21	FY22	FY23	H1FY24
Provision coverage ratio (%)	64.59%	67.40%	70.64%	69.37%
Basic EPS (Rs)	42.42	50.82	42.28	25.66
Diluted EPS (Rs)	42.42	50.82	42.28	25.66

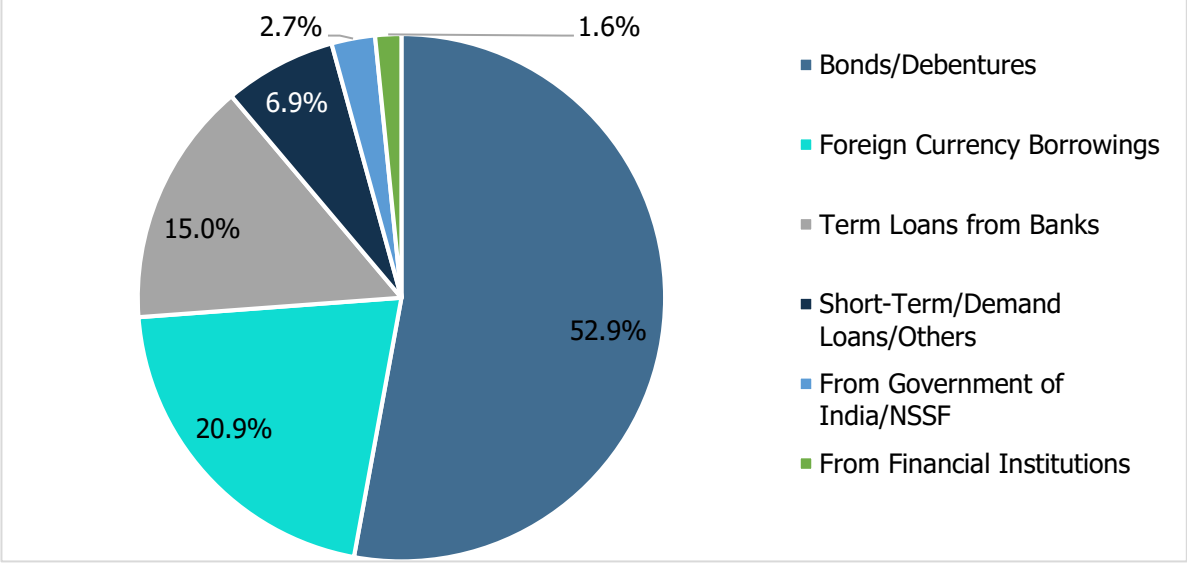
Note: Only 7% of RECs loan book is into renewables as on March 2023
Source: Company reports, CareEdge Research

Chart 103: Asset Mix of REC Ltd



Source: Company reports, CareEdge Research

Chart 104: Resource Profile of REC Ltd as on Mar-23



Source: Company reports, CareEdge Research

8.4 India Infradebt Limited

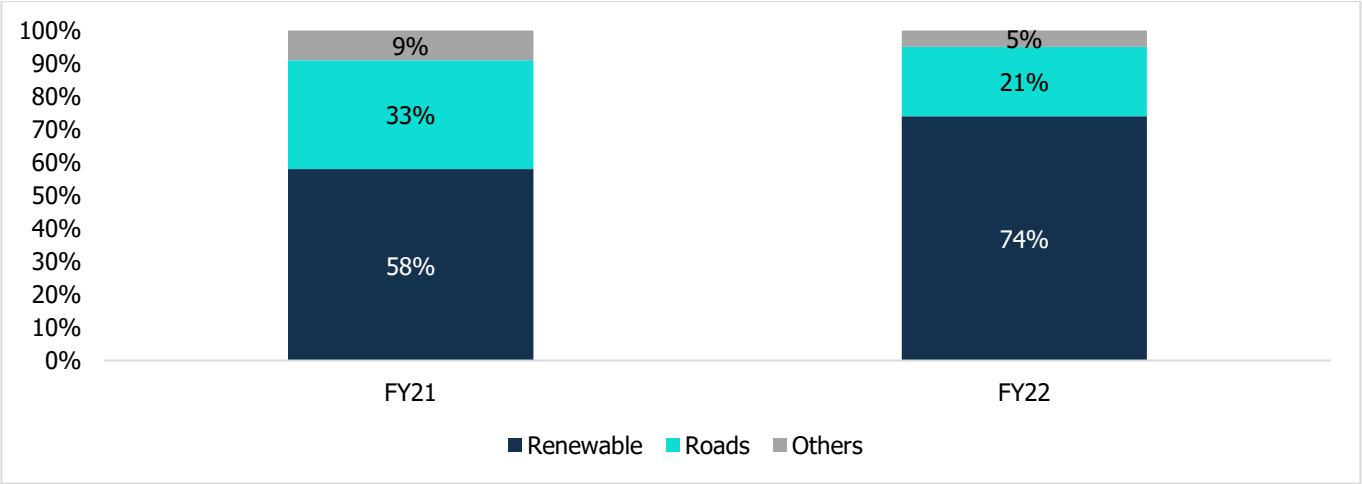
- India Infradebt Limited (Infradebt) is an Infrastructure Debt Fund (IDF) set up under Non-Banking Financial Company (NBFC) format.
- It was set up in 2012 by ICICI Bank, Bank of Baroda, Citicorp Finance, India Ltd and Life insurance corporation of India.
- The objective of the Company is to create an alternative class of funding infrastructure by bringing in long term domestic and offshore institutional investors such as insurance companies, provident and pension funds, banks amongst others.
- India Infradebt primarily invests in operational infrastructure projects such as power, roads and highways, transport, logistics, water and sanitation and more.
- Major chunk of India Infradebt's portfolio comprises of road projects awarded by the National Highways Authority of India and renewable energy projects (wind, solar and hydro).
- As on Mar-23, India Infradebt's loan book reached Rs.174.8 billion.

Table 55: Key financial performance summary of India Infradebt Ltd

Particular	India Infradebt Limited			
	FY21	FY22	FY23	H1FY24
Loan book size or AUM (Rs.Mn.)	1,26,751	1,45,223	1,74,864	NA
Revenue from operations (Rs. Mn)	13,012	14,434	15,932	9,712
Profit after tax (Rs.Mn.)	2,764	3,062	3,505	1,924
Net Interest Income (Rs. Mn)	3,064	3,407	3,749	2,429
Total Debt (Rs.Mn.)	1,23,960	1,42,716	1,62,990	1,81,565
Net Worth (Rs.Mn.)	20,992	23,856	27,173	28,877
Return on assets (%)	1.90%	1.84%	1.84%	0.96%
Return on equity (%)	14.02%	13.65%	13.74%	6.87%
Net Interest Margin (%)	2.54%	2.51%	2.34%	NA
CRAR (%)	22.34%	23.15%	21.79%	19.01%
Gross NPA (%)	0.00%	0.81%	0.74%	0%
Net NPA (%)	0.00%	0.57%	0.33%	0%
Provision coverage ratio (%)	25.02%	30.02%	49.49%	NA
Basic EPS (Rs)	3.19	3.53	4.04	2.22
Diluted EPS (Rs)	3.19	3.53	4.04	2.22

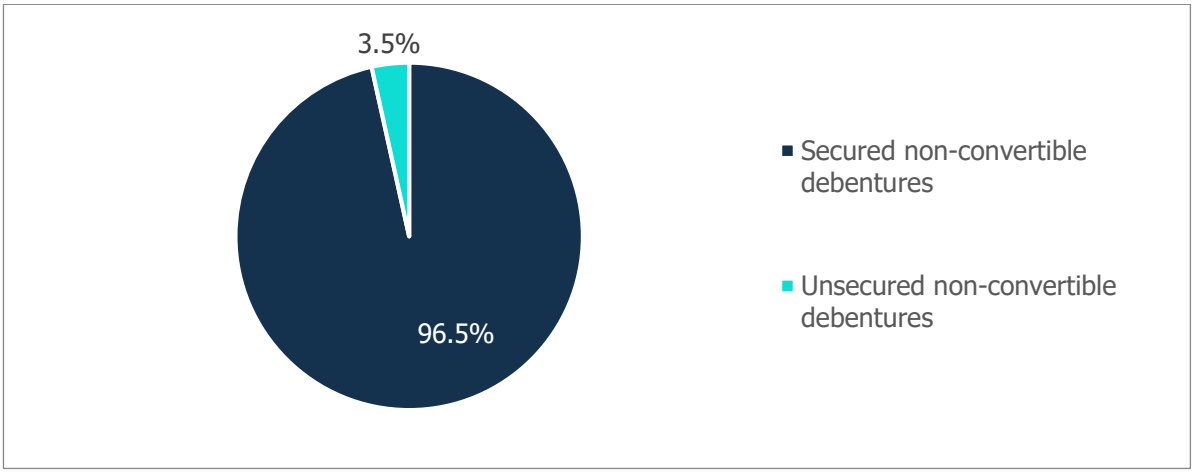
Note: Almost ~75% of India Infradebt Ltd in into renewables as on March 2023
Source: Company reports, CareEdge Research

Chart 105: Asset Mix of India Infradebt Limited



Source: Company reports, CareEdge Research
Note: For FY21- others include telecommunications, oil storage, education, transmission and hospitals projects. For FY22 others include Airports, Telecommunication, Warehousing and Transmission.

Chart 106: Resource Profile of India Infradebt Ltd as on Mar-23



Source: Company reports, CareEdge Research

8.5 Tata Cleantech Capital Ltd (TCCL)

• TCCL, a joint venture between Tata Capital Limited ('TCL') and International Finance Corporation ('IFC'), Washington DC, US is a Systemically Important Non-Deposit Accepting Non-Banking Financial Company that offers end to end business solutions in the clean technology and infrastructure space.
• TCCL services can be categorized into 4 types:
  - Project and structured finance: Underwriting, re-financing & take out finance
  - Debt syndication: Term Loan, Working Capital and Structured Finance
  - Financial advisory: Financial solutions and advisory services including equity fund raise, M&A, strategic partnership and bid advisory.
  - Cleantech advisory: Services on green infrastructure, resource efficiency and strategy development on sustainability.
• TCCL operates in various sectors such as utility scale solar, wind, distributed solar, power transmission, water treatment, small hydro, bioenergy, energy efficiency and e-mobility.
• As on Mar-23, the loan portfolio of the company reached Rs. 104.6 billion.
• The loan portfolio of the Company consists of projects in the wind energy, solar energy, rooftop solar, and other cleantech sectors, accounting for 80% of the funded asset book. The balance of the portfolio is made up of projects in the transmission, road, and other infrastructure sectors. Operational projects account for 62% of the funded asset book.

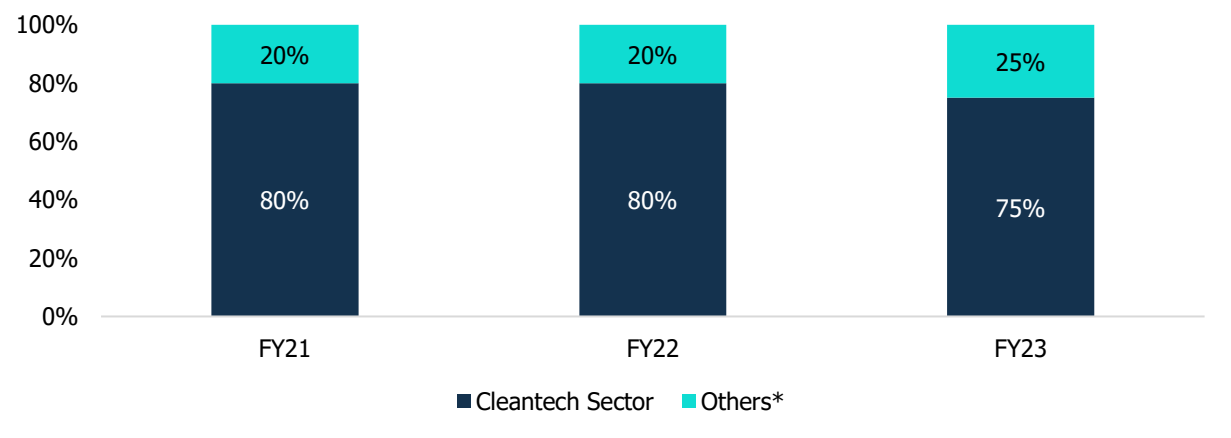
Table 56: Key financial performance summary of TCCL

Particular	Tata Cleantech Capital Ltd (TCCL)			
	FY21	FY22	FY23	H1FY24
Loan book size or AUM (Rs.Mn.)	62,810	78,400	1,04,640	NA
Revenue from operations (Rs. Mn)	6,682	7,041	10,247	6,366
Profit after tax (Rs.Mn.)	1,677	2,038	2,785	1,862
Net Interest Income (Rs. Mn)	2,701	3,243	4,519	2,652
Total Debt (Rs.Mn.)	53,032	67,372	91,866	96,750
Net Worth (Rs.Mn.)	11,625	16,768	19,570	21,409
Return on assets (%)	2.63%	2.69%	2.82%	1.61%

Particular	Tata Cleantech Capital Ltd (TCCL)			
	FY21	FY22	FY23	H1FY24
Return on equity (%)	15.60%	14.36%	15.33%	9.09%
Net Interest Margin (%)	4.64%	4.59%	4.94%	NA
CRAR (%)	24.84%	23.24%	22.20%	NA
Gross NPA (%)	0.96%	0.76%	0.52%	0.48%
Net NPA (%)	0.61%	0.48%	0.18%	0.17%
Provision coverage ratio (%)	63.63%	63.63%	65.00%	65.01%
Basic EPS (Rs)	4.32	4.81	6.06	4.05
Diluted EPS (Rs)	4.32	4.81	6.06	4.05

Source: Company reports, CareEdge Research

Chart 107: Asset Mix of TCCL

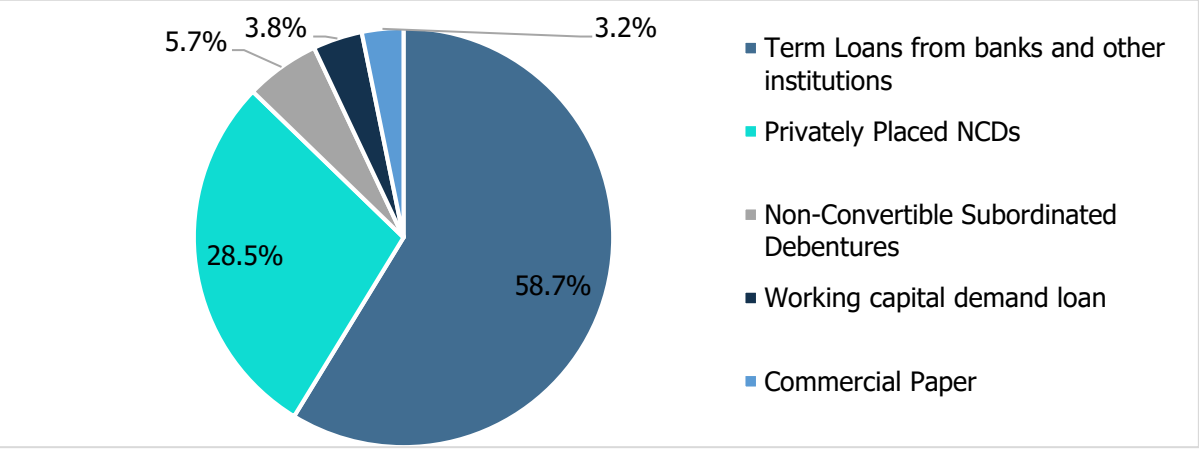


Source: Company reports, CareEdge Research

Note: For FY21 and FY22, cleantech sector includes Wind Energy, Solar Energy, Rooftop Solar and other cleantech sector; others include areas of transmission, roads and other Infrastructure sector.

For FY23, others include Electric Mobility, Energy Efficiency, Green Hydrogen and water treatment projects.

Chart 108: Resource Profile of TCCL as on Mar-23



Source: Company reports, CareEdge Research

8.6 PTC India Financial Services Ltd (PFS)

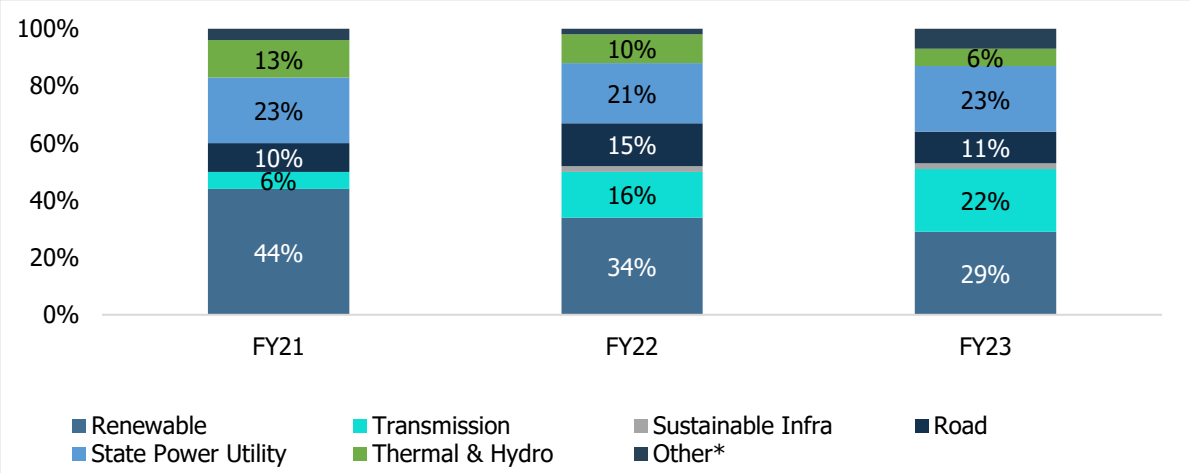
• PFS is a NBFC that primarily involves lending in infrastructure and power sector with a view on sustainable lending.
• The company offers various investment and financing products/solutions such as debt financing (includes Long Term Loan, Short Term Loan as well as Bridge Financing), fee-based services and advisory services.
• The company has been funding to different sectors such as power projects in generation, transmission, renewables, distribution and fuel sources.
• They also invest in equipment manufacturers, engineering, procurement and construction (EPC) Contractors, roads, airports manufacturers and engineering, procurement and construction (EPC) contractors, renewables, transmission, road HAM, annuity projects, e-mobility projects, other sustainable infrastructure projects and other economic strategy sectors.
• As on June 2023, PFS disbursed loans amounting to Rs. 33.2 billion.

Table 57: Key financial performance summary of PFS - Consolidated

Particular	PTC India Financial Services Ltd (PFS)			
	FY21	FY22	FY23	H1FY24
Loan book size or AUM (Rs.Mn.)	1,10,940	86,860	73,390	71,750
Revenue from operations (Rs. Mn)	11,306	9,529	7,909	3,800
Profit after tax (Rs.Mn.)	256	1,300	1,758	965
Net Interest Income (Rs. Mn)	3,537	3,449	3,347	1,615
Total Debt (Rs.Mn.)	94,003	71,214	51,218	48,132
Net Worth or Shareholders Equity (Rs.Mn.)	21,195	22,639	24,427	24,749
Return on assets (%)	0.22%	1.24%	2.05%	1.29%
Return on equity (%)	1.21%	5.93%	7.47%	3.93%
Net Interest Margin (%)	3.15%	3.49%	4.18%	4.40%
CRAR (%)	24.10%	26.71%	33.05%	38.58%
Gross NPA (%)	7.64%	8.29%	13.59%	13.74%
Net NPA (%)	3.08%	4.67%	8.00%	7.44%
Provision coverage ratio (%)	62.01%	46.58%	57.24%	61.86%
Basic EPS (Rs)	0.4	2.02	2.74	1.50
Diluted EPS (Rs)	0.4	2.02	2.74	1.50

Note: Almost ~30% of PFS loan book is into renewables as on March 2023
Source: Company reports, CareEdge Research

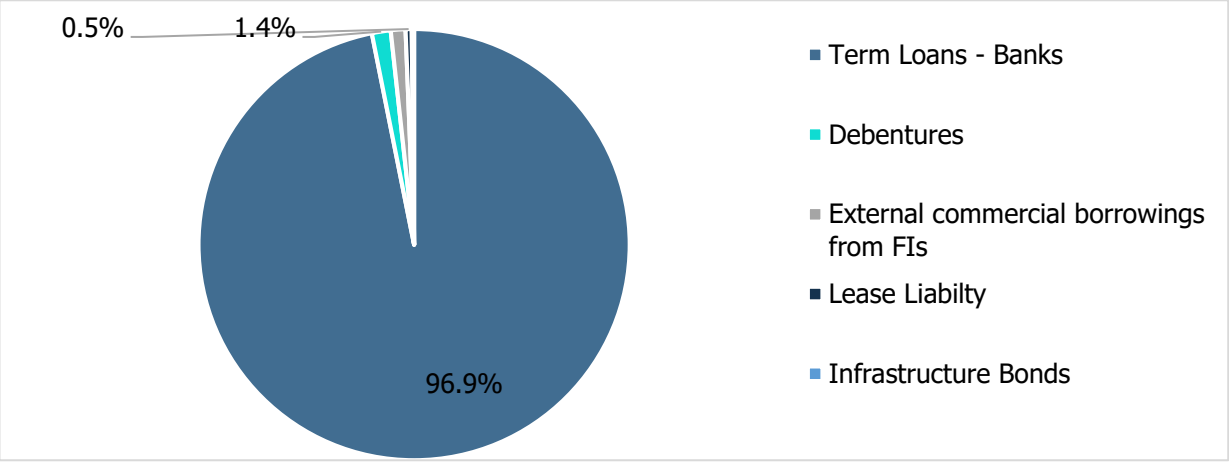
Chart 109: Asset Mix of PFS Ltd



Source: Company reports, CareEdge Research

Note: Others include Port, Manufacturing, Mining, Sustainable Infra include – Water Treatment, E- Mobility

Chart 110: Resource Profile of PFS Ltd as on Mar-23



Source: Company reports, CareEdge Research

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