INDUSTRY OVERVIEW

1. EXECUTIVE SUMMARY

India's energy landscape is transforming significantly, driven by ambitious targets to increase renewable energy capacity and reduce emissions. As of FY 2024, India's total installed power capacity stands at 441.96 GW, with coal remaining the dominant source at 48.46% of the power generation mix[1]. However, renewable energy sources, particularly solar power, have rapidly expanded, with solar energy capacity reaching 81.81 GW, contributing 18.51% to the total capacity[2].

The country's energy demand is set to grow rapidly, driven by urbanization and industrialization, which will require significant investments in generation and grid infrastructure. India has made notable progress in improving electricity access, with over 700 million people gaining access to electricity since 2000[3]. The government continues to focus on providing secure affordable, and sustainable energy while achieving its renewable energy targets and reducing local air pollution[4].

India's energy policy reflects a hybrid approach—supporting fossil fuels for short-term needs while advancing clean energy for long-term sustainability. Achieving its ambitious goals will require stronger implementation strategies, international support, and substantial investments in renewable technologies[5][6].

India's reliance on conventional energy sources remains significant, with thermal power, hydroelectric power, and nuclear power forming the backbone of its electricity generation. The thermal generation capacity in the country constitutes a dominant share of 53.5% of the total capacity in FY2024. Coal production surged to 90.62 million tonnes in November 2024[7], ensuring a stable supply for thermal plants. However, efforts are underway to modernize these plants with supercritical and ultra-supercritical technologies to improve efficiency and reduce emissions[8] [9].

Nuclear power contributes a smaller but important share of India's electricity generation. Nuclear energy offers a reliable and low-carbon option for base-load power generation, aligning with India's long-term climate goals. However, high capital costs and public opposition have slowed its growth. The government is exploring advanced reactor technologies to address these challenges and accelerate capacity expansion. The government, in the Union Budget 2025, has allocated INR 200,000 Mn for development of five indigenously designed and operational Small Modular Reactors ("**SMRs**") by 2033. The Government has also planned to expand nuclear capacity to 100 GW by 2047[10]. Furthermore, the government has introduced the Nuclear Mission for Viksit Bharat, aiming to enhance nuclear energy's role in the energy mix while making the sector more attractive to private investors through policy reforms.

Conventional energy sources continue to be indispensable for meeting India's growing electricity demand and ensuring energy security. While renewable energy is expanding rapidly, thermal, hydroelectric, and nuclear power remain critical for maintaining grid reliability and supporting industrial growth. Investments in modernizing infrastructure and adopting cleaner technologies are essential to balance economic development with environmental sustainability. India has set ambitious renewable energy targets, aiming for 500 GW of non-fossil fuel capacity by 2030, which includes solar, wind,

[1] https://www.india-briefing.com/news/indias-power-sector-in-2025-investor-outlook-36367.html/
[2] https://www.india-briefing.com/news/indias-power-sector-in-2025-investor-outlook-36367.html/
[3] https://www.iea.org/countries/india
[4] https://www.iea.org/countries/india
[5] https://www.iisd.org/publications/report/mapping-india-energy-policy-2023
[6] https://www.globallegalinsights.com/practice-areas/energy-laws-and-regulations/india/
[7] https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2079525#:~:text=The%20Ministry%20of%20Coal%20has,of%205.45%25%20(Provisional).
[8] https://www.globaldata.com/store/report/india-thermal-power-market-analysis/
[9] https://www.investindia.gov.in/sector/thermal-power
[10] https://ember-energy.org/latest-insights/union-budget-2025-focusing-on-long-term-energy-security-and-domestic-manufacturing/

hydro, and biomass energy. As of FY 2024, India's total renewable energy capacity has surpassed 191 GW, marking significant progress toward this goal. Solar energy is a leading component[11].

Despite the expansion of renewables, challenges such as grid integration and storage solutions persist. Hydropower remains crucial for balancing renewable intermittency, though environmental concerns and project delays hinder its growth. Nuclear power, accounting for a small share, is being increasingly focused on as a stable, low-carbon energy source, with plans to expand it over the next two decades[12]. India's energy trajectory is critical for achieving global climate goals, given its growing economic influence and population. The country's progress in renewable energy positions it as a potential leader in clean energy globally[13].

India has set ambitious Nationally Determined Contribution ("**NDC**") targets, including achieving 50% of its total installed capacity from non-fossil energy sources. India's non-fossil fuel energy capacity reached around 200.00 GW in FY 2024, underscoring the country's commitment to reducing its reliance on fossil fuels[14]. The electricity generated for FY 2024 was 1,739.01 billion units, reflecting a growth of around 7.06% over the previous year[15]. This growth in electricity demand highlights the need for continued investments in renewable energy and grid infrastructure to ensure a sustainable energy future for India.

India's National Energy Policy aims to balance energy security, economic growth, and environmental sustainability. It is shaped by the need to meet growing energy demand while transitioning to cleaner energy sources. The policy framework integrates multiple initiatives, including the National Electricity Plan 2023 ("**NEP 2023**"), the National Green Hydrogen Mission, and amendments to the Energy Conservation Act. These efforts align with India's commitment to achieving 500 GW of non-fossil fuel capacity by 2030 and reducing emission intensity by 45% from 2005 levels by the same year[16]. The plan emphasizes the need for significant investments in the Transmission, Distribution, and Generation Infrastructure, in FY 2024 it was INR 1,856.04 billion[17], to meet growing electricity demand. The government's approach involves encouraging private sector participation through policy incentives and public-private partnerships to enhance efficiency and attract capital. Renewable energy is expanding rapidly, now accounting for more than 33.00% of total capacity, driven by solar and wind power.

Challenges persist in phasing out coal and integrating renewable energy into the grid. The government plans to add 80 GW of coal power capacity by 2031-32 to meet rising demand, even as international models suggest coal must be phased out entirely by 2040 for India to align with a 1.5 °C pathway[18]. Enhancing grid flexibility and storage solutions is essential for renewable integration.

The Government of India has been actively investing in the power and energy sector to ensure long-term energy security and sustainability. In the Union Budget 2025, significant allocations were made to support renewable energy, nuclear power, and electric mobility. The budget for the Ministry of New and Renewable Energy ("**MNRE"**) was increased by 39% to INR 256.49 billion, with a substantial portion dedicated to solar energy initiatives, including INR 241 billion for solar-related projects[19]. This emphasis on solar energy reflects the government's commitment to achieving its renewable energy targets.

The National Green Hydrogen Mission launched with a budget of INR 197.44 Bn through FY2030, aims to make India a global hub for green hydrogen production and export. This complements other initiatives like the National Electric Mobility Mission, which promotes electric vehicles ("**EVs**") and hybrid technologies. Investments in clean energy are critical to meet renewable targets by 2030[20][21].

[11] https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2073038
[12] https://www.india-briefing.com/news/indias-power-sector-in-2025-investor-outlook-36367.html/
[13] https://www.iea.org/countries/india
[14] https://pib.gov.in/PressReleasePage.aspx?PRID=2098441
[15] https://powermin.gov.in/sites/default/files/uploads/power_sector_at_glance_Aug_2024.pdf
[16] https://climateactiontracker.org/countries/india/policies-action/
[17] https://www.india-briefing.com/news/indias-power-sector-in-2025-investor-outlook-36367.html/
[18] https://climateactiontracker.org/countries/india/policies-action/
[19] https://www.orfonline.org/expert-speak/budget-2025-powering-india-s-green-energy-future
[20] https://climateactiontracker.org/countries/india/policies-action/
[21] https://www.trade.gov/country-commercial-guides/india-renewable-energy

In terms of policy support, India allows 100% foreign direct investment under the automatic route for renewable energy generation and distribution projects, subject to provisions of the Electricity Act 2003. This liberal FDI policy, combined with assured demand driven by government bids and forward-looking policies like the waiver of inter-state transmission charges, makes India an attractive destination for renewable energy investments. The government's continued efforts to enhance the regulatory framework and provide incentives for renewable energy projects are crucial for achieving its ambitious energy targets.

Moreover, the government has been promoting investments in renewable energy projects, including wind, solar, and hydroelectric power, to accelerate the transition to a cleaner energy mix. India's commitment to green energy aligns with its Net Zero by 2070 goal, ensuring long-term sustainability while strengthening its energy security.

2. MACROECONOMIC OVERVIEW

2.1 Economic Growth and Industrial Development Outlook (Global and India)

Global economic growth is expected to remain moderate, with major economies facing challenges like inflation, geopolitical tensions, and supply chain disruptions. However, emerging markets, especially in Asia, are expected to clock faster growth driven by technology adoption and industrial expansion. In India, the outlook is optimistic with strong industrial development, supported by initiatives like "Make in India" and infrastructure improvements. Growth in sectors such as manufacturing, renewable energy, and digital technologies could drive economic progress, making India a key player in global industrial development. Challenges like labour market reforms and climate adaptation will need to be addressed for sustained growth.

2.1.1 Global GDP Growth

Figure Error! No text of specified style in document.**.1: Percentage Change in Global GDP, 2018-2029 F**

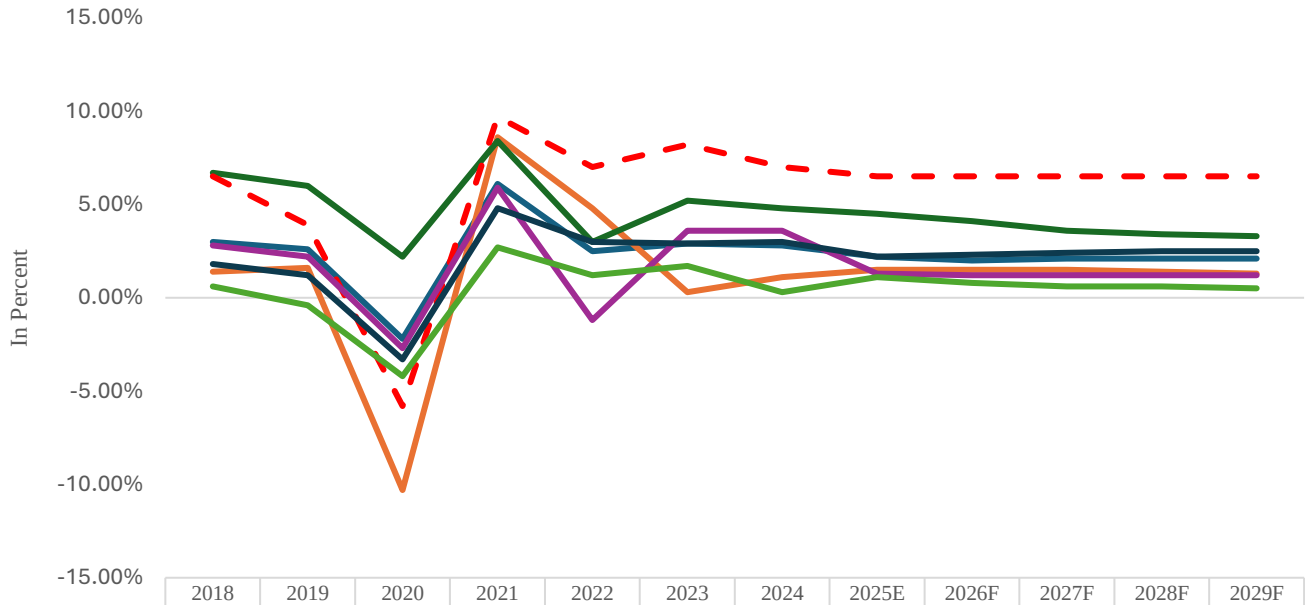
Source: International Monetary Fund (IMF) and Frost & Sullivan Analysis

Global GDP growth witnessed significant fluctuations between 2018 and 2024, marked by periods of strong growth, economic slowdowns, and the effects of major global events. In 2018, global growth was strong at 3.60%, driven by high consumer demand, trade, and investments in both advanced and emerging markets. However, growth slowed to 2.90% in 2019, mainly due to trade tensions, especially between the U.S. and China, and a decline in global manufacturing. The pandemic in 2020 triggered an unprecedented global recession, with GDP shrinking by 2.70% as widespread lockdowns, production

disruptions, and a sharp fall in international trade and travel took their toll. The global economy rebounded sharply in 2021, growing by 6.60%, fueled by vaccine rollouts, government stimulus measures, and pent-up demand as economies reopened. However, growth moderated in 2022 to 3.60%, as inflationary pressures and geopolitical tensions, particularly Russia's invasion of Ukraine, slowed economic activity. In 2023, global growth further decelerated to 3.30%, influenced by tighter monetary policies, ongoing supply chain challenges, and a volatile global economic environment. Projections for 2025 E suggest continued slowdown, with growth expected to reach 3.20%, further easing to 3.10% by 2029 F.

2.1.2 GDP Comparison India VS Advanced Economies VS EM and developing economies

Figure Error! No text of specified style in document.**.2: GDP Growth Trends in Key Economies, 2018-2029 F**



	2018	2019	2020	2021	2022	2023	2024	2025E	2026F	2027F	2028F	2029F
USA	3.00%	2.60%	-2.20%	6.10%	2.50%	2.90%	2.80%	2.20%	2.00%	2.10%	2.10%	2.10%
UK	1.40%	1.60%	-10.30%	8.60%	4.80%	0.30%	1.10%	1.50%	1.50%	1.50%	1.40%	1.30%
China	6.70%	6.00%	2.20%	8.40%	3.00%	5.20%	4.80%	4.50%	4.10%	3.60%	3.40%	3.30%
India	6.50%	3.90%	-5.80%	9.70%	7.00%	8.20%	7.00%	6.50%	6.50%	6.50%	6.50%	6.50%
Russia	2.80%	2.20%	-2.70%	5.90%	-1.20%	3.60%	3.60%	1.30%	1.20%	1.20%	1.20%	1.20%
Japan	0.60%	-0.40%	-4.20%	2.70%	1.20%	1.70%	0.30%	1.10%	0.80%	0.60%	0.60%	0.50%
Brazil	1.80%	1.20%	-3.30%	4.80%	3.00%	2.90%	3.00%	2.20%	2.30%	2.40%	2.50%	2.50%

Source: International Monetary Fund (IMF) and Frost & Sullivan Analysis

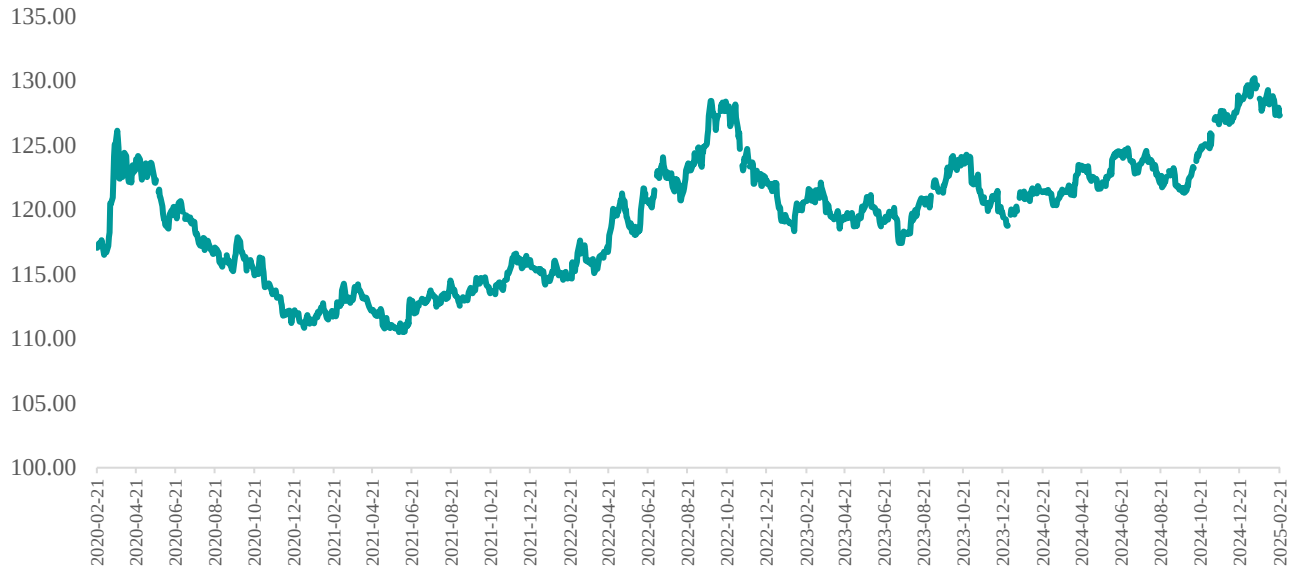
In 2018, advanced economies like the USA and the UK experienced moderate growth, with the USA at 3.00% and the UK at 1.40%. In contrast, emerging economies such as China and India saw stronger growth, with China at 6.70% and India at 6.50%, reflecting their rapid economic expansion. However, 2019 brought a global slowdown, with advanced economies like the USA and the UK registering lower growth, while India maintained a robust 3.90% growth. China's growth slowed to 2.20%, and India faced a sharp decline of -5.80% in 2020. The recovery in 2021 was strong, with India leading at 9.70%, followed by China at 8.40% and the USA at 6.10%. Growth slowed again in 2022, with advanced economies such as the UK and Japan witnessing weaker growth, while India continued its strong recovery at 7.00%. Looking forward, advanced economies are expected to experience slow growth, with moderate expansions in the USA, UK, and Japan. In contrast, emerging economies, especially India, are projected to maintain higher growth rates, fueled by a young population, infrastructure development, and digital transformation.

2.1.3 Global Currency Market

The global currency market, known as the foreign exchange ("**Forex**") market, is the largest and most liquid financial market in the world. As of April 2022, the average daily turnover in this market was approximately USD 7.50 Tr[22]. This market operates primarily through an Over-The-Counter ("**OTC**") system, meaning that transactions occur directly between parties rather than through a centralized exchange. There are five trading instruments in Forex, namely Options and Others, Currency Swap, Forex Swap, Outright Forwards and Spot Market. Out of these FX Trading (includes both spot and derivatives) accounts to more than 50.00% of the total trading value.

2.1.3.1 US Dollar Index Movement

Figure Error! No text of specified style in document.**.3: US Dollar Index, 2020-2025**



Source: Federal Reserve Bank and Frost & Sullivan Analysis | Note: 2025 data is up to 21st February 2025 [23]

The U.S. Dollar Index (**USDX**), which measures the dollar's strength against a basket of six major currencies, has experienced notable movements influenced by a combination of economic factors and shifting market expectations. The index includes the Euro (**EUR**), Japanese Yen (**JPY**), British Pound (**GBP**), Canadian Dollar (**CAD**), Swedish Krona (**SEK**) and Swiss Franc (**CHF**), with the Euro having the highest weighting.

Recent Performance

Since October 2024, the U.S. dollar has surged over 7.00%[24], driven by expectations related to potential economic policies and the Federal Reserve's (Fed) monetary stance. However, the U.S. Dollar Index slipped from its November 2-year high of 108.07 to a weekly low of 105.60, marking its first negative week in November.

October 2024: The index began at 105.71 points, averaged 104.48, and closed the month at 104.03, representing a 1.60% decrease.

November 2024: It started at 104.03 points, averaged 105.33, and ended at 105.84, showing a 1.70% increase.

[22] https://www.bis.org/publ/qtrpdf/r_qt2212f.htm
[23] https://fred.stlouisfed.org/series/DTWEXBGS
[24] https://www.ig.com/au/news-and-trade-ideas/_us-dollar-index-fundamental-and-technical-analysis-outlook-for--241129

December 2024: The index began at 105.84 points and is expected to reach 106.18 by the end of the month, a 0.30% increase.

Factors Influencing the Dollar

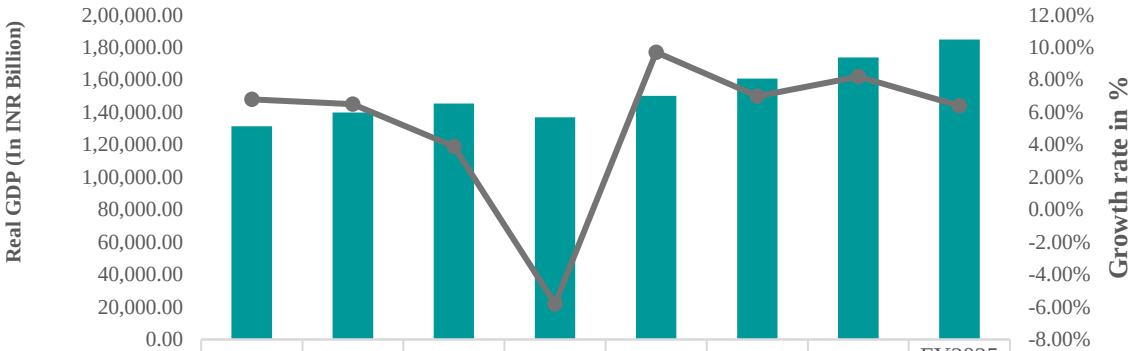
Federal Reserve Policies: The dollar's strength is closely tied to the Federal Reserve's decisions on interest rates and monetary policy. Expectations of less easing by the Fed have generally supported dollar strength.

Economic Data: Strong U.S. services data, resilient retail sales, and an uptick in core inflation have contributed to the dollar's strength.

Geopolitical Tensions: The dollar typically strengthens during periods of heightened geopolitical tension, benefiting from its safe-haven status.

2.1.4 Indian GDP

Figure Error! No text of specified style in document.**.4: Indian Real GDP (In INR Bn) & Growth Rate (In Percentage), FY 2018 – FY 2024**



	FY2018	FY2019	FY2020	FY2021	FY2022	FY2023	FY2024	FY2025 E
Real GDP	1,31,445.	1,39,929.	1,45,346.	1,36,871.	1,50,218.	1,60,714.	1,73,817.	1,84,883.
Growth Rate	6.80%	6.50%	3.90%	-5.80%	9.70%	7.00%	8.20%	6.40%

Source: Ministry of Statistics and Program Implementation (Mospi) and Frost & Sullivan Analysis | Note: FY refers to 1st April to 31st March

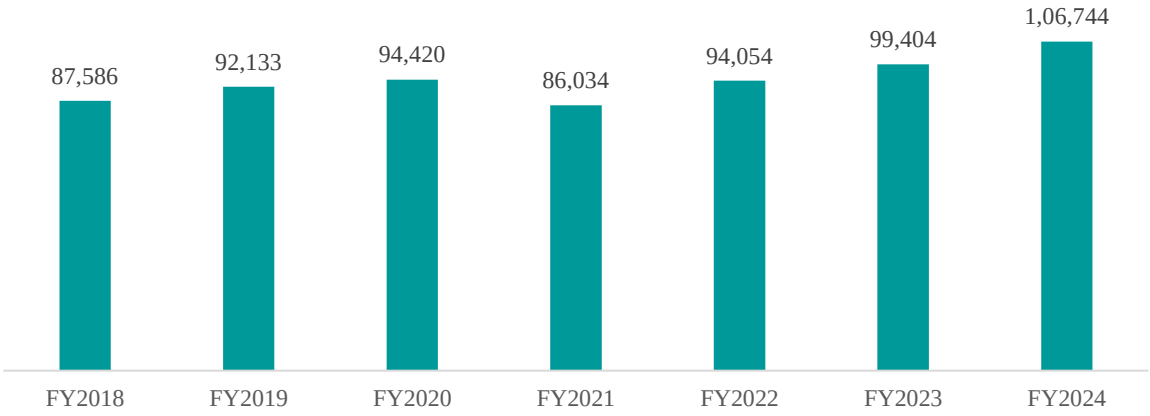
The Indian economy is currently experiencing moderate growth, driven by strong domestic consumption, a thriving services sector, and rising foreign investments. Despite resilience in industrial output, challenges such as global economic uncertainties and inflationary pressures continue to impact the broader macroeconomic environment. India's real GDP has followed a dynamic trajectory in recent fiscal years, showing both resilience and volatility. The economy rebounded in FY2022, growing by 9.70% and pushing the GDP to INR 150,218.46 Bn. This positive momentum carried into FY2023, with a 7.00% growth rate, bringing GDP to INR 160,714.29 Bn FY2024 witnessed a growth at 8.20%, with an GDP of INR 173,817.22 Bn, signaling a robust recovery and optimism for continued economic expansion.

2.1.5 Per Capita Income

India's per capita income, a measure of the average income earned per person, has seen substantial changes in recent years. In FY 2023, the per capita at constant prices was estimated at INR 99,404, it increased 13.49% compared to FY 2018. The per capita experienced a 7.38% increase in FY2024 compared to FY 2023[25].

[25] https://iced.niti.gov.in/economy-and-demography/key-economic-indicators/socio-economic

Figure Error! No text of specified style in document.**.5: Per Capita Income in India (In INR), FY 2018 – FY 2023**

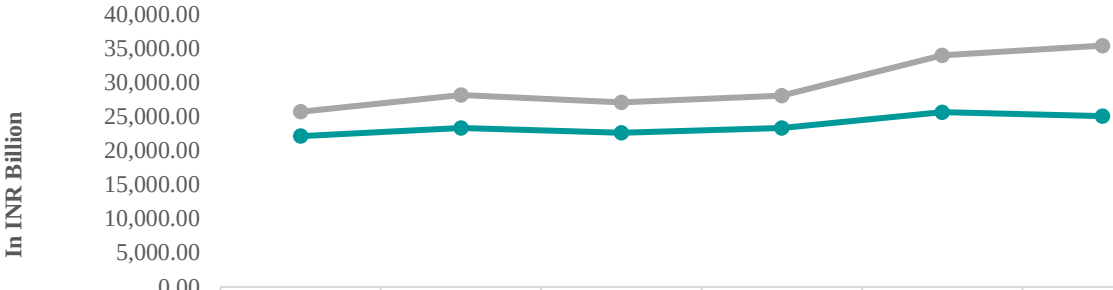


Source: NITI Aayog and Frost & Sullivan | Note: Constant | Note: FY refers to 1st April to 31st March

2.1.6 Contributions in Gross Value Added (GVA) in India

India's Gross Value Added (GVA) has shown steady growth in recent years, reflecting the resilience of the economy. In nominal terms, GVA increased from INR 25,666.23 Bn in FY 2018 to INR 35,364.61 Bn in FY 2023 with the expected CAGR of 6.62%, highlighting robust expansion driven by industrial output, services, and agriculture. In real terms, GVA grew from INR 22,094.28 Bn in FY 2018 to INR 25,046.63 Bn in FY 2023 with the projected CAGR of 2.54% for the given period.

Figure Error! No text of specified style in document.**.6: Contributions in Gross Value Added (GVA) in India (In INR Bn), FY 2018 – FY 2023**



	FY2018	FY2019	FY2020	FY2021 (TRE)	FY2022 (SRE)	FY2023 (FRE)
Nominal GVA	25,666.23	28,125.60	27,051.01	28,034.95	33,926.05	35,364.61
Real GVA	22,094.28	23,289.92	22,597.06	23,291.60	25,610.33	25,046.63

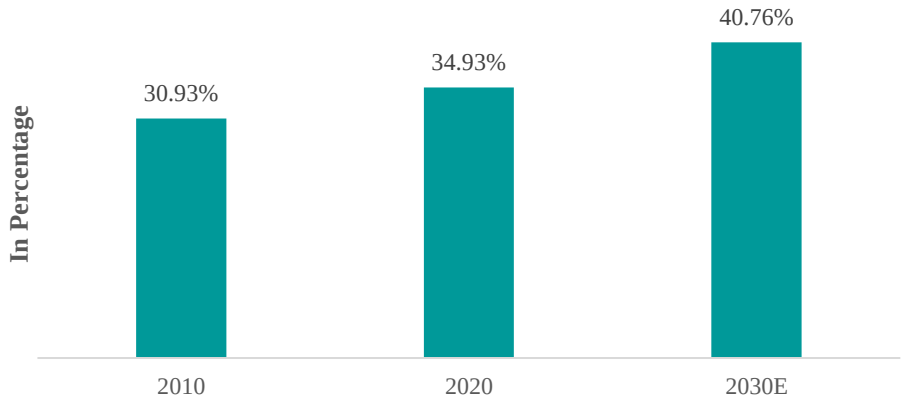
Source: Ministry of Statistics and Programme Implementation (MoSPI)|Note: TRE- Third Revised Estimate, SRE- Second Revised Estimates, FRE- First Revised Estimates | Note: FY refers to 1st April to 31st March

2.1.7 Urbanization

India is undergoing a significant transformation driven by urbanization, which is reshaping its demographic and economic landscape. As of 2023, approximately one-third of India's population lives in urban areas, reflecting an increase of over 4.00% in urbanization over the past decade. This shift is largely attributed to the migration of people from rural areas in search of better employment

opportunities, particularly in the burgeoning service sector, which has become increasingly dominant compared to agriculture.

Figure Error! No text of specified style in document.**.7: Urban Population in India, 2010 – 2030 E**



Source: World Bank and Frost & Sullivan Analysis

The urban population has been steadily increasing over the years, reflecting a shift from rural to urban living. In 2010, only 30.93% of the population resided in urban areas. By 2020, this number rose to 34.93%[26], indicating growing urbanization driven by economic opportunities, infrastructure development, and migration. Projections for 2030 suggest that 40.76%[27] of the population will be living in cities, highlighting a continued trend toward urban expansion. This shift is likely influenced by industrial growth, improved living conditions, and government policies supporting urban development.

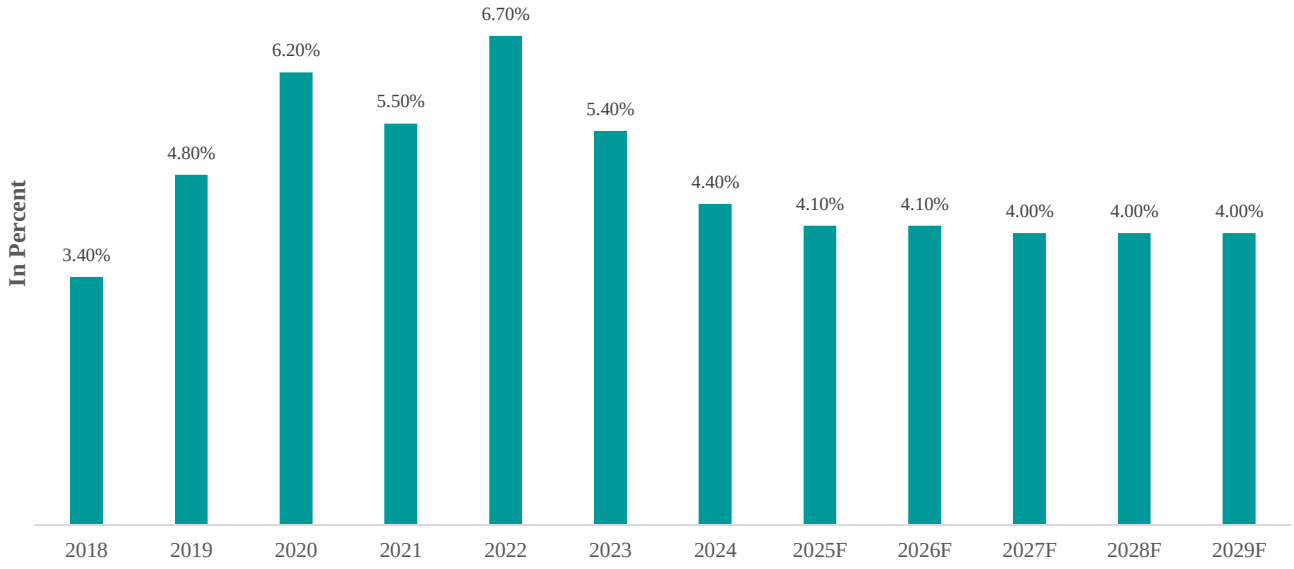
2.1.8 Inflation

India's inflation has fluctuated in recent years due to global and domestic factors. It was 3.40% in 2018, rising to 4.80% in 2019, and peaked at 6.20% in 2020 due to pandemic disruptions. After easing to 5.50% in 2021, it did rise again to 6.70% in 2022 due to supply chain issues and higher commodity prices. Inflation moderated to 5.40% in 2023, with forecasts showing a decline to 4.40% in 2024 and 4.00% in 2029 F.

Figure Error! No text of specified style in document.**.8: Inflation in India (In Percentage), 2018 - 2029 F**

[26] https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=IN

[27] https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2042542#:~:text=As%20cited%20in%20the%20latest%20Economic%20Survey,India's%20population%20will%20live%20in%20urban%20areas.&text=As%20cited%20in%20the%20latest%20Economic%20Survey,India's%20population%20will%20live%20in%20urban%20areas.



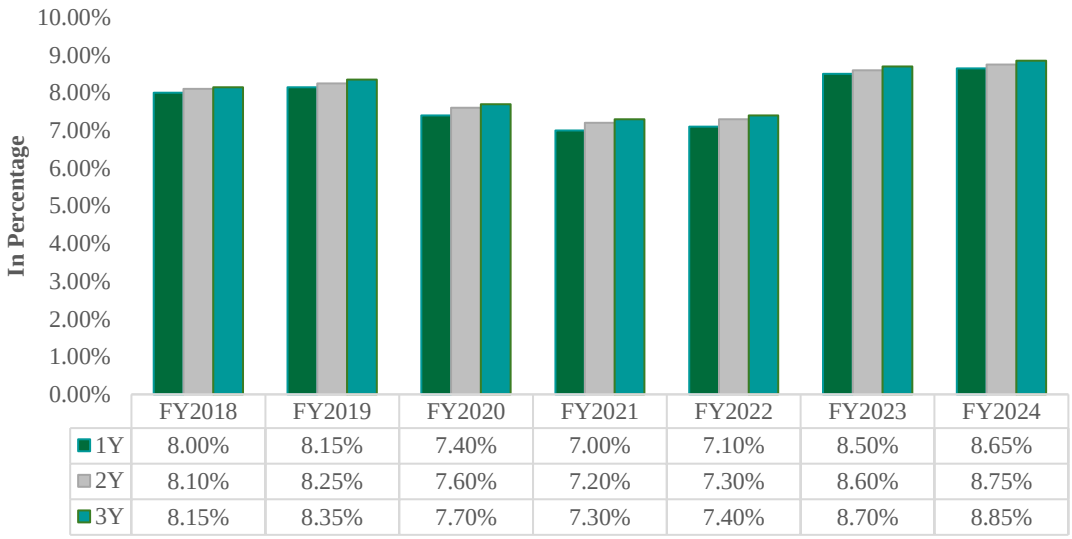
Source: International Monetary Fund (IMF)

2.1.9 Interest Movements in India

The Reserve Bank of India unanimously lowered its key repo rate by 25 basis points to 6.25% in February 2024[28], marking the first reduction since May 2020 and aligning with market consensus. This move brought borrowing costs to their lowest level since January 2023, aiming to counter slowing economic growth amid rising global trade uncertainty. Simultaneously, the RBI also slashed both the standing deposit facility (SDF) rate by 25 bps to 6.00% and the marginal standing facility (MSF) and bank rates to 6.50%. Meanwhile, the RBI maintained the CRR at 4.00% after a 50-bps reduction in December. The below Figureshows the Marginal Cost Lending Rate (MCLR) between the years FY2018-FY2024[29]

Figure Error! No text of specified style in document.**.9: Marginal Cost Lending Rates (In Percentage), FY 2018 – FY 2024**

[28] https://www.moneycontrol.com/economic-calendar/india-rbi-interest-rate-decision/4870699
[29] https://sbi.co.in/web/interest-rates/interest-rates/mclr-historical-data

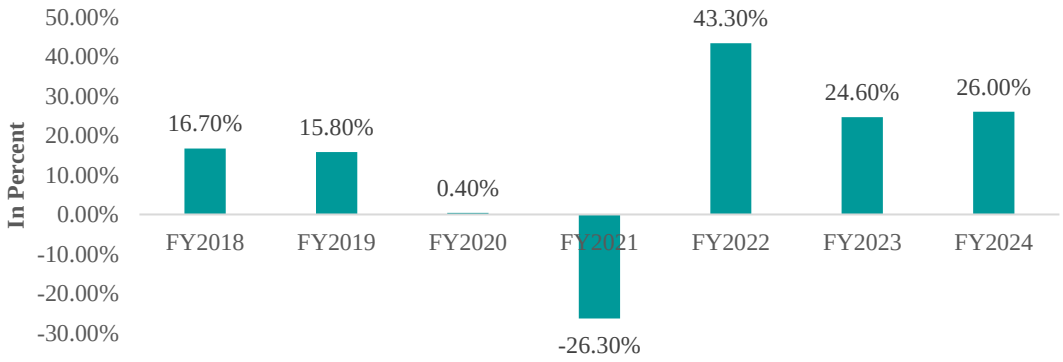


	FY2018	FY2019	FY2020	FY2021	FY2022	FY2023	FY2024
1Y	8.00%	8.15%	7.40%	7.00%	7.10%	8.50%	8.65%
2Y	8.10%	8.25%	7.60%	7.20%	7.30%	8.60%	8.75%
3Y	8.15%	8.35%	7.70%	7.30%	7.40%	8.70%	8.85%

Source: State Bank of India (SBI) and Frost & Sullivan Analysis | Note: FY refers to 1st April to 31st March

2.1.10 Industrial Growth in India (IIP)

Figure Error! No text of specified style in document.**.10: Growth Rate of IIP in India (In Percentage), FY 2018 – FY 2024**



Source: Ministry of Statistics and Programme Implementation (Mospi) and Frost & Sullivan Analysis | Note: FY refers to 1st April to 31st March

India's Index of Industrial Production (IIP) growth serves as a key indicator of the industrial sector's health, covering manufacturing, mining, and electricity. In recent years, IIP growth has been driven by increased production in critical sectors such as capital goods, infrastructure, and consumer durables, supported by growing domestic demand and policy backing. The overall growth rate of the IIP highlights the shifting performance of India's industrial sectors. After steady growth of 16.70% in FY 2018 and 15.80% in FY 2019, the IIP slowed to just 0.40% in FY 2020 due to both global and domestic challenges. The sector saw a sharp contraction of -26.30% in FY 2021 amid the COVID-19 pandemic. However, a strong recovery followed, with growth of 43.30% in FY 2022, 24.60% in FY 2023, and 26.00% in FY 2024.

2.1.11 Atmanirbhar Bharat Abhiyan

The Atmanirbhar Bharat Abhiyan, or Self-Reliant India campaign, was launched by Prime Minister Narendra Modi on May 12, 2020[30], as a response to the economic challenges posed by the COVID-19

[30] https://pib.gov.in/PressReleasePage.aspx?PRID=1660691

pandemic. The initiative encompasses a comprehensive economic package of INR 20.00 Tn, which is approximately 10.00% of India's GDP, aimed at fostering self-reliance across various sectors of the economy.

Objectives

The primary goal of the Atmanirbhar Bharat Abhiyan is to make India self-sufficient by strengthening its economic framework and reducing dependency on imports. The initiative seeks to transform the crisis brought on by the pandemic into an opportunity for growth and development. It promotes local manufacturing and aims to enhance the competitiveness of Indian products in global markets.

Five Pillars of Atmanirbhar Bharat Abhiyan

Economy: Focusing on creating a robust economic environment that supports growth and innovation.

Infrastructure: Developing infrastructure to improve connectivity and logistics, thereby enhancing industrial productivity.

System: Reforming governance systems, including simplifying laws and regulations to create an enabling environment for businesses.

Demography: Leveraging India's demographic dividend by investing in skill development and employment opportunities.

Demand: Stimulating domestic demand to drive consumption and economic activity.

2.1.12 PLI

The Production Linked Incentive (PLI) schemes in India aim to enhance the country's manufacturing capabilities and exports, supporting the vision of becoming 'Atmanirbhar' (self-reliant). The government has announced PLI schemes for 14 key sectors with an outlay of Rs. 1.97 Tn

Objectives

- Attract investments in key sectors and cutting-edge technology
- Ensure efficiency and economies of scale in the manufacturing sector
- Make Indian companies and manufacturers globally competitive
- Boost domestic manufacturing in sunrise and strategic sectors
- Curb cheaper imports and reduce import bills.
- Improve the cost competitiveness of domestically manufactured goods.
- Enhance domestic capacity and exports.

The 14 sectors covered under the PLI schemes are:

1. Mobile Manufacturing and Specified Electronic Components
2. Critical Key Starting Materials/Drug Intermediaries & Active Pharmaceutical Ingredients
3. Manufacturing of Medical Devices
4. Automobiles and Auto Components
5. Pharmaceuticals Drugs

6. Specialty Steel

7. Telecom & Networking Products

8. Electronic/Technology Products

9. White Goods (ACs and LEDs)

10. Food Products

11. Textile Products: MMF segment and technical textiles

12. High-efficiency solar PV modules

13. Advanced Chemistry Cell (ACC) Battery

14. Drones and Drone Components

Implementation and Impact

- The schemes are in various stages of implementation by the concerned Ministries/Departments, with all 14 sectors notified after due approval
- The PLI scheme is expected to significantly boost production, employment, and economic growth over the next five years
- The scheme is also expected to have a cascading effect on the MSME ecosystem by creating a new supplier/vendor base in the entire value chain
- As of November 2023, PLI scheme clocks INR 1.46 Tn in investment, INR 12.50 Tn in production, INR 4.00 Tn in exports and generates 0.95 million jobs.

2.2 Global Overview of capital goods sector – Key trends, drivers, and investment

The capital goods sector, encompassing machinery, equipment, and infrastructure essential for industrial production, plays a vital role in supporting industries like manufacturing, construction, transportation, and energy. As global economic dynamics shift, the sector is undergoing a transformation driven by technological advancements, sustainability imperatives, and supply chain changes.

Key Trends

- **Digitalization and Industry 4.0:**

Advanced technologies such as automation, AI, IoT, big data, and robotics are reshaping manufacturing. Industry 4.0 fosters smart factories where machines communicate autonomously, enhancing efficiency, reducing costs, and improving product quality. Key elements include predictive maintenance, real-time monitoring, and data-driven decision-making.

- **Sustainability and Green Technologies:**

In response to climate change, capital goods companies are prioritizing renewable energy infrastructure, EV manufacturing, and sustainable production practices. Innovations in wind turbines, solar panels, and circular economy initiatives are becoming critical drivers of growth.

- **Reshoring and Supply Chain Transformation:**

The pandemic exposed global supply chain vulnerabilities, prompting businesses to relocate production closer to home. This shift is fuelling demand for new factories and logistics infrastructure, particularly in sectors like automotive and electronics.

- **Digital Twin Technology:**

Digital twins—virtual replicas of physical assets—are gaining traction as tools for simulating, predicting, and optimizing machine and factory performance. They improve planning, reduce downtime, and enhance operational efficiency.

- **Customization and Modularization:**

As demand for personalized products grows, manufacturers are adopting flexible and modular production systems to rapidly adjust for varying specifications, particularly in aerospace, automotive, and consumer electronics sectors.

This evolution highlights the sector's adaptability and strategic importance in driving economic growth and innovation.

Key Drivers of Growth in the Capital Goods Sector

- **Global Trade and Export Potential:**

Indian manufacturers are increasingly tapping global markets, particularly in emerging economies. Competitive pricing, technological advancements, and skilled labour have boosted exports in sectors like construction, mining, and automotive.

- **Public-Private Partnerships (PPPs):**

Government-private collaborations in large infrastructure projects such as highways and railways accelerate development and drive demand for machinery and engineering equipment, including renewable energy solutions.

- **Smart Infrastructure:**

The rise of smart cities and digital infrastructure demands innovative solutions like energy-efficient systems, automated traffic management, and smart grids, spurring demand for advanced capital goods.

- **Skilled Workforce Advantage:**

A young, skilled workforce supported by government skill development initiatives ensures a steady supply of trained personnel for advanced manufacturing and technological operations.

- **Customized Solutions:**

Growing demand for specialized equipment drives innovation in aerospace, defense, healthcare, and clean technologies, offering new market opportunities.

- **Cost-Competitive Manufacturing:**

India's affordable labour, improving infrastructure, and favourable business climate position it as a cost-effective manufacturing hub.

- **Heavy Industry Investments:**

Growth in sectors like steel, cement, and mining propels demand for capital goods such as material handling systems and transport machinery.

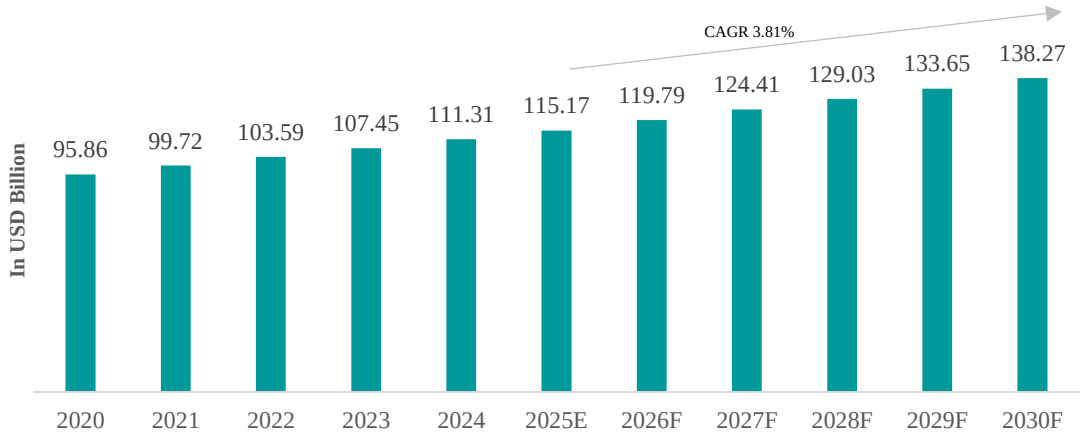
- **Sustainability-Driven Innovation:**

Focus on energy-efficient, low-emission machinery aligns with global environmental standards, enhancing export potential.

2.3 Indian Capital Goods Sector

The Indian capital goods sector plays a pivotal role in manufacturing, construction, energy, and infrastructure. Its growth is driven by evolving trends and strategic investments.

Figure Error! No text of specified style in document.**.11: Indian Capital Good Sector (In USD Bn), 2020 – 2030 F**



Source: All India Association of Industries and Frost & Sullivan Analysis

The Indian capital goods market is expected to grow at a CAGR of 3.81% between the years 2025 E to 2030 F. The Indian capital goods market is estimated at USD 115.17 Bn in 2025 E and is expected to reach USD 138.27 Bn in 2030 F[31].

2.3.1 Key Growth Drivers

- **Sustainability and Green Initiatives:** Demand for energy-efficient machinery and renewable energy solutions, like wind turbines and EV infrastructure, is rising due to environmental concerns.
- **Infrastructure Development:** Investments in tier-2 and tier-3 cities for transportation, housing, and energy spur demand for construction equipment and road machinery.
- **Digitalization of Manufacturing:** The adoption of smart technologies like AI, data analytics, and IoT drives demand for robotics and advanced industrial equipment.
- **Advanced Manufacturing Techniques:** Technologies like 3D printing and precision engineering enhance production efficiency in industries such as aerospace and automotive.
- **Contract Manufacturing:** Growing outsourcing to local suppliers increases the need for assembly equipment and precision tools.

2.3.2 Major Stakeholders

- **Domestic Players:** Companies like BHEL, Crompton Greaves, and Mahindra & Mahindra manufacture industrial machinery and electrical systems.
- **Global Majors:** Siemens, GE, Hitachi etc. contribute advanced technologies, creating jobs and facilitating knowledge transfer.

[31] https://aiaiindia.com/capital-goods/

- **SMEs and PSEs:** SMEs drive innovation with niche machinery, while PSEs like BHEL and Indian Railways modernize infrastructure.

- **Financial Institutions:** EXIM Bank and NABARD finance large projects and technological upgrades, fostering growth. The Indian Capital Goods Sector supports power projects, financed by key agencies PFC, REC, and IREDA through strategic funding initiatives.

2.3.3 Government Policies

- **National Infrastructure Pipeline (NIP):** Aims to upgrade roads, railways, and urban infrastructure, boosting demand for capital goods.

- **Pradhan Mantri Awas Yojana (PMAY):** The construction of affordable housing drives demand for construction materials and machinery.

- **Make in India:** Encourages domestic manufacturing and reduces import dependency, fostering innovation and job creation.

- **PLI Scheme:** Incentivizes production and technological advancements in key sectors like electronics and automotive.

2.3.4 Investments

- **FDI:** The FDI in renewable energy is 100.00% under automatic route. The total FDI in power sector reached INR 1,467.20 Bn between April 2000- June 2024 accounting for 2.64% of total FDI flow in India in the above-mentioned period[32].

- **Domestic Investment:** India has a planned investment of over INR 42.00 Tn by 2034F. The investments are in the areas of upgrading infrastructure and increasing generation.[33]

- **Public-Private Partnerships (PPP):** Collaborations on infrastructure projects like the Delhi-Mumbai Corridor increase demand for construction machinery.

3. OVERVIEW OF GLOBAL AND INDIAN POWER SECTOR

The energy and power sector plays a pivotal role in driving economic development and ensuring the functioning of industries and households. The global and Indian energy landscapes have witnessed significant transformations over the past few decades, influenced by factors like technological advancements, environmental concerns, policy changes, and shifting consumer demands.

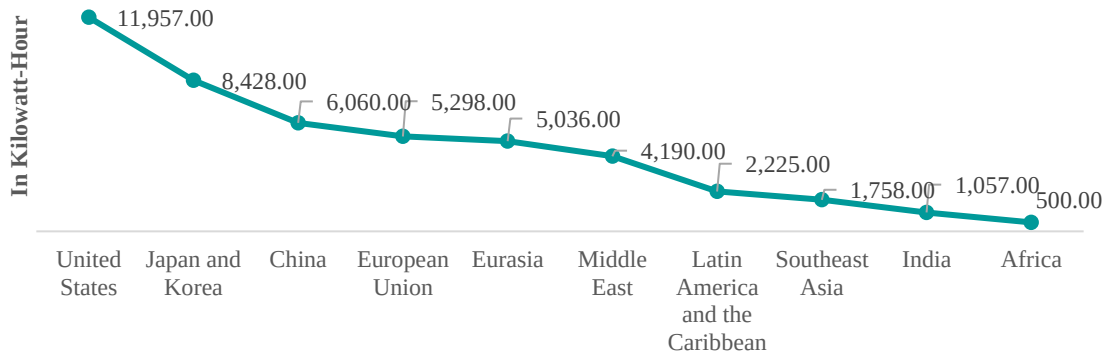
- **Current Electricity Demand and Supply**

In 2023, the United States led global per capita power consumption at 11,957 kWh, followed by Japan and Korea 8,428 kWh and China (6,060 kWh). The European Union, Eurasia, and the Middle East ranged from 5,298 to 4,190 kWh, while Latin America, Southeast Asia, India, and Africa consumed significantly less, highlighting global energy disparities. India's per capita power consumption was 1,057 kWh in 2023.

[32] https://www.ibef.org/industry/power-sector-india#:~:text=Total%20FDI%20inflows%20in%20the%20power%20sector%20reached%20US%24%2018.34,in%20India%20was%20951.10%20BU.

[33] https://economictimes.indiatimes.com/markets/stocks/news/indias-power-sector-a-trillion-dollar-investment-opportunity-for-the-next-decade/articleshow/114501329.cms?from=mdr

Figure Error! No text of specified style in document.**.12: Global Per Capita Power Consumption (In Kilowatt-Hour (kWh), 2023**

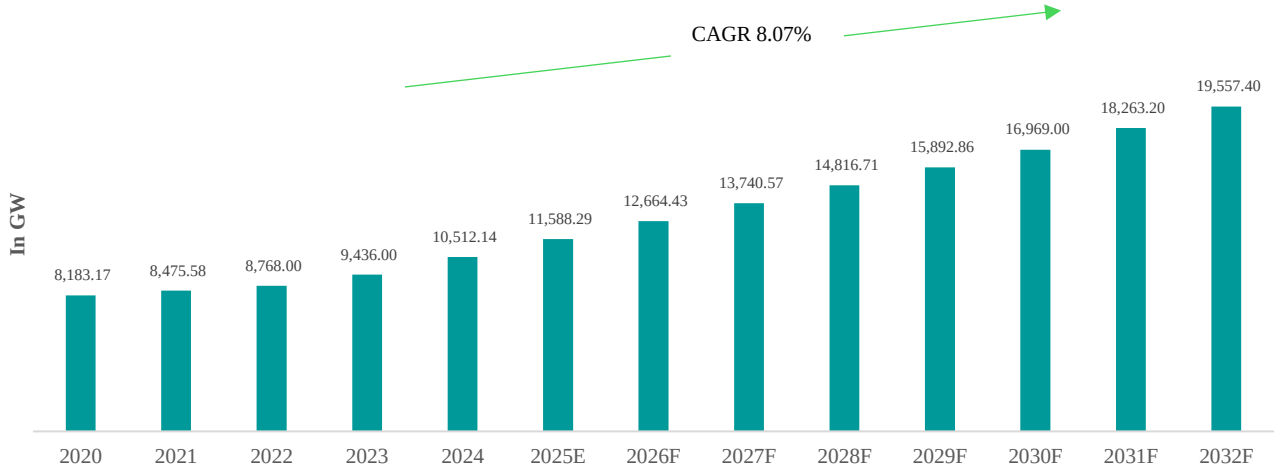


Source: Central Electricity Authority (CEA) and Frost & Sullivan Analysis

3..1 Global Electricity I nstalled Capacity

Global electricity installed capacity measures the total power generation capability of energy sources worldwide, including fossil fuels, nuclear, and renewables like solar and wind. It plays a vital role in supporting economic growth, technological development, and societal needs, ensuring energy security, and enabling the transition toward cleaner and more sustainable power solutions. The global installed capacity is expected to increase from 10,512.14 GW in 2024 to 19,557.40 GW in 2032 F at a CAGR 8.07%.

Figure Error! No text of specified style in document.**.13: Global Electricity Installed Capacity (In Gigawatts (GW)), 2020 - 2032 F**

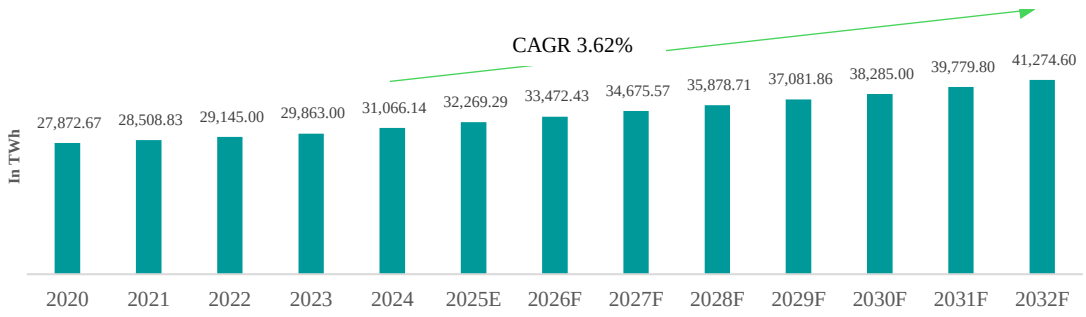


Source: International Energy Agency (IEA) and Frost & Sullivan Analysis

3..2 Global Electricity Supply

The global electricity supply is marked by a dynamic shift toward cleaner and more diverse sources. The global electricity supply is expected to grow from 31,066.14 TWh in 2024 to 41,274.60 TWh in 2032 F at a CAGR 3.62%. The overall economic growth in the global industrial sector and the higher electricity requirements by the residential segment are expected to be key drivers which are contributing to the growth of the electricity supply.

Figure Error! No text of specified style in document.**.14: Global Current Energy Supply Outlook (In Terawatt-hour), 2020 - 2032 F**



Source: International Energy Agency (IEA) and Frost & Sullivan Analysis

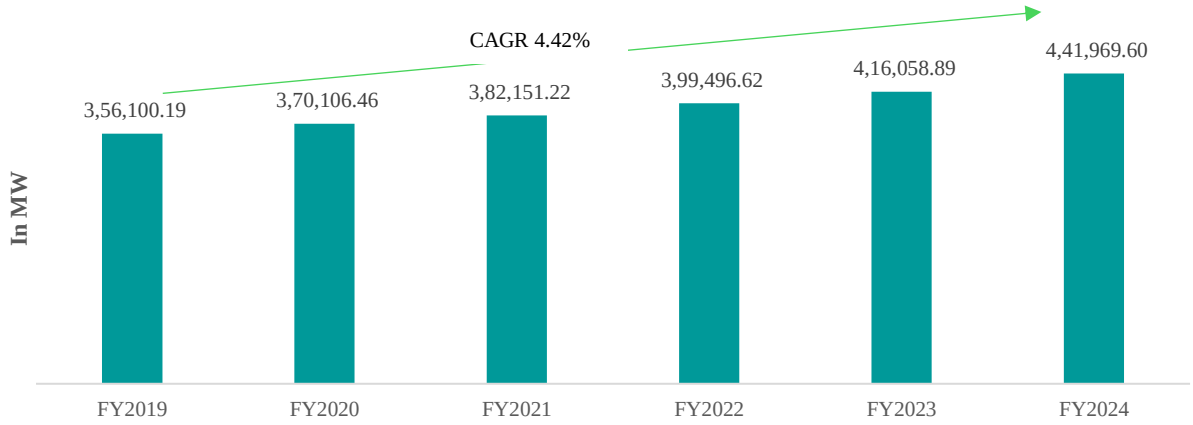
3..2.1 Global Electricity Consumption Trends

- **Renewable Energy Transition:** A significant shift from fossil fuels to renewables (solar, wind, hydro, etc.) driven by climate change policies and falling renewable costs.
- **Electrification of Transportation & Heating:** Growing adoption of electric vehicles, heat pumps, and similar technologies is increasing overall electricity demand.
- **Smart Grids & Digitalization:** Integration of digital technologies (smart meters, IoT, AI) is transforming grid operations, improving efficiency, and enabling real-time demand management.
- **Distributed Generation & Decentralization:** Rise of rooftop solar, microgrids, and local energy storage is leading to a more decentralized grid structure, allowing for better integration of renewable sources.
- **Increase in Data Centers and related hardware:** The rapid increase in data centers globally is significantly driving up energy consumption. As digital transformation accelerates and the demand for cloud computing, big data analytics, and AI-powered services grows, organizations are expanding their infrastructure to handle the ever-increasing electricity needs.

3.1.3 India Electricity Installed Capacity

India's electricity installed capacity reflects a mix of challenges and progress. India’s total energy supply was in FY 2019 was 3,56,100.19 MW and it reached 4,41,969.60 in FY 2024 accounting for a CAGR of 4.42%.

Figure Error! No text of specified style in document.**.15: India Electricity Installed Capacity (In Megawatts (MW)), FY 2019 – FY 2024**

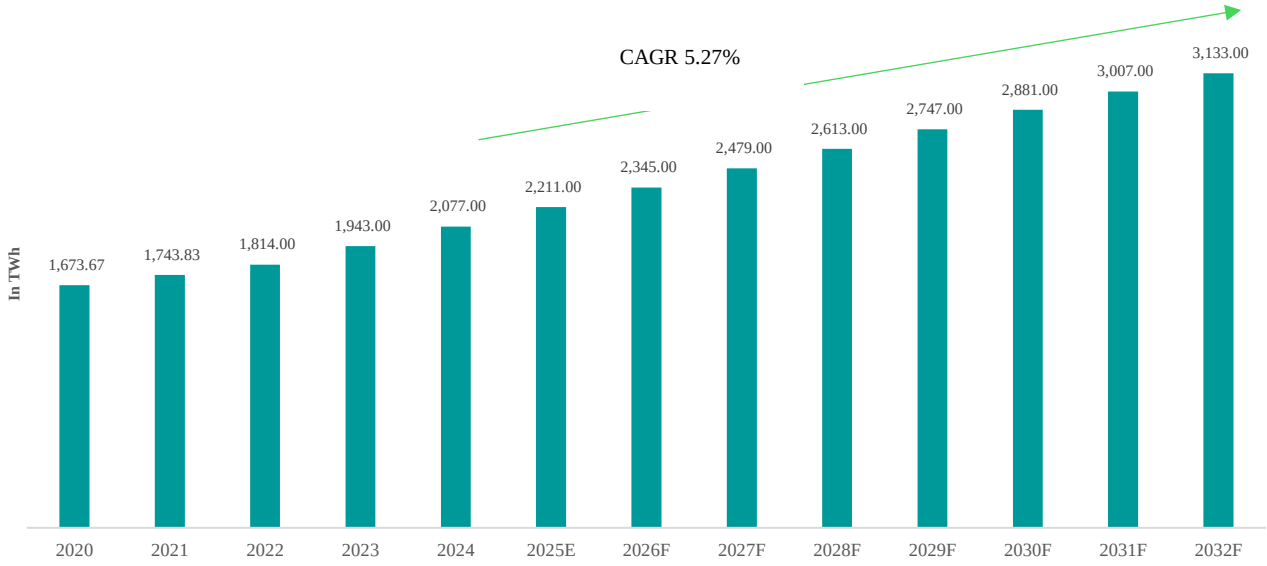


Source: Central Electricity Authority (CEA) and Frost & Sullivan Analysis | Note: Data available only from 2019 in CEA website | Note: FY refers to 1st April to 31st March

3.1.4 India Electricity Supply

India's current energy supply outlook reflects a mix of challenges and progress. While coal remains the primary source, the country is rapidly expanding its renewable energy capacity, particularly solar and wind. India's total energy supply was in 2024 was 2,077.00 TWh and it is expected to reach 3,133.00 in 2032 E, at a CAGR of 5.27%.

Figure Error! No text of specified style in document.**.16: India Electricity Supply (In Terawatt-hour), FY 2020 – FY 2032F**



Source: Central Electricity Authority (CEA) and Frost & Sullivan Analysis

3.1.4.1 Indian Electricity Consumption Trends

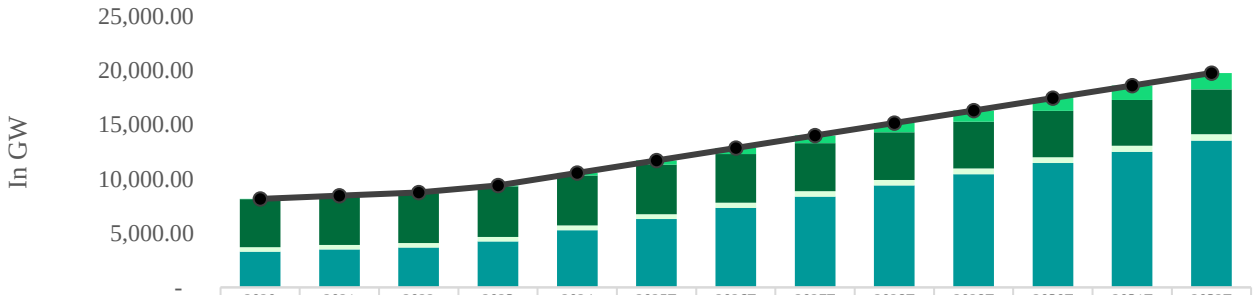
- **Rapid Demand Growth:** Driven by economic development, urbanization, and rising incomes, electricity demand in India is growing at a robust pace.
- **Aggressive Renewable Expansion:** India is scaling up its renewable energy capacity—particularly in solar and wind—to reduce reliance on coal and meet sustainability goals.
- **Rural Electrification & Energy Access:** Government initiatives like the Saubhagya scheme are accelerating rural electrification, ensuring broader access to electricity and driving overall consumption.
- **Grid Modernization & Loss Reduction:** Investments in upgrading grid infrastructure and deploying smart grid technologies are aimed at reducing transmission and distribution losses and improving reliability.
- **Electrification of New Sectors:** The push for electric vehicles, smart cities, and a digital economy is reshaping consumption patterns, leading to increased demand and the need for supporting infrastructure.

3.1.5 Fuel-wise Electricity installed capacity over the past 10 years- Global & India

3.1.5.1 Global Fuel-wise Electricity Installed Capacity

The global fuel wise electricity installed capacity is witnessing a clear shift towards renewable energy. This segment accounted to 33.01% in 2014, and this grew to 49.96% in 2024. This segment is expected to account to 71.66% of the total global electricity installed capacity in 2032 F. The unabated fossil fuel segment is expected to witness a reduction from 60.39% in 2014 to 17.12% in 2032 F due to the higher adoption of renewable based sources. Battery storage is expected to be the fastest growing segment, it is expected to grow at a CAGR of 35.22% between the year 2024 and 2032 F, expected to account to around 8.52% in 2032 F from 2.33% in 2024.

Figure Error! No text of specified style in document.**.17: Fuel-wise Installed Capacity, Global (In Gigawatts), 2020 - 2032 F**



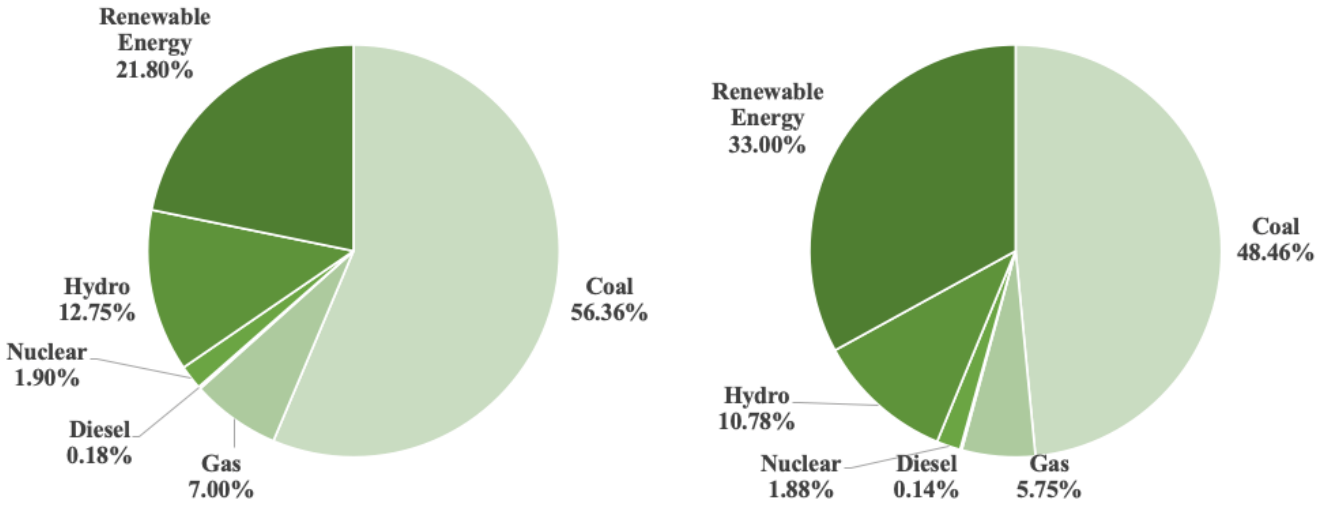
	2020	2021	2022	2023	2024	2025E	2026F	2027F	2028F	2029F	2030F	2031F	2032F
Battery storage	37.67	41.33	45.00	89.00	246.67	404.33	562.00	719.67	877.33	1,035.00	1,192.67	1,350.33	1,508.00
Unabated fossil fuels	4,420.00	4,511.00	4,602.00	4,665.00	4,607.75	4,550.50	4,493.25	4,436.00	4,378.75	4,321.50	4,264.25	4,207.00	4,149.75
Nuclear	414.67	415.83	417.00	416.00	433.58	451.17	468.75	486.33	503.92	521.50	539.08	556.67	574.25
Renewables	3,292.33	3,488.17	3,684.00	4,246.00	5,280.00	6,314.00	7,348.00	8,382.00	9,416.00	10,450.00	11,484.00	12,518.00	13,552.00
Total	8,164.67	8,456.33	8,748.00	9,416.00	10,568.00	11,720.00	12,872.00	14,024.00	15,176.00	16,328.00	17,480.00	18,632.00	19,784.00

Source: International Energy Agency (IEA) and Frost & Sullivan Analysis

3.1.5.2 India Fuel-wise Electricity Installed Capacity

Coal based fuel capacity in India was 56.36% in FY 2019, this reduced to 48.46% in FY 2024. This segment grew at a CAGR of 1.00% between FY 2019 and FY 2024. The renewable energy witnessed the highest CAGR growth of 13.09% between FY 2019 and FY 2024, the installed capacity of renewable energy is 33.00% of the total electricity installed capacity in India in FY 2024. The Diesel fuel reduced from 637.63 MW in FY 2019 to 589.20 MW in FY 2024 and its accounts to 0.14% in FY 2024.

Figure Error! No text of specified style in document.**.18: Fuel-wise Electricity Installed Capacity, India (In Percentage), FY 2019 & FY 2024**

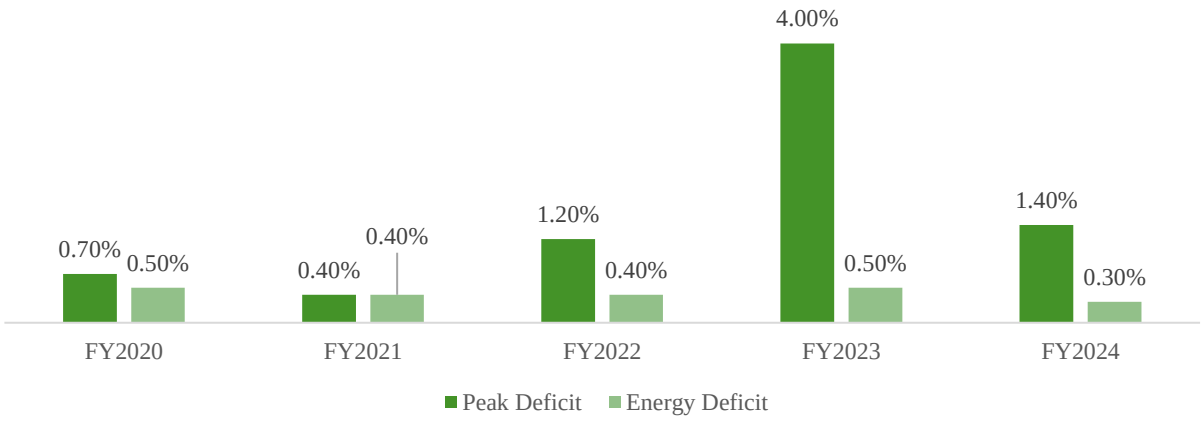


Source: Central Electricity Authority (CEA) and Frost & Sullivan Analysis | Note: FY refers to 1st April to 31st March

3.1.6 Demand Supply Gap of Energy in India

India's peak power deficit improved from 17.00% in FY 2008 to 0.40% in FY 2021 but rose to 1.20% in FY 2022 and 4.00% in FY 2023 due to a surge in electricity demand and insufficient capacity additions. As of FY 2024, the peak deficit has reduced to 1.40%. India's peak power deficit improved from ~17% in FY 2008 to 0.4% in FY 2021 but rose to 1.20% in FY 2022 and 4.00% in FY 2023 due to a surge in electricity demand and insufficient capacity additions. The government intends to add 88 GW of baseload thermal power to fulfil peak demands of 295 GW by FY 2028 E and 366 GW by FY 2032 E to solve future deficits.

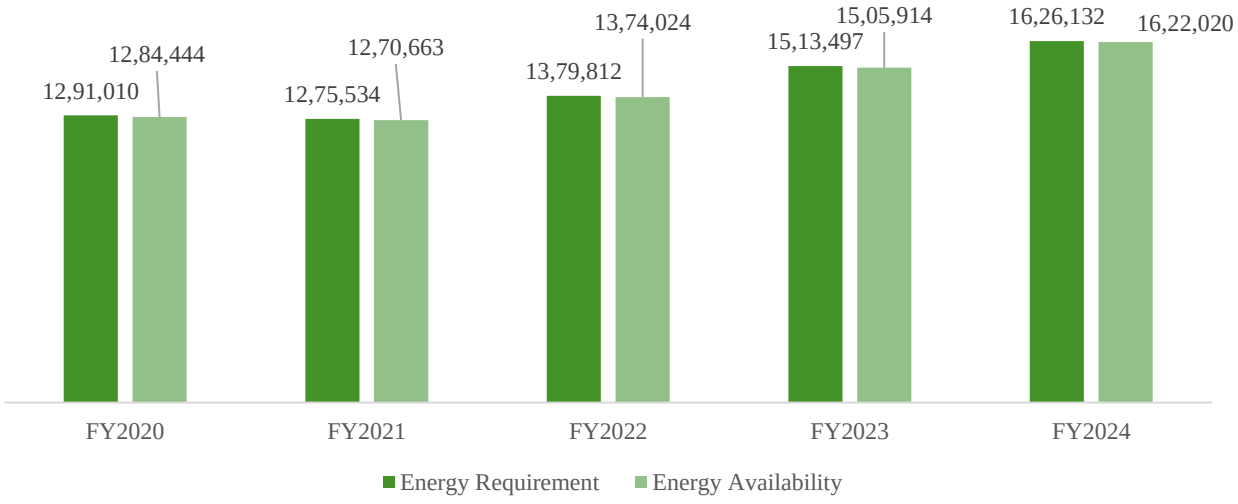
Figure Error! No text of specified style in document.**.19: Peak Deficit and Energy deficit in India, (In Percentage), FY 2020 – FY 2024**



Source: CEA and Frost & Sullivan | Note: FY refers to 1st April to 31st March

The energy availability refers to the amount of energy that can be produced and supplied by a power system or plant and energy requirement refers to the to the total amount of energy needed to meet the demands of consumers, including residential, industrial, and commercial sectors. In FY 2024 the Energy requirement was 16,26,132 MU and the energy available was 16,22,020 MU.

Figure Error! No text of specified style in document.**.20: Energy Requirement and Energy Availability in India (In MU), FY 2020 – FY 2024**

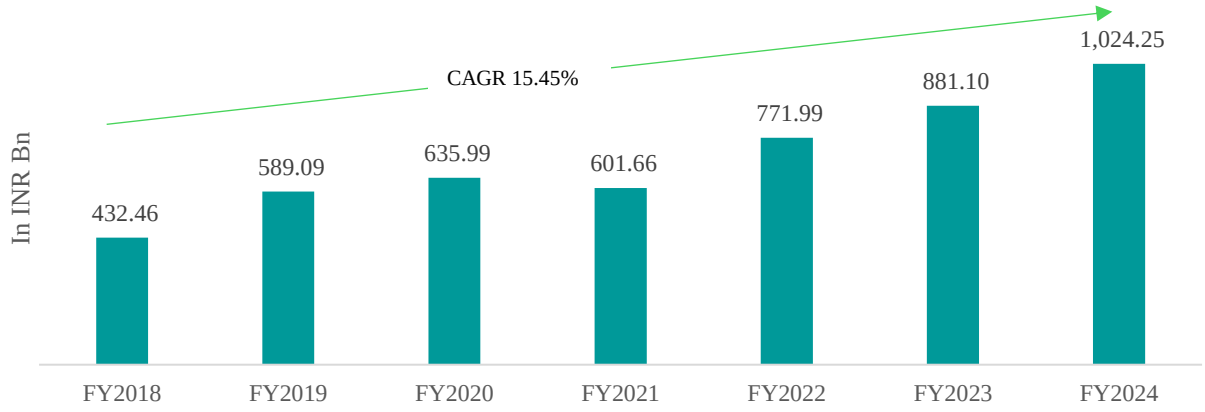


Source: CEA and Frost & Sullivan | Note: FY refers to 1st April to 31st March

3.1.7 India Electrical Equipment Market

The India electrical equipment market has grown from INR 432.46 Bn in FY 2018 to INR 1,024.25 Bn in FY 2024 with a CAGR of 15.45% between the given period.[34] The cumulative Indian export market is expected to account to INR 4,936.54 Bn between FY 2018 and FY 2024.

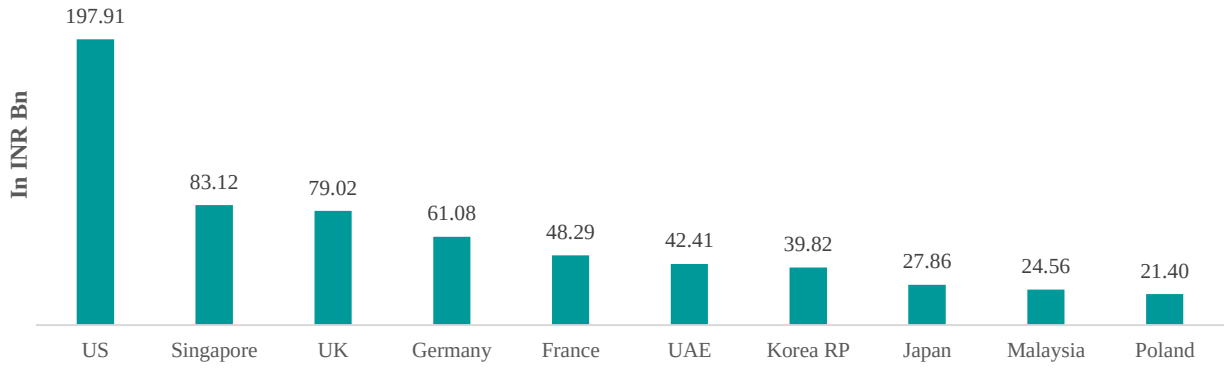
Figure Error! No text of specified style in document.**.21: Export of Electrical Equipment, India (In INR Bn), FY 2018 – FY 2025E**



Source: Ministry of Commerce and Industry and Frost & Sullivan Analysis | Note: FY refers to 1st April to 31st March

The total Indian electrical equipment export market accounted for INR 625.47 Bn in FY 2024. US accounted for around 31.64% share of India's total electrical equipment export translating to INR 197.91 Bn in terms of value. The second largest market for Indian electrical equipment was Singapore, it accounted for 13.29% share in FY 2024. The third largest market for Indian electrical components for India was UK and this accounted for INR 79.02 Bn by value in FY 2024[35]. These three countries, US, Singapore, and UK accounted for 57.56% of the total Indian electrical equipment exports for FY 2024.

Figure Error! No text of specified style in document.**.22: Top 10 Countries Export on Electrical Equipment (In INR Bn), FY 2024**

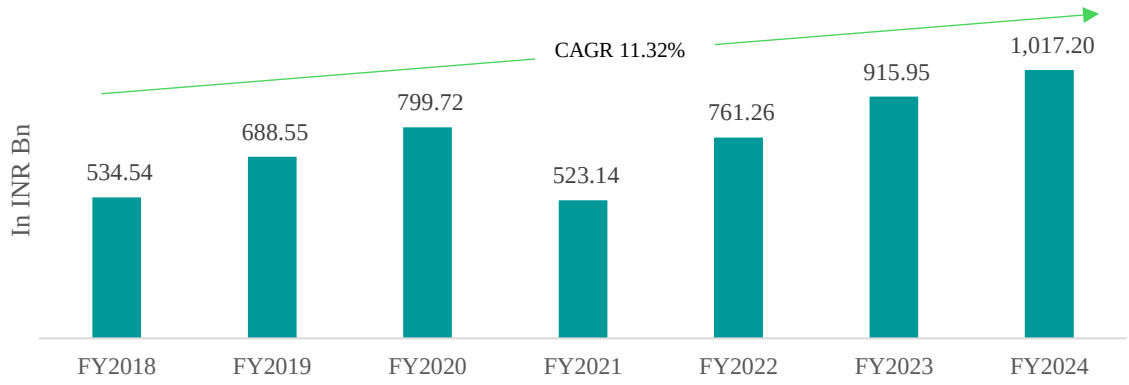


Source: Ministry of Commerce and Industry and Frost & Sullivan Analysis

[34] https://dashboard.commerce.gov.in/commercedashboard.aspx
[35] https://dashboard.commerce.gov.in/commercedashboard.aspx

The Indian Electrical Equipment import market has been experiencing significant growth, reflecting the country's increasing demand driven by economic expansion and industrial development. In FY 2018, India's Electrical Equipment imports accounted at INR 534.54 Bn in FY 2018, and it increased to INR 1,017.20 Bn in FY 2024 with a CAGR of 11.32%. This rise is due to the country's dependence on fossil fuels, particularly crude oil, and natural gas, as well as the need to supplement domestic energy production.

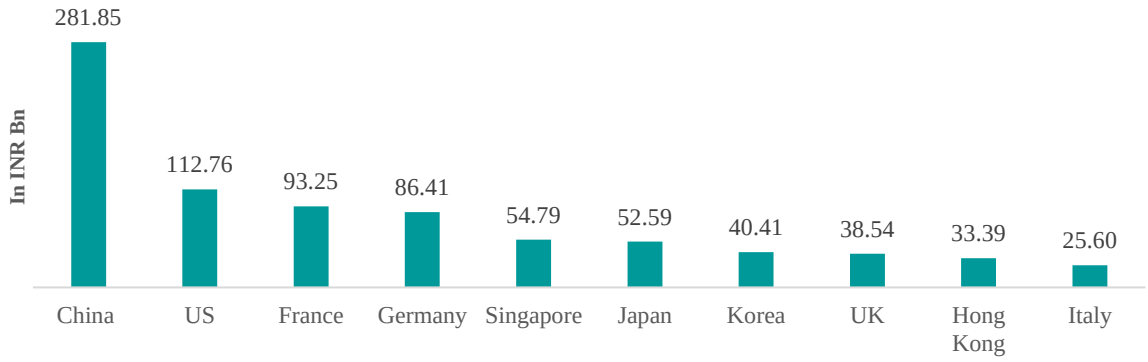
Figure Error! No text of specified style in document.**.23: Import of Electrical Equipment, India (In INR Bn), FY 2018 – FY 2025E**



Source: Ministry of Commerce and Industry and Frost & Sullivan Analysis | Note: FY refers to 1st April to 31st March

The Indian electrical equipment market accounted for INR 819.58 Bn in FY 2024. China led the list with imports valued at INR 281.85 Bn, which accounted for 34.39% of the total imports of electrical equipment in FY 2024. The US was the second at INR 112.76 Bn and France at INR 93.25 Bn[36]. These three countries accounted to 59.52% of the total electrical equipment imports to India in FY 2024.

Figure Error! No text of specified style in document.**.24: Top 10 Countries Import of Electrical Equipment, India (In INR Bn), FY 2024**



Source: Ministry of Commerce and Industry and Frost & Sullivan Analysis

3.2 Policy and Regulatory Framework in India

This section deals with policy and regulatory implications, government initiatives, impact of energy transition and green energy policy, break up of investment in infrastructure in this market and C&I tariff trends.

3.2.1 Government Initiatives and Incentives

[36] https://dashboard.commerce.gov.in/commercedashboard.aspx

India has emerged as a leader in promoting renewable energy and sustainable development. The government has launched numerous initiatives and incentives to transform the energy and power sector:

- **National Solar Mission (NSM):** The NSM aims to promote solar energy deployment in India. It includes various schemes such as solar parks, rooftop solar programs, and solar pumps for agriculture.

- **National Wind-Solar Hybrid Policy:** This policy promotes the development of hybrid projects combining wind and solar power generation, which can improve grid stability and utilization.

- **Production Linked Incentive (PLI) Scheme:** The PLI scheme provides financial incentives to domestic manufacturers of solar PV modules, batteries, and other renewable energy equipment. This scheme aligns with the "Make in India" and "Aatmanirbhar Bharat" initiatives.

- **Green Energy Corridors:** These corridors are being developed to facilitate the transmission of renewable energy from generation centres to load centres.

- **Renewable Purchase Obligations (RPOs):** RPOs mandate that electricity distribution companies procure a certain percentage of their electricity from renewable sources.

- **Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM):** This scheme promotes the use of solar pumps for agriculture, reducing reliance on diesel pumps and providing income to farmers by selling surplus solar power to the grid.

- **National Infra Pipeline (NIP):** With an investment of INR 111 Tn, the NIP focuses on transforming India's infrastructure, particularly in the power sector through renewable energy expansion, enhanced power distribution, and nuclear energy development, including small modular reactors, ensuring sustainable growth[37].

3.2.2 Policy and Regulatory Implications in India

Policy Implications

- Energy Access and Affordability: India is focused on ensuring universal access to affordable and reliable electricity. This involves expanding generation capacity, strengthening transmission and distribution networks, and promoting energy efficiency.

- Renewable Energy Push: India has set ambitious targets for renewable energy deployment. Various policies and incentives are in place to promote solar, wind, and other renewable energy technologies.

- Energy Security and Self-Reliance: India is striving to enhance its energy security by diversifying its energy mix and reducing reliance on imports. This includes promoting domestic coal production, developing nuclear power, and investing in renewable energy.

- Environmental Sustainability: India is committed to reducing its carbon footprint and mitigating climate change. This involves promoting cleaner energy sources, improving energy efficiency, and adopting sustainable development practices.

Regulatory Implications:

- Electricity Act 2003 and Amendments: The Electricity Act 2003 provides the overarching legal framework for the Indian power sector. Subsequent amendments have focused on promoting competition, renewable energy, and grid modernization.

- Renewable Purchase Obligations (RPOs): These obligations mandate that a certain percentage of electricity distribution companies' procurement must come from renewable sources.

[37] https://pib.gov.in/PressReleasePage.aspx?PRID=1894919

- Grid Integration and Balancing: Regulations are evolving to address the challenges of integrating large amounts of variable renewable energy into the grid, including grid codes, forecasting, and balancing mechanisms.

3.2.3 Impact of Energy Transition and Green Energy Policies in India

India's energy transition is focused on scaling up renewable energy, particularly solar and wind. The country has set some of the most ambitious renewable energy targets globally. Policies such as renewable energy auctions, which have resulted in significant price reductions, have attracted both domestic and international investment in solar and wind energy projects.

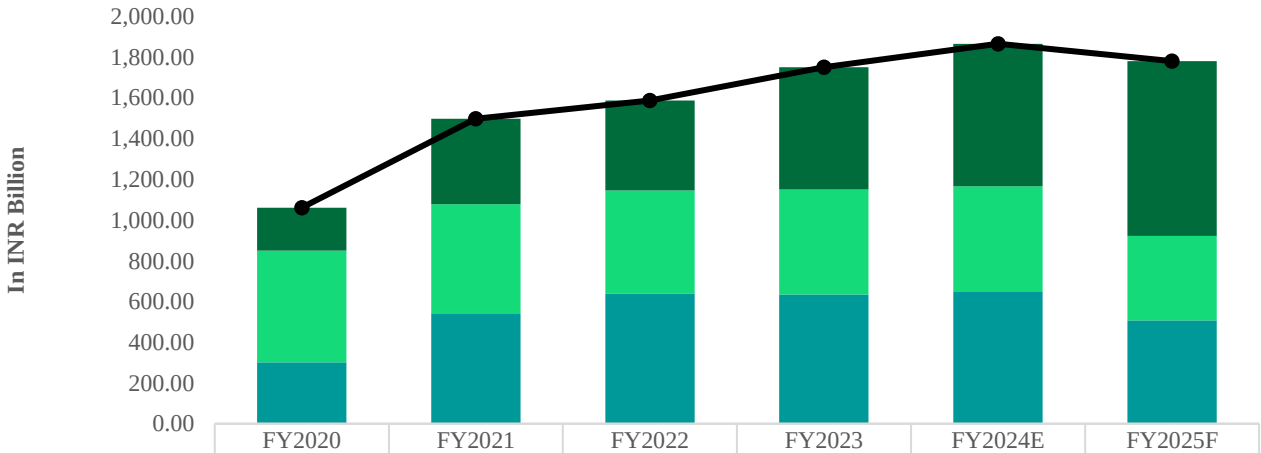
India's green energy policies also extend to energy access in rural and remote areas. With a quarter of its population still lacking access to reliable electricity, India is investing in decentralized renewable energy solutions such as solar microgrids, which can provide off-grid communities with much-needed power. These efforts not only improve living standards but also contribute to achieving the United Nations' Sustainable Development Goals (SDGs) by providing affordable and clean energy to underserved populations.

Energy efficiency is also a critical focus area in India's energy policy. The Bureau of Energy Efficiency (BEE) has introduced energy efficiency standards and labelling programs for appliances, vehicles, and buildings. These programs are aimed at reducing energy consumption across sectors, helping to curb India's overall emissions and ensure that economic growth is decoupled from rising energy demand.

3.2.4 Breakup of investments in generation, transmission, and distribution infrastructure in India

The total investment in the Transmission, Distribution and Generation market in India is expected to account to INR 9,538.94 Bn between FY 2020 and FY 2025F. The investment was INR 1,050.68 Bn in FY 2020 and is expected to grow to INR 1,779.12 Bn in FY 2025F at a CAGR of 10.90%. Generation segment accounted to the maximum investment of INR 3,268.10 Bn, which is around 34.26% of the total investment between FY 2020 and FY 2025F. The fastest growing segment is expected to be the distribution segment which is expected to grow at a CAGR of 32.32% between FY 2020 and FY 2025F.

Figure Error! No text of specified style in document.**.25: Breakup of investments in generation, transmission, and distribution infrastructure (In INR Bn), FY 2020 – FY 2025F**



	FY2020	FY2021	FY2022	FY2023	FY2024E	FY2025F
Distribution	211.27	420.00	442.07	600.00	700.00	857.00
Transmission	548.75	538.97	507.12	515.22	515.22	415.22
Generation	300.56	538.19	637.89	634.74	649.82	506.90
Total	1,060.58	1,497.16	1,587.08	1,749.96	1,865.04	1,779.12

Source: Report of the Task Force National Infrastructure Pipeline (NIP) and Frost & Sullivan Analysis | Note: FY refers to 1st April to 31st March

3.2.5 Commercial &Industrial (C&I) Tariff Trends in India

The C&I tariffs differ by states in India, as an example, the demand charges for Commercial and Industrial are the same at INR 320/ KW in FY 2021 and INR 400/ KW in FY 2024. In FY 2024 the Commercial and Industrial demand rates are the same for Maharashtra, Andhra Pradesh, and Tamil Nadu. In general, the C&I pricing trends are on the rise.

Figure Error! No text of specified style in document.**.26: Commercial &Industrial (C&I) Tariff Trends in India**

State	Sector	Demand Charge Per Month (Rs. / KW)	Energy Charges (Rs. /Kwh)	Demand Charge Per Month (Rs. / KW)	Energy Charges (Rs. /Kwh)
Maharashtra	Commercial	320.00 (FY 2021)	6.01 (FY 2021)	400.00 (FY 2024)	7.70 (FY 2024)
	Industrial	320.00 (FY 2021)	5.65 (FY 2021)	400.00 (FY 2024)	8.84 (FY 2024)
Andhra Pradesh	Commercial	55.00 (FY 2020)	5.40 (FY 2020)	75.00 (FY 2024)	5.40 (FY 2024)
	Industrial	75.00 (FY 2020)	6.70 (FY 2020)	75.00 (FY 2024)	6.70 (FY 2024)
Telangana	Commercial	50.00 (FY 2018)	6.00 (FY 2018)	60.00 (FY 2024)	7.00 (FY 2024)
	Industry	60.00 (FY 2018)	6.70 (FY 2018)	75.00 (FY 2024)	7.70 (FY 2024)
Tamil Nadu	Commercial	NA	NA	589.00 (FY 2024)	9.10 (FY 2024)
	Industrial	NA	NA	589.00 (FY 2024)	7.25 (FY 2024)

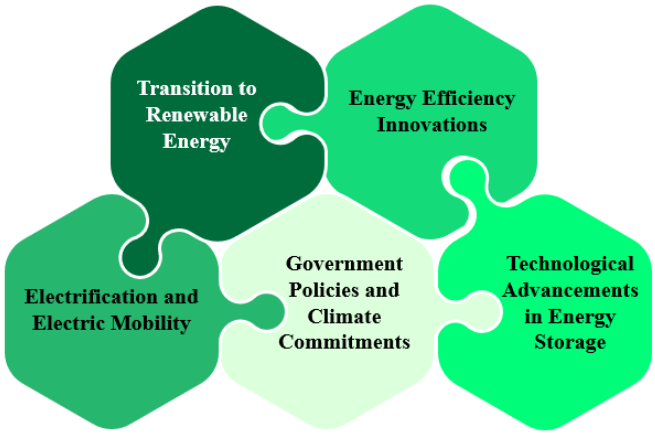
Source: State Electricity Department | Note: C&I tariffs considered based on information availability

3.3 Key Market Drivers and Restraints of Energy Sector in India

This section covers the key market drivers and restraints in the energy sector

3.3.1.1 Key Drivers in the Energy Sector in India

Figure Error! No text of specified style in document.**.27: Key Drivers in the Energy Sector**



Source: Frost & Sullivan Analysis

- **Transition to Renewable Energy**

The shift toward renewable energy is a defining trend. Rising demand for clean energy has accelerated the adoption of solar, wind, hydroelectric, and geothermal sources. Technological advancements and decreasing costs have made renewables competitive with traditional fossil fuels. India's abundant solar resources and favourable wind conditions further fuel this growth.

- **Innovations in Energy Efficiency**

The focus on energy efficiency is another critical driver. As energy consumption rises, there is an increased push for smarter energy use. Innovations such as smart grids, energy-efficient appliances, LED lighting, and advanced storage systems are transforming industries and households alike. Energy efficiency plays a vital role in lowering demand and reducing carbon emissions, making it essential for meeting climate targets.

- **Electrification and Electric Mobility**

Electrification, particularly in transportation, is reshaping energy markets. The adoption of electric vehicles (EVs) is accelerating, driven by the need to reduce fossil fuel dependency. Governments, including India's, are offering incentives and subsidies to boost EV production and purchase. This shift is also spurring the development of robust charging infrastructure, redefining energy consumption patterns.

- **Government Policies and Climate Commitments**

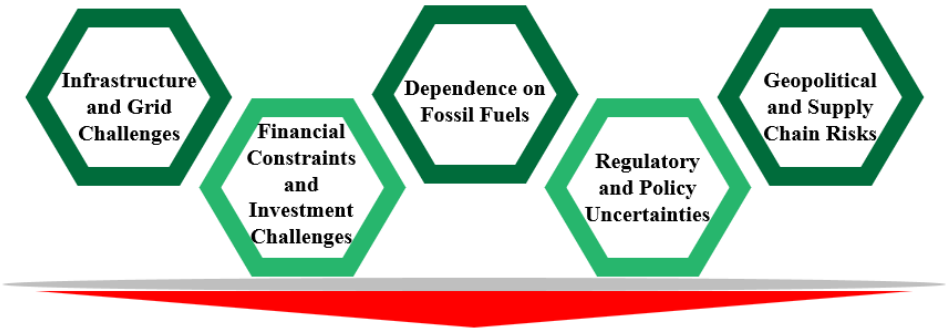
Government initiatives and climate agreements play a vital role in transforming the energy sector. India's commitment to net-zero emissions has driven regulatory frameworks that promote sustainable energy practices, with national and state programs focused on reducing carbon emissions, expanding renewable energy capacity, improving energy efficiency, and encouraging green technology investments through policies like Make in India and Smart Cities.

- **Advancements in Energy Storage Technologies**

Emerging energy storage solutions, such as lithium-ion batteries and hydrogen storage, are key enablers for renewable energy integration. These technologies address the intermittency of solar and wind power by storing excess energy during low demand periods for use during peak times. Innovations in storage are critical for a stable, clean energy future.

3.3.1.2 Key Restraints in the Energy Sector in India

Figure Error! No text of specified style in document.**.28: Key Restraints in the Energy Sector**



Source: Frost & Sullivan Analysis

- **Infrastructure and Grid Challenges**

India's energy transition is hampered by inadequate infrastructure and unreliable grid systems. The existing grid often struggles to accommodate the variable output of renewable sources like solar and wind. Transmission and distribution losses, especially in rural areas, further complicate matters. The absence of a strong national grid limits seamless renewable energy integration and disrupts the creation of a reliable power network.

- **Financial and Investment Barriers**

Financing clean energy projects remains a pressing issue. In India, high initial capital costs and the financial instability of some state-run utilities deter investment. The delay on obtaining subsidies and international financial assistance further impacts the pace of energy transitions.

- **Fossil Fuel Dependency**

Despite the push for renewable energy, fossil fuels continue to dominate energy production. In India, coal remains the primary source of power generation due to its affordability and accessibility. Entrenched industry interests and energy security concerns slow the shift to renewables.

- **Regulatory and Policy Uncertainty**

Frequent policy changes related to tariffs, subsidies, and renewable targets present challenges to long-term investment. In India, delays in approvals and inconsistent regulatory frameworks deter investors. The shifting government priorities and geopolitical factors add to the unpredictability of energy policies. The Central Pollution Control Board sets the standards and implementation timelines under the Ministry of Environment, Forest and Climate Change which is one of the key factors in implementation of new emission norms.

- **Geopolitical and Supply Chain Risks**

Energy security is impacted by geopolitical tensions and supply chain disruptions. Volatile oil and gas prices affect markets, particularly in nations like India that rely on imports. Supply chain disruptions, such as those seen during COVID-19, have highlighted vulnerabilities, especially in sourcing critical materials for renewable energy technologies like batteries and solar panels.

3.4 Digitalization across the energy value chain in India

The digital transformation of the energy and power sectors is reshaping how energy is generated, distributed, and consumed globally, including in India. Digitalization, encompassing a broad spectrum of advanced technologies, is revolutionizing the energy value chain by enhancing operational efficiency,

grid reliability, and decision-making. As renewable energy, electric vehicles, and decentralized power systems rise, digitalization becomes critical in addressing modern energy challenges.

- **Digitalization in Energy Generation**

The energy generation phase is experiencing profound digital disruption. Power plants, whether fossil fuel-based or renewable, are integrating predictive maintenance tools, real-time performance monitoring, and digital twins. AI-powered predictive maintenance allows operators to pre-empt equipment failures. Wind turbines and solar panel inverters equipped with sensors can detect early signs of malfunction, reducing downtime and prolonging asset life.

- **Digitalization in Transmission and Distribution (T&D)**

Digital technologies have a transformative impact on the T&D segment, helping manage the complexities of decentralized energy systems. Smart grids, enabled by digital communication networks, provide two-way communication between energy providers and consumers. They monitor energy usage in real time, detect faults, and restore service quickly. In India, smart grids are being piloted in urban areas to reduce transmission losses and enhance operational efficiency.

- **Digitalization in Energy Consumption**

Consumers are gaining more control over their energy usage through digital technologies. In India, smart homes and IoT-integrated buildings are becoming more common, allowing efficient energy management. Smart appliances, thermostats, and lighting systems enable users to remotely optimize energy usage, reducing waste. Smart meters facilitate real-time consumption tracking, making consumers more energy conscious.

- **Digitalization in Energy Management and Decision Making**

Data analytics and digital platforms empower smarter decision-making across the energy value chain. Energy providers leverage vast amounts of real-time data to optimize operations and enhance forecasting. AI-driven analytics help identify trends, anticipate demand spikes, and detect anomalies. In India, digital energy management tools are boosting efficiency for public and private providers. Businesses benefit from reduced energy consumption, lower costs, and progress toward sustainability goals.

3.5 Role of Renewable Energy and Transition Goals in India

The energy sector worldwide is undergoing a significant shift toward sustainability, with renewable energy emerging as a central solution to climate, economic, and geopolitical challenges. As nations seek alternatives to fossil fuels, renewable energy provides an avenue for cleaner, more resilient power systems. Similarly, India is leveraging renewable energy to meet growing demand, reduce emissions, and achieve long-term sustainability. This shift is reshaping energy production, distribution, and consumption on both a global and national scale.

- **Global Renewable Energy Transition accelerating the transition in India**

The global move toward renewable energy is driven by the need to address climate change and reduce the environmental impact of fossil fuels is also accelerating the transition in India. While fossil fuels have historically dominated energy production, their unsustainable nature has prompted a shift toward cleaner alternatives. Renewables such as solar and wind have gained traction due to declining costs, making them viable solutions for large-scale power generation.

- **Overcoming Transition Challenges**

Energy storage systems are crucial for India's renewable energy future. Given the intermittency of solar and wind power, energy storage technologies are essential to store excess power during peak production and release it during high-demand periods. Investments in storage will be vital for ensuring a consistent power supply. Grid integration is another significant challenge. India's existing grid was designed for

centralized fossil-fuel-based power generation and modernizing it to accommodate renewable sources requires substantial upgrades.

- **India's Renewable Energy Vision**

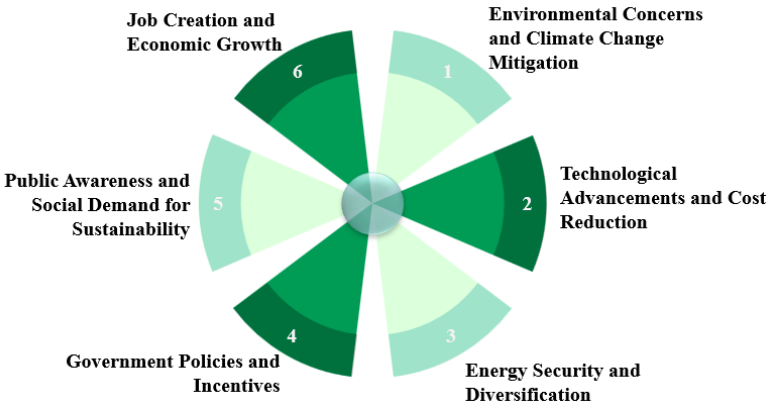
India faces unique energy challenges as a rapidly growing economy with an expanding population. Rising energy demand driven by urbanization and industrialization presents an opportunity for India to pivot toward renewable energy. With abundant sunlight and strong wind currents, India is well-positioned to harness solar and wind energy on a large scale. Decentralized solutions, such as solar microgrids, provide electricity to rural regions where extending the central grid may be economically unfeasible. These initiatives improve living standards, support economic development, and alleviate poverty.

3.6 Key Drivers and Restraints of Renewable Technologies in India

This section deals with the key drivers and restraints of renewable technologies

3.6.1 Key Drivers of Renewable Technologies in India

Figure Error! No text of specified style in document.**.29: Key Drivers of Renewable Technology**



Source: Frost & Sullivan Analysis

Environmental Concerns and Climate Change Mitigation

The growing urgency to combat climate change is one of the primary drivers of renewable energy adoption. The need to reduce greenhouse gas emissions from fossil fuel-based energy sources is a central concern.

Technological Advancements and Cost Reduction

Significant advancements in renewable energy technologies have led to considerable reductions in their costs over the past decade. Solar photovoltaic (PV) panels and wind turbines have become much more efficient and affordable, making them highly competitive with traditional fossil fuel sources.

Energy Security and Diversification

The increasing demand for energy, combined with concerns about energy security and reliance on fossil fuels, has encouraged governments and businesses to invest in renewable energy. Renewable technologies provide a way to diversify energy sources, reduce dependency on imported fossil fuels, and enhance national energy security.

Government Policies and Incentives

Governments worldwide promote renewable energy through subsidies, tax incentives, and regulatory frameworks. India supports renewable technologies via the National Solar Mission (280 GW target by 2030), the PLI scheme for solar manufacturing, Green Energy Corridor, Renewable Energy Certificates, and accelerated depreciation benefits, fostering investment, capacity growth, and sustainability. The other Government policies for Renewable energy include Renewable Purchase Obligation (RPO), Green Energy Open Access Rules, 2022 and PM Surya Ghar Muft Bijli Yojana.

Public Awareness and Social Demand for Sustainability

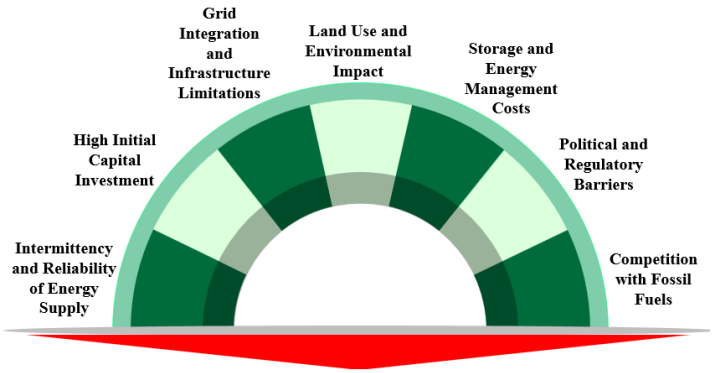
There is a growing consciousness about the environmental and social impacts of energy generation. This has driven increased consumer demand for cleaner, more sustainable energy sources. As a result, there is a greater willingness to support renewable energy initiatives, making them more financially attractive.

Job Creation and Economic Growth

The renewable energy sector is a significant source of new jobs, particularly in manufacturing, installation, operation, and maintenance of renewable energy infrastructure. This job creation potential is an attractive driver for governments and local economies, which are increasingly focusing on renewable technologies as a means of fostering economic growth and employment.

3.6.2 Key Restraints of Renewable Technologies in India

Figure Error! No text of specified style in document..**30: Key Restraints of Renewable Technologies**



Source: Frost & Sullivan Analysis

Intermittency and Reliability of Energy Supply

One of the most significant challenges of renewable energy technologies, particularly solar and wind, is their intermittency. These energy sources are highly dependent on weather conditions, time of day, and season, which can make their energy supply unreliable.

High Initial Capital Investment

Despite the falling costs of renewable energy technologies, the initial capital investment required to develop large-scale renewable energy projects can still be prohibitive. The construction of renewable energy plants, such as wind farms or solar parks, as well as the installation of necessary infrastructure (like energy storage systems and smart grids), requires significant upfront costs.

Grid Integration and Infrastructure Limitations

Integrating renewable energy into existing energy grids can be a complex challenge. The electricity grids were designed to accommodate centralized, consistent power generation from fossil fuel plants. Renewable energy, especially solar and wind, is often decentralized and variable, which can lead to issues with grid stability and reliability.

Land Use and Environmental Impact

Renewable energy is environmentally friendly in terms of carbon emissions. However, large-scale renewable energy projects can have environmental and social impacts. For example, the installation of solar farms and wind turbines requires significant land area, which can compete with agricultural or natural habitats.

Storage and Energy Management Costs

One of the significant technological challenges to the widespread adoption of renewable energy is energy storage. However, energy storage solutions remain expensive and have not yet reached the scale or cost-effectiveness needed to store large quantities of energy for extended periods. Until storage technologies become more affordable and efficient, the role of renewables in providing baseload power will remain limited.

Political and Regulatory Barriers

Despite the widespread policy support for renewable energy, political and regulatory barriers still exist in many regions. Some governments may be resistant to transitioning from fossil fuels due to economic and political reasons, such as the influence of fossil fuel industries or concerns over job losses.

Competition with Fossil Fuels

In many regions, fossil fuels are still heavily subsidized, making them artificially cheaper than renewable energy sources. This continues to create market distortion and presents a barrier to the competitiveness of renewables.

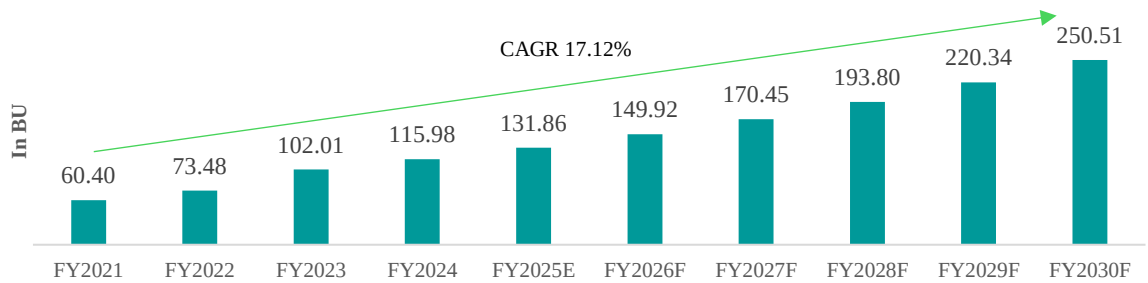
3.7 Market Overview Pertaining to Renewable Technologies

India's renewable energy market is rapidly expanding, driven by the country's commitment to achieving 50% of its energy from non-fossil fuel sources by 2030[38]. The country has made significant strides in solar, wind, and hydropower projects, becoming a global leader in solar energy capacity.

3.7.1 Solar PV

Solar PV is expected to lead India’s renewable energy generation, driven by ongoing investments in solar infrastructure and increasing capacity across the country India’s solar PV generation in FY 2021 was 60.40 BU, with projections indicating substantial growth to 250.51 BU by FY 2030F. The solar PV is expected to account to 51.35% of the total renewable energy generation by FY 2030F.

Figure Error! No text of specified style in document.**.31: Renewables Generation by Solar PV (In Billion Units), FY 2021 – FY 2030F**

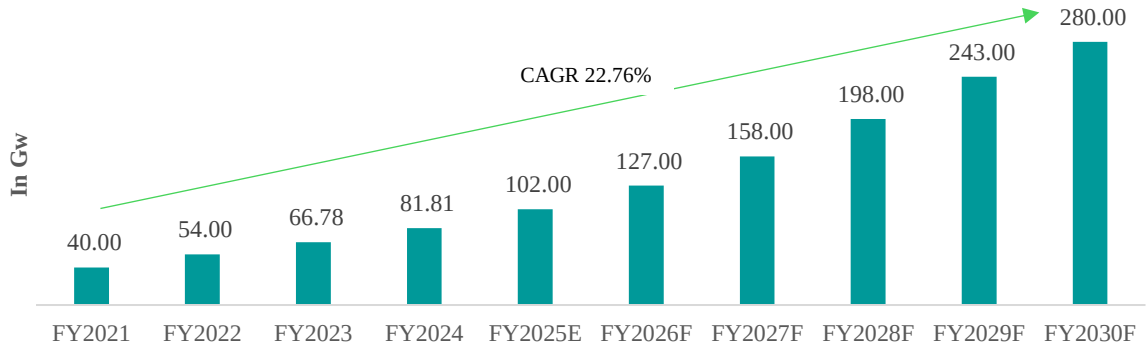


38 https://pib.gov.in/PressReleasePage.aspx?PRID=2073038#:~:text=As%20part%20of%20the%20updated,the%20UNFCCC%20in%20November%202022.

Source: Ministry of New and Renewable Energy and Frost & Sullivan Analysis | Note: FY refers to 1st April to 31st March

In FY 2021, India's Solar PV installed capacity was 40.00 GW. By FY 2030F, this is projected to increase significantly to 280.00 GW with a CAGR of 22.76%. This rapid growth highlights India's aggressive push towards expanding its solar energy infrastructure as part of its renewable energy goals.

Figure Error! No text of specified style in document.**.32: Installed Capacity by Solar PV (In Gigawatts), FY 2021 – FY 2030F**

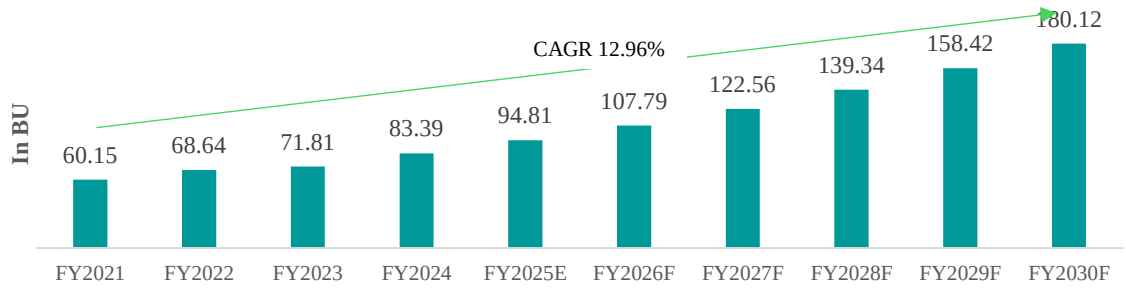


Source: Ministry of New and Renewable Energy and Frost & Sullivan Analysis | Note: FY refers to 1st April to 31st March

3.7.2 Wind Energy

Wind energy is an essential part of India's renewable energy transition, and its generation is set to increase as more wind farms are developed, particularly in regions with high wind potential. Wind energy generation in FY 2021 stood at 60.15 BU and is forecast to grow to 180.12 BU by FY 2030F.

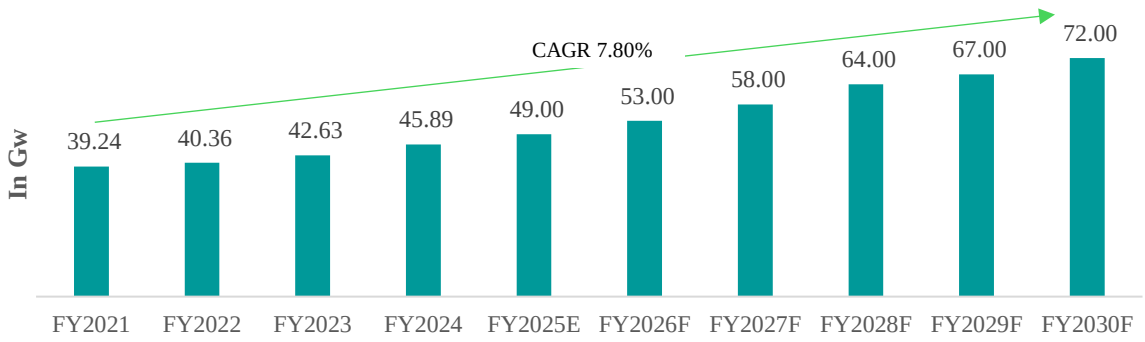
Figure Error! No text of specified style in document.**.33: Renewables Generation by Wind (In Billion Units), FY 2021 – FY 2030F**



Source: Ministry of New and Renewable Energy and Frost & Sullivan Analysis

The wind energy capacity in FY 2021 stood at 39.24 GW in India and is expected to grow to 72.00 GW by FY 2030F, with a CAGR of 7.80%. This growth reflects the country's continued focus on wind energy as a major renewable source to meet future energy demands while reducing carbon emission.

Figure Error! No text of specified style in document.**.34: Installed Capacity by Wind (In Gigawatts), FY 2021 – FY 2030F**

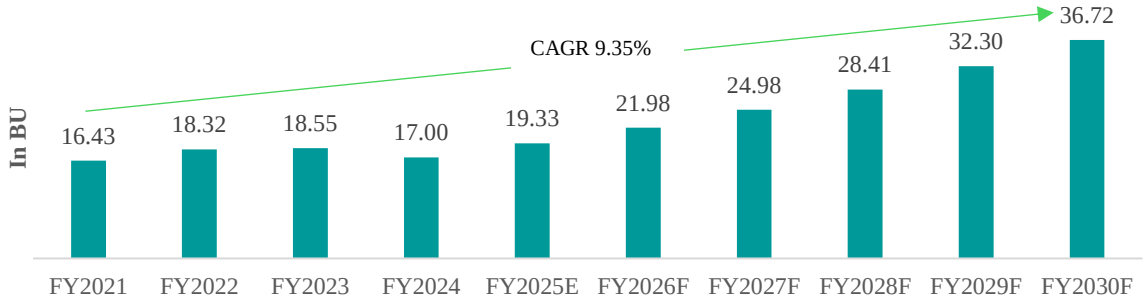


Source: Ministry of New and Renewable Energy and Frost & Sullivan Analysis | Note: FY refers to 1st April to 31st March

3.7.3 Biomass

Biomass plays a key role in India's renewable energy landscape, particularly in supporting rural areas and providing an additional avenue for clean energy generation. In FY 2021, bioenergy generation was 16.43 BU, and it is expected to rise to 36.72 BU by FY 2030F, reflecting a CAGR of 9.30%.

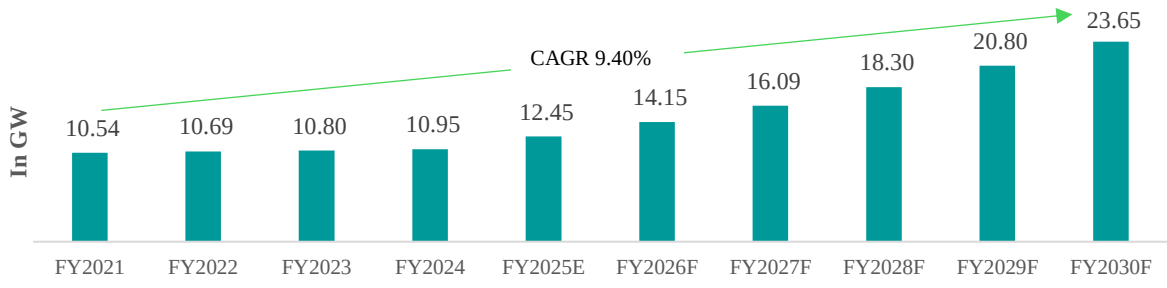
Figure Error! No text of specified style in document.**.35: Renewables Generation by Biomass (In Billion Units), FY 2021 – FY 2030F**



Source: Ministry of New and Renewable Energy and Frost & Sullivan Analysis | Note: FY refers to 1st April to 31st March

India's biomass installed capacity was 10.54 GW in FY 2021 and is expected to increase to 23.65 GW by FY 2030F, reflecting a CAGR of 9.40%. This growth signifies the potential of biomass to contribute to India's renewable energy future, particularly for decentralized energy production and rural electrification.

Figure Error! No text of specified style in document.**.36: Installed Capacity by Biomass (In Gigawatts), FY 2021 – FY 2030F**

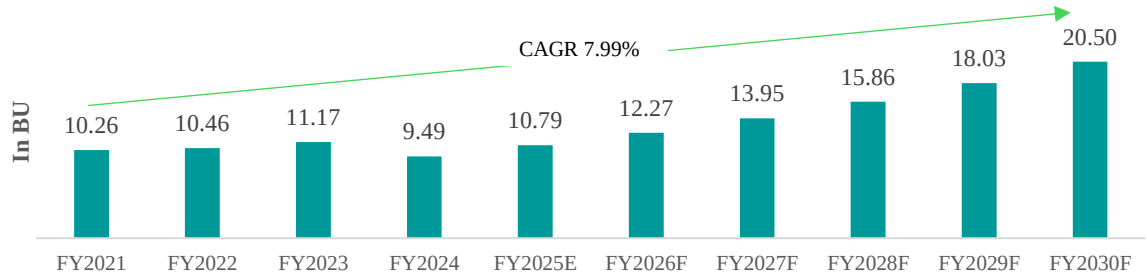


Source: Ministry of New and Renewable Energy and Frost & Sullivan Analysis | Note: FY refers to 1st April to 31st March

3.7.4 Hydro Energy

India's hydro generation was 10.26 BU in FY 2021, and it is expected to reach 20.50 BU by FY 2030F, with a CAGR of 8.00%. While hydro growth is slower compared to other renewables, it remains a reliable and important energy source, especially in areas with significant water resources, providing a stable supply of clean energy.

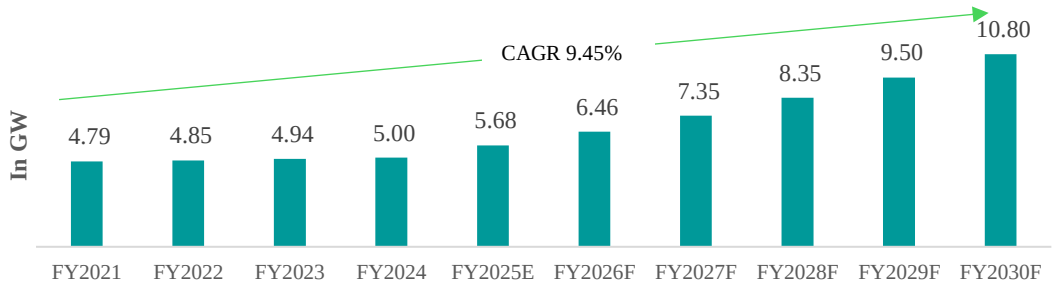
Figure Error! No text of specified style in document.**.37: Renewables Generation by Hydro (In Billion Units), FY 2021 – FY 2030F**



Source: Ministry of New and Renewable Energy and Frost & Sullivan Analysis\ Note: FY refers to 1st April to 31st March

In FY 2021, India had 4.79 GW of installed small hydro capacity and is expected to grow to 10.80 GW by FY 2030F. While small hydro capacity is growing at a slower pace compared to solar and wind, it remains an important part of India's renewable energy mix, contributing to stable, clean power

Figure Error! No text of specified style in document.**.38: Installed Capacity by Small Hydro (In Gigawatts), FY 2021 – FY 2030F**



Source: Ministry of New and Renewable Energy and Frost & Sullivan Analysis | Note: FY refers to 1st April to 31st March

3.8 Market Overview Pertaining to Energy Storage Solutions in India

3.8.1 Key factors driving demand

This section covers the key drivers specific to the energy storage solutions

Decentralized Energy Systems

Renewable energy technologies are promoting a shift toward decentralized energy systems. Unlike centralized power plants, distributed generation allows individuals and communities to produce their own electricity through rooftop solar panels, small-scale wind turbines, and community-based projects.

Emerging Market Demand

Rapid industrialization and urbanization in emerging economies have led to unprecedented energy demand. Solar and wind energy offer scalable and cost-effective solutions to meet these needs without the environmental burdens of fossil fuels.

Corporate Integration and Green Supply Chains

Driven by sustainability goals, multinational corporations are investing in renewable energy projects and entering power purchase agreements (PPAs) to reduce their carbon footprints. Industries such as manufacturing, logistics, and data centres, which have high energy demands, are increasingly turning to clean energy sources to meet operational needs.

Technological Advancements and Energy Efficiency

Innovation in energy storage systems, such as batteries and thermal solutions, addresses the intermittency of renewable energy sources. Combined with energy-efficient technologies, these advancements enable consumers to optimize energy use and further drive renewable adoption.

Green Finance and Investment Growth

The rise of green finance, including impact investments and sustainable infrastructure funds, is accelerating renewable energy projects. Institutional investors are drawn to the stability and long-term returns of clean energy investments, fostering further expansion and technological development.

Environmental Awareness and Policy Pressure

Environmental activism and societal shifts are influencing governments and businesses to adopt cleaner energy practices. Public demand for sustainability and investor pressure have catalysed stronger regulatory support for renewable technologies worldwide.

3.8.2 Capacity gap analysis in India

India's energy landscape is rapidly evolving, driven by ambitious renewable energy targets and increasing power demands. However, significant capacity gaps hinder the widespread adoption and deployment of energy storage technologies.

3.8.2.1 Demand and Supply Disparity

The rising share of renewable energy, particularly solar and wind, has led to fluctuating power generation patterns. Energy storage systems (ESS) are essential to manage these fluctuations, store surplus power, and supply electricity during peak demand. However, the current installed capacity for advanced storage technologies such as lithium-ion batteries remain minimal, creating a considerable gap between supply and demand.

3.8.2.2 Technological Constraints

One of the primary challenges in bridging the capacity gap is the limited availability of advanced and affordable storage technologies. While lithium-ion batteries dominate the market globally, their high costs and dependency on imported raw materials restrict large-scale adoption in India.

3.8.2.3 Manufacturing Ecosystem Gaps

India's battery manufacturing ecosystem is in its nascent stages. Despite policy measures such as the Production-Linked Incentive (PLI) scheme, which aims to boost the manufacturing of advanced chemistry cells (ACC), the country faces challenges in establishing a comprehensive supply chain for critical components, including electrodes, electrolytes, and separators.

3.8.2.4 Policy and Regulatory Barriers

While the government has introduced several initiatives to promote energy storage, including guidelines for battery energy storage systems (BESS) in grid applications, policy frameworks remain fragmented.

3.8.2.5 Financial and Investment Challenges

High upfront costs of storage systems and the lack of viable business models are significant obstacles to scaling up energy storage capacity. Financing options for large-scale projects remain limited due to concerns about technology risks and uncertain returns.

3.8.2.6 Skilled Workforce and R&D Deficiencies

There is a notable shortage of skilled professionals and research capabilities in the energy storage domain. Bridging this gap requires investments in skill development programs, partnerships between academia and industry, and incentives for R&D activities.

3.9 LCOE comparison for RE vs. Coal and Gas

The levelized cost of energy (LCOE) varies significantly across different energy sources, depending on their scale and integration with storage systems. For solar energy, rooftop residential systems have a higher LCOE at 248 USD/MWh compared to utility-scale systems, which can be as low as 29 USD/MWh. This stark difference reflects economies of scale, with utility solar benefiting from larger installations and more efficient technology. Similarly, solar combined with storage for utilities has an LCOE of 60 USD/MWh on the lower end, while the higher end can reach 210 USD/MWh. Geothermal energy has a moderate cost range, with an LCOE between 64 USD and 106 USD/MWh[39], offering a stable price point

Figure Error! No text of specified style in document**..39: Global LCOE data for Lower LCOE and Higher LCOE (USD/ MWh), 2024**

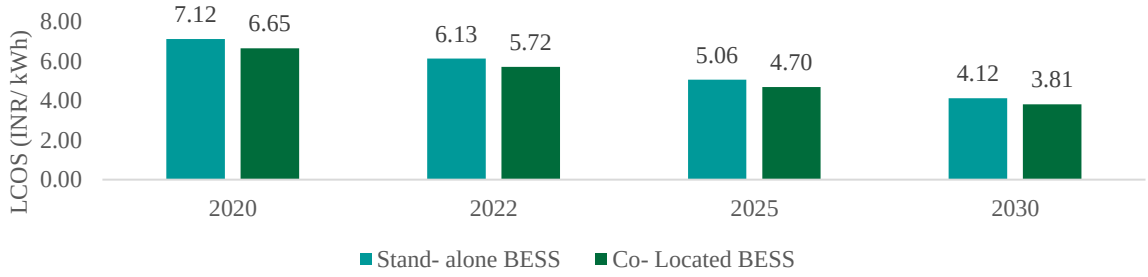
Energy	Lower LCOE (USD/MWh)	Higher LCOE(USD/MWh)
Solar PV—Rooftop Residential	122	248
Solar PV—Community & C&I	54	191
Solar PV—Utility	29	92
Solar PV + Storage—Utility	60	210
Geothermal	64	106
Wind—Onshore	27	73
Wind + Storage—Onshore	45	133
Wind—Offshore	74	139
Gas Peaking	110	228
U.S. Nuclear	142	222
Coal	69	168
Gas Combined Cycle	45	108

[39] https://www.lazard.com/research-insights/levelized-cost-of-energyplus/

Source: Lazard and Frost & Sullivan Analysis

Wind energy follows a similar pattern: onshore wind is more cost-effective with an LCOE as low as 27 USD/MWh, while offshore wind is more expensive, ranging from 74 USD/ MWh to 139 USD/MWh. Gas-fired power generation, both peaking and combined cycle, shows a significant range, with gas peaking ranging from 110 USD/MWh to 228 USD/MWh and combined cycle plants from 45 USD to 108 USD/MWh. Nuclear power has one of the highest LCOEs, ranging from 142 USD/ MWh to 222 USD/MWh, while coal remains in the mid-range with values between 69 USD/ MWh and 168 USD/MWh. These variations highlight the different cost structures and scalability of each energy type. The LCOS per kWh is around INR 7.12 for Stand- alone BESS and INR 6.65 for Co-located BESS. The LCOS cost per kWh is exhibiting a reducing trend. The Stand-alone BESS is expected to reduce by around 42.13% and reach INR 4.12 by 2030, similarly the co-located BESS is also expected to reduce by 42.71% and reach INR 3.81 in 2030[40].

Figure Error! No text of specified style in document.**.40: Levelized Cost of Storage estimates for 1 MW/4 MWh BESS in India, 2020**



Source: Mercom India and Frost & Sullivan Analysis

4. OUTLOOK FOR GRID TECHNOLOGIES MARKET IN INDIA

The grid technology market in India is growing rapidly as the country shifts toward a more sustainable energy future. With increasing renewable energy capacity, especially solar and wind, India requires advanced grid technologies for efficient energy distribution and integration. Key innovations such as smart grids, automation, energy storage solutions, and advanced metering infrastructure (AMI) are being adopted to enhance grid reliability, manage intermittency, and reduce transmission losses. These technologies also help improve real-time monitoring, load management, and overall operational efficiency.

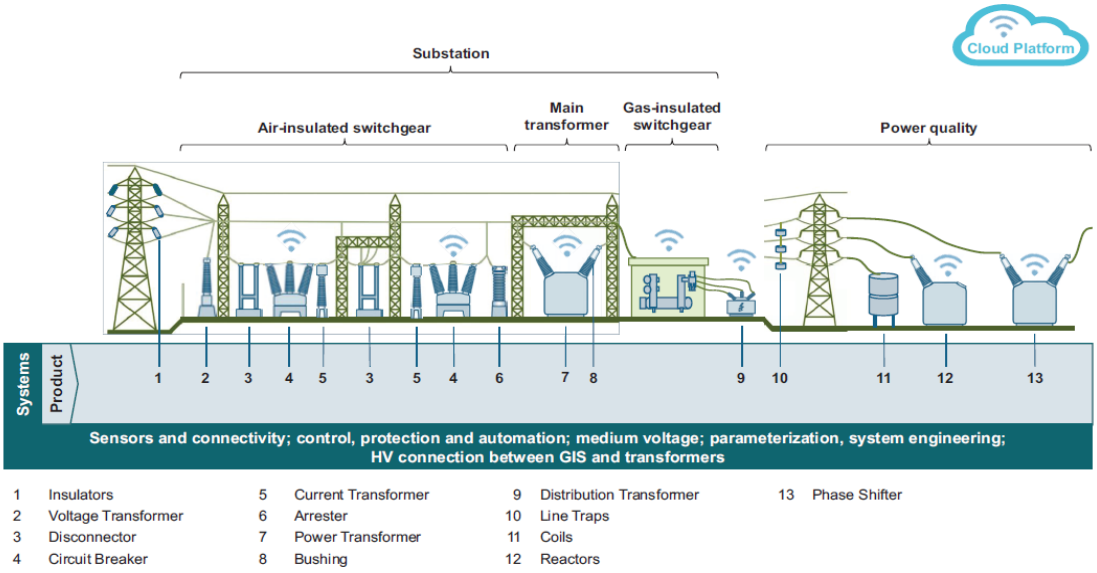
4.1 Value chain analysis of transmission

Figure Error! No text of specified style in document.**.41: Value Chain Analysis of Transmission**

Source: Frost & Sullivan Analysis

Figure Error! No text of specified style in document.**.42: Infographic of Value Chain Analysis of Transmission**

[40] https://www.mercomindia.com/levelized-cost-storage-standalone-bess



Source: Siemens

Power Generation:

This is the first stage wherein electricity is produced using coal, natural gas, or renewable resources like solar and wind energy at power plants.

Transmission Line Construction:

This stage involves the design, material procurement, and construction of high-voltage transmission lines that transport electricity over long distances.

Transmission Network Maintenance:

Routine inspections, timely repairs, and system upgrades ensure the efficient and reliable operation of transmission infrastructure.

Grid Operation and Control:

Managing electricity flow within the transmission network involves tasks like load balancing, voltage regulation, and dispatching power from generating plants.

System Monitoring and Optimization:

Advanced technologies such as SCADA (Supervisory Control and Data Acquisition) systems are used to monitor system performance, detect issues, and enhance power flow efficiency.

Delivery to Distribution Networks:

Electricity is transferred from the transmission system to local distribution companies, facilitating delivery to homes, businesses, and industrial users.

4.2 Market Overview for Siemens Energy India Limited Portfolio

Siemens Energy India Limited product portfolio includes AIS (upto 800 kV), GIS (upto 420 kV), Bushings, Instrument Transformers and Coils. Power Transformers (upto 765 kV, 500 MVA), Reactors (upto 765 kV), Traction Transformers (upto 33 kV, 10 MVA). Under solutions, Siemens Energy India Limited provide EPC for high and extra high voltage projects for high and extra high voltage AIS and GIS Substation projects, Grid Stabilization with Flexible Alternating Current Transmission System (FACTS) - Synchronous Condensers (SYNCONs) and Static Synchronous Compensators (STATCOMs)

and High Voltage Direct Current (HVDC) VSC. Further, Siemens Energy India Limited offers an extensive range of services for the complete lifecycle of the High Voltage /Extra High Voltage asset and projects including bay extension, substation modernisation, product retrofitting and overhauling, emergency services, breakdown services, Long Term Service Agreements (LTSAs), maintenance contracts, O&M contracts and spares. The products, solutions and services are explained below:

Air Insulated Switchgear (AIS):

Siemens Energy India Limited offers/provides a comprehensive range of AIS circuit breaker for diverse high-voltage outdoor applications. Leveraging our trusted design, advanced arc-quenching technology & decades of manufacturing and operating experience we are committed to continuous product development. This ensures reliable, durable & economical product offerings. The 3AP series covers high voltage needs up to 765 kV, designed on modular platform concept leading to a wide diversity of types and high flexibility for AIS power transmission applications.

Gas Insulated Switchgear (GIS):

Siemens Energy India Limited offers/provides 8D type GIS up to 420 kV with compact and highly flexible configuration representing successful product concept. Our Intensive research clubbed with decades of system experience enables us to offer design ensuring long service life, lower life cycle costs & reliable operations under extreme environmental conditions. Siemens Energy India Limited offers customised solution to cater our customers' needs with varying environmental & technological conditions suitable for indoor & outdoor application. Serving our customers across Transmission Utility, Industry & Infrastructure.

Flexible AC transmission systems (FACTS):

Siemens Energy India Limited offers/provides Flexible AC Transmission Systems (FACTS) enhances grid stability, efficiency, and power quality, addressing challenges from renewable energy integration. Key offerings include SVC PLUS® (STATCOM), SVC PLUS FS® (E-STATCOM), Synchronous condenser, Fixed series capacitor (FSC), Mechanically switched capacitors (MSC and MSCDN), Unified power flow controller (UPFC PLUS®) to achieve Grid resilience, Grid-forming & Grid stabilization.. These modular, scalable solutions optimize grid performance, reduce power failures, and support CO_2-free energy transitions. .

High-voltage direct current (HVDC):

Siemens Energy India Limited offers/provides High-Voltage Direct Current (HVDC) advanced solutions for efficient, long-distance power transmission and renewable energy integration. Siemens Energy India Limited's HVDC system uses Voltage-Sourced Converter (VSC) technology for superior flexibility, grid stability, and bidirectional power flow.

High-voltage refurbishment solutions:

Siemens Energy India Limited offers/provides high-voltage refurbishment solutions focus on extending the lifespan, reliability, and efficiency of HVDC systems.

High-voltage substations:

Siemens Energy India Limited offers/provides high-voltage substations offer tailored solutions for efficient and reliable power transmission. It includes Air-Insulated Switchgear (AIS) substations for voltages up to 800 kV, known for cost-efficiency and low maintenance, and Gas-Insulated Switchgear (GIS) substations, ideal for urban areas with compact designs and voltages up to 420 kV.

Offshore grid connections:

Siemens Energy India Limited can offer offshore grid connections provide advanced solutions for integrating renewable energy into power grids. Utilizing HVDC and HVAC technologies, Siemens enables efficient, low-loss transmission of offshore wind energy to onshore grids.

Blue high-voltage products:

Siemens Energy India Limited can offer blue high-voltage products focus on sustainable, SF6-free solutions using vacuum switching technology and clean air insulation. These products eliminate harmful F-gases, achieving Zero Global Warming Potential (GWP) while maintaining high performance and reliability. The portfolio includes Blue Gas-Insulated Switchgear (GIS), Blue Circuit Breakers, and Blue Instrument Transformers, designed for voltages up to 420 kV.

Power Transformers & Reactors:

Siemens Energy India Limited offers/provides power transformers, and reactors to meet diverse energy needs. Power Transformers and reactors include fluid immersed units for diverse applications in Transmission, Generation and Industrial fields including Data Centres with ratings up to 765 kV class. Power transformers are custom-built for large capacities such as 500 MVA and voltages up to 765 kV, enabling long-distance transmission, grid expansion, pooling of renewable energy. Siemens Energy also provides reactors, including shunt and series types up to 765 kV, to stabilize voltage, improve power quality, and optimize grid performance.

Instrument Transformers:

Siemens Energy India Limited offers/provides instrument transformers both for outdoor & GIS applications, including current transformers (CTs) and potential transformers (PTs), designed for accurate measurement and protection in power systems. These transformers cover voltage levels from 66 kV to 765 kV, ensuring precise conversion of high currents and voltages into measurable values. Siemen Energy India Limited offers – CTs and PTs (SF6 insulated) and CVTs (oil insulated) which are tailored for diverse applications such as substations, switchgear, and industrial setups. We also offer Gas Insulated Bushings for GIS application (up to 420 kV) & Dry type bushing for Power Transformers (up to 420 kV).

Traction Transformers:

Siemens Energy India Limited offers/provides Traction Transformers for Railway applications up to 25 kV, 10 MVA which are part of propulsion system and fitted on Trains such as EMU/MEMU/Metros/Locomotive/ Vande Bharat Trains.

Grid Services:

Services for various generations of switchgear, transformers for AC and DC applications, ensuring maximum grid up-time through a rich network of solution experts for service to avoid unplanned shutdowns of assets. Details of the Grid Technologies service portfolio are as follows:

- **HV & EHV Spares of SE Products for AC & DC substations:** Supply of the right parts/spares (modules, subassemblies, units or packages) to ensure operational readiness of customer assets. Used for preventive & corrective maintenance or for strategic safety stock. The provision of expertise or strategic advice that is presented for consideration and decision-making (incl. Obsolescence Management).

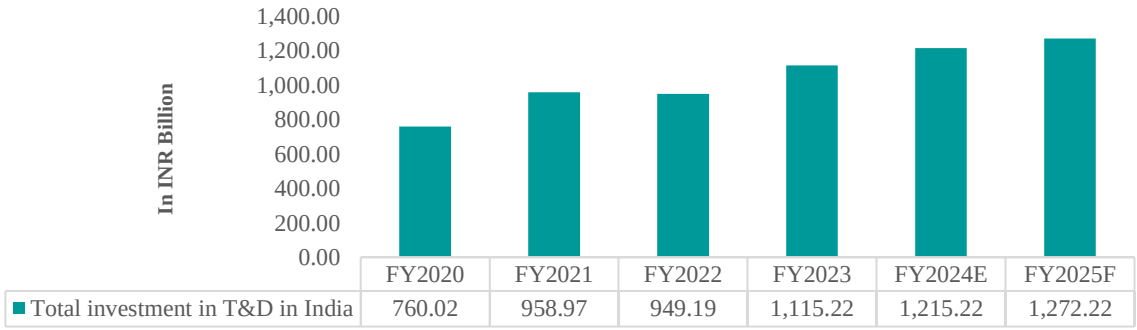
- **Modernization & Upgrades:** Modernizing assets by exchange of aged components or adding additional functions or capacity. Keep assets updated; extend useful asset life; retrofits of individual components. Supporting grid flexibility and peak capacity through various service models in the area of extensions, modernizations and upgrades.

- **Services - Maintenance, Installation & Commissioning, Asset consulting, Repairs & Monitoring & Diagnostics**: Improving grid operation by offering services based on asset health and safety for OEM and non-OEM installations. This includes creating maintenance plans to ensure assets remain reliable, using OEM expertise and local qualified experts, following local regulations. Commissioning activities include testing, starting operations, and handing over the installation to the customer. This involves setting up assets according to design specifications and repairs provision for failed equipment for its restoration.

4.2.1 T&D Equipment

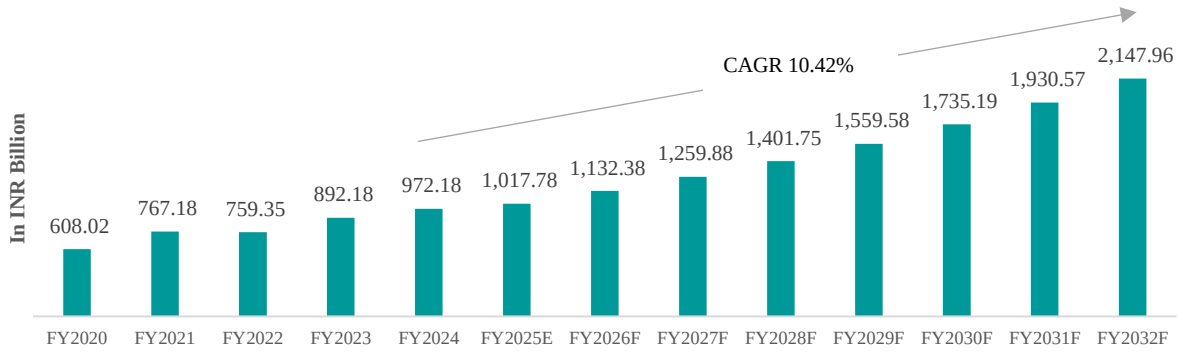
The investment in T&D infrastructure in India increased from INR 760.02 Bn in FY 2020 to INR 1,215.22 Bn in FY 2024 and this is expected to increase to INR 1,272.22 in FY 2025E. The increased investments in the T&D infrastructure in India is the key driver for the T&D equipment market in India. The total T&D equipment market in India is estimated at INR 972.18 Bn in FY2024 and this is expected to grow to INR 2,147.96 in FY 2032F. The market is expected to grow at a CAGR of 10.42% between the period FY 2024 to FY 2032F.

Figure Error! No text of specified style in document.**.43: Investments in Transmission & Distribution Infrastructure (In INR Bn), FY 2020**



Source: Report of the Task Force National Infrastructure Pipeline (NIP) and Frost & Sullivan Analysis | Note: FY refers to 1st April to 31st March

Figure Error! No text of specified style in document.**.44: Transmission & Distribution Market (In INR Bn), FY 2020 – FY 2032F**



Source: Frost & Sullivan Analysis | Note: FY refers to 1st April to 31st March

4.2.2 Key High-Voltage Products and Their Functions:

AIS: High-voltage air-insulated switchgear (AIS) is a cost-effective and reliable choice for substations with voltage ratings up to 800 kV. AIS primary substation equipment can handle up to 1100 kV and includes live tank circuit breakers, dead tank circuit breakers, instrument transformers, disconnectors, and surge arresters. Circuit breakers in AIS serve as protection against electrical faults by interrupting the flow of electricity.

GIS: Gas-insulated switchgear (GIS) is a compact, high-voltage electrical system that uses a sealed enclosure filled with a gas, often Sulphur Hexafluoride (SF6), for insulation. GIS is suitable for use in harsh environments. GIS is ideal for space-constrained applications like substations, industrial facilities, and renewable energy projects and can be available in the voltage range up to 800 kV under high voltage and upto 1200 kV under Ultra high voltage categories

FACTS: Flexible AC Transmission Systems (FACTS) are power electronic devices designed to enhance the control and efficiency of AC transmission networks. They improve power flow and voltage stability by providing dynamic reactive power compensation, which can adapt quickly to changing grid conditions. Common FACTS devices include Static VAR Compensators (SVC), Static Synchronous Compensators (STATCOM), and Unified Power Flow Controllers (UPFC).

Transformers: Transformers are crucial for voltage transformation, increasing voltage for efficient long-distance transmission and decreasing it for safe use in homes and industries

Substations: Substations contain equipment that control and protect elements of an electrical system

High-Voltage Direct Current (HVDC) Transmission: HVDC technology is particularly useful for long-distance transmission with minimal energy losses and for connecting grids with different AC frequencies. It is valuable for integrating large-scale renewable energy projects located far from consumption centres and for connecting grids across national borders.

4.2.3 Grid Automation

Grid automation refers to the use of advanced digital technologies to monitor, control, and optimize power grid operations. It enhances the reliability, efficiency, and flexibility of the grid, which is crucial as India increases its renewable energy capacity and strives for a more resilient and sustainable power system.

High-voltage products play a crucial role in grid automation, facilitating the efficient and reliable transmission of electricity over long distances. These products are essential for integrating renewable energy sources, enhancing grid stability, and enabling advanced control features.

- **Key Features of Grid Automation**

Enhanced Grid Reliability and Stability

Automation improves the reliability of the grid by quickly detecting faults and minimizing service interruptions. Automated systems can isolate faults and reroute power, ensuring continuous electricity supply.

Seamless Integration of Renewable Energy

Grid automation helps manage the variability of renewable energy sources like solar and wind, ensuring efficient energy distribution, storage, and usage, even during periods of low renewable generation.

Improved Load Management

Real-time monitoring and control of electricity demand and supply allow for better load distribution and optimization, preventing overloading and reducing energy wastage.

Operational Cost Reduction

Automation reduces the need for manual intervention, leading to lower operational costs and extended lifespan of grid assets through improved maintenance and optimization.

Faster Recovery from Disruptions

Automated systems enable faster fault detection and grid reconfiguration, minimizing downtime and ensuring quicker recovery from disruptions.

4.3 Key Drivers and Restraints in Grid Technologies:

The grid technologies market in India is a rapidly growing sector with significant potential. This section covers the key drivers and restraints:

- **Key Drivers in Grid Technology**

Increasing Energy Demand: India's rapidly growing economy and population are driving a surge in energy demand. Grid technologies are crucial for efficiently managing and distributing this increasing power supply.

Renewable Energy Integration: India has ambitious targets for renewable energy generation. Grid technologies are essential for integrating these intermittent sources (solar, wind) into the existing grid infrastructure.

Government Initiatives: The Indian government is actively promoting the development of smart grids through various initiatives and policies, such as the Smart Meter National Programme and investments in grid modernization under the Smart City Mission.

Focus on Energy Efficiency: Grid technologies enable better monitoring and management of energy consumption, helping to reduce losses and improve overall efficiency.

Technological Advancements: Advancements in communication technologies, data analytics, and automation are enabling the development of more sophisticated and efficient grid solutions.

- **Key Restraints in Grid Technology:**

High Initial Costs: The deployment of advanced grid technologies requires significant upfront investment, which can be a barrier, especially for smaller utilities.

Legacy Infrastructure: Upgrading existing grid infrastructure to accommodate new technologies can be complex and costly.

Cybersecurity Concerns: As grids become more digitized, they become more vulnerable to cyberattacks. Ensuring the security of these systems is a major challenge.

Data Management and Privacy: Smart grids generate vast amounts of data. Effectively managing this data and ensuring privacy is crucial.

Lack of Skilled Workforce: Implementing and maintaining advanced grid technologies requires a skilled workforce, which is currently in short supply.

4.4 Comparison of transmission infrastructure requirements for renewable vs. traditional power (coal)

Figure Error! No text of specified style in document.**.45: Comparison of transmission infrastructure requirements for renewable vs. traditional power**

Aspect	Renewable Power (Solar/Wind)	Traditional Coal Power
Location of Generation	Often located far from load centres (remote areas, rural)	Typically located near coal mines or industrial zones, close to demand centres
Transmission Distance	Requires long-distance transmission to reach urban areas or industrial hubs	Shorter transmission distances due to proximity to demand centres
Grid Infrastructure Need	Requires more extensive grid expansion and upgrading to handle long-distance transmission and intermittent generation	Simpler grid infrastructure due to consistent and predictable generation locations

Grid Flexibility	Needs more advanced and flexible grid systems, including energy storage, smart grids, and dynamic voltage control due to intermittency	Requires less flexibility due to steady and predictable output
Integration of Energy Storage	Critical for managing intermittency; requires large-scale energy storage systems (batteries, pumped hydro)	Generally, not required as coal plants provide continuous, stable output
Transmission Lines	Need for high-voltage transmission lines, especially for offshore wind or large solar farms, to minimize losses	Typically use medium to high-voltage lines, as power generation is more consistent and local
Grid Balancing	Requires advanced technologies for balancing supply and demand (demand response, real-time monitoring)	Grid balancing is less complex due to predictable output from coal plants
Environmental Impact	Requires less land in power plant areas but has higher environmental impact in transmission (e.g., high-voltage power lines crossing large distances)	Limited transmission infrastructure expansion needed, but coal plants have a higher environmental footprint in terms of emissions

Source: Frost & Sullivan Analysis

4.5 Opportunities in the Storage Solutions Market

The storage solutions market is estimated at USD 3.10 Bn in 2024, and this is expected to grow to USD 5.27 Bn at a CAGR of 11.20% between the period 2024 to 2029[41]. Battery Energy Storage Systems (BESS) are critical. They store solar energy for use at night or on cloudy days, improving reliability and reducing fossil fuel reliance. Another key development is the focus on Pumped Storage Projects (PSP), the potential for PSP in India is estimated at 174.00 GW, out of which 4.70 GW are operational as of August 2024[42].

- **Grid Stabilization and Flexibility**: As India integrates an increasing share of renewable energy into its power grid, storage solutions are required to provide grid stability. Energy storage systems help balance supply and demand by storing excess energy generated during periods of high renewable output and discharging it during peak demand.

- **Decentralized and Off-Grid Solutions**: Many rural areas in India still face unreliable access to electricity. Off-grid solar and storage systems provide an effective solution to these challenges. These systems offer the ability to store solar power generated during the day and use it later.

- **Cost Reduction and Technological Advancements**: The cost of energy storage technologies, particularly lithium-ion batteries, has been steadily decreasing. This trend, driven by advances in battery technology and economies of scale, is making energy storage solutions more affordable and accessible to a broader range of applications.

- **Regulatory Support and Market Incentives**: The Indian government has recognized the importance of energy storage in achieving its renewable energy and sustainability goals. Policies

[41] https://www.pv-magazine-india.com/2024/08/02/powering-indias-renewable-future-the-pivotal-role-of-battery-energy-storage-systems/

[42] https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2040582#:~:text=The%20government%20has%20prioritized%20the,this%20requirement%20in%20Mission%20mode.

like the National Energy Storage Mission are aimed at reducing storage system costs create favourable conditions for the market to expand.

- **Energy Storage in Industry and Manufacturing**: Industrial facilities in India, particularly those with high energy demands, are increasingly adopting energy storage solutions to manage costs and improve energy efficiency

4.6 Role of green hydrogen in enabling storage and decarbonization

Green hydrogen provides a solution for long-duration energy storage that traditional battery systems cannot offer. Unlike conventional storage solutions that are designed for short-term energy backup, green hydrogen can store excess renewable energy for extended periods, even days or months, and release it when demand peaks or renewable generation is low. Green hydrogen is pivotal in supporting the decarbonization goals across sectors.

- **Industry and Heavy Manufacturing**: Industries like steel, cement, and chemicals are among the largest emitters of carbon dioxide in India. These sectors often require high-temperature heat for production processes, which is currently supplied by coal or natural gas. Green hydrogen can replace these fossil fuels, reducing emissions from industrial operations.

- **Transport**: The transportation sector is another area where green hydrogen offers decarbonization potential. Hydrogen fuel cells can be used in vehicles, including buses, trucks, and trains, to replace internal combustion engines powered by gasoline and diesel. This is particularly relevant for long-distance transport, where electric batteries may not be practical due to weight and charging infrastructure limitations.

- **Power Generation**: Green hydrogen can also play a significant role in decarbonizing the power generation sector. Hydrogen can be used in gas turbines or fuel cells to generate electricity, either as a standalone fuel or as a hybrid with natural gas. This offers a solution to balancing the grid when renewable power generation fluctuates.

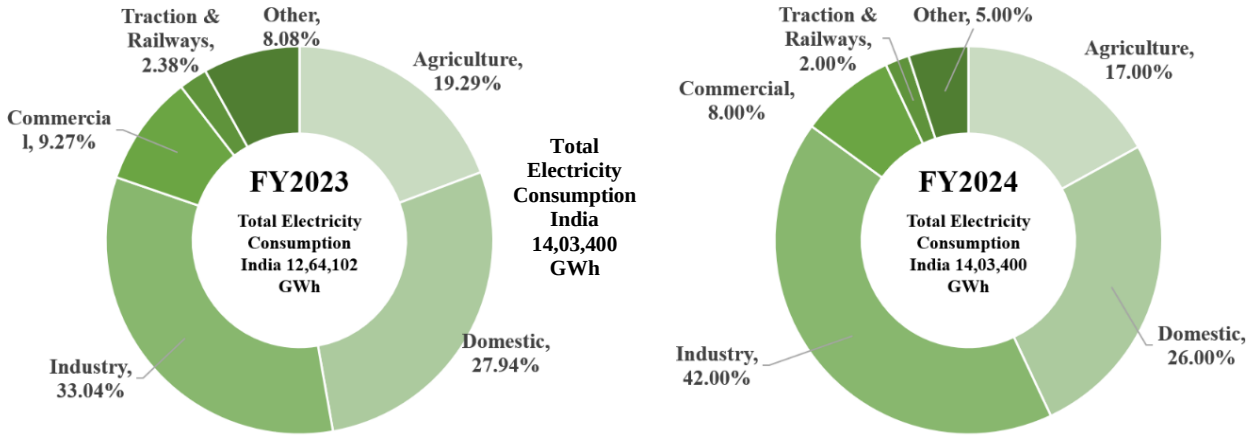
- **Shipping and Aviation**: Green hydrogen has the potential to revolutionize the shipping and aviation industries, which are major contributors to global emissions. Hydrogen-powered ships and airplanes could reduce the reliance on conventional fuels such as bunker oil and jet fuel, leading to cleaner transport options across long distances.

4.7 End-Use Customer Base by Industry

In FY 2024 the electricity consumption in India was driven by the industrial sector, which accounted for 42.00% of total usage, reflecting the country's expanding manufacturing and production activities. The domestic sector followed with a 26.00% share, fuelled by rising urbanization, improved living standards, and greater adoption of household electrical appliances. Agriculture, a vital part of the economy, consumed 17.00% of the total electricity, for irrigation and farm operations, highlighting the sector's dependence on reliable energy supply. The commercial sector, comprising retail spaces, offices, and service industries, accounted for 8.00%, while traction and railways contributed 2.00% as the rail network continued its transition toward electrification. The remaining 5.00% was categorized under other uses, which includes public lighting, waterworks, and miscellaneous government functions[43].

Figure 0.46: End-Use Customer Base by Industry (In Percentage), FY 2023 and FY 2024

[43] https://www.mospi.gov.in/sites/default/files/publication_reports/EnergyStatistics_India_publication_2024N.pdf



Source: Energy Statistics India 2024 and Frost & Sullivan Analysis | Note: FY refers to 1st April to 31st March

4.8 Market Entry Barriers

The key market barriers in the Indian T&D market are covered in this section

Capital Intensive Investments: Setting up operations in the T&D equipment sector requires substantial capital expenditure. As per Central Electricity Authority (CEA) estimates, the approximate cost to set up a coal-based power plant in India is around INR 83.00 Mn per MW[44] (at FY 2021 - 22 price levels). The capital investment includes Land acquisition, Civil works, Equipment (boilers, turbines), Transmission and Distribution and Environmental compliance

Regulatory and Compliance Hurdles: The sector is heavily regulated, requiring multiple licenses and approvals from authorities such as the Central Electricity Authority (CEA). Additionally, products must adhere to stringent standards, including BIS (Bureau of Indian Standards) certifications. Navigating these compliance requirements demands expertise and resources, which may be difficult for new market players.

Technological Expertise: The Indian market is gradually shifting towards advanced solutions such as smart grids and energy-efficient technologies. To remain competitive, companies must possess cutting-edge technological capabilities. Lack of proprietary technology or the inability to form strategic partnerships can hinder the entry and survival of new players.

Established Player Dominance: The market is dominated by well-established domestic and international players like GE, Hitachi, BHEL, Siemens, ABB, Schneider Electric, Crompton Greaves Power & Industrial Solutions Limited, etc. These companies benefit from strong brand recognition, extensive distribution networks, and long-standing customer relationships, making it difficult for new entrants to secure market share.

Supply Chain Complexities: The T&D equipment industry relies on high-quality raw materials and components, many of which are sourced internationally. Delays or disruptions in the supply chain can negatively affect production timelines and cost efficiency. New entrants without robust supply chain networks face greater risks and operational challenges.

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44 https://pib.gov.in/PressReleasePage.aspx?PRID=2003922#:~:text=The%20estimated%20capital%20cost%20for,2021%2D22%20price%20level).

Skilled Workforce Availability: Designing, developing, and maintaining advanced T&D equipment requires specialized skills. However, the shortage of trained and experienced professionals in the field can be a major bottleneck for new market participants.

Economic and Pricing Pressures: The market is highly price-sensitive, with established players adopting aggressive pricing strategies to maintain their competitive edge. New entrants may struggle to achieve cost efficiencies in the initial stages, limiting their ability to compete on price without compromising margins.

Policy and Procurement Barriers: Government contracts often prioritize suppliers with proven track records, limiting opportunities for new players. Although initiatives like "Make in India" are designed to encourage domestic manufacturing, they can pose challenges for entrants who lack prior experience in dealing with complex procurement processes.

5. OUTLOOK FOR CONVENTIONAL POWER EQUIPMENT MARKET IN INDIA

Conventional power equipment includes turbines, generators, boilers, transformers, and related machinery used in coal, gas, and hydro power plants and industries as well like oil & gas, chemical, cement etc. This equipment plays a crucial role in generating and distributing electricity. The market is characterized by a wide range of manufacturers and suppliers, providing both domestically produced and imported products. Technological advancements in efficiency and reliability are enhancing the performance of conventional power plants.

5.1 Market Overview for Siemens Energy India Limited Portfolio

Siemens Energy India Limited offers/provides a wide range of services and solutions to Power Generation Utilities and IPPs, for large Gas and Steam turbines, including operation and maintenance services, modernization and upgradation, plant flexibilization, control and digitalization solutions (digital control systems, field instruments and equipment) and professional consulting. Industrial Gas Turbines and Steam Turbines for Industries, Oil & Gas, Data Centers, medium sized Power Generation Utilities and IPPs. SEIL also offers a wide range of services and solutions including operation and maintenance services, modernization and upgradation, plant flexibilization, control and digitalization solutions (digital control systems, field instruments and equipment) and professional consulting. Details of the portfolio are shared below:

Key Products and Solutions

Turbine/Generator Service program and Maintenance solution: Siemens Energy India Limited can offer comprehensive service portfolio for industrial and aeroderivative gas turbines from 1 MW to 66 MW, heavy-duty Gas Turbines up to 600 MW, large utility Steam Turbines and Generators upto 800 MW.

Siemens Energy India Limited service programs are designed to ensure the optimal performance and longevity of your equipment. The Long-Term Program offers sustained support over extended periods, providing comprehensive maintenance and upgrades to keep the systems running efficiently. The Annual Maintenance Contract ensures regular upkeep and reliability through scheduled inspections and preventive maintenance. These services include modernization and upgrades to incorporate the latest technologies, heat rate improvements, lifetime extension programs to prolong equipment lifespan, and integrated controls and electrical service solutions for seamless operation. Additionally, plant flexibilization services are provided to adapt to cyclic operational demands from coal-based power plants, ensuring maximum absorption of RE power on the grid.

Siemens Energy India Limited maintenance solutions are designed to ensure the reliability and efficiency of the equipment. Field Service provides on-site support for inspections, troubleshooting, and repairs, ensuring minimal downtime. Overhaul and Repair services restore equipment functionality and extend its operational life. Remote Operational Service offers continuous monitoring and assistance, allowing for proactive maintenance and quick resolution of issues. Emergency Repair services address urgent problems promptly to minimize disruptions. Additionally, Siemens Energy India Limited maintain a reliable supply of parts to ensure smooth and uninterrupted operations.

Training and consulting services: Siemens Energy India Limited offers/provides training and certification at the SIROTEC facility for performance guarantee tests, residual life assessments, vibration analysis, and plant performance assessments. These services are designed to enhance skills and ensure the optimal performance and longevity of the equipment.

Digital Control Solutions and Services: Siemens Energy India Limited offers/provides remote diagnostic services for real-time monitoring and troubleshooting, additive manufacturing for innovative production methods, and performance optimization to maximize system output. Siemens Energy India Limited offers/provides maintenance optimization to ensure the longevity and reliability of the equipment, virtual reality services for immersive training and simulation, and robust cybersecurity measures to protect the digital assets.

Siemens Energy India Limited also offers/provides comprehensive instrumentation and control solutions for automating power plants (Greenfield and Brownfield) and renewable energy projects like hydrogen, battery storage, synchronous condensers, and solar/wind power plants. The portfolio features the advanced Omniwise T3000 control system, combining deep process knowledge with cutting-edge digital technology to address critical customer issues such as asset management, performance improvement, cybersecurity, and decarbonization.

Turbo Compressor Services: Siemens Energy India Limited offers/provides a comprehensive range of compressor services for compressors ranging from 400 KW to 50 MW to enhance performance and reliability across various industries. Siemens Energy India Limited services include modernizations and upgrades, remote diagnostic services, and repair solutions, ensuring optimal efficiency and reduced downtime.

Renovation and Modernization Services R&M:

Siemens Energy India Limited offers/provides Renovation & Modernization (R&M) of old thermal plants, particularly 200/210 MW units, transitioning from LMZ to KWU make. Our R&M includes comprehensive "Extended Scope" and "Shaft-line Upgrade," as well as need-based modernization for selected turbine modules, enhancing efficiency, life extension, and flexibilization.

Gas Turbine: Siemens Energy India Limited can offer a wide range of gas turbines (ranging from 2 MW to 600 MW) used in utilities and various process industries like refineries, petrochemical plants etc.

Industrial Steam Turbines – Siemens Energy India Limited offers/provides a wide range of industrial steam turbines (ranging from 10 KW to 250 MW) used in various process industries like refineries, chemical plants, cement, sugar & ethanol, and paper & pulp to name a few.

Industrial Generators – Siemens Energy India Limited offers/provides SGen series generators specifically optimized for industrial applications, offering a robust power range upto 370 MVA.

5.2 Industry Segmentation

5.2.1 Gas Turbines

Gas turbines are an essential component of India's conventional power equipment landscape, playing a pivotal role in power generation, particularly in combined cycle and open cycle power plants. These turbines are favoured for their high efficiency, quick-start capabilities, and ability to generate power from natural gas, a relatively cleaner fossil fuel compared to coal. Gas turbines are also increasingly being used in industrial cogeneration applications.

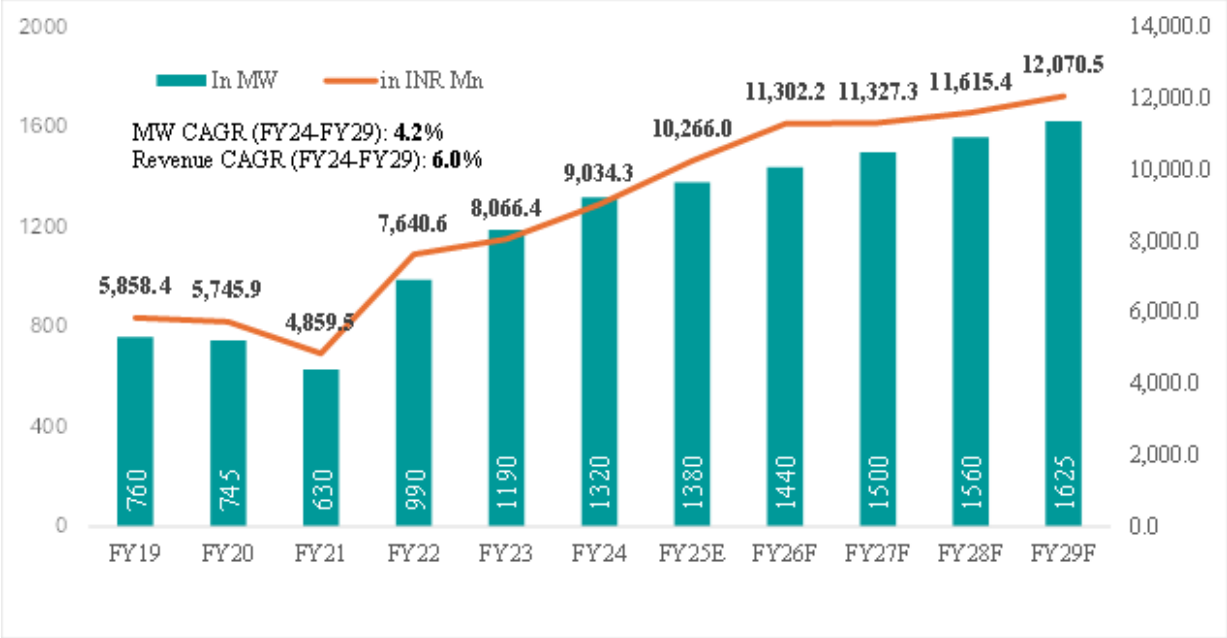
5.2.2 Steam Turbines

These turbines convert steam energy into mechanical energy, driving generators to produce electricity. Technological advancements focus on enhancing turbine efficiency, optimizing performance under varying load conditions, and minimizing emissions. While Steam turbines are used for Utility scale power plants (with capacity of one 1-unit up to 800 MW), the industrial scale steam turbine are typically

used for captive power plants in industries such as metals, cement, chemicals, sugar, textiles, oil & gas etc. (with capacity of 1 unit of up to 250 MW).

Steam turbines is industries are used for various applications including captive power generation, providing process heat required in these facilities and drive machinery as well. The increase in industrial / manufacturing activity and new plants being setup in these industries drives demand for industrial steam turbines. Additionally, the need for reducing green-house gas emissions due to increasing focus on environmental sustainability, is leading to use of steam turbines for waste heat recovery application and Combined Heat and Power (CHP) systems

Figure Error! No text of specified style in document.**.47: Industrial Steam Turbine Market in India – upto 250 MW range (MW), FY 2019-FY 2029F**



Source: Frost & Sullivan Analysis | Note: Revenue Figs for Steam turbine have been computed basis pricing of INR 7.5 Mn / MW (upto 100 MW range), and INR 7 Mn / MW in the > 100 MW and upto 250 MW. Avg price increase of 1-2% per MW factoring in inflation, labour cost, material cost etc, considered over the forecast period FY25 to FY29; FY refers to 1st April to 31st March

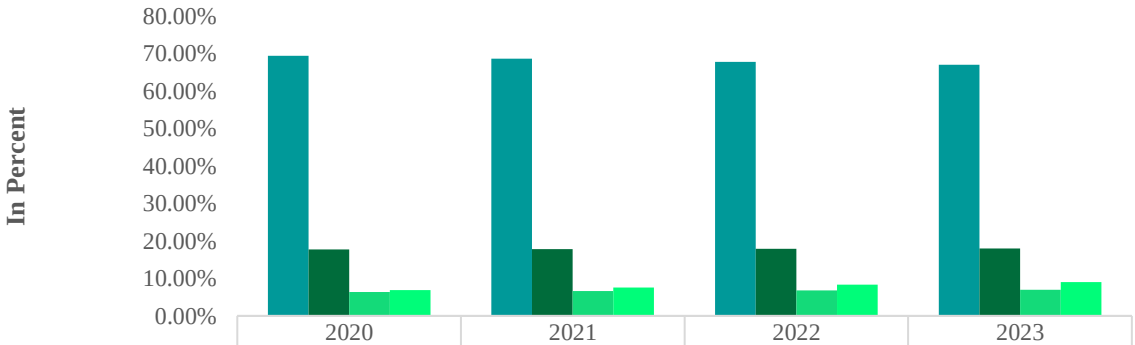
Industrial Steam Turbine market (up to 250 MW range) in India was 760 MW (INR 5,858.4 Mn) in FY 2019. The market dipped in 2020 and 2021 due to drop-in manufacturing activity and projects being put on hold during the pandemic. However, the industrial steam turbine market witnessed strong rebound in FY 2022 to reach 990 MW (INR 7640.6 Mn). The recovery in FY 2022 was driven by demand for heat power in energy intensive segments like cement, steel, distillery etc. An increasing trend of steam turbines for thermal renewable (biomass, waste-heat) based power plants is gaining prominence in India, like the trend globally. In FY 2024, the industrial steam turbine market in India was pegged at 1,320 MW (INR 9,034.3 Mn) growing at 10.90% as compared to FY 2023.

The industrial steam turbine market driven by industry CAPEX, is highly vulnerable to fluctuations and follows the trajectory of the end-market investment and activity growth. With the manufacturing activity in India set to continue an upward trend, and greenfield / brownfield plants planned to be setup in the steel, cement, pulp & paper etc. sectors, the market for Industrial Steam turbines is expected to grow to 1,625 MW (12,070.5 Mn) by FY 2029, with a CAGR of 4.2% for the FY 2024 to FY 2029F period.

The global steam turbine market has experienced a shift in fuel type usage between 2020 and 2023, reflecting evolving energy trends. Fossil fuel-based turbines continue to dominate but have declined from 69.4% in 2020 to 67.0% in 2023, indicating a gradual transition to cleaner alternatives. Combined cycle steam turbines saw a slight increase from 17.7% to 18.0%, driven by their higher efficiency. Thermal renewable sources, including biomass and geothermal, grew from 6.4% to 7.0%, highlighting the push

for sustainable energy. The other fuel category saw the highest increase, from 6.9% to 9.0%, suggesting diversification in steam turbine applications[45].

Figure 0.48: Global Steam Turbine Market, By Fuel Type (In Percentage), 2020 and 2023



	2020	2021	2022	2023
Fossil	69.40%	68.60%	67.80%	67.00%
Combined Cycle	17.70%	17.80%	17.90%	18.00%
Thermal Renewable	6.40%	6.60%	6.80%	7.00%
Others	6.90%	7.60%	8.30%	9.00%

Source: Frost & Sullivan Analysis

The Indian steam turbine market was largely driven by thermal renewable-based power plants, including biomass, waste heat, and waste-to-energy (WtE) projects, followed by fossil fuel-fired power plants. In 2022, most steam turbine demand came from power generation applications, utilizing municipal solid waste (MSW), biomass, waste heat, and fossil fuels. Additionally, energy-intensive industries such as steel and cement contributed significantly to demand, alongside sectors like sugar, distilleries, food processing, pulp and paper, chemicals, and oil & gas, which relied on steam turbines for combined heat and power (CHP) applications[46].

5.2.3 Generators

Generators are integral to the generation, transmission, and distribution of electricity. It is used across coal, gas, hydro, and thermal power plants, generators convert mechanical energy from turbines into electrical energy. The demand for generators is driven by India's growing energy needs, with increasing investments in power plants and infrastructure. The market is witnessing a demand for high-efficiency, low-emission generators that comply with environmental standards while enhancing performance. The average life span of a generator is 20-30 years, which is around 10,000- 30,000 hours.

5.2.4 Energy/Gas Services

Energy & Gas services is a solution to enhance the flexibility, efficiency, reliability and availability of the gas turbine, steam turbine or generator throughout their entire lifecycle. This solution would include asset Renovation & Modernisation (R&M), lifetime extensions, preventive & breakdown maintenance, overhauls, remote monitoring, condition monitoring & diagnostics, digital services, turnkey services etc.

The average life of steam turbines are around 30-40 years, which can be extended by periodic maintenance. Similarly, the average life span of gas turbines are 20 to 25 years, which is around 100,000 equivalent operational hours. The Energy & Gas services solutions enable renovation, modernisation, and life extension of these assets.

[45] https://www.triveniturbines.com/wp-content/uploads/2024/08/TTL_Annual-Report_2024.pdf
[46] https://www.triveniturbines.com/wp-content/uploads/2023/10/TTL_AR23_For-website-1.pdf

Energy & Gas services Opportunity in India

Of India's total 466.3 GW of power generation installed capacity, at end of 31st January 2024[47], more than half (51.2%) of the capacity is for coal and gas-based plants combined. Power generation installed capacity of 238.7 GW of coal and gas based combined in India comprises of legacy fleet of Steam and Gas turbines of varying capacity installed in the country decades ago. These legacy fleets provide significant LE and R&M opportunities for turbine equipment suppliers

1. **Renovation & Modernization (R&M) / Life Extension (LE) of Power Plants**: As per CEA, during 2017-22 period, R&M/LE works was identified for 14,929 MW with eight units 1,197 MW already completed up to September 2024[48]. The remaining projects are at various stages, including feasibility studies, detailed project reports, and tendering.

2. **Fuel Flexibilization:** The power sector globally has been undergoing transformation due to environmental concerns, thus leading to increasing share of Renewable Energy in the overall Energy mix. India has been moving ahead rapidly to add renewable energy with a target to have renewable energy capacity of 500 GW by 2030, in line with its NDC commitment of 40% of installed renewable capacity by 2030. The introduction of large-scale renewable generation in the grid is bringing a new set of challenges in the power sector – the inconsistency and intermittency of solar & wind power availability and generation affects the T&D grid stability. While maximizing generation for Renewable energy sources & integration into the grid, the flexible operation (adjust output quickly to compensation for fluctuations in renewable generation) of existing coal-based plants is critical to ensure reliability of power supply, energy security and most importantly stability of the T&D grids.

Since the thermal generation capacity in the country constitutes a dominant share – 52.74%1. of the total capacity (as on 31st January 2025) , flexible operation of thermal power plant is essential for handling the intermittency & instability of renewable energy generation and integration into the grid.

As per CEA, 148 units with a total capacity of 38 GW, 150 MW have been identified as potential units for Fuel Flexibilization program during the time frame of 2024-2033. These units of coal-based plants would be able to switch between switch between different fuel sources, like coal, gas, or biomass, depending on availability and market conditions, primarily to better integrate large amounts of intermittent renewable energy would be plants for R&M/LE / Retrofits works. Retrofitting existing coal plants to operate flexibly requires significant investment in new equipment and control systems, thus providing an opportunity for Energy & Gas services. The retrofitting would also include investing in advanced upgrades like condition monitoring systems, control and instrumentation enhancements, combustion optimisation and steam/flue gas management. Additionally, with focus on equipment performance monitoring & optimisation, and predictive maintenance, digitalisation will play a critical role, with data-driven decision-making powered by AI/ML. and use of analytics to enhance equipment uptime.

3. **Thermal Power Expansion Opportunities to meet Baseload Power Needs**: As per National Electricity Plan (NEP), to meet the country's baseload power needs, an additional 80 GW of thermal power capacity is required by FY 2031 - 32. Currently, 27 GW of thermal power generation capacity is under construction. As a result, to meet the growing power demand, an additional ~ 55-60 GW of thermal capacity must be added, which is ~ 2X higher than the planned addition of 25 GW. This would further increase the installed base of thermal power plants, thus offering opportunity for Energy & Gas services in the subsequent years.

As compared to one time equipment (steam / gas) turbine sale, the retrofit, R&M, Life Extension, Digitalization, services provide recurring service revenue stream to the service provider / Equipment OEM over the life cycle of the equipment.

5.3 Key Drivers and Restraints

[47] https://cea.nic.in/wp-content/uploads/executive/2025/02/Executive_Summary_Jan_2025_Actual.pdf
[48] https://cea.nic.in/old/reports/others/thermal/trm/R_ampGuideline.pdf

Key Drivers:

- **Grid Modernization and Expansion:**

As Indian grids undergo modernization to enhance efficiency and incorporate more diverse energy sources, there's increased demand for conventional power equipment to support grid stability, load balancing, and voltage regulation.

- **Energy Storage Integration:**

Conventional power plants can be integrated with energy storage systems (such as batteries) to store surplus energy during off-peak hours, helping to address challenges of power fluctuations in renewable energy sources and improving grid reliability.

- **Fuel Availability:**

Availability of resources like coal, natural gas, and nuclear fuel continues to be a key driver. For many countries, these resources are abundant and cost-effective, enabling the continued operation of conventional power plants.

- **Capacity Expansion in Emerging Markets:**

Rapid economic growth and industrialization in emerging economies require the construction of new power plants, leading to a surge in demand for conventional power equipment, which is considered more reliable in meeting large-scale energy needs.

- **Others**

  - **Growing Energy Demand:** Rising electricity consumption due to industrialization, urbanization, and economic growth, particularly in emerging economies. Increased power requirements for sectors like manufacturing, data centres, and transportation.

  - **Advancements in Turbine Technology:** Digitalization & AI-Driven Monitoring: Predictive maintenance, efficiency optimization, and real-time performance tracking using AI & IoT. Improved Efficiency developments in gas and steam turbines, leading to higher operational efficiency and lower emissions.

  - **Infrastructure Development & Electrification:** Government initiatives for rural electrification and expansion of transmission & distribution networks. Investment in power plants, grid modernization, and cross-border electricity trade.

Key Restraints:

- **Public Opposition & NIMBY (Not in My Backyard) Syndrome:**

Local opposition to new power plant developments, especially fossil-fuel-based plants, due to environmental and health concerns, often delays projects and increases costs for developers.

- **Energy Market Shifts Towards Renewables:**

As renewable energy sources become more cost-competitive and receive greater policy support, there is a shift away from conventional power, reducing demand for related infrastructure and equipment, especially in advanced economies.

- **Strict Emission Regulations:**

Governments around the world are imposing stricter emissions standards on conventional power plants, especially coal-fired plants, leading to higher compliance costs or the need for expensive retrofitting technologies (e.g., carbon capture and storage).

- **Fuel Price Volatility:**

The price volatility of fossil fuels such as coal, natural gas, and oil can destabilize operational costs for conventional power plants, making them less attractive in comparison to renewable options that have no fuel costs.

- **Geopolitical Risks:**

Energy dependencies on certain regions for fossil fuel imports, especially natural gas and oil, expose conventional power generation to geopolitical risks such as trade disruptions, price hikes, or supply shortages.

- **Others**

  - **Operational & Efficiency Challenges:** Conventional power plants depend on coal, gas, and oil, making them susceptible to fuel price fluctuations. Transmission and distribution losses reduce efficiency, particularly in aging grids. Additionally, high maintenance costs, including regular servicing, spare parts, and skilled labour, further increase operational expenses, impacting overall profitability and long-term sustainability.

  - **Long Project Development Timelines:** High capital investment poses financing challenges for large-scale power developments. Additionally, construction delays due to weather conditions, supply chain disruptions, and engineering complexities further extend project timelines, impacting overall power capacity expansion and operational efficiency.

5.4 Market Entry Barriers

Barriers to entry in the traditional power equipment market include:

High Capital Costs:

Establishing a new power equipment manufacturing plant or network requires significant investment, which can deter many potential entrants. High capital costs in the range of INR 6-8 crore per MW are typical for coal fired power plants in India. The key cost elements are Boilers, turbines, generators, emission control systems, land acquisition, and fuel handling infrastructure

Economies of Scale: Existing large players benefit from economies of scale, making it difficult for new, smaller firms to compete. New entrants struggle to match the production volumes and cost efficiencies of established competitors.

Government Regulations and Policies: Strict regulations, licensing, and compliance requirements can create financial and administrative burdens for new entrants. Industries like energy and utilities often require licenses and adherence to rigid government regulations.

Technology Capability: The energy sector requires mastery of complex technologies, making it more challenging for new companies to enter.

Patents: Existing patents can prevent new entrants from manufacturing similar products or offering similar services until the patents expire.

Consolidated Trademarks and Brand Reputation: Entering a market with established and prestigious brands is difficult.

Monopolization of Resources: Incumbent firms may have priority access or control over essential resources, like raw materials, needed for production, creating a barrier for new companies.

High Fixed Operating Costs: High fixed costs associated with operating in the power equipment sector can make new companies wary of entering the market.

Distribution and After Sales Service: Entering the traditional power equipment market is challenging due to high capital investment, regulatory compliance, and complex distribution networks. After-sales service demands skilled workforce, spare parts availability, and long-term maintenance. Established players dominate with service contracts, while new entrants struggle to build networks, secure contracts, and offer reliable support.

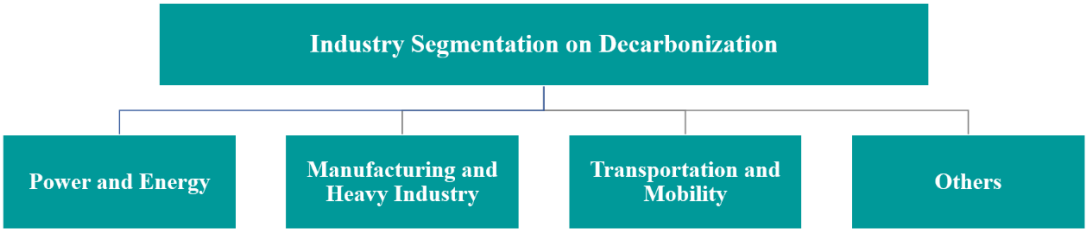
6. OUTLOOK FOR DECARBONIZATION MARKET IN INDIA

India's decarbonization outlook is strong, with a growing focus on clean energy solutions and it is making significant progress in scaling up renewable energy production, contributing to a greener grid. There is increasing adoption of renewable technologies and advanced energy-efficient technologies across sectors.

6.1 Industry Segmentation (Utility/Industrial decarbonization)

Decarbonization spans across multiple industries, each adopting tailored strategies to reduce emissions. The power sector focuses on renewable energy, energy storage, and Carbon Capture, Utilization, and Storage (CCUS). Manufacturing industries like steel, cement, and chemicals prioritize process electrification and low-carbon fuels. Transportation sectors adopt Electric Vehicles (EVs), Sustainable Aviation Fuels (SAFs), and green shipping solutions

Figure Error! No text of specified style in document.**.49: Industry Segmentation**



Source: Frost & Sullivan Analysis

6.2 Market Overview for Siemens Energy India Limited Portfolio

Siemens Energy India Limited offers/provides a comprehensive range of products and solutions in the decarbonization market, focusing on reducing CO_2 emissions and improving resource efficiency across various sectors. Siemens Energy India Limited also offers/provides solutions for energy efficiency as Waste Heat Recovery (WHR), and a wide range of services and solutions including operation and maintenance services, modernization and upgradation, control and digitalization solutions (digital control systems, field instruments and equipment) and professional consulting. Siemens Energy India Limited also focus on providing solutions for the Electrification, Digitalization and Automation of the Process Industry (oil and gas, chemicals, petrochemicals, paper & pulp, sugar & ethanol, etc.), Marine industry (electrical traction systems for e-ferry, e-vessels) and Defense industry (electrical traction systems for submarine and other vessels). The products and services are explained in detail below:

Key Products and Solutions

Decarbonisation Solutions – Siemens Energy India Limited has a portfolio of decarbonisation and energy storage solutions to help customers to reduce their energy consumption, greenhouse gas emissions and support sustainability. The solutions are as below:

- Compressed air energy storage (CAES) - Siemens Energy India Limited can offer CAES which is a comprehensive, proven, grid-scale energy storage solution.

- Waste Heat Recovery (WHR) – Siemens Energy India Limited offers/provides WHR solution which is an efficient method of recovering thermal energy from the waste heat in industries like cement, steel etc.

- Concentrated Solar Power (CSP) – Siemens Energy India Limited can offer steam turbines & auxiliaries for concentrated solar power to help achieve the full dispatchability of solar energy power plants.

- Organic Rankin Cycle (ORC) – Siemens Energy India Limited offers/provides Organic Rankin Cycle based solution which helps in recovering energy from the hot exhaust gas using an organic fluid as the heat exchange medium.

Electrification and Automation – Siemens Energy India Limited offers/provides industry specific integrated offerings for power management and automation solutions for industry like (pulp and paper, marine and biofuel etc.).

Green Hydrogen – Siemens Energy India Limited can offer systems/solutions for green hydrogen production using PEM electrolyzer to produce hydrogen as a clean and sustainable source, as it provides a way to generate hydrogen gas using renewable electricity and water, without producing greenhouse gas emissions.

6.2.1 Green Hydrogen

Green hydrogen plays a pivotal role in the decarbonization market by offering a sustainable alternative to fossil fuels. It enables the reduction of carbon emissions across energy-intensive sectors, such as manufacturing, transportation, and power generation, supporting global efforts to transition to cleaner energy systems and achieve Net Zero climate goals. In the backdrop of Green Hydrogen as a promising alternative for enabling India's Energy Transition, the Union Cabinet in January 2022 approved the National Hydrogen Mission with the intended following objectives –

a. Making India a leading producer and supplier of Green Hydrogen in the world

b. Creation of export opportunities for Green Hydrogen and its derivatives

c. Reduction in dependence on imported fossil fuels and feedstock

d. Development of indigenous manufacturing capabilities

e. Attracting investment and business opportunities for the industry

f. Creating opportunities for employment and economic development

g. Supporting R&D projects

The National Green Hydrogen Mission was approved with a total initial outlay of INR 197.44 Bn. This includes INR 174.90 Bn for the SIGHT (Strategic Interventions for Green Hydrogen Transition) programme for domestic manufacturing of electrolysers and green hydrogen production, INR 14.66 Bn for pilot projects focusing on emerging end-use sectors and innovative production pathways, INR 4.00 Bn for R&D, and INR 3.88 Bn for other Mission components[49].

6.2.2 CCUS

Carbon Capture, Utilization, and Storage (CCUS) is a critical technology for reducing carbon emissions. It involves capturing CO_2 from industrial processes, storing it underground, or repurposing it for commercial use. CCUS supports climate goals, fosters innovation, and contributes to sustainable economic growth through decarbonization efforts.

India, as one of the world's largest greenhouse gas emitters, faces significant challenges in reducing its carbon footprint while supporting its rapidly growing energy and industrial sectors. The country's reliance on coal for power generation and its expanding industrial base create difficulties in achieving decarbonization through renewable energy alone. India has set ambitious Nationally Determined

[49] https://static.pib.gov.in/WriteReadData/specificdocs/documents/2024/may/doc2024510336301.pdf

Contribution (NDC) targets, including achieving 50% of its total installed capacity from non-fossil energy sources, reducing emission intensity by 45% by 2030F, and advancing toward Net Zero by 2070F. Carbon Capture, Utilization, and Storage (CCUS) emerges as a critical strategy for decarbonizing hard-to-abate sectors. In addition to environmental benefits, CCUS projects are expected to drive significant job creation. It is expected capturing around 750 million tonnes per annum (mtpa) of carbon by 2050F could generate approximately 8-10 million Full-Time Equivalent (FTE) employment opportunities over time[50].

The CCUS funding in India was INR 438.57 Bn in 2024 and this is expected to grow to INR 2,558.00 Bn in 2032F with a CAGR of 24.66% between the period 2024-2032F.

6.3 Key Drivers and Restraints including

Key Drivers of Decarbonization in India

- **International Climate Commitments:** India's commitment to the Paris Agreement and its climate goals, such as achieving net-zero emissions by 2070, act as significant drivers for decarbonization. These global commitments push India to adopt sustainable practices and reduce its carbon footprint to meet international standards.

- **Rising Air Pollution:** India faces severe air pollution issues, particularly in urban centres. The need to improve air quality and public health is motivating the government and businesses to adopt cleaner technologies, such as electric vehicles (EVs) and cleaner industrial processes, accelerating decarbonization efforts.

- **Technological Advancements in Clean Energy:** Emerging technologies such as hydrogen fuel, advanced battery storage, and grid management solutions are diving the shift to clean energy. These innovations make renewable energy more reliable and cost-competitive, further supporting India's decarbonization goals.

- **Corporate Sustainability Initiatives:** India’s private sector is increasingly aligning with global sustainability trends. Many large corporations are adopting green practices to improve their environmental footprint and meet the growing demand for sustainable products and services, fostering a corporate-driven push toward decarbonization.

- **Public Awareness and Demand for Sustainability:** Growing awareness about climate change and its impacts is driving consumer demand for green products, sustainable solutions, and low-emission technologies. This shift in consumer behaviour incentivizes businesses to adopt cleaner energy alternatives.

- **Make in India:** The "Make in India" initiative can significantly benefit Indian companies in the decarbonization market. The Indian government is actively promoting the adoption of cutting-edge decarbonization technologies across various sectors, presenting substantial opportunities for domestic manufacturing and investment[51].

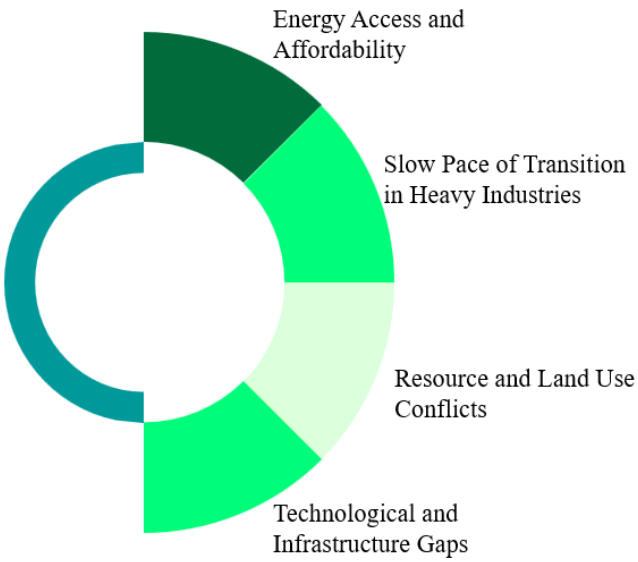
- **China + 1 Strategy:** The "China Plus One" (C+1) strategy is a business approach focused on diversifying investments and supply chains beyond China to mitigate risks and enhance resilience. This strategy encourages companies to reduce their dependence on China by establishing operations in other promising developing economies. The goal is not necessarily to abandon China, but to strategically spread business operations across multiple countries.

Key Restraints of Decarbonization in India

Figure Error! No text of specified style in document.**.50: Key Restraints of Decarbonization in India**

[50] https://pib.gov.in/PressReleasePage.aspx?PRID=1879865

[51] https://www.trade.gov/market-intelligence/india-decarbonization-and-carbon-capture-utilization-and-storage-ccus-market



Source: Frost & Sullivan Analysis

- **Energy Access and Affordability**: A large segment of India's population still lacks reliable access to energy. Prioritizing decarbonization while ensuring affordable energy access for rural and low-income populations is a significant challenge. Balancing these needs is crucial for equitable development.

- **Slow Pace of Transition in Heavy Industries:** Sectors like cement, steel, and chemical manufacturing are among the largest CO2 emitters. Despite the potential for technological advancements, these industries are slow to adopt cleaner technologies due to the high cost of retrofitting existing infrastructure and the energy intensity of their operations.

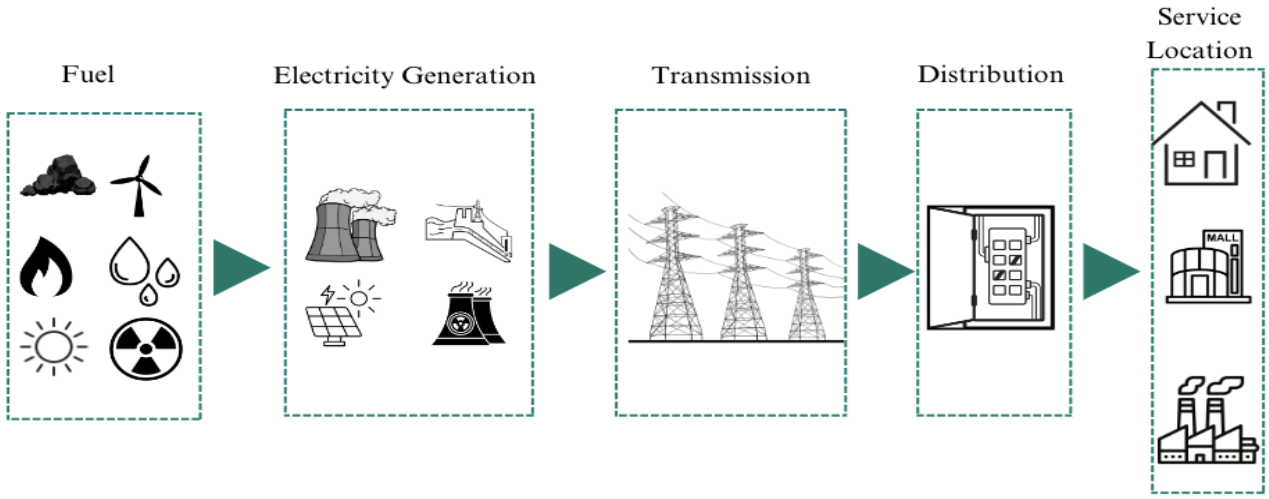
- **Resource and Land Use Conflicts:** Large-scale renewable energy projects, such as solar and wind farms, require significant land and water resources. In densely populated areas, conflicts arise over land use, agricultural needs, and local community concerns, complicating the expansion of clean energy infrastructure.

- **Technological and Infrastructure Gaps**: India faces challenges in scaling up necessary infrastructure, including reliable grid connectivity and storage solutions, to accommodate renewable energy. The intermittent nature of renewable energy sources like solar and wind requires improved energy storage and grid management technologies, which remain underdeveloped in many regions.

7. COMPETITIVE LANDSCAPE AND KEY PLAYERS

7.1 Value chain connecting above segments of Power and Energy industry

Figure 0.51: Value chain of Power and Energy Industry



Source: Frost & Sullivan Analysis

The value chain in the power and energy industry is a comprehensive process that transforms primary energy sources into usable forms for end consumers. It is typically divided into upstream, midstream, and downstream segments. The upstream segment involves the exploration, extraction, and production of energy resources, such as coal, natural gas, and renewable energy sources like solar and wind. This stage is crucial for generating electricity and extracting fossil fuels.

In the midstream segment, energy is transported and stored. This includes infrastructure like transmission lines for electricity and pipelines for gas. Midstream activities also involve managing energy portfolios and optimizing supply chains to ensure efficient delivery between production and consumption.

The downstream segment focuses on delivering usable energy products to end-users. This includes refining petroleum products, processing natural gas, and distributing electricity to households and businesses. Downstream companies are involved in marketing and retail activities, ensuring that energy reaches consumers in a consumable form. The industry is evolving to incorporate more renewable energy sources, enhancing sustainability and reducing carbon emissions.

7.2 Major Companies in the Indian Power and Energy Sector

- **NTPC Limited –** India's largest power producer, generating electricity from coal, gas, hydro, solar, and wind. Expanding into green hydrogen, battery storage, and renewables to support India's clean energy transition and reduce carbon emissions.

- **Power Grid Corporation (PGCIL)** – Government-owned entity managing India's high-voltage transmission network. Ensures efficient electricity distribution, grid stability, and renewable energy integration through modern smart grid technologies and interstate transmission projects.

- **Tata Power** – A diversified private energy company with a strong renewable energy portfolio, including solar, wind, hydro, and EV charging. Expanding rooftop solar solutions, microgrids, and smart energy management systems across India.

- **Adani Power** – India's largest private-sector thermal power producer, operating large coal-based plants. Rapidly expanding in solar power and green energy projects to align with India's renewable energy targets.

- **JSW Energy** – Focused on thermal, hydro, solar, and wind energy, with major investments in battery storage and green hydrogen. Committed to transitioning toward sustainable energy solutions for long-term growth.

- **NHPC Limited** – India's largest hydropower company, developing hydroelectric projects and expanding into solar and wind energy. Plays a crucial role in reducing reliance on fossil fuels.

- **Reliance Industries (Renewables)** – Investing in green energy with solar panel giga factories, battery storage, hydrogen production, and EV infrastructure.

- **ReNew Power** – An independent power producer specializing in wind and solar energy. Developing battery storage solutions and supporting India's shift to 500 GW of non-fossil fuel capacity by 2030.

- **Coal India Limited** – The world's largest coal producer, supplying fuel to India's thermal power plants. Exploring cleaner coal technologies and diversification into renewable energy solutions.

- **GAIL (India) Limited** – GAIL supplies gas for power generation, it is also diversifying into renewables like biofuels, hydrogen, and solar energy.

7.3 Key competitors to Siemens Energy India Limited and their market positioning

- **BHEL** – Bharat Heavy Electricals Limited is India's largest power equipment manufacturer, producing turbines, boilers, generators, and transformers for thermal, hydro, nuclear, and renewable energy projects. The company expanding into advanced grid solutions, energy storage, and hydrogen technologies to support India's clean energy transition.

- **Hitachi Energy India** – The company focuses on energy solutions, including high-voltage equipment, transformers, and smart grids. The products and solutions are used for energy-efficient transmission systems, digital substations, and energy storage technologies.

- **Crompton Greaves Power & Industrial Solutions Limited** –They are manufacturer of transformers, switchgear, and power automation systems, providing solutions for utilities, industries, and renewable energy projects.

- **Transformers & Rectifiers India Limited (TRIL)** – TRIL specializes in manufacturing power, distribution, and furnace transformers. The end client's include utilities, industrial clients, and renewable projects. The TRIL equipment include medium to ultra-high voltage Transformers / Switchgears.

- **Schneider Electric Infrastructure Limited** – The company provides smart energy management, electrical distribution, and automation solutions. The products are used in grid modernization, renewable energy integration, microgrid solutions, and smart substations. The products of Schneider electric infrastructure limited are low to medium Transformers / Switchgears

- **ABB India Limited** – It is one of the global leaders in electrification, automation, and robotics, offering high-voltage transmission solutions, smart grid technology, and industrial automation.

- **Hyosung T&D India** – It specializes in gas-insulated switchgear (GIS) and high-voltage transformers. Hyosung T&D India provides solutions for improving grid stability and enhancing energy efficiency.

- **GE Power India Limited (GEPIL)** – GEPIL manufactures steam turbines, boilers, and environmental control systems for thermal and renewable power plants.

- **GE Vernova T&D India Limited –** The company offers products and solutions ranging from medium voltage to ultra-high voltage (upto 1200 kV) for power generation, transmission and distribution industry.

- **Toshiba Transmission & Distribution Systems (TTDI)** – Manufactures transformers, switchgear, and energy-efficient transmission solutions. The end usage of the products manufactured by Toshiba are in grid modernization and distribution technologies. Toshiba Transmission & Distribution Systems (TTDI) specializes in high-voltage equipment for power transmission and distribution.

- **Triveni Turbines** – It is one of leading manufacturer of industrial steam turbines for power generation, oil & gas, and process industries.

7.3.1 Financial Benchmarking of Key Players

The revenue of Siemens Limited (Energy Business) was INR 63,452 Mn in FY 2024, and the EBIT was 9,101.00 Mn during the above-mentioned period. The EBIT Margin was 14.34% during the period FY 2024.

Figure Error! No text of specified style in document.**.52: Financial Benchmarking of Key Players, FY 2024**

	Siemens Limited (Energy Division)	BHEL (Power Segment)	GE Vernova T&D India Limited	GE Power India Ltd (GEPIL)	GE Vernova (GE PIL +GE T&D India)	Hitachi Energy India	Crompton Greaves Power & Industrial (Figs of Power Systems Division)	Transformers & Rectifiers India Ltd. (TRIL)	Schneider Electric Infrastructure Limited	ABB India Limited	Hyosung T&D India	Toshiba Transmission & Distribution Systems (TTDI)	Triveni Turbines
Headquaters	Mumbai	Delhi	Delhi	Noida	Delhi	Bengaluru	Mumbai	Ahmedabad	Gurgaon	Bengaluru	Pune	Telangana	Noida
Company Type	Public	Public	Public	Public	Public	Public	Public	Public	Public	Public	Private	Private	Public
Revenue from Operation (In INR Mn) FY2024	63,452.00	1,77,096.00	31,679.10	16,247.60	47,926.60	52,374.90	25,984.80	12,733.13	22,066.80	1,20,876.70	9,823.27	40,660.00	16,539.40
EBIT (In INR Mn)	9,101.00	16,570.00	2,913.50	-2588.30	325.20	2,601.90	4,099.90	1,151.92	2,788.89	25,297.10	791.79	6,847.00	3,602.48
EBIT Margin (%)	14.34%	9.36%	9.20%	-15.93%	0.68%	4.97%	15.78%	8.90%	12.64%	20.93%	8.06%	16.85%	21.78%
Key Industries	Turbines, Grid Solutions, Energy Management, Sub-station Automation etc.	Power Generation and Transmission, Transformer Manufacturing	Power Transmission & Distribution	Power Generation Solutions	Power Transmission & Distribution + Generation Equipment	Power Systems & Grid Solutions, Transformer Manufacturing, Energy Management & Automation	Power Systems & Equipment	Transformer Manufacturing	Energy Management & Automation	Power & Automation Technology	Transmission & Distribution Equipment	Transmission & Distribution Equipment	Turbine Manufacturing

Source: Website, Annual reports | Note: FY for Siemens Limited (Energy Business) end on 30th September | The FY for rest of the companies is from 1st April to 31st March, EBIT for Siemens Limited (Energy Business) considered a positive impact of exceptional items of INR 692 million in FY2024, EBIT margin for Siemens Limited (Energy Business) considers a positive impact of the exceptional items of 110bps in FY2024.

7.3.2 Comparison of Revenue from Operations of Key Players

The revenue from operations of Siemens Limited (Energy Business) grew from INR 47,341.00 Mn in FY 2021 to 63,452.00 Mn in FY 2024 at a CAGR of 10.26%.

Figure 0.53: Revenue from Operations of Key Players, FY 2021 – FY 2024

Revenue (In INR Mn)	FY2021	FY2022	FY2023	FY2024	CAGR FY2021-FY2024
BHEL (Power Segment)	1,13,861.00	1,53,613.00	1,74,990.00	1,77,096.00	15.86%
GE Vernova T&D India Limited	34,523.70	30,659.50	27,732.00	31,679.00	-2.83%

Revenue (In INR Mn)	FY2021	FY2022	FY2023	FY2024	CAGR FY2021-FY2024
GE Power India Ltd (GEPIL)	33,430.20	26,204.40	17,958.10	16,247.60	-21.38%
GE Vernova (GE PIL +GE Vernova T&D India Limited)	67,953.90	56,863.90	45,690.10	47,926.60	-10.99%
Hitachi Energy India	37,705.00	38,684.00	44,685.10	52,374.90	11.58%
Crompton Greaves Power & Industrial Solutions Limited (Figs of Power Systems Division)	86,093.00	15,931.80	20,229.20	25,984.80	-32.92%
Transformers & Rectifiers India Limited (TRIL)	7,420.85	11,583.35	13,959.70	12,946.76	20.38%
Schneider Electric Infrastructure Limited	12,971.28	15,303.39	17,771.90	22,066.80	19.38%
ABB India Limited	69,340.00	85,680.00	1,04,470.00	1,20,876.70	20.35%
Hyosung T&D India	2,392.09	5,597.08	4,527.01	9,823.27	60.14%
Toshiba Transmission & Distribution Systems (TTDI)	18,095.00	24,726.80	32,477.00	40,631.00	30.95%
Triveni Turbines	7,026.00	8,522.00	12,475.50	16,539.40	33.03%
Siemens Limited (Energy Business)	47,341.00	53,710.00	60,803.00	63,452.00	10.26%

Source: Website, Annual reports | Note: FY for Siemens Limited (Energy Business) end on 30th September | The FY for rest of the companies is from 1st April to 31st March.

Siemens Limited (Energy Business), an energy technology company is one of the leading player (in terms of Revenue from Operations) providing solutions for the Power Generation and Transmission segment in India.

7.3.3 Comparison of EBIT of Key Players

The EBIT of Siemens Limited (Energy Business) grew from INR 5,918.00 Mn in FY 2021 to 9,101.00 Mn in FY 2024 at a CAGR of 15.43%.

Figure Error! No text of specified style in document.**.54: EBIT of Key Players, FY 2021 – FY 2024**

EBIT (In INR Mn)	FY2021	FY2022	FY2023	FY2024	CAGR FY2021-FY2024
BHEL (Power Segment)	-12,462.00	19,492.00	15,851.00	16,570.00	-

EBIT (In INR Mn)	FY2021	FY2022	FY2023	FY2024	CAGR FY2021-FY2024
GE Vernova T&D India Limited	1,487.00	-1,409.60	801.20	2,913.50	25.13%
GE Power India Ltd (GEPIL)	2,027.10	-616.60	-1,163.80	-2,588.30	-208.49%
GE Vernova (GE PIL +GE T&D India)	3,514.10	-2,026.20	-362.60	325.20	-54.77%
Hitachi Energy India	1,862.00	2,730.00	1,732.00	2,601.90	11.80%
Crompton Greaves Power & Industrial Solutions Limited (Figs of Power Systems Division)	-822.00	1,613.30	2,248.00	4,099.90	-
Transformers & Rectifiers India Limited (TRIL)	587.19	668.87	1,050.30	1,151.92	25.18%
Schneider Electric Infrastructure Limited	471.84	761.11	1,766.00	2,788.89	54.75%
ABB India Limited	7,349.70	13,758.90	16,715.60	25,297.10	50.98%
Hyosung T&D India	-107.84	-76.60	354.63	791.79	-
Toshiba Transmission & Distribution Systems (TTDI)	595.40	1,454.70	2,941.00	6,847.00	125.72%
Triveni Turbines	1,667.00	1,921.00	2,764.00	3,810.00	31.72%
Siemens Limited (Energy Business)	5,918.00	5,648.00	6,873.00	9,101.00	15.43%

Source: Website, Annual reports | Note: FY for Siemens Limited (Energy Business) end on 30th September | The FY for rest of the companies is from 1st April to 31st March; EBIT for Siemens Limited (Energy Business) considers a positive impact of exceptional items of INR 692 million in FY 2024.

7.3.4 Comparison of EBIT Margins of Key Players

The EBIT Margin of Siemens Limited (Energy Business) grew 12.50% in FY 2021 to 14.34% in FY 2024.

Figure Error! No text of specified style in document.**.55: EBIT Margins of Key Players, FY 2021 – FY 2024**

EBIT Margin (%)	FY2021	FY2022	FY2023	FY2024
BHEL (Power Segment)	-10.94%	12.69%	9.06%	9.36%
GE Vernova T&D India Limited	4.31%	-4.60%	2.89%	9.20%

EBIT Margin (%)	FY2021	FY2022	FY2023	FY2024
GE Power India Ltd (GEPIL)	6.06%	-2.35%	-6.48%	-15.93%
GE Vernova (GE PIL +GE T&D India)	5.17%	-3.56%	-0.79%	0.68%
Hitachi Energy India	4.94%	7.06%	3.88%	4.97%
Crompton Greaves Power & Industrial Solutions Limited (Figs of Power Systems Division)	-0.95%	10.13%	11.11%	15.78%
Transformers & Rectifiers India Limited (TRIL)	7.91%	5.77%	7.52%	8.90%
Schneider Electric Infrastructure Limited	3.64%	4.97%	9.94%	12.64%
ABB India Limited	10.60%	16.06%	16.00%	20.93%
Hyosung T&D India	-4.51%	-1.37%	7.83%	8.06%
Toshiba Transmission & Distribution Systems (TTDI)	3.29%	5.88%	9.06%	16.85%
Triveni Turbines	20.85%	20.16%	20.56%	21.78%
Siemens Limited (Energy Business)	12.50%	10.52%	11.30%	14.34%

Source: Website, Annual reports | Note: FY for Siemens Limited (Energy Business) end on 30th September | The FY for rest of the companies is from 1st April to 31st March; EBIT margin for Siemens Limited (Energy Business) considers a positive impact of exceptional items of 110 bps in FY 2024.

7.4 SWOT analysis of top 5 competitors

Product Offerings of Top 5 Competitors (Portfolio / offering subject to revision basis alignment with Siemens Energy India Limited).

7.4.1 Product Offerings of Top 5 Competitors

Figure Error! No text of specified style in document.**.56: Product Offerings of Top 5 Competitors**

	Siemens Energy India Limited	BHEL (Power Segment)	GE Vernova T&D India Ltd	Hitachi Energy India	Crompton Greaves Power & Industrial Solutions Ltd.
Industrial Steam Turbines	☑	☑			
Industrial Generators	☑	☑			☑
Turbine/Generator Service program and Maintenance solution	☑	☑			☑

	Siemens Energy India Limited	BHEL (Power Segment)	GE Vernova T&D India Ltd	Hitachi Energy India	Crompton Greaves Power & Industrial Solutions Ltd.
Digital Control Solutions and Services	☑	☑	☑	☑	
Flexible AC transmission systems (FACTS)	☑	☑	☑	☑	
High-voltage direct current (HVDC)	☑	☑	☑	☑	
High-voltage refurbishment solutions	☑	☑	☑	☑	☑
High-voltage substations	☑	☑	☑	☑	☑
Power Transformers & Reactors	☑	☑	☑	☑	☑
Traction Transformers	☑	☑	☑	☑	☑
Gas Insulated Switchgear (GIS)	☑	☑	☑	☑	☑
Air Insulated Switchgear (AIS)	☑	☑	☑	☑	☑
Instrument Transformers	☑	☑	☑	☑	☑
Grid Services	☑	☑	☑	☑	☑
Decarbonisation & Energy Efficiency Solutions	☑	☑	☑	☑	

Source: Company websites| Note: Kindly refer to company websites for detailed product/solution specification and offerings

Siemens Energy India Limited has the largest portfolio of product offerings amongst its competitors.

7.4.2 Bharat Heavy Electricals Limited (Power Segment) (BHEL)

7.4.2.1 Strength:

- BHEL was founded in 1956 and has 6 manufacturing locations across India
- The order books of BHEL accounted to around INR 7,79,070 Mn in FY 2024. The order books in FY 2023 were INR 235480 Mn, the order books witnessed a growth of around 2.31x times between the period FY 2024 and FY 2023.
- 2.50% of the annual revenue is invested into the R&D of new products, the company has filed around 543 patents, according to their declaration in annual report.
- Strong presence in 89 countries, the company has manufactured 465 coal-based utility sets, 424 hydro utility sets, 103 gas-based utility sets and 14 nuclear based utility sets in India since inception.
- 200 GW+ power equipment installed in India and Abroad and 20 GW captive power plant commissioned.
- The total outstanding orders account to around INR 13,15,980 Mn in FY 2024.
- BHEL accounts to 54% in India's total installed thermal capacity of utility scale power projects. It also accounts to 57% of nuclear power generation capacity (secondary side) and 44% of hydro power generation capacity as on FY 2024.

- BHEL is only large turbine manufacturer which is catering to New Coal Capacity it recently signed agreement with Adani for 3 Super Critical Units in Rajasthan and Maharashtra.

7.4.2.2 Weakness:

- BHEL has an installed capacity of around ~442 GW as on 31st March 2024, out of which around 49% of the capacity are dependent on Coal and Lignite based fuel.

- Limited installations in markets outside of the Indian market, 13 GW installed capacity overseas and over 4 GW under installation as of 31st March FY 2024.

- Heavy dependency on Coal and Lignite based business

7.4.2.3 Opportunities

- Increase in Electricity demand in India, which is expected to grow at 7% till FY 2032.

- India may require an additional ~280 GW of coal based installed capacity by FY 2032 to sustain India's rapid growth and increasing energy need.

- Heavy investments in the T&D equipment by the Indian Government to meet the electricity demand is one of the key drivers in this market.

- The decision by the Government to invest into nuclear plants is a key opportunity for BHEL

7.4.2.4 Threat

- Global adoption of renewable energy source.

- Rapid technological changes in the energy sector require BHEL to continuously innovate to remain competitive.

- BHEL faces competition from global firms like Siemens, GE, and ABB, which can challenge its market position.

7.4.3 GE Vernova T&D India Ltd

7.4.3.1 Strength

- The company was founded in 1957 and has 5 manufacturing units in India.

- The company holds a significant position in India's transmission and distribution sector, leveraging its expertise in grid management and electrification.

- GE T&D India has successfully adapted to technological advancements, focusing on digital and secure grid automation, which enhances its competitive edge

- Parent group operated in around 70+ countries globally and serves 8+ industries.

- The company witnessed a 14% increase in revenue from operations in FY2024, compared to FY2023 revenues. The revenue from operations was in FY2024 was INR 31,679.00 Mn and INR 27,732.00 in FY2023.

- The total order backlog as on 31st Market FY2024 was INR 62.70 Bn, the order backlog experienced a 70% growth in FY2024 compared to FY2023. Around 68% of the orders were from domestic customers and 32.00% was from international customers.

7.4.3.2 Weakness

- GE T&D Limited is considered as a foreign OEM due to the Headquarters of the parent group. There is a perception of a high cost of the product of GE.

- The growth of GE T&D India Limited is heavily influenced by government policies and regulations, which can be unpredictable.

- Heavy dependency of the Indian market on Coal and Lignite based fuel supply for electricity.

7.4.3.3 Opportunities

- Global adoption of renewable energy source.

- Increase in Electricity demand in India, which is expected to grow at 7% till FY2032.

- India may require an additional ~280 GW of coal based installed capacity by FY2032 to sustain India's rapid growth and increasing energy need.

- Investments by the Government in digital technologies and investment in smart meters are a key opportunity in India.

- Dedicated infrastructure for Renewable Energy under TBCB and Green Corridors would propose opportunity

- Heavy investments in the T&D equipment by the Indian Government to meet the electricity demand is one of the key drivers in this market.

7.4.3.4 Threat

- Rapid technological changes in the energy sector require GE T&D India Limited to continuously innovate to remain competitive.

- GE T&D India Limited faces competition from global firms like Siemens, BHEL, and ABB, which can challenge its market position.

7.4.4 Hitachi Energy India

7.4.4.1 Strength

- The company was founded in 1949 and was renamed to Hitachi Energy India limited in 2021 and has a high level of localization. It has 8 manufacturing units in India.

- Hitachi Energy India is a key player in the HVDC LCC segment

- The orders for FY2024 accounted to around INR 55,363.00 Mn, the orders grew ~14% compared to the financial year FY2023.

- The revenue witnessed a 17% growth in FY2024 compared to FY2023, the revenue in FY2024 was INR 52,468.00 Mn.

- Hitachi has invested more than INR 2,500 Mn in the Indian market to expand its manufacturing capability.

- There is a strong brand recall due to its presence in the Indian FMCG segment.

7.4.4.2 Weakness

- Limited exposure to the coal / lignite market in India.

- The growth of Hitachi Energy India Limited is influenced by government policies, which can be unpredictable.

- Lack of long term/ considerable work done for the Indian Government and Indian customer.

7.4.4.3 Opportunities

- Global adoption of renewable energy source.

- Increase in Electricity demand in India, which is expected to grow at 7% till FY2032.

- India may require an additional ~280 GW of coal based installed capacity by FY2032 to sustain India's rapid growth and increasing energy need.

- Shift towards renewable energy is a key opportunity for Hitachi Energy.

- Heavy investments in the T&D equipment by the Indian Government to meet the electricity demand is one of the key drivers in this market.

7.4.4.4 Threat

- Rapid technological changes in the energy sector require Hitachi Energy India Limited to continuously innovate to remain competitive.

- Hitachi Energy Limited faces competition from global firms like Siemens, BHEL, and ABB, which can challenge its market position.

7.4.5 Siemens Energy India Limited

7.4.5.1 Strength

- Siemens Limited, India was founded in 1922 and began manufacturing operations in India in 1956. The company currently operates manufacturing facilities across 10 locations in the country

- Siemens Limited (Energy Business) recorded a growth of 4.36% in revenue between FY2023 and FY2024, increasing from INR 60,803.00 Mn to INR 63,452.00 Mn.

- Siemens Limited (Energy Business) also saw a significant 32.42% rise in Operating profit during the same period, with EBIT (Earnings before Interest and Tax) growing from INR 6,873.00 Mn to INR 9,101.00 Mn.

- Cost reduction initiatives through localization included the domestic production of various components for Static Synchronous Compensator (STATCOMs), High Voltage Air Insulated Switchgear (HV AIS) Circuit Breakers (CB), and Steam Turbine and Generator spares. Key localized components include converter and valve cooling systems, insulating discs, no-volt coils, SF6 density monitors, and generator rotor manufacturing.

- In FY2024, the Energy Business announced an expansion plan to double power transmission capacity from 15 GVA to 30 GVA, backed by a capital investment of INR 3,600.00 Mn over the next two to three years.

- New orders for FY2024 increased by 29.90% to INR 87,997.00 Mn.

7.4.5.2 Weakness

- Limited exposure to the Renewable energy market in India.

- The growth is influenced by government policies, which can be unpredictable.

- Lack of long term/ considerable work done for the Indian Government and Indian customer

- Yet to establish as a strong player in the Indian Renewable energy market.

- German brands are more expensive than locally available equipment in India.

7.4.5.3 Opportunities

- Global adoption of renewable energy source.

- Increase in Electricity demand in India, which is expected to grow at 7.00% till FY2032.

- India may require an additional ~280 GW of coal based installed capacity by FY2032 to sustain India's rapid growth and increasing energy need.

- The newly formed entity Siemens Energy India Limited is expected to provide end-to-end solutions across the energy value chain, covering power and heat generation, transmission, and storage. Its diverse portfolio includes conventional and renewable energy technologies, such as gas and steam turbines, hydrogen-powered hybrid power plants, power generators, and transformers, this is expected to create new revenue streams.

- Shift towards renewable energy is a key opportunity for Siemens Energy India Limited.

- Heavy investments in the T&D equipment by the Indian Government to meet the electricity demand is one of the key drivers in this market

7.4.5.4 Threat

- Rapid technological changes in the energy sector require Siemens Energy India Limited to continuously innovate to remain competitive.

- Siemens Energy India Limited faces competition from global firms like Hitachi, BHEL, and ABB, which can challenge its market position

7.4.6 Crompton Greaves Power & Industrial Solutions Limited

7.4.6.1 Strength

- Crompton Greaves Power & Industrial Solutions Limited ("**CG Power and Industrial Solutions**") was originally established in 1937 as Crompton Parkinson Works Private Ltd and rebranded in 1966.

- CG Power and Industrial Solutions operates world-class manufacturing facilities across nine locations in India and one in Sweden

- The Power Systems business recorded revenue of INR 25,984.80 Mn in FY2024, up from INR 20,229.20 Mn in FY2023, reflecting a growth of 28.45%.

- Order intake reached an all-time high of INR 43,150.00 Mn in FY2024, reflecting a 51.00% year-on-year growth compared to INR 28,650.00 Mn in FY2023.

- The unexecuted order book stood at INR 37,310.00 Mn as of March 31, 2024, marking a 64.00% increase from INR 22,790.00 Mn as of March 31, 2023.

7.4.6.2 Weakness

- The company has faced challenges in developing new technologies, which can hinder its ability to innovate and stay competitive in the rapidly evolving electrical equipment sector.

- CG Power and Industrial Solutions has limited financial resources compare to other players, for large-scale projects, which can restrict its expansion and investment in new ventures.

- The company has facilities across 9 locations in India and one in Sweden which would act as a hinderance to expand in global markets.

- Past incidents like production losses due to plant explosions and delays in project execution have impacted the company's operational efficiency.

7.4.6.3 Opportunities

- Global adoption of renewable energy source.

- Increase in Electricity demand in India, which is expected to grow at 7.00% till FY2032.

- India may require an additional ~280 GW of coal based installed capacity by FY2032 to sustain India's rapid growth and increasing energy need.

- Heavy investments in the T&D equipment by the Indian Government to meet the electricity demand is one of the key drivers in this market.

7.4.6.4 Threat

- Rapid technological changes in the energy sector require CG Power and Industrial Solutions to continuously innovate to remain competitive.

- CG Power and Industrial Solutions faces competition from global firms like Hitachi, BHEL, and ABB, which can challenge its market position.

8. GROWTH OPPORTUNITIES FOR SIEMENS ENERGY INDIA LIMITED

8.1 Summary of growth opportunities for Siemens Energy India Limited and its translation to the present Market Scenarios

The key opportunities for Siemens Energy India Limited business is covered in this section are as follows:

8.1.1 GRID TECHNOLOGIES MARKET

8.1.1.1 Opportunities in Grid Technology Market for Siemens Energy India Limited

Integration of Renewable Energy: India's ambitious goals for solar and wind power expansion create challenges in maintaining grid stability due to the intermittent nature of these sources. Siemens Energy India Limited's grid technology solutions can facilitate seamless renewable energy integration, ensuring a balanced and reliable power supply.

Upgradation of Transmission Infrastructure: Upgrading transmission networks will be critical in meeting India's rising power consumption while maintaining energy security. Many regions in India still rely on outdated systems that cause inefficiencies and energy losses. Siemens Energy India Limited advanced grid technology solutions and high-voltage direct current (HVDC) VSC technology can enhance grid capacity, reliability, and efficiency.

Grid Expansion: Transmission projects in India which are part of the Green Energy Corridor (GEC) program, develop transmission infrastructure for evacuating large-scale renewable energy, using the Tariff-Based Competitive Bidding (TBCB) mechanism. The phase II of GEC program, Government of India targets to construct electrical substations having a capacity of 27.5 GVA. Additionally, the aim is to lay around 10,500 km of transmission lines across the country, by end of FY 2026-27. For purposes of efficiently evacuating power generated through renewable energy sources, over long distances, HVDC lines and sub-stations need to be built, which provides opportunities for Siemens Energy India Limited's HVDC and High voltage sub-station solutions.

Grid Resilience: India is rapidly expanding its renewable energy capacity. However, the intermittent nature of solar and wind energy poses challenges for grid stability. Siemens Energy India Limited can play a crucial role in deploying grid technology solutions, and FACTS solution to ensure seamless renewable energy integration. By improving grid resilience, Siemens Energy India Limited can help India maximize the potential of its renewable energy resources while reducing dependence on fossil fuels

Government initiatives and Policy Support: As governments and regulatory bodies worldwide and in India push for grid modernization and clean energy initiatives, Siemens Energy India Limited can strengthen its market position by collaborating on large-scale infrastructure projects and public-private partnerships. By aligning its solutions with national energy policies, Siemens Energy India Limited can drive sustainable energy transformation while expanding its global footprint.

Energy Security: By focusing on digitalization, renewable integration, and energy security, Siemens Energy India Limited is well-positioned to shape the future of global power infrastructure. Its ability to provide end-to-end grid solutions makes it a key partner for utilities, governments, and private enterprises striving for a more sustainable and resilient energy future.

8.1.2 CONVENTIONAL POWER EQUIPMENT MARKET

8.1.2.1 Opportunities in Conventional Power Equipment market for Siemens Energy India Limited

Upgradation of Existing Power Plants: Many coal-based power stations in the country operate with outdated and inefficient technologies, leading to high fuel consumption, low operational efficiency, and excessive emissions. Siemens Energy India Limited can make a substantial impact is in upgrading India's existing thermal power plants by modernizing and upgrades of conventional power plants to help utilities comply with stringent environmental regulations while enhancing overall performance.

Nuclear Power Sector: India is increasing its focus on nuclear energy to meet the decarbonization goals vis-à-vis meeting mounting power demand. Hence, the nuclear power sector presents a growth opportunity for Siemens Energy India Limited through its digital control systems, turbines and grid integration technology. However, this opportunity is subject to adoption of a more conducive liabilities framework.

Digital Transformation: It is reshaping the conventional power industry, and Siemens Energy India Limited has a unique advantage in providing smart solutions for power plant optimization. Siemens Energy India Limited can offer control and digitalisation solutions that enable power producers to monitor performance, and optimize fuel consumption, ensuring competitive operations in a changing energy landscape.

8.1.3 DECARBONIZATION MARKET IN INDIA

8.1.3.1 Opportunities in Decarbonization Market for Siemens Energy India Limited

Climate Targets: With ambitious climate targets, India is investing heavily in clean energy, industrial sustainability, and smart infrastructure. Siemens Energy India Limited, with its expertise in energy efficiency, digitalization, and low-carbon technologies, is well-positioned to support India's decarbonization journey by providing solutions that enhance energy efficiency, electrification, and emissions reduction across multiple sectors. Siemens Energy India Limited can also leverage India's policy push toward sustainability, including initiatives such as the Green Hydrogen Mission, carbon market regulations, and incentives for clean technologies.

Industrial Decarbonization: Another key area where Siemens Energy India Limited can make an impact to India's industrial sector, particularly in energy-intensive industries such as steel, cement, chemicals, oil & gas etc. These industries are the largest contributors to carbon emissions, and Siemens Energy India Limited can offer advanced electrification and automation solutions, efficient industrial steam turbines, industrial heat recovery and energy efficiency solutions to drive decarbonization and improve energy efficiency in these industries.