INDUSTRY REPORT ON NON AUTOMOTIVE PRECISION FORGED AND MACHINED COMPONENTS

15th January 2025

FINAL REPORT

FROST & SULLIVAN

Contents

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Abbreviations

CAGR: Compound Annual Growth Rate

COP: Conference of the Parties

EU: Europe

EUR: Euro

INR: Indian Rupees

NA: North America

MT: Metric Ton

MW: Mega Watt

MWe: Megawatt Electrical

GW: Giga Watt

ICT: Information Technology

IMF: International Monetary Fund

PDP8: The Power Development Plan 8

EVs: Electric Vehicles

SEZ: Special Economic Zone

GFCF: Gross Fixed Capital Formation

DRDO: Defence Research and Development Organization

FDI: Foreign Direct Investment

BSI: British Standards Institution

NABL: National Accreditation Board for Testing and Calibration Laboratories

ODF: Open Die Forging

CDF: Closed Die Forging

RR: Ring Rolling

NDT: Non-Destructive Testing

NDE: Non-Destructive Evaluation

Twh: Terawatt hours

Mbpd: Millions of barrels per day

PNG: Piped Natural Gas

ONGC: Oil and Natural Gas Corporation

GAIL: Gas Authority of India Limited

BPCL: Bharat Petroleum Corporation Limited

HPCL: Hindustan Petroleum Corporation Limited

IOCL: Indian Oil Corporation Limited

HAL: Hindustan Aeronautics Limited

MMTPA: Million Metric Tonnes per Annum

MNRE: Ministry of New and Renewable Energy

RE: Renewable Energy

KTPA: Kilo tonnes per annum

BHP Group: Broken Hill Proprietary Company

HEMM: Heavy Earth Moving Machines

Pvt: Private

Ltd: Limited

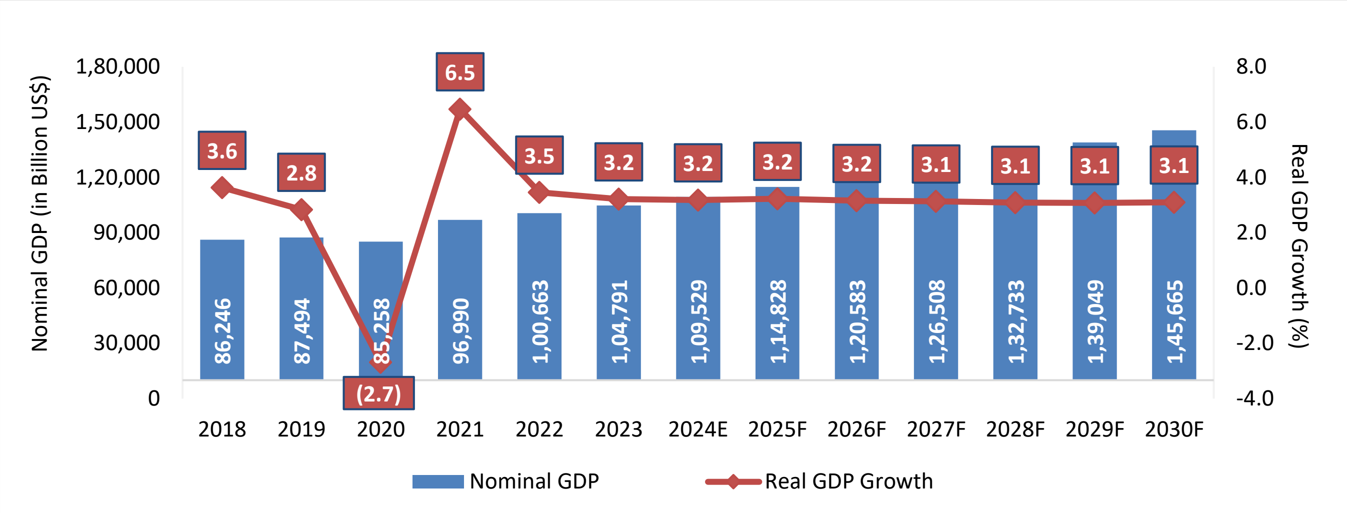
Global & India Macroeconomic Overview

1.1 Global Macroeconomic Overview

1.1.1 Global Gross Domestic Product (GDP) Growth Outlook

Global real GDP growth saw a sharp rebound post-pandemic, reaching 6.5% in 2021. The breakout of the Russo-Ukrainian war, consequent inflationary pressures, and tight credit conditions weighed heavily on business and consumer spending, curtailing growth to 3.5% in 2022. Economic growth remained divergent in 2023, with most advanced nations except the United States seeing subdued growth momentum, whereas emerging markets remained the growth frontrunners. Elevated geopolitical tensions and high borrowing costs weighing on investment streams, and tepid household spending amidst high inflation were the key factors which saw global GDP growth slowing to 3.2% in 2023.

Exhibit 1: Nominal GDP (in Billion US$) and Real GDP Growth (%), Global, 2018-2030F



Note: E: Estimate, F: Forecast; Source: International Monetary Fund (IMF), Frost & Sullivan

Despite elevated interest rates, US economic growth remained resilient throughout 2023, owing to expansionary fiscal support and upbeat consumer spending. On the other hand, high food and fuel inflation, tight credit conditions, sluggish manufacturing activity, and weak exports significantly lowered growth momentum of major European Union (EU) economies such as Germany, France, Italy, and Spain in 2023.

Nations like India, Vietnam, Indonesia, and the Philippines were some of the bright spots in the 2023 global economic landscape due to their high domestic consumption, fiscal and monetary policy stability, steady investment inflows, and diversified industrial economies of scale. China witnessed constrained economic activity in 2023, as property market concerns, high government debt levels, sluggish domestic spending, and deflation weighed on economic health. Middle Eastern nations like Saudi Arabia and the United Arab Emirates (UAE) also posted a modest performance as oil production cuts amidst falling oil prices weighed on growth.

In 2024, the world economy will expand at 3.2%, as moderating price pressures and interest rate burdens spur economic activity. However, geopolitical tensions, trade fragmentation, and fiscal debt burdens are the key downside risks. Lower-than-expected Chinese growth rebound and an escalation in the Middle East conflict are other near-term headwinds to growth.

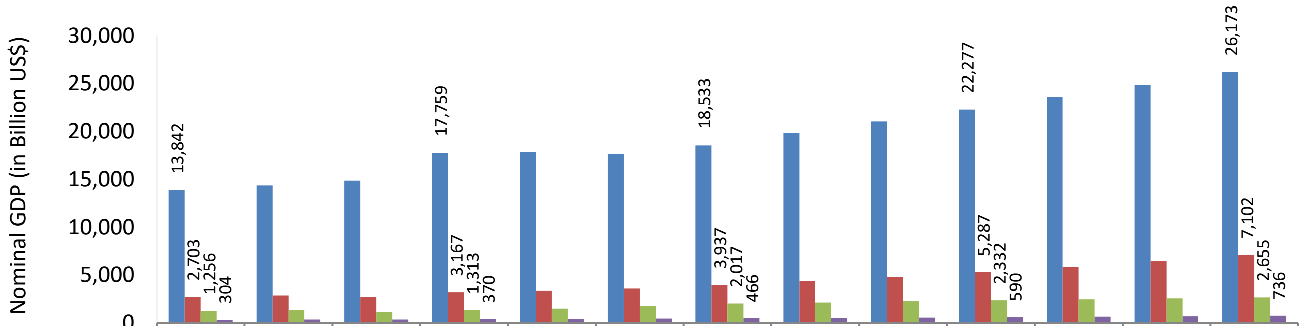
Between 2025 and 2030, the global economy is expected to grow at an average of 3.1%, with emerging and developing economies being the main drivers. Upbeat consumer demand, competitive labor costs, local manufacturing prowess, and accommodative monetary policies will boost emerging market growth. Developed economies, however, are likely to see a modest acceleration over the forecast period. An ageing population, high debt levels, and continued weakness in property markets will be the key factors underpinning this outlook.

1.1.2 Key Global Economic Trends

- **Interest Rate Cuts in H2 2024 will Support Growth Momentum 2025 Onwards:** In September 2024, the US Federal Reserve cut rates by 50 basis points – for the first time since 2020 – with the Federal funds rate now at 4.75-5%, amid falling price pressures and cooling labor markets. Between June and September 2024, the European Central Bank (ECB) has made two rate cuts as inflation across the Eurozone has been consistently falling. Easing credit conditions will buoy investment and consumer spending growth 2025 onwards.
- **Global Supply Chain Architecture is Undergoing a Transformation:** The Panama Canal crisis, the Red Sea conflicts, the massive disruptions due to geopolitical tensions over the past few years are driving the re-architecture of global trade and supply chains with nations like India, Mexico, Indonesia, and Vietnam, emerging as the go-to manufacturing destinations. Coupled with the adverse impacts of long-drawn trade wars, global firms are now focusing on building parallel supply chains and multiple sourcing alternatives. Given the sizable fiscal support in advanced nations (e.g., 2022 CHIPS Act, 2023 EU Chips Act), strategic sub-industries within manufacturing such as semiconductors, pharmaceuticals, clean energy, EVs will see the production lines shifting closer to end consumers and boosting manufacturing growth in long-term within the developed nations.
- **Near-term Fiscal Instability is Likely Due to Developing Nations' Widening Debt Burdens**: In 2024, given the elevated interest rate environment globally, the general government fiscal deficit in the low-income developing and Latin American countries is pegged at 3.6% and 4.7% of GDP, respectively. High fiscal pressures not only pose financial instability risks but also curtail the economic development in the less developed and developing economies. Over the medium term, falling borrowing costs, fiscal consolidation, and improvement in public finances will help bring global debt into a sustainable range.

1.1.3 Growth Outlook for Key Emerging Markets

Exhibit 2: Nominal GDP (in Billion US$), Select Emerging Markets[1], 2018-2030F



	2018	2019	2020	2021	2022	2023	2024E	2025F	2026F	2027F	2028F	2029F	2030F
China	13842	14341	14863	17759	17849	17662	18533	19790	21028	22277	23579	24842	26173
India	2703	2836	2675	3167	3353	3572	3937	4340	4790	5287	5833	6437	7102
Mexico	1256	1305	1121	1313	1463	1789	2017	2128	2231	2332	2438	2544	2655
Vietnam	304	332	346	370	408	434	466	506	546	590	636	684	736

Note: 1. India's data is presented for fiscal years; for example, 2024 data refers to data for the FY2024 i.e., April 2023 to March 2024. E: Estimate; F: Forecast.

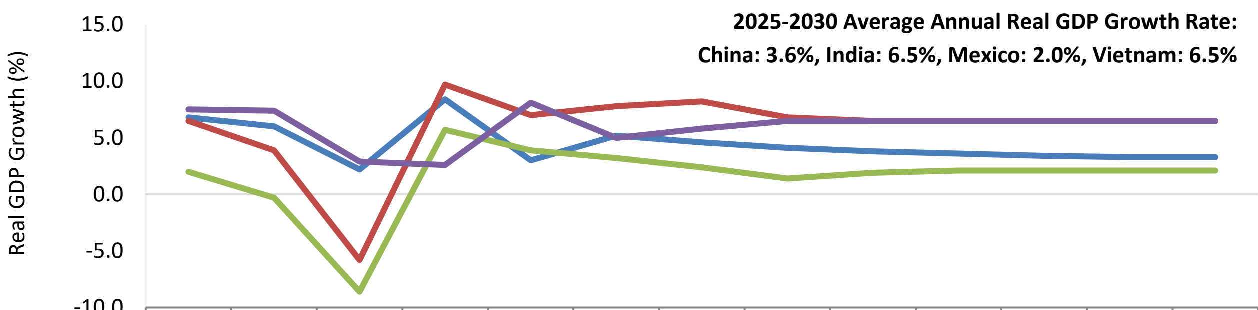
Source: IMF; Frost & Sullivan

<u>**China**</u>: China's nominal GDP rose at a compounded annual growth rate (CAGR) of 12.4% between 2000 and 2023, reaching US$17.6 trillion in 2023. However, long-term economic growth in China will see a significant deceleration from 5.8% in the 2015-2023 period to an annual average real GDP growth rate of 3.7% between 2024 and 2030.

<u>**India**</u>: With its real GDP growth in FY2024 (March 2023 to April 2024) standing at an estimated 8.2%, India has emerged as a global economic bright spot. FY2025 real GDP growth is pegged at 6.8% and is forecast to average 6.5% between FY2025 and FY2030. By 2030, India is set to become the 3rd largest economy globally, overtaking Germany and Japan. India's nominal GDP will rise at a CAGR of 7.1% in the 2010-2030 period and will surpass US$7 trillion mark by 2030. Long-term growth drivers are demographic dividend, rapidly expanding middle class purchasing power, massive capital expenditure thrust, and conducive government policies. For instance, the

Production Linked Incentives (PLI) scheme, covering 14 key sectors like automobiles and auto components, pharmaceuticals, electronic products and solar photovoltaic (PV). – helped sales reach INR 8.6 lakh crore, created around 7 lakh jobs, and boosted exports to INR 3.2 lakh crore in late 2023.[1]

Exhibit 3: Real GDP Growth (in %), Select Emerging Markets[1], 2018-2030F



	2018	2019	2020	2021	2022	2023	2024E	2025F	2026F	2027F	2028F	2029F	2030F
China	6.8	6.0	2.2	8.4	3.0	5.2	4.6	4.1	3.8	3.6	3.4	3.3	3.3
India	6.5	3.9	-5.8	9.7	7.0	7.8	8.2	6.8	6.5	6.5	6.5	6.5	6.5
Mexico	2.0	-0.3	-8.6	5.7	3.9	3.2	2.4	1.4	1.9	2.1	2.1	2.1	2.1
Vietnam	7.5	7.4	2.9	2.6	8.1	5.0	5.8	6.5	6.5	6.5	6.5	6.5	6.5

Note: 1. India's data is presented for fiscal years; for example, 2024 data refers to data for the FY2024 i.e., April 2023 to March 2024, while 2030 data refers to April 2029 to March 2030. E: Estimate; F: Forecast. Sources: IMF; Frost & Sullivan

Mexico: The economy grew by 3.2% in 2023 amidst a strong export, automotive, and services sector performance. Mexico's real GDP growth average is forecast to rise to 2.0% in the 2024-2030 period and nominal GDP is expected to reach US$2.6 trillion by 2030. The North American nation launched new incentives to attract manufacturing investments. Fiscal incentives and tax breaks will be provided to electronic and electrical equipment, semiconductors, automotive, medical devices, and pharmaceutical sectors.

Vietnam: Robust domestic consumption and public investment levels along with strong exports will drive real GDP growth to 5.8% in 2024. Nominal GDP will surpass the US$736 billion by 2030, posting a CAGR of 6.8% in the 2022-2030 period. Vietnam will establish investment funds for high-tech sectors and train 50,000-100,000 engineers by 2030 to expand the availability of a skilled labor force. Under the Power Development Plan 8 (PDP8), Vietnam's renewable energy sector will attract investments worth US$134.7 billion between 2021 and 2030.[2]

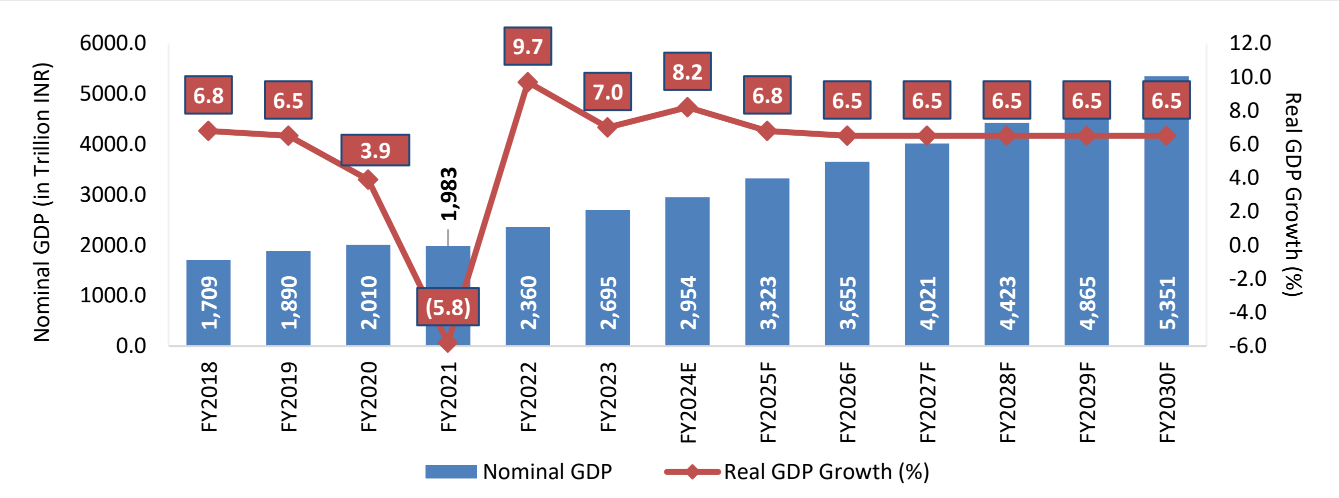
1.2 India Macroeconomic Overview

1.2.1 India GDP Growth and Outlook

India remains the fastest growing large economy, with an estimated real GDP growth rate of 8.2% in FY2024. With softening external growth, India's growth momentum is likely to moderate to 6.8% in FY2025. Near term drivers include financial sector resilience, robust consumer demand, and steady fiscal support. However, tense geopolitical situation in adjacent geographies (Bangladesh coup and China-Taiwan tensions) along with dampening exports demand from developed markets will be the key risks to outlook.

[1] Indian Ministry of Commerce and Industry
[2] Vietnam Ministry of Industry and Trade

Exhibit 4: Nominal GDP (in Trillion INR) and Real GDP Growth (%), India, FY2018-FY2030F



Note: E: Estimate, F: Forecast, India's data is represented in fiscal years. For e.g. FY2018 data refers to April 2017 to March 2018, Source: Ministry of Statistics and Programme Implementation (MOSPI) – India, IMF, Frost & Sullivan

India's real GDP growth is forecast to average 6.5% between FY2025 and FY2029. Emphasis on renewable energy adoption, strengthening the start-up, tech and innovation ecosystem, supporting domestic micro, small and medium-sized enterprises (MSMEs), and digital transformation will help sustain long-term economic growth momentum. Some of the key macro drivers include:

- **Robust Capital Expenditure:** India has opted for an infrastructure led economic growth model in recent years, with a consistent rise in capital expenditure (capex). Government capex rose from INR 3.37 lakh crore ($40.3 billion) in FY2018 to INR 11.1 lakh crore ($133.7 billion) in FY2025, growing at a CAGR of 18.8%. Sectors such as infrastructure, Information Technology (ITC), transportation and logistics, defence have been the key beneficiaries of capex thrust and will result in a sizable multiplier effect on manufacturing prowess, industrial productivity, as well as employment generation.

- **Rising Per Capita Income Levels**: Forecasts indicate that India will have the highest per capita income growth across the globe, rising at 5.4% per annum between 2024 and 2033.[3] A burgeoning tech and innovation ecosystem, upbeat investment climate, a conducive policy and business environment, and a robust GDP growth trajectory will support income levels. As domestic purchasing power grows positive spillovers effects will seep into multiple manufacturing and services sub-sectors.

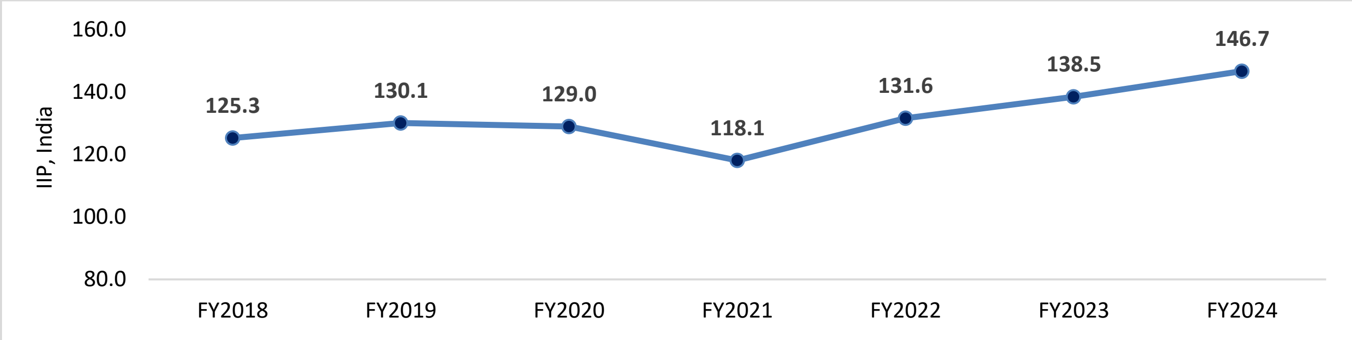
- **Promising Export Potential:** Access to a vast talent pool, cost competitiveness, economies-of-scale within manufacturing, rapidly developing transportation and multi-modal logistics, business-friendly and investment-conducive regulatory climate are the key factors which will help the nation reach $2 trillion in exports by the end of this decade. Additionally, the Special Economic Zones' (SEZ) development, expanding export incentives, and robust digital infrastructure will further enhance India's exports growth potential.

1.2.2 India: Index of Industrial Production (IIP)

Between FY2018 and FY2024, India's IIP has grown at a CAGR of 2.7%. Demographic dividend, rising purchasing power, and investment-friendly government policies are the key drivers of industrial activity. In June 2024, the mining and manufacturing sub-segments within IIP stood at 134.9 and 145.3, respectively, owing to upbeat domestic demand. Allocation for the Performance Linked Incentive (PLI) scheme will rise from INR 4,645 crores in FY2024 to INR 6,200 crores FY2025 – a 33% increase. This will stimulate growth in high value-add manufacturing sub-segments like mobility, electronics, renewable energy, semiconductors, and pharmaceuticals.

[3] Organization for Economic Co-operation and Development; Food and Agriculture Organization. OECD-FAO Agricultural Outlook 2024-2033

Exhibit 5: IIP, India, FY2018-FY2024



Note: India's IIP is represented in fiscal years. For e.g. FY2018 is the 12-month period between 1 April 2017 and 31 March 2018; Source: MOSPI – India, Frost & Sullivan

The focus on building a manufacturing centric growth model is centered on the objectives of establishing a robust and cost-effective local production ecosystem and boosting the nation's exports competitiveness. Directed and rapidly expanding policy support in recent years – with the likes of Make in India, Rapid (Research, Analysis, Programme Implementation, and Data Intelligence) mission, Industrial Corridor Development Programme, PLI – lie at the core of the national target to become a major global manufacturing hub.

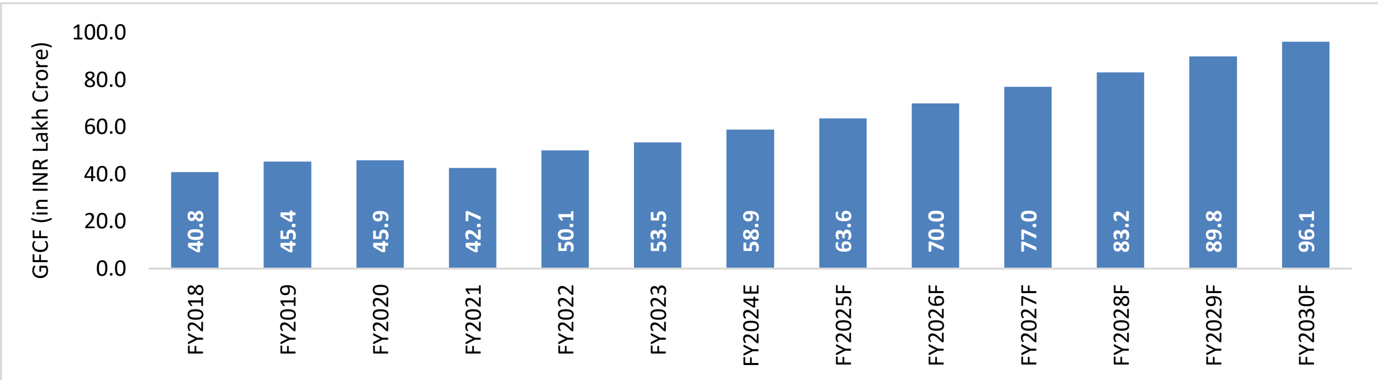
Investment attractiveness, digital and physical infrastructure development, accelerated renewable energy adoption are factors which are building India's industrial expertise, improving cost competitiveness, and streamlining production processes. This will ensure that the IIP levels remain elevated through 2030.

1.2.3 India: Gross Fixed Capital Formation (GFCF)

After a slight decline in FY2021 to INR 42.7 lakh crore due to the adverse impacts of the pandemic, India's GFCF rebounded to INR 50.1 lakh crore in FY2022, and advanced estimates show that it reached INR 58.9 lakh core in FY2024. Over the long-term, India's GFCF will show consistent growth, reflecting strong investment momentum and is forecasted to reach INR 96.1 lakh crore by FY2030, rising at a CAGR of 6.8% between FY2018 and FY2030.

There has been a steady rise in public capex allocations in union government budgets. Rising foreign direct investments coupled with rapidly developing digital and physical infrastructure are expected to sustain GFCF's long-term growth momentum, also indicative of the nation's strong macroeconomic fundamentals.

Exhibit 6: GFCF (in INR Lakh Crore), India, FY2018-FY2030F



Note: FY2018 data refers to April 2017 to March 2018. E: Estimate; F: Forecast. Source: MoSPI; Frost & Sullivan

In the FY2025 Union Budget, the government has announced investment of INR 10 lakh crores for urban housing catering to the 1 Crore middle and poor class citizens. The Pradhan Mantri Gram Sadak Yojana's (PMGSY) 4th phase will be rolled out, which includes the construction of all-weather roads connecting 25,000 Indian rural habitats. Along with the establishment of 12 industrial parks under the National Industrial Corridor Development Programme; projects like Amritsar Kolkata Industrial Corridor, Vishnupad Temple Corridor, and Mahabodhi Temple Corridor will also commence in coming quarters. In the near to medium-term, these plans will have strong spill-over effects positively impacting the infrastructure and construction industries in India.

India is moving towards becoming an investment-led economy, with the expansion of high value-add and capital-intensive sectors like construction and infrastructure supporting India's GFCF growth. As the national manufacturing capacities expand, urban infrastructure growth will boost the construction of power, transportation, as well as residential projects. A booming construction sector growth, hence, bodes well for long-term GFCF growth trajectory – with factors like government expenditure on infrastructure development, rising income levels, a significant housing shortage in major cities, population expansion – cumulatively providing an impetus.

1.2.4 India's Emergence as the Go-to Manufacturing Destination

India is a strong growth frontrunner across the globe amidst favorable policy support, massive infrastructure and logistics thrust, rapidly expanding manufacturing prowess, and a stable monetary policy. Key drivers cementing India's position as the go-to manufacturing destination are:

- **Government Capital Expenditure Grew at a 18.4% CAGR between FY2016 and FY2024:** India's capex has risen at a CAGR of 18.4% rising from INR 2.35 lakh crore in FY2016 to INR 9.1 lakh crore in FY2024. The government is targeting capital expenditure of INR 11.1 lakh crore over the coming fiscal year – with a 11.1% year-on-year rise – which will position capex at an estimated 3.4% of total GDP. The country's marked shift towards an infrastructure, manufacturing, and investment driven growth model is being facilitated by the steady capex growth – this which will in-turn foster multi-sector growth in the medium to long-term.

- **Conducive Policy Environment Is a Key Enabler of Manufacturing Growth:** In mid-2024, a novel mission called Rapid (Research, Analysis, Programme Implementation, and Data Intelligence) was launched which will boost manufacturing GVA significantly and incentivize R&D growth. Policy and fiscal support will enable the nation's pivot towards high-tech manufacturing segments. For instance, with the Atmanirbhar Bharat as a key target, the government announced an allocation of INR 6.2 lakh crore for defence modernization and domestic manufacturing in FY2025 Union Budget. Hence, investor-friendly industrial policies remain crucial enablers of India's target to become a global manufacturing powerhouse.

- **China+1 Strategies amidst Supply Chain Diversification Pivot Will Boost India's Manufacturing Gross Value Add (GVA):** India's manufacturing capabilities are steadily catching up to China's. However, as global firms rapidly expand supply chain investments beyond China, policies such as PLI, Rapid mission, Make in India coupled with a strong GDP growth momentum will make India a manufacturing hotspot. India's manufacturing value add, rose from US$289.1 billion in 2012 to US$455.8 billion in 2023, posting a CAGR of 4.2%.[4] China's, on the other hand, rose at a CAGR of 5.1% in the same period. Forecasts indicate that between 2019-2027, India's manufacturing GVA CAGR will significantly accelerate compared to China's, with India at 10.8% and China at 6.9%.

- **Demographic Dividend and Competitive Labor Costs are Crucial Comparative Advantages:** 68% of Indian population falls in the 15-64 years age bracket[5]. Rising working-age population will boost labor and industrial productivity and consumption potential – factors which will help attract investment inflows and unlock business opportunities. An expanding skilled labor force will support the nation establish economies of scale in the construction, healthcare and pharmaceuticals, mobility, and other manufacturing sub-segments. As per the International Labour Organization's (ILO), average monthly earnings in the manufacturing sector were at US$812.6 for China (as of 2021), US$604.7 for Malaysia (as of 2020), US$456.2 for Thailand (as of 2021), US$321 for Vietnam (as of 2022), and US$195.8 India (as of 2022) – underscoring the India's advantageous position with respect to availability of cost-effective labor.

- **Skilling-Centered Policy Support and a Multilingual Workforce Reinforce India's Investment Attractiveness:** The government has prioritized reskilling/ upskilling and vocational training through targeted policies under

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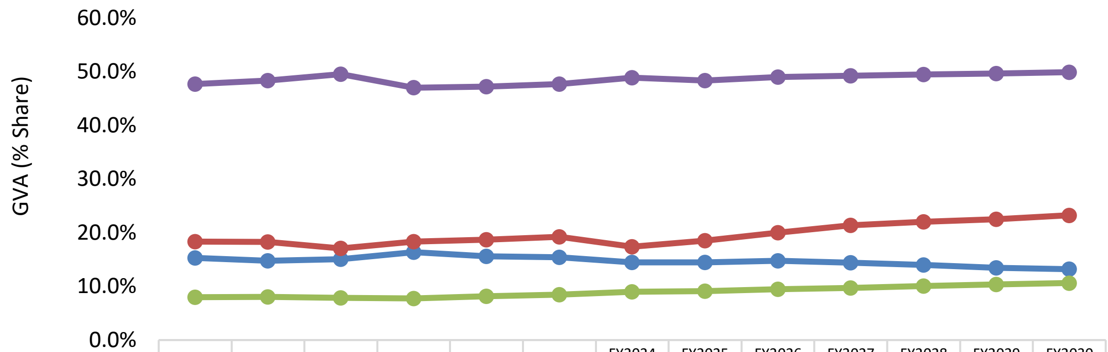
[4] World Bank
[5] United Nations Population Fund's (UNFPA) State of World Population - 2024

the National Skill Development Corporation (NSDC). India's National Skill Development Mission outlines comprehensive skilling plans divided into pillars like institutional training, overseas employment, infrastructure, and sustainable livelihoods. In the FY2025 Union Budget, a scheme covering the skilling of 20 lakh youth and upgradation of 1,000 Industrial Training Institutes has been announced. Coupled with the bilingual education system across the nation, India is positioned to remain an attractive investment destination for international players.

1.2.5 India: Sectoral GVA Share

By FY2030, the sectoral GVA shares of manufacturing, construction, and services are projected to reach 23.3%, 10.6%, and 49.9%, respectively. On the other hand, steady industrialization will see the agriculture, forestry, and fishing sector's share falling to 13.2%. However, the government policies continue to target sustainable agriculture growth rate to boost farm income levels and enhance per hectare crop yields. This gradual structural transformation underscores the nation's steady development trajectory and will ensure long-term economic resilience.

Exhibit 7: Sectoral GVA Share (% of Total GVA), India, FY2018-FY2028



	FY2018	FY2019	FY2020	FY2021	FY2022	FY2023	FY2024 E	FY2025 F	FY2026 F	FY2027 F	FY2028 F	FY2029 F	FY2030 F
Agriculture, forestry and fishing	15.3%	14.8%	15.1%	16.4%	15.6%	15.4%	14.5%	14.5%	14.8%	14.4%	14.0%	13.5%	13.2%
Manufacturing	18.4%	18.3%	17.1%	18.3%	18.7%	19.2%	17.4%	18.5%	20.0%	21.4%	22.0%	22.5%	23.3%
Construction	8.0%	8.1%	7.9%	7.8%	8.2%	8.5%	9.0%	9.1%	9.5%	9.7%	10.1%	10.4%	10.6%
Services	47.7%	48.3%	49.5%	47.0%	47.2%	47.7%	48.9%	48.3%	49.0%	49.2%	49.5%	49.7%	49.9%

Note: Services includes Transport, storage, communication & services related to broadcasting, Financial services, Real estate, ownership of dwelling & professional services, and Other services. The sum of shares will not add up to 100% because only manufacturing and construction have been included in the above chart from the industry segment. FY2018 data refers to April 2017 to March 2018. Note: E: Estimate; F: Forecast. Source: MoSPI; Frost & Sullivan

Robust capex and domestic consumption, sizable fiscal policy support along with improving exports competitiveness will be the key manufacturing growth drivers. Clean energy sectors are also seeing a robust growth potential in India as firms increasingly adopt sustainable practices and the national policies enforce stringent energy transition rules. Between 2024 and 2028, the nation's wind energy sector is expected to add 22.8 gigawatt of onshore wind capacity.

Infrastructure development will be critical to accelerate construction sector growth – and will be supported by the national highway network, other transportation, and logistics development targets. These initiatives will enhance growth in EVs, semiconductors, renewable energy, medical devices and pharmaceuticals. Fast-paced digital transformation and technological integration will bolster services sector growth, cementing India's role in global knowledge-based services like finance, business services, education, transportation and logistics.

Market Overview: Global & India

2 Market Overview: Global & India

2.1 Product Overview & Types

- **Forging:** A manufacturing process that involves shaping and forming metal using compressive forces is called forging. In this process, a metal is shaped through hammering, pressing, or rolling. A hammer or die is used to impart compressive forces on the metal. Carbon, alloy, and stainless steel are frequently used in forging. Aluminum, brass, and copper, which are very soft metals, can also be forged. The method can produce parts in large quantities and can be used to induce desired mechanical properties to the finished product. Typically forging are of four types closed die, open die, ring rolling and radial forging.

- **Closed Die Forging:** It is a forging process in which dies move towards each other and covers the workpiece in whole or in part. The heated raw material, which is approximately the shape or size of the final forged part, is placed in the bottom die. The shape of the forging is incorporated in the top or bottom die as a negative image.

- **Open Die Forging:** Open die forging is the process of deforming a piece of metal between multiple dies that do not completely enclose the material. The metal is altered as the die's "hammer" or "stamp" the material through a series of movements until the desired shape is achieved. Products formed through open forging often need secondary machining and refining to achieve the tolerances required for the finished specifications. Open die forging is widely used for the products in small quantity that are simple, rather than complex, such as discs, rings, sleeves, cylinders and shafts. Custom shapes can also be produced with open die forging.

- **Ring Rolling:** Ring Rolled forging is a metal shaping process involving extreme pressure and heat to form seamless circular rings. This technique results in products with superior strength, enhanced grain structure, and better fatigue resistance compared to other manufacturing methods. It is commonly used in the aerospace, automotive, and energy industries for producing high-quality components such as gears, bearings, flanges, and shafts. Unlike traditional machining processes, rolled ring forging allows to produce complex shapes with minimal material waste. In addition to its durability and versatility, this technique offers cost-effectiveness due to its ability to produce large quantities faster than other methods.

- **Radial Forging:** Forging process where the workpiece is subjected to repeated press strokes from several dies mounted around the axis of the workpiece. Several dies usually between two to four are mounted on workpiece linear axis. Each die is radially shaped so that they together form a circular cross section. The workpiece, usually a rod of a reasonably round shape, is heated up and rotated through the dies that through repetitive blows mold workpiece. This way rod is transformed into a circular cross section of predetermined diameter.

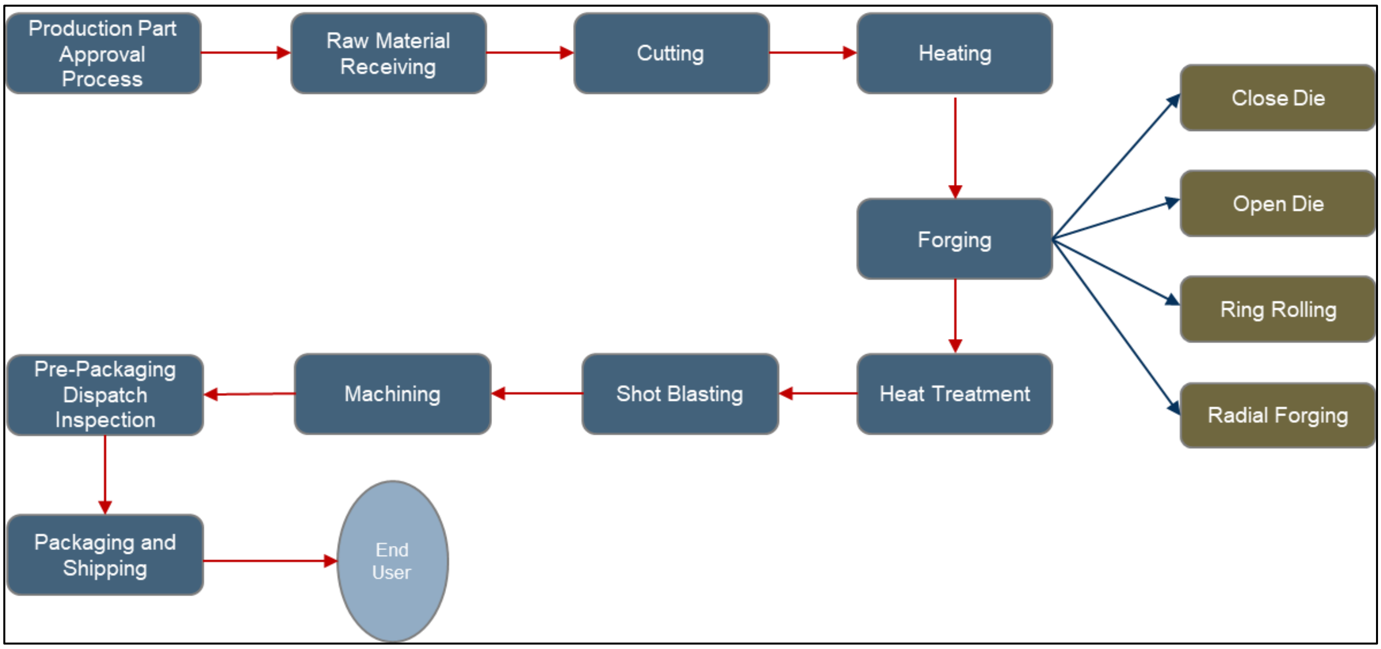
2.2 Production Process: Forging

Production of forging parts undergoes a series of operations starting from production part approval, raw material purchase and receiving from the supplier, cutting and sizing it to the desired shape and dimensions to actual forging taking place based on the application and function of the product, forging type is selected whether closed die, open die, ring rolling or radial forging.

General production process flow of the forging is as follows:

- **Production Part Approval Process:** At this stage design of the produced parts is finalized along with the designed mechanical properties and appropriate manufacturing process, grades of the raw materials used is decided keeping in view the economics of the produced parts.
- **Raw Material Procurement, Receiving and Quality Inspection:** Raw material is received from registered suppliers or procured directly. The quality of raw material is inspected with spectrometric and microscope testing facilities either within the plant or from outside testing facilities for proper grade and quality testing.
- **Raw Material Cutting:** At this stage raw material is cut on bandsaw machine and/or shearing machine in the form of billets as per weight required for forged job in desired length.
- **Raw material heating**: The billets are heated in furnaces or in an induction billet heater up to a certain temperature depending on the metal and its grades. It is heated to 1,200–1,270 °C in case of different grades of steel.
- **Forging**: The heated billets are removed one by one from the furnace and placed in hammer for forging. The heated billet is forged in desired shape in one or number of strokes in the hammer. Different forging types could be selected such as closed die, open die, ring rolling, and radial forging based on the application and functionality of the developed product. Also, some units use presses for forging products. Trimming/coining presses are used for removing extra material on the forged job. Visual Inspection, Dimension Check, Nondestructive Evaluation (NDE) or Non-Destructive Testing (NDT) is performed if required.
- **Heat Treatment:** Heat treatment is done on the forged part to obtain the desired properties such as the relieving of internal stresses, the refinement of grain structure, and the attainment of improved mechanical and physical properties. For machinability annealing, normalization, tempering, process annealing, spheroidized or full annealing is performed as per the requirements then quenching and tempering is done to achieve the final properties.
- **Shot Blasting:** After Heat treatment Shot, Blasting is performed to obtain excellent cleaning and surface preparation for secondary finishing operations on the forged part. This process is a highly effective solution for removing contamination on metal substrates or changing the coarseness or smoothness of a surface before coating.
- **Machining:** Forging machining is a manufacturing method that involves cleaning up a metal part to the precise dimensions as per the end user requirements. The finished product is a loosely formed part because of the forging operation. For specific applications, specific dimensions and shapes are needed, which is achieved through machining process. During the machining process, the part is mastered using a range of methods and techniques. Digging, scraping, grinding, milling, and turning tools are suitable for this process.
- **Pre-Packaging Dispatch Inspection:** Final inspection of jobs is done with respect to the dimensions and quality of the product at this stage.
- **Packing and shipping:** Once the product is tested by the quality department then it reaches packing and shipping section for suitable packaging and then shipping section from where it will be sent to the different end users from the oil and gas, aerospace and defence, railways, earthmoving, energy and other general engineering sectors.

Exhibit 8: High Level Forging Production Process Flow



Source: Industry Sources

2.3 End Use Sector Wise Key Forging Products

Exhibit 9: End Use segment wise key products

End Use Segments	Key Products
Energy	Valve body, Gates, Studded Tee, Crosses, Rings, Slip Bowls, Bonnets, Body, Housing, Gates, Square Block, Cross, Studded Tees, Valve Casing, Y Block, Flanges, Tube Sheet, Clad Body Valves, Hatch Cover, Bonnet, Frame, Coupling hub, clamp, body, adapters, flange, caps, blocks, Rings, Profile Rings, Round Bar, Spring Plate, Rotor-Pole End Plate, Planet Bucket Ring, Gear Blank, Cross Head, Connect Flange, T Block, Hydro Shaft, Generator Shaft, Crosshead pin, Turbine Shaft, Parts of valve bodies, gate, stem, seat ring,
Energy Turbines	Rotor Shafts, Gear Box, Low and high-speed drive shafts, Hubs, Turbine discs, Forged bar used in drilling for steam to blades for turbines
Aerospace	Airfoils, Unison Rings, Arm Levers, Compressor, Mount, Plate Butterfly, Guide, Poppet, Tees and Elbow Connecting Rod, Road Wheel Arm, Integral Axle arm, Cam shaft, Flange, Caps, Blocks, Rings, Profile Rings and Seamless Rings, Hot Gas Parts, Cam plates, Throttle levers, Mounting flanges, Under carriage Bracketry, Under Carriage Pintles, Regulator Heads, Bearer Beams, Actuator Bodies, Rudder Pedals, Valve bodies, Toggles, Links
Defence	Crank shaft, Breach Base, Carrier, Crank, Driven Gear, Extractor Lower, Flange, Shoe, Intermediate Gear, Roadwheel Arm, Gear Ring, Planet Wheel, Shoe, Track Link, Sun Gear, Clamp, Handle, Collar, Stopper, Flange, Cam
Earthmoving, Hydraulics and Mining	Rod Eyes, Caps, Trunnions, Spindles, Cam Shafts, Track rollers, teeth's ball stud, Arm Steering, Arm Centre, Rod Head, Caps, Vertical Shafts, Idler Rims, Support Rings, Profile Rings
Railways	Gears, Pinions, Couplings, shafts and cylinder heads, Gear Blanks, Pinions and Shafts, Rings, Profile Rings, Bearing Cap, Bevel Pinions, Yoke Forgings, Bush, Connecting Rod, Camshaft

Others	Sprocket, Spacer Plates, Yokes, Chain links, Shafts, Spindles, Flanges, Tie rods, Universal joints, Steel Structures, Fasteners

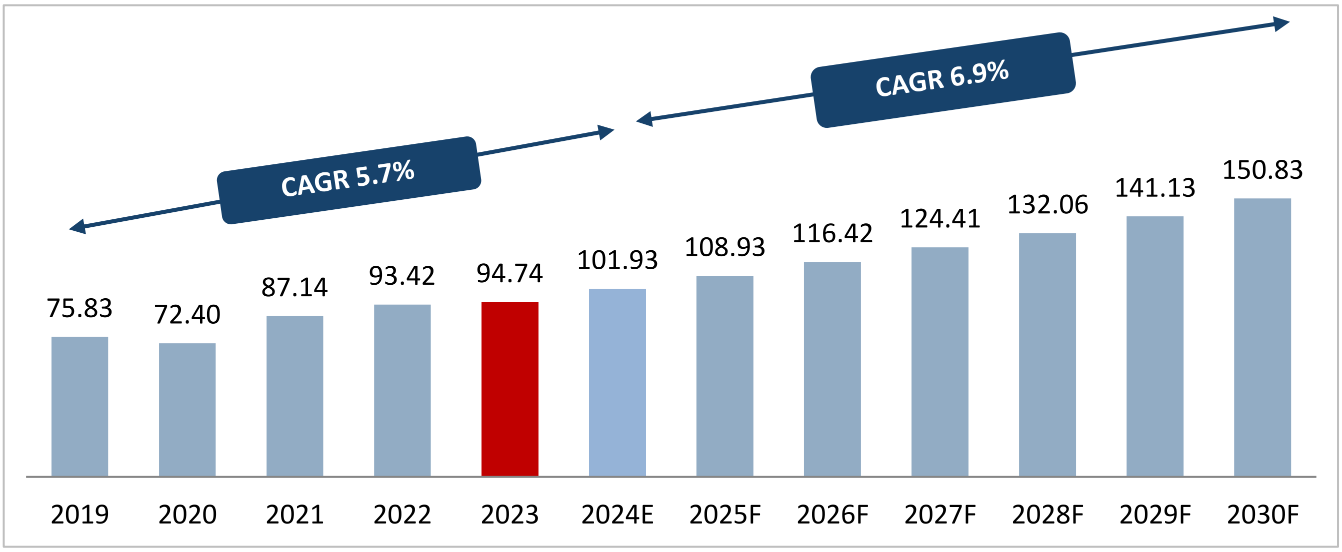
2.3 Overview of Global Forging Market

The Global Overall Forging Market is valued at **USD 94.74 Bn in 2023**.

- Automotive sector contributes **65% (USD 61.58 Bn)** to the overall global forging demand while remaining **35% (USD 33.16 Bn)** is contributed by the non-automotive sectors such as oil and gas, aerospace & defence, earthmoving, hydraulics and mining, railways, energy and other general engineering sectors.

2.3.1 Market Size Estimates and Forecasts for Overall Global Forging Market

Exhibit 10: Global Overall Forging Market Forecast Year CY 2019–2030, USD Bn



Source: Frost & Sullivan Analysis
The base year is CY 2023, E-Estimated, F-Forecasted

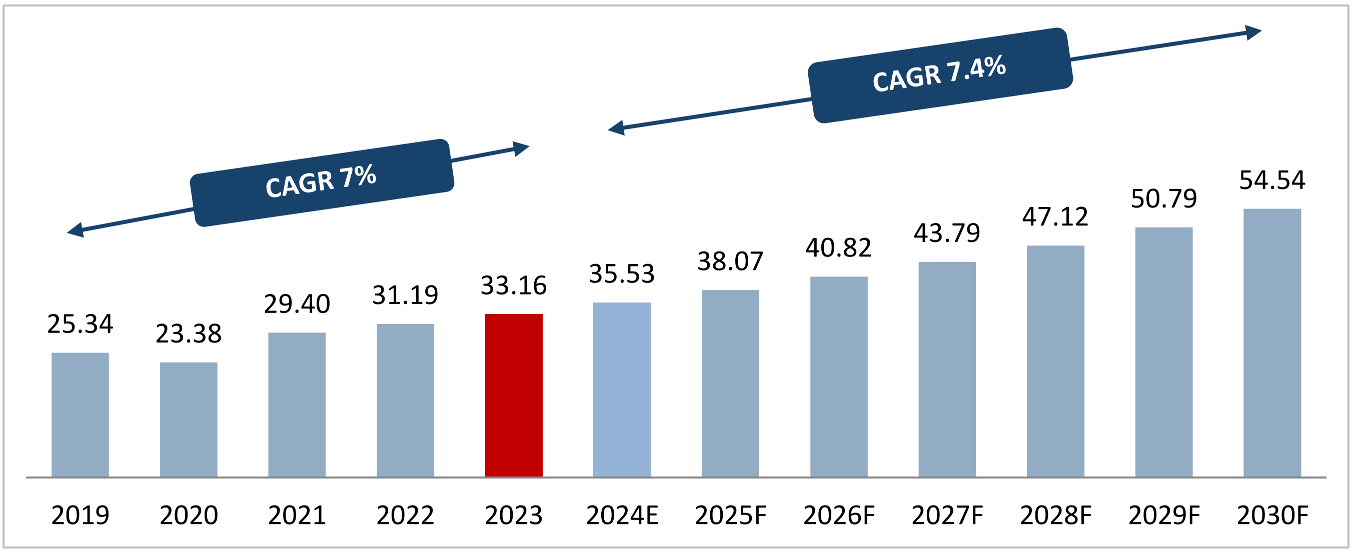
- Overall Global Forging Market was valued at **USD 94.74 Bn in 2023** and is estimated to grow to **USD 150.83 Bn** by **2030** at a CAGR of **6.9%** from **2023** to **2030** driven **~65%** by automotive sector where forged parts such as connecting rods, crankshaft, pistons, injectors, camshafts, chassis parts such as bearings, gears and axles are widely used and remaining **35%** by the growing demand from non-automotive end use sectors such as energy, energy turbines, aerospace and defence, earthmoving, hydraulics and mining, railways and others.

- In the Past in 2019 the overall global forging market was valued at USD **75.83 Bn** and had grown with a CAGR of **5.7%** till 2023.The global economy was severely impacted by the COVID-19 pandemic. Due to the pandemic, economic activity had drastically decreased, which had a negative demand shock effect on the global forging market.

- In 2020 global overall forging market was valued at **USD 72.40 Bn** and experienced a downfall of **4.5%** from 2019 due to impact of Covid-19 restrictions imposed in movements and transportations. However, as the market started recovering from the pandemic the demand again accelerated and marked **USD 87.14 Bn** in 2021.

2.3.2 Market Size Estimates and Forecasts for Non-Automotive Global Forging Market

Exhibit 11: Global Non-Automotive Forging Market Forecast, CY 2019–2030,USD Bn



Source: Frost & Sullivan Analysis

The base year is CY 2023 E-Estimated, F-Forecasted

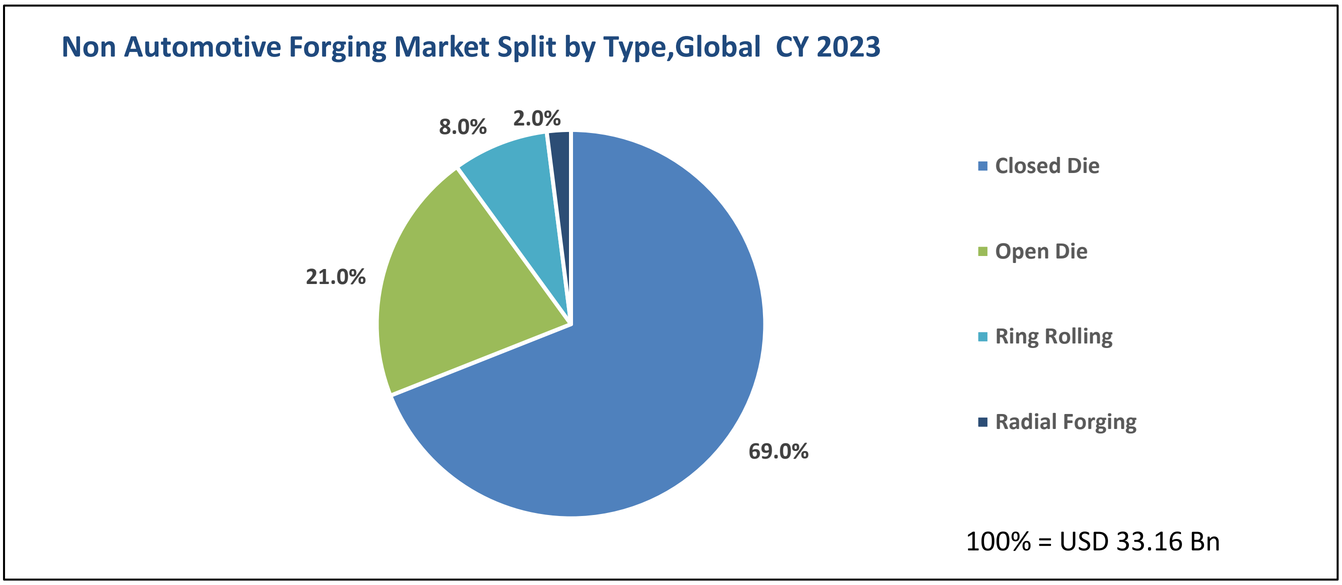
- In the past in 2019 the global non-automotive forging market was valued at **USD 25.34 Bn** and had grown with a CAGR of **7%** till 2023 and have marked USD 33.16 Bn market value sustained by the impact of pandemic COVID-19. The global economy was severely impacted by the COVID-19 Pandemic. Due to the pandemic, economic activity had drastically decreased, which had a negative demand shock effect on the global non-automotive forging market.
- In 2020 global non-automotive forging market was valued at **USD 23.38 Bn** and experienced a downfall of **7.73%** due to restrictions imposed in movements and transportations during COVID-19 period. However, as the market started recovering from the pandemic the demand again accelerated and marked USD **29.4 Bn** in 2021 with a growth of **25.75%** from the previous year.
- Global non-automotive forging market was valued at **USD 33.16 Bn in 2023** which accounts for **35%** of the overall forgings demand and is estimated to grow to **USD 54.54 Bn** by 2030 at a **CAGR of 7.4%** from 2023 to 2030 driven mainly by growth of demand from non-automotive end use sectors such as oil and gas, aerospace and defence, earthmoving, hydraulics and mining, railways and energy sector.
- Non-automotive forged parts include valve body, gates, studded Tee, crosses, plate butterfly, guide, poppet, Tees, rod eyes, caps, trunnions, spindles, gears, pinions, couplings, coupling hub, clamp, body, adapters and flanges. China was the leader in this niche segment of forging and witnessed **32% global** forging demand, followed by **Europe (17%), North America (16%)**, **Rest of Asia (excluding China and India) (12%)**, **India (6%)**, **Middle East (1%)** and **Rest of the world (16%)**. Closed Die Forging is the most widely used forging type globally.

2.3.3 Global Non -Automotive Forging Market Size by Type & Segment (Open Die, Close Die, Ring Forging and Radial Forging)

- Evolving from ancient blacksmithing techniques to modern, highly sophisticated methods, metal forging continues to play a vital role in producing strong and durable components essential for various industries. The demand for advanced, high-strength components across industries is propelling the metal forging market.

- Maintaining and enhancing reliability in metal forging plants is crucial, requiring regular equipment checks, preventive maintenance programs, and adherence to established safety standards. Globally typical forging types used are closed die forging, open die forgings, ring rolling and radial forging.
- Out of the total non-automotive forgings demand Globally, **69% (USD 22.88 Bn)** is met through closed die forging, **21% (USD 6.96 Bn)** by open die forging, **8% ring rolling (USD 2.65 Bn)** and balance 2**% (USD 0.66)** by radial forging.
- The major demand driver of forgings is the economic growth and massive investment in infrastructure, oil gas and focus on aerospace & defence sector across the globe.

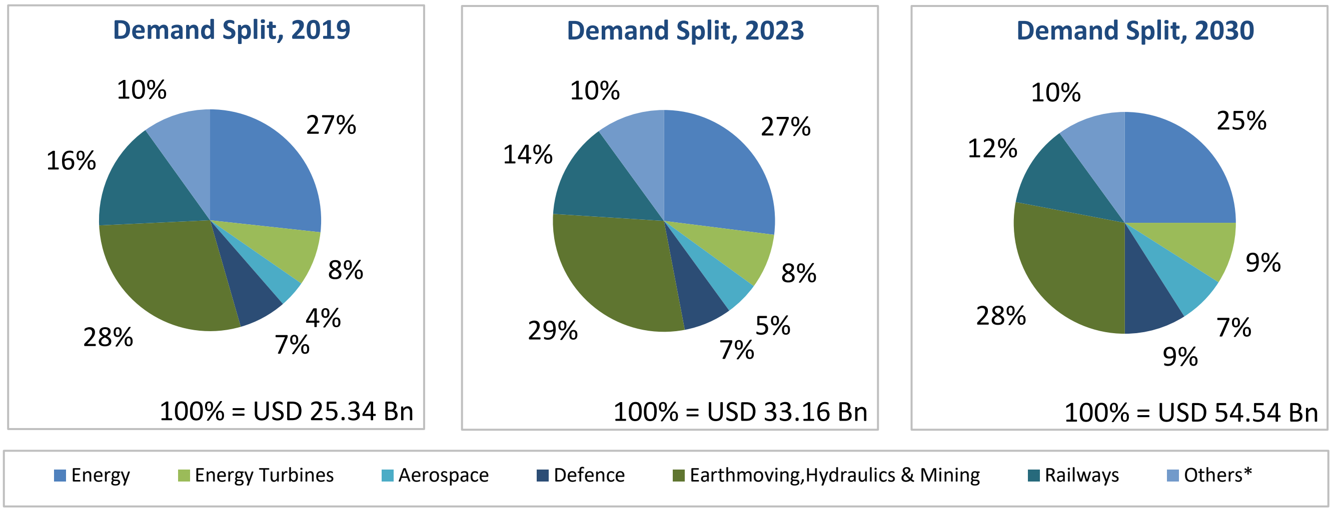
Exhibit 12: Global Non-Automotive Forging Market Split by Type, CY 2023



Source: Frost & Sullivan Analysis

2.3.4 Global Non-Automotive Forging Market Demand by End Use Industries

Exhibit 13: Demand Split by End-use segment, USD Bn, CY 2019-30



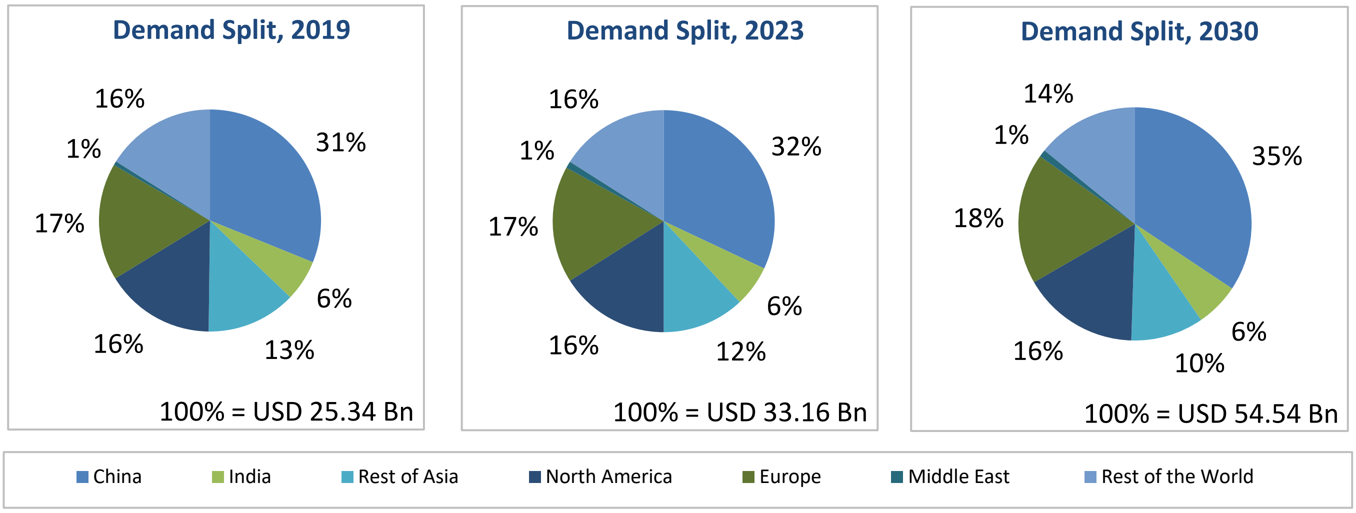
Others includes any general engineering segment such as manufacturing sector, Construction, Agricultural equipment, Source: Frost & Sullivan Analysis*

Exhibit 14: Non-Auto Global Forging Market End-use segment wise growth rate, CY 2019-30

Year/CAGR Growth	Energy	Energy Turbines	Aerospace	Defence	Earthmoving, Hydraulics and Mining	Railway	Others*
2019-2023	7.7%	10.1%	10.2%	7%	7%	3.9%	7.7%
2023-2030	6.5%	8.1%	14.4%	11.3%	6.8%	6.9%	7.4%

2.3.5 Global Non-Automotive Forging Market Demand by Geography

Exhibit 15: Demand Split by Geography, USD Bn, CY 2019-30



Rest of Asia includes all Asian nations excluding China and India

Source: Frost & Sullivan Analysis

Rest of the world include other global nations such as Russia, Australia, African nations and South American nations

Exhibit 16: Non-Auto Global Forging Market Geography wise growth rate, CY 2019-30

Year/CAGR Growth	North America	Europe	Middle East	China	India	Rest of Asia	Rest of the World
2019-2023	7%	7%	21.5%	7.8%	6.9%	4.8%	6.3%
2023-2030	7.4%	8.2%	7.4%	8.3%	7.8%	4.6%	6.1%

- North America and Europe have a well-established market for forged parts due to a mature industrial base.
- China and India are witnessing significant growth in this niche forging market due to rapid industrialization and increasing investments in infrastructure projects.
- In 2023 Key regional contributor to the global non-automotive forging demand (USD 33.16 Bn).
- Key demand contributors were **China (32%), Europe (17%), North America (16%), India (6%), Rest of Asia (12%), Middle East (1%) and rest of the world (16%) in 2023.**

North America:

- The North American non-automotive forging market was valued at **USD 5.31 Bn in 2023** and accounts for **16%** of the global non-automotive forging demand and is estimated to reach **USD 8.73 Bn by 2030** with a growth rate of **7.4% from 2023 to 2030.**
- Highly competitive, market is committed towards the adoption of strategic initiatives, such as capacity expansion, product launches, and mergers & acquisitions, to strengthen their presence and position in the industry. North America is among the largest consumers of forged parts due to high product demand from aerospace and defence, oil & gas, energy and construction sectors.
- Further, industry-wide collaborations and joint efforts between forging firms, suppliers, universities, and government laboratories are expected to enable to leverage its resources in advanced technology implementation and production and implementation.
- Growing use of forged steel in various non-automotive sectors and developments in forging equipment & process are the major factor driving the growth of the North America forging market.
- Key forging manufacturers in this region are **Scot Forge, Ellwood Group, Bharat Forge, Forge Resources Group, Aichi Forge, North American Forgemasters, Trenton Forging, FRISA & HHI Forgings**.
- **Hydraulic fracturing,** propelling the US to become the world's largest producer of oil and natural gas.
- New upcoming Trump administration emphasized on fracking by stating **"drill, baby, drill".** The dominance of fossil fuels shows no sign of slowing. With the expectation of the start of fracking in North America, the forged components market will experience a boost due to the wide range of drill rigs expected to come in operation.

Europe

- The European non-automotive forging market was valued at **USD 5.64 Bn in 2023** and is estimated to reach **USD 9.82 Bn by 2030** with a growth rate of **8.2%** from 2023 to 2030.
- With industries adopting advanced technologies, the Europe Metal forging market is experiencing substantial growth.
- The application of innovative solutions is driving improvements in efficiency and effectiveness. Companies are investing heavily in research and development to maintain a competitive edge and address evolving market requirements.
- This emphasis on technological advancement is anticipated to propel market expansion and create new opportunities. The Europe metal forging market offers promising prospects for continued growth and development.
- The metal forging market is expanding rapidly as industry leaders capitalize on the region's emphasis on innovation and sustainability. Key players are increasingly focusing on developing solutions that cater to the unique needs of European consumers, fostering a highly competitive landscape.
- The market is supported by favorable government policies and substantial investments in technology. As Europe continues to prioritize digitalization and eco-friendly practices, the metal forging market is set to benefit significantly.
- Although there are obstacles such as regulatory compliance and market saturation, the overall trajectory points towards sustained growth and new opportunities. Germany, France and United Kingdom are the top three forging producing nations in the European union and closed die forging is the most preferred

forging type in the region. As France Aerospace hub in Europe, it is driving the forging demand from the Aerospace segment in Europe.

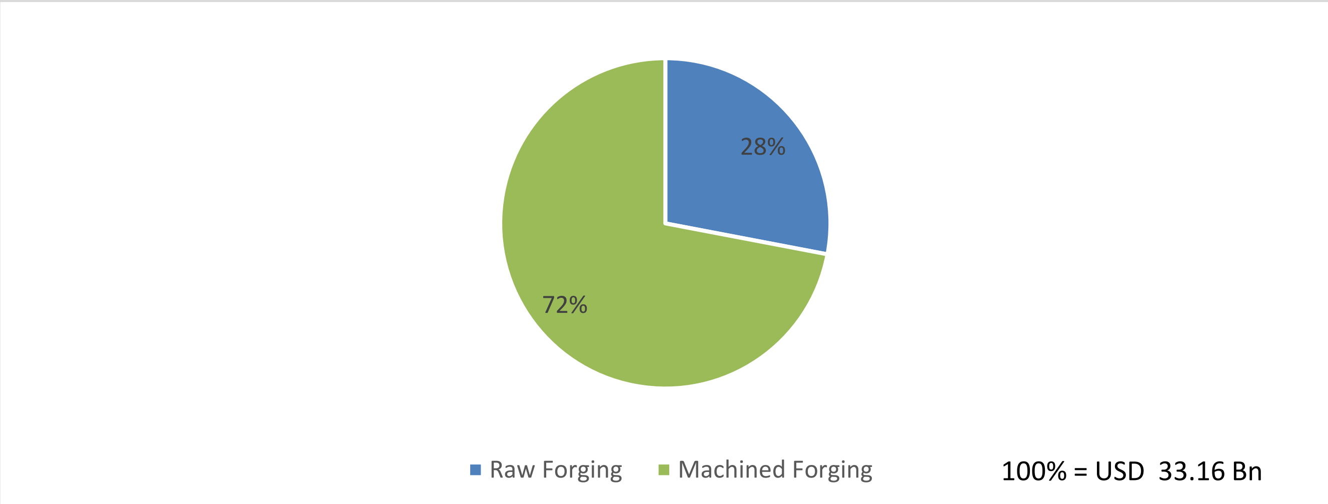
- Key forging manufacturers in Europe are **Precision Castparts Corp. (PCC), Scot Forge, Farinia Group, Otto Fuchs Kg, Lucchini RS, Bharat Forge and Siderforgerossi Group.**

Middle East

- Middle East non-automotive forging market was valued **at USD 0.33 Bn in 2023** and is estimated to reach **USD 0.55 Bn by 2030** with a growth rate of **7.4% from 2023 to 2030**.
- Metal forgings market in the Middle East region is driven by the increasing use of forged components in oil and gas, industrial machinery and construction applications. Growing automotive aftermarket and easy availability of raw materials (aluminium and steel) are likely to boost metal forgings market. The Middle East region is the world leader in crude oil production.
- Many major countries of the region are dependent on oil business, such as Saudi Arabia, Kuwait, Oman, Bahrain, UAE and Iran. Forged components are used in assemblies of rotary drilling machinery & equipment, field production, and drilling rigs. Carbon steel, alloy steel, aluminium, magnesium, stainless steel, titanium etc are the key materials driving the forging market in the middle east region.
- Key forging manufacturers in the Middle East region are **Steel Forgings Gulf FZC, CD Industries, Precision Metal Industries FZC, ULMA Forja and Galperti Group.**

2.3.6 Global Non-Automotive Demand by Raw Forging and Precision Machined Forging

Exhibit 17: Non-Automotive Demand Split by Raw Forging and Precision Machined Forging, Global CY 2023

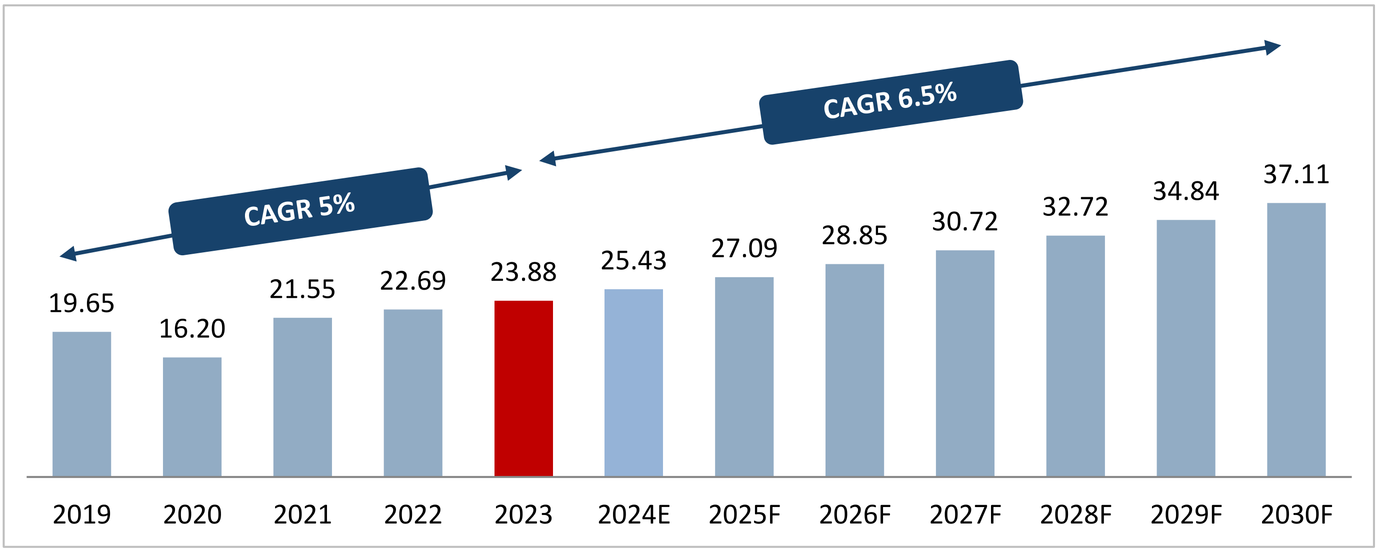


Source: Frost & Sullivan Primary Research and Analysis

- Non-Automotive Forging Market is valued **at USD 33.16 Bn** in 2024 out of which machined forging is the major contributor with **72% (USD 23.88 Bn)** and used for high precision and close dimensional tolerances becomes crucial while volume wise raw forging is huge but in terms of value raw forgings contribute **28% (USD 9.28 Bn)** to the total market demand and finds applications where high tolerance is not required.

2.3.7 Global Non-Automotive Precision Machined Forging Demand Historic Trend and Market Forecast, CY 2019-30

Exhibit 18: Global Non-Automotive Precision Machined Forging Market Forecast, CY 2019-30, USD Bn



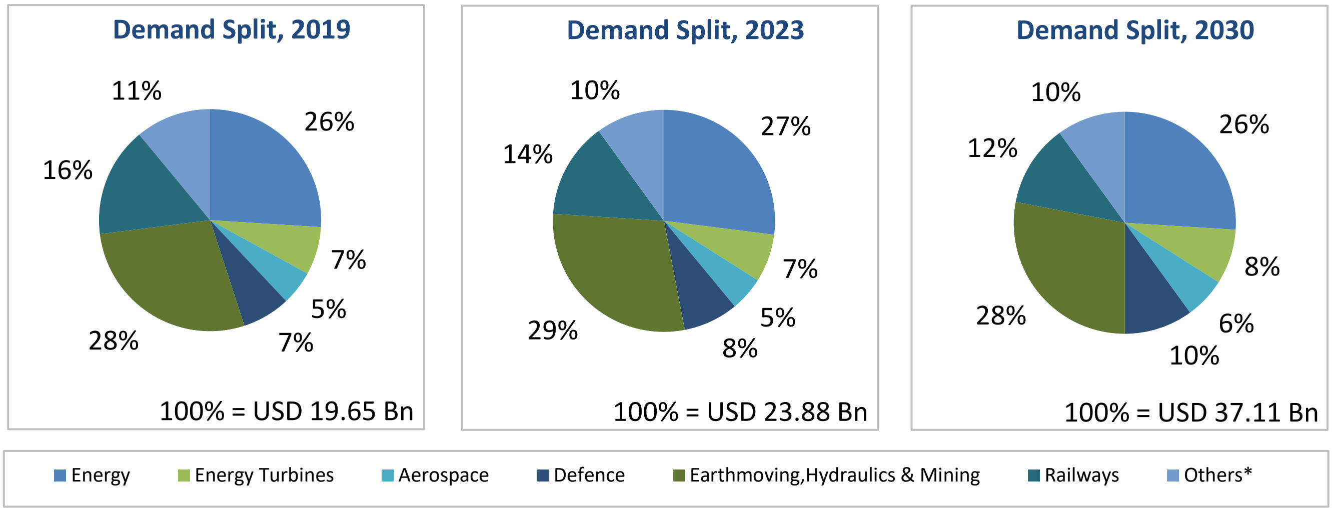
Source: Frost & Sullivan Primary Research and Analysis

E-Estimated, F-Forecasted

- In the past in 2019 the global non-automotive precision machined forging market was valued at **USD 19.65 Bn** and had grown with a CAGR of **5%** till 2023 and have marked **USD 23.88 Bn** market value sustained by the impact of pandemic COVID-19.
- The Global economy was severely impacted by the COVID-19 Pandemic. Due to the pandemic, economic activity had drastically decreased, which had a negative demand shock effect on the global non-automotive forging market.
- In 2020 it was valued at **USD 16.20 Bn** and experienced a downfall of **17.56%** due to restrictions imposed in movements and transportations during COVID-19 period. However, as the market started recovering from the pandemic the demand again accelerated and marked **USD 21.55 Bn** in 2021 with a growth of **33%** from the previous year.
- Global Non-Automotive Precision Machined Forging Market was valued at **USD 23.88 Bn** in 2023 which accounts for **72%** of the overall forgings demand and is estimated to grow to **USD 37.11 Bn** by **2030** at a CAGR of **6.5%** from 2023 to 2030 driven mainly by growth of demand from non-automotive end use sectors such as Energy (Oil and Gas), Aerospace and Defence, Earthmoving, Hydraulics and Mining and Railways.

2.3.8 Global Non-Automotive Precision Machined Forging Market Demand by End Use Industries

Exhibit 19: Demand Split by End-use segment, USD Bn, CY 2019-30



Others includes any general engineering segment such as manufacturing sector, Construction, Agricultural equipment, Spaceframes*
Source: Frost & Sullivan Analysis

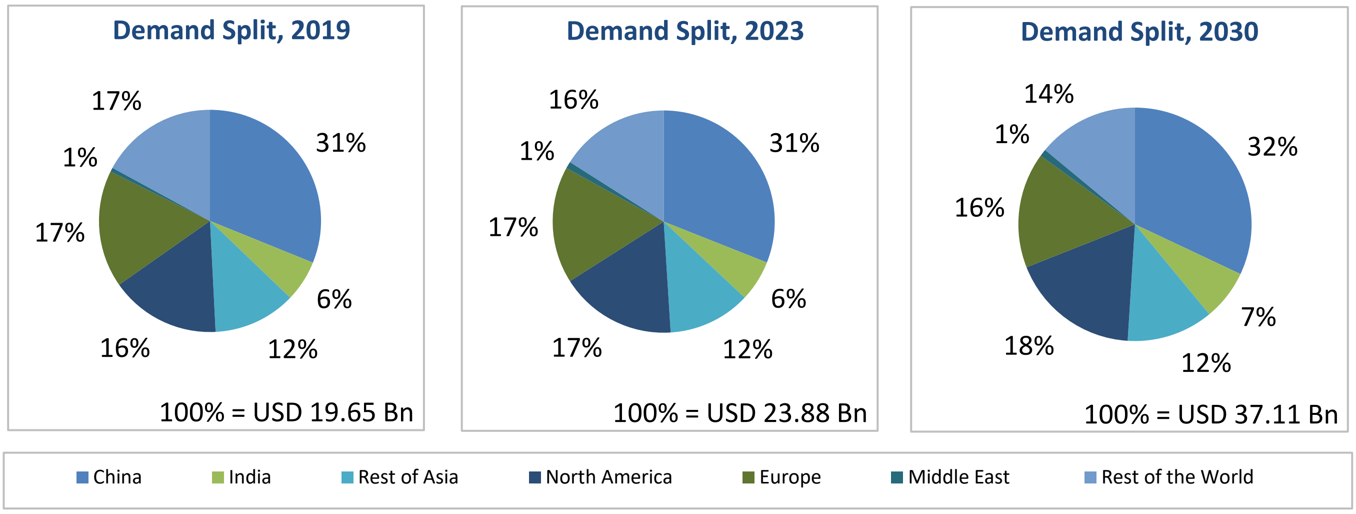
Exhibit 20: Non-Auto Global Precision Machined Forging Market End-use segment wise growth rate, CY 2019-30

Year/CAGR Growth	Energy	Energy Turbines	Aerospace	Defence	Earthmoving, Hydraulics and Mining	Railway	Others *
2019-2023	5.6%	5%	5%	8.6%	5.9%	2%	3%
2023-2030	6.2%	8.6%	9.3%	10%	6%	3.9%	6.2%

- The Non-Auto Global Precision Machined Forgings market was valued at **USD 23.88 Bn** in 2023 where the Energy sector accounts for **27%, Energy Turbines (7%), Aerospace (5%), Defence (8%), Earthmoving hydraulics and mining (29%), Railways (14%) and others (10%).**

2.3.9 Global Non-Automotive Precision Machined Forging Market Demand by Geography

Exhibit 21: Demand Split by Geography, USD Bn, CY 2019-30



Rest of Asia includes all Asian nations excluding China and India

Source: Frost & Sullivan Analysis

Rest of the world include other global nations such as Russia, Australia, African nations and South American nations

Exhibit 22: Non-Auto Global Precision Machined Forging Market Geography wise growth rate, CY 2019-30

Year/CAGR Growth	North America	Europe	Middle East	China	India	Rest of Asia	Rest of the World
2019-2023	6.6%	5%	5%	5%	7.1%	5%	2.7%
2023-2030	7.4%	5.6%	6.5%	7%	8.9%	6.5%	4.5%

- Key demand contributors were **China (31%), Europe (17%), North America (17%), India (6%), Rest of Asia (12%), Middle East (1%) and rest of the world (16%) in 2023.**

2.4 Overview of Indian Forging Market

2.4.1 Key Characteristics of Indian Forging Industry

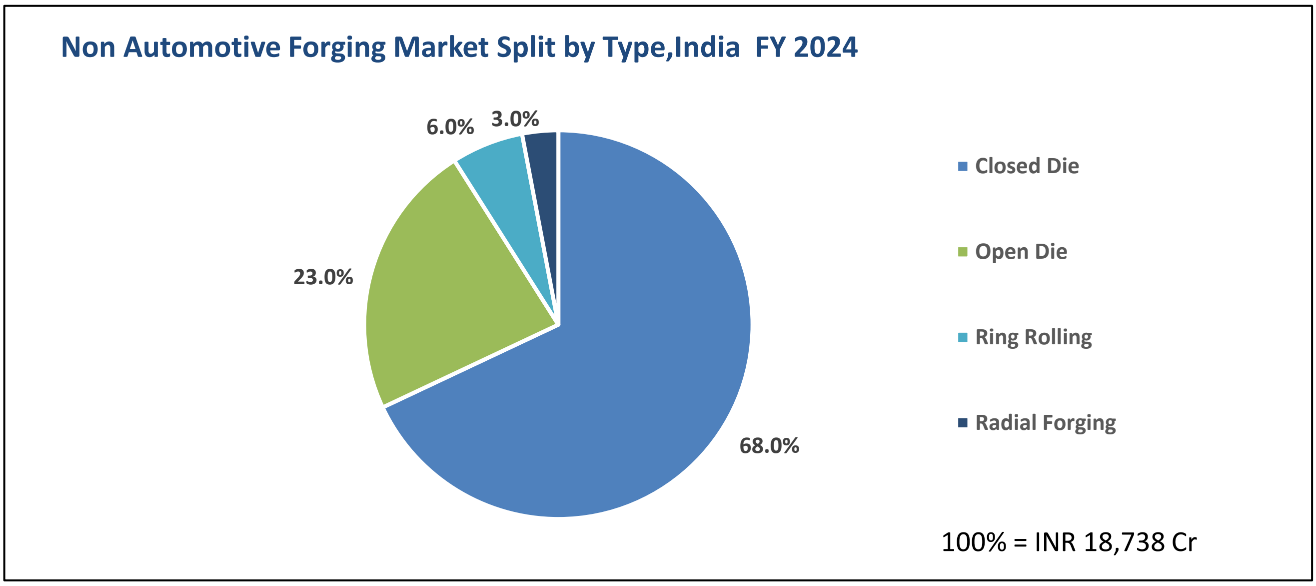
- India is the 2nd largest Forging producer second to China.
- The industry has an annual output of more **20 lakh metric tonnes** and nearly 380 forging units across the country, located in proximity to its end user customers, Major forging clusters are found in the States of Maharashtra, Punjab, Gujarat, Tamil Nadu, Haryana, Delhi, Karnataka, Jharkhand, West Bengal and Andhra Pradesh. SMEs contribute 30% to forging production, while medium and large-scale units contribute 70%.
- The forging industry provides direct employment to over 300,000 people in India and an additional 60,000 contract laborers.
- In **FY 2024** Indian Forging Industry was valued at **INR 43,636 Crores** where in Automotive sector **accounts for 57% share and the remaining 43% for non-automotive sector**.
- India has imported **61.9% of the non-automotive forgings** from various nations of the world to meet the domestic forging demand from sectors such as Oil and Gas, Aerospace and Defence, Earthmoving equipment, Railways and other sectors including construction and farm equipment.
- Indian Non-Automotive Forging Market was valued at **INR 18,738 Crores for FY 2024.** The Indian Forgings Industry has made rapid strides and in increasing export revenue for better diversification of its product portfolio.

2.4.2 Forging Market Size by Type & Segment (Open Die, Close Die, Ring Forging and Radial Forging)

- Forgings are part of seven primary groups of metals/alloy types: carbon, micro alloy and alloy steels, stainless steels, aluminium alloys, copper alloys, iron, nickel, or cobalt-based heat-resistant alloys, titanium, and magnesium alloys. High-strength alloys have better tensile and fatigue strength, making them ideal for load bearing and rotating components in high-pressure environments.
- Steel alloys are primarily forged in hot conditions for industrial applications, while brass, bronze, copper, and precious metals are manufactured for special applications. Aluminium, titanium, and other nonferrous metal forged parts are mainly used in aerospace, automotive, and other engineering fields for high safety standards against failure due to abuse, shock, or vibratory stresses.
- The domestic forging industry is characterized by fragmented capacities. The unorganized sector has a major presence in the Open Die Forging segment, which has lower capital costs, while the organized players dominate the Closed Die Forging segment.
- **Out of the total non-automotive forgings demand in the country, 68% (12,658 Cr) is met through Closed Die Forging, 23% (4,353 Cr) by Open Die Forging, 6% Ring Rolling (1,146 Cr) and balance 3% (581 Cr) by Radial Forging**.

- The major demand driver of forgings is the economic growth and massive investment in infrastructure, Energy (Oil Gas) and upcoming Aerospace & Defence sector where India aspires to be self-reliant. Government's thrust on manufacturing sector with initiatives like 'Make in India' and 'Skill India' has created positive economic impact across target sectors.

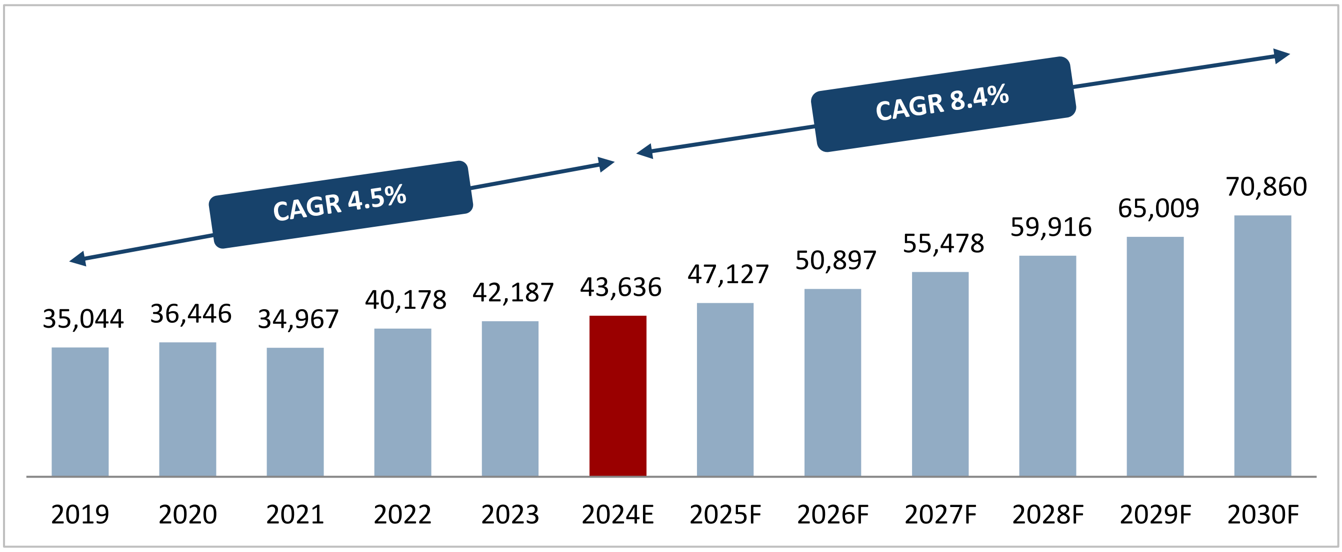
Exhibit 23: Indian Non-Automotive Forging Market Split by Type, FY 2024



Source: Frost & Sullivan Primary Interviews and Analysis
E-Estimated, F-Forecasted

2.4.3 Market Size Estimates & Forecast for Overall Forging in India

Exhibit 24: Indian Overall Forging Market Forecast Year FY 2019–2030 (INR Cr)



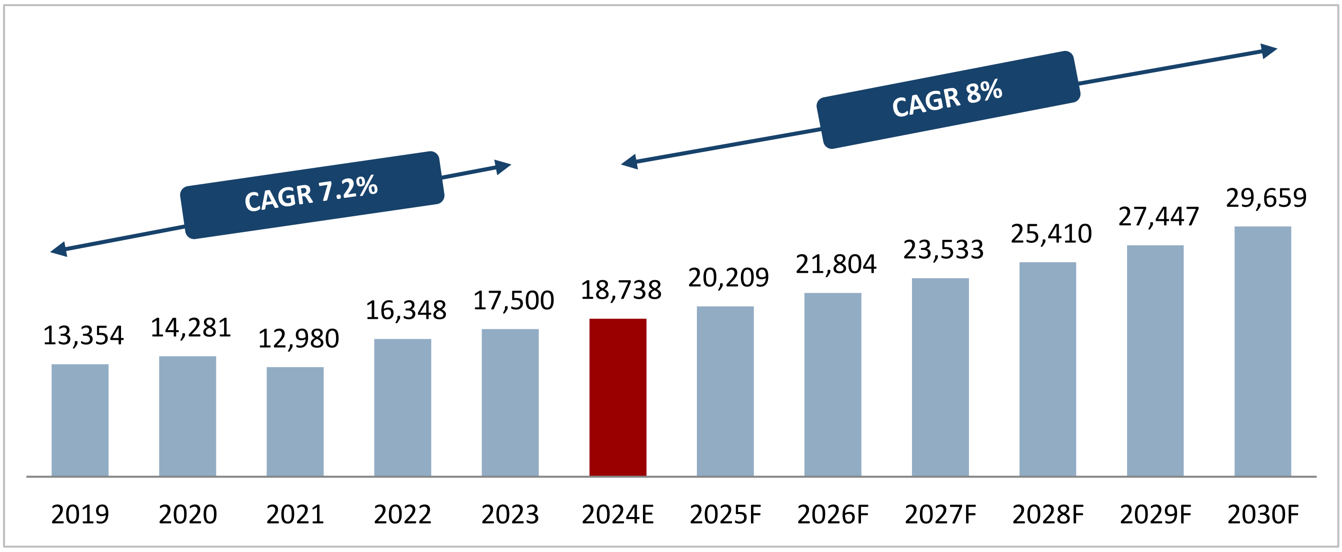
Source: Frost & Sullivan Analysis
All figures are rounded. The base year is 2024.
E-Estimated, F-Forecasted

- Indian Overall Forging Market was valued **at INR 43,636 Cr in FY 2024** and is estimated to grow to **INR 70,860 Cr** by FY 2030 at a **CAGR of 8.4% from FY 2024 to FY 2030** driven **~60%** by automotive sector where forged parts such as connecting rods, crankshaft, pistons, injectors, camshafts, chassis parts such as bearings, gears and axles are widely used and remaining **40%** by the growing demand from non-automotive end use sectors such as Energy (Oil and Gas), Energy Turbines, Aerospace and Defence, Earthmoving, Hydraulics and Mining, Railways and others.

- In the Past in FY 2019 the Indian Forging Market was valued **at INR 35,044 Cr** and had grown with a moderate **CAGR of 4.5% till FY 2024** and have marked **INR 43,636 Cr** market value sustained by the impact of pandemic COVID-19. The Indian economy was severely impacted by the COVID-19 Pandemic. Due to the pandemic, economic activity had drastically decreased, which had a negative demand shock effect on the Indian Forging Market. In FY 2020 Indian Forging Market was valued at **INR 36,446 Cr** and it plunged to **INR 34,967 Cr** with a downfall of **4.1%** due to restrictions imposed in movements and transportations. However, as the market started recovering from the pandemic the demand again accelerated and marked **40,178 Cr** in 2022.

2.4.4 Market Size Estimates and Forecasts for Non-Automotive Forging Market in India

Exhibit 25: Indian Non-Automotive Forging Market Forecast Year FY 2019–2030 (INR Cr)

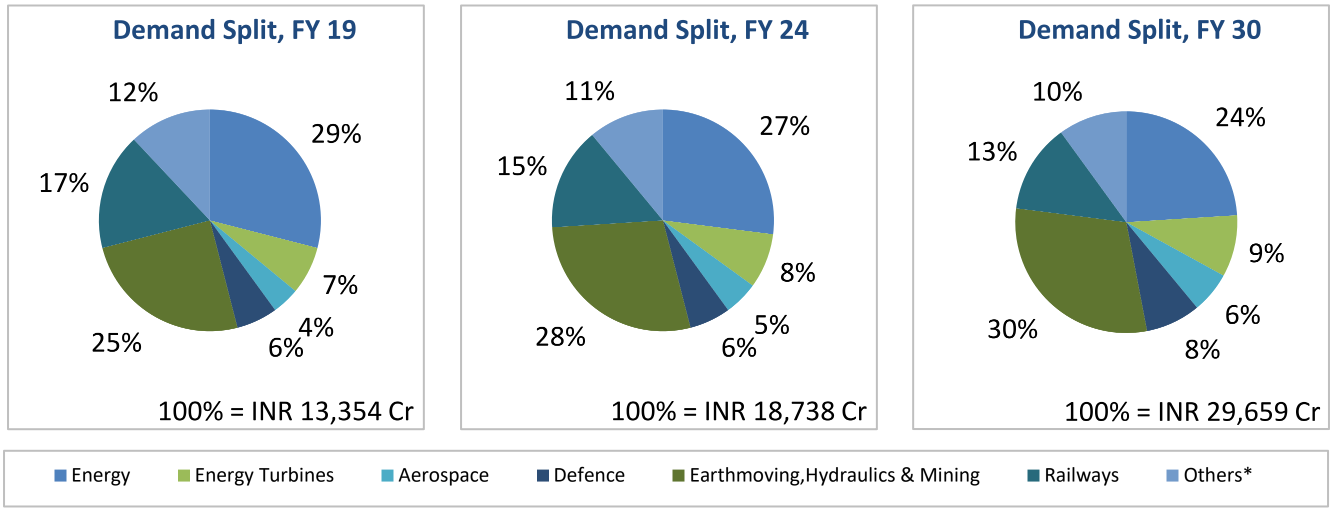


Source: Frost & Sullivan Analysis
All figures are rounded. The base year is 2024.
E-Estimated, F-Forecasted

- Valued at **INR 18,738 Cr in FY 2024** which accounts for **43% of the total forgings** demand and is estimated to grow to **INR 29,659 Cr by FY 2030 at a CAGR of 8% from FY 2024 to FY 2030** driven mainly by growth of demand from non-automotive end use sectors such as Energy (Oil and Gas), Aerospace and Defence, Earthmoving, Hydraulics and Mining, Railways and others high end segments.
- In the Past in FY 2019 the Indian Non-Automotive Forging Market was valued at **INR 13,354 Cr** and had grown with a CAGR **of 7.2%** till FY 2024 and have marked **INR 18,738 Cr** market value sustained by the impact of pandemic COVID-19.
- The Indian economy was severely impacted by the COVID-19 Pandemic. Due to the pandemic, economic activity had drastically decreased, which had a negative demand shock effect on the Indian Forging Market. In FY 2020 Indian Non-Automotive Forging Market was valued at **INR 14,281 Cr** and it plunged to INR **12,980 Cr** with a downfall of **9.1%** due to restrictions imposed in movements and transportations during COVID-19 period. The market started recovering from the pandemic the demand again accelerated and marked **16,348 Cr** in 2022.

2.4.5 Indian Non-Automotive Forging Market Demand by End Use Industries

Exhibit 26: Demand Split by End-use segment, INR Cr, FY 2019-30



Others includes any general engineering segment such as manufacturing sector, Construction, Agricultural equipment, Source: Frost & Sullivan Analysis*

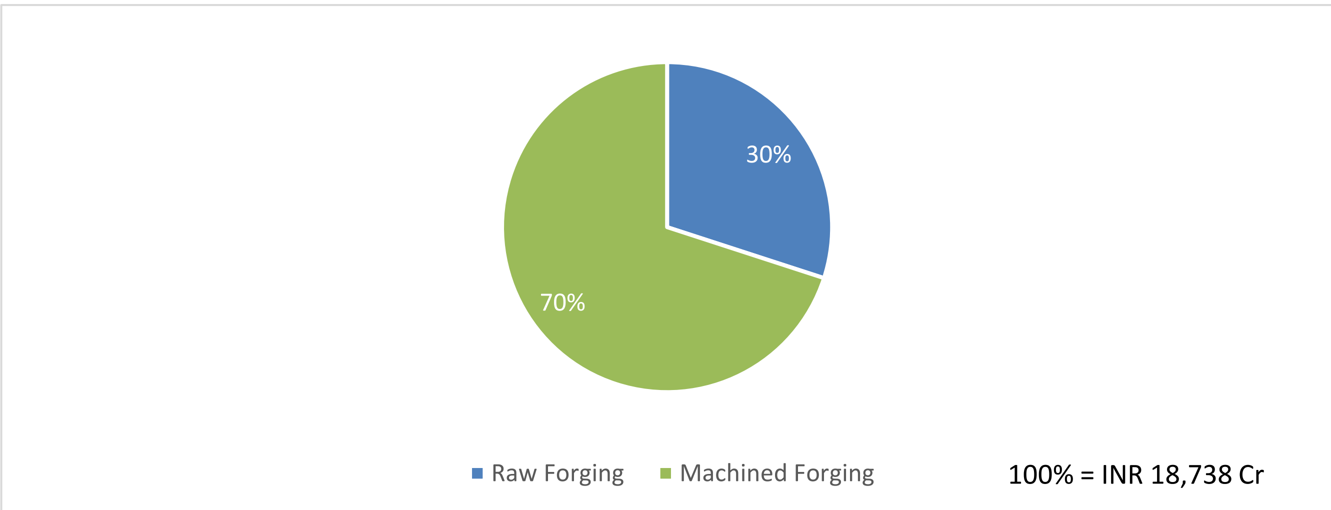
Exhibit 27: Non-Auto Forgings Sectoral Historic and projected Growth Rates

Year/CAGR Growth	Energy	Energy Turbines	Aerospace	Defence	Earthmoving, Hydraulics and Mining	Railways	Others*
FY 2019 -24	5.2%	9.2%	11.8%	6.4%	9.3%	4.2%	7.2%
FY 2024 -30	5.9%	10.1%	11.2%	12.7%	9%	5%	7.5%

Others includes any general engineering segment such as manufacturing sector, Construction, Agricultural equipment, Space Frames*

2.4.6 Indian Non-Automotive Demand by Raw Forging and Machined Forging

Exhibit 28: Non-Automotive Demand Split by Raw Forging and Machined Forging, India FY 2024



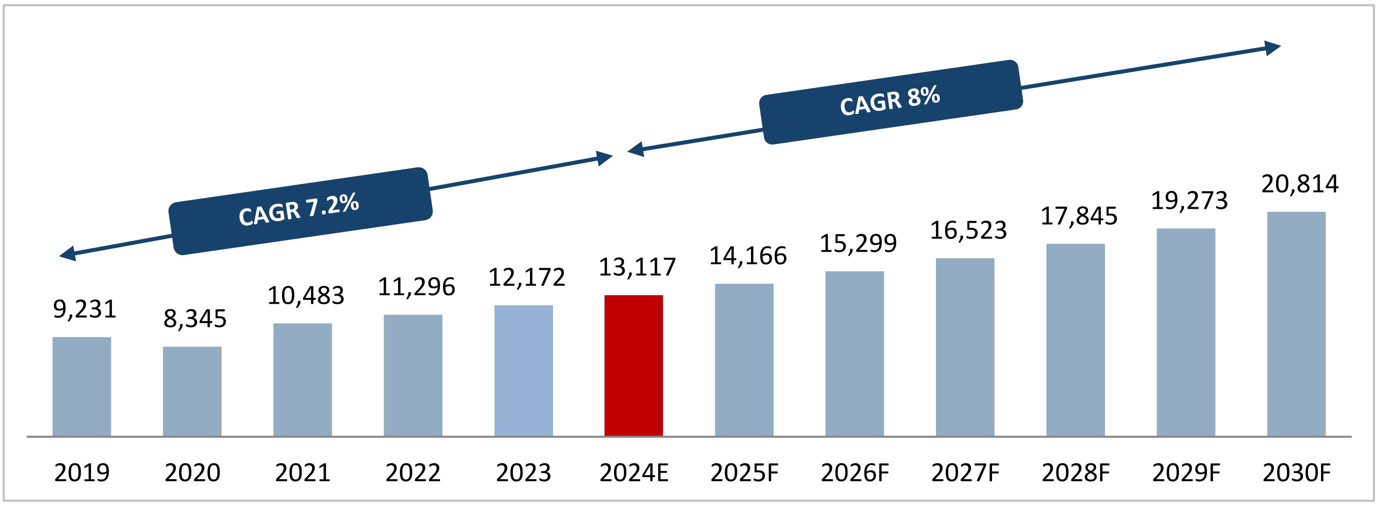
Source: Frost & Sullivan Primary Research and Analysis

- Non-Automotive Forging Market is valued at **INR 18,738 Crores in FY 2**4 out of which Machined Forging is the major contributor with **70% (INR 13,116.6 Crores)** and used for high precision and close dimensional tolerances becomes crucial while volume wise raw forging is high volume but low value, Raw Forgings Contribute **30% (INR 5,621.4 Crores)** to the total market demand and finds applications where high tolerance is not required.

- Vinir Engineering is present in the precision forged and machined components segments with their strong capabilities to meet their customer's demand.

2.4.7 India Non-Automotive Precision Machined Forging Demand Historic Trend and Market Forecast, FY 2019-2030

Exhibit 29: India Non-Automotive Precision Machined Forging Market Forecast, FY 2019-30, IN



Source: Frost & Sullivan Primary Research and Analysis, all figures are rounded. The base year is 2024.
E-Estimated, F-Forecasted

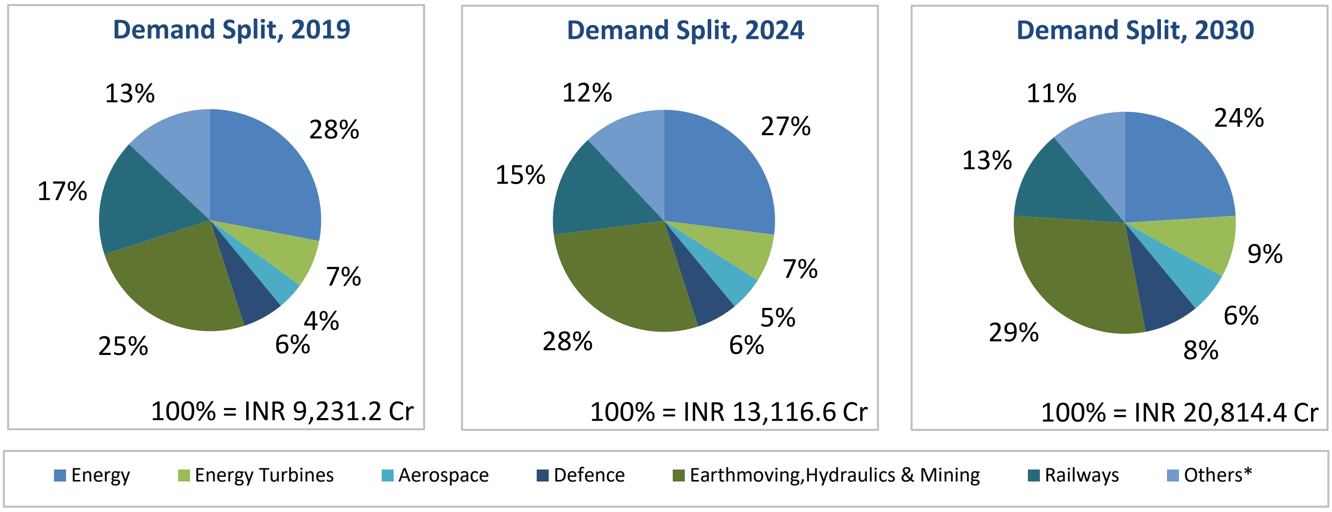
- In the Past in FY 2019 the Indian Non-Automotive Precision Machined Forging Market was valued at INR **9,231 Crores** and had grown with a CAGR of **7.2%** till FY2024 and have marked **INR 13,117 Crores** market value sustained by the impact of pandemic COVID-19. The Indian economy was impacted by the COVID-19 Pandemic.

- In FY 2020 it was valued at **INR 8,345** and experienced a downfall of **9.6%** due to restrictions imposed in movements and transportations during COVID-19 period. However, as the market started recovering from the pandemic the demand again accelerated and marked **INR 10,482.5** in FY 2021 with a growth of **25.61%** from the previous year.

- Indian Non-Automotive Precision Machined Forging Market was valued at **INR 13,117 Crores** in FY 2024 which accounts for **70%** of the overall forgings demand and is estimated to grow to **INR 20,814** by **2030** at a CAGR of **8%** from FY 2024 to 2030 driven mainly by growth of demand from non-automotive end use sectors such as Energy (Oil and Gas), Energy Turbines Aerospace and Defence, Earthmoving, Hydraulics and Mining and Railways.

2.4.8 India Non-Automotive Precision Machined Forging Market Demand by End Use Industries

Exhibit 30: Demand Split by End-use segment, INR Cr, FY 2019-30



Others includes any general engineering segment such as manufacturing sector, Construction, Agricultural equipment, Spaceframes*
Source: Frost & Sullivan Analysis

Exhibit 31: Non-Auto India Precision Machined Forging Market End-use segment wise growth rate, FY 2019-30

Year/ CAGR Growth	Energy	Energy Turbines	Aerospace	Defence	Earthmoving , Hydraulics and Mining	Railway	Others*
2019-2023	6.2%	7.3%	12.1%	6.7%	9.6%	4.6%	7%
2023-2030	5.9%	12.6%	11.2%	12.7%	9%	5%	6.1%

- Non-Auto Indian Precision Machined Forgings market was valued at **INR 13,116.6 Cr** where the Energy sector accounts for **27%,** Energy Turbines **(7%),** Aerospace **(5%),** Defence **(6%),** Earthmoving hydraulics and mining **(28%),** Railways **(15%)** and others **(12%).**
- Vinir Engineering Operates in this niche segment and are a leading, integrated engineering solutions company engaged in the **manufacturing of specialized, critical and heavy, precision-forged and machined components** for a wide range of industries and applications, including energy, defence, aerospace, railways, energy turbines, hydraulics, earthmoving, high-end engineering, amongst others.

2.4.9 Trends in the Usage of Precision Forged Machined Components in India

Exhibit 32a: Trends in the Usage of Precision Forged Machined Components in India

Trends in the Usage of Precision Forged Machined Components in India	
Adoption of Ring Rollings in Energy (Oil and Gas) Sector	• Ring Rollings are used in Energy (Oil and Gas Sector) for a range of functions. Ring Rolling is gaining attention in the extraction and storage of Oil and Gas. • Fracturing has grown in popularity as a technique of locating and extracting oil from the solid ground, and seamless rolled rings play a crucial part in the fracking process.

Trends in the Usage of Precision Forged Machined Components in India	
Aerospace & Defence	• Demand of forged components made from various alloys in Aircrafts is in trend. There is rise in commercial aircraft production along with localization of demand for aircraft parts such as engine parts, landing gears, machined parts and turbines. The demand for aerospace forged elements is expected to rise as the number of military-grade aero planes such as helicopters, specialty fighters, and jets increases to improve air defence. Therefore, the increased applications across aerospace sector will further accelerate the heavy forging market in India. • Defence Research and Development Organisation (DRDO) has established the near isothermal forging technology to produce all the five stages of high-pressure compressors (HPC) discs out of difficult-to-deform titanium alloy using its unique 2000 MT isothermal forge press. The technology has been developed by Defence Metallurgical Research Laboratory (DMRL), a premier metallurgical laboratory of DRDO at Hyderabad. This is a crucial technology for establishing self-reliance in aeroengine technology. With this development, India has joined exclusive list of global engine developers to have the manufacturing capabilities of such critical aero engine components. These developments will create the opportunities for local forging manufacturers to enhance their capabilities to meet the Defence requirements.
Sustainability and Localization Driving Supply Chain Transformation	• The Energy sector is focusing on sustainability and localization throughout the supply chain.
Floating Wind Turbines and Hybrid Power Solutions	• Floating wind turbines are gaining popularity to harness wind energy in deeper water. • This move aligns with India's objectives of producing cleaner, sustainable energy.
Technological Advancements Driving Efficiency, Energy Saving and Cost Reduction	• Technical advances in product design, manufacturing, and materials are driving efficiency improvements. • Forging manufacturers are adopting automation to boost their productivity and efficiency. • Green Certification is in trend to reduce the carbon footprint by the forging manufacturers and emphasis on the usage of renewable energy, thereby reducing the energy cost.

Vinir Engineering's extensive material capabilities position them strategically to cater to a diverse array of products and industrial applications, enabling them to meet the evolving demands of various sectors.

The firm specializes in producing precision-forged and machined components with alloy steel, titanium, Hastelloy, carbon steels, stainless steels, duplex steels, special steels, Inconel, Monel, and Aluminum, amongst others.

Exhibit 32 b: Insights on Special Metals (Inconel, Monel & Titanium)

Inconel	Monel	Titanium
Superalloy composed primarily of nickel, iron, and, to a lesser extent, chromium with **advantages of corrosion**-resistant & structural rigidity with integrity maintained as high as 1390°C – 1425°C	**Precipitation-hardened alloy formed by mixing nickel, copper and other metals**. Its composition is approximately 65–70% nickel, 20% copper, and 5% iron and manganese, depending on the piece to be manufactured, key advantages are High corrosion resistance, Resistance to High Temperatures, Good	Extracted from titanium ore using the Kroll Process (magnesium reduction) and emerges as sponge titanium. Key advantages are **Enhanced Mechanical Properties: Weight Reduction, Corrosion Resistance, Design Flexibility, Cost Effectiveness**

	mechanical strength, Non-magnetic, Ease of machining & Fire resistance	
Key Applications **Aerospace:** Airframe and jet engine components such as turbine seals and exhaust liners are made from Inconel alloys. **Oil and Gas:** Finds application in Extraction being a preferred material of choice for the lining of steel transfer piping commodity **Marine:** Propulsion motors, propeller blades, platform risers & hangers	**Key Applications** **Aerospace:** Jet aircraft coatings, aeronautical constructions, and in locking wire. **Marine:** Pipes, pump shafts, basket strainers, anchor cables, magnetic field measuring equipment, water and fuel tanks, propellers, bolts, valves and even fishing lines. **Oil and Gas:** Crude oil towers, extraction wells, and valves, among many other things. It is commonly used with slurries in the presence of hydrofluoric acid, sulfides and very high temperatures.	**Key Applications** **Aerospace:** Landing gear, engine parts, and structural elements. **Oil and Gas:** Valves, pumps, and piping systems
Alloys: 600 601 625 718 725 X750.	**Alloys:** 401 R-405 R-450	**Alloys:** Ti- CP4 (Grade 1 CP3 (Grade 2) CP2 (Grade 3) CP1 (Grade 4) 6Al-4V (Grade 5) 5Al-2.5 Sn (Grade 6) CP Ti 0.15 Pd (Grade 11)

3. End user Overview: Forging

3.1 Energy

3.1.1 Energy Global Overview

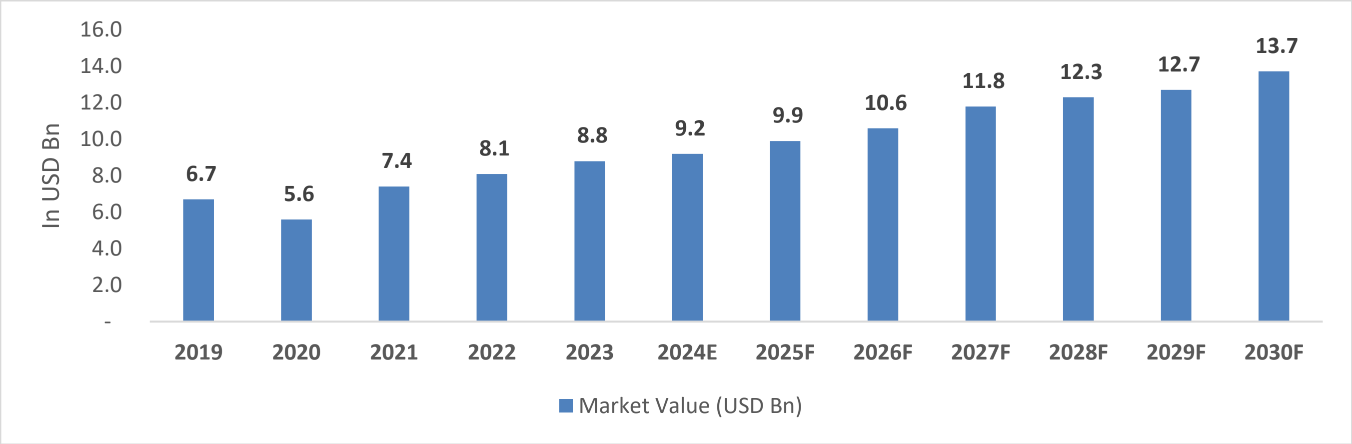
Exhibit 33: Global Energy Sector Overview

Overview Parameters	Description
Market Size and Growth Rate	• The Overall forging market for Energy sector was valued at **USD 8.82 Bn in 2023**. • Accounts for **27% of the total non-automotive forging global demand** • Projected to reach **USD 13.72 Bn by 2030** with a growth rate of **6.5%** from the period **2023 to 2030**. • Global Precision Forged Machined Components market for Energy sector was **valued at USD 6.4 Bn in 2023.** • Projected to reach **USD 10 Bn by 2030** with a growth rate of **6.2%** from the period **2023 to 2030.**
Growth Drivers	• The electricity surge is largely driven by rapid industrialization and population growth in emerging economies like India and China. • India is expected to see an 8% rise in electricity demand, primarily due to continued economic expansion. • China's electricity consumption is anticipated to grow by more than 6%, fueled by intense manufacturing and service activity. • The utilization of forged parts in machines within the nuclear power segment which operates under extreme conditions is a significant driver of growth in the forging market.
Energy Crisis Recovery	• Global energy markets that were hit particularly hard by the global energy crisis are set to see pressures ease in the next couple of years. • Natural gas markets have been dominated by fears about security and price spikes after Russia cut supplies to Europe, and market balances have remained precarious. • There is a surge in new liquefied natural gas (LNG) projects coming on stream from 2025 adding an additional capacity of 250+ billion cubic meters per year by 2030, equivalent to around 45% of today's total global LNG supply
Energy sector outlook	• Climate change to achieve NetZero target by various economies towards cleaner and more sustainable energy sources, a comprehensive overview of global energy consumption serves as a roadmap for shaping the future of energy production and consumption worldwide. Green forged products are in trend and are produced by major players to curb their carbon footprints. • The growth of Energy sector Globally is promising and the demand for energy will increase with the growing population, industrialization and urbanization.

	• The Nuclear power industry extensively uses forged metal parts for various critical applications such as reactors, nuclear waste storage and transportation of raw materials and waste.

Global Overall Forging Market: Energy, 2019-2030

Exhibit 34: Global Overall Forging Market Trend, Energy, USD Bn, 2019-30



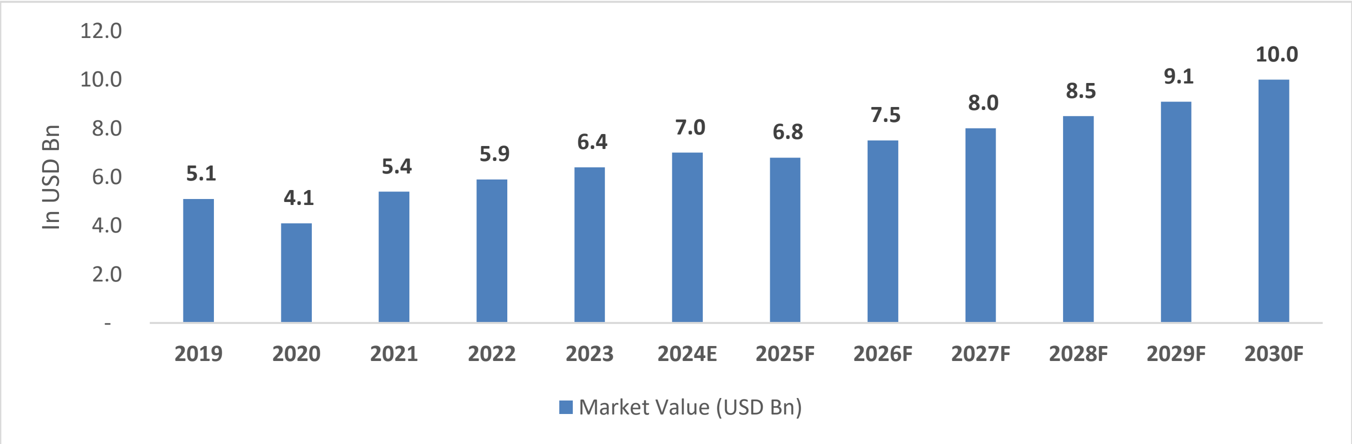
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global overall forging market for Energy was valued at **USD 8.8 Bn in 2023** and is projected to mark **USD 13.72 Bn by 2030** with a **CAGR of 6.5% from 2023 to 2030 driven by forgings demand from the Oil and Gas, Renewables and Nuclear Energy segments.**

Global Precision Forged Machined Components Market: Energy, 2019-2030

Exhibit 35: Global Precision Forged Machined Components Market Trend, Energy, USD Bn, 2019-30



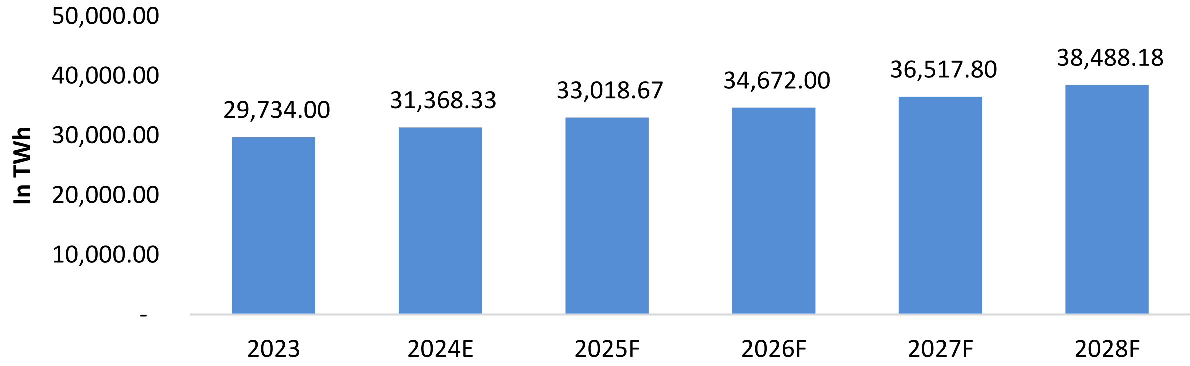
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global Precision Forged Machined Components Market for Energy was valued at **USD 6.4 Bn in 2023** and is projected to mark **USD 10 Bn by 2030** with a **CAGR of 6.2% from 2023 to 2030 driven by growth of precision forged machined components demand from the Oil and Gas, Renewables and Nuclear Energy segments.**

Global Electricity Demand

Exhibit 36: Global Electricity Demand,2023-2028F



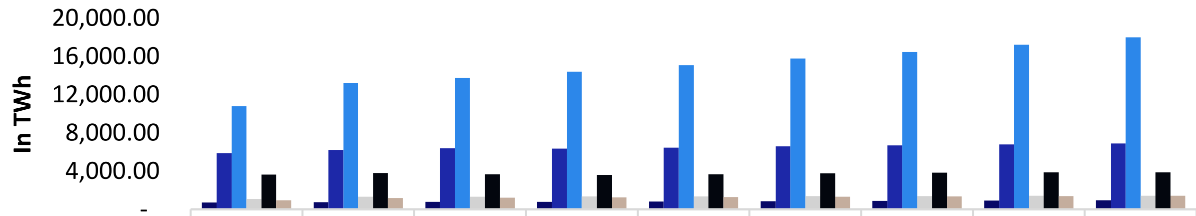
Source: IEA, Electricity Report 2024

E-Estimated, F-Forecasted

- Regional energy consumption encompasses various sectors, including transportation, industry, residential, and commercial sectors, each with its unique patterns and drivers
- Key Trends for Electricity demand growth is **population growth, economic development, and increasing electrification** across various sectors coupled with urbanization, industrialization growth in emerging economies, particularly in Asia and Africa.
- This trend is also fueled by the **electrification of transportation** and other systems, as countries strive to reduce and derisk themselves from reliance on fossil fuels and transition to cleaner energy sources.

Overview of Regional Energy Consumption

Exhibit 37: Global Regional Energy Consumption,2018-2028F



	2018	2021	2022	2023	2024E	2025F	2026F	2027F	2028F
Africa	703.00	753.00	765.00	780.00	815.67	851.33	887.00	916.61	947.20
Americas	5,867.0	6,219.0	6,382.0	6,353.0	6,461.0	6,569.0	6,677.0	6,772.9	6,870.2
Asia Pacific	10,792.	13,193.	13,733.	14,394.	15,082.	15,770.	16,459.	17,203.	17,981.
Eurasia	1,084.0	1,302.0	1,316.0	1,335.0	1,352.0	1,369.0	1,386.0	1,403.4	1,421.1
Europe	3,631.0	3,813.0	3,674.0	3,586.0	3,672.3	3,758.6	3,845.0	3,852.8	3,860.6
Middle East	954.00	1,172.0	1,210.0	1,235.0	1,272.3	1,309.6	1,347.0	1,385.0	1,424.1

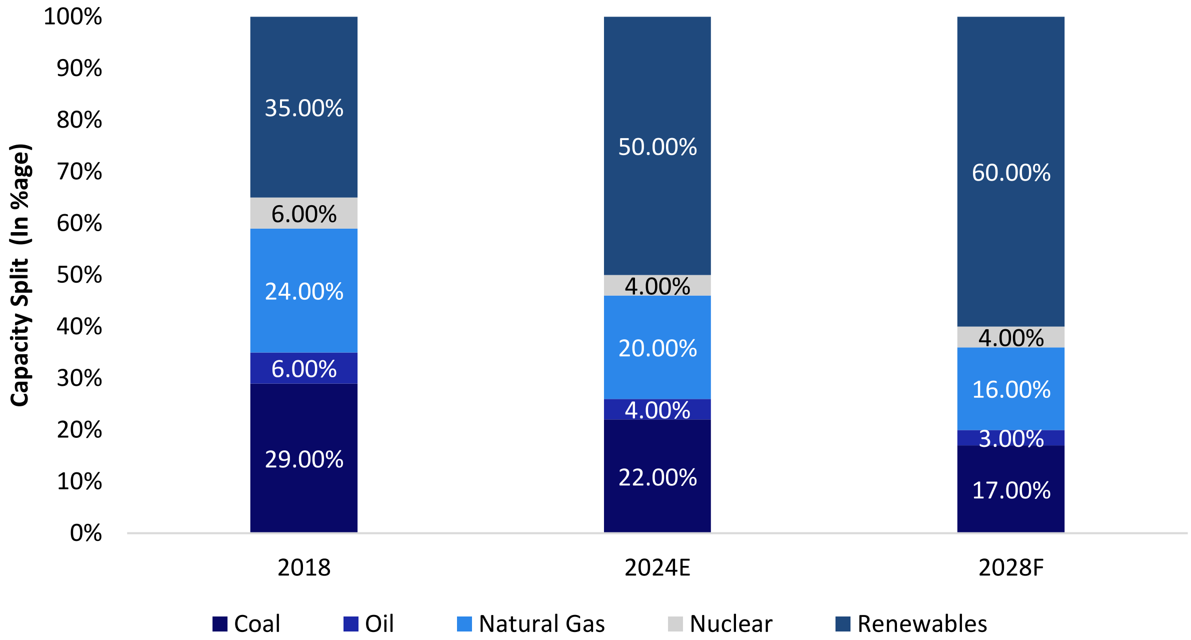
Source: IEA, Electricity Report 2024

E-Estimated, F-Forecasted

- **The Americas** are expected to grow at a moderate **CAGR of 1.6% between the period 2024-2028**
- **Emerging economies Asia Pacific** accelerates at **a CAGR of 4.6%** driven by industrial expansion and urban development.
- **Eurasia &** Europe accelerates at a CAGR **of 1.3% from 2024-2028.**
- **Middle East**: accelerates at a CAGR of **2.9% from 2024-2028.**

Global Power Generation and Capacity Overview Across Different Energy Sources

Exhibit 38: Global Energy Capacity, By Source, 2018-2028F



Source: IEA and Frost & Sullivan estimates

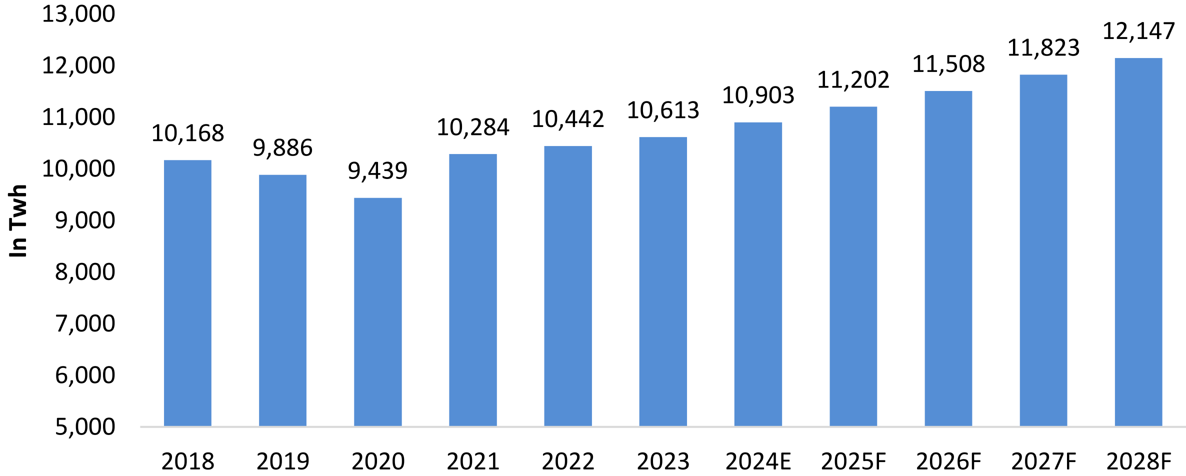
E-Estimated, F-Forecasted

- **Coal and natural gas** remain dominant due to their affordability and reliability in 2023.
- **Renewable energy** capacity is driven by environmental concerns and technological advancements, the mix is projected to reach **60.0% by 2028F** contributed by Solar energy which is rapidly growing in China, Europe, North America.
- Nuclear power is emerging globally driven by need for clean energy and necessity to combat carbon emissions.

Fossil Fuels: Coal & Gas

Global Power Generation and Capacity:

Exhibit 39: Global Power Generation-Fossil Fuel (In Twh),2018- 2028F

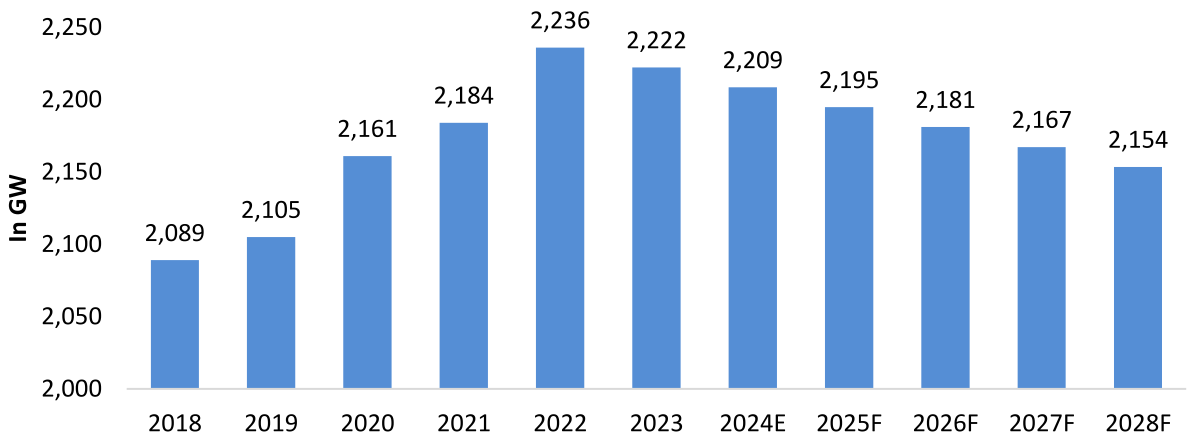


Source: iea.org

E-Estimated, F-Forecasted

- **Coal will account for 22% portion of the global power capacity in 2024E**. Developing countries continue to invest in coal-fired power infrastructure to meet their growing energy demands.
- As the world strives to achieve carbon neutrality and combat climate change, the future of coal in global power generation remains uncertain.

Exhibit 40: Global Power Capacity Fossil Fuel (In GW),2018- 2028F



Source: iea.org

E-Estimated, F-Forecasted

Global Trends in Fossil Fuel

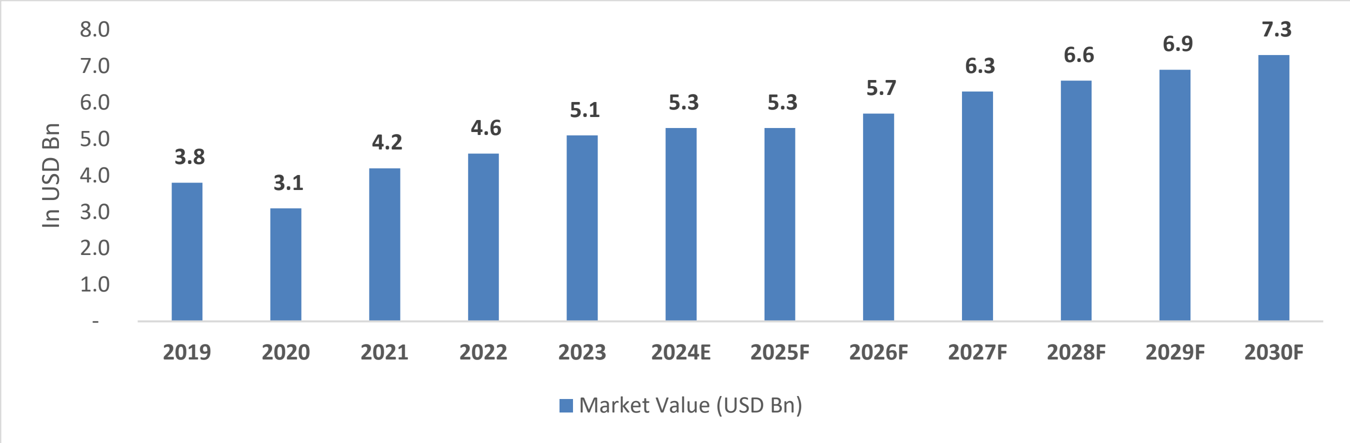
- The fossil fuel generation in **2023 was 10,613.00 Twh** and is expected to grow to **12,147.00 Twh in 2028F at a CAGR of 2.7%.** The capacity in fossil fuel production is expected to reduce from **2,222.25 GW in 2023 to 2,153.50 GW in 2028F**, experiencing a negative **CAGR of 0.6%.**
- Fossil fuels, including coal, oil, and natural gas, have shown an increasing trend over time and are projected to continue rising until 2030.
- The consumption of liquid fuels, such as natural gas plant liquids and crude oil, surpasses that of other fossil fuel types.

3.1.1.1 Oil and Gas Sector

- Global oil demand remains on track to grow **from 2.3 mbpd in 2023** and cross the **100 mbpd mark for the first time in history**.
- Global oil demand is projected to rise by **38 million barrels a day to 115 million barrels a day by 2025**.Asian countries will remain the key source of demand increase in the developing world with the China and India at its central.

Global Overall Forging Market: Oil and Gas 2019-2030

Exhibit 41: Global Overall Forging Market Trend, Oil and Gas, USD Bn, 2019-30



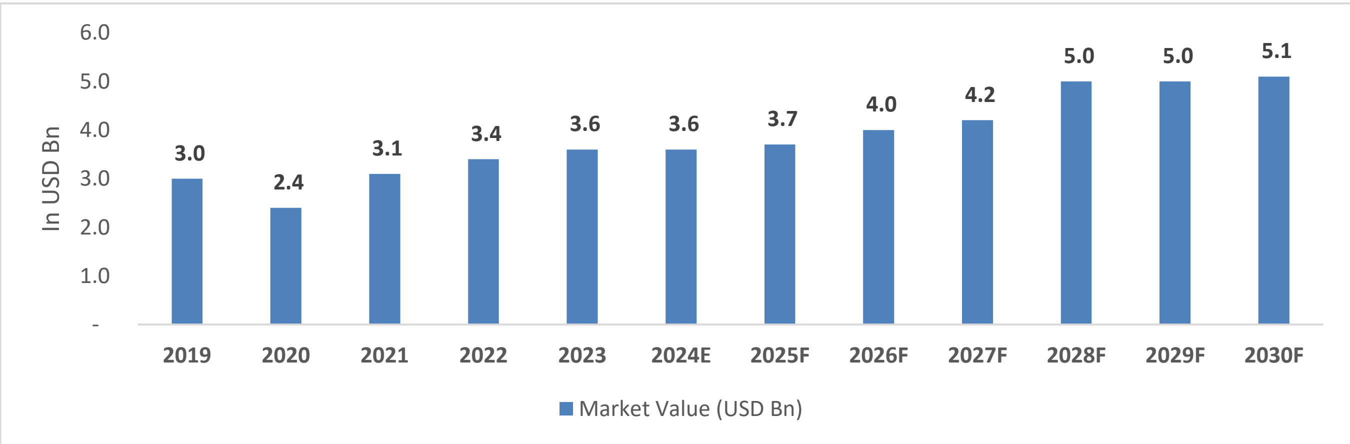
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global overall forging market for Oil and Gas was valued at **USD 5.1 Bn in 2023** and is projected to mark **USD 7.3 Bn by 2030** with a **CAGR of 5.2% from 2023 to 2030 driven by growth in demand of raw forgings and machined forged components such as Valve body, Gates, Studded Tee, Crosses, Rings, Slip Bowls, Bonnets, Body, Housing, Gates, Square Block, Cross, Studded Tees, Valve Casing, Y Block, Flanges, Tube Sheet, Clad Body Valves, adapter bodies and slip bowls.**

Global Precision Forged Machined Components Market: Oil and Gas 2019-2030

Exhibit 42: Global Precision Forged Machined Components Market Trend, Oil and Gas, USD Bn, 2019-30



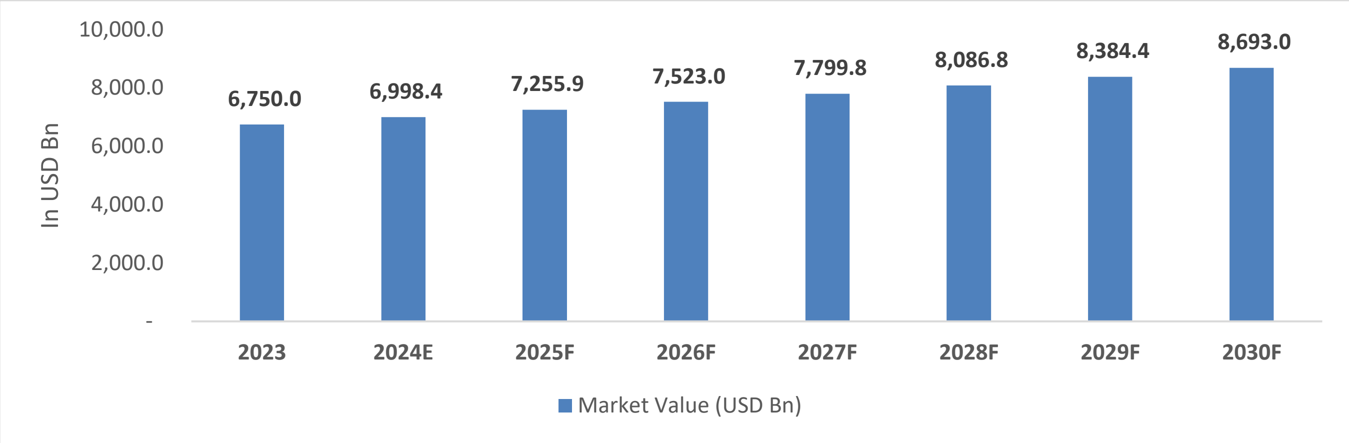
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global Precision Forged Machined Components Market for Oil and Gas was valued at **USD 3.6 Bn in 2023** and is projected to mark **USD 5.1 Bn by 2030** with a **CAGR of 5.1% from 2023 to 2030 driven by growth in demand of components such as Valve body, Gates, Studded Tee, Crosses, Rings, Slip Bowls, Bonnets, Body, Housing, Gates, Square Block, Cross, Studded Tees, Valve Casing, Y Block, Flanges, Tube Sheet, Clad Body Valves, adapter bodies and slip bowls**

Global Oil and Gas Overall Market Size, 2023-2030

Exhibit 43: Global Oil and Gas Market Trend, USD Bn, 2023-2030



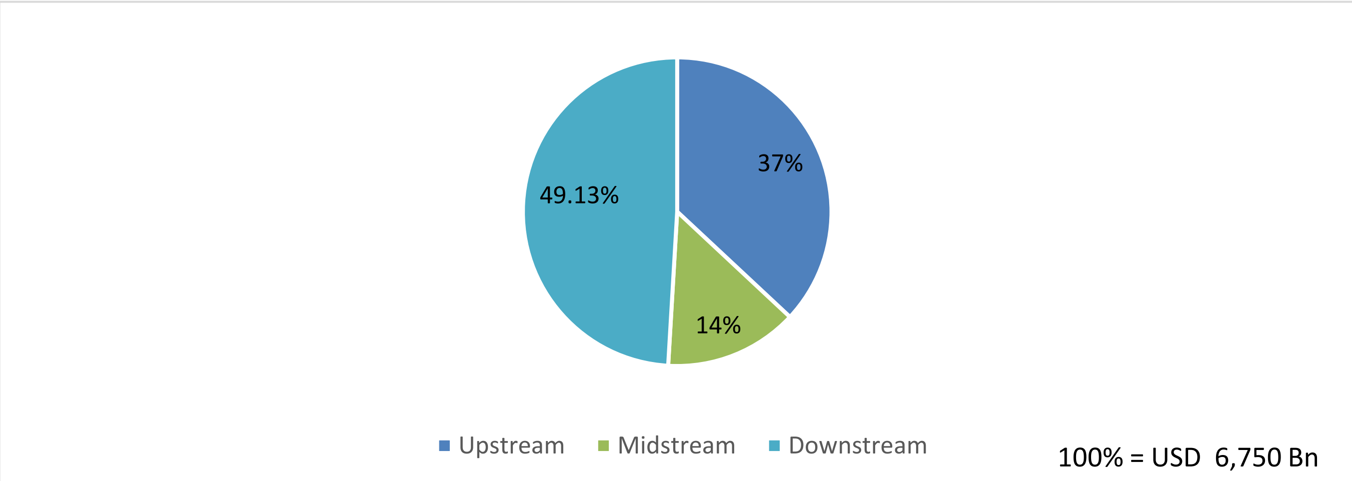
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global Oil and Gas market was valued at **USD 6,750 Bn in 2023** and is estimated to mark **USD 8,693 Bn by 2030** with a **CAGR of 3.68% from 2023 to 2030.**

Segmentation of Oil and Gas Sector by Type, 2023

Exhibit 44: Segmentation of Oil and Gas by Type, 2023



Source: Frost & Sullivan Analysis

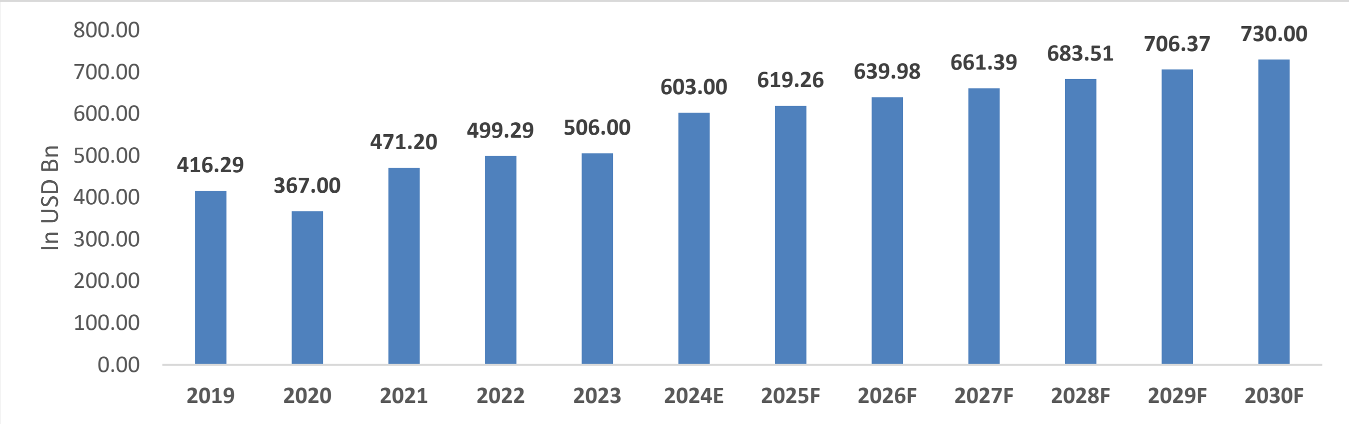
Exhibit 45: Segmentation by Stream and Impact on Forging

Stream	Remarks	Impact on Forging
Upstream	Underground or underwater crude oil and natural gas fields, Drilling exploratory wells that recover and bring the crude oil or raw natural gas to the surface	**High**
Downstream	Key forging components Valve body, Gates, Studded Tee, Crosses, Rings, Slip Bowls, Bonnets, Body, Housing, Gates, Square Block, Cross, Studded Tees, Valve Casing, Y Block, Flanges, Tube Sheet, Clad Body Valves	**High**

Stream	Remarks	Impact on Forging
Midstream	Has minimal impact on forging largely driven by pipes to distribution within refineries, processing plants, pipeline systems, tanker ships for liquefied natural gas (LNG) and crude oil, rail tank cars, and trucking fleets, as well as storage facilities.	**Low**

Global Historic and Forecasted Upstream Capex, 2019-2030

Exhibit 46: Global Historic and Forecasted Upstream CAPEX, USD Bn 2019-2030



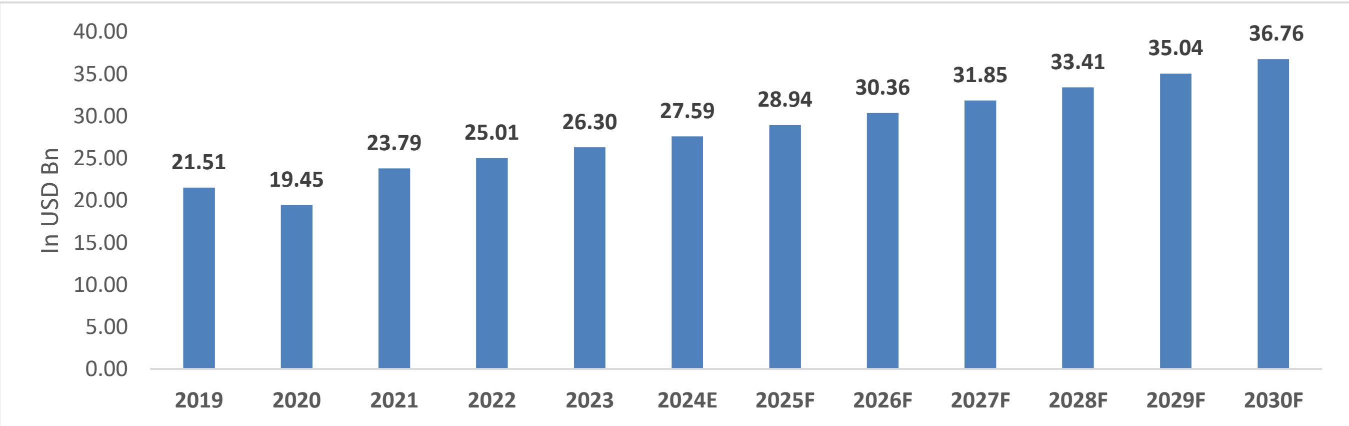
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global Oil and Gas Upstream CAPEX increased by **19.17% to USD 603 Bn** in 2024 from **USD 506 Bn** in 2022 and is estimated to grow with a **CAGR of 3.2%** from 2024 to 2030 and CAPEX is expected to mark **USD 730 Bn** by 2030.
- Oil and Gas companies have started transitioning to other forms of energy. The demand for fossil fuels will grow and drive Upstream CAPEX investments in the short to mid-term.

Global Drilling Equipment Market Historic and Forecasted Trend, 2019-2030

Exhibit 47: Global Drilling Equipment Market Trend, USD Bn 2019-2030



Source: Frost & Sullivan Analysis

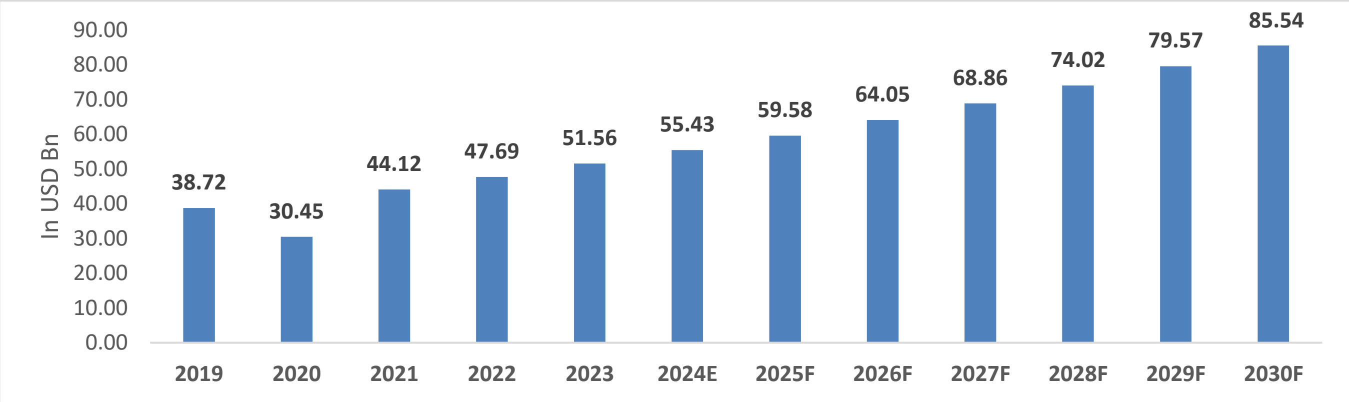
E-Estimated, F-Forecasted

- Global Drilling equipment market was valued at **USD 26.3 Bn in 2023** poised to grow with a CAGR of **4.9%** from 2024 to 2030 is estimated to reach **USD 36.76 Bn by 2030.**

- **A 5% increase in Oil demand by 2025 is expected,** requiring drilling equipment for exploration, well development, and pipeline construction.
- The growing demand for fabricated metal products and heavy industrial equipment is also propelling the market, as precision drilling is essential for manufacturing and assembly processes.

Global Hydraulic Fracturing Market Historic and Forecasted Trend, 2019-2030

Exhibit 48: Global Hydraulic Fracturing Market Trend, USD Bn 2019-2030



Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

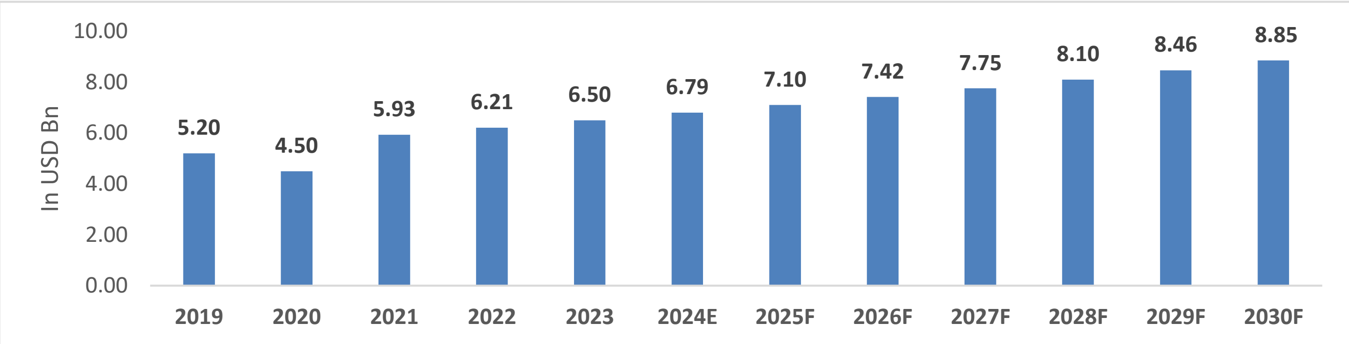
Exhibit 49: Region Wise Growth Drivers

Key components driving demand: Well head connectors, Pressure tubing, Pistons, Cylinder rods, Clevis, End cap & Gland		
Key Regions	**Growth Drivers**	**Impact**
Global Trend	Innovations such as hydraulic fracturing (fracking) and horizontal drilling have unlocked previously inaccessible reserves, significantly increased supply and changing the global energy market landscape. Global Hydraulic Fracturing market was valued at **USD 51.56 Bn in 2023** and is estimated to grow with a CAGR of **7.5%** from **2024 to 2030** and mark **USD 85.54 Bn by 2030**.	**High**
North America	High market penetration driven by hydraulic fracturing has enabled increased exploration and production activities in unconventional reserves. USA is one of the world's largest producers of shale gas, with abundant availability of prime shale resources. Permian (includes Occidental Petroleum, Chevron, Exxon Mobil), Eagle ford Woodbine, Appalachia (includes Marcellus and Utica shales), Hayneville-Brown Dense are among the key players involved in Hydraulic fracturing.	**High**
Saudi Arabia	Investments over **USD 100 billion** in unconventional gas program, driven by 3 major fields which are Jafurah, North Arabia, South Ghawar From 2018-2022, Saudi Aramco has awarded various contracts to Oil-Field Services companies to execute services covering fracturing, testing, wireline, coiled tubing, slickline services and all associated chemistry, logistics and site services.	**High**

	Saudi Aramco the ultimate end user along with, **U.S based Schlumberger, Halliburton Co. and Baker Hughes Co**. on the field and to develop the technology to fracture the rock and release the oil and gas it holds, a technology known as fracking. critical components driven by large Oil field entities such as Halliburton, Schlumberger, Baker Hughes, TAQA and NESR	
Asia Pacific	Has large technically recoverable shale and CMB reserves in China, Indonesia, and Australia, as well as heavy investment in the hydrocarbon sector through FDI channels in these countries, is expected to boost the market for leading companies to discover the opportunities that exist in these regional markets' unconventional hydrocarbon reserves.	**Low**

Global Wellhead Components Market Historic and Forecast, 2019-2030

Exhibit 50: Global Wellhead Components Market, USD Bn 2019-2030



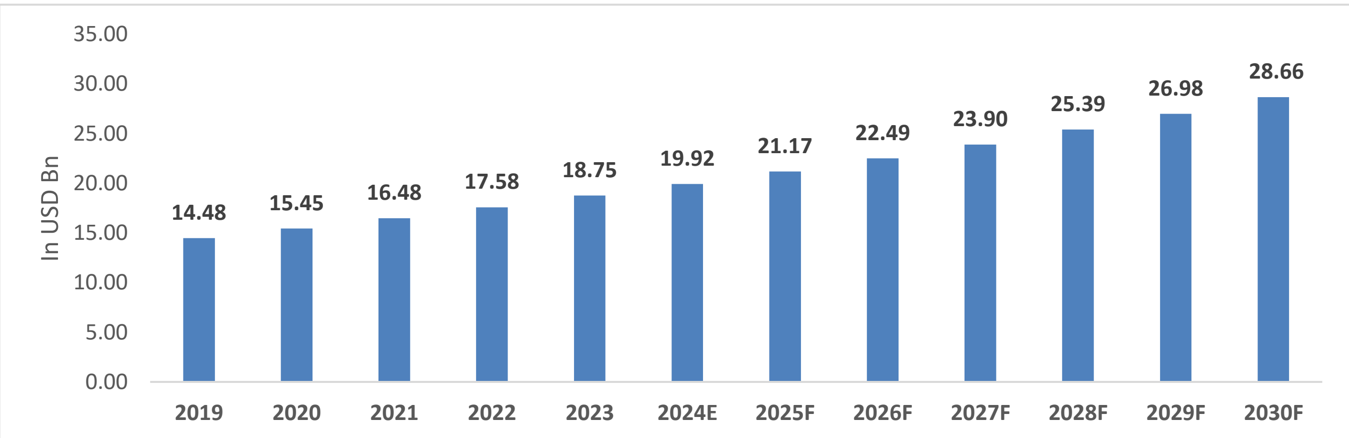
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global Wellhead components market was valued at **USD 6.5 Bn in 2023** and is estimated to grow with a CAGR of **4.5%** from **2024 to 2030** and mark **USD 8.85 Bn by 2030**.
- As accessible onshore reserves become depleted, Oil and Gas companies are increasingly turning to offshore fields to meet global energy demands. This shift requires specialized wellhead components that can operate reliably in harsh marine environments and at great depths.
- **North America driven by US. and Canada** are the world's largest producers of oil and natural gas, with extensive onshore and offshore operations.

Subsea Equipment Market Historic and Forecast, 2019-2030

Exhibit 51: Subsea Equipment Market, USD Bn 2019-2030



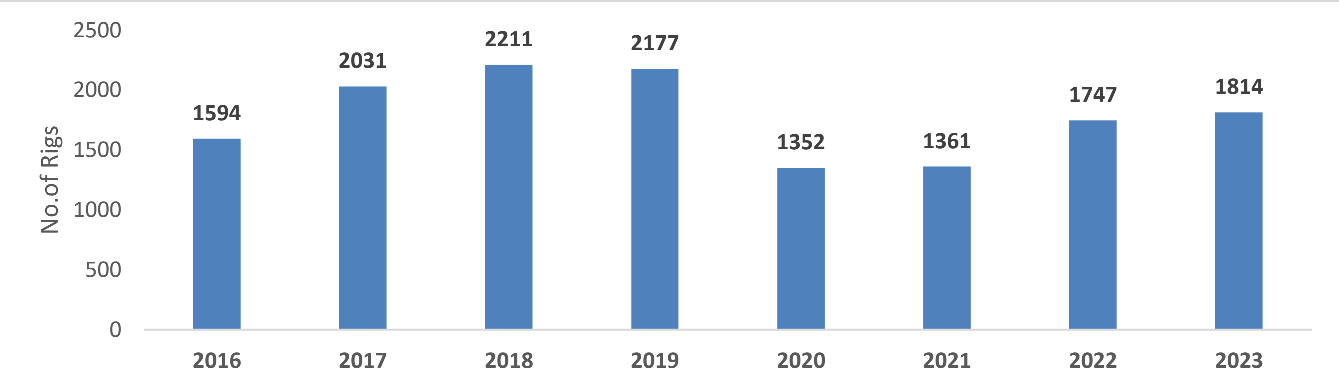
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global Subsea Equipment market was valued at **USD 18.75 Bn in 2023** and is estimated to grow with a CAGR of **6.25%** from **2024 to 2030** and mark **USD 28.66 Bn by 2030**, Riser, keel and stress joints, Kelly mandrels, reamer bodies, Drill heads, Tension rings are some of the key Forging components.
- Stringent regulatory requirements regarding safety and environmental protection are driving the demand for advanced subsea equipment.
- Governments and regulatory bodies have implemented rigorous standards to mitigate risks associated with offshore operations.

Global Rigs Count

Exhibit 52: Global Rigs Count, 2016-2023

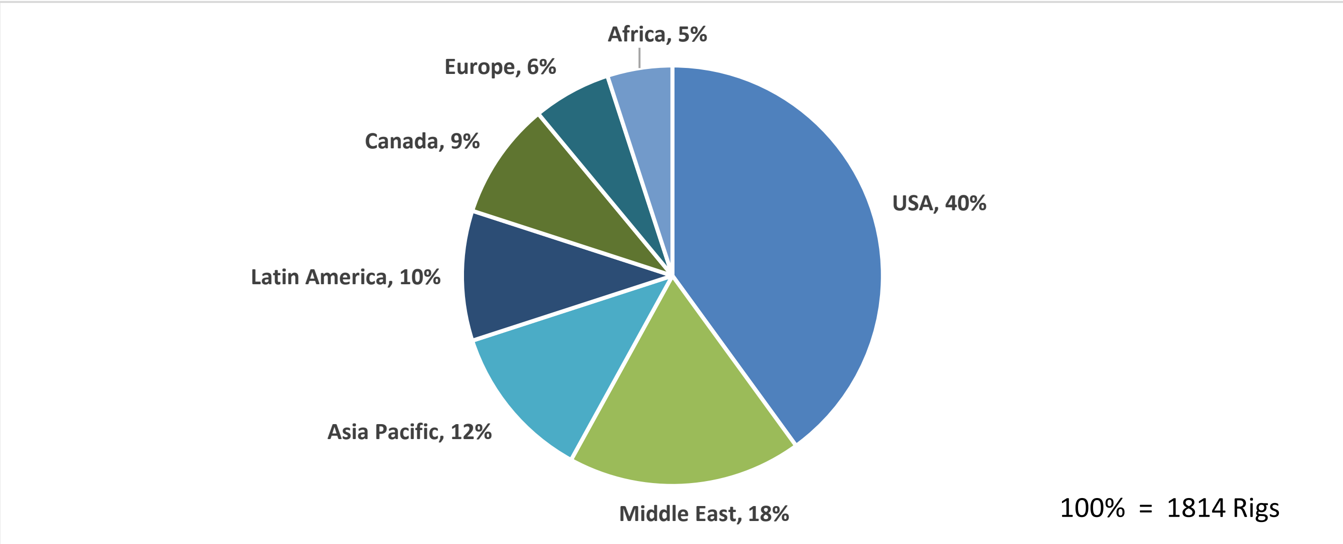


Source: Statista

- Global average rig count (including both land and offshore rigs) has grown at a **CAGR of 1.9% from 2016 to 2023.**
- Following the trend in upstream capex, the rig count also witnessed a decline in **2020** but recovered and had marked **1,814 rig counts in 2023.**

Rigs Count by Region, 2023

Exhibit 53: Global Rigs Count by Region, 2023

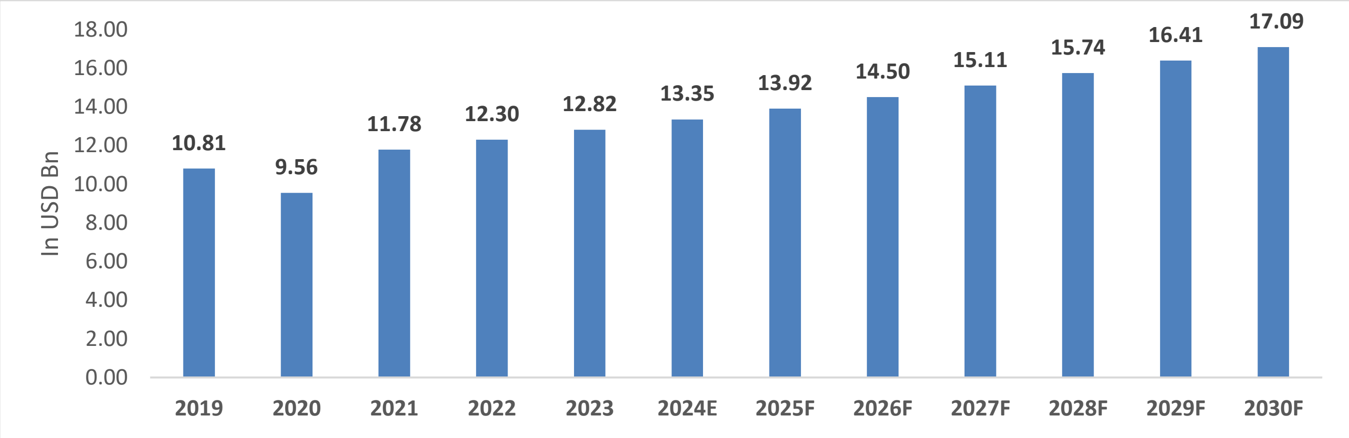


Source: Baker Hughes

- US leads the average rig count with **40% of the Global average rig count**, followed by **Middle east (18%) in 2023.**

Global Oil and Gas Valve Market, 2019-30

Exhibit 54: Global Oil and Gas Valves Market, USD Bn 2019-2030



Source: Frost & Sullivan Analysis

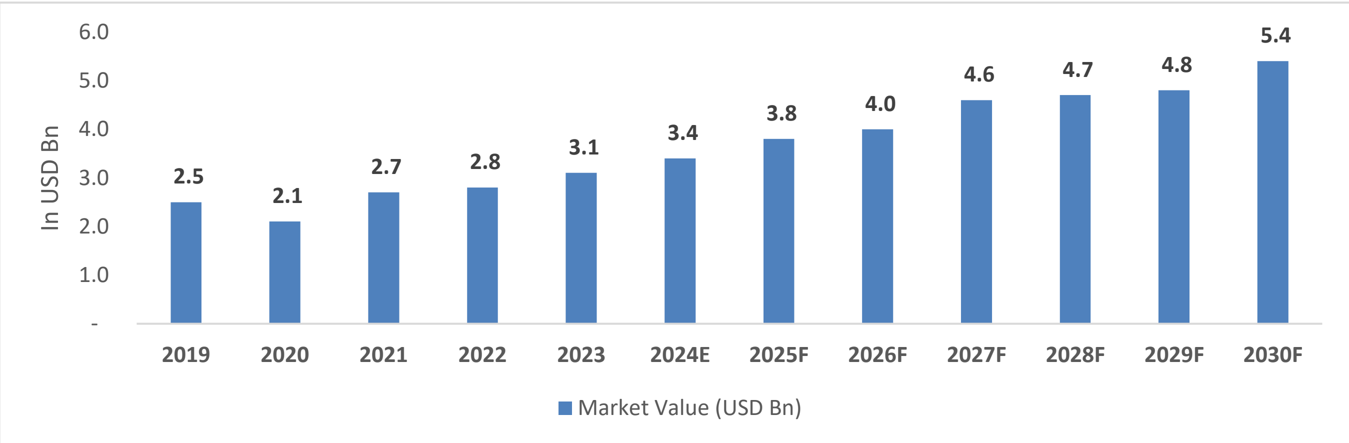
E-Estimated, F-Forecasted

- Global Oil and Gas Valves Market was valued at **USD 12.82 Bn in 2023** and is estimated to grow with a CAGR of **4.2 %** from **2024 to 2030** and mark **USD 17.09 Bn by 2030**, driven by the ever-increasing energy demands of the world, requiring innovative solutions and advanced technologies to ensure efficient and sustainable extraction, distribution, and utilization of oil and gas resources.

3.1.1.2 Global Renewable Energy

Global Overall Forging Market: Renewables 2019-2030

Exhibit 55: Global Overall Forging Market Trend, Renewables, USD Bn, 2019-30



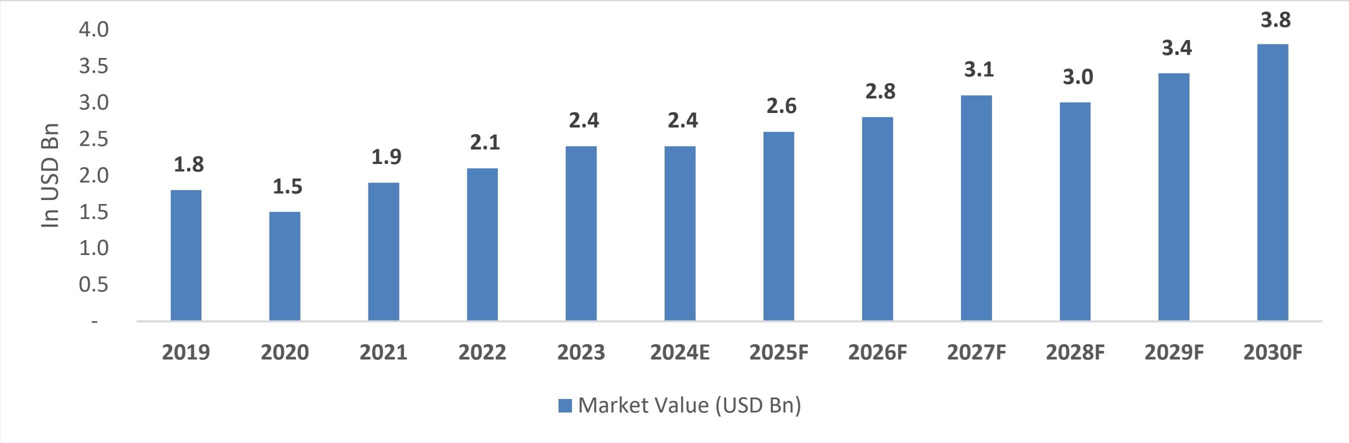
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global Overall Forging Market for Renewables was valued at **USD 3.1 Bn** in 2023 and is projected to mark **USD 5.4 Bn by 2030** with a CAGR of **8.2% from 2023 to 2030** driven by demand from wind energy segment, Solar and other segments.

Global Precision Forged Machined Components Market: Renewables 2019-2030

Exhibit 56: Global Precision Forged Machined Components Market Trend, Renewables, USD Bn, 2019-30



Source: Frost & Sullivan Analysis

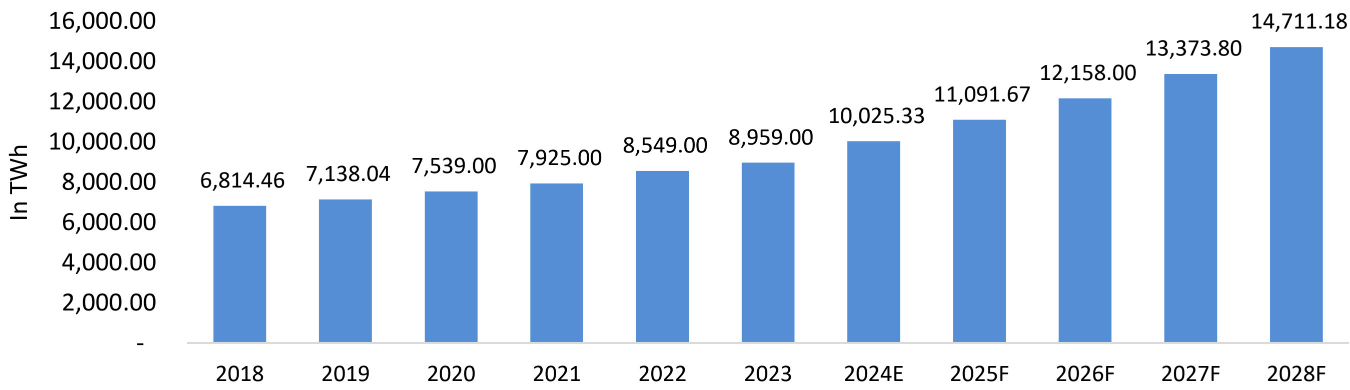
E-Estimated, F-Forecasted

- Global Precision Forged Machined Components Market for Renewables was valued at **USD 2.4 Bn** in 2023 and is projected to mark **USD 3.8 Bn by 2030** with a CAGR of **7% from 2023 to 2030** driven by demand from wind energy segment.

Global Renewable Power Generation and Capacity

- Renewable energy, including solar, wind, hydroelectric, and biomass, has gained traction due to declining costs, technological advancements, and increasing awareness of environmental issues such as climate change.
- The renewable power generated increased growing at a **CAGR of 10.1%** from **8,959.00 Twh** in 2023 to **14,711.18 Twh in 2028F.**
- Renewable power generation accounted for **28.2% in 2020** and is expected to grow to **41.6% in 2028F.**

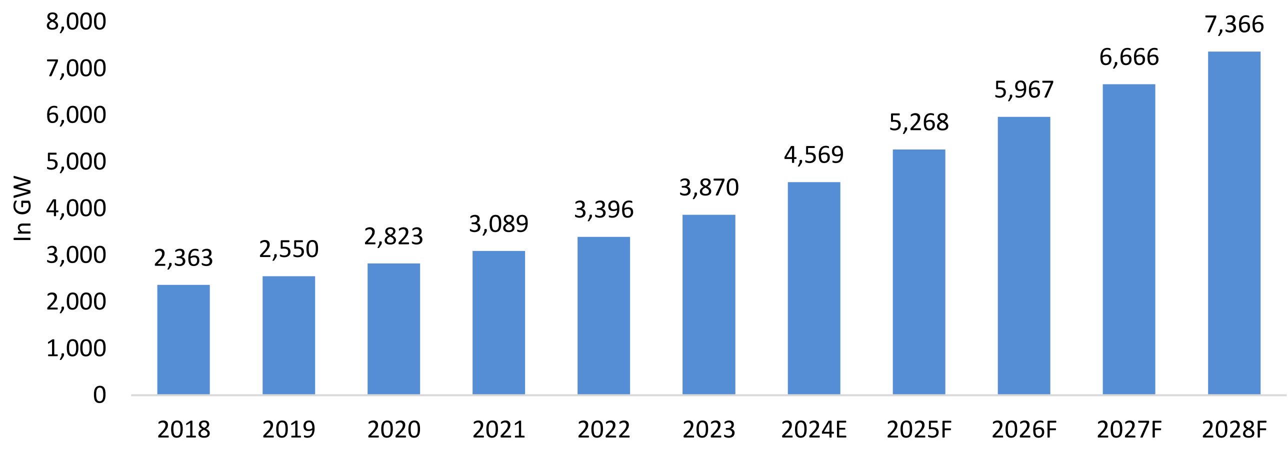
Exhibit 57: Global Power Generation-Renewable (In Twh),2018- 2028F



Source: iea.org

E-Estimated, F-Forecasted

Exhibit 58: Global Power Capacity-Renewable (In GW),2018- 2028F



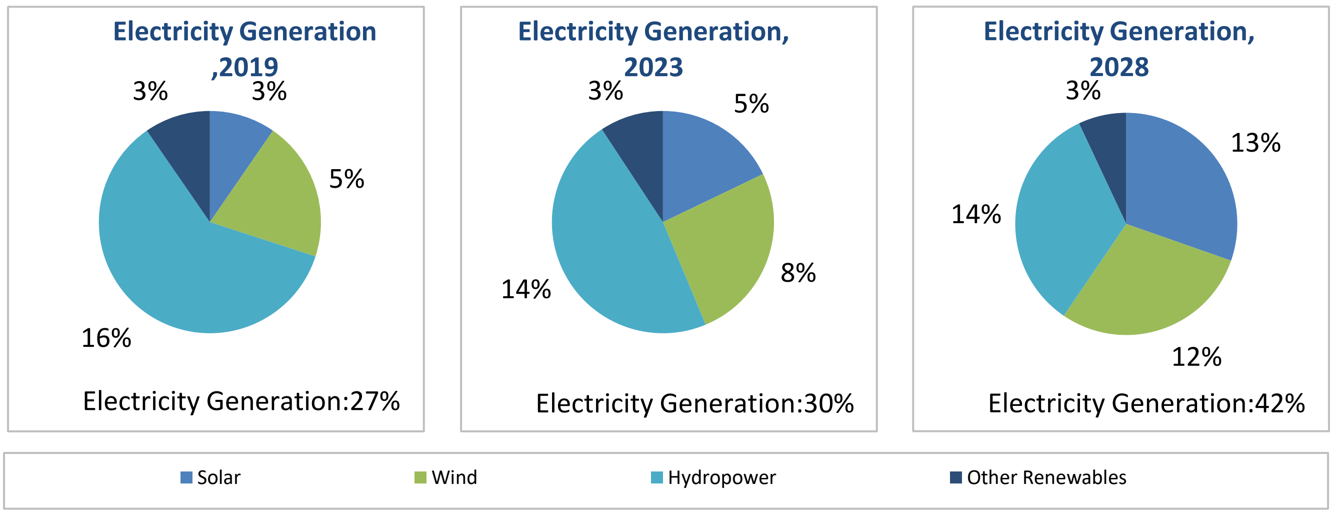
Source: iea.org

E-Estimated, F-Forecasted

Global Trends in Renewables

- Solar PV energy accounts to around three-quarters of renewable capacity additions in 2023.
- Wind power is driven by public policies playing a key role in driving expansion.
- Hydropower generation would remain the largest source through 2030.
- Green hydrogen, produced using renewable energy, is gaining traction as a potential clean energy carrier.

Exhibit 59: Global Electricity Generation by Renewable Energy, 2019-2028

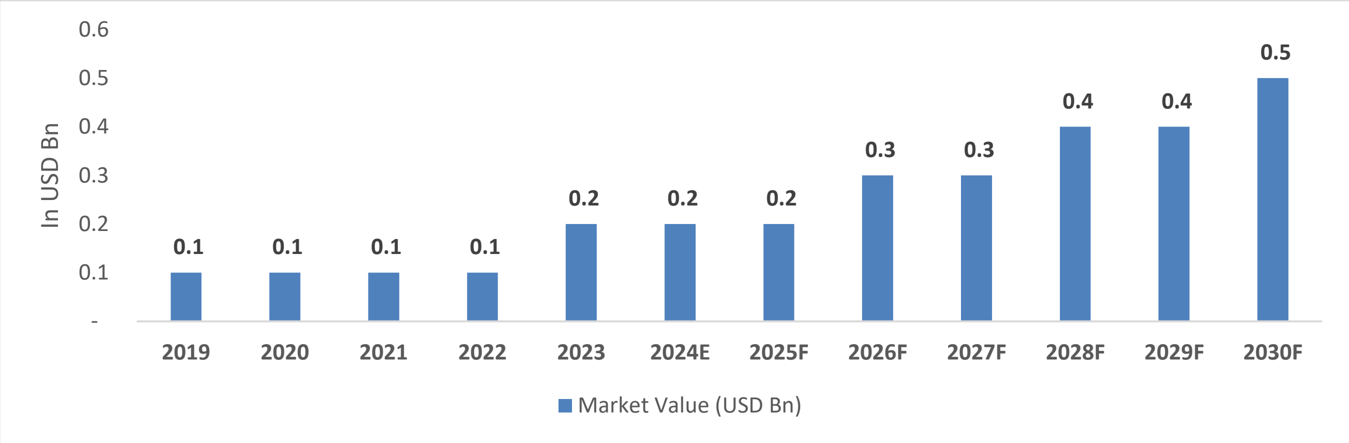


Source: IEA

- Electricity Generation by Renewable Energy accounted for **27%** of the total electricity generated globally in 2019.
- It witnessed a 30% share out of the total electricity generated supported by **Solar (5%), Wind (8%), Hydropower (14%) and others (3%) in 2023.**
- Electricity Generation by Renewables is projected to witness a **42% share** by 2028.

Global Precision Forged Machined Components Market: Wind Energy 2019-2030

Exhibit 60: Global Precision Forged Machined Components Market Trend, Wind Energy, USD Bn, 2019-30



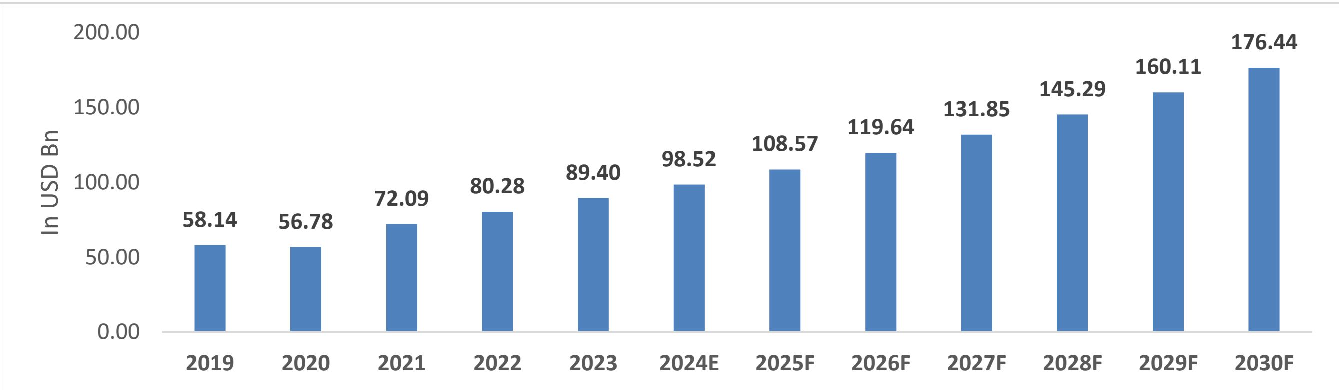
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global Precision Forged Machined Components Market for Wind Energy was valued at **USD 0.2 Bn** in 2023 and is projected to mark **USD 0.5 Bn by 2030** with a CAGR of **16.5% from 2023 to 2030** driven by demand of wind energy components such as **Parts in the nacelle (gearbox, high-speed shaft, low-speed shaft and brake), the yaw drive for upwind turbines (shaft and gear) and tower components** for both downwind and upwind turbines.

Global Wind Energy Market Trend

Exhibit 61: Global Wind Energy Market Trend, USD Bn 2019-2030



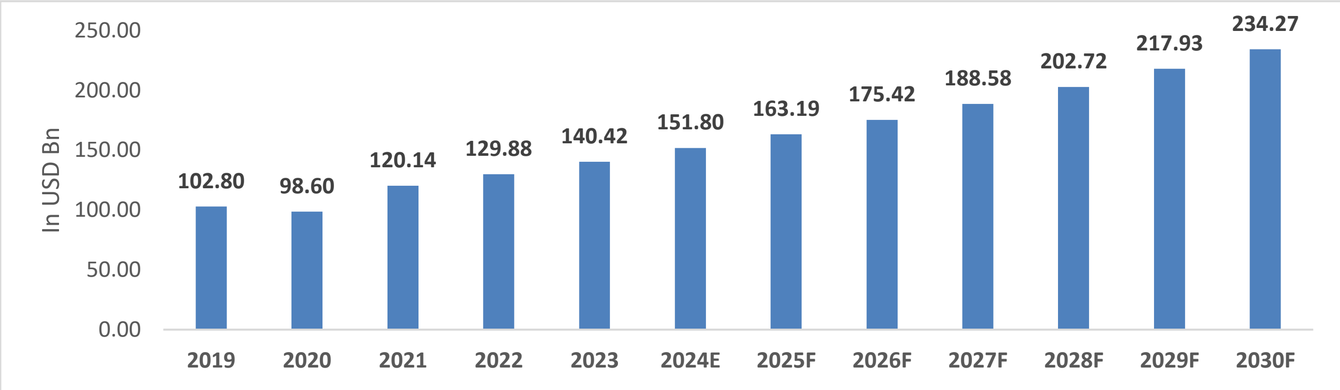
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Globally **117 GW** of new installations of Wind Power took place in 2023 and is projected to reach at least **320 GW** of new additions by 2030 to meet COP28 targets.
- Global Wind Energy Market was valued at **USD 89.40 Bn in 2023 and** is projected to grow at a **CAGR of 10.2% from 2023 to 2030 driven by policy support and to meet COP28 targets across the world.**
- In 2023, **Asia pacific accounted for 43% share**, **North America (28%), Europe (21%), Latin America (5%) and Middle East and Africa (3%) of the Wind Energy Share**.
- Asia Pacific contributed **71%, Europe (16%), North America (7%), Latin America (5%) and Africa and Middle East (1%) to the new capacity installations in 2023**.

Global Wind Turbines Market Trend

Exhibit 62: Global Wind Turbine Market Trend, USD Bn 2019-2030



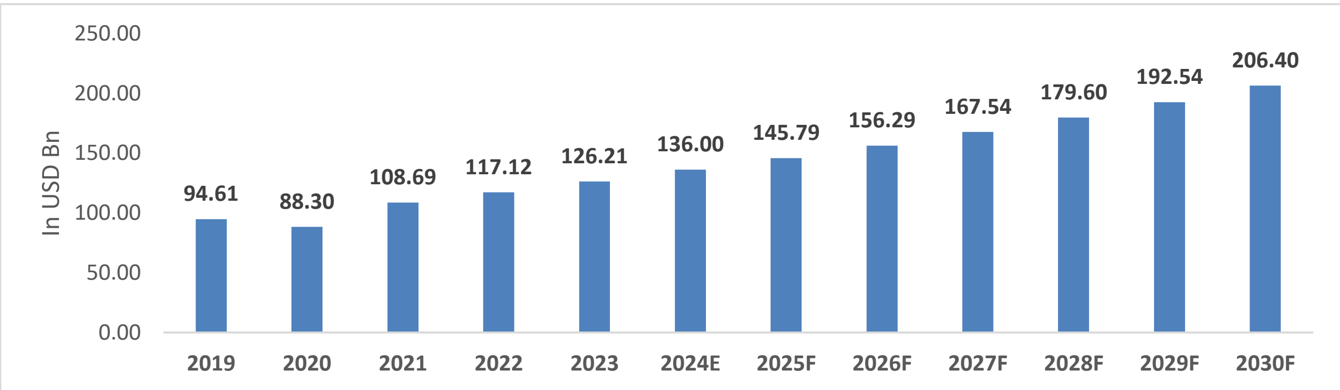
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global Wind Turbine Market was valued at **USD 140.42 Bn in 2023 and** is projected to grow at a **CAGR of 7.5% from 2023 to 2030 driven by favorable regulatory norms and NetZero emissions targets set by different countries.**
- A total of **23,833** wind turbines were installed globally in 2023 manufactured by **30 different companies**. Main contributing companies were from Asia Pacific (19), Europe (8), America (2) and Middle East (1).
- Goldwind installed 16.7 GW in 2023 and was positioned as the number one turbine supplier, Envision **(15.94 GW**) in second, **Vestas (12.70 GW)** at third place.
- More than 120 GW capacity of wind turbine was mechanically installed worldwide in 2023, of which 2/3rd was delivered by Chinese wind turbine suppliers.

Global Wind Turbine Components Market Trend

Exhibit 63: Global Wind Turbine Components Market Trend, USD Bn 2019-2030



Source: Frost & Sullivan Analysis

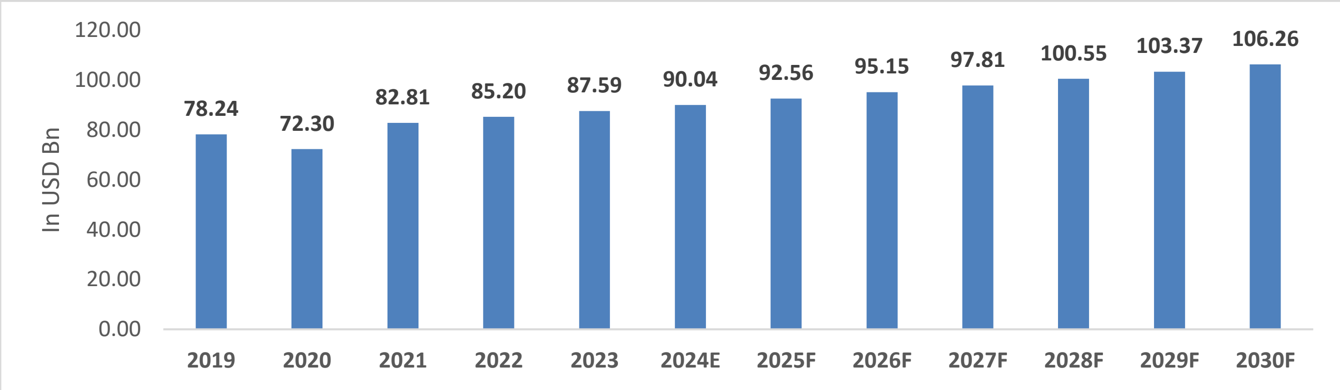
E-Estimated, F-Forecasted

- Global Wind Turbine Market was valued at **USD 126.21 Bn in 2023 and** is projected to grow at a **CAGR of 7.2% from 2023 to 2030** driven by growing demand of renewable energy, rising incentives for wind energy projects, technological advancements in turbine design and the commitment to fulfill NetZero emission targets.
- Key components of the wind turbines are **Rotor Blades, Gearbox, Generator, Nacelle and Tower**. Rotor blades account for majority of the market share.

3.1.1.3 Global Nuclear Energy

Global Nuclear Power Market

Exhibit 64: Global Nuclear Power Market Trend, USD Bn 2019-2030



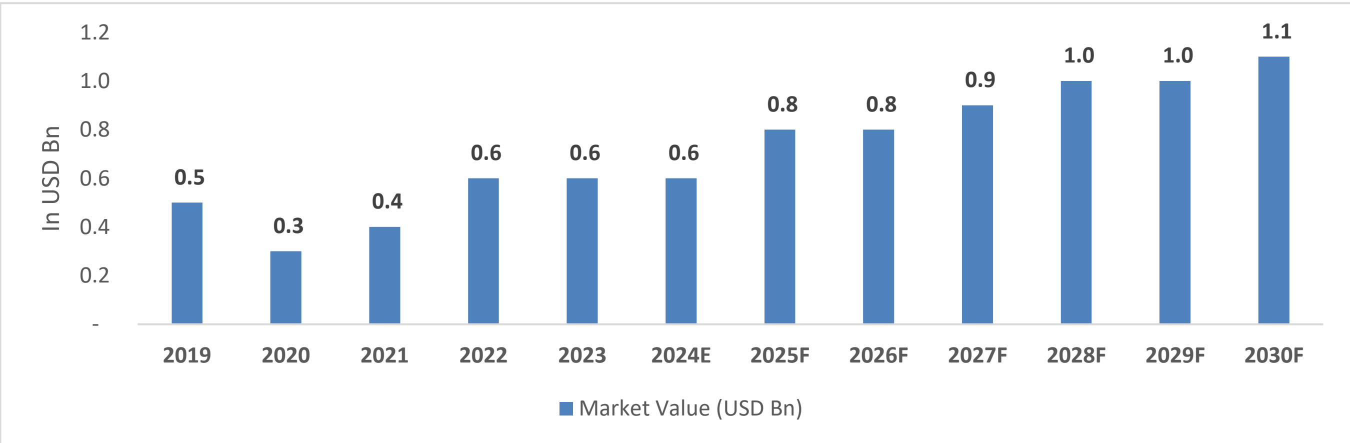
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global Nuclear Power Market was valued at **USD 87.59 Bn in 2023 and** is projected to grow at a **CAGR of 2.8% from 2023 to 2030** driven by advantage of low carbon emission energy source.

Global Overall Forging Market: Nuclear Energy 2019-2030

Exhibit 65: Global Overall Forging Market Trend, Nuclear Energy, USD Bn, 2019-30



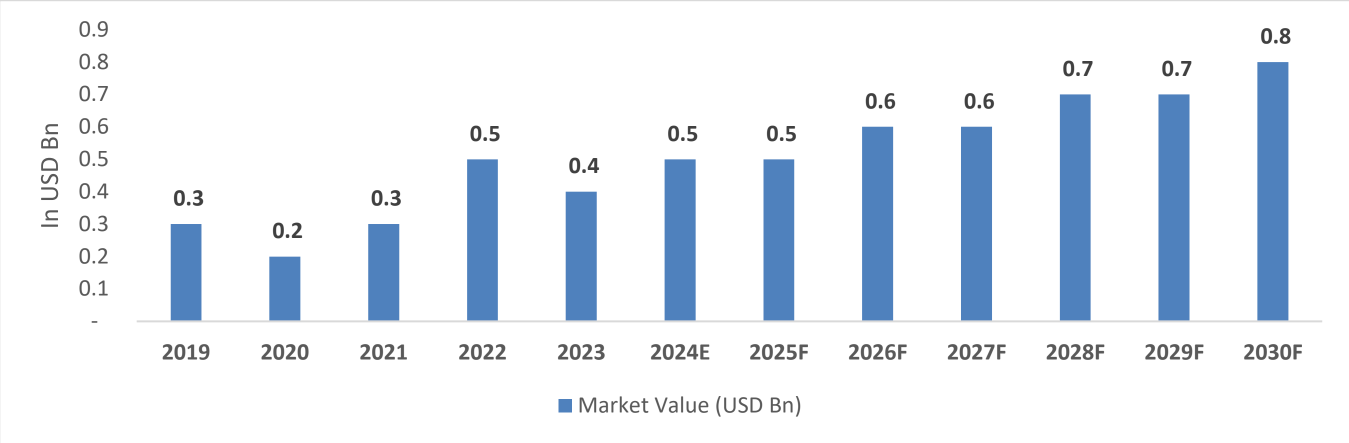
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global Overall Forging Market for Nuclear Energy was valued at **USD 0.6 Bn** in 2023 and is projected to mark **USD 1.1 Bn by 2030 with a CAGR of 8.6% from 2023 to 2030** driven by demand of raw forging and machined components such as pump and pump shafts, flanges, gears and tubes, drilling block, tees and bends, connectors, rings, transition cones and discs.

Global Precision Forged Machined Components Market: Nuclear Energy 2019-2030

Exhibit 66: Global Precision Forged Machined Components Market Trend, Nuclear Energy, USD Bn, 2019-30



Source: Frost & Sullivan Analysis

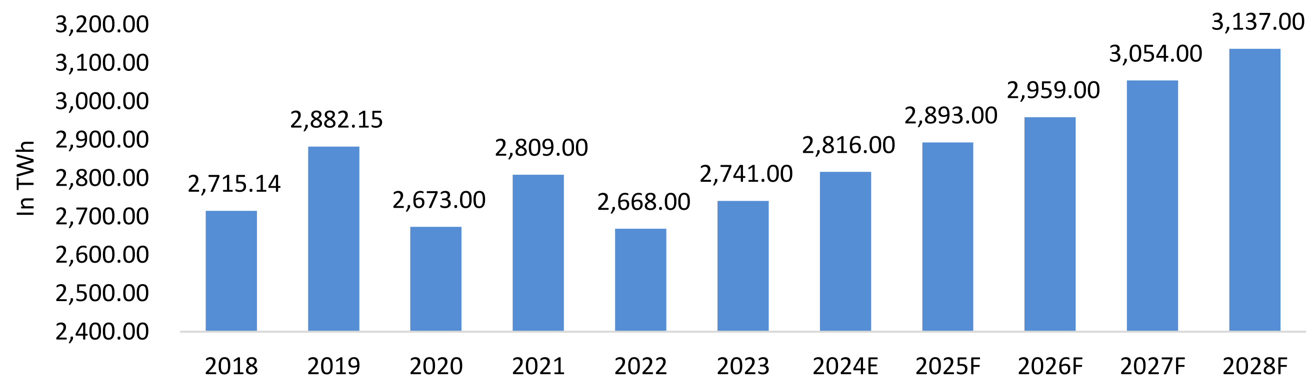
E-Estimated, F-Forecasted

- Global Precision Forged Machined Components Market for Nuclear Energy was valued at **USD 0.4 Bn** in 2023 and is projected to mark **USD 0.8 Bn by 2030 with a CAGR of 10.6% from 2023 to 2030** driven by demand of components such as pump and pump shafts, flanges, gears and tubes, drilling block, tees and bends, connectors, rings, transition cones and discs.

Global Power Generation and Capacity:

- Nuclear energy accounts to around 4% of the total installed capacity, especially as countries seek to transition towards cleaner and more sustainable energy systems to address the challenges of climate change and ensure energy security.
- Remains a key component of the global energy mix, particularly in countries like the **United States, France, China, and Russia,** which host a substantial number of nuclear reactors who rely on nuclear power to meet their electricity demands while reducing greenhouse gas emissions and mitigating climate change

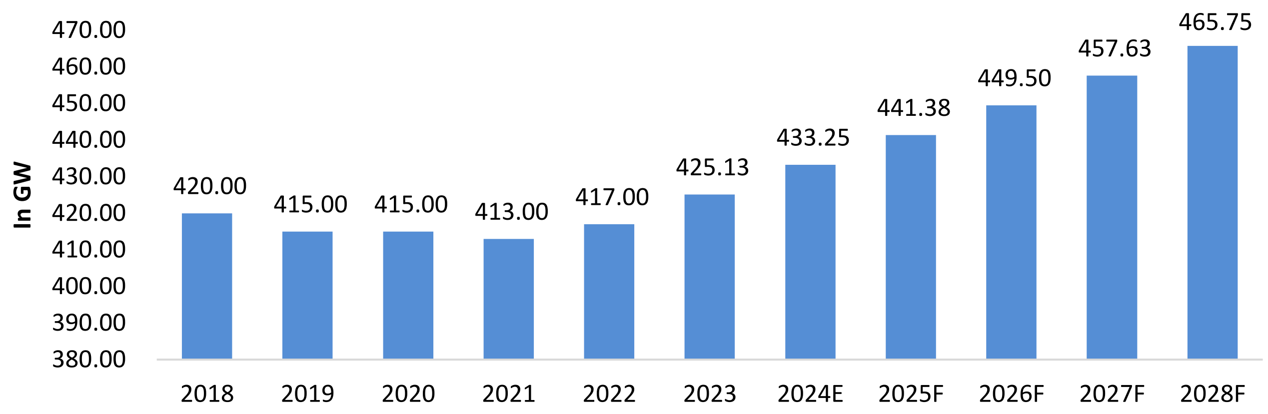
Exhibit 67: Global Power Generation-Nuclear (In Twh), 2018- 2028F



Source: iea.org

E-Estimated, F-Forecasted

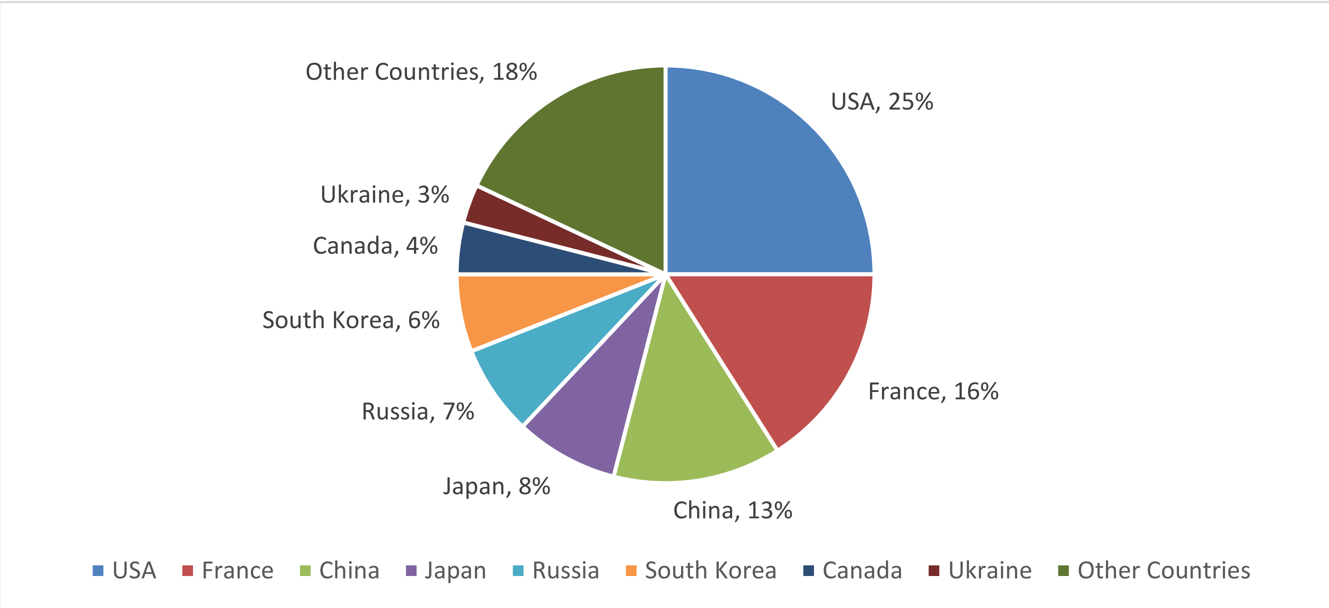
Exhibit 68: Global Power Capacity-Nuclear (In GW),2018- 2028F



Source: iea.org

E-Estimated, F-Forecasted

Exhibit 69: Global Nuclear Power Generation Capacity by Country, 2022



Source: IAEA Report,2022

- There were **440** nuclear reactors in operation globally in 2023 with USA leading with 94 reactors, followed by China (58), **France (56), Russia (36), Japan (33), South Korea (26) and India (23)** are among the key nations.
- **Approximately one hundred nuclear plants** are currently in the planning stages across fifteen countries, set to provide a total capacity of **102 GW.**
- **USA** has the highest installed capacity that amounts to **25%** of the global nuclear capacity, followed by **France and China at 16% and 13% respectively**, out of which **US and France's** reactors are nearing end of their useful life.
- **China** has the largest number of young power plants that are currently operating accounts for **45%** of this overall addition, planning to increase its capacity by **49 GW.**
- **Russia and India** have 25 and 12 reactors, respectively, in the pipeline.

Exhibit 70: Nuclear Capacity Panned by Countries.

Country	No. of Reactors	Capacity (MW)
China	45	49,810
Russia	25	23,525
India	12	8,400
USA	3	2,550
Hungary	2	2,400
Romania	2	1,440
United Kingdom	2	3,340
Uzbekistan	2	2,400
Others*	7	8,162
World	**100**	**1,02,027**

Source: World Nuclear Association

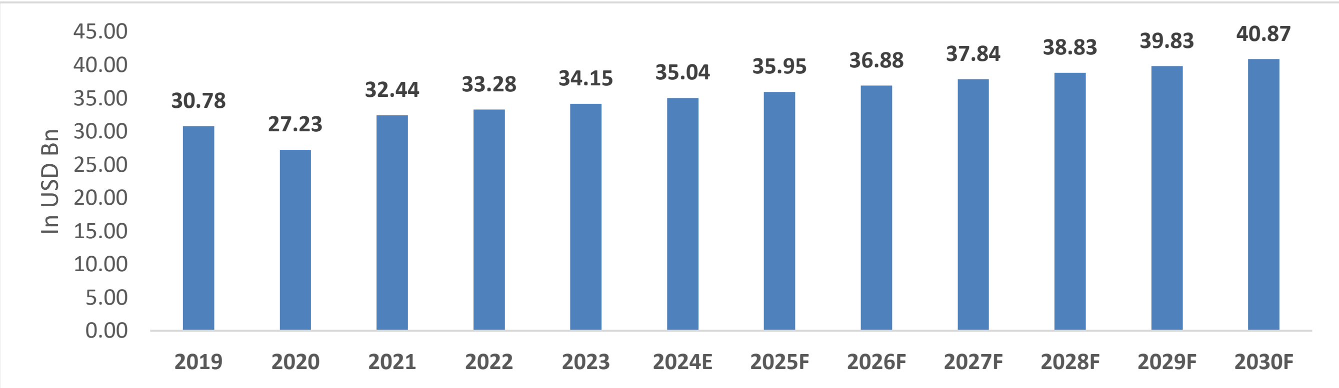
Others includes Argentina, Bulgaria, Czech, Egypt, Iran, Japan and Pakistan, each planning 1 reactor*

Global Trends in Nuclear:

- **Over +168 nuclear plants** in Europe and another **10 are under construction.** France generates around 62.6% of the global electricity generated from nuclear power source. Europe remains divided on the topic of power generation from nuclear sources.
- **Germany, Lithuania and Italy** have completely phased out nuclear based power generation. Few countries, particularly those seeking to reduce reliance on fossil fuels and meet climate targets, are reevaluating their stance on nuclear power.

Global Nuclear Power Equipment Market

Exhibit 71: Global Nuclear Power Equipment Market Trend, USD Bn 2019-2030



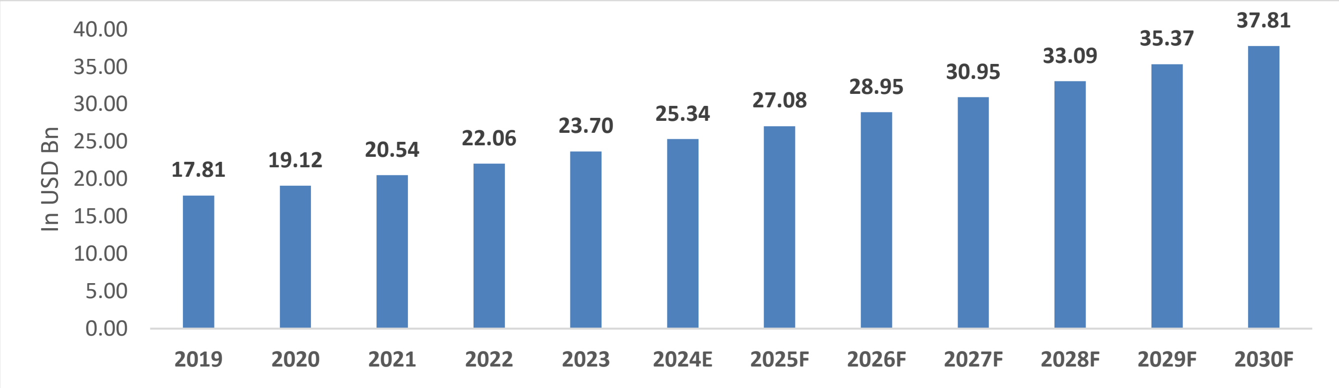
Source: Industry Report

E-Estimated, F-Forecasted

- Global Nuclear Power Equipment Market was valued at **USD 34.15 Bn in 2023 and** is projected to grow at a **CAGR of 2.6% from 2023 to 2030** driven by rising energy demand production of clean electricity.

Global Cryogenic Equipment Market

Exhibit 72: Global Cryogenic Equipment Market Trend, USD Bn 2019-2030



Source: Industry Report

E-Estimated, F-Forecasted

- Global Cryogenic Equipment Market was valued at **USD 23.70 Bn in 2023 and** is projected to grow at a **CAGR of 6.9 % from 2024 to 2030** driven by its unique properties of cryogenic technology for metallurgy and in automotive segments.
- Cryogenic Equipment are used for **Storage and Distribution applications. The storage application segment led the market and accounted for a share of 56.3% in 2023 while distribution applications witnessed 43.7% share.**
- Globally, the metallurgy sector is seeing a sharp increase in demand for cryogenic equipment, which is essential for enabling advanced processing methods.
- In metallurgical applications, cryogenic equipment is essential, especially when it comes to treating and working with metals at very low temperatures.
- The demand for cryogenic equipment market is driven by increasing demand for natural gas and the expanding energy industry. As more countries shift towards cleaner energy sources, the need for liquefied natural gas is rising, which in turn requires extensive cryogenic equipment for storage and transportation.

3.1.2 Energy India Overview

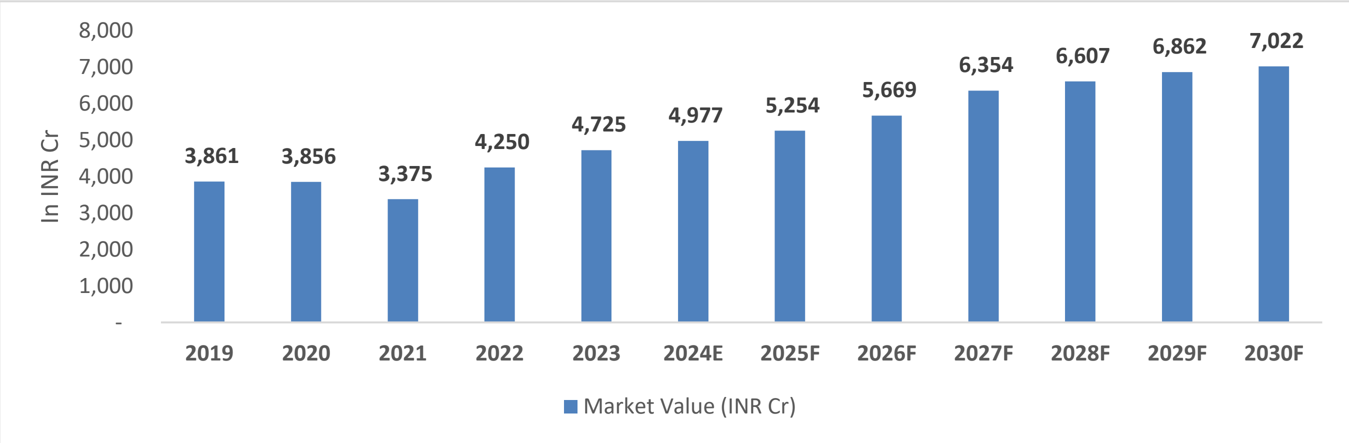
3.1.2.1 Energy:

- The Demand for Energy in India is mostly met by fossil fuels where in Coal accounts for **55.1%,** Crude Oil **27.6%, Renewables 5.9%, Natural Gas 5.7%, Hydroelectricity 4.5% and nuclear energy 1.2%.**
- **The increasing adoption of nuclear power** as an alternative to conventional energy sources further contributes to expanding the forging industry.
- Overall Forging market for Energy sector was valued at **INR 6,381 Crores in FY 24** which accounts for **34%** of the total non-automotive forging demand in India.
- The demand of forgings in Energy sector is projected to grow at a **CAGR of 5.9%** from **FY 2024 to 2030**.
- Forged products such as **Valve body, Gates, Studded Tee, Crosses, Rings, Slip Bowls, Bonnets, Body, Housing, Gates, Square Block, Cross, Studded Tees, Valve Casing, Y Block, Flanges, Tube Sheet and Clad Body Valves** will experience a boost with the growth of Energy sector in India.
- The Nuclear power industry extensively on forged metal parts for various critical applications such as **reactors, nuclear waste storage and transportation** of raw materials and waste.

- **Precision Forged components** are crucial in manufacturing of pressure vessels due to their ability to withstand high temperature and pressures. The utilization of forged parts in machines within the nuclear power segment which operates under extreme conditions is a significant driver of growth in the forged market.

India Overall Forging Market: Energy, FY 2019-2030

Exhibit 73: India Overall Forging Market Trend, Energy, INR Cr, FY 2019-30



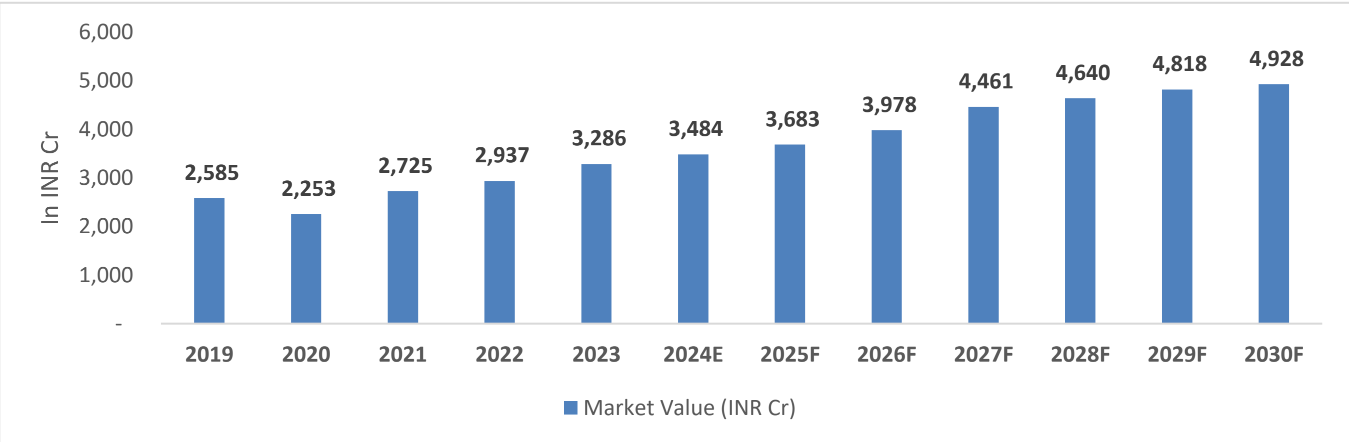
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Indian Overall forging Market for Energy was valued at **INR 4,977 Crores in FY 2024** and is projected to mark **INR 7,022 Crores by 2030** with a **CAGR of 5.9% from FY 2024 to 2030 driven by demand of raw forgings and forged machined components from the Oil and Gas, Renewables and Nuclear Energy segments.**

India Precision Forged Machined Components Market: Energy, FY 2019-2030

Exhibit 74: India Precision Forged Machined Components Market Trend, Energy, INR Cr, FY 2019-30



Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

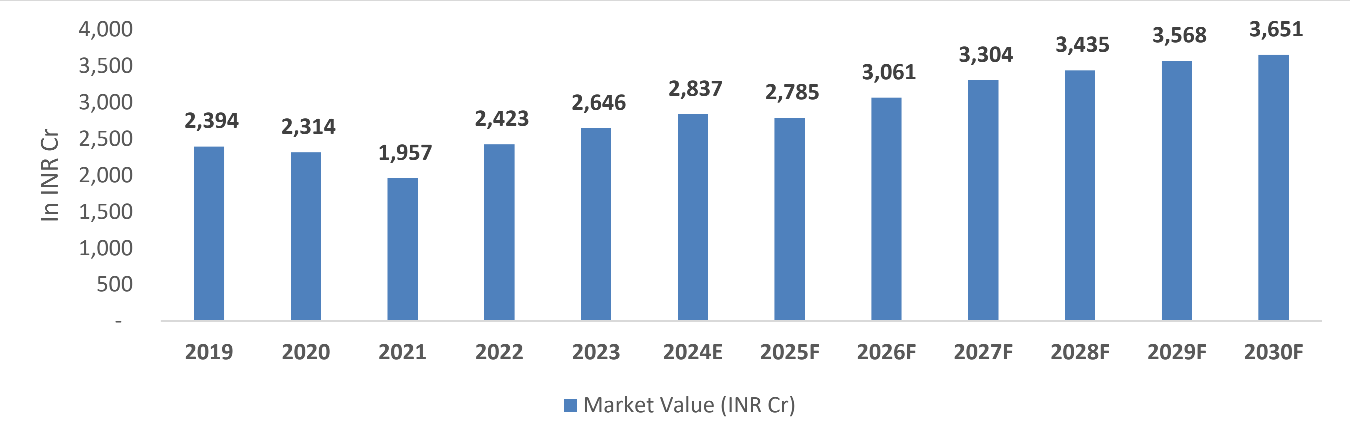
- Indian Precision Forged Machined Components Market for Energy was valued at **INR 3,484 Crores in FY 2024** and is projected to mark INR 4,928 Crores **by 2030** with a **CAGR of 5.9% from FY 2024 to 2030 driven by growth of precision forged machined components demand from the Oil and Gas, Renewables and Nuclear Energy segments.**

3.1.2.2 Oil and Gas

- India is the world's 3rd largest oil importer and consumer.
- India's economic growth is closely related to its energy demand, it retained its spot as **the third-largest consumer** of oil in the world as of 2023.
- India has set a target to raise the share of natural gas in the energy mix to **15% by 2030 from about 5.7%** now. India is expected to be the largest driver of global oil demand between 2024 to 2030 taking a lead from top importer China.
- The Government has allowed **100%** foreign direct investment (FDI) in natural gas, petroleum products and refineries.

India Overall Forging Market: Oil and Gas, FY 2019-2030

Exhibit 75: India Overall Forging Market Trend, Oil and Gas, INR Cr, FY 2019-30



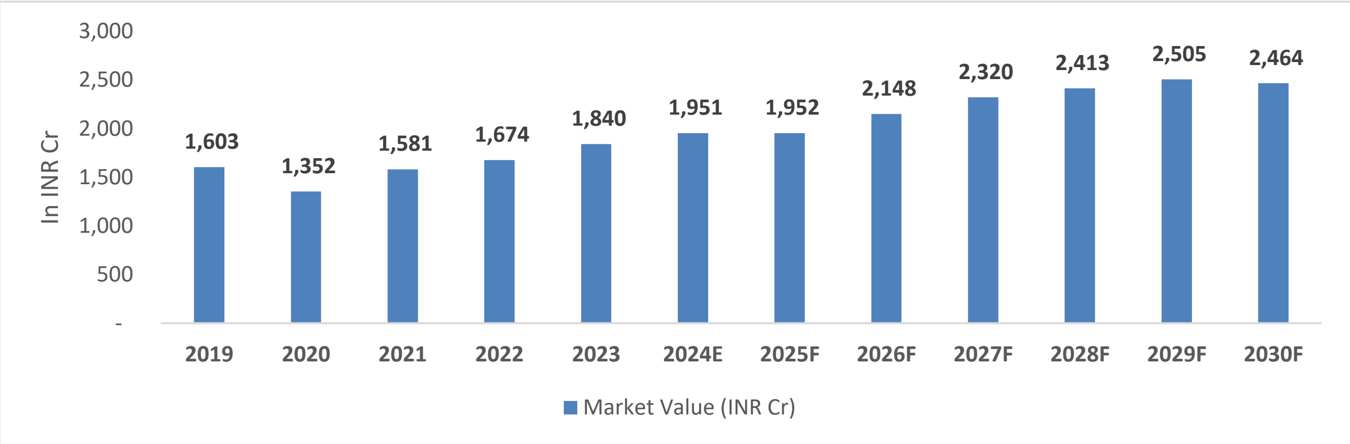
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Indian Overall Forging Market for Oil and Gas was valued at **INR 2,837 Crores in FY 2024** and is projected to mark **INR 3,651 Crores by 2030 with a CAGR of 4.3% from FY 2024 to 2030** driven by growth in demand of raw forgings and machined components such as flanges, bonnet forgings, valve bodies, stems and impellers.

India Precision Forged Machined Components Market: Oil and Gas, FY 2019-2030

Exhibit 76: India Precision Forged Machined Components Market Trend, Oil and Gas, INR Cr, FY 2019-30

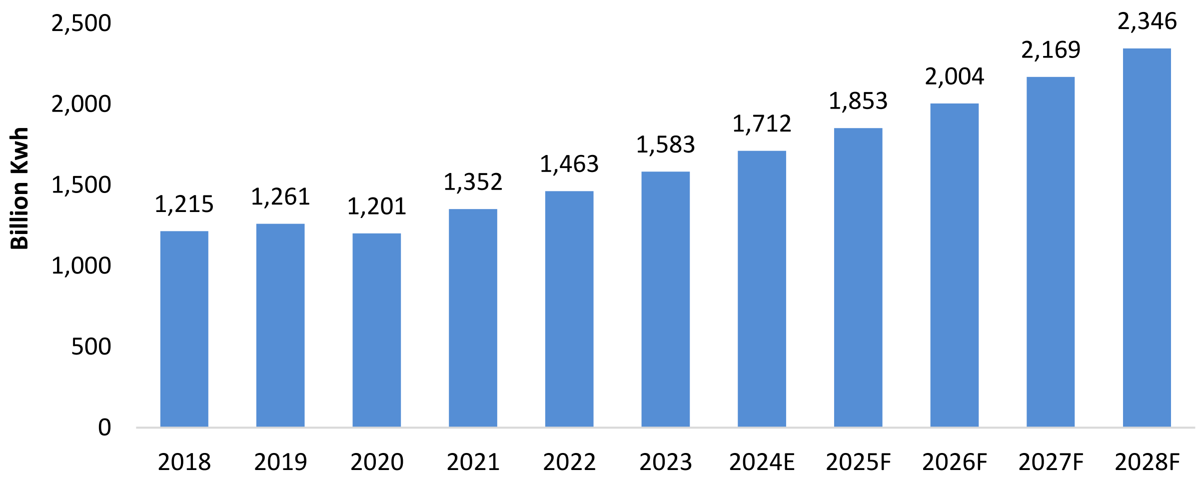


Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Indian Precision Forged Machined Components Market for **Oil and Gas was valued at INR 1,951 Crores** in FY 2024 and is projected to mark **INR 2,464 Crores by 2030** with a **CAGR of 4%** from FY 2024 to 2030 driven by growth in demand of components such as flanges, bonnet forgings, valve bodies, stems and impellers.

Exhibit 77: India's Power Consumption, FY 2018-FY 2028F

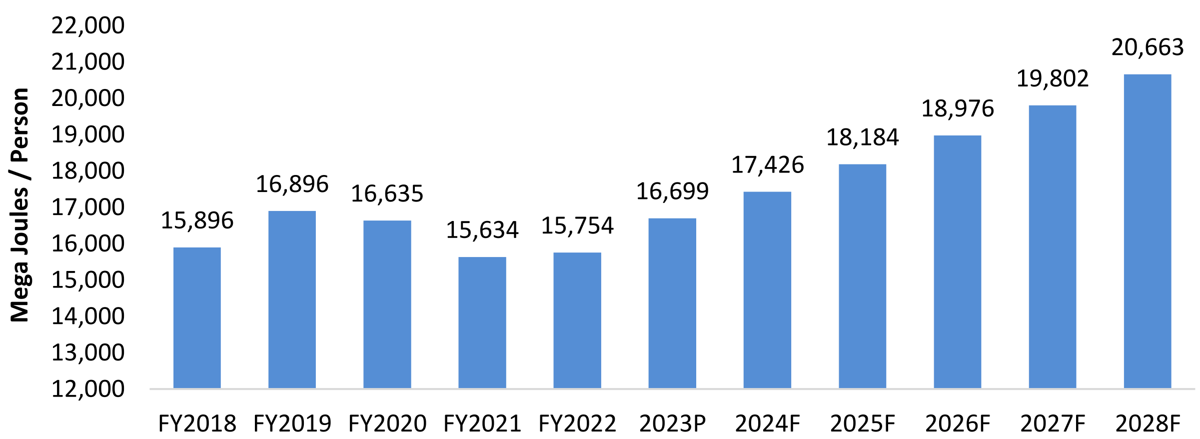


Source: EIA, Electricity Data, India

E-Estimated, F-Forecasted

- India's power consumption is on a steep climb, fueled by a booming economy, rising living standards, and rapid urbanization. The Indian power consumption has increased from **1,215.00 billion Kwh in 2018 to 1,582.81 billion Kwh in 2023 and is expected to further grow to 2,346.16 billion Kwh by 2028F.**

Exhibit 78: India's Per Capita Power Consumption



Source: Energy Statistics India Publication,2024

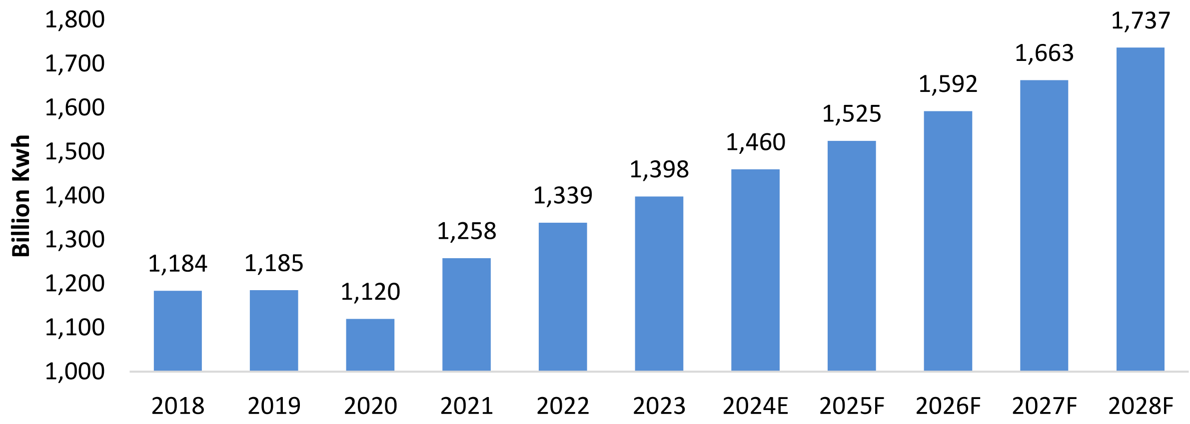
E-Estimated, F-Forecasted

Indian Per capita power consumption

- The average electricity consumption per person was around **16,896.00 Mega Joules/ Person in FY2019**, which was the highest in the Pre COVID period. However, this reduced to 15,634.00 Mega Joules/ Person in FY2021.

India Power Generation and Capacity- Fossil Fuel (2018-2028F)

Exhibit 79: India Power Generation-Fossil fuel (Billion Kwh) 2018-2028F



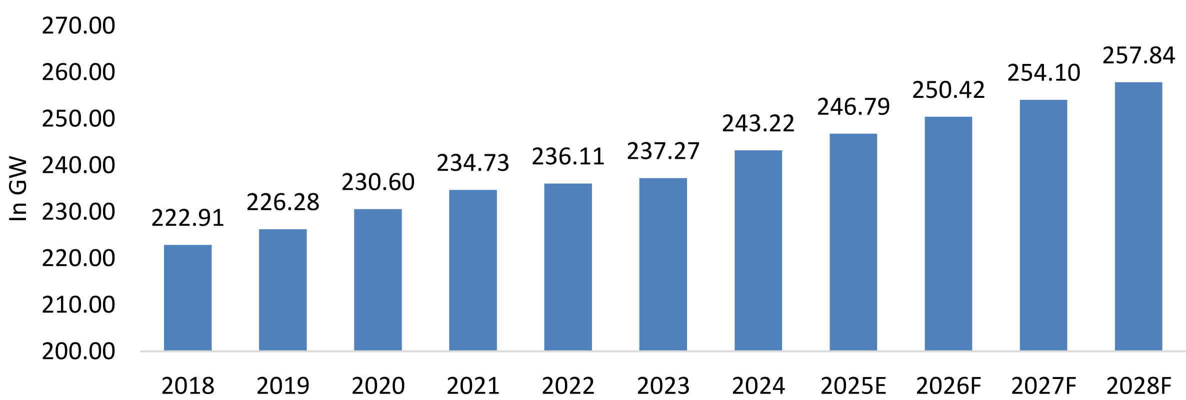
Source: Energy Information Administration, India

E-Estimated, F-Forecasted

India Power Generation-Fossil Fuel

- India relies heavily on Thermal generation, the other fossil fuels which are used are natural gas, lignite and diesel.
- As of 2023, fossil fuels constituted **approximately 76.1% of the nation's electricity generation**, a reduction from 79.5% in 2018, due to the increased focus on renewable based electricity generation sources.
- Despite coal's abundance and domestic availability, it poses significant environmental challenges of greenhouse gases, exacerbating air quality and climate change issues.
- The power generation in India from fossil fuel was 1,398.30 billion Kwh in 2023 and this is expected to grow to **1,736.62 billion Kwh in 2028F**. The government aims to augment the proportion of cleaner energy sources like solar and wind in the energy matrix. However, due to their cost-effectiveness and established infrastructure, fossil fuels are anticipated to remain the primary source of power generation in India during the forecast period.

Exhibit 80: India Power Capacity-Fossil Fuel (Million Kwh) 2018- 2028F



Source: Central Electricity Authority, Installed Capacity Report

E-Estimated, F-Forecasted

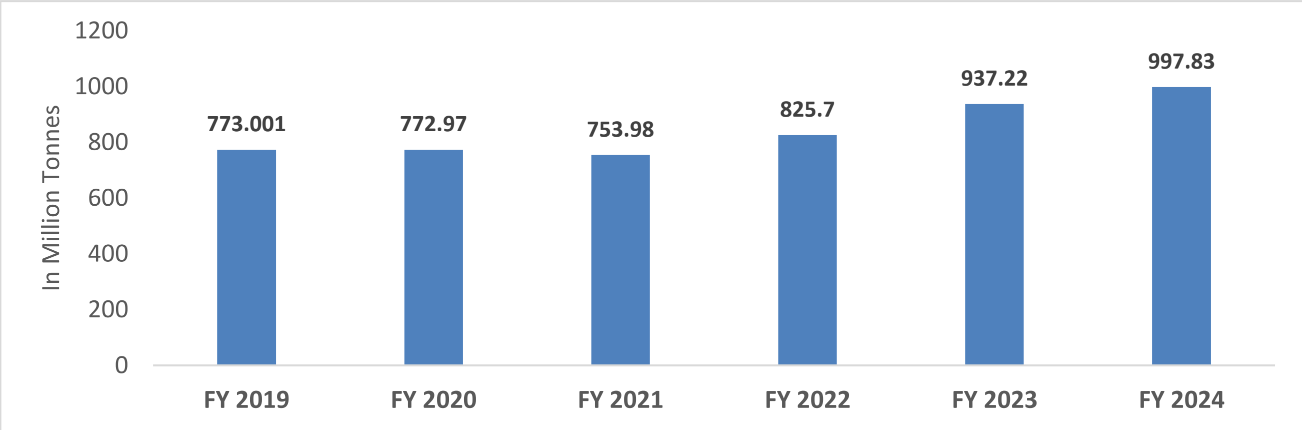
India Power Capacity-Fossil Fuel:

- Coal contributes **55% of** the total capacity. Despite being abundant and reliable, these sources pose environmental challenges, contributing to pollution and climate change.

- The capacity of fossil fuels is expected to increase from **243.22 GW in 2024 to 257.84 GW in 2028F** at a **CAGR of 1.47%.** Despite environmental apprehensions, coal continues to be favored for its affordability and domestic abundance.
- Initiatives to incorporate cleaner options like solar and wind are progressing, but fossil fuels are poised to retain their prominence in India's energy generation due to established infrastructure and economic viability.

Coal Production Trend in India (in Million Tonnes), FY 2019-24

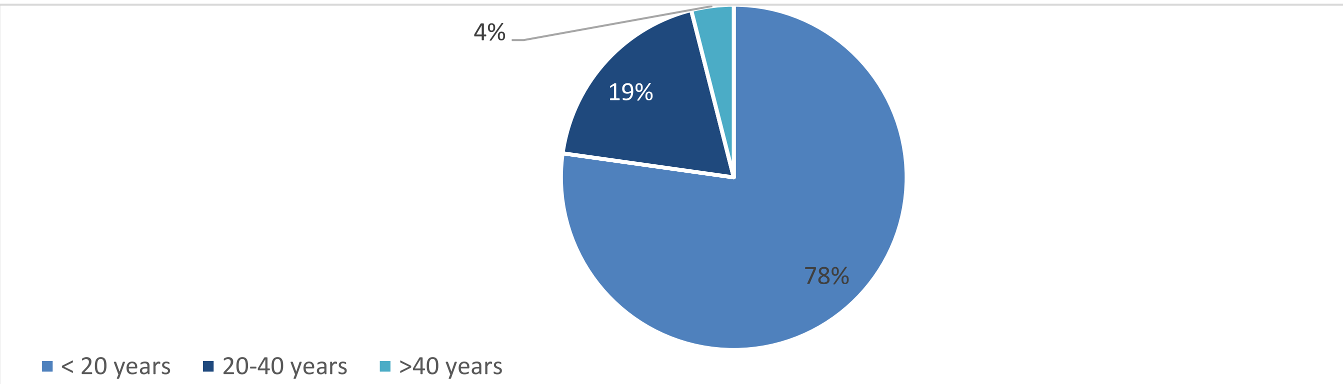
Exhibit 81: Coal Production Trend, India FY 2019-24



Source: NITI Aayog, India Climate & Energy Dashboard

- Coal production of India marked **997.83 million tonnes in FY 2024** which is highest of all times and the production has grown with a **CAGR of 5.2% from FY 2019 to FY 2024**, this accounted for 14% of global demand, second after China, which accounted for **54% of global coal consumption**.
- **Coal India** is the major producer of Coal in India which produced ~**78% of** the total coal production in India. India is dependent on electricity generated from coal-based power plants. To meet the growing demand, a greater number of coal blocks need to explore and mined which generates the demand of machineries and eventually the demand for forged products will increase.
- **The Ministry of Coal has planned 45 new coal mines in five years** Allocated **175 coal blocks** of which 65 received mine opening permissions out of these 54 mines are currently operational, contributing to India’s growing domestic coal production. Coal India Limited will develop 36 projects, Singareni Collieries Company Ltd will open seven new mines and NLC India Ltd will add two mines during this period.

Exhibit 82: Coal Power Generation Capacity in India, by Age



Source: Global Energy Monitor

Age of Coal Power Generation Capacity in India

In India similar to China, over 75% of the coal power generation capacity in India is within 20 years age group with roughly 20% of the capacity between 20 to 40 years age group.

Key companies in the oil and gas industries in India are **Oil and Natural Gas Corporation (ONGC), Gas Authority of India Limited (GAIL), Bharat Petroleum Corporation Limited (BPCL), Hindustan Petroleum Corporation Limited (HPCL).**

Exhibit 83: Key Company Insights

Country	Key Insights
ONGC	• Leading oil drilling companies in India. Drilling services account for more than 55% of ONGC's capex. • Operates 105 drilling and 74 work over rigs. • There has been a major progress in terms of technology infusion introduction of Under-Balanced Drilling, use of Advanced Hybrid Bits, resource optimization through Batch Drilling in Offshore & Pad Drilling in Onshore.
GAIL	• Owns and operates a network of around 16,240 km of natural gas pipelines spread across the length and breadth of country. It is also working concurrently on execution of multiple pipeline projects to further enhance the spread. • Commands 66% market share in gas transmission and has a Gas trading share of over 54% in India. GAIL and its Subsidiaries, JVs also have a formidable market share in City Gas Distribution. In the Liquefied Natural Gas (LNG) market, GAIL has significantly large portfolio. • Pioneer in using gas for producing petrochemicals and has an integrated 810 KTPA gas based petrochemical complex in Uttar Pradesh.
BPCL	• India's second-largest government-owned downstream oil producer. The firm develops strategic pipeline networks connecting refineries to key markets. • Mumbai refinery's access to Northern markets via pipelines to Kota, Mathura, Piyala • Bina refinery's connection to key markets via Bina-Kota-MMPL & Bina-Kanpur pipelines • Kochi refinery's access to TN market via pipeline to Karur • They have significantly reduced logistics cost due to pipeline network.
HPCL	• Engaged in the business of refining Crude Oil and marketing of various petroleum products like Asphalt, Diesel, Kerosene, LPG, Lube Oils, Petrol, branded products like ATF (Aviation Turbine Fuel), Power, Turbojet, Naphtha, throughout India and at select foreign countries. • HPCL owns and operates two refineries situated at Mumbai (West coast of India) and Visakhapatnam (East Coast of India).

Source: Company Websites

India's Gas Energy Industry

- As more development initiatives are carried out, India's electricity requirements continue to rise. The nation's gas power capacity, which comprises both natural gas and LNG-based power plants, is essential to its energy landscape. Natural gas is the main fuel used by these facilities, and they have a number of advantages for the environment over coal and oil, including reduced emissions and increased efficiency. These gas-based power plants are a good fit for the nation's peak load requirements and renewable energy mix.

Exhibit 84: Gas Reserves in India (in billion cubic meters), FY 19-23

`				
FY19	**FY20**	**FY21**	**FY22**	**FY23**
1384.04	1373.56	1372.37	1149.45	1141.74

Source: NITI Aayog, India Climate & Energy Dashboard

India's gas reserves are quite small, and no significant discoveries have been made in the past five years.

Exhibit 85: Natural Gas Production in India (in billion cubic meters), FY 19-23

Natural Gas Production in India (in billion cubic meters)				
FY19	**FY20**	**FY21**	**FY22**	**FY23**
32.87	31.18	28.67	34.02	34.45

Source: IPNG Statistics Report 2022-23

Natural Gas production during the year 2022-23 stood at 34.45 billion Cubic Meters (BCM) which is 1.5% higher than production of 34.02 BCM in 2021-22.

LNG Terminal and Plans for Gas Production

- LNG is crucial to India's energy mix with the ever-increasing demand of the country & need to reduce carbon emissions. Plan of developing LNG terminals in India along with formulation of plans for gas production has been in the forefront with increased need to diversify energy sources & promotion of sustainability. India has made considerable progress in establishing LNG terminals along its coastline, facilitating the import and distribution of LNG across the country. Some notable LNG terminals in India include:

Exhibit 86: Operational LNG Terminal in India, As of March 2023

Terminal Location	Promoters	Capacity (MMTPA)	Capacity Utilization (%)
Dahej, Gujarat	Petronet LNG Ltd (PLL)	17.5	78
Kochi, Kerala	Petronet LNG Ltd (PLL)	5	19
Hazira, Gujarat	Hazira LNG Pvt Ltd (HLPL)	5.2	37
Dabhol, Maharashtra	Ratnagiri Gas and Power Pvt. Ltd. (RGPPL- JV of GAIL & NTPC)	5	39
Ennore, Tamil Nadu	Indian Oil LNG Pvt. Ltd. (IOLPL)	5	13
Mundra, Gujarat	GSPC LNG Ltd (GLL)	5	16

Source: IPNG Statistics Report 2022-23

Exhibit 87: Planned/Under Construction LNG Terminals

Terminal Location	Promoters	Capacity (MMTPA)
Dhumra, Odisha	Adani LNG Pvt Ltd	5
Dabhi Expansion	GAIL (KLPL)	3
Jaigarh, Maharashtra	H-Energy	4
Jafrabad, Gujarat	Swan Energy	5
Chhara, Gujarat	HSEPL	5
Proposed Total Capacity		**22 MMTA**

Source: IPNG Statistics Report 2022-23

India's Gas Power Generation Capacity

- In recent years, India has witnessed a surge in gas power capacity additions with existing gas-based power plants being modernized and new projects being initiated to enhance the country's energy infrastructure. Notable projects include the expansion of existing LNG terminals, the establishment of new regasification facilities, and the introduction of advanced gas turbine technology for improved efficiency.

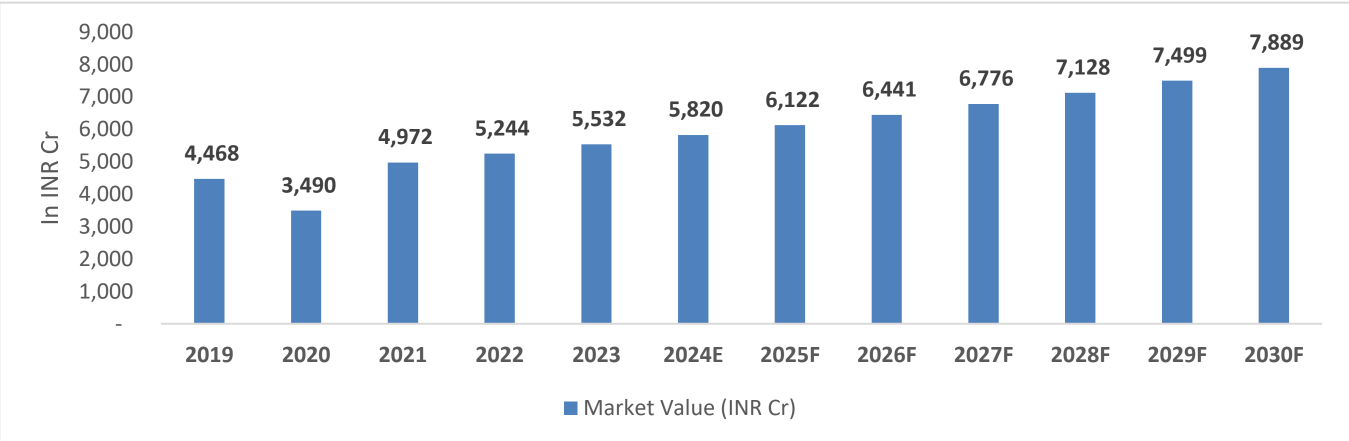
Exhibit 88: Planned/Under Construction LNG Terminals

Region	Sector	Capacity in MW
ALL INDIA	State	7,012.6
	Private	10,568.24
	Central	7,237.91
	Total	**24,818.21**

Source: CEA Installed Capacity Report, CT 2024

India Oil and Gas Valves Market Trend, FY 2019-2030

Exhibit 89: Market Trend, Oil and Gas Valves, India, INR Cr, FY 2019-30



Source: Frost & Sullivan Analysis

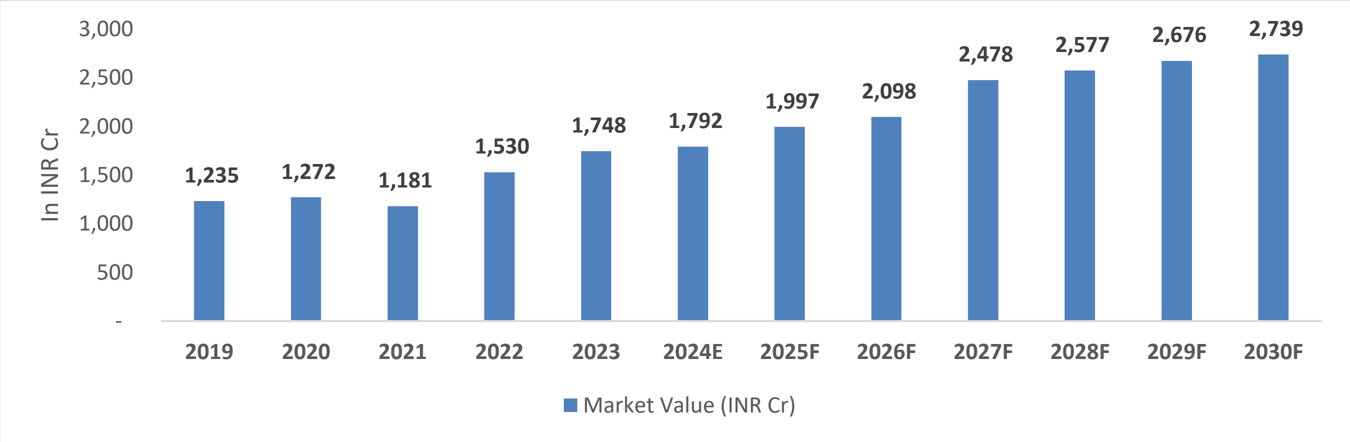
E-Estimated, F-Forecasted

- Oil and Gas Valve market was valued at **INR 5,820 Crores in FY 2024** and is projected to mark **INR 7,889 Crores by 2030** with a **CAGR of 5.2% from FY 2024 to 2030** driven by increasing population, urbanization, increase in energy demand and technological advancement for more efficient valves.

3.1.2.3 India Renewable Energy

India Overall Forging Market: Renewables, FY 2019-2030

Exhibit 90: India Overall Forging Market Trend, Renewables, INR Cr, FY 2019-30



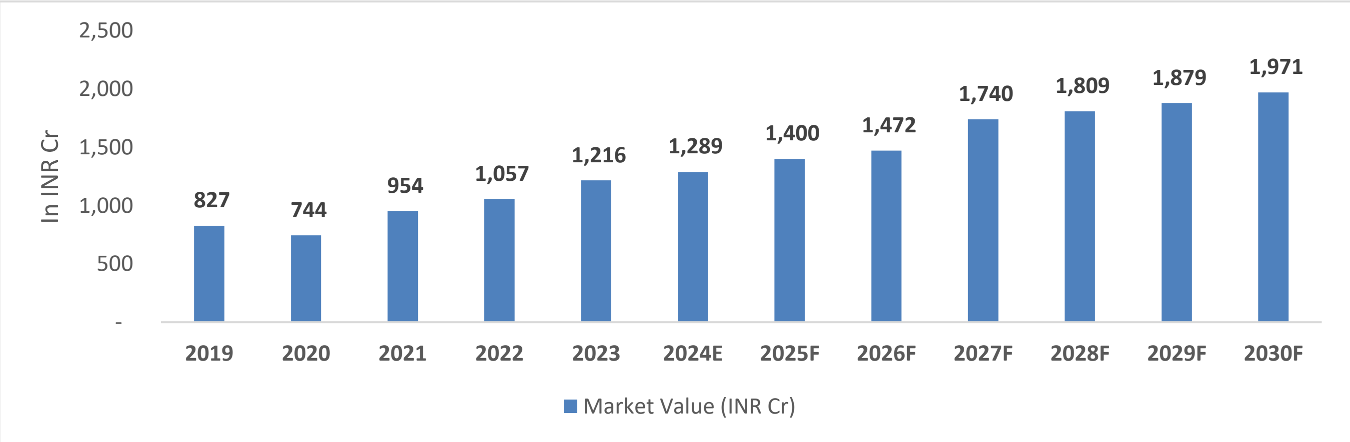
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Indian Overall Forging Market for Renewables was valued at **INR 1,792 Crores in FY 2024** and is projected to mark **INR 2,739 Crores by 2030** with a CAGR of **7.3% from FY 2024 to 2030** driven by growth in demand of raw forgings and precision forged machined components from wind segment, solar and other segments.

India Precision Forged Machined Components Market: Renewables, FY 2019-2030

Exhibit 91: India Precision Forged Machined Components Market Trend, Renewables, INR Cr, FY 2019-30



Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Indian Precision Forged Machined Components Market for Renewables was valued at **INR 1,289 Crores in FY 2024** and is projected to mark **INR 1,971 Crores by 2030** with a **CAGR of 7.3% from FY 2024 to 2030** driven by growth in demand of precision forged machined components from wind segment.

India Power Generation-Renewable:

- **Renewable sources** have increased from 267.65 billion Kwh in 2018 to 391.88 billion Kwh in 2023.
- India is exploring emerging technologies such as tidal and geothermal energy to further diversify its renewable energy sources.

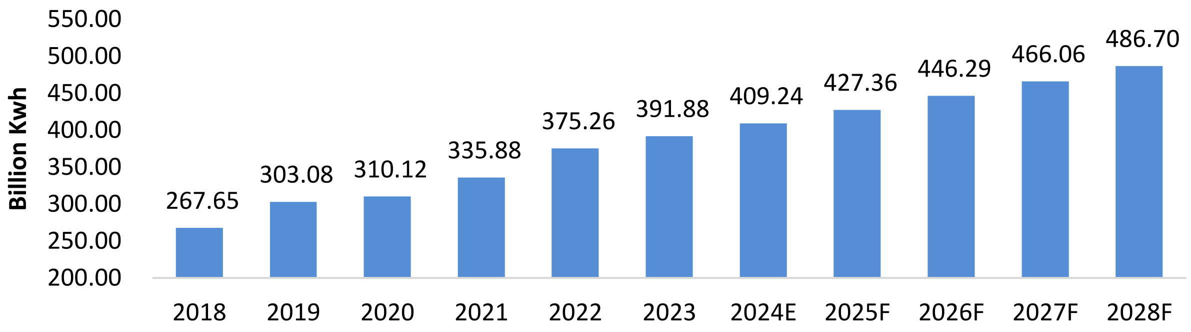
- India's commitment to renewable energy remains unwavering, as it strives to achieve its targets for clean, affordable, and accessible electricity for all while mitigating the impacts of climate change. The overall power generation from renewable sources is expected to reach **486.70 billion Kwh in 2028.**

- Government's targets for solar power installation have been driving growth in the sector, supported by favorable policies and incentives.

- **Wind energy** contributes substantially to India's renewable energy mix, with wind farms dotting the landscape in states with favorable wind conditions.

- **Hydropower** plays a crucial role in India's renewable energy portfolio, leveraging the country's rivers and water resources for clean electricity generation.

Exhibit 92: India Power Generation Renewable (Billion Kwh) 2018-2028F



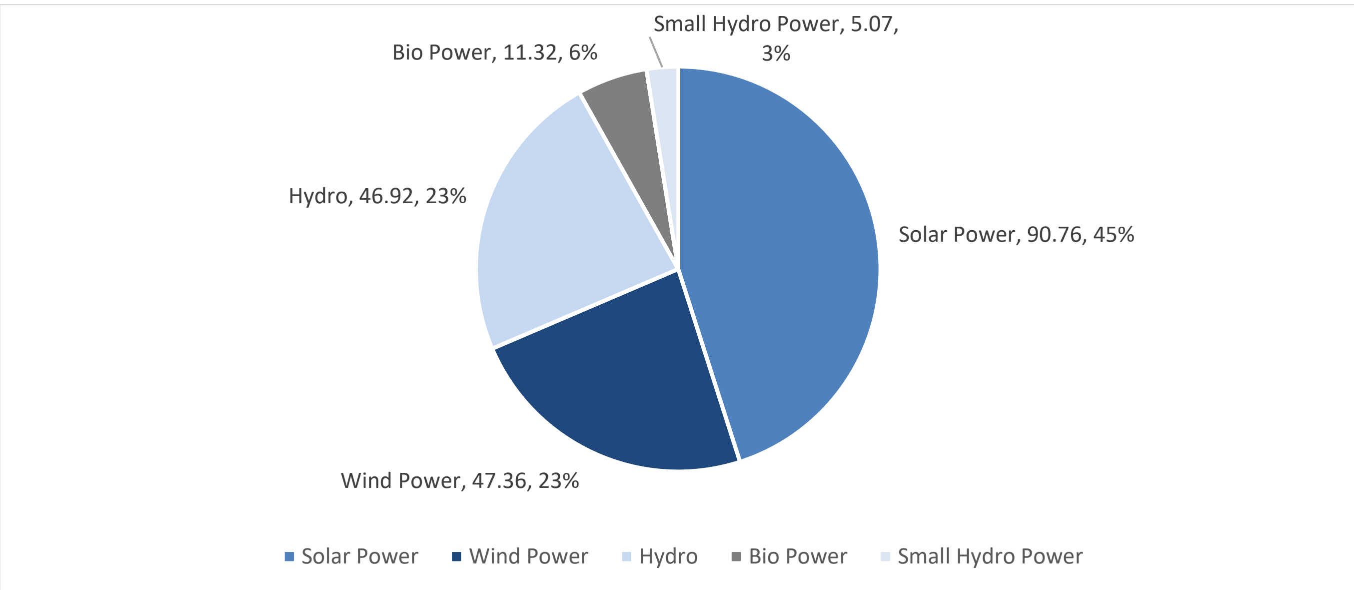
Source: MoSPI, Energy Statistics India Publication 2024

E-Estimated, F-Forecasted

India Power Capacity- Renewable

- As of Oct 2024, renewable energy-based electricity generation capacity stands at **201.43 GW accounting for 46.3% of the country's total installed capacity.**
- India’s total electricity generation capacity has reached **452.59 GW,** with renewable energy contributing a significant portion of the overall power mix.

Exhibit 93: India Renewable Energy Capacity Mix (GW), As of October 2024



Source: National Power Portal

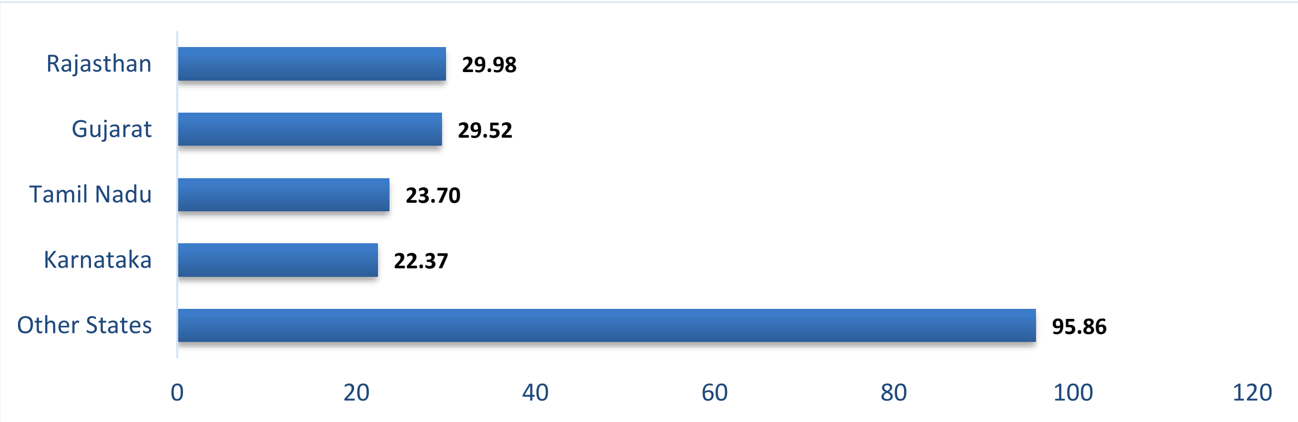
- **Solar Energy leads the renewable energy segment** in India currently with 90.76 GW (45%) playing a crucial role in India's efforts to harness its abundant sunlight. **Wind power follows closely with 47.36 GW (23%),** driven by the vast potential of the coastal and inland wind corridors across the country.

- **Hydroelectric power is another key contributor**, with large hydro projects generating 46.92 GW (23%) and small hydro power adding 5.07 GW (3%), offering a reliable and sustainable source of energy from India's rivers and water systems. Biopower, including biomass and biogas energy, adds another 11.32 GW (6%) to the renewable energy mix.

Leading States in Renewable Energy Capacity

- **Rajasthan** tops the list with 29.98 GW of installed renewable energy capacity, benefiting from its vast land and abundant sunlight. Gujarat with a capacity of **29.52 GW driven by its strong focus on solar and wind energy projects.**
- **Tamil Nadu** ranks third with **23.70 GW** leveraging its favorable wind patterns to generate substantial energy. Karnataka stood at fourth with a Capacity of **22.37 GW** supported by a mix of solar and wind initiatives. These four States are driving the India's renewable Energy Capacity

Exhibit 94: Top States Driving India's Renewable Energy Capacity (GW), As of October 2024

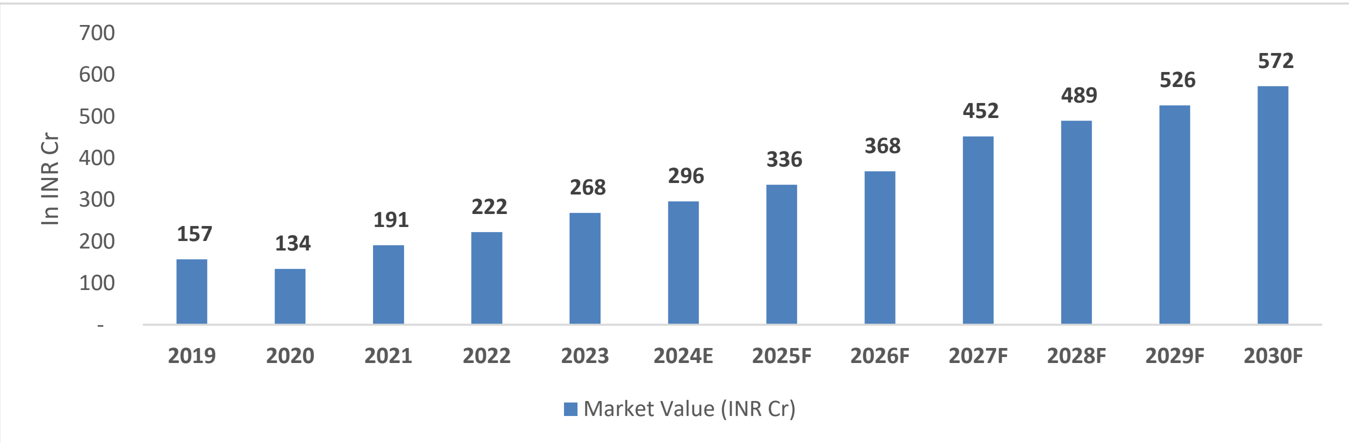


Source: National Power Portal

*Other States includes Maharashtra, Andhra Pradesh, Madhya Pradesh, Telangana, Uttar Pradesh, Punjab, Himachal Pradesh

India Precision Forged Machined Components Market: Wind Energy, FY 2019-2030

Exhibit 95: India Precision Forged Machined Components Market Trend, Wind Energy, INR Cr, FY 2019-30



Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Indian Precision Forged Machined Components Market for Wind Energy was valued at **INR 296 Crores in FY 2024** and is projected to mark **INR 572 Crores by 2030** with a **CAGR of 11.6% from FY 2024 to 2030** driven by growth in demand of precision forged machined components from wind segment such as Parts in the nacelle (gearbox, high-speed shaft, low-speed shaft and brake), the yaw drive for upwind turbines (shaft and gear) and tower components for both downwind and upwind turbines.

Key Schemes and Programs

- The Government of India has implemented a range of measures and initiatives aimed at promoting and accelerating renewable energy capacity across the nation, with an ambitious target of achieving 500 GW of installed electric capacity from non-fossil sources by 2030.
- Key programs include the National Green Hydrogen Mission, PM-KUSUM, PM Surya Ghar, and PLI schemes for solar PV modules.

National Green Hydrogen Mission

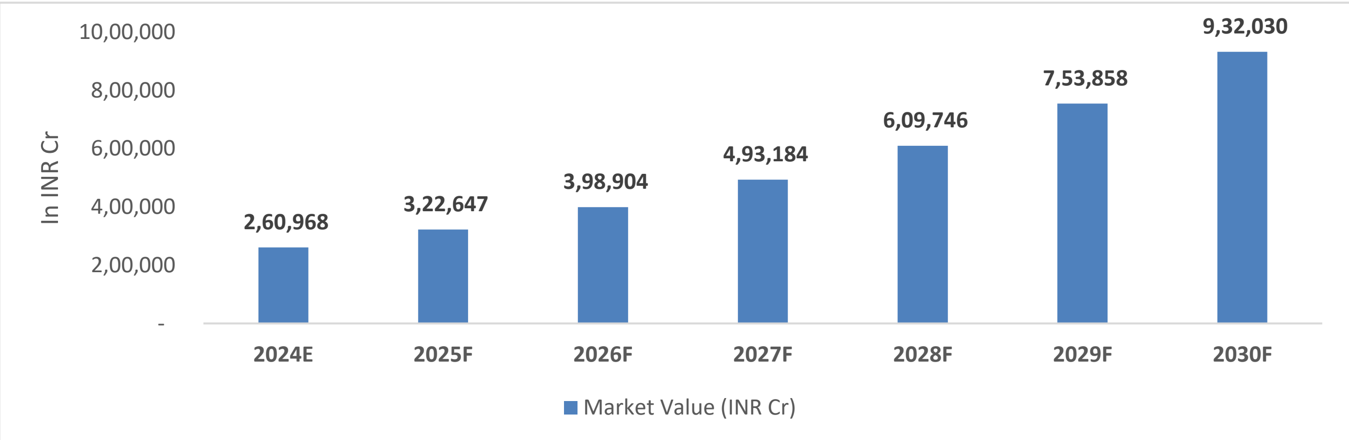
The key objective of this mission is to make India the Global Hub for production, usage and export of Green Hydrogen and its derivatives. This will contribute to India’s aim to become Aatmanirbhar through clean energy and serve as an inspiration for the global Clean Energy Transition.

- **Exports:** This mission will facilitate export opportunities through supportive policies and strategic partnerships.
- **Domestic Demand:** The Government of India will specify a minimum share of consumption of green hydrogen or its derivative products such as green ammonia and green methanol by designated consumers as energy or feedstock. The year-wise trajectory of such minimum share of consumption will be decided by the Empowered Group (EG).
- **Competitive Bidding:** Demand aggregation and procurement of green hydrogen and green ammonia through the competitive bidding route will be undertaken**.**
- **Certification framework:** MNRE will also develop a suitable regulatory framework for certification of Green Hydrogen and its derivatives as having been produced from RE sources.

3.1.2.4 India Nuclear Energy

Business Potential in Nuclear Energy in India (INR Cr), FY 2024-2030

Exhibit 96: Business Potential in Nuclear Energy in India, INR Cr, FY 2024-30



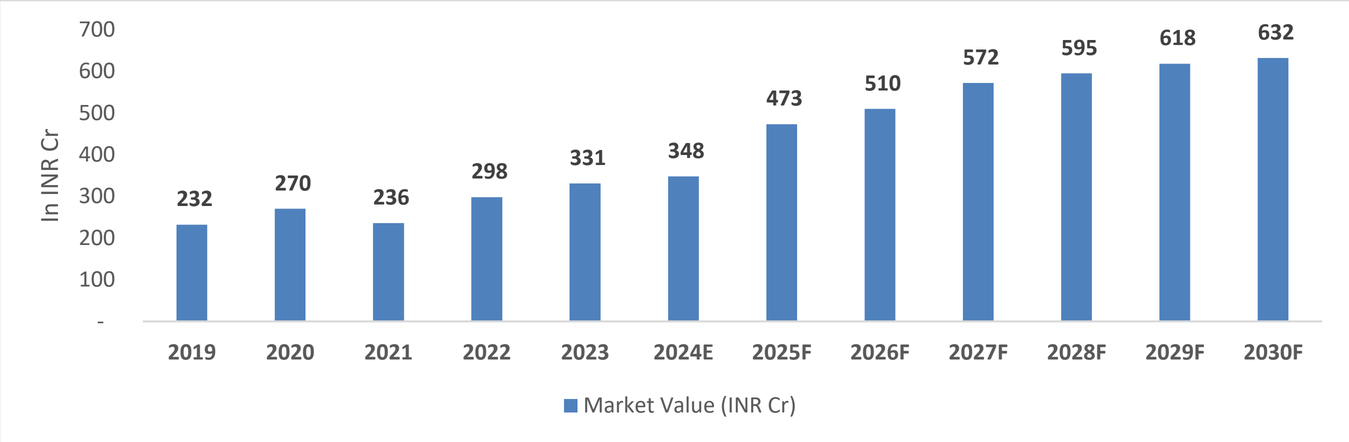
Source: Nuclear Business Platform and Frost & Sullivan

E-Estimated, F-Forecasted

- It is estimated that Nuclear Energy segment in India holds a business opportunity of **INR 2,60,968 Crores in FY 2024** and is projected to create a business opportunity of **INR 9,32,030 Crores by FY 2030** with a growth rate of **23.63% from FY 2024-30** driven by the construction of **20 nuclear projects** currently under construction and those with financial sanctions, with an anticipated completion date by 2031.

India Overall Forging Market: Nuclear Energy, FY 2019-2030

Exhibit 97: India Overall Forging Market Trend, Nuclear Energy, INR Cr, FY 2019-30



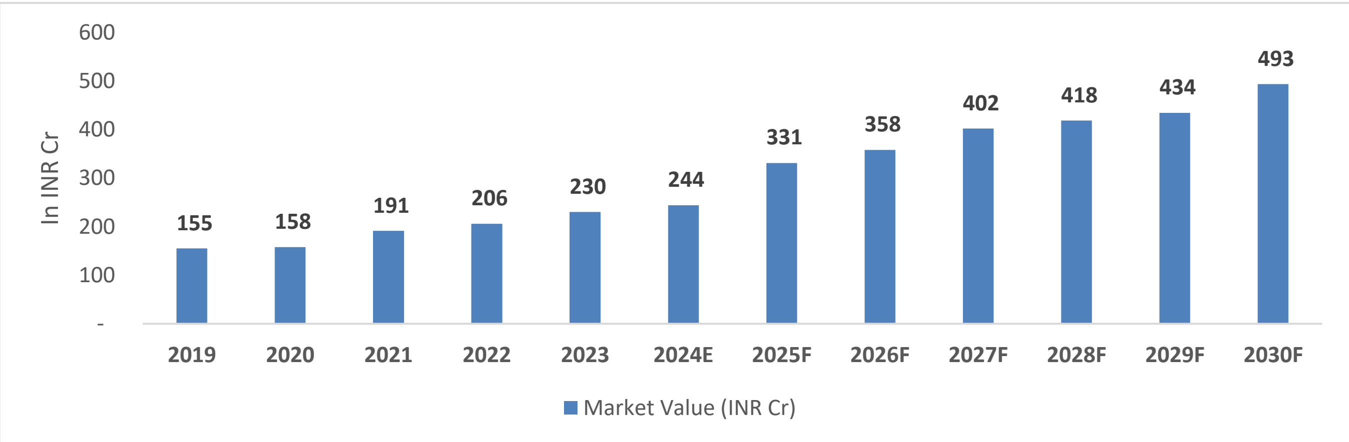
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Indian Overall Forging Market for Nuclear Energy was valued at **INR 348 Crores in FY 2024** and is projected to mark **INR 632 Crores by 2030** with a **CAGR of 10.4 % from FY 2024 to 2030** driven by demand of raw forgings and forged machined components such as pump and pump shafts, flanges, gears and tubes, drilling block, tees and bends, connectors, rings, transition cones and discs and global shift towards clean and sustainable form of energy.

India Precision Forged Machined Components Market: Nuclear Energy, FY 2019-2030

Exhibit 98: India Precision Forged Machined Components Market Trend, Nuclear Energy, INR Cr, FY 2019-30



Source: Frost & Sullivan Analysis

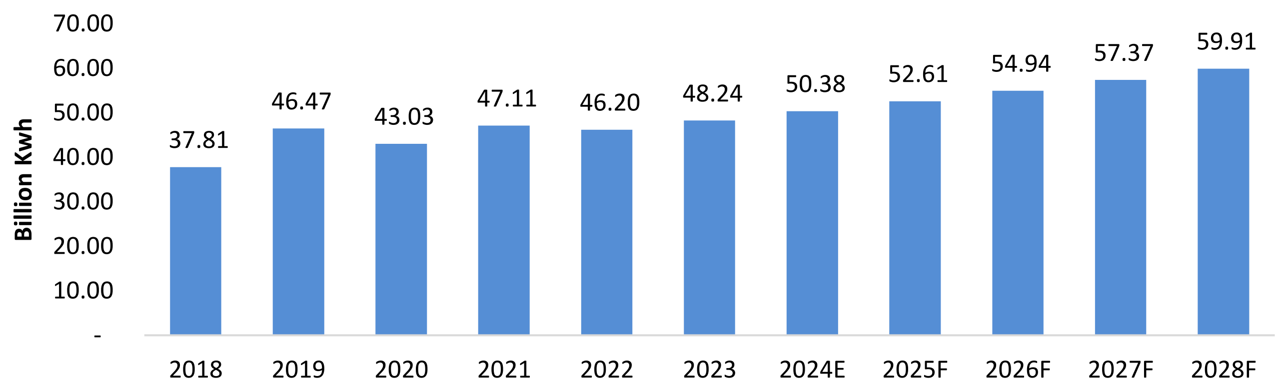
E-Estimated, F-Forecasted

- Indian Precision Forged Machined Components Market for Nuclear Energy was valued at **INR 244 Crores in FY 2024** and is projected to mark **INR 493 Crores by 2030** with a **CAGR of 12.4 % from FY 2024 to 2030** driven by demand of precision forged machined components such as pump and pump shafts, flanges, gears and tubes, drilling block, tees and bends, connectors, rings, transition cones and discs.

India Power Generation and Capacity-Nuclear: FY 2018-2028F

- India's nuclear power source constitutes to **2.6% of the total power generation** in India.
- It is projected to grow from **48.24 billion Kwh in 2023 to 59.91 billion Kwh in 2028F**. India is expected to use three stage programs for power generation with a combination of Pressurized Heavy Water Reactor (PHWR) and Fast Breeder Reactor (FBR). This would give the capability to grow multi fold capacity additions through uranium- plutonium route.

Exhibit 99: India Power Generation -Nuclear (Billion kwh) 2018-2028F



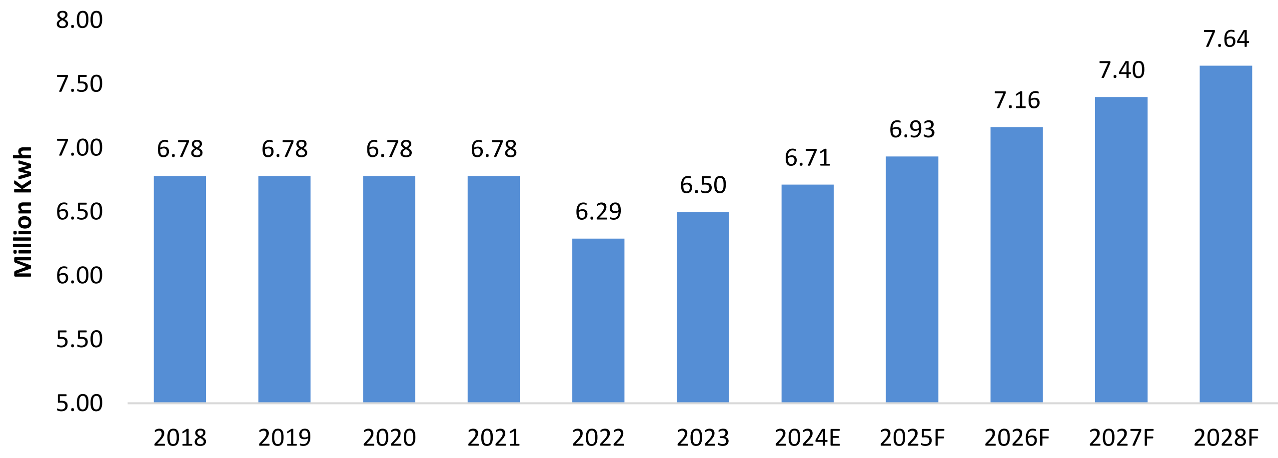
Source: MoSPI, Energy Statistics India Publication 2024

E-Estimated, F-Forecasted

India Power Capacity-Nuclear:

- India nuclear power has a total installed capacity of **6.71 million Kwh in 2024E,** and this is expected to grow to **7.64 million Kwh in 2028F.** The Government is adding capacity into the nuclear power generation sector.
- **Two more reactors of 1,000 MWe** have been approved and is expected to be ready by 2030. These two reactors are expected to be in Kudankulam, this would increase the nuclear capacity capability to **22,480 MWe by 2030.** There are around 22 operational nuclear reactors in India and another 11 nuclear stations are expected to be commissioned with a cumulative capacity of 8,700 MW.
- India has plans to increase nuclear power generation mix of nuclear from 3% to 10% in the future. Shifting to the nuclear energy sector, large tenders are expected from the energy and power sector for the construction of 10 new reactors within the next 8 years.

Exhibit 100: India Power Capacity -Nuclear (Billion kwh) 2018-2028F



Source: MoSPI, Energy Statistics India Publication 2024

E-Estimated, F-Forecasted

Exhibit 101: Major Nuclear Installations in India, As of October 2024

Name	State	Capacity	Highlights
Kudankulam Nuclear Power Plant	Tamil Nadu	2,000 MW (2 units of 1,000 MW each)	This plant uses VVER-1000 reactors supplied by Russia and is the largest nuclear power station in India.
Tarapur Atomic Power Station	Maharashtra	1,400 MW (2 units of 540 MW and 2 units of 160 MW)	It is the oldest nuclear power plant in India, with its first units commissioned in 1969.
Rajasthan Atomic Power Station	Rajasthan	1,180 MW (8 units of varying capacities)	The first unit of this plant was commissioned in 1973, and it now has multiple reactors in operation.
Kaiga Atomic Power Station	Karnataka	880 MW (4 units of 220 MW each)	Known for its indigenous pressurized heavy water reactors (PHWR).
Madras Atomic Power Station (MAPS)	Tamil Nadu	440 MW (2 units of 220 MW each)	Located at Kalpakkam, it uses PHWR and was among the first reactors in India to be constructed indigenously.
Narora Atomic Power Station	Uttar Pradesh	440 MW (2 units of 220 MW each)	This plant is located on the banks of the Ganges River and uses PHWR technology.
Kakrapar Atomic Power Station	Gujarat	440 MW (2 units of 220 MW each, with additional units under construction)	It uses PHWRs and is undergoing expansion to increase its capacity.
Kalpakkam PFBR	Tamil Nadu	500 MW (under construction, expected to be operational soon)	This plant will be a significant step for India's fast breeder reactor program.
Bhimpur Nuclear Power Plant	Madhya Pradesh	1,400 MW (proposed)	This plant is in the planning stage and will significantly boost nuclear capacity upon completion.
Chutka Nuclear Power Plant	Madhya Pradesh	1,400 MW (proposed)	Another planned project expected to add to India's nuclear power generation capability.

Source: Frost & Sullivan Research

Nuclear Reactors Planned in India

Exhibit 102: Nuclear Reactors Planned

State	Reactor Name	Capacity (MW) each	Construction Planned
Haryana	Gorakhpur 1 & 2	700	2023

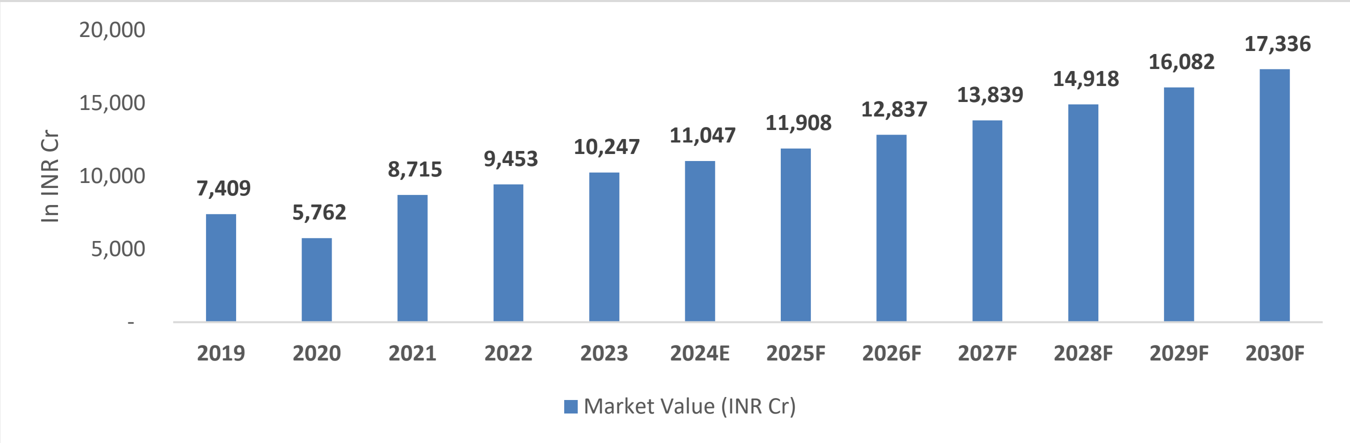
Haryana	Gorakhpur 3 & 4	700	By 2031
Madhya Pradesh	Chutka 1 &2	700	
Rajasthan	Mahi Banswara 1&2	700	
Rajasthan	Mahi Banswara 3&4	700	
Karnataka	Kaiga 5 & 6	700	

Source: World Nuclear Association

- There is tremendous potential for growth of Energy sector in India to meet the Energy needs of the fast-growing population which in turn will create opportunities for local manufacturer to fulfill the gap in the value chain by supplying the various forging raw materials and products to reduce the dependency on imports and promoting localization.

India Cryogenic Equipment Market

Exhibit 103: India Cryogenic Equipment Market Trend, INR Cr, FY 2019-30



Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

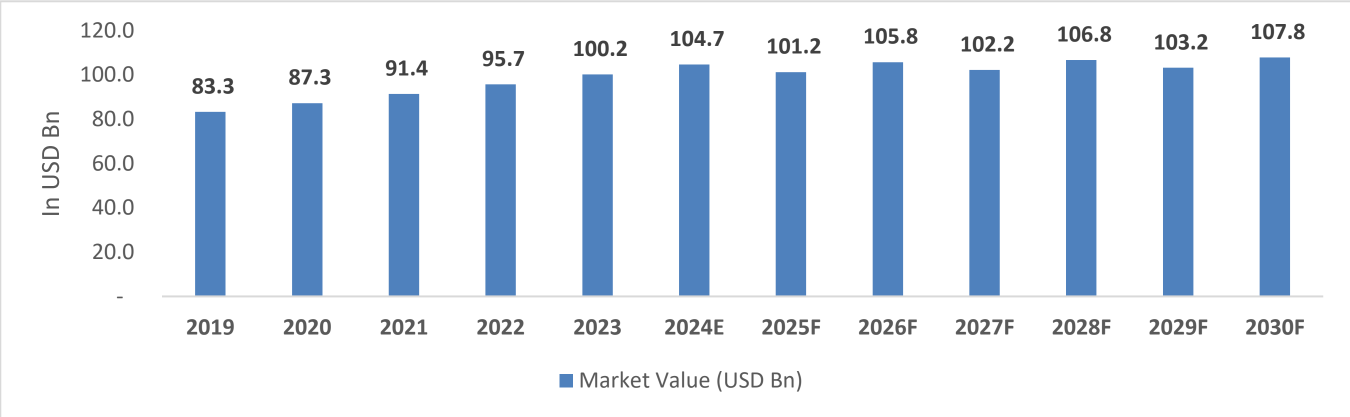
- Indian Cryogenic Equipment Market for was valued at **INR 11,047 Crores in FY 2024** and is projected to mark **INR 17,336 Crores by 2030** with a **CAGR of 7.8% from FY 2024 to 2030.**
- Key drivers are government initiatives and policies promoting the adoption of cleaner fuels enhancing healthcare infrastructure and strengthening industrial capabilities, incentivization for the cryogenic technology.
- **Cryogenic Tankers** are widely used in India particularly in the transportation of liquified natural gas (LNG). Cryogenic tankers enable the safe and efficient transportation of LNG from production facilities to distribution hubs and end users. **Forged valves are crucial component** used for regulating gas flow within the cryogenic tankers ensuring safety.

3.2 Energy Turbine Overview:

3.2.1 Global Energy Turbine Market Overview

Global Energy Turbine Market Trends, 2019-2030

Exhibit 104: Global Energy Turbines Market Trend, USD Bn, 2019-30



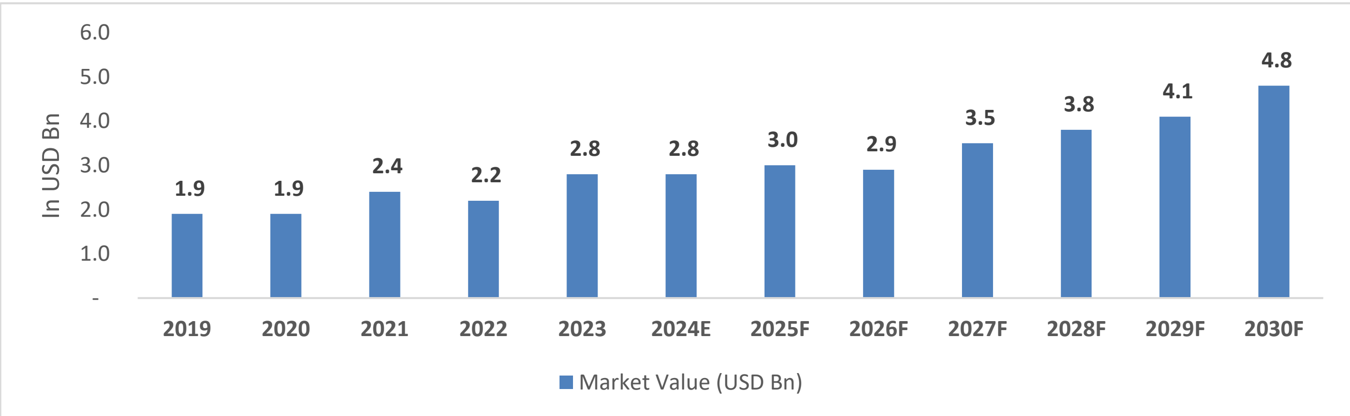
Source: Industry Report

E-Estimated, F-Forecasted

- Global Energy Turbine Market was valued at **USD 100.2 Bn in 2023** and is projected to mark **USD 107.8 Bn** by **2030** with a **CAGR of 4.5 % from 2023 to 2030** driven by increasing energy demand, advancements in turbine technology, and a global shift towards sustainable energy sources.
- The factors driving the market growth include the rise in investments in power infrastructure and focus on cleaner energy solutions

Global Overall Forgings Market: Energy Turbines, 2019-2030

Exhibit 105: Global Overall Forgings Market Trend, Energy Turbines, USD Bn, 2019-30



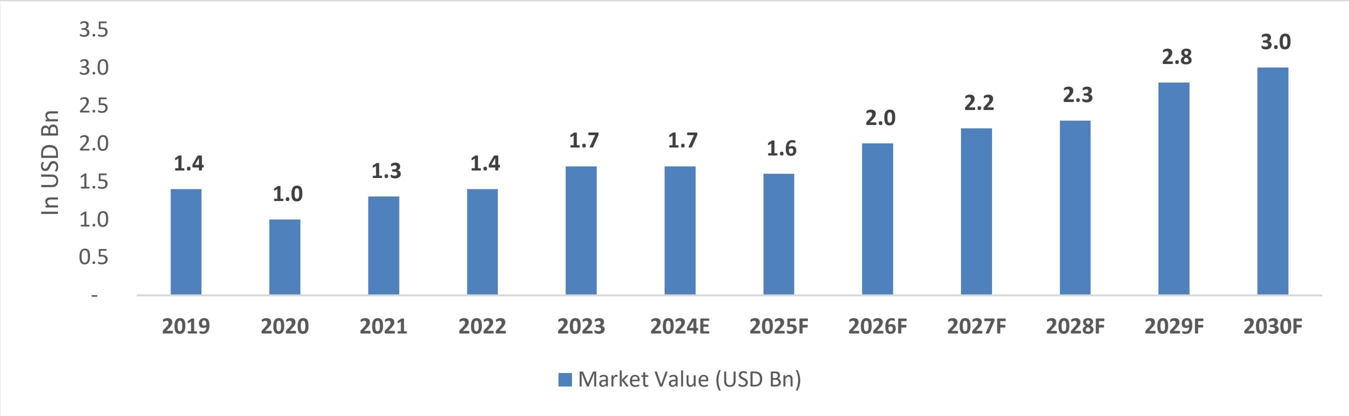
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global Overall Forgings Market for Energy Turbines was valued at **USD 2.8 Bn** in **2023** and is projected to mark **USD 4.8 Bn by 2030 with a CAGR of 8.1% from 2023 to 2030** driven by growth of demand of forgings and forged machined components from the gas turbines and steam turbines segments.

Global Precision Forged Machined Components Market: Energy Turbines, 2019-2030

Exhibit 106: Global Precision Forged Machined Components Market Trend, Energy Turbines, USD Bn, 2019-30



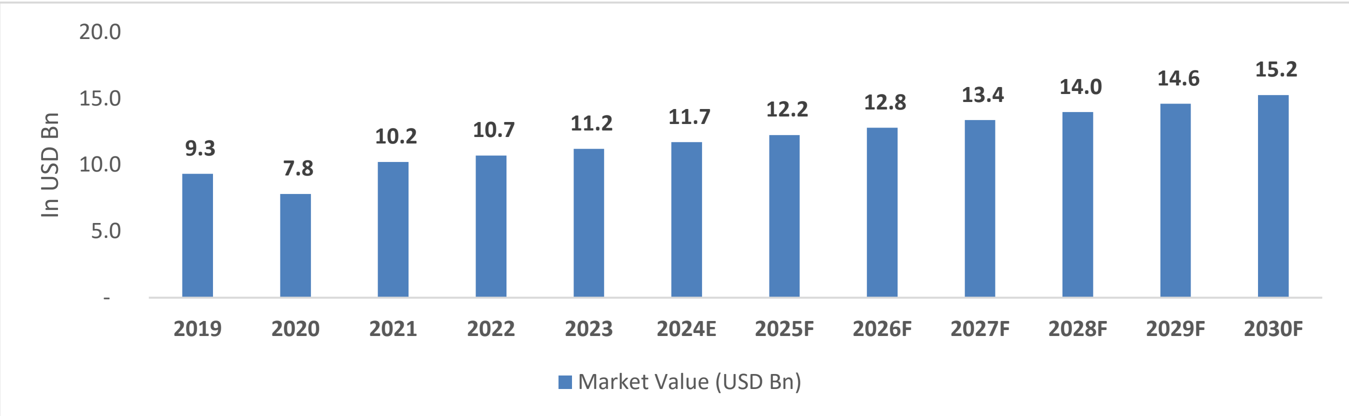
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global Precision Forged Machined Components Market for Energy Turbines was valued at **USD 1.7 Bn** in **2023** and is projected to mark **USD 3 Bn by 2030 with a CAGR of 8.6% from 2023 to 2030** driven by growth of precision forged machined components demand from the gas turbines and steam turbines.

Global Gas Turbine Market Trends, 2019-2030

Exhibit 107: Global Gas Turbines Market Trend, USD Bn, 2019-30



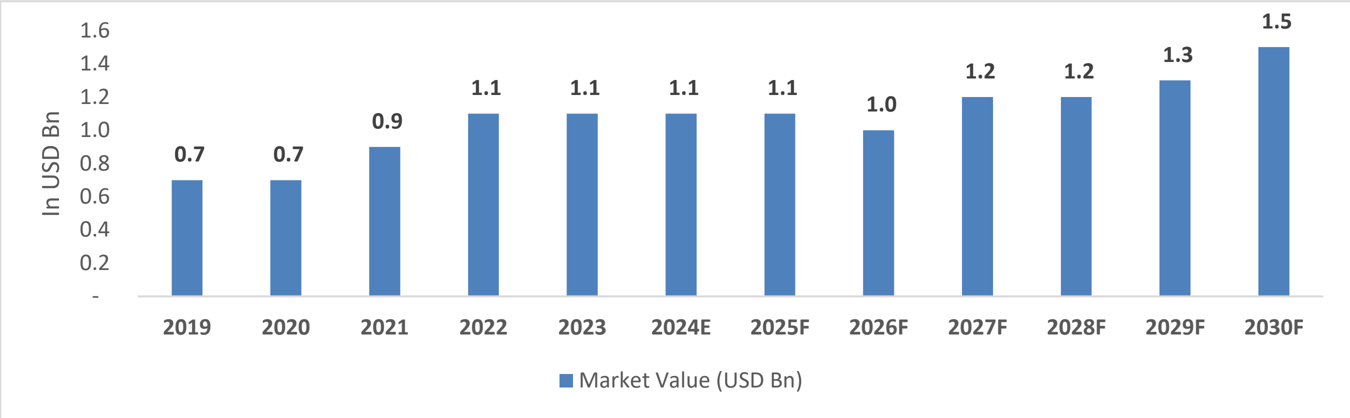
Source: Industry Report

E-Estimated, F-Forecasted

- Global Gas Turbine Market was valued at **USD 11.2 Bn in 2023** and is projected to mark **USD 15.2 Bn** by 2030 with a **CAGR of 4.5 % from 2023 to 2030** driven by **rapid technological advancements in energy industry combined with a shift towards distributed power production technologies**.

Global Overall Forgings Market: Gas Turbines, 2019-2030

Exhibit 108: Global Overall Forgings Market Trend, Gas Turbines, USD Bn, 2019-30



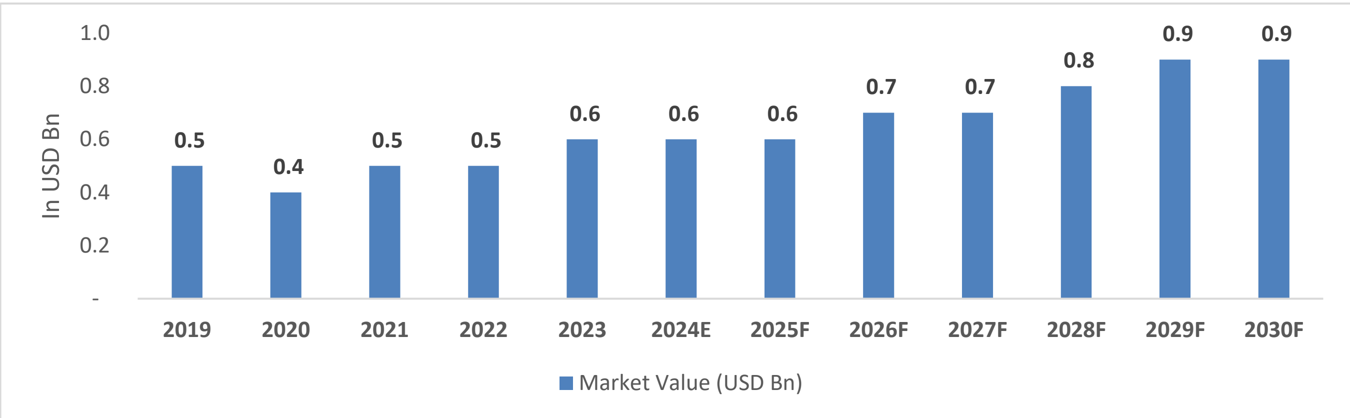
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global overall forgings Market for Gas Turbines was valued **at USD 1.1 Bn in 2023** and is projected to mark **USD 1.5 Bn by 2030** with a **CAGR of 5.1% from 2023 to 2030** driven by growth of raw forgings and forged machined components **such as drive shaft, Rotor Shaft, blades and vanes, impellers and retainer rings.**

Global Precision Forged Machined Components Market: Gas Turbines, 2019-2030

Exhibit 109: Global Precision Forged Machined Components Market Trend, Gas Turbines, USD Bn, 2019-30



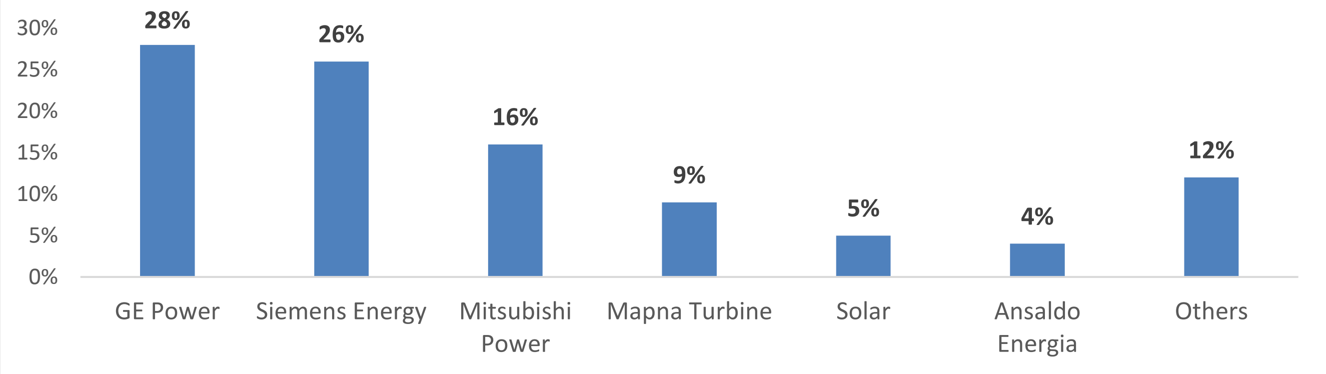
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global Precision Forged Machined Components Market for Gas Turbines was valued **at USD 0.6 Bn in 2023** and is projected to mark **USD 0.9 Bn by 2030** with a **CAGR of 5.8% from 2023 to 2030** driven by growth of precision forged machined components **such as drive shaft, Rotor Shaft, blades and vanes, impellers and retainer rings.**

Gas Power Turbines Ordered (2017-2022H1)

Exhibit 110: Market Share of Gas Power Turbines manufacturers based on Orders in 2022H1

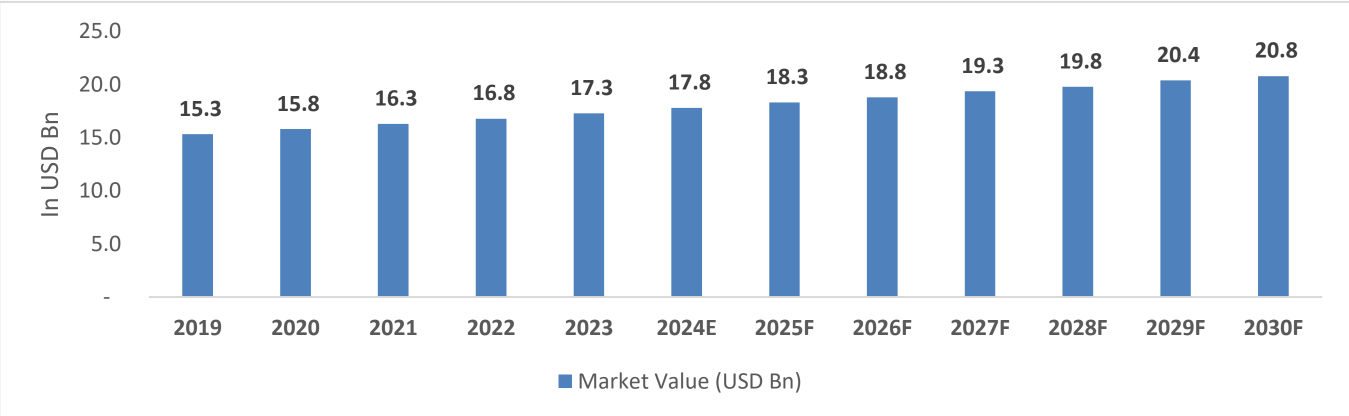


Source: McKoy Reports

- During the **6M'2022 period,** the orders for Gas Turbines (GTs) were **183 units** vs **172 units** in **6M'21** for simple-cycle power plant. Additionally, there were 91 units ordered for combined cycle in **6M'2022.**
- The total number of orders in H1 2022 for Gas Turbines (across simple cycle & combined cycle) was **274 units.** Total number of orders for gas turbines (across simple cycle and combined cycle) was 461 units in 2021.
- The gas turbine manufacturing market is highly concentrated with the top 5 players contributing to more than 80% of the market (based on orders in 2022H1). Based on the market share of orders in **H12022, GE Power & Siemens Energy** are two players with almost half of the market share.

Global Steam Turbine Market Trends, 2019-2030

Exhibit 111: Global Steam Turbines Market Trend, USD Bn, 2019-30



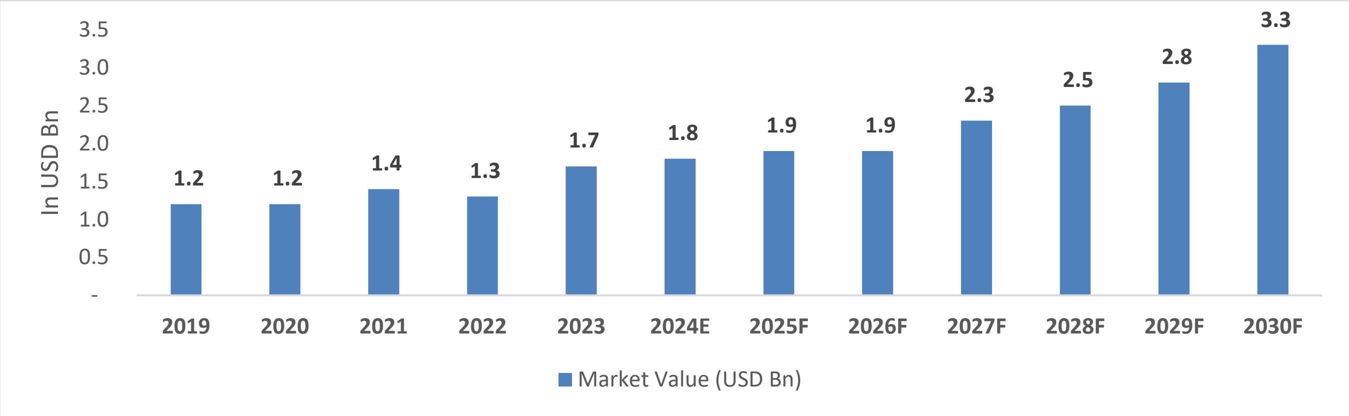
Source: Industry Report

E-Estimated, F-Forecasted

- Global Steam Turbine Market was valued at **USD 17.3 Bn in 2023** and is projected to mark **USD 20.8 Bn** by 2030 with a **CAGR of 3% from 2023 to 2030** driven by rising demand of electricity and dependency on coal-based power plants for electricity generation.

Global Overall Forgings Market: Steam Turbines, 2019-2030

Exhibit 112: Global Overall Forgings Market Trend, Steam Turbines, USD Bn, 2019-30



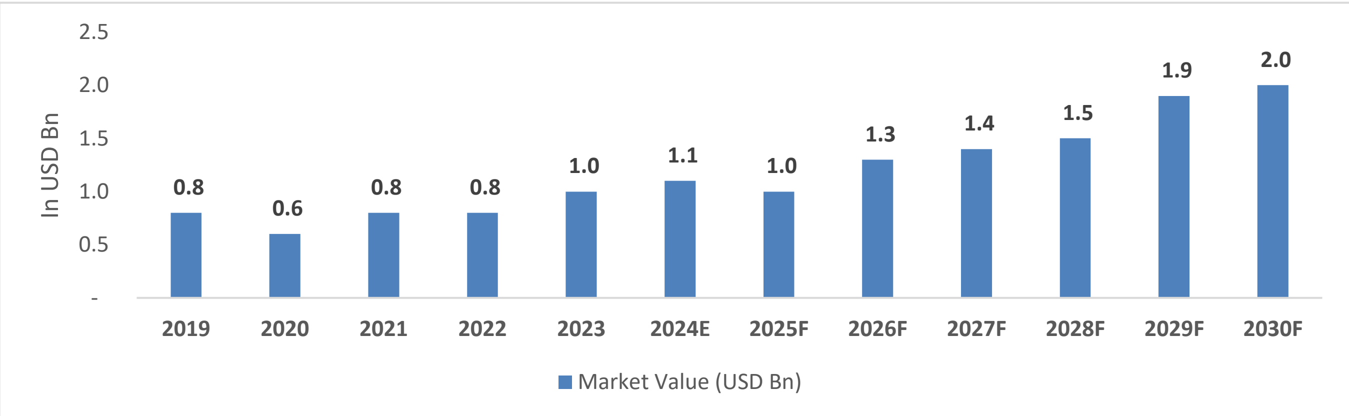
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global Overall Forgings Market for Steam Turbines was valued **at USD 1.7 Bn in 2023** and is projected to mark **USD 3.3 Bn by 2030** with a **CAGR of 9.2 % from 2023 to 2030** driven by growth of raw forgings and forged machined components such as drive shaft, Rotor Shaft, blades and vanes, impellers, Turbine wheel components and retainer rings.

Global Precision Forged Machined Components Market: Steam Turbines, 2019-2030

Exhibit 113: Global Precision Forged Machined Components Market Trend, Steam Turbines, USD Bn, 2019-30

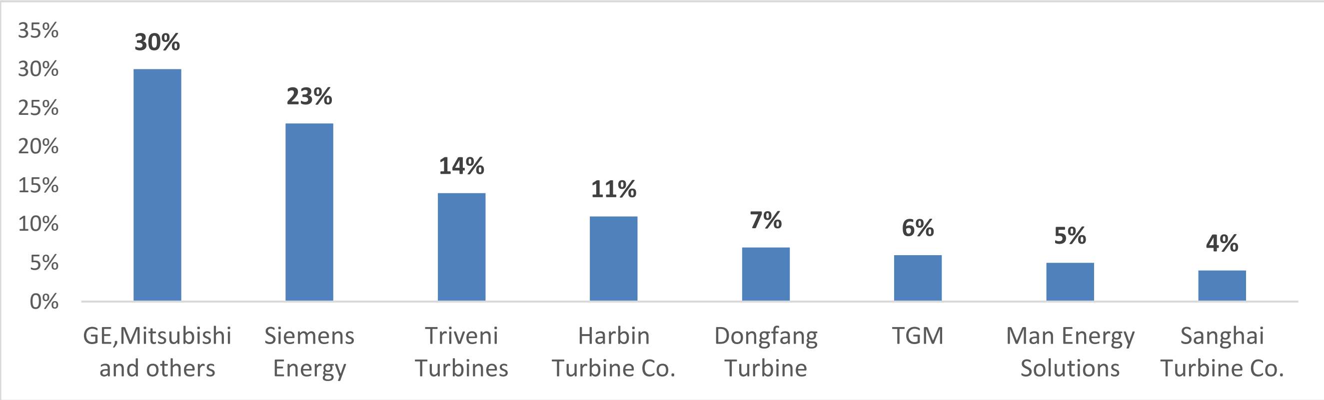


Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global Precision Forged Machined Components Market for Steam Turbines was valued **at USD 1 Bn in 2023** and is projected to mark **USD 2 Bn by 2030** with a **CAGR of 10% from 2023 to 2030** driven by growth of precision forged machined components such as drive shaft, Rotor Shaft, blades and vanes, impellers, Turbine wheel components and retainer rings.

Exhibit 114: Market Share of Steam Power Turbines manufacturers based on Orders in 2022H1



Source: McKoy Reports

Steam Power Turbines Ordered (2017-2022H1)

- **In H1'2022,** the orders for steam turbines (STs) were 265 units vs 232 units in 6M'21 for simple-cycle power plant.
- There were **58 units** ordered for combined cycle in **6M'22.** The total number of orders in **H1 2022** for steam turbines (across simple cycle & combined cycle) were **323 units.**
- Total number of orders for steam turbines (across simple cycle and combined cycle) were 610 units in 2021. Steam turbines include multiple fuel types such as fossil, biomass and nuclear.

With the growth of the Renewable Energy segment demand for forged components from various segment such as Wind, Solar, Hydropower, Biomass and Geothermal is increasing.

- **Forged Products for Wind Power Segment:** Parts in the nacelle (gearbox, high-speed shaft, low-speed shaft and brake), the yaw drive for upwind turbines (shaft and gear) and tower components for both downwind and upwind turbines.
- **Forged Products for Hydropower:** Rings, discs and shafts are ideal for components such as blades, wheels and driveshafts for both turbines and generators.
- **Forged Products for Solar Energy Segment:** Solar energy harvesting employs turbines, and solar panels frequently require gearing in the manufacturing process, which are great applications for forgings.
- **Forged Products for Biomass Segment**: Kiln Components
- **Forged Products for Geothermal Power Segment:** Forged bar used in drilling for steam to blades for turbines, shafts for generators and blanks for gearboxes.

Key Global Manufacturers of Gas and Steam Turbines are **General Electric Company, Siemens AG, Mitsubishi Hitachi Power Systems (MHPS), Shanghai Electric Group Company Limited, Dongfang Electric Corporation Limited, Bharat Heavy Electricals Limited (BHEL), Ansaldo Energia S.p.A, Toshiba Corporation, Doosan Group, Harbin Turbine Company Limited and Triveni Turbines Limited.**

Exhibit 115: List of Turbine Manufacturers and Description

Turbine Manufacturer	Description
General Electric Company	Leading component manufacturer and service provider. The acquisition of Alstom has not been a success, burdening the company with excess coal/gas component capacity at a time when the market is depressed. Digital solutions have been well received in principle, but it has yet to effectively monetize many of these

Turbine Manufacturer	Description
	innovations. To combat the decline in large gas turbine sales, GE has been aggressively trying to boost its service revenues through solutions such as its advanced gas path for gas turbines
Siemens AG	Number two global supplier behind GE. Like GE, Siemens has been severely impacted by the global slowdown in the large gas turbine business, particularly in Europe. Siemens has been actively targeting markets where competitors like GE and MHPS were traditionally stronger, such as the Middle East. The company won massive supply contracts in Egypt in the past two years, but at low margins. Siemens has expanded its presence in the hydropower market via a minority stake in a JV with Voith, one of the leading hydropower OEMs
Mitsubishi Hitachi Power Systems (MHPS)	Mitsubishi-Hitachi Power Systems is now the leading power OEM in North Asia across a number of different power sub-sectors. Its combination of assets has created a market leader in the region. It is also aggressively competing against the likes of GE and Siemens to win projects in Southeast Asia.
Shanghai Electric Group Company Limited	One of the big three in the Chinese turbine market. Shanghai Electric has traditionally been strong in steam turbines, but the company acquired a 40% stake in Ansaldo that has expanded its gas turbine capabilities. Ansaldo's technology is now being leveraged in the Chinese market. Shanghai Electric is also continuing to target projects across Asia.
Dongfang Electric Corporation Limited	Company is another of the big three in the gas and steam turbine market. The model is largely the same as Shanghai Electric: preserve a strong stake in the local Chinese market and then focus on expanding across Asia
Bharat Heavy Electricals Limited (BHEL)	Market leader in India and increasingly moving to compete with Chinese players in other parts of Asia. BHEL has traditionally had a close working relationship with Siemens but rejected a formal relationship in 2014. BHEL still relies on Siemens for certain key components.
Ansaldo Energia S.p.A	Strong ties and market access in China with part ownership by Shanghai Electric. Traditionally very strong in southern Europe, although new equipment sales in this region have been very weak since the start of the decade. Also, traditionally strong in North Africa – again that market has been weak during this decade due to political issues. Turbine technology is derived for Siemens as the company used to have a licence agreement in the early 2000s.
Toshiba Corporation	Toshiba has historically had a strong footprint in North Asia and North America. Supplies the entire turbogenerator for coal-fired projects. For CCGT plants, Toshiba has traditionally worked in partnership with GE on many projects (GE supplies the gas turbine, Toshiba the steam turbine). Relationship is under considerable pressure as GE has made a move to service Toshiba turbines, prompting Toshiba to target GE equipment.
Triveni Turbines Limited	Triveni Turbines caters to diverse sectors through a wide range of steam turbine products that are built to suit the customer's requirement. Their commitment to offer cost effective, energy-efficient and environment-friendly solutions have led to the substantial investment in undertaking extensive research and development. This dedication yields to produce innovative and robust product offerings tailored to meet the demands of customers from over 20 industries and across 80+ countries
Doosan Group	Doosan has increased its presence in both developing and developed countries with proven steam and gas turbine technology. Doosan's increasing presence in the

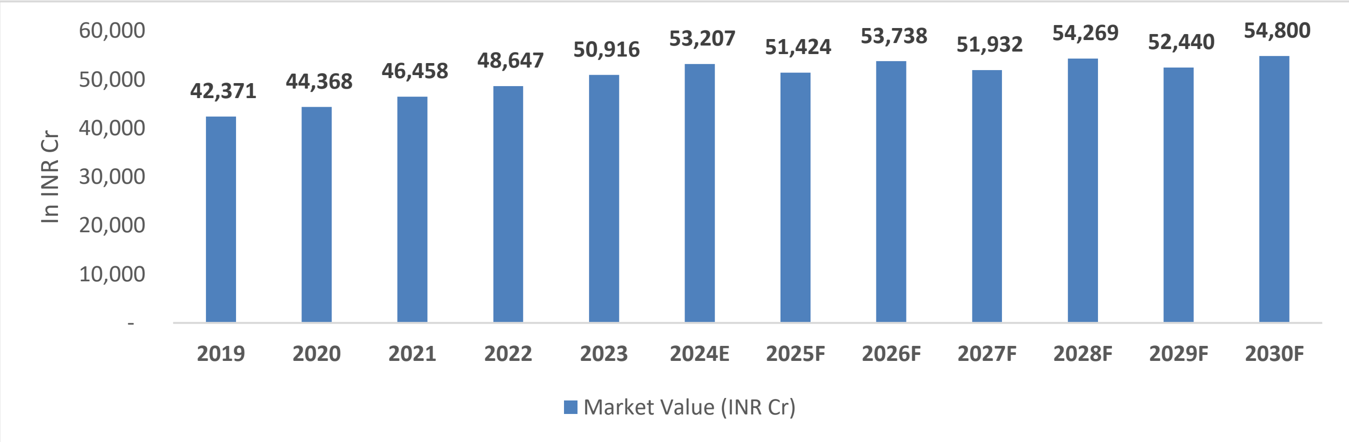
Turbine Manufacturer	Description
	Middle East, Africa, and Eastern Europe, along with expanding presence in India, should help the company become a major player in these regions
Harbin Turbine Company Limited	Harbin is expected to benefit from China's expansion of power projects under its One Belt One Road (OBOR) initiative as Chinese equipment makers would be preferred for power projects. With strong domestic presence in steam turbine technology, the company is moving towards manufacturing gas turbines, which could benefit it in China's growing gas market as well as international markets

Source: Frost & Sullivan Research

3.2.2 India Energy Turbine Market Overview

India Energy Turbine Market Trend FY 2019-2030

Exhibit 116: India Energy Turbine Market Trend, INR Cr, FY 2019-30



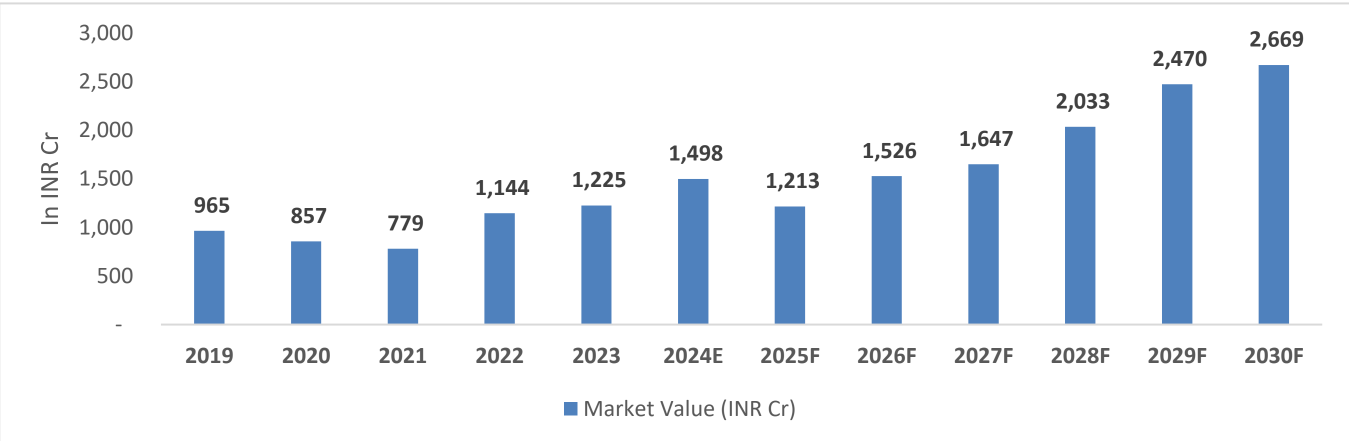
Source: Industry Report

E-Estimated, F-Forecasted

- Indian Energy Turbines market was valued at **INR 53,207 Crores in FY 2024** and is projected to mark **INR 54,800 Crores by 2030** with a **CAGR of 4.4% from FY 2024 to 2030** driven by **rapidly rising investments in the country's power generation infrastructure, coupled with growing concerns about environmental degradation.**

India Overall Forgings Market: Energy Turbine, FY 2019-2030

Exhibit 117: India Overall Forgings Market Trend, Energy Turbine, INR Cr, FY 2019-30



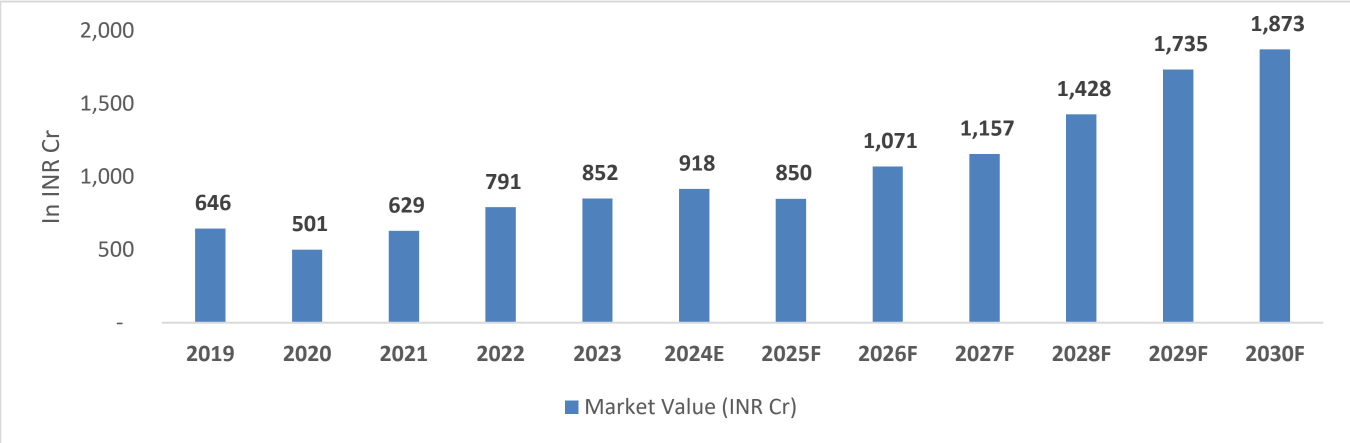
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Indian Overall forgings market for **Energy Turbines** was valued at **INR 1,498 Crores in FY 2024** and is projected to **mark INR 2,669 Crores by 2030** with a **CAGR of 10.1 % from FY 2024 to 2030** driven by demand of forgings and forged machined components from Gas and Steam Turbines segments.

India Precision Forged Machined Components Market: Energy Turbine, FY 2019-2030

Exhibit 118: India Precision Forged Machined Components Market Trend, Energy Turbine, INR Cr, FY 2019-30



Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

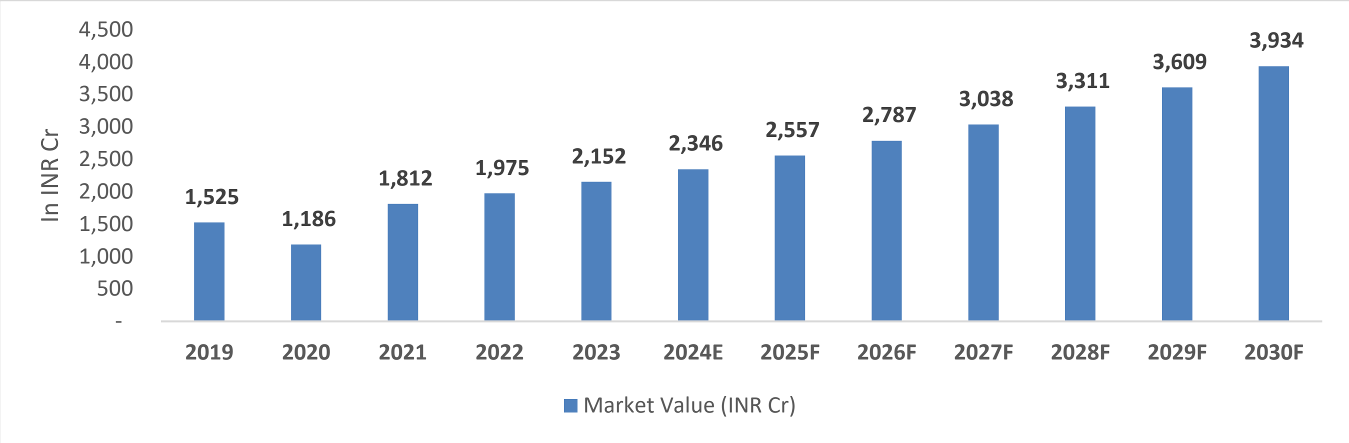
- Indian Precision Forged Machined Components Market for **Energy Turbines** was valued at **INR 918 Crores in FY 2024** and is projected to **mark INR 1,873 Crores by 2030** with a **CAGR of 12.6 % from FY 2024 to 2030** driven by precision forged machined components from Gas and Steam Turbines segments.
- Precision forged and machined components used in these **segments are Drive Shafts and Rotor Shafts, forged tubes, forged Disks, blocks, blades and vanes of turbines, seamless rings, stators, spacers, retainers, flanges, adapters, nozzles, casings, bearing blocks and shells.**

With the growth of the Renewable Energy segment demand for forged components from various segments such as Wind, Solar, Hydropower, Biomass and Geothermal is increasing.

- **Forged Products for Wind Power Segment:** Parts in the nacelle (gearbox, high-speed shaft, low-speed shaft and brake), the yaw drive for upwind turbines (shaft and gear) and tower components for both downwind and upwind turbines.
- **Forged Products for Hydropower:** Rings, discs and shafts are ideal for components such as blades, wheels and driveshafts for both turbines and generators.
- **Forged Products for Solar Energy Segment:** Solar energy harvesting employs turbines, and solar panels frequently require gearing in the manufacturing process, which are great applications for forgings.
- **Forged Products for Biomass Segment**: Kiln Components
- **Forged Products for Geothermal Power Segment:** Forged bar used in drilling for steam to blades for turbines, shafts for generators and blanks for gearboxes.

India Gas Turbine Market Trend FY 2019-2030

Exhibit 119: India Gas Turbine Market Trend, INR Cr, FY 2019-30



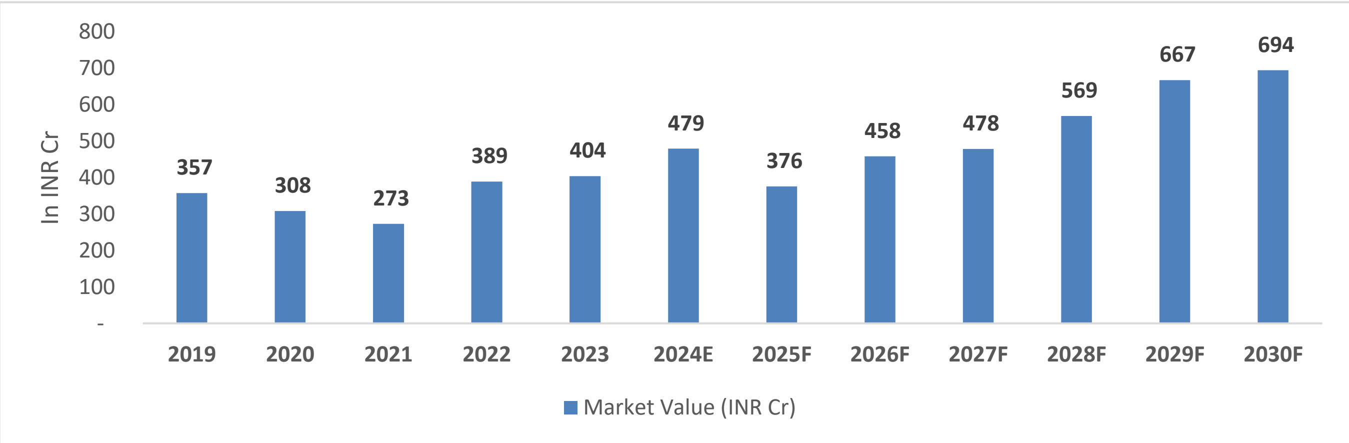
Source: Industry Report

E-Estimated, F-Forecasted

- Indian Gas Turbines market was valued at **INR 2,346 Crores in FY 2024** and is projected to mark **INR 3,934 Crores by 2030** with a **CAGR of 9% from FY 2024 to 2030** driven by **rapidly rising investments in the country's power generation infrastructure, coupled with growing concerns about environmental degradation.**

India Overall Forgings Market: Gas Turbine, FY 2019-2030

Exhibit 120: India Overall Forgings Market Trend, Gas Turbine, INR Cr, FY 2019-30



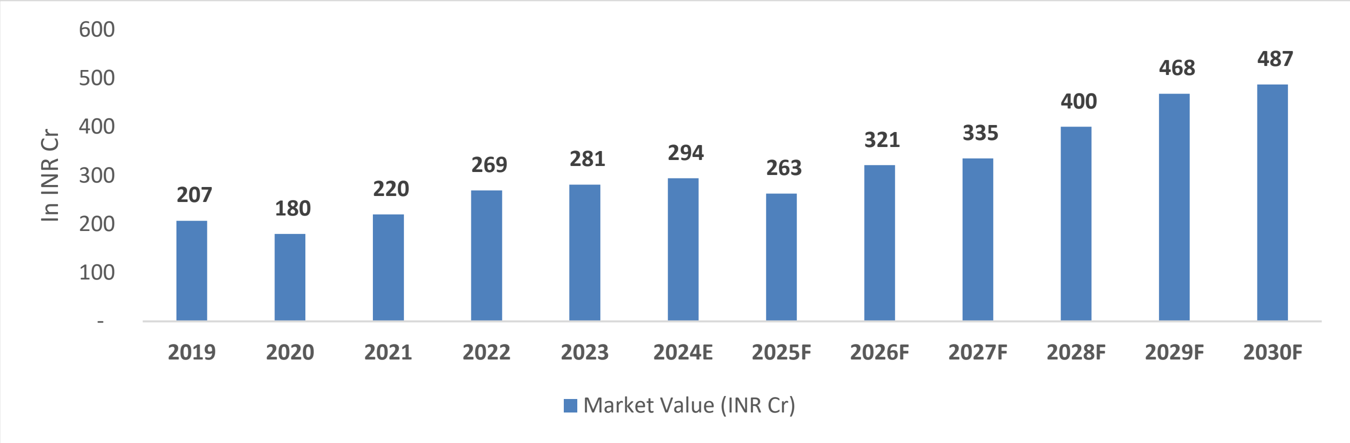
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Indian Overall Forgings Market for **Gas Turbines** was valued at **INR 479 Crores in FY 2024** and is projected to **mark INR 694 Crores by 2030** with a **CAGR of 6.4 % from FY 2024 to 2030**.

India Precision Forged Machined Components Market: Gas Turbine, FY 2019-2030

Exhibit 121: India Precision Forged Machined Components Market Trend, Gas Turbine, INR Cr, FY 2019-30



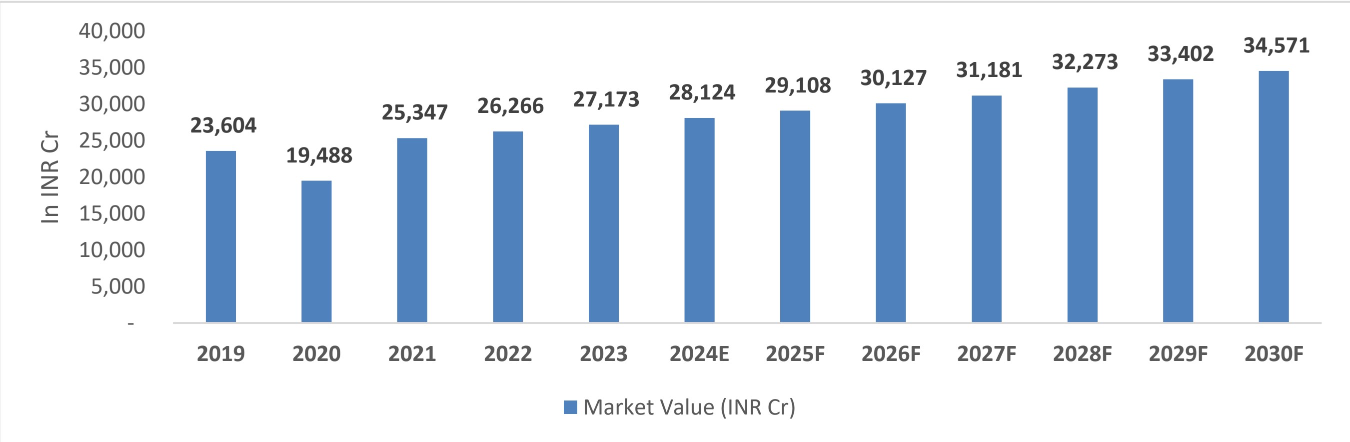
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Indian Precision Forged Machined Components Market for **Gas Turbines** was valued at **INR 294 Crores in FY 2024** and is projected to **mark INR 487 Crores by 2030** with a **CAGR of 8.8 % from FY 2024 to 2030**.

India Steam Turbine Market Trend FY 2019-2030

Exhibit 122: India Steam Turbine Market Trend, INR Cr, FY 2019-30



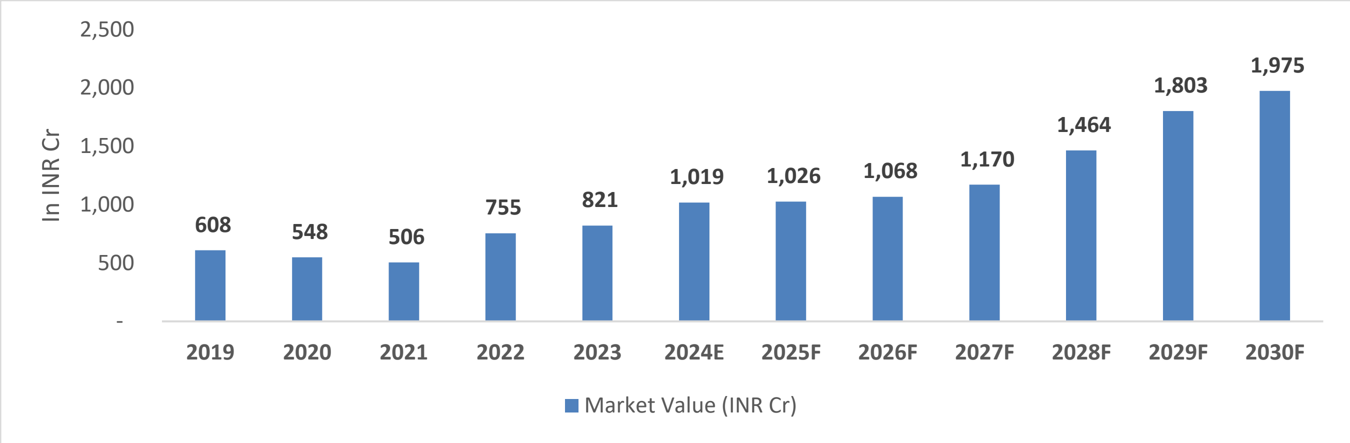
Source: Industry Report

E-Estimated, F-Forecasted

- Indian Steam Turbines market was valued at **INR 28,124 Crores in FY 2024** and is projected to mark **INR 34,571 Crores** by **2030 with a CAGR of 3.5%** from **FY 2024 to 2030** driven by increasing demand of electricity and rapidly rising investments in the country's power generation infrastructure.

India Overall Forgings Market: Steam Turbine, FY 2019-2030

Exhibit 123: India Overall Forgings Market Trend, Steam Turbine, INR Cr, FY 2019-30



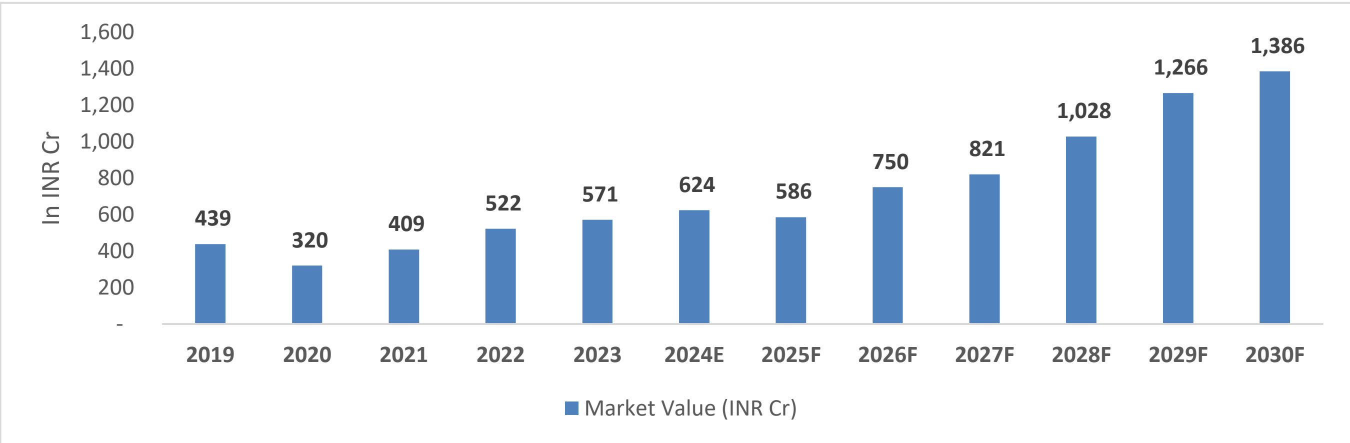
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Indian Overall Forgings market for **Steam Turbines** was valued at **INR 1,019 Crores in FY 2024** and is projected to **mark INR 1,975 Crores by 2030** with a **CAGR of 11.7 % from FY 2024 to 2030**.

India Precision Forged Machined Components Market: Steam Turbine, FY 2019-2030

Exhibit 124: India Precision Forged Machined Components Market Trend, Steam Turbine, INR Cr, FY 2019-30



Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Indian Precision Forged Machined Components Market for **Steam Turbines** was valued at **INR 624 Crores in FY 2024** and is projected to **mark INR 1,386 Crores by 2030** with a **CAGR of 14.2 % from FY 2024 to 2030**.

Key Turbine Manufacturers

- **GE Power, Siemens Energy AG & Mitsubishi Power Ltd. have the largest number of orders (70% share as per orders in H12022)** for gas turbines, whereas Siemens Energy & Triveni Turbines Ltd. have the largest number of orders (37% share as per orders in H1 2022) for steam turbines.

Exhibit 125: Details of Key Turbine Manufacturers

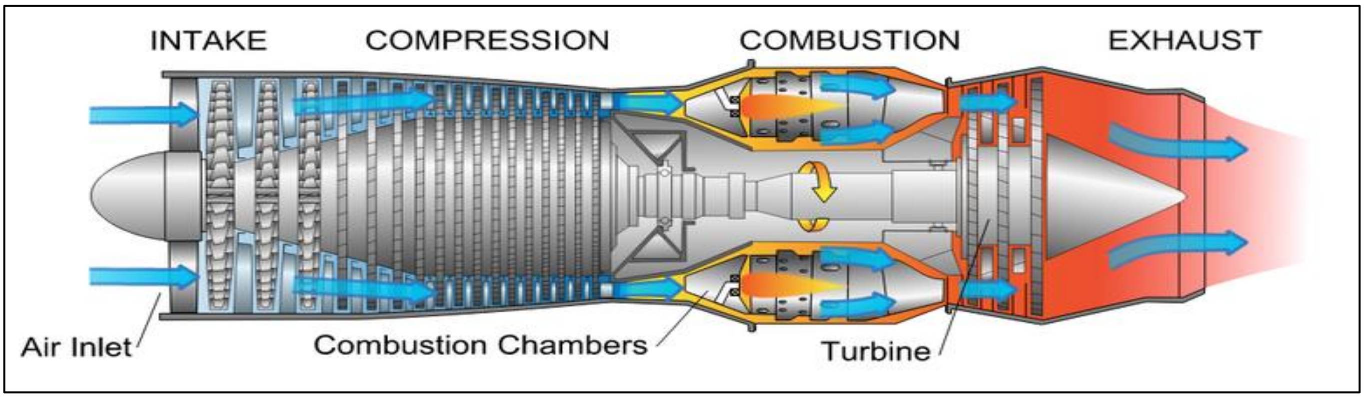
Manufacturer	Description	Energy Related Products	End Use Segments
General Electric	US based conglomerate that is present is diverse industries.	Gas Turbine Steam Turbine Generators Boilers	Power generation Renewable energy Healthcare Oil and gas Industrial solutions
Siemens Energy AG	Germany based MNC that provides solutions and services across different industries.	Energy Automation & Smart Grid Turbine Other power gen. equipment	Power generation Industry & manufacturing Infrastructure & buildings Healthcare Digitalization and software solutions
Mitsubishi Power Ltd.	Japan based company with expertise in power generation, industrial equipment & infra solutions.	Gas Turbine Steam Turbine Generators Power plant solution Boilers	Thermal power plants Renewable Energy Integrated Energy solution Environmental solutions
Ansaldo Energia S.P.A.	Italy based company recognized for its expertise in power generation equipment.	Gas Turbine Steam Turbine Generators Power Plant solution	Thermal power Generation Industrial power generation Renewable energy
Bharat Heavy Electricals Limited (BHEL)	Indian PSU that manufacturers power generation equipment.	Gas Turbin Steam Turbine Generators Boilers	Aerospace Defence Electrical Equipment Locomotive
Triveni Turbines Ltd.	India based Steam Turbine manufacturer	Steam Turbine	Textiles Oil & Gas Chemical Power Generation
Harbin Turbine Co. Ltd.	China based enterprise that manufactures all types of turbines	Gas Turbine Steam Turbine Nuclear Turbine Fossil Turbine	Power generation Transmission distribution Nuclear Oil and Gas
Dongfang Electric Corporation	China state-owned company that builds steam turbines	Steam Turbine	Power generation Transmission distribution Oil and Gas
Shanghai Electric Power Generation Group	China based MNC that deals in power generation & electrical equipment	Steam Turbine Wind Turbines	Power generation Transmission, distribution Electrical

Manufacturer	Description	Energy Related Products	End Use Segments
Baker Hughes	US based company with diverse offerings across energy & industrial value chain	Gas Turbine Steam Turbine	Oil and Gas Industrial applications
Solar Turbines	US based company which supplies energy solutions for power generation & other applications	Gas turbines	• Energy • Industrial • Renewable • Marine

Source: Company websites

Key Components of a Turbine and its maintenance Cycle

Exhibit 126: Pictorial Representation of a Gas Turbine



Source: Energy Education

A gas turbine is an internal combustion engine used in power plants. It converts natural gas or other liquid fuels into mechanical energy, which in turn drives a generator to produce electrical energy transmitted through power lines. Major components of a gas turbine include:

1. **Air Inlet:** It is an important component that makes huge amount of air to enter the turbine maintaining the pressure or flow, the filters used remove contaminants from the air. The air inlet is designed to ensure a steady air flow & maximize air compression.

2. **Compressor:** Airfoils in this section perform the function to pull in large air volume, compresses the air to required pressure & pushes it to the combustion chamber at high speed. Usually axial-flow compressors are used due to their ability to maintain continuous air flow. These compressors consist of rotor blades/airfoils, drums and stator blades/airfoils which work in creating an 'adverse' pressure gradient to push gas to high static pressure from low across the compressor. Component critically is of high importance to prevent flow reversal and avoid 'stalling' of blades/airfoils which increases power required and decreases component life.

3. **Combustion Chamber:** Here the fuel is injected, post that ignition of fuel-air mixture is done using spark plugs located in the chamber. The job of flame stabilizers is to ensure that the flame stays in the combustion zone & is stopped from moving back in the compressor section.

4. **Power Turbine:** The most vital component that converts the energy from high temperature & high-pressure gas into mechanical energy, which generates electricity. The gas flowing through the turbine

expands and exerts a force on the blades and makes them move. The moving blades draw more pressure in the combustion section & spin the generator to produce electricity. Cooling systems are mounted to maintain the temperature of the turbine.

5. **Blades/Airfoils:** A turbine blade can be divided into 4 parts: Air foil, platform, shank & dovetail. They contain rows of hollow airfoils for cooling purposes. The compressor and turbine sections of a gas turbine use two types of blades:

    - **Rotor Blades/Airfoils:** These blades are responsible to accelerate & compress the incoming air in the compressor & extract energy from gas flow in the turbine. They are shaped in aerodynamic manner to hold high centrifugal forces & run at high speeds.
    - **Stator Blades/Airfoils (Guide Vanes):** They are used to compress the air near the rotor blades, optimize the angle of attack & reroute the airflow. These blades are important to the performance & efficiency of the turbine.
    - **Key Components are Casing, Rotor, Blades Airfoils, Diaphragms, Bearings, Governor & support system**

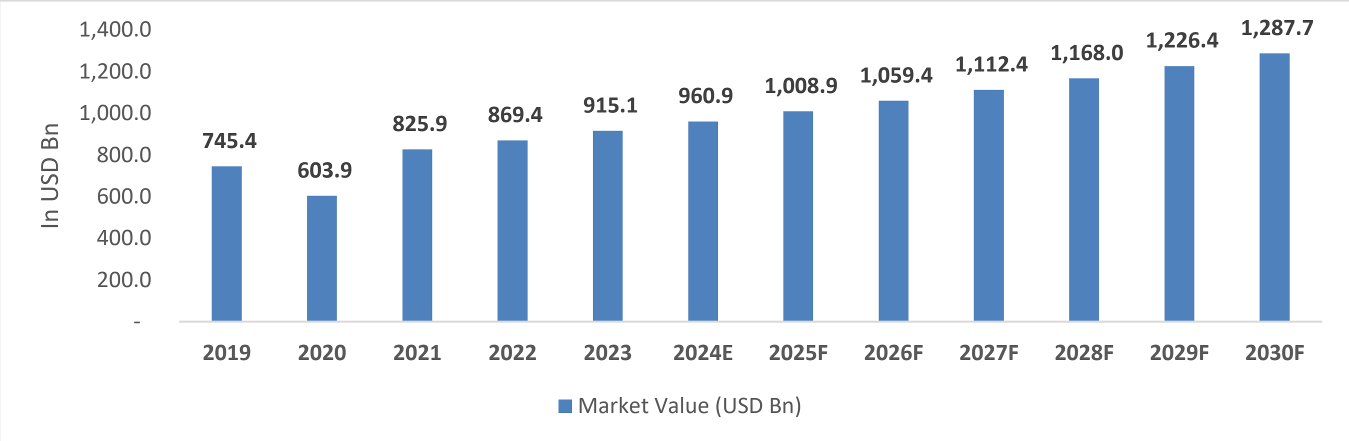
3.3 Aerospace

3.3.1 Aerospace Global Overview:

- The Global Aerospace sector is on a high growth trajectory. Rapid Urbanization, increasing commercial aircraft orders and rising government support and increasing commercial aircraft orders are expected to drive the growth.
- Aircraft orders refer to the contractual agreements between an airline or aircraft operator and an aircraft manufacturer for the purchase of new aircraft.
- Huge demand for aircraft from Airbus and Boeing and other major manufacturers such as Lockheed Martin, Northrop Grumman across the globe is expected to boost the forging requirement in this segment.

Global Overall Components Market Trend: Aerospace 2019-2030

Exhibit 127: Global Overall Components Market Trend: Aerospace, Aerospace, USD Bn, 2019-30



Source: Frost & Sullivan Analysis

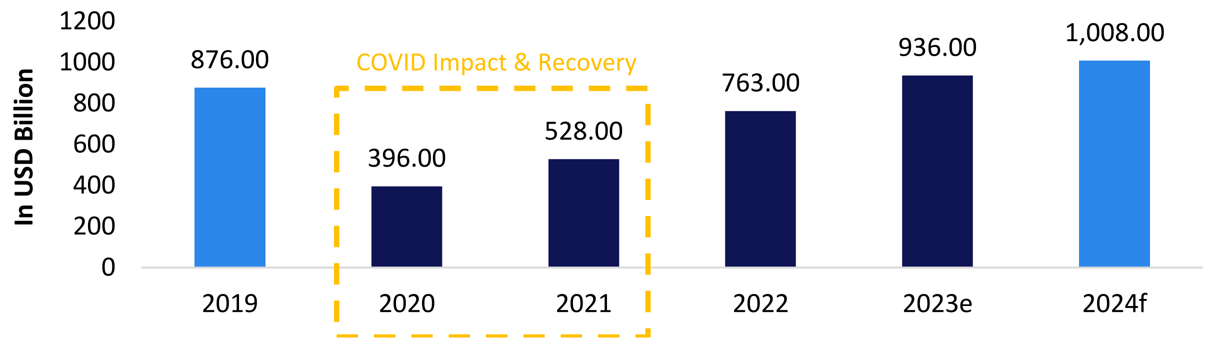
E-Estimated, F-Forecasted

- Global Overall Components market for Aerospace was **valued at USD 915.1 Bn in 2023** and is projected to mark **USD 1,287.7 Bn by 2030 with a CAGR of 5%** from 2023 to 2030 driven by increase in demand of aircraft components such as **air fuselage, landing gear, Engine discs, components of wings, undercarriage components, aircraft structural systems** propelled by requirement of more number of aircrafts to combat growing air passenger traffic.

Market Overview and Growth in the Commercial Aircraft Industry

- The post COVID air travel passenger volumes has witnessed a rebound and is expected to reach 4.7 billion in 2024E according to IATA.
- Passenger revenues are expected to reach **USD 717 billion in 2024**, compared **to USD 642 billion in 2023**. The airline profits are also expected to reach **USD 49.30 billion in 2024,** compared to **USD 40.7 billion** in 2023, according to IATA.

Exhibit 128: Total Global Spend on Air Travel, 2019-2024 (In USD Billion)



Source: IATA

- Global travel has been resilient after being impacted by the COVID pandemic and - recovered to beyond pre-COVID levels by the end of 2023.
- Global air travel spends had amounted to **USD 876 billion in 2019**, which had contracted to less than half by a **54% reduction in 2020 due to COVID pandemic**.
- The market recovered **33% to reach USD 528 billion in 2021** and further by **44% to reach USD 763 billion in 2022.** The milestone of recovery of air travel spend to pre-pandemic levels of 2019 was reached in 2023 and is further expected to surpass the **USD 1 trillion mark in 2024.**

Exhibit 129: Total Global Spend on Air Travel, 2019-2024 (In USD Billion)

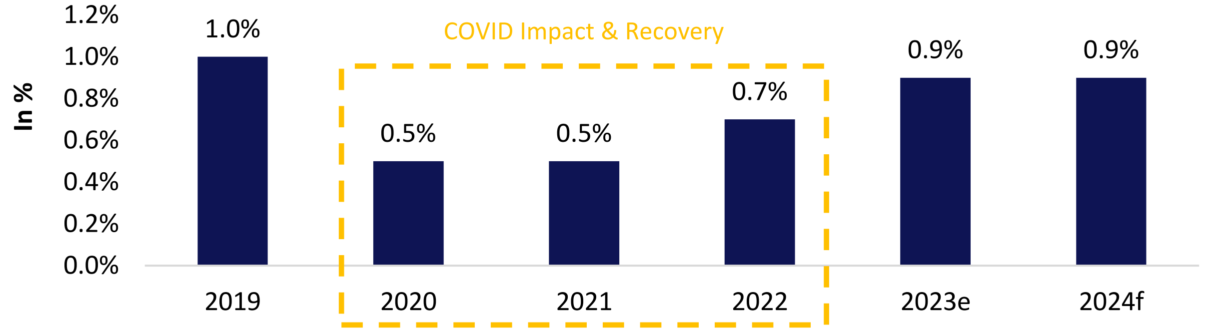
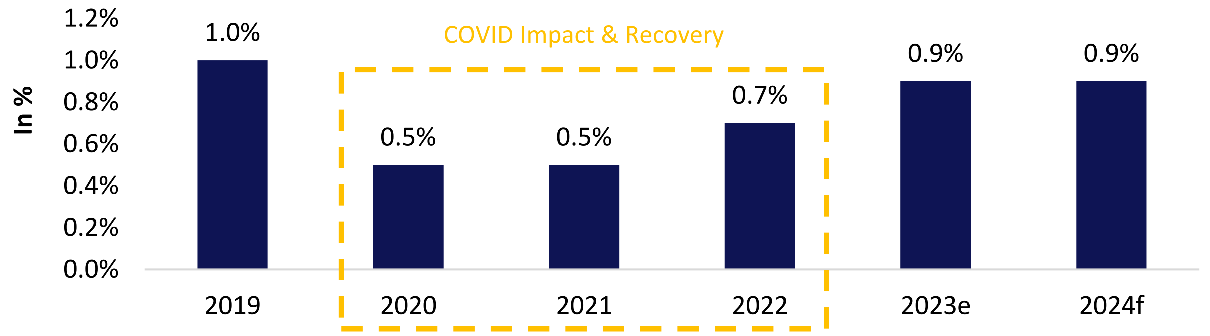


Exhibit 130: Total Global Spend on Air Travel as a %age of GDP, 2019-2024 (In USD Billion)



Source: IATA

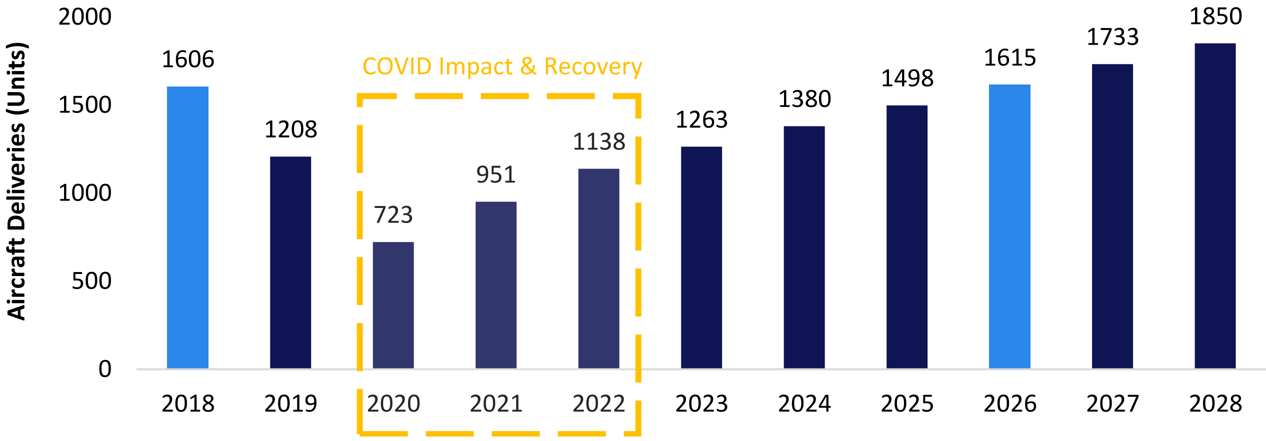
e-Estimated, f-Forecasted

- The contribution of Global air travel to global GDP has historically been less than 1% and fluctuating between 1% in 2019 to 0.5% in 2020 and 2021.

- This grew to 0.7% of the Global GDP in 2022 and further to 0.9% in 2023. However, the contributions remain small as other economic sectors globally accelerate faster.

Overview & Outlook on Commercial Aircraft Deliveries

Exhibit 131: Global Commercial Aircraft Deliveries (in Unit Volume), 2018-2028

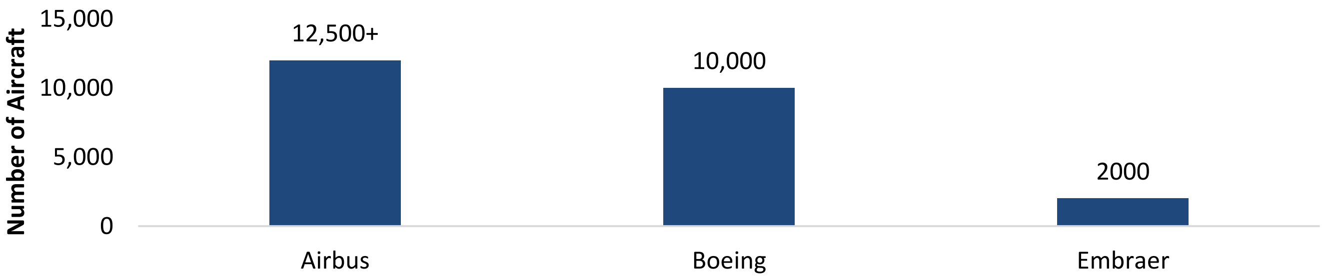


Source: Airbus, Boeing, and Frost & Sullivan Estimates

- The number of passenger fleet deliveries globally reached a substantial **1,606 units aircraft in 2018**, indicating a period of robust growth and investment in the global transportation sector, driven by strong air passenger demands from Asia.
- 2019 witnessed a huge fall in passenger fleet deliveries, dropping to 1,208, across narrow and wide body aircraft due to COVID.
- The year 2020 marked a significant disruption for the transportation sector, with passenger fleet deliveries plummeting to 723 aircraft. Cash flow issues with many airlines resulted in airlines either postponing the delivery of the new aircraft or cancelling the orders altogether.
- 2021 saw a partial recovery in passenger fleet deliveries to **951 aircraft**. The momentum of recovery continued into 2022, with passenger fleet deliveries further increasing to 1,138 aircraft, driven by rebound in air passenger traffic.
- In 2023, the upward trajectory in passenger fleet deliveries continued, reaching **1,263 units**. The aircraft deliveries are expected to reach **1,850 aircraft in 2028** owing to the increase of monthly production rates of narrow body aircraft by Airbus and Boeing.

Commercial Aircraft Global Fleet Size

Exhibit 132: Fleet Size for Commercial Aircraft, 2023, Number of Aircraft

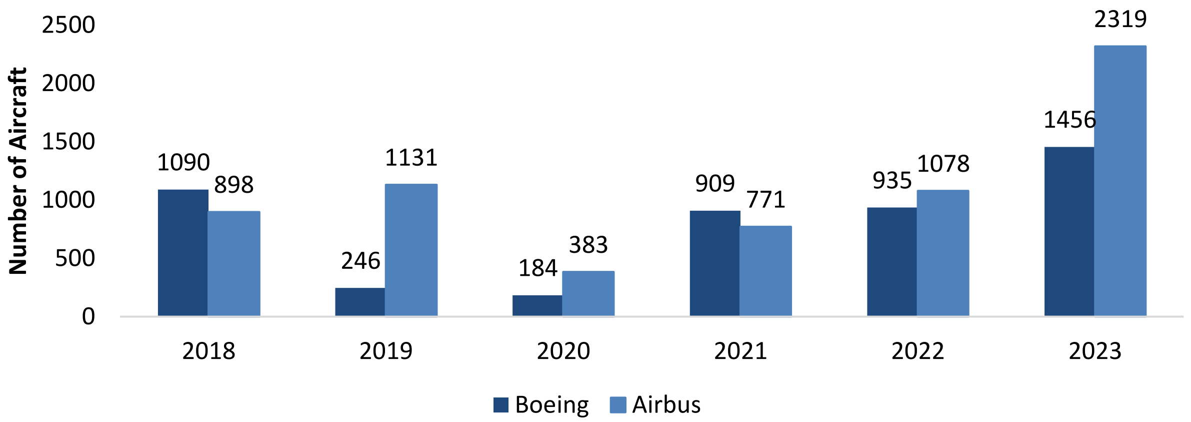


Source: Airbus, Boeing and Embraer report and secondary sources | Frost & Sullivan Estimates| Note: These are estimates and will not add up to exact fleet

- The aircraft market is split almost equally between Airbus and Boeing, accounting for the lion's share of all aircraft purchases globally.

- Airbus accounting for **12,500+ aircrafts and Boeing for 10,000** aircraft globally in 2023, Embraer also accounts for a total fleet of around 2,000 aircraft.
- The most popular aircraft families of Airbus are A320 and for Boeing it is B737.
- The majority of the historical deliveries were in the Americas and Europe, however the next two decades are expected to be dominated by deliveries in the Asia Pacific region.

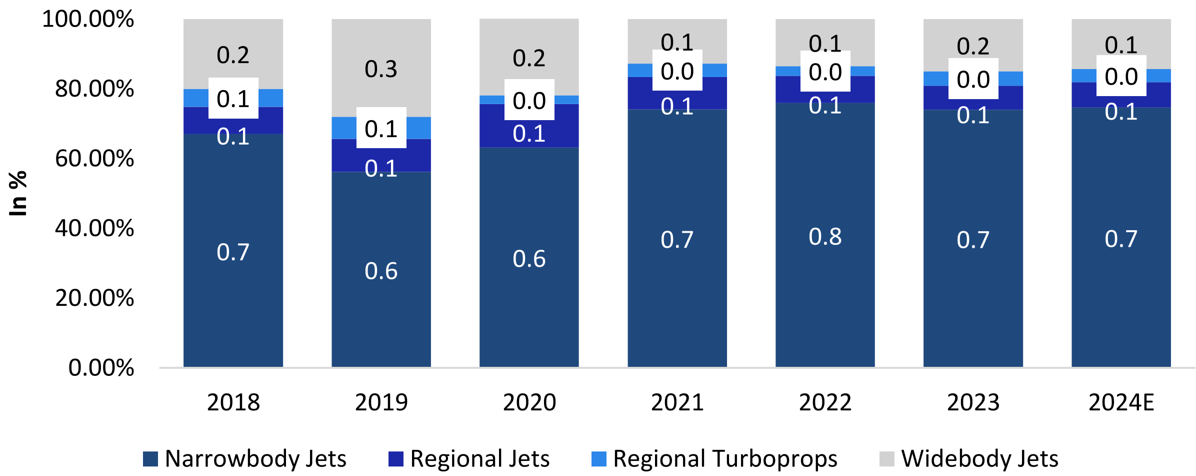
Exhibit 133: Airbus and Boeing Aircraft Orders for Commercial Aircraft, 2018-2023



Source: Airbus and Boeing report

- The order backlog for Airbus accounted to **8,598 aircraft as in 2023, including the new orders for 2,319 aircraft for the year 2023**. The majority of the Airbus orders for 2023 were,**1,835 A320 aircraft** and another **300 accounted to A350.**
- Boeing has a backlog of around **6,188 aircraft as of 2024**, the most popular being the narrow body fleet B737 and the Boeing 787.

Exhibit 134: Airbus and Boeing Aircraft deliveries by Type of Aircraft, 2018-2024E (In %)



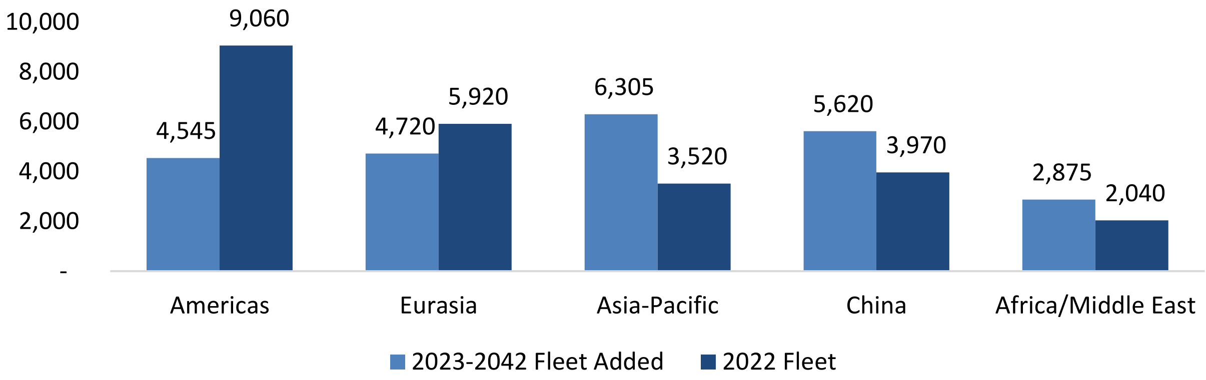
Source: Airbus and Boeing report

- The narrow body aircraft have traditionally been mostly in demand owing to the increase in air travel for shorter connectivity for flights which last around 3.5 hours (one way).
- Narrow body aircraft which are the B737 and A320 have accounted for nearly **75% of the deliveries** from 2018 to 2023, with a mild drop in 2019 and 2020.
- The narrow body aircraft are usually used by low-cost carriers, the growth of which has been a significant driver for the narrow body aircraft market.

- The demand for widebody aircraft was about **20% in 2018** and have reduced in the Post COVID scenario from 2020. Regional jets and regional turbo props make up smaller segments of about **10%** each and have remained stable.

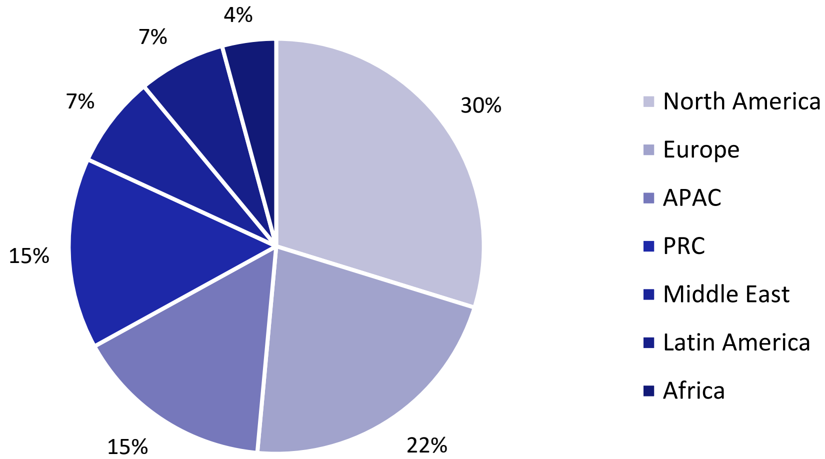
Commercial Aircraft Regional Fleet Distribution

Exhibit 135: Global Fleet across Regions, Current & Forecast, 2023



Source: https://cmo.boeing.com/

Exhibit 136: Regional Fleet Distribution, 2022 (%)



Source: IATA

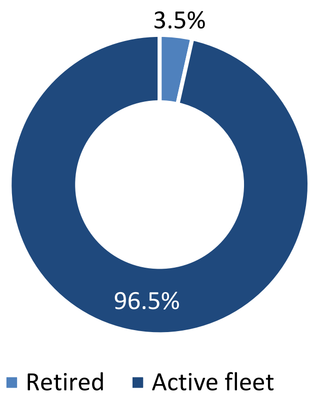
- **The regional fleet distribution pattern** is skewed towards developed economies, with North America and Europe accounting for 50% of the total active fleet in the world in 2022. APAC, including China and India accounted for around 30% of the global aircraft fleet in 2022. The fleet size of developing economies is expected to grow faster due to the increase in new low-cost carrier airlines entering these markets.
  - **In the Americas,** 4,545 aircraft are slated to be added to the fleet, reflecting sustained demand for air travel in the region by 2040.
  - **Eurasia,** comprising Europe and parts of Asia, accounted for a fleet size of 5,920 aircraft in 2022. This region serves as a major hub for air travel, connecting continents and facilitating trade and tourism flows. Eurasia is set to see the addition of 4,720 aircraft, driven by economic recovery and increasing passenger volumes by 2040.
  - **Asia-Pacific region** is the hub of the world's fastest-growing economies, with fleet size standing at 3,520 aircrafts in 2022. The region's strategic importance as a global economic powerhouse and tourism destination fuels the demand for air travel, contributing to the growth of its commercial

aircraft fleet. The Asian (Asia Pacific +China) region is poised to witness the largest fleet expansion, with 11,925 aircraft slated for addition by 2042, reflecting the region's status as a global aviation powerhouse.

- **China,** with its huge economy and growing aviation market, accounted for a fleet size of 4,000-4,500 aircraft in 2023, it is expected to add another 5,620 aircrafts. China plays a pivotal role in shaping global aviation trends and driving demand for commercial aircraft and is one of the world's fastest growing aviation markets.
- **Africa/Middle East region,** fleet size was 3,040 aircrafts in 2022, Owing to tourism industry fuel demand for air travel, supporting the expansion of its commercial aircraft fleet. In the Africa/Middle East region, 2,875 aircraft are set to be added until 2040, signaling confidence in the region's potential for aviation growth despite challenges.

Commercial Aircraft Fleet Retirement

Exhibit 137: Commercial Aircraft Fleet Retirement, 2028

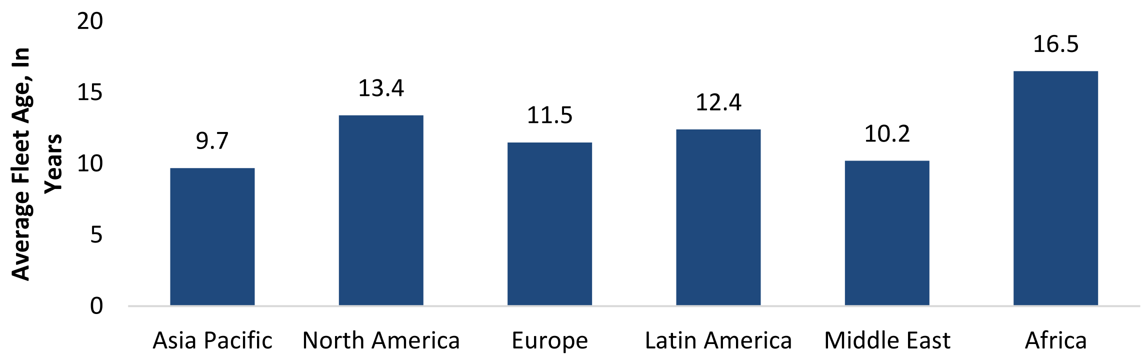


Source: Aviation News

- It is estimated that **5,000-5,500** aircraft would retire and be de-fleeted during the forecast period of 2024-2028.
- In 2028, the aviation industry anticipates a **retirement rate of 3.5%** for commercial aircraft.
- Active fleet is projected to comprise **96.5%** of all commercial aircraft in operation, representing the vast majority of aircraft continuing to serve airlines and passengers worldwide.
- Most of the commercial aircraft that are removed from commercial passenger flights are usually converted into freighters to extend their life by another 5 to 10 years, depending on the aircraft.
- Older aircraft models like the **MD80/717, A320ceo, 737NG** have a faster declining rate in the narrow body segment and models like **B747, A380, B767 and A330** have a faster declining rate in the wide body segment according to Boeing.

Average Age of Fleet- Commercial Aircraft

Exhibit 138: Average Age of the Fleet based on region (in Years)

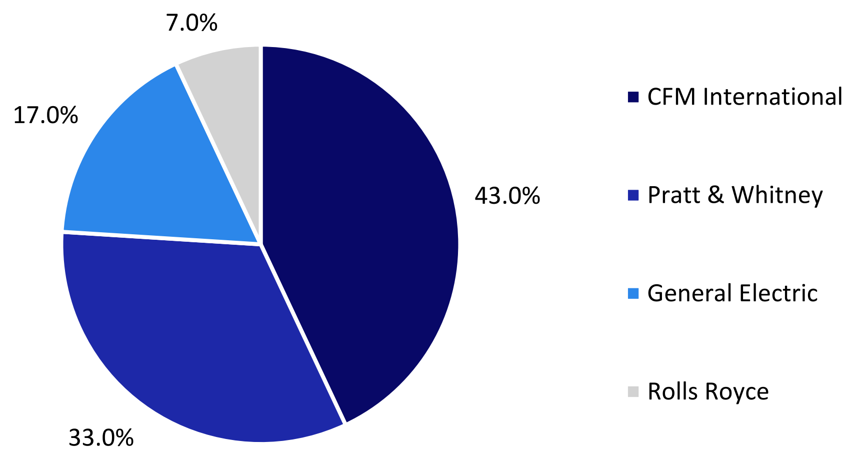


Source: Airbus and Boeing reports

- The average age of commercial aircraft fleets varies significantly across regions, reflecting diverse market dynamics, regulatory frameworks, and operational practices.
- The aircraft from the advanced economies like North America and Europe have a shorter average fleet life of 13.4 years and 11.5 years respectively due to the historical additions of fleet by the airlines in the region
- In Latin America and Africa, the lack of investment availability to procure new aircraft has resulted in much higher average life of the fleet of 12.4 years and 16.5 years respectively.
- The Asian region is expected to add around **11,925 aircrafts by 2042** due to demand for Low-Cost Carriers (LCC) in this marketlike Indigo, which order aircrafts in bulk.
- The induction of the new aircraft reduces the average age of the fleet.
- The age of the fleet of the Asia Pacific airline are much lesser due to the recent fleet additions in the airline industry in these regions.

Overview of Different Types of Engines Used in Commercial Aircrafts

Exhibit 139: Commercial Aircrafts Engine in Service, 2023



Source: Order and Delivery report from OEs

- **Narrow body commercial aircraft** usually have a two-engine configuration, while very large aircraft like **A380 and B747** have a four-engine configuration.
- The recently launched wide body aircraft like the **B787 and the A350** have a two-engine configuration. The use of composites to reduce the weight of the aircraft with focus on environmental sustainability are the key factors which drive this market.

- The commercial aircraft market is dominated by **CFM international** which accounts for 43% of the commercial aircraft engines. **CFM International is a joint venture between Safran Aircraft Engines and GE Aerospace.**
- The next dominant player is **Pratt & Whitney** which accounts for 33% of the total market. These engines are typically used on the narrow body aircraft like the **B737 and A320** which accounts to about approximately**75-80%** of the delivery of Airbus and Boeing.

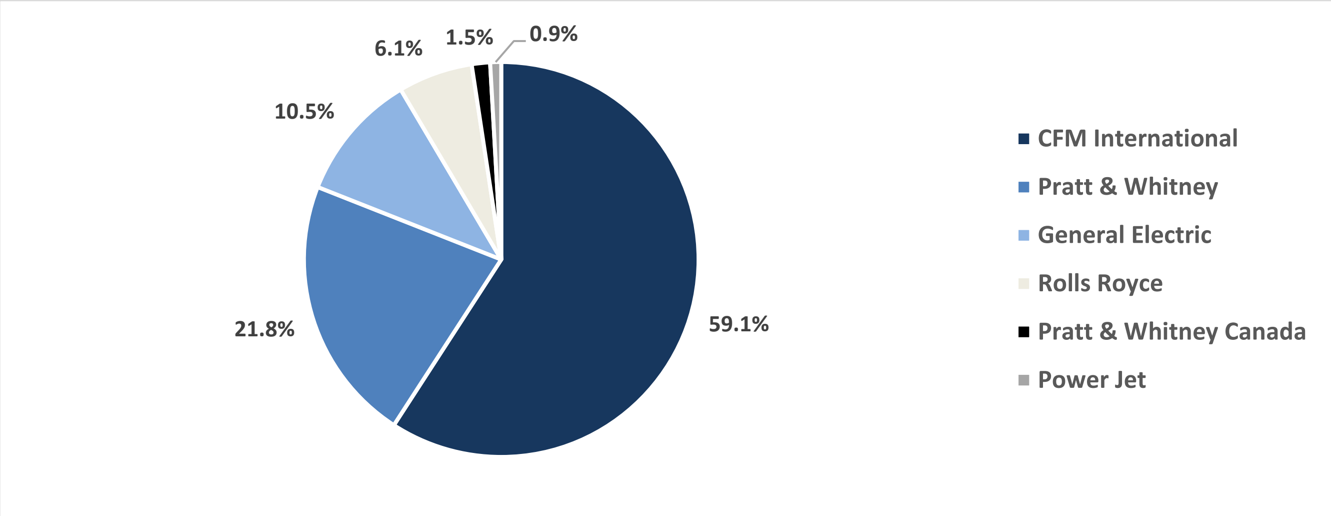
Exhibit 140: List of Commercial Aircraft Programs and their Engine Supplier

Name of the Aircraft Program	Type of Aircraft	Aircraft OEM	Engine OEM	Engine Name
E1	Narrow Body	Embraer	Pratt & Whitney	PW 1600/PW 1900
E2				PW 1600/PW 1900
A220		Airbus	Pratt & Whitney	Pratt & Whitney PW1500G
A320Family			CFM International	LEAP-1A from CFM International.
A320Family			Pratt & Whitney	Pratt & Whitney GTF™
A330	Wide body		Rolls Royce	Rolls-Royce Trent 700
A330			Pratt & Whitney	Pratt & Whitney PW4164/8
A330			GE Aerospace	General Electric CF6-80E1
A350			Rolls Royce	Rolls-Royce Trent XWB
A380				Rolls-Royce's Trent 900
Boeing 737	Narrow Body	Boeing	CFM International	CFM56
Boeing 747	Wide Body		GE Aerospace	General Electric CF6
Boeing 767				General Electric CF6
Boeing 777				General Electric GE90
Boeing 787			GE Aerospace/ Rolls Royce	The General Electric Genx

Source: Frost & Sullivan Analysis

Commercial Aircraft Engine Orders

Exhibit 141: List of Commercial Aircraft Programs and their Engine Supplier



Source: aviation.com

- **80% of the Commercial Aircraft Engine** orders lie with 3 companies- **CFM International, Pratt & Whitney and General Electric in 2023**.
- The commercial aircraft order books of Airbus and Boeing are dominated by narrow body aircrafts which are **B737 and A320,** powered by the CFM international engines, which accounts for **59.1%** of the overall market. This is expected to be followed by Pratt and Whitney which is expected to account to around **21.8%** of the overall market in 2023.
- The commercial aircraft engine market is expected to continue to be dominated by CFM international engines in the forecast period. The increase in aircraft orders from airlines in APAC, who cater to the Low-Cost Carrier (LCC) model are expected to drive the demand in this market.
- Growth of Fleet Sizes and Engine market will boost the growth of forging products in the Aerospace segment.

Market Overview of Global MRO Market

- The global aircraft maintenance, repair, and overhaul (MRO) market is a vital sector supporting the safety, reliability, and efficiency of commercial aircraft. As the aviation industry continues to expand, driven by increasing air travel demand and fleet modernization initiatives, the aircraft MRO market also experiences significant growth and evolution in tandem.
- MRO services encompass a wide range of activities, including scheduled maintenance checks, unscheduled repairs, component replacement, and overhaul services.
- The key objective of the MRO is to ensure aircraft safety and compliance with stringent regulatory standards set by aviation authorities like the Federal Aviation Administration (FAA) and the European Aviation Safety Agency (EASA).

Key Technologies in Global MRO Market

The aircraft MRO industry is experiencing significant transformations due to the introduction of advanced technologies. These technologies aim to enhance efficiency, quality, cost, safety, and productivity in all maintenance phases and aspects of delivery. Here are the top 5 technologies in aircraft MRO:

- <u>Artificial Intelligence (AI) and Machine Learning (ML)</u>: AI and ML are being used to optimize maintenance schedules, predict the component failures, and automate inspection processes. These technologies can analyse large amounts of data from sensors and systems on the aircraft to identify patterns and trends that can help predict of maintenance. This can help reduce downtime, increase aircraft availability, and lower maintenance costs.

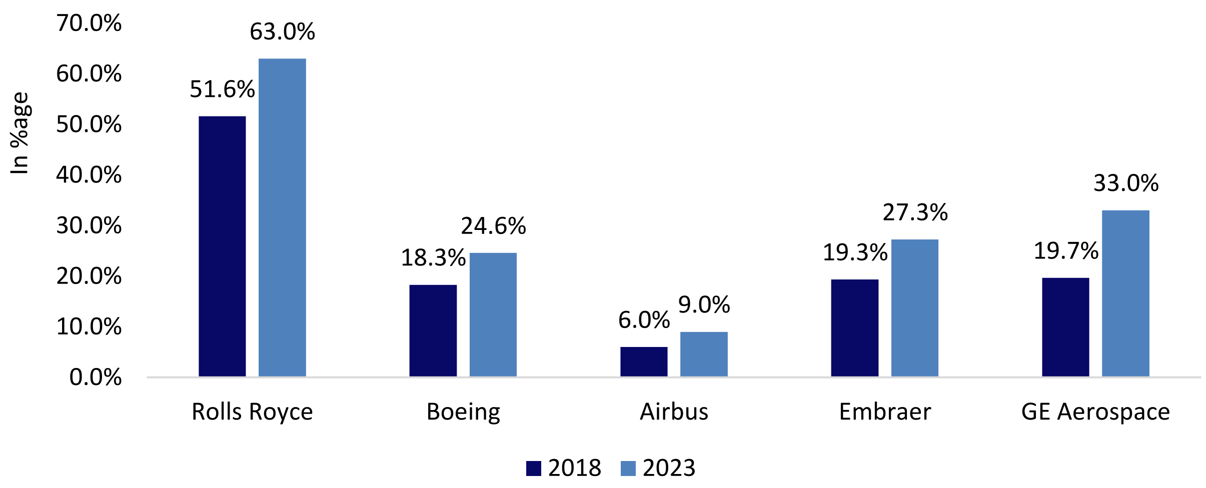
- **Augmented Reality (AR) and Virtual Reality (VR)**: AR and VR are being used to provide technicians with real-time information and guidance during maintenance tasks. These technologies can overlay digital information onto the physical world, allowing technicians to see inside components and systems without disassembling them. This can help reduce maintenance time, increase accuracy, and improve safety.
- **Additive Manufacturing**: Additive manufacturing, also known as 3D printing, is being used to produce spare parts and components on demand. This can help reduce inventory costs, lead times, and logistics costs. It can also help produce complex and custom parts that are difficult or impossible to produce using traditional manufacturing methods. Boeing reported that it would save around USD 2 million. to USD 3 million per B787 aircraft due to use of 3D printed titanium parts. Similarly, 3D printing also reduces the part cost by 50% and time to market by 64%.
- **Blockchain**: Blockchain is being used to create a secure and transparent record of maintenance activities and component history. This can help reduce fraud, improve traceability, and enhance safety. It can also help streamline supply chain processes and reduce administrative costs. This technology has gained importance in the recent months due to reports of fake parts on aircraft.
- **Robotics and Automation**: Robotics and automation are being used to perform repetitive and dangerous tasks, such as cleaning and inspection. These technologies can help reduce maintenance time, increase accuracy, and improve safety. They can also help reduce labour costs and improve productivity. These technologies are transforming the aircraft MRO industry, making it more efficient, cost-effective, and safe. However, the adoption of these technologies requires significant investment and expertise. MRO providers must carefully evaluate the benefits and costs of these technologies and develop a clear strategy for implementation.

Types of Commercial Aircraft MRO

Commercial Aircraft MRO activities can be categorized into four main types: engine, airframe, line maintenance, and component maintenance, it is also referred as Check A, C and D.

- **Engine maintenance**: This involves the inspection, repair, and overhaul of aircraft engines. Engine maintenance is crucial for maintaining the performance and safety of the aircraft. It includes the replacement of worn or damaged parts, testing, and calibration of engine systems. They typical time frame for Engine Maintenance is around 6-8 years.
- **Airframe maintenance**: This type of maintenance focuses on the aircraft's structure, including the fuselage, wings, and control surfaces. Airframe maintenance involves the inspection, repair, and replacement of structural components to ensure the airworthiness of the aircraft. The airframe maintenance is usually scheduled between 18 months to 2 years.
- **Line maintenance**: This type of maintenance is performed on the aircraft during scheduled stops, such as at airports or during flights. Line maintenance checks all operational fluid levels and minor maintenance are undertaken at the parking bay.
- **Component maintenance**: This involves the inspection, repair, and replacement of aircraft components, such as landing gear, hydraulic systems, and electrical systems. Component maintenance ensures that these critical systems function correctly and safely.

Exhibit 142: Service Revenue Contribution of Major OEMs in Aerospace and Defence, 2018 Vs 2023

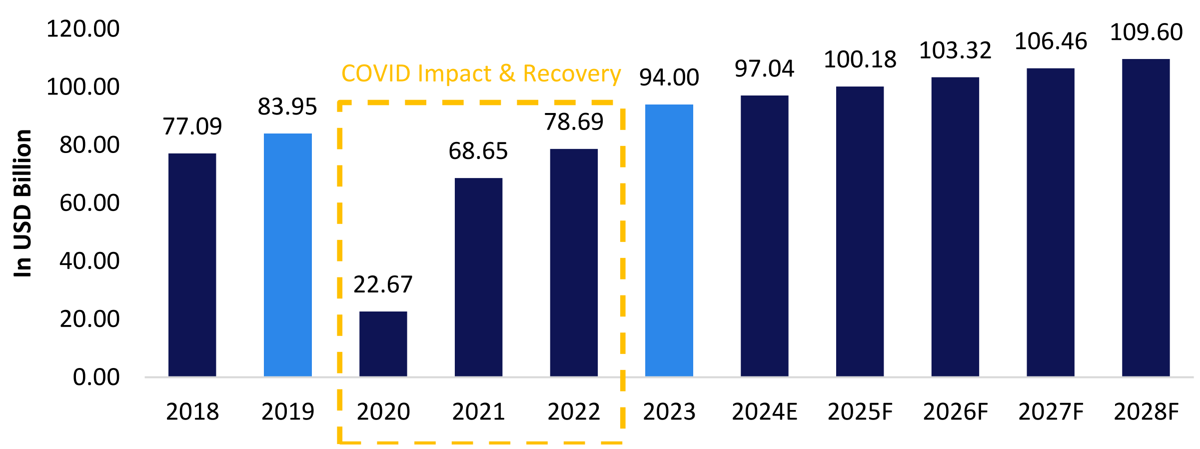


Source: Frost & Sullivan Estimates

The key advantage of the OEM MRO service providers is the superior technology enabled maintenance service with the use of tools like real time monitoring. However, the cost would be high compared to third party or in-house maintenance. In modern engine deals additional areas like standby engines for replacement and services are built into the contract.

Global MRO Market: Sizing and Forecast

Exhibit 143: Global MRO Market, 2018- 2028



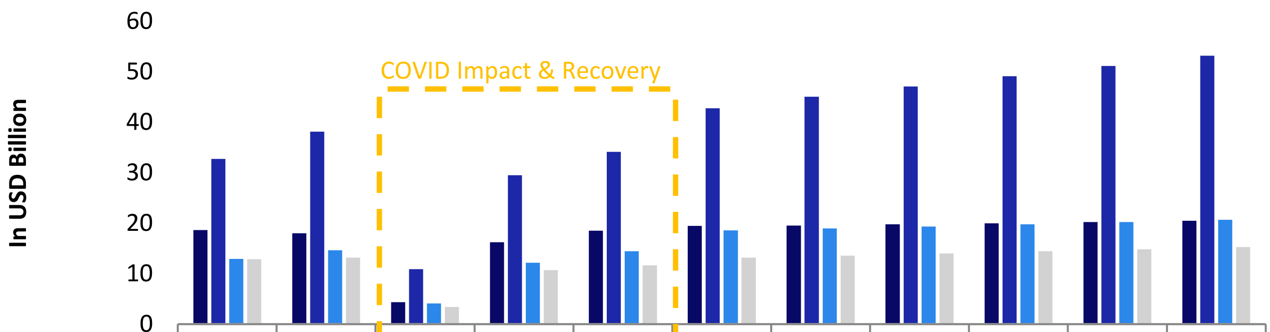
Source: Frost & Sullivan Estimates

E-Estimated, F-Forecasted

- Large airlines in US and Europe have their own in-house MRO services.
- The airlines with in-house MRO also outsource their services to other airlines, there by generating additional revenue.
- The market in 2023 has recovered from the impact of COVID-19. The Global Commercial aircraft MRO market is estimated at **USD billion 93.90 in 2023** and is expected to grow at a **CAGR of 3.1%** during the period **2023- 2028F** to reach **USD billion 109.60 in 2028F.**
- The key drivers for the market are the increase in aircraft deliveries, ageing of existing fleet and the increase in low-cost carrier models.

Global MRO: Market Sizing and Forecast: by MRO Type

Exhibit 144: Global MRO Market, By MRO Type, 2018- 2028F



	2018	2019	2020	2021	2022	2023	2024E	2025F	2026F	2027F	2028F
Airframe	18.63	18.03	4.35	16.24	18.52	19.45	19.53	19.76	19.99	20.22	20.45
Engine	32.72	38.12	10.87	29.51	34.1	42.75	45.04	47.08	49.12	51.16	53.20
Component	12.91	14.61	4.07	12.18	14.43	18.60	18.93	19.36	19.79	20.22	20.65
Line	12.83	13.19	3.38	10.72	11.64	13.20	13.54	13.98	14.42	14.86	15.30

Source: Frost & Sullivan Estimates

E-Estimated, F-Forecasted

- **The Engine MRO** segment accounted to **USD 42.75 billion** or 46% of the total MRO revenue in 2023 and expected to grow to **49% by 2028** to reach **USD billion 53.20 by 2028.**
- The engine MRO market is expected to grow at a **CAGR of 4.5%** and is the fastest growing market. The second fastest growing market is the line maintenance market which is expected to grow at a CAGR of 3.0% during the forecast period **2023-2028F from USD 13.2 billion in 2023 to 15.30 billion in 2028.**
- The line maintenance segment is expected to account for **14% of the total MRO market in 2028F.** CFM 56 & Leap engines have come into maintenance phase increasing the number of tools needed by MRO shops. Further, the establishment of new MRO shops will help increase the overall market demand from MROs. For example: Safran is establishing an aero-engine MRO facility in India, Hyderabad will enable new demand from such MRO and result into significant cost savings in terms of supply and logistics.

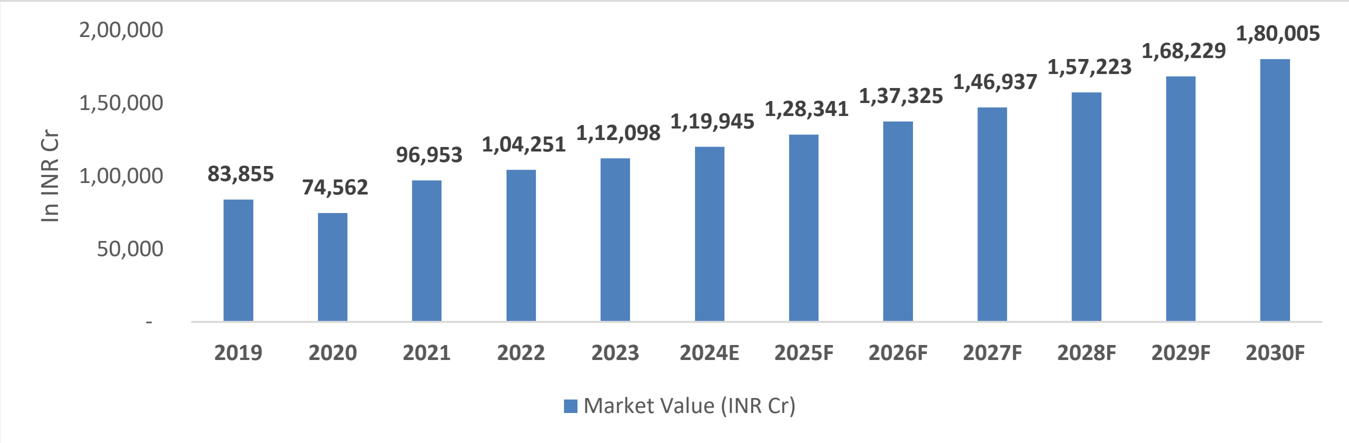
3.3.2 Aerospace India Overview:

- The Indian Aerospace sector is on a high growth trajectory driven by passenger traffic the past five years at over 15% per year and this has increased from around 70 to 200 million passengers in the past 10 years in domestic and international air travel. Further, the number of flyers from India for international travel is also estimated to be around 100 million last year which indicates high demand for airline services and seats.
- MRO services are gaining the attention of the OEMs and key service providers which is boosting the growth of the sector. The production of commercial aircraft is experiencing growth due to factors such as population increase and expansion in trade.
- A typical commercial aircraft incorporates approximately 450 structural forged parts along with numerous forged engine components. Forged parts are favored in aircraft construction due to their excellent strength to weight ratio.
- India is expected to overtake China and the United States as the world's third-largest air passenger market in the next ten years, by 2030, according to the International Air Transport Association (IATA).
- As of June 2024, airports in India pegged the domestic passenger traffic to be **81 million, a 5.6% YoY** growth, and international passenger traffic to be 18.54 million, a 14.2% YoY growth, over the same period last year.

- Forged Components requirement will be boosted with the growth of MRO sector in India.

India Overall Components Market Trend: Aerospace, FY 2019-2030

Exhibit 145: India Overall Components Market Trend, Aerospace, INR Cr, FY 2019-30



Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

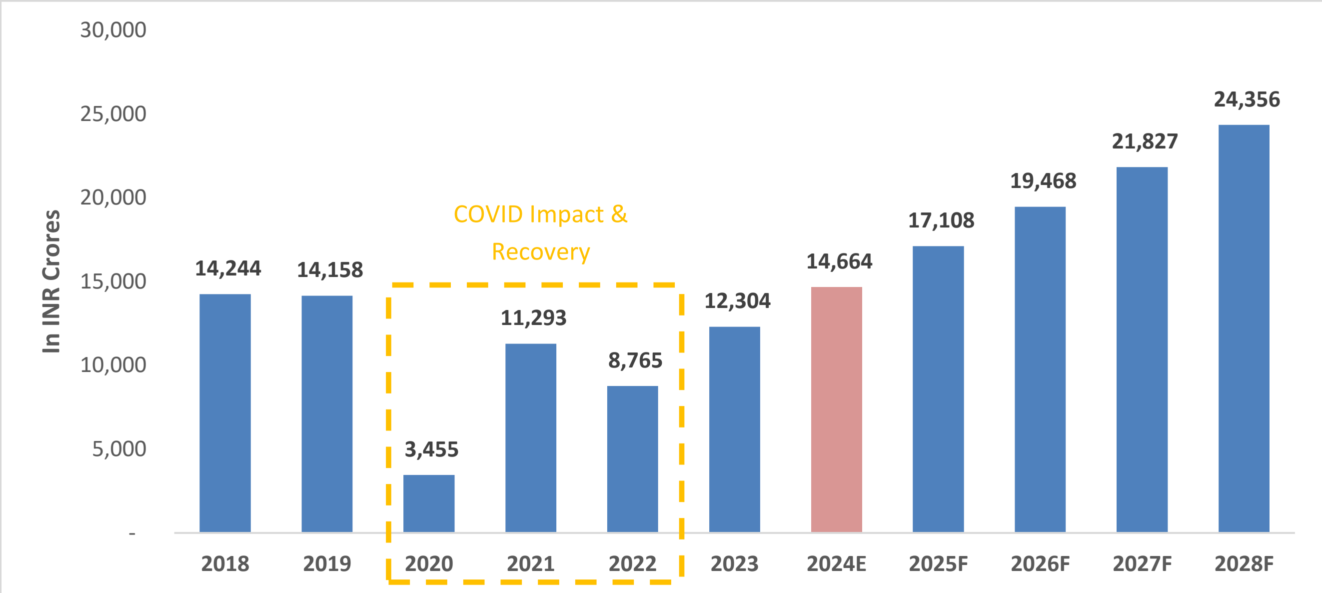
- Indian Overall Aerospace Components Market was valued at **INR 1,19,945 Crores in FY 2024** and is projected to mark **INR 1,80,005 Crores by 2030** with a **CAGR of 7% from FY 2024 to 2030** by increase in demand of aircraft components such as **air fuselage, landing gear, Engine discs, components of wings, undercarriage components, aircraft structural systems propelled by requirement of more number of aircrafts to combat growing air passenger traffic** and **growing Aerospace MRO market in India.**

Key Trends and Business Models

There are three key business models in the commercial aircraft MRO market, they are:

- **<u>In- House MRO</u>**
  - In-house MRO (Maintenance, Repair, and Overhaul) business models refer to the strategies adopted by airlines to manage and maintain their aircraft fleets in-house, rather than outsourcing the work to third-party MRO providers. This approach can be beneficial for commercial air carriers that have the resources and capabilities to invest in their own infrastructure, as it allows them to control the entire maintenance process and ensure that their aircraft are maintained to the highest standards.
  - In conclusion, in-house MRO business models can be beneficial for commercial air carriers that have the resources and capabilities to invest in their own infrastructure. However, it requires a significant upfront investment and ongoing maintenance costs.
- **<u>Third Party MRO Service Providers</u>**
  - Third-party Maintenance, Repair, and Overhaul (MRO) business models have emerged as vital components in industries reliant on complex machinery and equipment. These models offer specialized services to maintain, repair, and overhaul assets, enabling organizations to focus on core operations while outsourcing technical expertise.
- **<u>OEM MRO Service Providers</u>**
  - In OEM MRO service provider model the maintenance services are provided by the OEMs. The OEMs are predominantly present in the Engine maintenance segment of the MRO. In companies like Rolls Royce, 64% of the commercial aviation revenues are accounted for from services, which includes MRO

Exhibit 146: Indian MRO Market Size (2018-2028F)



Source: Frost & Sullivan estimates

E-Estimated, F-Forecasted

- The Indian airlines have been taking aircraft to Southeast Asian countries and Middle East to cater to the MRO needs, predominantly due to the taxation issues and lack of skilled labour in India. Even though the basic checks take place in India, the major MRO works are conducted outside India.
- The Indian MRO commercial market has experienced a rebound post the COVID-19. The market reduced to **INR 3,455 Crores in 2020 from INR 14,158 Crores in 2019**. The bankruptcy of Jet Airways in 2019 coupled with the impact of COVID-19 are the key reasons for the market to shrink in 2020. The market is projected to grow at a **CAGR of 14.6% between the period 2023- 2028F from INR 12,304 Crores to INR 24,356 Crores in 2028F.**

Potential of MRO in India

Factors which are expected to provide necessary fillip to the Indian MRO Industry are:

- **Rising Demand because of growing fleet size:**
  - Various MRO facilities are being built to promote localization. Air India is developing Mega MRO facility in **Bengaluru India with an investment of INR 1,400 Crores and the operation is expected to commence from early 2026.**
  - OEMs and leading MROs across the world. Various domestic and foreign investors could also consider investing in the MRO sector in India by way of alliance and collaboration.SR Technics announced its selection by Air India, India's largest full-service global carrier, as the partner of choice for long-term maintenance support of the airline's CFM56-5B/-7B engine fleet.
  - Under the terms of the six-year agreement, SR Technics will provide comprehensive MRO services for Air India's fleet, ensuring the highest levels of engine performance and operational reliability.
  - The MoU between Air India Engineering Services Ltd. (AIESL) with Pratt & Whitney – to launch a joint engine MRO facility in Mumbai – and the venture between Wadia group and SIA Engineering Company have been key developments in the sector.
- **Availability of low-cost diverse pool of workforce:**
  - India is globally recognized for its strong engineering curriculum. This holds true for the MRO industry as well, wherein the scope of benefiting from a strong and competent workforce is considerable. One of the

most significant benefits that India provides to the rest of the world is the availability of highly qualified engineers with the capability of being trained for an array of technical MRO activities.

- Another important reason that puts India on the map for MRO activity is its cost advantage. Labour cost which forms a considerable share of overall cost in airframe and component maintenance is comparatively lower in India, thereby ensuring higher labour arbitrage as compared to global counterparts.

- **Prevalent sale and lease back model providing a large scope for redelivery maintenance services:**

Redelivery maintenance is an important aspect of an airline and lessor's MRO requirements, especially in India, where the sale-and lease-back model is common. This is a big opportunity for component repair as well as heavy maintenance.

Collaboration between Aircraft makers and the technology providers are in trend.

The new face of Indian Aerospace: Tata Boeing JV

The Tata Boeing Aerospace Limited (TBAL):

- The Tata Boeing Aerospace Limited (TBAL) facility represents the future of India as a global exporter of aerospace. Spread over 14,000 square meters, the state-of-the-art manufacturing facility located at Hyderabad, India has been producing aero-structures for Boeing's AH-64 Apache helicopter, including fuselages, secondary structures and vertical spar boxes for customers worldwide. TBAL is setting an example of Boeing's commitment towards Aatmanirbhar Bharat and the co-development of integrated systems in aerospace and defence not just for India, but for the world.
- After the foundation of the facility was laid in 2016, TBAL delivered the first Apache fuselages in 2018. In July 2021 TBAL delivered the 100th fuselage for the AH-64 Apache combat helicopter to Boeing. TBAL, as of today, has delivered over 250 AH-64 fuselages. TBAL also manufactured and shipped its first vertical fin structure for the 737 airplane.

TATA Advanced Systems (TASL):

- Tata Advanced Systems Limited (TASL), a wholly owned subsidiary of Tata Sons, is the strategic Aerospace and Defence arm of the TATA Group. Tata Advanced Systems Limited is one of the country's leading private players for aerospace and defence solutions and aspires to be the 'Partner of Choice', especially for the government's 'Make in India' program and for global Original Equipment Manufacturers (OEMs).
- Tata Advanced Systems provides full range of Integrated solutions across Aerostructures & Aero-Engines, Airborne Platforms and Systems, Defence & Security and Land Mobility.
- Tata Advanced Systems are working with top notch OEMs and Tier 1 global suppliers such as Airbus, Boeing, Collins Aerospace, Dassault Aviation, Lockheed Martin, GKN Aerospace, Spirit Aerosystems.
- As a major milestone for India's Aerospace & Defence industry, Tata Advanced Systems Limited (TASL) and Airbus inaugurated the Final Assembly Line (FAL) complex for the Airbus C295 aircraft in Vadodara, Gujarat in India.
- TASL and Airbus are partnering for the pioneering 'Make in India' project to deliver 56 C295 aircraft to the Indian Air Force (IAF).
- As per the contract, 40 units will be manufactured and assembled in partnership with TASL at this FAL, while 16 will be delivered to the IAF in 'fly-away' condition from Airbus' final assembly line in Seville, Spain.
- In September 2024 Tata Advanced Systems has entered into an agreement with U.S. aviation giant Lockheed Martin to "expand C-130J Super Hercules opportunities in India".

TATA Sikorsky Aerospace Limited:

- A Joint Venture (JV) based in Hyderabad, Telangana, India, between Tata Advanced Systems Limited, India and Sikorsky Aircraft Company, USA.
- Primarily started with focus on manufacturing parts for the S-92 Helicopter Cabins and has expanded its capacity and capabilities to serve more Customers / Programs in Aerostructures and Aero-engines**.**

Godrej Aerospace:

- The Company is a tier 1 manufacturer of precision and hi-tech aerospace components, assemblies and systems, executing global aerospace projects as well as partnering with global majors like Honeywell, GE, Rolls-Royce, and Boeing for the manufacture of precision component.
- Won an order for manufacturing eight modules of the DRDO turbojet Engines and became the first Indian Company to manufacture this class of Engines.
- The Company started with developing high precision components made of exotic alloys for the spacecrafts built by Indian Space Research Organization (ISRO) for its missions.
- Company is committed contributing to the Indian government's Make-In-India initiative and helping India achieve self-sufficiency in developing indigenous advanced fighter jet engines.
- Invested 500 crores for aerospace and defence projects and has incorporated new processes into its manufacturing processes.

Upcoming Aerospace Corridors in India

Government has set up some Aerospace Parks in select States of India such as Tamil Nadu, Kerala and Karnataka. to promote the Aerospace Industry.

Exhibit 147: Aerospace Corridor: Tamil Nadu

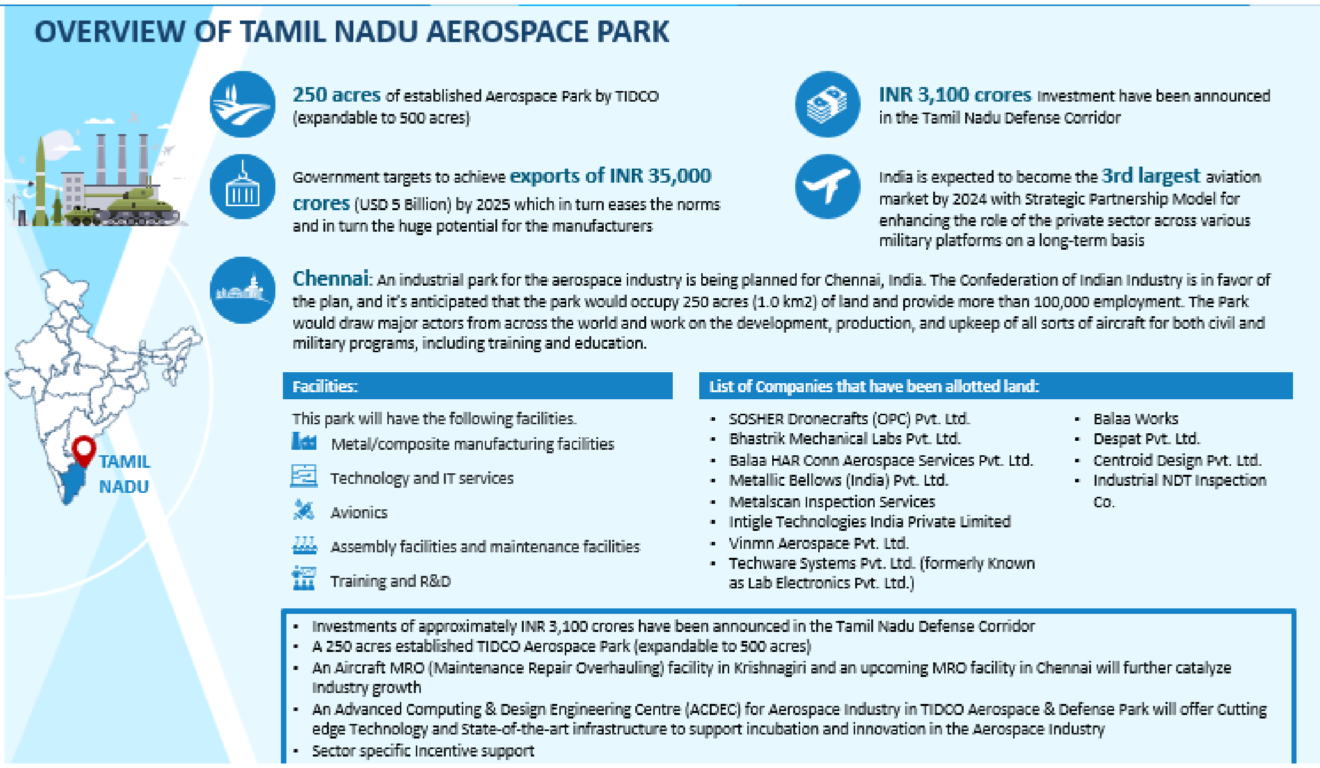
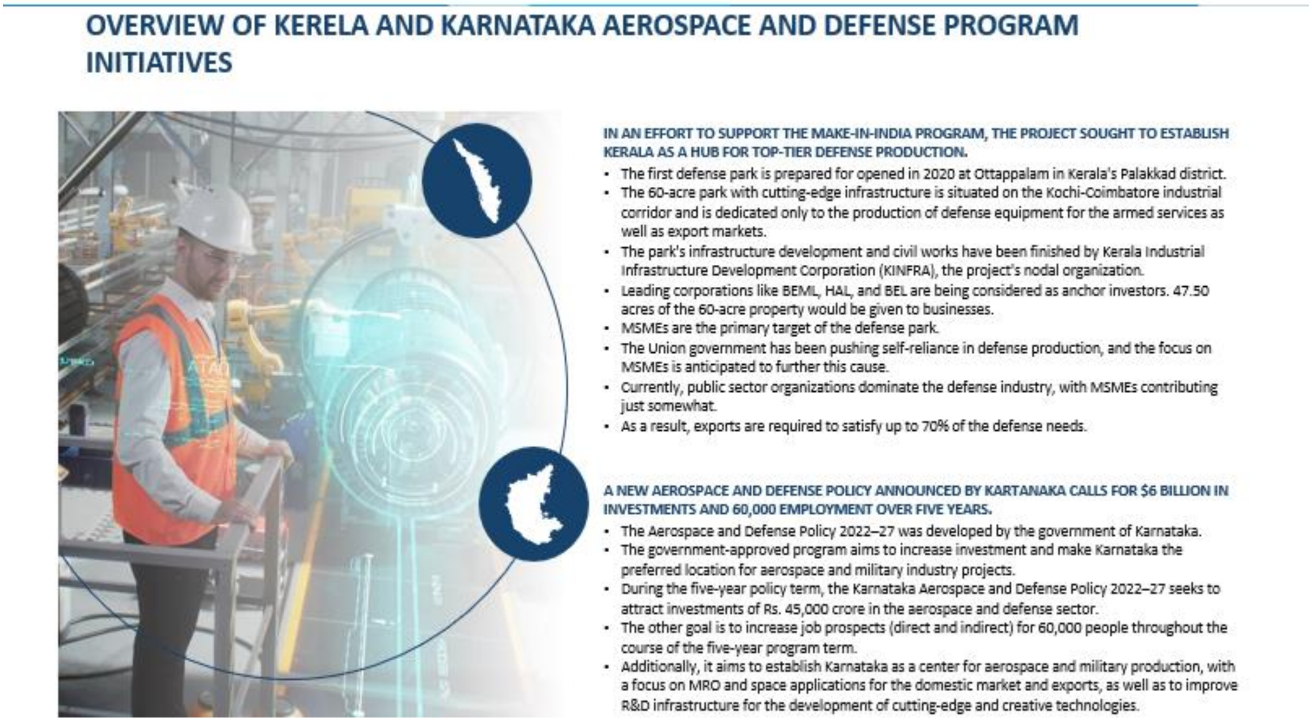


Exhibit 148: Aerospace Corridor, Kerala & Karnataka



Government Policies and Regulations:

- The Indian government's proactive approach in formulating policies and regulations to support the aviation sector has been instrumental in its growth. Policies aimed at promoting air travel, reducing costs, and enhancing safety are continuously being developed and implemented.
- The relaxation of FDI norms, the UDAN scheme for regional connectivity, and various safety regulations ensure that the industry remains competitive and robust. These policies not only attract investments but also ensure that the sector operates efficiently and safely.

Growth of Indian Aerospace segment will create the need for a greater number of airplanes and airports and to maintain the availability of the fleets MRO Service will flourish which is expected to bring opportunities for manufacturers for the supply of forged and other components required for smooth functioning of the aircrafts.

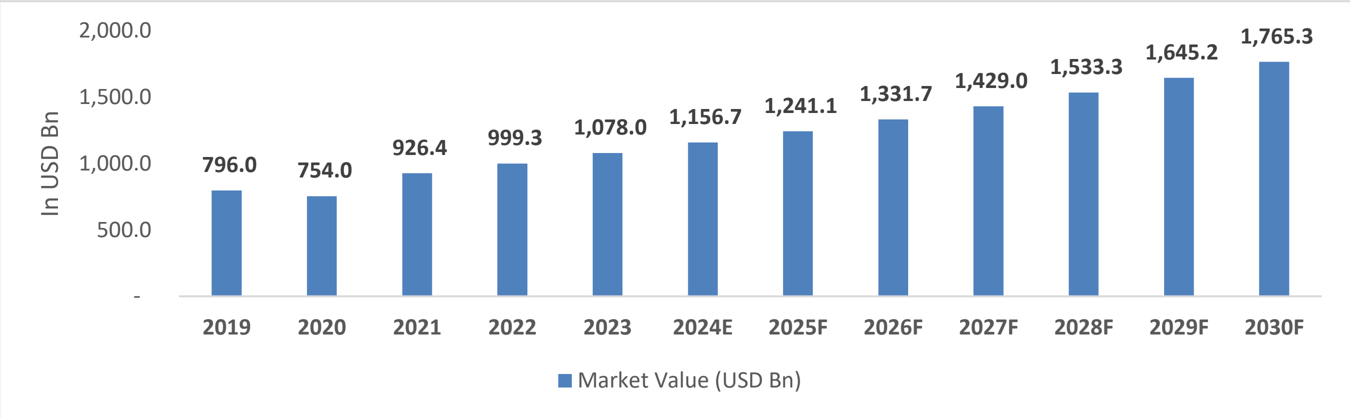
3.4 Defence

3.4.1 Defense Global Overview

- The world is ever-changing, and with emerging geopolitical tensions, weapons stock depletion, and increasing global defence spending, the stage is set for significant developments.
- Geopolitical tensions and weapons depletion are fueling a surge in global defence spending. **In terms of GDP, it grew from 2.3% to 2.4%** of global GDP from 2022 to 2023.
- The US, China, Russia, India, and Saudi Arabia contribute 63% of this figure, highlighting the growing focus on national security amidst a complex geopolitical landscape. In Europe, Germany alone has announced a spending **of USD 108.32 billion in defence** in response to the ongoing Ukraine-Russia conflict. Investments in defence segment is expected to boost the metal forgings requirement in this segment

Global Overall Components Market Trend: Defence, 2019-2030

Exhibit 149: Global Overall Components Market Trend, Defence, USD Bn, 2019-30



Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global Overall Components Market for Defence was valued at **USD 1,078 Bn in 2023** and is projected to mark **USD 1,765.3 Bn by 2030** with a **CAGR of 7.3%** from **2023 to 2030 driven by the growth of components such as Armored Vehicles parts for Engines, Suspension, turret, main body, track Armaments and Ammunition: Body, Extractors, ejectors, barrel Military Hardware: Parts for engines, suspension, main body and Track.**

Global Conflicts:

<u>Israel – Palestine Conflict</u>

- The Israel-Palestine conflict of 2023 is one of the most complex conflicts in recent past that has had a strong impact on the geopolitics of the Middle East and significant repercussions in military spending plans globally.
- The ongoing war has created need for defense equipment from the western region

<u>Iran- Israel Tensions</u>

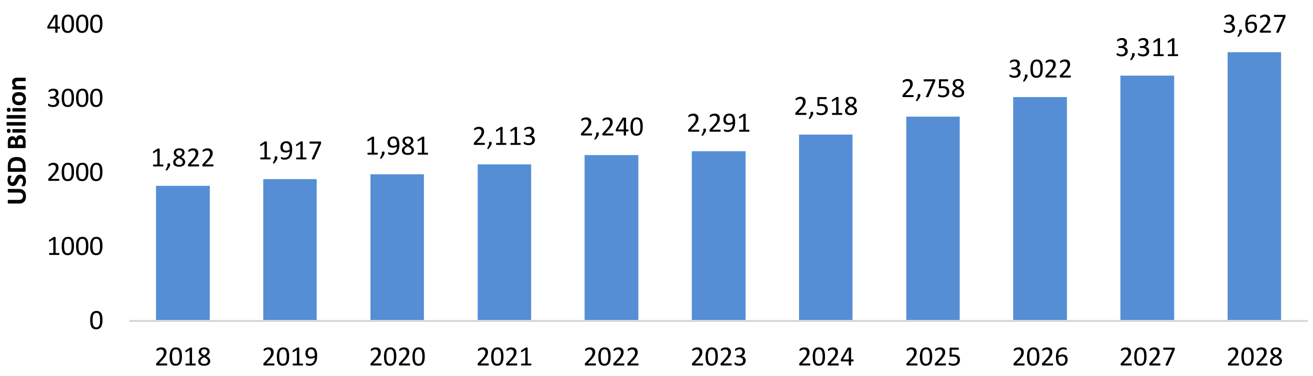
- Iran launched its first direct attack on Israel on 13th April 2024, in response to an air strike on Tehran's consulate in Damascus on 1st April 2024. As tension escalates, the head of the United Nations nuclear watchdog expressed concern about Israel potentially targeting Iranian nuclear facilities.
- The Israel-Iran conflict carries significant implications for the broader international community. The prospect of a military confrontation between two nuclear-capable states in a strategically vital region has sparked fears of a wider conflagration with potentially catastrophic consequences.

- Furthermore, the interplay of regional rivalries and global power dynamics, including the involvement of major players such as the United States and Russia, adds another layer of complexity to the conflict.

Ukraine – Russia Conflict

- The ongoing conflict between Ukraine and Russia has reshaped the geopolitical landscape of Eastern Europe, with significant implications for global military spending for Ukraine and Russia and its allies. Ukraine's political orientation has escalated into a conflict involving military intervention, territorial annexation, and geopolitical maneuvering.

Exhibit 150: Global Military Expenditure Trends and Outlook (In USD billion) (2018-2028F)

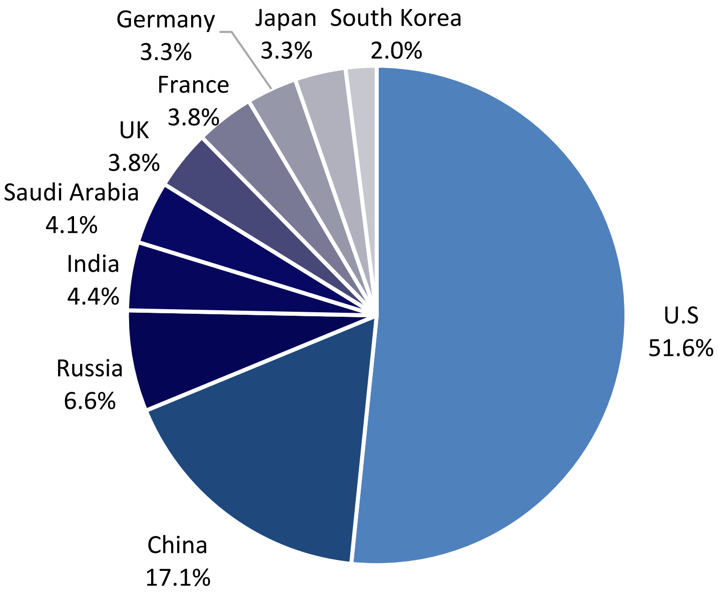


Source: SIPRI and Frost and Sullivan estimates

Global Defence Spending

- Russia has set a revenue target of **USD 391.20 billion for 2024 which is a 22.3%** increase compared to 2023.
- **Russia** increased its military spending, and the armed forces received approximately 30% of fiscal expenditure in 2024.
- **The U.S Department of Defence (DoD)** has requested a budget of **USD 842 billion for 2024**, an increase of **USD 26 billion over 2023 levels and USD 100 billion over 2022**. A record USD 145 billion is being requested for research, development, test, and evaluation (RDT&E) in the 2024 budget request. Around USD 170 billion is expected to be allocated to procurement.
- **Japan** has allocated USD 54.25 billion defence budget for 2024. This is to counter the changing security environment, which is influenced by North Korean aggression and frequent conflicts with China.
- **China** has proposed an increase of defence spending by 7.2%. USD 236.10 billion in 2024. Chinese defence spending is 4X of Japan’s defence spending.

Exhibit 151: Global Top 10 Defence Spenders, (In USD Billion), 2023



Source: SIPRI and Frost and Sullivan estimates

Trends in Global Military Spending:

- Military spending has been on the rise in recent years, with many countries increasing their defence budgets. This trend is driven by various factors including regional tensions, modernization of military equipment, and responses to emerging security threats.

Regional Variances:

- The distribution of military spending varies significantly by region, depending on the geopolitical situation. Countries in regions with ongoing conflicts or security challenges tend to allocate a larger portion of their budgets to defence. The Middle East, for example, has historically been a region with high military spending due to regional conflicts and geopolitical tensions.

Technological Advances:

- Technological advancements are shaping the future of military expenditure. Modernization efforts often focus on acquiring cutting-edge technologies such as cyber capabilities, unmanned systems, and artificial intelligence. Countries are investing heavily in research and development to maintain a technological edge over potential adversaries.

Budgetary Pressures:

- While some countries are increasing their military spending, others face budgetary constraints that limit their ability to invest in defence. Economic downturns or competing domestic priorities can impact military expenditure.

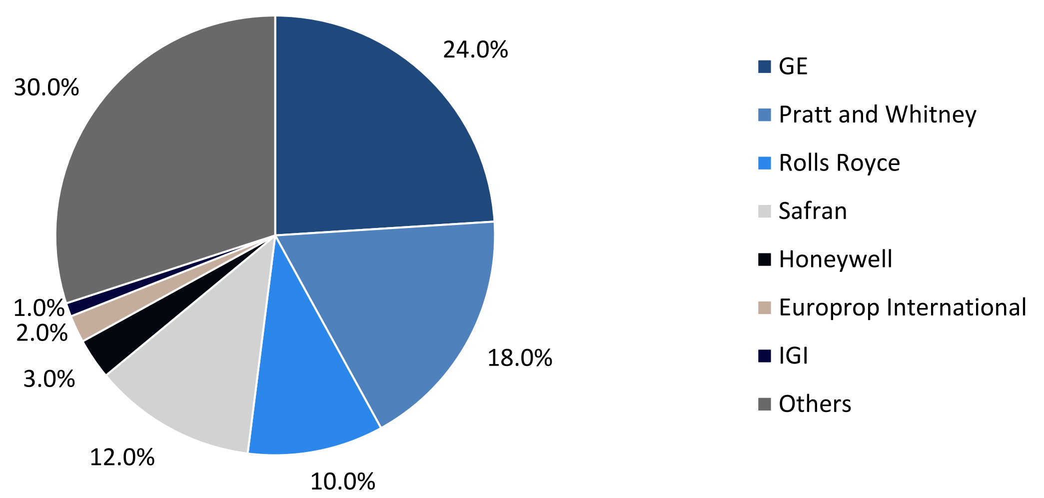
Geopolitical Dynamics:

- NATO heads had committed 2% of the GDP on defence spending in 2014, the collective commitment was aimed at increasing the overall defence capabilities and combat readiness of NATO forces. European NATO countries have increased their collective spending on defence from **1.5% in 2014 to 2.0% in 2024** and this accounts to USD 380 billion.
- Around **20%** of the collective spending towards defence are expected to be spent on Research & Development of new systems.

- With the rise in conflicts between the nations, across the globe countries have allocated more money to Defence and Security. The growth of Defence sector will boost the opportunities forgings manufacturer as need for forged components in the segment will increase.

Overview of Defence Aircraft Engine in Service,2023

Exhibit 152: Defence Aircraft Engine in Service,2023



Source: Estimated from Ministry documents

- **70%** of the global defence aircraft engine market lies **with 7 companies only in 2023** which represents a competitive market. **General Electric (GE) Aviation** is a significant player in the military aircraft engine market holding a **24% share in 2023**.
- **GE engines,** such as the **F110 and F414**, power a variety of military aircraft worldwide, including fighters such as the **F-15 and F/A-18.** The F110 powers the new, fly-by-wire F-15EX Advanced Eagle, the fifth F-15 variant designed to replace the oldest **F-15s** in the U.S. Air Force fleet. It is estimated that more than **100 F-15EX** multirole fighters will be purchased.
- **Pratt & Whitney** accounts for **18%** of the market share of defence aircraft engines and is the 2nd largest player in the same, producing engines such as the **F135,** which powers the **F-35 Lightning II**, one of the world's most advanced fighter aircraft.
- **Pratt & Whitney**'s **F-22 Raptor** and the **C-17 Globemaster III** are some major Engines, controlling 18% of the military air engine market. It recently secured **the sole-source contract for F-35 engine upgrades**. The program, known as **the Engine Core Upgrade (ECU)**, is scheduled to begin with engine testing in **2026 and fielding in 2029.**
- Other significant players in defence aircraft engines are **Safran and Rolls Royce with 12% and 10% market** share respectively in 2023. Other small players are **Honeywell, Euro prop International and IGI with market shares between 1-3% in 2023.**

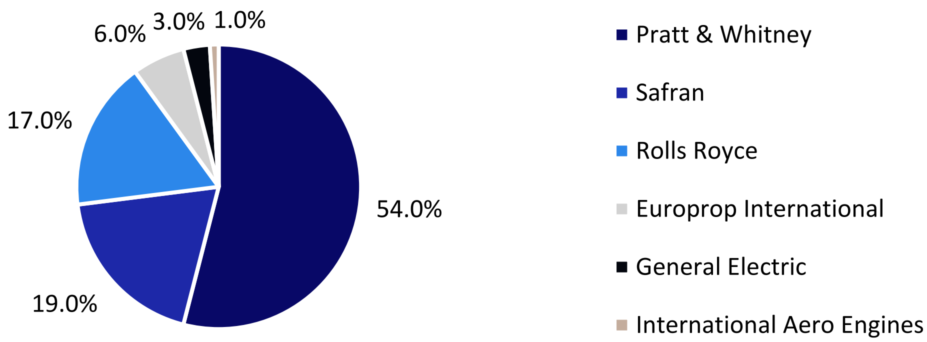
Exhibit 153: List of Defence Aircraft Programs and their Engine Supplier

Name of the Aircraft Program	Type of Aircraft	Airframe OEM	Engine OEM	Engine Name
F-35	Fighter	Lockheed Martin	Pratt & Whitney	F- 135
Eurofighter Typhoon	Fighter	Eurofighter Jagdflugzeug Gmbh	Rolls Royce	EJ- 2000
Rafale	Fighter	Dassault	Safran	Snecma M88

Name of the Aircraft Program	Type of Aircraft	Airframe OEM	Engine OEM	Engine Name
F-15 E	Fighter	Boeing	Pratt & Whitney	F100 PW 229
F/A-18	Fighter	Boeing	GE Aerospace	F414 GE 400
Gripen E	Fighter	Saab	GE Aerospace	F414 GE 39E
LCA-Tejas	Fighter	HAL	GE Aerospace	F404 IN20
C-130	Transport Aircraft	Lockheed Martin	Rolls Royce	AE 2100
A-400 M	Transport Aircraft	Airbus	Euro Prop	TP400
C-27 J	Transport Aircraft	Leonardo's Aircraft Division	Rolls Royce	AE 2100
C-390/ KC 390	Transport Aircraft	Embraer	International Aero Engines	V2500
C-295	Transport Aircraft	Airbus	Pratt & Whitney	PW100
A-330 MRTT	Transport Aircraft	Airbus	GE Aerospace	CF6
C-17	Transport Aircraft	Boeing	Pratt & Whitney	PW2000
KC-46	Transport Aircraft	Boeing	Pratt & Whitney	PW4062
P 8	Special Mission	Boeing	CFM International	CFM56
Embraer E-99	Special Mission	Embraer	Rolls Royce	AE3007
Global 6000	Special Mission	Bombardier	Rolls Royce	BR710A2
EC-37B	Special Mission	General Dynamics	Rolls Royce	BR710 C4-11
ERJ-145I	Special Mission	Embraer	Rolls Royce	AE 3007

Source: Frost & Sullivan Analysis

Exhibit 154: Defence Aircraft Engine Orders, 2023



Source: Estimated from Ministry documents

- The global defence aircraft engine orders are highly concentrated with only 6 players in the market and **87%** of it in the hands of **3 players- Pratt and Whitney, Safran and Rolls Royce in 2023**.
- The US driven F35 program is the leading fifth generation aircraft program in the world to meet the future operational requirements of the US and its allied forces, at an overall estimated cost of USD 1.70 trillion.

- The F35 program is expected to predominantly replace the aging fleet of F16s, A10s and F18s. The F35 is a single engine multirole fighter aircraft developed by Lockheed Martin, capable of delivering a thrust of 43,000 lbs.

- The Pratt and Whitney accounts to about **54 %** of the total defence aircraft engine, which are in order market due to the backlog of the F35 fleet orders as of 31st December 2023.

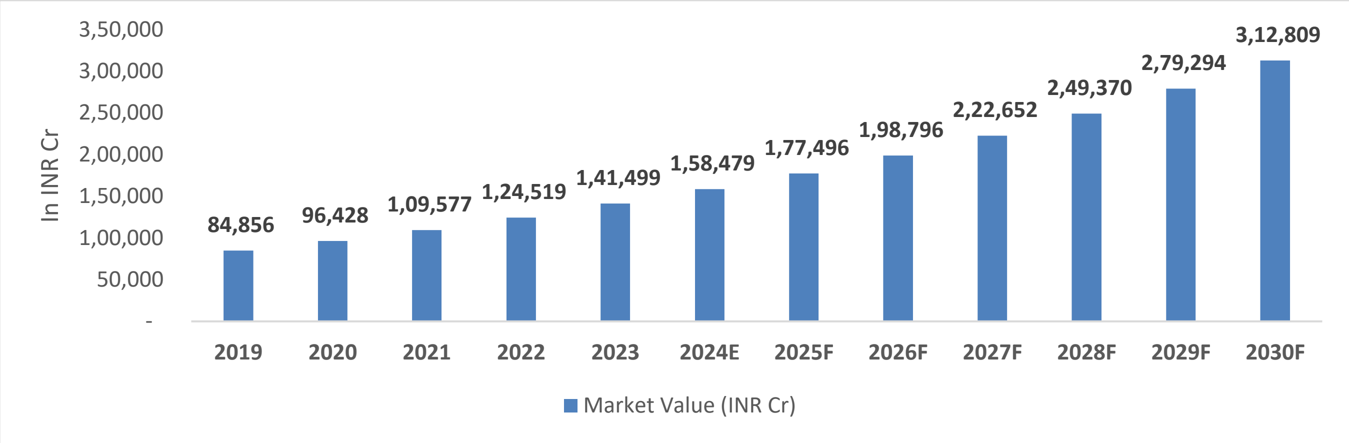
3.4.2 Defence India Overview

- India's Defence sector, **the second largest armed force**, is on the verge of a revolution. The government has identified the defence and aerospace sector as a focus area of the Aatmanirbhar Bharat or Independent India initiative, which has a huge push to build a domestic manufacturing infrastructure backed by an R&D ecosystem.
- The Defence segment got **6.22 Lakhs Crore** in the financial year 2024-25. The allocation to MoD **for FY 2024-25 is higher by approx. Rs one lakh crore (18.43%)** over the allocation for FY 2022-23 and 4.79% more than allocation of FY 2023-24 which clearly shows growing importance of Defence sector in India.
- The allocation breakdown highlights the need for self-sufficiency by showing that a sizeable portion, 27.7%, is set aside for capital expenditures. Furthermore, 30.7% goes into pay and benefits, 22.7% goes toward defence pensions, 14.8% goes for revenue spending to maintain operational preparedness, and 4.1% goes toward MoD-affiliated civic organizations.
- **Forging market for Defence sector** was valued at **INR 1,127 Crores in FY 24** which accounts for **6%** of the total non-automotive forging demand in India. The demand of forgings in Defence sector is estimated to grow at a **CAGR of 12.7 % from FY 2024 to 2030** and estimated to reach **INR 2,307 Crores.**
- The Defence Industry is a major consumer of forging components from small firearm parts to large components for military vehicles and aircraft. **Forged components are integral to various defence equipment including riffle triggers, nuclear submarine drive shafts, heavy tanks missiles and shells.**
- During interim budget FY 2024-25, the Government has made an additional allocation to the tune **of Rs 400 crores on innovation in defence through the Acing Development of Innovative Technologies with iDEX (ADITI) scheme.**
- Through this scheme, Ministry of Defence is engaging with start-ups/MSMEs and innovators to develop Def-Tech solutions and supply the Indian military with innovative and indigenous technological solutions.
- A grant of up to 50% of Product Development Budget with enhanced limit (Max) of Rs 25 crore per applicant will be awarded as per extant iDEX guidelines.
- The Government has announced 2 dedicated Defence industrial Corridors in the States of Tamil Nadu and Uttar Pradesh to act as cluster of defence manufacturing.
- The increase in capital investment in defence is in line with the 'Aatmanirbharta' (self-reliance) strategy. The capital investment would equip the Armed Forces with modern cutting-edge equipment, ships, aircraft, unmanned aerial vehicles, and specialized vehicles.

- The investments are expected to be allocated for the **Su-30 fleet**, further aircraft procurement, upgraded engines for **MiG-29, C-295 transport aircraft**, and **LCA MK–I IOC/FOC program.**
- **As per GFR 2017, amended in June 2020**, Government Initiatives such as Mandate of **No Global Tender Enquiry (GTE) for tenders up to INR 200 Crores** will create **opportunities of localization** by **promoting procurement from domestic manufacturing industries**.

India Overall Components Market Trend: Defence, FY 2019-2030

Exhibit 155: India Overall Components Market Trend, Defence, INR Cr, FY 2019-30



Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

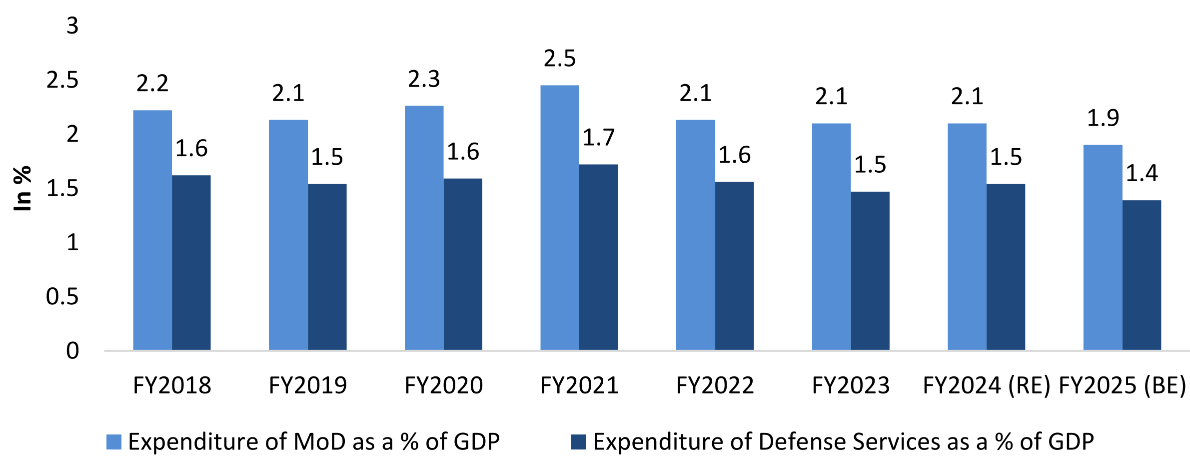
- Indian Overall Components Market for Defence was valued at **INR 1,58,479 Crores in FY 2024** and is projected to mark **INR 3,12,809 Crores by 2030** with a **CAGR of 12% from FY 2024 to 2030** driven growth of demand components **such as Engines, Suspension, turret, main body, track Armaments and Ammunition: Body, Extractors, ejectors, barrel Military Hardware: Parts for engines, suspension, main body and Track and Governments focus on boosting the domestic Defence production.**

Key Components of Defence Aircrafts

An aircraft typically consists of three key components: Outer structure, engine, and operational systems.

- Outer Structure consists of Fuselage, Wings, Empennage, Landing Gears.
- Engine consists of Fan, Compressor, Combustor, Turbine and Nozzle.
- Operational System consists of Avionics Technology, Engine Control Systems, Flight Control Systems, Pneumatic Systems, Hydraulic Systems, Rotary Wing Systems, Fuel Systems and Environmental Control Systems.

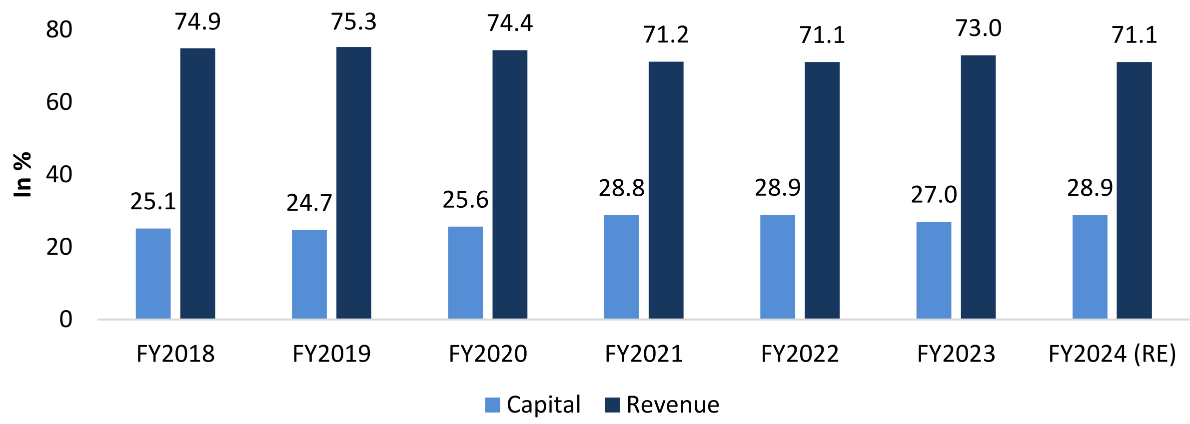
Exhibit 156: MoD and Defence Services expenditure as a % of GDP, (In %), 2018-2025F



Source: Union Budget and Economic Survey

Split of Defence Budget Revenue and Capital

Exhibit 157: Revenue and Capital Budget, (In %), 2018-2024F (BE)

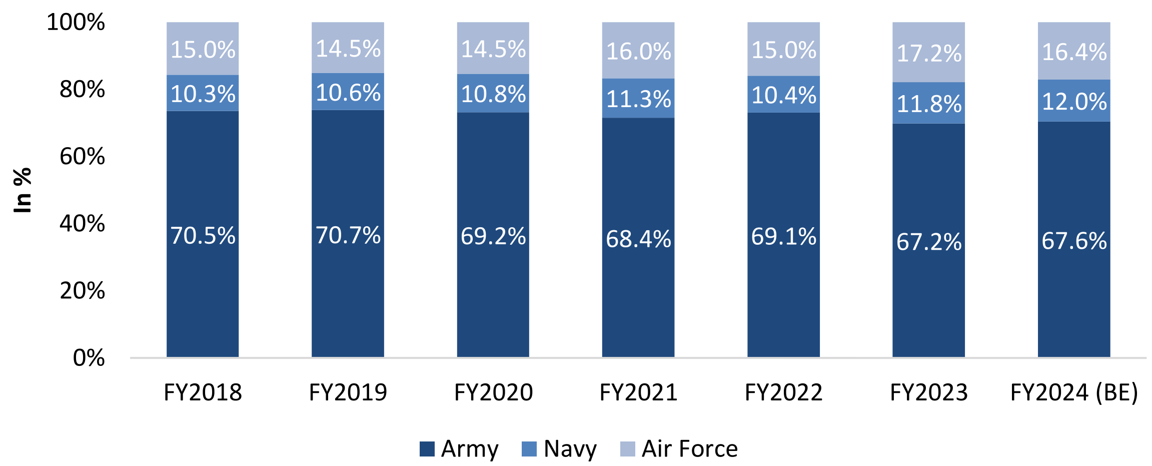


Source: IDSA, Defence Budget 2023-24

- The capital outlay has steadily increased **from 25.1% in FY2018 to 28.9% in FY2024F.** The increase in capital expenditure showcases the increased spending on procurement of new assets across land, naval and air platforms. During the same period, the revenue budget has decreased from **74.9% in FY2018 to 71.1% in FY2024F.**

Indian Revenue Budget Allocation Across Forces

Exhibit 158: Revenue Budget Allocation Across Forces, (in %), 2018-2024F

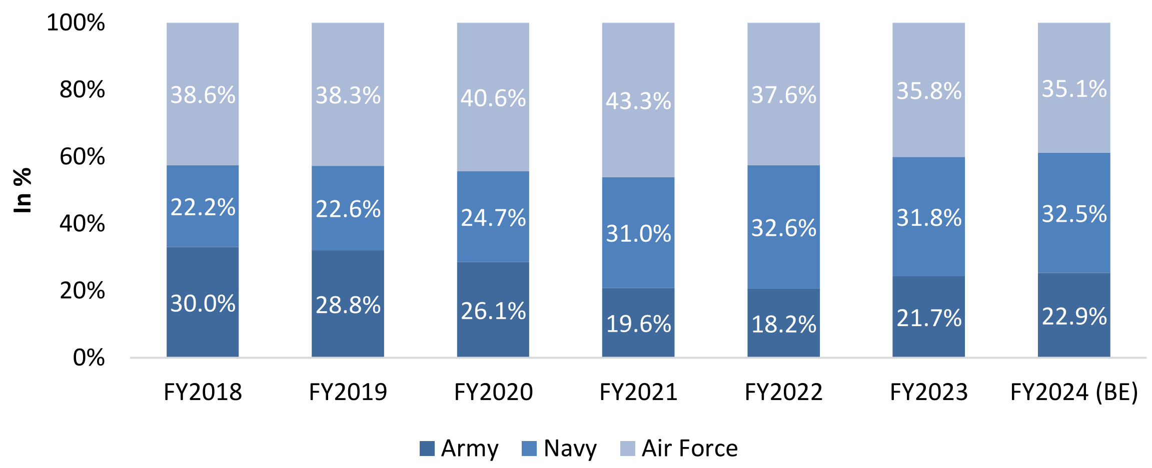


Source: IDSA, Defence Budget 2023-24, Note: Total will not be equal to 100%

- Revenue includes MoD (Civil Revenue), Defence Services (Revenue) and Defence Pensions. The revenue budget allocation of the Air Force and Navy has increased between the period FY2018 to FY2024. However, the revenue budget allocation for army has reduced **from 70.5% in FY2018 to 67.6% in FY2024**.

Revenue Budget Allocation Across Forces

Exhibit 159: Capital Outlay allocation across forces, (In %), 2018-2024F

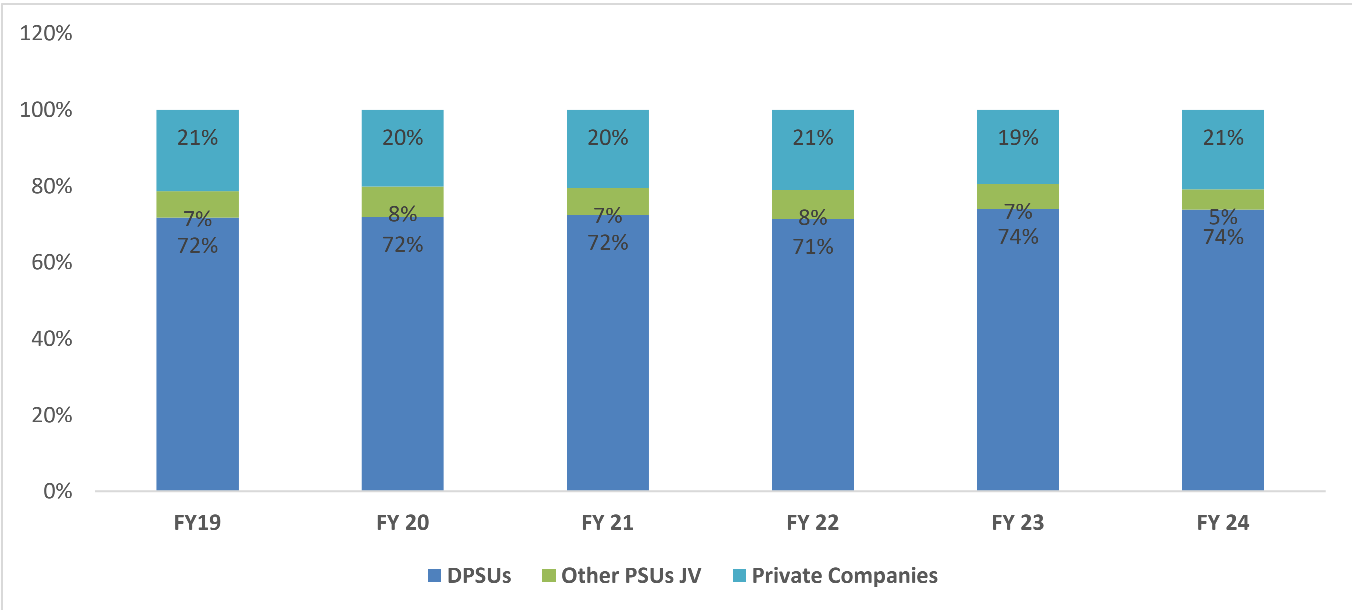


Source: IDSA, Defence Budget 2023-24, Note: Total will not be equal to 100%

- Revenue includes MoD (Civil Revenue), Defence Services (Revenue) and Defence Pensions. The revenue budget allocation of the Air Force and Navy has increased between the period FY2018 to FY2024. However, the revenue budget allocation for army has reduced from **70.5% in FY2018 to 67.6% in FY2024**.

Trends in Defence Production in India

Exhibit 160: Trend in Defence Production in India, FY 2019-24



Source: MoD, Dashboard

- For the year FY 24 the DPSUs contribute **74%** of the total Defence production, Other PSUs & JV **(5%)** and the rest are private sector companies **(21%).** Total Defence production in **FY 24** stood at **INR 1,27,265 Crores** driven by companies

Exhibit 161: Trend in Defence Production sector wise in India, FY 2019-24

Year	DPSUs*	Other PSUs JV	Private Companies	Total Production (INR Crores)
FY19	58,203	5,567	17,350	81,120
FY 20	56,882	6,295	15,894	79,071
FY 21	61,346	6,029	17,268	84,643
FY 22	67,703	7,222	19,920	94,845
FY 23	80,464	7,137	21,083	1,08,684
FY 24	93,985	6,774	26,506	1,27,265

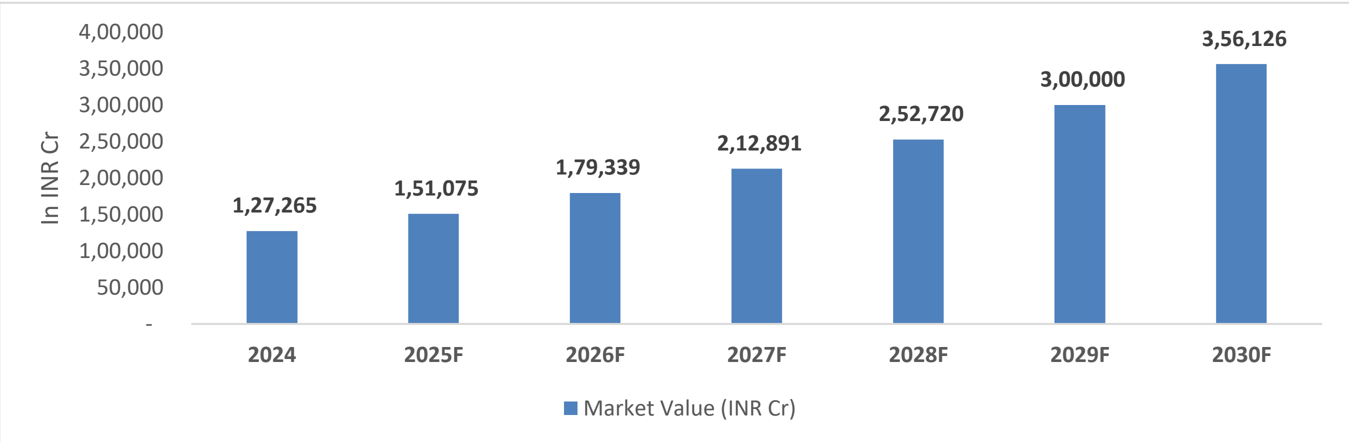
Source: MoD, Dashboard

**DPSUs stand for Defence Public sector Undertakings*

- To boost local manufacturing and reduce dependence on imports, the Indian Government recognized defence segment as a core sector for achieving '**AtmaNirbhar' in 2020**. The Scheme pushed for reforms across verticals and adequate funding to achieve 'self-reliance'. Post the launch of the scheme Defence production has grown at **14.56% between FY 21 and FY 24.**
- **As per the Ministry of External Affairs the Ministry of Defence has set a target of INR 3 Lakhs Crores for Defence Production by FY 2028-29 which will drive the Defence precision forged components market.**

India Projected Production: Defence FY 2024-2030

Exhibit 162: India Projected Production Market Trend, Defence INR Cr, FY 2024-30



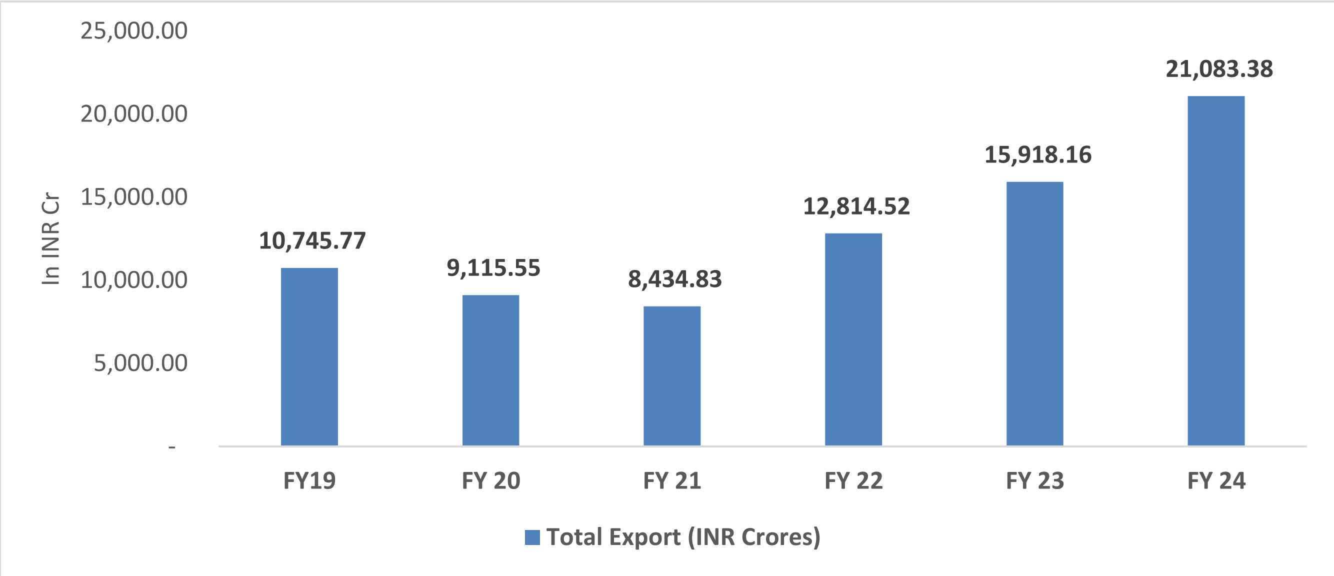
Source: Frost & Sullivan Analysis

F-Forecasted

- Indian Defence Production was valued at **INR 1,27,265 Crores in FY 2024** and is projected to mark **INR 3,56,126 Crores by 2030** with a **CAGR of 18.7% from FY 2024 to 2030** driven by government focus on Indigenization.

Indian Defence Export FY 2019-24

Exhibit 163: Defence Export Trend, India, FY 2019-24



Source: MoD, Dashboard

- Defence Export reached an all-time high **to INR 21,083.38 Crores** in **FY 24 and grew with a CAGR of 35.71 % from FY 21 to FY 24.**
- **The Ministry of Defence has set a target of achieving INR 50,000 Cr of Defence Export by FY 2028-29**.
- The country exported to over 85 countries, according to a press release from the defence ministry. Currently, 100 Indian firms have exported products such as Dornier-228, 155 mm Advanced Towed Artillery Guns, Brahmos Missiles, the Akash Missile System, radars, simulators, Arms and Ammunition, Weapon Spares, Chemicals & Explosives, Parachutes, Leather and Clothing items, Electronic Warfare Technologies, radars, composite materials for LCA, AEW&C, Astra, LCA Tejas, ASAT, BrahMos, Nag missile, SAAW, Arjun MBT Mk 1A, 46-meter Modular Bridge, MPR, LLTR Ashwin, and Pinaka multi-barrel rocket launcher.
- Global demand for LCA-Tejas, light combat helicopters and maintenance of naval ship activities has increased. India has been negotiating with several countries, such as Argentina and Egypt, to export the LCA Tejas.
- **Defence PSUs have contributed around 40% to the total Defence exports, while the private sector accounts for 60% of the exports.**
- The growth in defence exports is attributed to the government's efforts to promote exports, improve defence manufacturing capabilities, and foster innovation through tie-ups with R&D institutions, startups, and industry.

Atmanirbhar Bharat (Self Reliance) in Defence Sector

- The Defence Acquisition Procedure (DAP 2020) is being implemented to maximize the acquisition of defence equipment from indigenous sources and promote domestic manufacturing.
- The Government of India has ensured that the most preferred capital acquisition option is 'Buy Indigenously Designed, Developed, and Manufactured (IDDM)' category equipment, followed by 'Buy (Indian)'.

- The 'Make' categories aim to achieve self-reliance by increasing participation in the Indian industrial eco-system, including the private sector.
- Government funding has been provided for Make-I, Technology Development Fund (TDF), and Innovations for Defence Excellence (iDEX) projects. DRDO's TDF Scheme encourages MSMEs and start-ups to develop components, products, systems, and technologies on their own.
- The DRDO's 'Development cum Production Partner (DcPP)' model is implemented, in which Industry serves as the DcPP in system development projects. Industries can now use DRDO test facilities. Two Defence Industrial Corridors have been established in Uttar Pradesh and Tamil Nadu to boost domestic production of defence and aerospace products.

Defence PSUs in India

- **Defence PSUs (Public Sector Undertakings**) in India play a crucial role in the country's defence production and development. These PSUs are government-owned entities tasked with manufacturing and supplying defence equipment and systems to meet the requirements of the Indian armed forces. Here are some key points regarding defence PSUs in India:
- **Contribution to Defence Production:** Defence PSUs contribute significantly to India's defence manufacturing sector by producing a wide range of defence equipment, including aircraft, missiles, naval vessels, firearms, ammunition, and electronic systems.
- **Strategic Importance**: These PSUs are strategically important for India's self-reliance in defence production. They are often involved in the development of indigenous defence technologies and systems, reducing dependency on foreign suppliers.
- **Navratna and Mini Ratna Status:** Some defence PSUs have been conferred with Navratna and Mini Ratna status by the Government of India, granting them greater operational and financial autonomy to compete effectively in the global market.
- **Collaborations and Joint Ventures:** Defence PSUs often collaborate with foreign defence manufacturers through joint ventures and technology transfer agreements to enhance their capabilities and access advanced technologies.
- **Modernization and Expansion:** The Indian government has been emphasizing the modernization and expansion of defence PSUs to meet the evolving requirements of the armed forces and to boost indigenous defence production capacity.

Some of the major defence PSUs in India include:

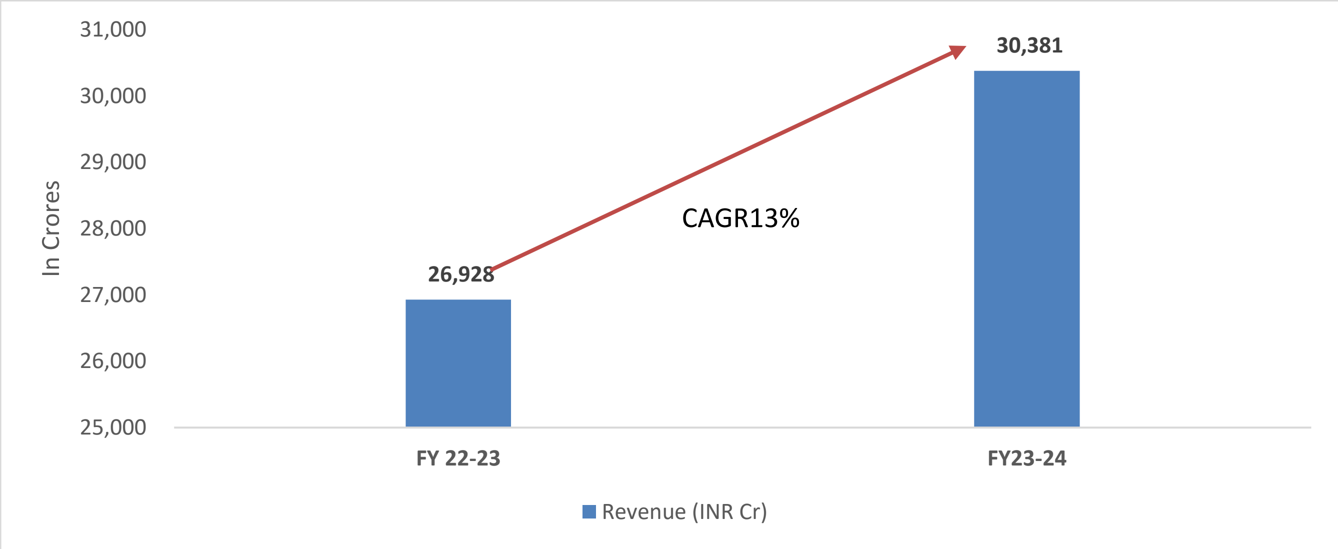
Hindustan Aeronautics Limited (HAL): HAL is involved in the design, development, and manufacture of aircraft, helicopters, and related systems.

- HAL’s operations are organized into five complexes, namely the Bangalore Complex, MiG Complex, Helicopter Complex, Accessories Complex, and Design Complex, which together include 20 production divisions and 10 Research and Design centers (“R&D Centres”) located across India.
- In addition, HAL have 12 commercial joint venture companies and 2 subsidiary companies to enhance their operations. HAL rely on indigenous design and development as well as enter into technology transfer and license agreements with foreign OEMs to manufacture their products. HAL has so far produced 17 types of aircraft from in-house design and development and 14 types under license.

HAL Revenue Growth

- Hindustan Aeronautics Limited (HAL) had a stellar financial year, showcasing resilience and innovation. The company reported a robust revenue from operations of **INR 30,381 crores for FY '23-'24, a 13**% surge compared to the previous year's **INR 26,928 crores**. This leap was achieved despite global geopolitical challenges and disruptions in the supply chain.

Exhibit 164: HAL Revenue Growth Rate

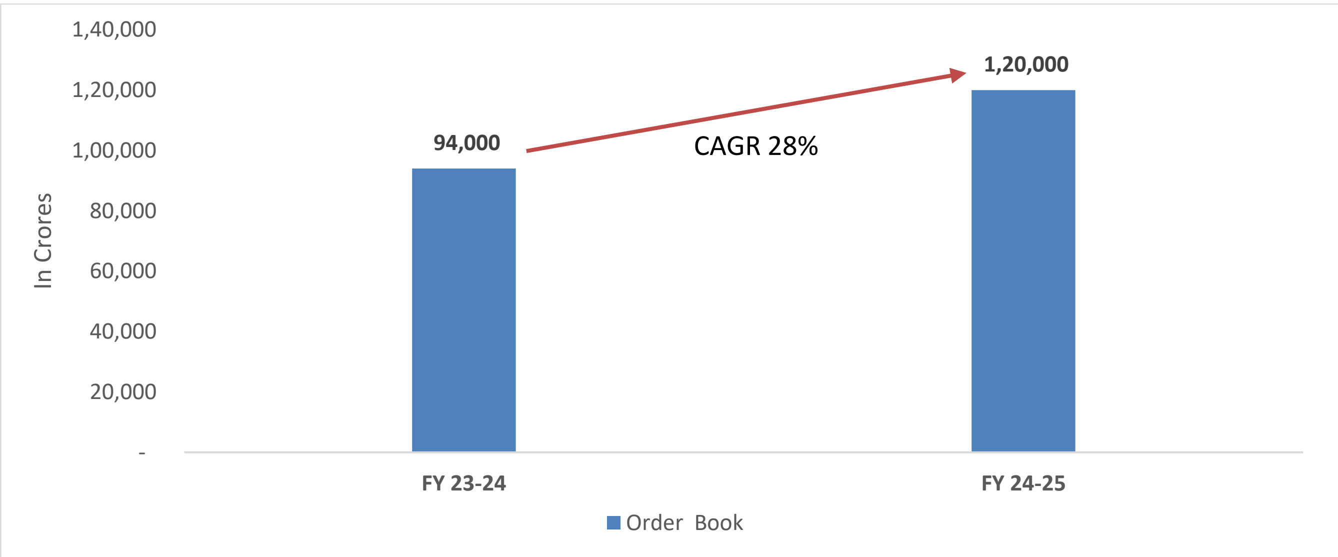


Source: HAL Earnings Call

HAL Enhanced Order Book and Future Prospects

- The company's order book is a significant highlight, standing at **INR 94,000 crores**, with an outstanding addition of nearly **INR 19,000 crores** last year.
- HAL expects this to grow further to approximately **INR 120,000 crores** by the end of March 2025, supported by anticipated contracts including 97 LCA Mark-1A units and 156 light combat helicopters.

Exhibit 165: HAL Order Book Growth



Source: HAL Earnings Call

- Major Orders bagged include Contracts for supply of ALH to Indian Army and Indian Coast Guard, RD-33 engine to Indian Air Force, Dornier-228 Mid Life Upgrade to Indian Navy, Dornier-228 to Indian Coast Guard, **6 sets of LM2500 Gas Turbines (GT)** and **Gas Turbine Auxiliary Equipment (GTAE)** for NGMV Program of Cochin Shipyard Ltd and 2 Nos. of Hindustan 228 export to Guyana Defence Forces**.**

Strong Product Pipeline and Capacity Expansion

- HAL's strategic focus on capacity and capability building is evident. Significant investments have been made in greenfield projects and capacity augmentation, such as the new helicopter factory in Tumakuru. The company is prepared to meet growing demands by maintaining independent manufacturing facilities for different platforms, ensuring there is no production bottleneck**.**

Exhibit 166: List of Ongoing Programs of HAL

Sl No.	HAL Program Name	Description and Status
1.	**Basic Trainer Aircraft (HTT-40)**	HTT-40 is the Basic Trainer Aircraft indigenously designed and developed by the Company. HTT-40 would be used for basic flight training, aerobatics, instrument flying and close-formation flights whereas its secondary roles would include navigation and night flying. Features of the aircraft include Air-conditioned cockpit, Tandem seating, Zero ejection seats and Multifunction Displays. A total of 3 prototypes have been built which includes two flying prototype and one Structural Test Specimen (STS).
2.	**Light Combat Aircraft (LCA Mk1A)**	LCA Mk1A is an advanced variant of indigenously developed LCA MK1 equipped with Mission Computers (MC), Digital Map Generator (DMG), Smart Multi-function Displays (SMFD), Combined Interrogator and Transponder (CIT), Advanced Radio Altimeter and integrated with Air to Air and Air to Ground weapons. The design and development activities for LCA Mk1A systems were undertaken, and certification activities are progressing. Concurrently, series production activities are also being progressed. The first production series fighter Aircraft of LCA Mk1A completed its maiden flight. Further, software fine-tuning and flight tests for weapon trials are being progressed to facilitate delivery of aircraft.
3.	**Light Utility Helicopter (LUH)**	The LUH is a single engine, 3 Ton weight class helicopter having Glass Cockpit with Multi-Function Displays. LUH is intended to meet different role requirements including high altitude operation. Three flying prototypes have been built and were extensively flight tested. Work on Automatic Flight Control System (AFCS), Autorotation, Emergency Flotation System (EFS), Helmet Mounted Display System (HMDS) is progressing.
4.	**Indian Multi Role Helicopter (IMRH)**	The Company has undertaken design and development of IMRH, a Medium Lift Helicopter of 13 Ton class primarily for high altitude troop and cargo transport. The sea variant of IMRH is named Deck Based Multi Role Helicopter (DBMRH). IMRH and DBMRH would be designed to meet the requirement of all the three military services and its future extension will cater to offshore operations, utility, VVIP transport roles will help diversify into Civil market.
5.	**Utility Helicopter-Maritime (UH-M)**	Utility Helicopter – Maritime (UH-M) is a 5.7 Ton dedicated Helicopter for deck-based operations with all four Main Rotor Blades foldable, to enable stowage in Navy's ships. Ministry of Defence accorded Acceptance of Necessity (AoN) for procurement of Utility Helicopter-Maritime.
6.	**25 kN Turbofan**	Design and Development of a 25kN thrust class turbofan engine, which can be used on Basic/ Advanced military trainers, on small business jets and also large

Sl No.	HAL Program Name	Description and Status
	Engine (HTFE-25)	UAV applications is under progress. The engine can be used on a 5 Ton weight class aircraft in single engine configuration and on aircraft of up to 9 Ton weight class with twin engine configuration. Two core engines have been produced so far and are undergoing development trials.
7.	**1200 kW Turbo Shaft Engine (HTSE-1200)**	The 1200 kW Turbo shaft engine would be used as a power plant for 3 to 6 Ton category helicopters. One Technology Demonstrator of HTSE-1200 engine has been built and presently under testing.

Source: HAL Annual Report 2024

- Ministry of Defence (MoD) has signed a contract with Hindustan Aeronautics Limited (HAL) for **240 AL-31FP Aero Engines for Su-30MKI aircraft** at a cost of over INR **26,000 crores.**
- HAL aims to **deliver 30 Aero engines annually over the next eight years**, with plans to enhance indigenization to **63% by the program's completion, significantly increasing local content in repair and overhaul tasks.**
- This initiative emphasizes collaboration with India's defence manufacturing ecosystem, **including MSMEs and both public and private sectors**, reinforcing the nation's self-reliance in defence production.

Bharat Electronics Limited (BEL): BEL manufactures a range of defence electronics, including radars, communication systems, and electronic warfare equipment. **As of 1st October 2024, order book of BEL stood at INR 74,500 Crores and they are planning to double their order book in next 5 years.**

Bharat Dynamics Limited (BDL): BDL is engaged in the production of missiles and missile systems for the Indian armed forces. BDL is a leading manufacturer of missiles and missile systems in India. It designs, develops, produces, and integrates surface-to-air and surface-to-surface missile systems. BDL's products include the Akash surface-to-air missile, Prithvi series of surface-to-surface missiles, and various other missile systems. **Total order book of BDL stood at INR 18,852 Crores as of September 2024. In next 2-3 years they are planning to achieve INR 20,000 Crores order book.**

Mazagon Dock Shipbuilders Limited (MDL): MDL constructs naval vessels, including warships and submarines, for the Indian Navy. It builds a variety of ships for the Indian Navy, including destroyers, frigates, corvettes, and submarines. **The order book of MDL stood at INR 39,117 Crores as of June 2024**.

Garden Reach Shipbuilders & Engineers (GRSE): GRSE is another major shipbuilding company in India, specializing in the construction of naval vessels and commercial ships. It builds a range of ships, including frigates, corvettes, offshore patrol vessels, and amphibious warfare vessels. **Total order book of GRSE stood at INR 25,231.29 Crores as of 30 June 2024**.

Bharat Earth Movers Limited (BEML): BEML is involved in the design, manufacture, and supply of a variety of defence equipment, including earthmoving equipment, armoured recovery vehicles, and transporters. It also manufactures high-mobility vehicles for the Indian Army and other defence forces.

The defence PSUs in India play a vital role in ensuring the country's defence preparedness, promoting self-reliance in defence production, and contributing to the nation's security and sovereignty. **The Order book of BEML stood at INR 11,872 Crores in FY 2024 which is 38.53% higher than the previous financial year**.

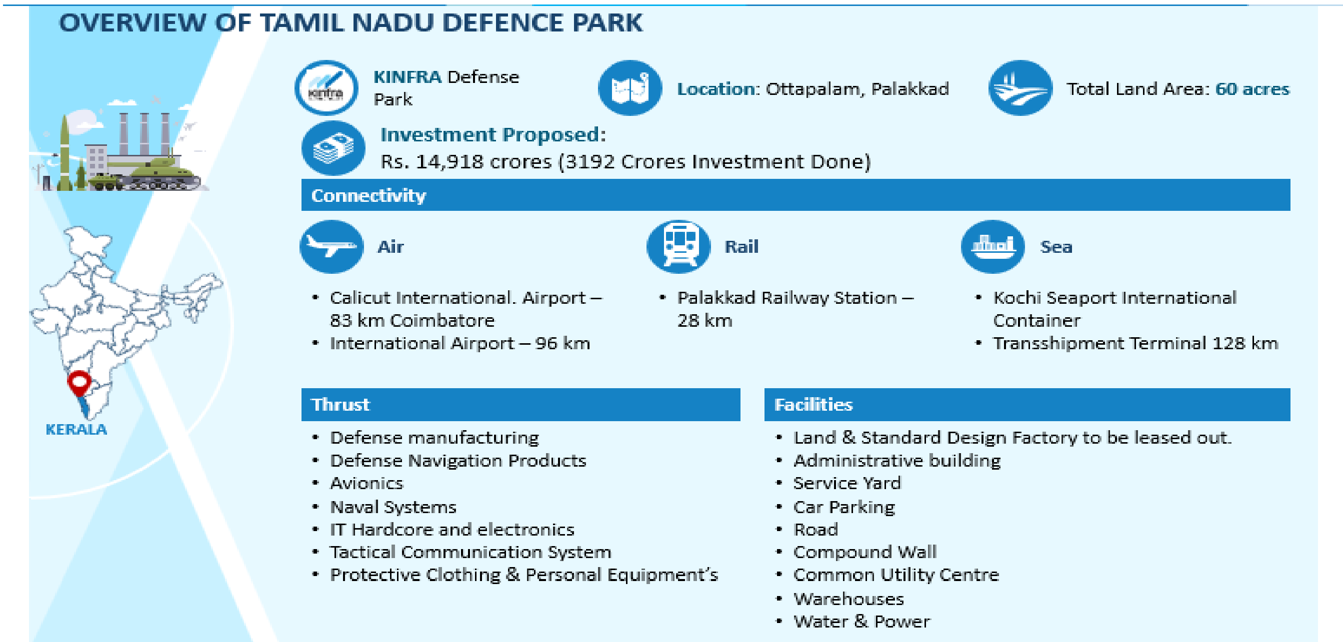
Indian Defence Acquisition Procedure (DAP)

- **It promotes indigenous development and production of defence equipment through the "Make in India" initiative.**
- The DAP serves as a comprehensive framework for the acquisition of defence materiel by the Indian Ministry of Defence, aims to modernize the Indian Armed Forces, promote indigenous production, and enhance the nation's defence capabilities while adhering to principles of transparency, efficiency, and accountability.
- It encourages the involvement of the Indian defence industry in the acquisition process, promoting self-reliance, technology transfer, and the development of domestic manufacturing capabilities. Under the "Make in India" category, projects are classified into Make-I (government-funded), Make-II (industry-funded), and Make-III (MSME-funded), each aimed at fostering innovation and indigenous production.
- The DAP also lays down procedures for the procurement of defence equipment from foreign vendors through various routes, such as government-to-government agreements, direct commercial contracts, and international competitive bidding.
- **It includes provisions for offset obligations, which require foreign vendors to invest a certain %age of the contract value in India's defence industry, thereby promoting technology transfer, skill development, and investment in the domestic defence sector.**

Upcoming Defence corridors: India

Government has set up Strategic Defence corridors in select States of India such as Tamil Nadu, Karnataka and Uttar Pradesh to promote the Defence sector.

Exhibit 167 Tamil Nadu Defence Corridor



Tamil Nadu Aerospace and Defence Policy, 2022

- Goal is to attract investments to the tune of INR 75,000 Crores, over a period of 10 years.
- Creating direct and indirect employment prospects for 1 lakhs person in 10 years.

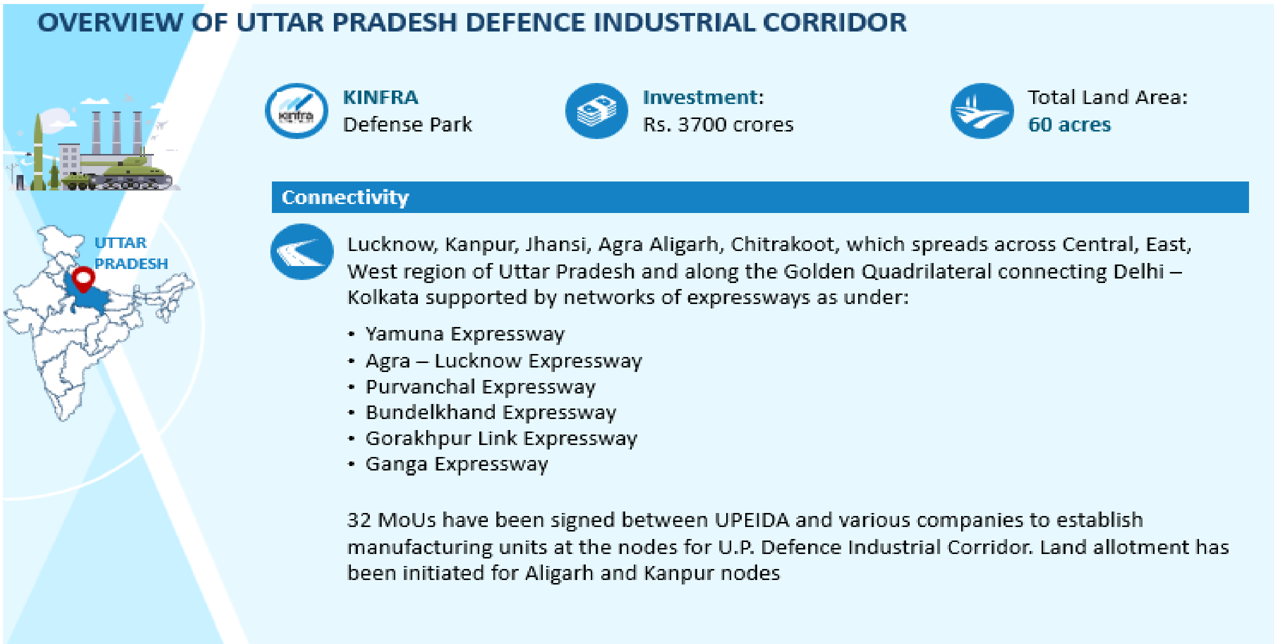
Exhibit 168: List of Aerospace and Defence SEZ in Tamil Nadu

Sl No.	Industrial Park	Proposed Aerospace and Defence Focus Sector
1.	Aerospace Park, Vallam Vadagal	A&D (R&D and Manufacturing)
2.	Sulur	Military Aircraft Assembly
3.	Varapatti Village near Coimbatore	Defence components Manufacturing Park
4.	Annur	Dual Use Industrial Park
5.	Manallur	Defence Electronics
6.	Hosur	Aircraft components
7.	Tindivanam (Phase II)	Helicopter MRO
8.	Thoothikudi	Space Industrial Park

Source: Tamil Nadu Defence Corridor

- The creation of thematic A&D industrial parks will provide a plug and play ecosystem for the companies planning to expand or set up new industrial facilities related to the A&D sector.

Exhibit 169: Uttar Pradesh Defence corridor



Karnataka Aerospace and Defence

Karnataka has rolled out Karnataka Aerospace and Defence Policy 2022-27 which is driving and regulating the segment in the State and promoting it as a leading hub in the country.

- **25%** of the India's Aircraft and Spacecraft Industry is based in Karnataka.
- **67%** of all Aircraft and Helicopters manufacturing for Defence Services is done in Karnataka.
- With **65%** of India's Aerospace related exports originating from Karnataka, the state is a preferred investor destination for Aerospace & Defence companies.

- Karnataka's strong ecosystem blossomed with decades of presence of PSUs like **HAL, DRDO, BEM**L. Today the state is home to all major global leaders like Airbus, Boeing.
- Expertise in Aerospace with more than **2,000 SMEs and 70%** of India's supplier base which execute niche sub-contracting work for the Defence PSUs.

Incentives for Large, Mega, Ultra Mega and Super Mega Enterprises

- Up to **2.25%** of turnover as investment promotion subsidy for 6-10 years up to 40-60% of fixed asset value.
- Low concessional registration charges of 0.1%.
- **50% subsidy** on cost of CETP/ETP/STPs (up to INR 6 Cr.)
- Up to **100% exemption** on stamp duty.
- Up to **100% reimbursement** on land conversion fee.
- Investment subsidy for anchor industries of up to INR 10 Cr.

Vinir Engineering with their plant location in the Aerospace and Defence hub of the country will have a strategic advantage over their competitors in the precision forged and machined components market of Aerospace and Defence.

Indian Defence Offset Policy

- It's an FDI initiative to gain and leverage the technology prowess of leading Global Defence players.
- It is an obligation by foreign suppliers to invest in India and aid the domestic defense industry either through direct investment or by partnering with domestic defense players or by transfer of technology to an Indian defense enterprise.
- The Indian defense offset policy is applicable only if the procurement value exceeds **INR 300 crores.**
- Presently the offset obligation for a foreign agency is **30% of the contract value**.

Exhibit 170: List of OEMs having Offset Contracts

Sl. No.	OEM Name	Offset Contracts Description
1	Airbus Defence and Space S.A.	Procurement of 56 Transport Aircraft with Associated Equipment
2	BAE Systems GCS International Limited	145 X 155 mm 39 calibre Ultra-Light Howitzers (M777A2)
3	Dassault Aviation	36 Aircraft Package Supply Protocol Offset Contract (RAFALE EH/DH)
4	Elbit System Ltd	Search and Rescue Equipment (SAR)
		12.7MM stabilized remote control control guns (SRCG) AND AMMUNITION WITH TOT
		Radio Sets (RS) Tadiran
		Upgrade Medium Lift Helicopters
		Thermal Imaging Fire Control Systems (TIFCS) for T-72 Tanks

Sl. No.	OEM Name	Offset Contracts Description
5	Elbit Systems Electro Optics ELOP Ltd	TISK
6	ELTA Systems Ltd	12 x Recce pods (Su-30)
		06 SETS of RADAR AMDR-2D
		Medium Power Radar (MPR)
		Air Route Surveillance Radar (ARSR)
7	Fincantieri - Cantieri Navalli Italiani S P A	Fleet Tanker (Option)
		FLEET TANKER (MAIN)
8	Israel Aerospace Industries (IAI)	UAV HERON
		Two Troops Heron UAV (Indian Army)
9	Israel Aerospace Industries MBT Missiles Division	Augmentation of Barak System Repair Facility
		HAROP
		Air Defence Fire Control Radars
10	James Fisher Defence Ltd	Deep Submergence and Rescue Vessel (DSRV)
11	Lockheed Martin Corporation	C-130J-30 Aircraft (Main)
		Indian Navy 24 MRH
		C-130J Aircraft
12	MBDA	MICA for M2000
		36 RAFALE FIGHTER WEAPONS PACKAGE SUPPLY PROTOCOL (RAFALE EH/DH)
13	MBDA UK LIMITED	New Generation Close Combat Missile
14	Nexter Munitions	20 MM Gun Ammunition (Indian Air Force)
		20 MM Ammunition and associated equipment for ALH (WSI)
15	Pilatus Aircraft Ltd	Basic Trainer Aircraft Pilatus
16	Qinetiq Target Systems Ltd	MEAT
17	Rafael Advanced Defence Systems Ltd	Barak 1 (Option)
		164 LDPs
		SDR GLOBAL LINK NETCOR
		SPICE-2000 NGPGM Weapon Systems (OPTION)
		BARAK 1 SAM

Sl. No.	OEM Name	Offset Contracts Description
		Medium Altitude EO/IR Recee System for Jaguar
		Spice 2000 Weapon Systems
		Medium Altitude EO/IR Recce System for Jaguar Option Clause
18	Rosoboron Export	80 Helicopters Mi-17V-5
		KAMOV 28 MID LIFE UPGRADE
19	Russian Aircraft Corporation "MIG" Russian Federation	Extension of service Life and Upgrade of MiG-29
20	Textron Systems Corporation	SENSOR FUZED WEAPONS (SFW)
21	Thales Air Systems SA	Low Level Transportable Radar (LLTR)
22	Thales Belgium S.A	Procurement of 70 MM Rockets and Associated Equipment for ALH(WSI) for Indian Army
		Procurement of 70 MM Rockets and Associated Equipment for ALH(WSI)
23	Thales Systemes Aeroportes	UPGRADE OF MIRAGE 2000 AIRCRAFT
24	The Boeing Company	C-17 Globemaster III Aircraft
		P-8I Training Solutions
		Four(04) P-8I LRMRASW Aircraft
		AH-64E APACHE ATTACK HELICOPTERS (OPTION CLAUSE)
		HARPOON MISSILES
		AH-64E Apache Attack Helicopters
		CH-47F(I) Chinook Heavy Lift Helicopters
		P-8I Main
25	Ultra Electronics Maritime Systems	New Torpedo Defence System

Source: MoD

5th Positive Indigenization List

- 5th Positive Indigenization list was released during Naval Innovation and indigenization International Seminar '**SWAVLAMBAN' in 2023.**
- 98 additional Defence items worth more than 1,40,000 Cr will be procured from indigenous sources.
- Highly complex Systems, sensors, weapons and ammunition have been included in the list.

- **This list also provides an excellent opportunity for 'Startups' as also MSMEs which will get tremendous boost from this initiative and lead to creation of a world class defence industrial ecosystem in the country.**

Exhibit 171: 5th Positive Indigenization list, w.e.f 2023

Sl No.	Description
With Effect from December-2023	
1.	Quantum Key Distribution System for Optic Fiber based Networks (Up to 200 Km range)
2.	Satellite Based ELINT System
3.	Very High Frequency (VHF) Radar
4.	Electro Optic Fire Control System for Naval Platforms
5.	Front, Middle and Rear Outer for Tank (ARV VT-72B)
6.	Torque Motor (EU) for 155mm Bofors Gun
7.	Armour Plates for Cabin Nose Section for Mi-17 Helicopter
8.	Directional Control Valve (EU) for 155mm Bofors Gun
With Effect from December-2024	
9.	Automated Mobile Test System (AKIPS) for OSA-AK-M Missile System
10.	Wire Rope Antenna for Mi-17 Helicopter
11.	Transmitter (Power Amplifier Assembly for LLLWR)
12.	5KW & 10 KW HF Transmitter for Naval Ships
13.	4G LTE Secure Handset for Navy
14.	Multifunction Aviation Ground Equipment (MFAGE) for Air Force
15.	Self-Generating Nitrogen Servicing Cart for Chinook Helicopter
16.	Gravity Rollers for Mi-17 V5 Helicopter
17.	Air Conditioning Unit for Chinook Helicopter
18.	Foaming Agent Morpene
19.	Hydraulic Supply Cart for Chinook Helicopter
20.	Poly Urethane Block for Mi-17 V5 Helicopter
21.	Tail Rotor Cable for Mi-17 V5 Helicopter
22.	Canister Missile (CM) Transportation Module for SPYDER Missile System
23.	HP Air Compressor for Ships and Submarines
With Effect from December-2025	
24.	Futuristic Infantry Combat Vehicle (FICV)
25.	Articulated All-Terrain Vehicles (AATV)

26.	Remotely Piloted Air Borne Vehicles (RPAV) upto 25 Km with 2Kg Payload for Army
27.	Naval Shipborne Unmanned Aerial System (NSUAS)
28.	Medium Upgrade Low Endurance (MULE) Class Tactical Drone
29.	Electric Light Vehicle for Army
30.	Nag Missile System (NAMIS) Tracked (Limited Series Production)
31.	Medium Range Precision Kill System (MRPKS) for Artillery
32.	Next Generation Low Level Light Radar (LLLR) for Army
33.	Automatic Chemical Agent Detection & Alarm System (ACADA)
34.	Armored Fighting Vehicle (AFV) Protection and Counter Measures System

Source: Srijan Defence

Tank Upgradation

- The modernization of ageing T-72M tanks has also been a priority with the Army. India currently possesses around 2,500 T-72Mtanks which were first introduced in 1970’s.
- Despite their age these tanks are still considered reliable and continue to be in demand globally. Countries in Africa, Middle East, Far East Asia have expressed in acquiring T-72M tanks even as India prepares to phase them out.
- Modernization and Export of T-72 M tank aligns with India’s Border Strategy of promoting Defence Exports.
- By Upgrading these tanks India will have cost effective and reliable solution for potential buyers.

Brahmos Indigenization Program

- BrahMos Aerospace, the Indo-Russian Joint Venture of Supersonic Cruise Missile has achieved 83% Indigenization level. This Milestone is an attribute to the Systematic Approach and Renewed Push for Self-Reliance.
- BrahMos in Collaboration with various Indian Industries has successfully manufactured crucial sub systems like boosters and seekers as well as several smaller components.
- BrahMos is targeting to achieve **100% Indigenization by 2026** coupled with advancement in domestic technology and production capabilities.

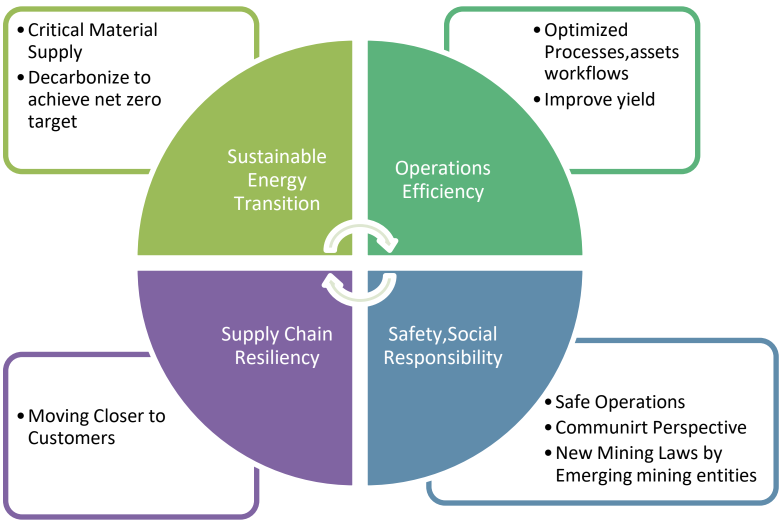
3.5 Earthmoving, Hydraulics and Mining:

3.5.1 Earthmoving, Hydraulics and Mining Global Overview:

Earthmoving, Hydraulics and Mining:

- The mining industry powers the global economy with the building blocks of metals, minerals, and fossil fuels such as coal.
- Mining contributed **1.4%** to the US GDP in 2023, yet casts a much longer shadow in its overall economic impact. Efficiently mining critical materials such as lithium, cobalt, and copper is now essential to satisfy current demand, achieve energy transition goals, and meet net-zero carbon emissions in multiple industries.
- The global mining market is expected to grow from **USD 2 trillion in 2022 to USD 3.5 trillion by 2032** at a CAGR of **5.8%.** But there is a gap between what the world demands and what the mining companies can produce. For example, green initiatives like battery production need vast quantities of lithium, cobalt, and copper. However, by 2030, existing mines will produce only about half of the lithium and cobalt and around 80% of the copper required.
- There is increasing focus on circularity at the end of the product life cycle to reuse, recycle, or refurbish parts and materials, reducing demand for virgin resources. Manufacturers must now report the proportion of virgin materials compared to recycled product content. Additionally, mining for battery raw materials may peak by 2030s due to recycling efforts.
- With Four business trends in the mining sector have emerged: sustainable energy transition from supply of critical materials and decarbonization; operational efficiency for better yield with cheaper, faster workflows; supply chain resiliency to spring back from unforeseen disruptions; and safe and socially responsible operations.
- Technologies driving these trends are artificial intelligence (AI) for automation and autonomous decision-making; industrial internet of things (IoT) with IT-OT integration for enhanced visibility from the top floor of the enterprise to the mines; 5G for real-time communication; and fog computing for local decision-making between data sources like IoT at the edge with central cloud systems.
- The broad operational trends in the mining industry are sustainable mining for energy transition, operations efficiency that includes workforce skill development, safe and socially responsible mining, and supply chain resilience.

Exhibit 172: The four broad business trends in the mining sector



Source: Industry Report

Strategic Changes in Mining

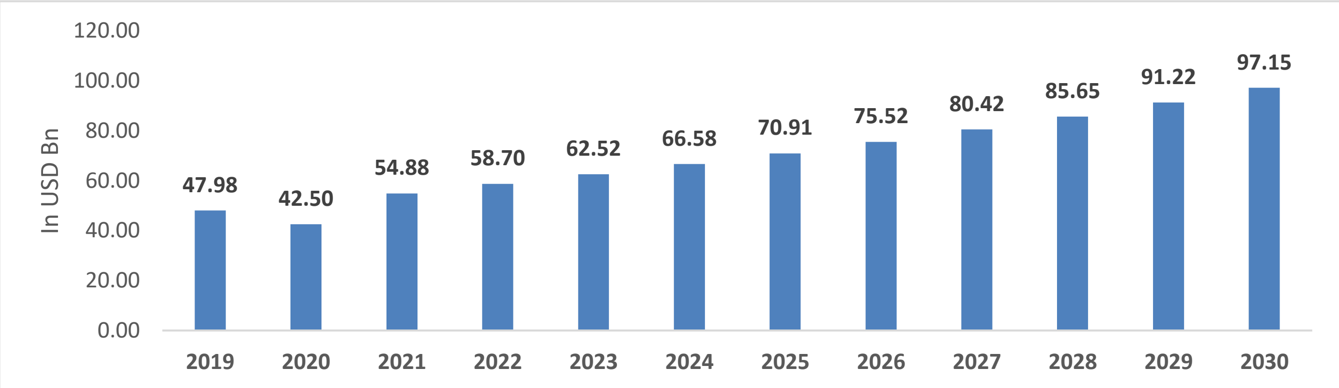
- Traditional mining companies face challenges to keep pace with growing demand for critical materials. Organic growth is a long business cycle in mining. Traditional mining sectors operate slower than fast-moving, competitive critical materials businesses, where quick decisions are necessary.
- Critical materials need to follow and catch up with trends like electrification, renewable energy, and energy transition. These conditions have led to and will continue to see mergers, acquisitions, business consolidations, and carving out critical material business. For example, Rio Tinto acquired Turquoise Hill in 2022 to strengthen its copper portfolio, and BHP completed its acquisition of OZ Minerals in 2023 to expand its portfolio in copper and nickel.

Sustainable Mining for Energy Transition

- The mining sector accounts for between 2% and 3% of global carbon emissions, and mining companies have announced initiatives to achieve net-zero carbon emissions. The industry is focused on sustainability, driven by environmental regulations and social responsibility.
- Companies are adopting green technologies such as electric vehicles and renewable energy sources to minimize their carbon footprint. For example, Rio Tinto aims for net-zero emissions by 2050 and has initiated solar and wind projects to power operations. The industry also prioritizes responsible sourcing of materials like lithium and cobalt for batteries, emphasizing reduced habitat destruction. This trend reflects a growing demand for eco-friendly practices in mining.

Global Earthmoving, Hydraulics and Mining Equipment Market

Exhibit 173: Global Earthmoving, Hydraulics and Mining Equipment Market Trend, USD Bn 2019-2030

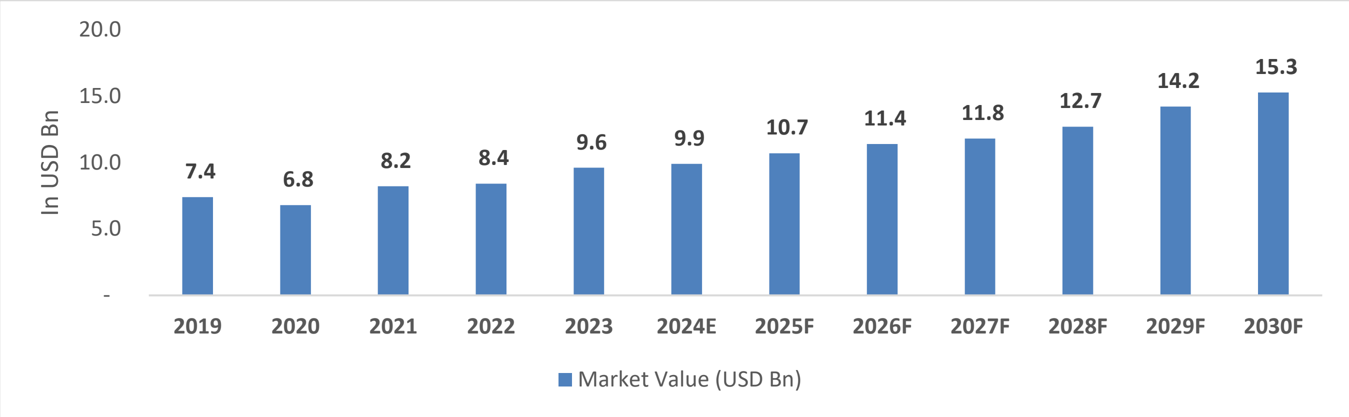


Source: Frost & Sullivan Analysis

- Global Earthmoving and Hydraulics Equipment and Mining Equipment Market was valued at **USD 62.52 Bn in 2023** and is projected to grow at a **CAGR of 6.5% from 2023 to 2030** driven by increasing infrastructure development activities in developing countries and rise in commercial and industrial construction activities.

Global Overall Forgings Market: Earthmoving, Hydraulics and Mining 2019-2030

Exhibit 174: Global Overall Forgings Market Trend, Earthmoving, Hydraulics and Mining, USD Bn, 2019-30



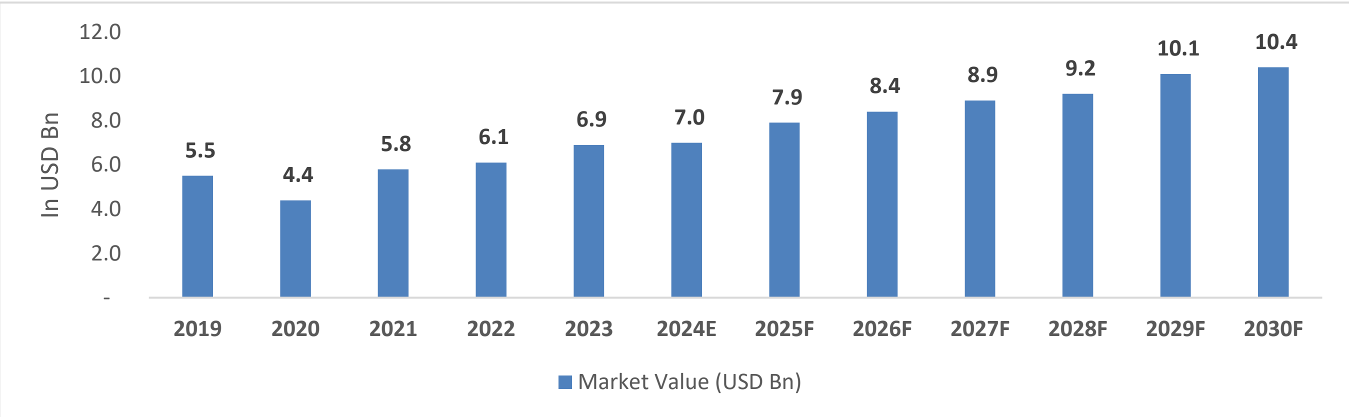
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global Overall forgings market for Earthmoving, Hydraulics and Mining was valued at **USD 9.6 Bn in 2023** and is projected to mark **USD 15.3 Bn by 2030** with a **CAGR of 6.8 %** from **2023 to 2030.**

Global Precision Forged Machined Components Market: Earthmoving, Hydraulics and Mining 2019-2030

Exhibit 175: Global Precision Forged Machined Components Market Trend, Earthmoving, Hydraulics and Mining, USD Bn, 2019-30

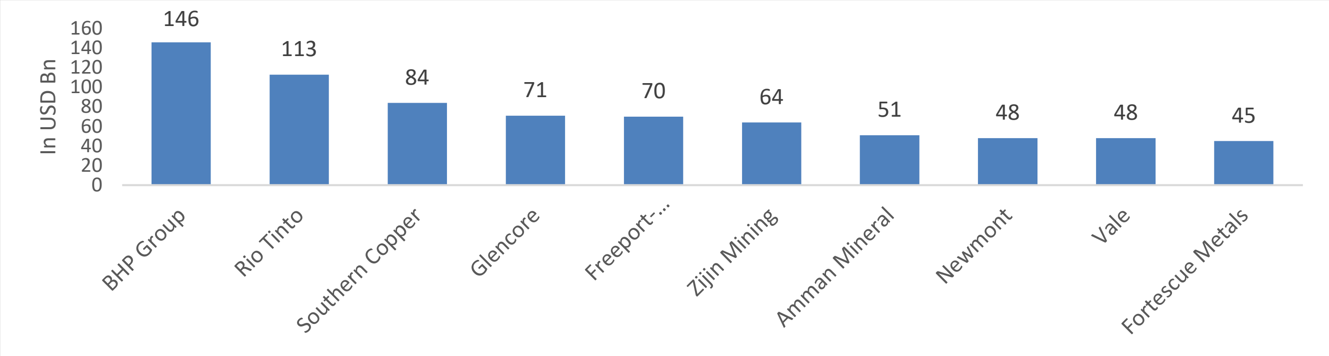


Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global Precision Forged Machined Components Market for Earthmoving, Hydraulics and Mining was valued at **USD 6.9 Bn in 2023** and is projected to mark **USD 10.4 Bn by 2030** with a **CAGR of 6 %** from **2023 to 2030 driven by key components such as Rod Eyes, Caps, Trunnions, Spindles, Cam Shafts, Track rollers, teeth's ball stud, Arm Steering, Arm Centre, Rod Head, Caps and Vertical Shafts, parts of track, parts of boom, parts of bucket and attachments.**

Exhibit 176: Top 10 Mining Companies by Market Value, Q2 2024



Source: Mining.Com

- **Forged products such as Rod Eyes, Caps, Trunnions, Spindles, Cam Shafts, Track rollers, teeth's, ball stud, Arm Steering, Arm Centre, Rod Head, Caps, Vertical Shafts, Idler Rims, Support Rings, Profile Rings will experience a boost with the growth of this sector.**
- Broken Hill Proprietary Company (BHP Group) is the leading Mining company Globally with a market capitalization of USD 146 Bn.
- Heavy Earthmoving Machines (HEMMs) generate standard business opportunities for forged components as it is driven by lifecycle of components. It is worn of spare parts-based Industry and needs replacement or repair in case of failure or malfunctioning of the component.
- Growing mining activity is also driving the earth moving equipment market. Continued growth in infrastructure, mining and construction projects is expected to increase the use of earthmoving equipment and **thereby the requirement of forged products is expected to increase.**

Key HEMMs used in the Mining sector include Excavators, Dump trucks, Loaders, Motor Graders and Dozers.

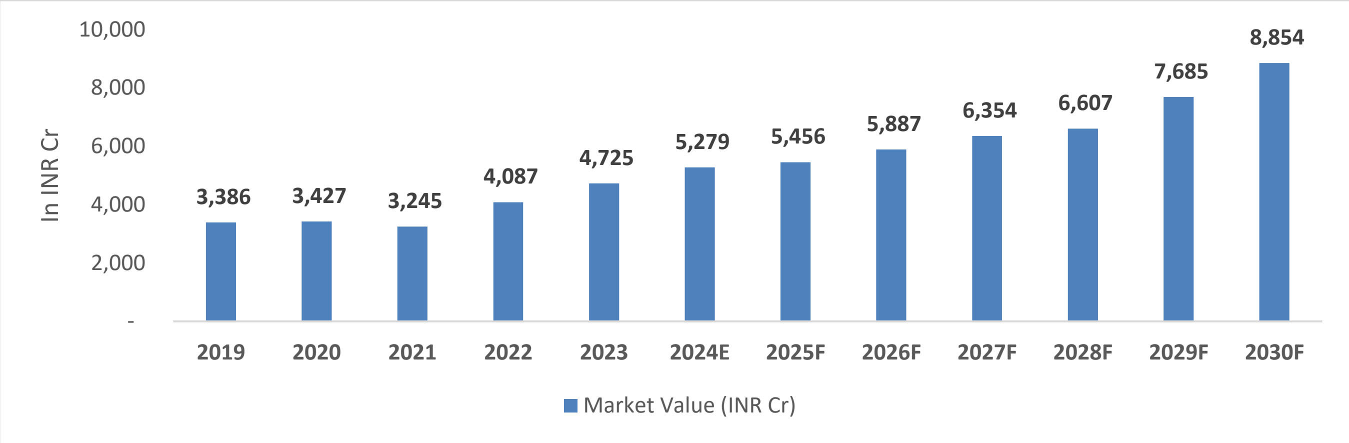
- The Demand of forgings in Earthmoving, Hydraulics and Mining is linked to factors such as rapid industrialization, urbanization and increased import-export activities. Countries such as India, China, and Australia are focused on improving the present infrastructure by initiating multiple projects related to roadway development, airport developments.
- Key HEMM manufacturers globally are Caterpillar Inc, Komatsu Ltd, CNH Industrial NV, AB Volvo, Terex Corporation, Sandvik AB, Epiroc Mining Limited, John Deere, Liebherr, Metso Corporation, Wirtgen Group, Sany Heavy Industry Company Ltd.
- Precision Forged and machined components markets look promising globally and HEMMs will drive the growth of forged products in the Mining Industry.

3.5.2 Earthmoving, Hydraulics and Mining India Overview:

- The adoption of new CEV -IV emission standards by the Indian Off highway industry presents significant opportunities for Indian Earthmoving equipment manufacturers to enter developed markets.
- Key Precision Forged components such as **Rod Eyes, Caps, Trunnions, Spindles, Cam Shafts, Track rollers, teeth's, ball stud, Arm Steering, Arm Centre, Rod Head, Caps, Vertical Shafts, Idler Rims, Support Rings, Profile Rings will experience a boost with the growth of this sector.**

India Overall Forgings Market: Earthmoving, Hydraulics and Mining, FY 2019-2030

Exhibit 177: India Overall Forgings Market Trend: Earthmoving, Hydraulics and Mining, INR Cr, FY 2019-30



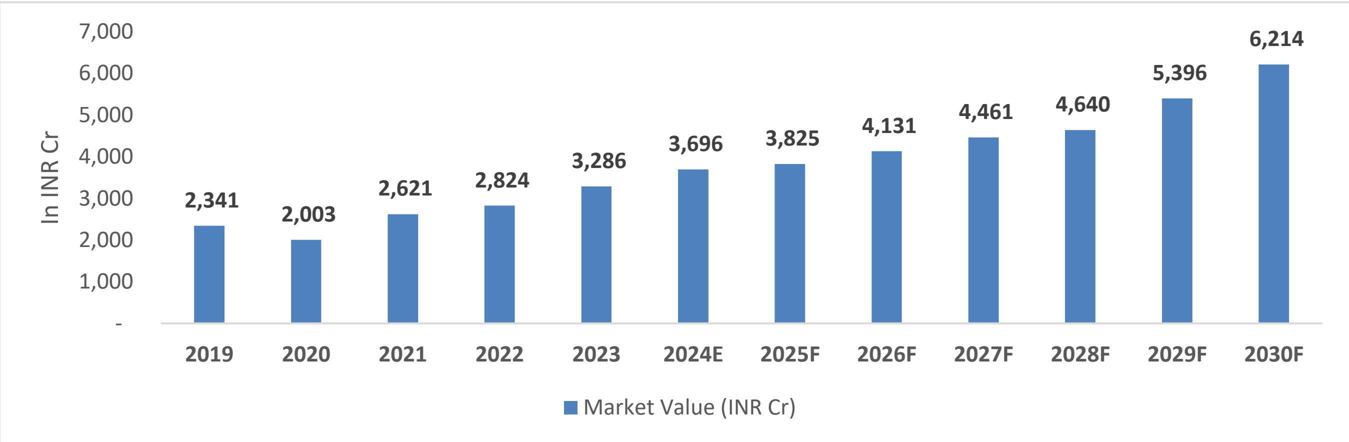
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Indian Overall Forgings Market for Earthmoving, Hydraulics and Mining was valued at **INR 5,279 Crores in FY 2024** and is projected to mark **INR 8,854 Crores by 2030** with a **CAGR of 9 % from FY 2024 to 2030** driven by rapid industrialization, urbanization and increased import-export activities.

India Precision Forged Machined Components Market: Earthmoving, Hydraulics and Mining, FY 2019-2030

Exhibit 178: India Precision Forged Machined Components Market Trend, Earthmoving, Hydraulics and Mining, INR Cr, FY 2019-30



Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Indian Precision Forged Machined Components Market for Earthmoving, Hydraulics and Mining was valued at **INR 3,696 Crores in FY 2024** and is projected to mark **INR 6,214 Crores by 2030** with a **CAGR of 12.7% from FY 2024 to 2030** driven by rapid industrialization, urbanization and increased import-export activities.

Drivers Supporting the growth of Earthmoving, Hydraulics and Mining Sector in India

<u>Policy Support</u>

- Enactment of Mines and Minerals (Development and Regulation) Amendment Act, 2021 enabled captive mines owners (other than atomic minerals) to sell up to 50% of their annual mineral (including coal) production in the open market which will bring more profits to them and active participation of private players will be promoted.

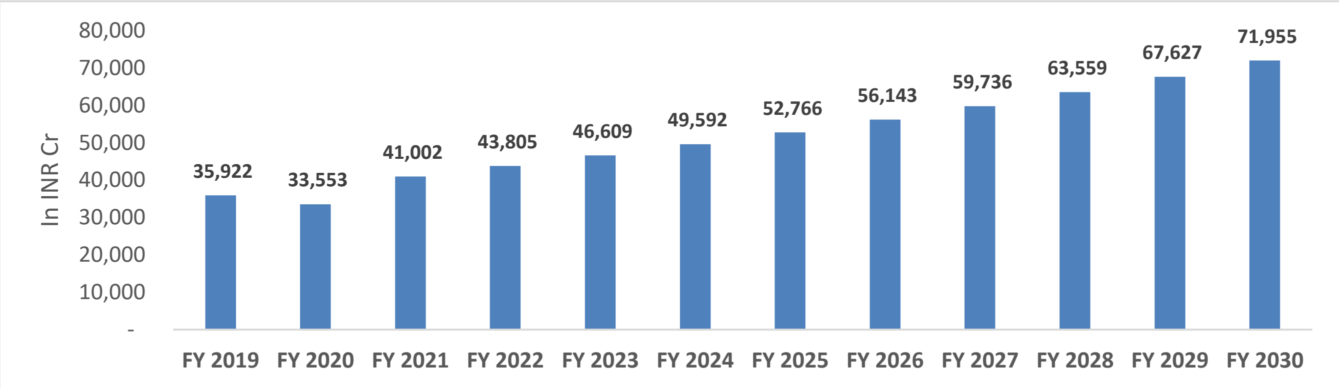
- In December 2023, the Ministry of Mines proposed capping performance security and upfront amounts for mining critical minerals to attract more bidders, reduce barriers to participation in auctions and expedite the process for mining leases. Active participation of bidders will be enhanced, and more mining activities will be promoted in adherence to the Environmental and Forest Compliances. Expansion of mining activities will boost the demand of Earthmoving machines where forged components are used thereby promoting the forging market and ensuring growth of forging components manufacturers.

Lifecycle of Parts

- Earthmoving Equipment consists of wearable parts and has a standard lifecycle subjected to environmental conditions and needs replacement at regular intervals of time and if any failure or malfunctioning of the parts takes place. This will generate a demand for the forged components for this specific segment.

India Earthmoving Equipment Market

Exhibit 179: India Earthmoving Equipment Market Trend, INR Cr 2019-2030



Source: Frost & Sullivan Analysis

- India Earthmoving Equipment Market was valued **at INR 49,592 Crores in FY 2024** and is projected to grow at a CAGR of **6.4% from FY 2024 to 2030** driven by increasing infrastructure activities countries and rise in commercial and industrial construction activities.

Government Initiatives on Critical Minerals: 2024 Budget

- In February 2024, the Union Cabinet approved the amendment to the Mines and Minerals (Development and Regulation) Act,1957 specifying royalty rates for **12 critical minerals,** thus completing the rationalization process for all 24 strategic minerals.
- In October 2023, the Union Cabinet approved the amendment of the Second Schedule of the Mines and Minerals (Development and Regulation) Act, 1957, specifying royalty rates for three critical minerals: Lithium, Niobium, and Rare Earth Elements (REEs) paving the way for the auctioning of blocks for these minerals, as outlined in the MMDR Amendment Act, 2023.
- The government plans to monetize assets worth Rs. 28,727 crores in the mining sector over 2022-25.
- Mines and Minerals (Development and Regulation) Amendment Act, 2021, notified on 28.03.2021, for giving boost to mineral production, improving ease of doing business in the country and increasing contribution of mineral production to GDP.

The government is focusing on introducing a Production-linked Incentive (PLI) Scheme for Earth Moving Machinery (HEMM) and Underground mining equipment.

- With a strong commitment to reducing India's dependence on imports and promoting domestic production, Ministry of Coal is taking consistent steps to foster indigenous manufacturing capabilities within the coal mining sector. These efforts are closely aligned with the core principles of Atmanirbhar Bharat, driving the "Make in India" campaign**.**
- In pursuit of this goal, an interdisciplinary high-level committee under the chairmanship of Director (Technical), CIL was constituted to provide recommendations for bolstering domestic manufacturing of Heavy Earth Moving Machinery (HEMM) and underground mining equipment, including High Wall Miners, Standard and Low-Capacity Miners, and associated ancillary equipment. It is projected that coal will remain as the **predominant energy source even beyond 2030,** thus, the Committee expected a huge requirement of equipment in the next 10 years in the country, both for Opencast mines and Underground mines.
- Coal India Limited (CIL) imports high-capacity equipment, such as **Electric Rope Shovels, Hydraulic Shovels, Dumpers, Crawler Dozers, Drills, Motor Graders, and Front-End Loaders Wheel Dozer, valued at INR 3,500 Crores, incurring additional expenses of INR 1,000 Crores in customs duty**.
- To curb these imports and boost domestic manufacturing, **CIL has devised a strategic plan to phase out imports gradually over the next six years.** This approach aims to encourage and develop domestically manufactured equipment. Notably, high-capacity machines are already being procured from domestic manufacturers.
- Five-year scheme to boost domestic manufacturing Heavy Earth Moving Machinery which is largely being imported. Inclusion of '**Make in India'** clauses in the tenders for sourcing mining equipment and Standardization of equipment in the mining sector to boost domestic manufacturing.

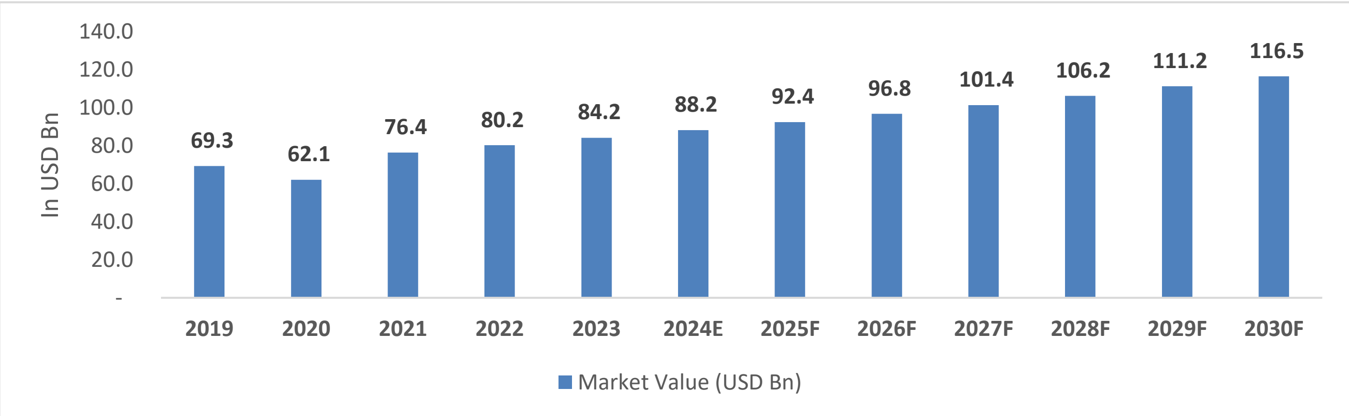
3.6 Railway

3.6.1 Global Railways Overview:

- Advancements in storage facilities and power sources, as well as improvements in transportation timings are likely to create new growth prospects for the railways which eventually will boost the metal forging requirements in Railways.
- Rail traffic can be broken down into passenger rail travel and cargo rail transport. Around the world railway activities and infrastructure are a range of public and private operations as well as mixed systems, depending on location and the aspect of the rail sector.
- One of the boldest projects currently underway is being undertaken by China, which has become one of the largest investors in rail in in recent years, both at home and abroad. The country intends to invest in almost **70 countries through its Belt and Road Initiative**, which includes large-scale investment in rail.
- In 2022, China had nearly a million freight trains in operation, while the number of train passengers reached 2.2 billion people. **The largest passenger rail provider, however, can be found in India. Indian Railways holds an 11% market share globally, the largest worldwide**.
- While the crises of recent years affected the global rail industry severely through plummeting passenger numbers, supply chain disruptions, and rising energy prices, the rail sector is back on a path towards growth.
- Global freight transport by rail is expected to grow in the coming years, as are global rail passenger numbers. This is supported by investment in expanding rail infrastructure in many countries around the world, notably in China and in the United States.
- **Forged Products such as Gears, Pinions, Couplings, shafts and cylinder heads, Gear Blanks, Pinions and Shafts, Rings, Profile Rings, Bearing Cap, Bevel Pinions and Yoke Forgings will experience a boost with the growth of the Railways.**

Global Rail Components Market: Railways 2019-2030

Exhibit 180: Global Rail Components Market Trend, Railways, USD Bn, 2019-30



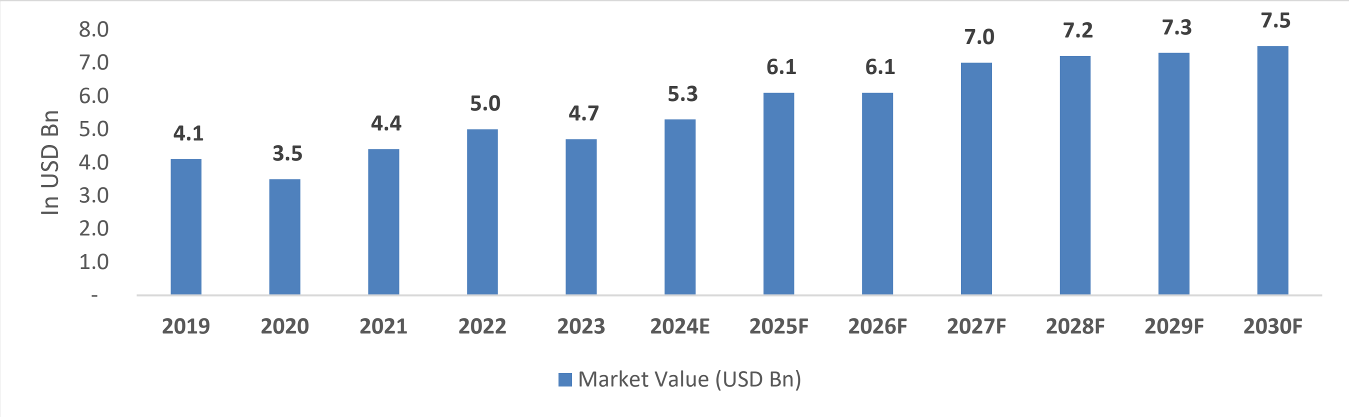
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global Rail Components Market was valued at **USD 84.2 Bn in 2023** and is projected to mark **USD 116.5 Bn by 2030** with a **CAGR of 4.75 %** from **2023 to 2030 driven by increasing population, rising investment in infrastructure and increased use of trains as a mode of transport specially in the region of Asia pacific region.**

Global Overall Forgings Market: Railways 2019-2030

Exhibit 181: Global Overall Forgings Market Trend, Railways, USD Bn, 2019-30



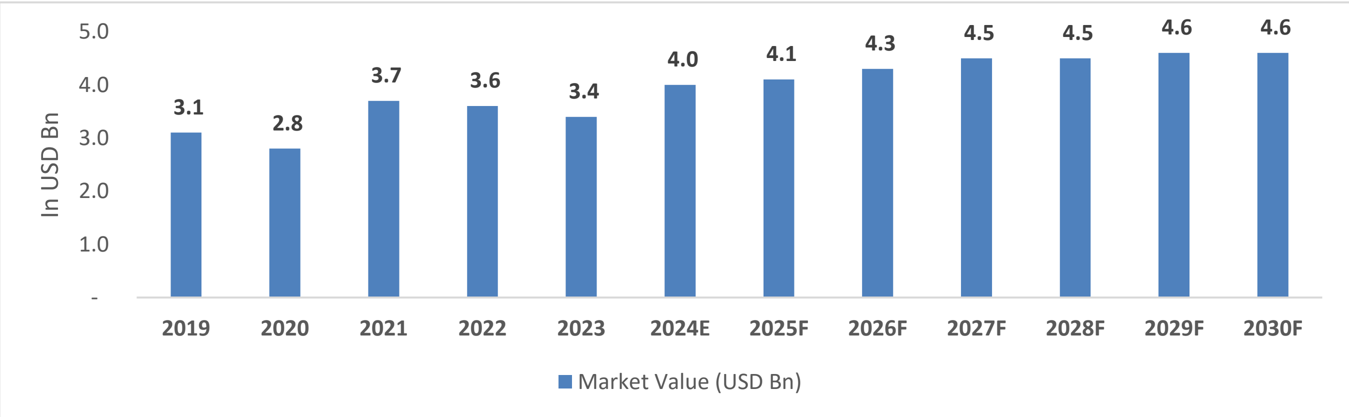
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global Overall forgings market for Railways was valued at **USD 4.7 Bn in 2023** and is projected to mark **USD 7.5 Bn by 2030** with a **CAGR of 6.9 %** from **2023 to 2030.**

Global Precision Forged Machined Components Market: Railways 2019-2030

Exhibit 182: Global Precision Forged Machined Components Market Trend, Railways, USD Bn, 2019-30

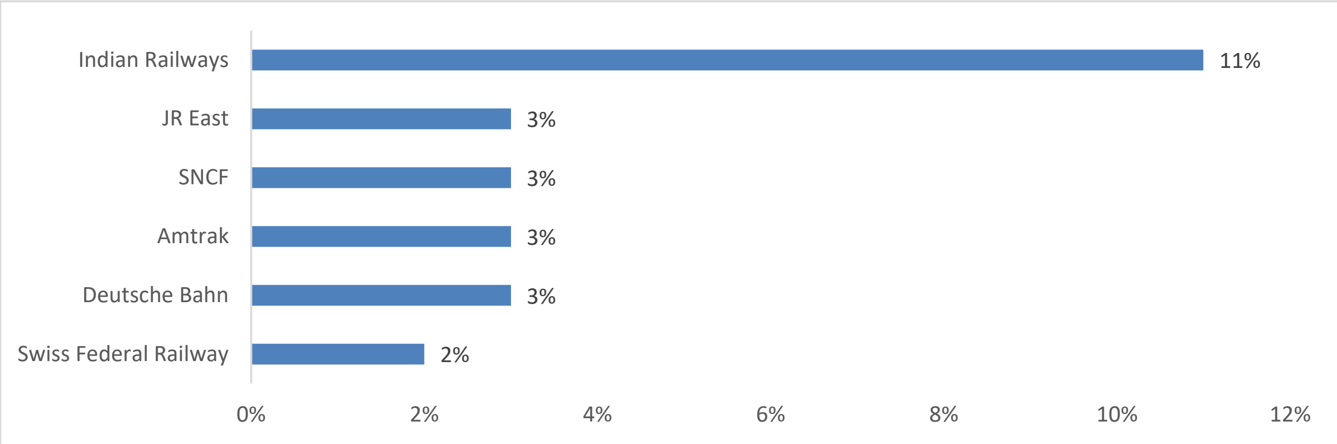


Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Global Precision Forged Machined Components Market for Railways was valued at **USD 3.4 Bn in 2023** and is projected to mark **USD 4.6 Bn by 2030** with a **CAGR of 3.9 %** from **2023 to 2030.**

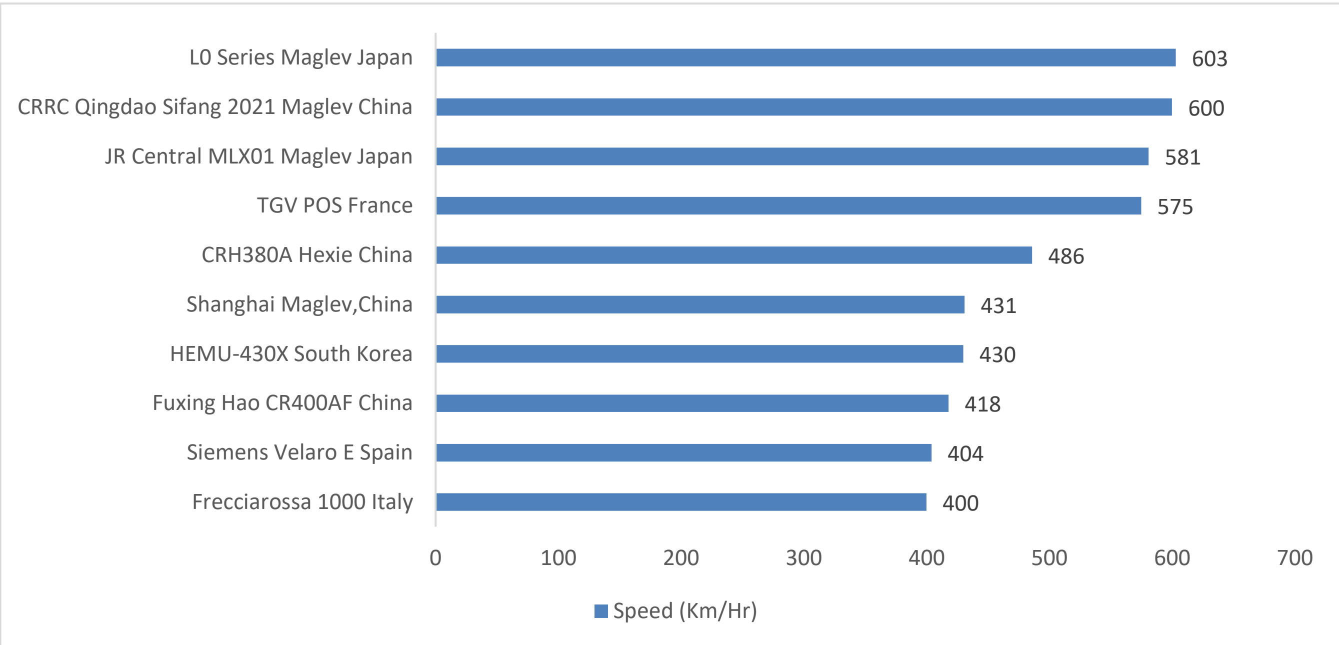
Exhibit 183: Market shares of leading passenger rail providers worldwide 2022



Source: Statista

- Indian Railways is the leading Passenger rail provider with **11% global share**, followed by JR East, SNCF, **Amtrak, Deutche Bahn each 3% and Swiss Federal Railway 2%**
- The largest companies in the rail sector are rail freight operators, which often also own and run the railway infrastructure on which they transport goods. This is the case for the leading rail company worldwide, the U.S.-based freight operator Union Pacific, which owns large swathes of the U.S. rail network.
- Its closest competitor is the Canadian National Railway. Among passenger rail operators, Indian Railways hold the largest market share globally.

Exhibit 184: World's fastest trains in 2022, ranked by speed (Km/hr)



Source: Statista

- As of August 2022, the fastest train on Earth, based on its record speed, is the Japanese L0 Series Maglev with a record speed of 603 kilometers per hour.
- The L0 Series was followed closely by the CRRC Qingdao Sifang 2021 Maglev of China, with a record speed of 600 kilometers per hour, although both trains are not yet in operation.
- The fastest train in operation is the Japanese MLX01 Maglev, with a record speed of 581 kilometers per hour.

Japan is a highspeed Pioneer since the 1960s

- Originally built to connect distant regions with Tokyo, the Shinkansen (colloquially called "the Bullet Train" in English) is a highspeed railway network in Japan.
- The first Shinkansen line was inaugurated in 1964 and was considered the first modern highspeed rail in the world, with the 0 Series Shinkansen train reaching a top speed of 210 kilometers per hour. Today, the Shinkansen network has an operating length of approximately 3,000 kilometers, covering most of the Japanese territory.
- From 2015 to 2019, ridership of Japanese highspeed trains remained relatively consistent, but dropped significantly from 370 million to 156 million passengers in 2020 as a result of the COVID-19 pandemic.

China takes the lead

- The history of highspeed rail in China is relatively recent compared to other highspeed leaders worldwide. The first highspeed dedicated rail line in China started operations in 2008, connecting the cities of Beijing and Tianjin.
- Despite being considered a newcomer to the industry, China has grown exponentially in the last two decades and has managed to take the lead among countries with highspeed trains.

Rail Freight

- Despite setbacks related to the pandemic, the transport of cargo by rail remains a sizeable industry. In 2020, the global rail freight boasted a market size of just under **USD 247.4 billion** which is projected to steadily increase to around **USD 278.6 billion by 2026.**
- Railway businesses consistently rank amongst the leading freight transportation companies, with the China State Railway Corporation recorded as the third major freight company worldwide as of 2020. Russian Railways and North American Class I railways also made the ranking**.**
- Rail freight transport is a dominant issue worldwide. Throughout North and South America, 2.5 trillion tonne-kilometers of freight cargo were hauled by rail as of 2019.
- The year 2021 recorded the unveiling of the world's first all battery-electric freight locomotive, introduced by Wabtec in September of that year. Rail freight is also one of the modes of freight transport with the lowest greenhouse gas emissions.
- In Europe, in 2018, this amounted to 24 grams of carbon dioxide per tonne-kilometer. Comparatively, heavy goods vehicles reported emissions fivefold greater than rail freight.
- Growing Demand for Railway Passenger Transport drives the expansion of the Rail Transport Market. Advanced driver assistance system (ADAS) technology is becoming popular in the rail transportation industry to optimize energy usage, enhance operational management, and safety aid in cost reduction.

Exhibit 185: List of top 10 Countries with Railway Network Lengths

Sl. No.	Country	Total Length (Kms)	% of Total Electrified
1.	USA	220,044	0.84%
2.	China	159,000	75.2%
3.	Russia	105,000	51.48%
4.	India	68,584	97%

Sl. No.	Country	Total Length (Kms)	% of Total Electrified
5.	Canada	49,422	0.2%
6.	Argentina	36,966	0.51%
7.	Germany	33,351	62.52%
8.	Australia	33,168	10.23%
9.	Brazil	29,817	30.27%
10.	France	27,483	58.46%

Source: Frost & Sullivan Research and Published Data

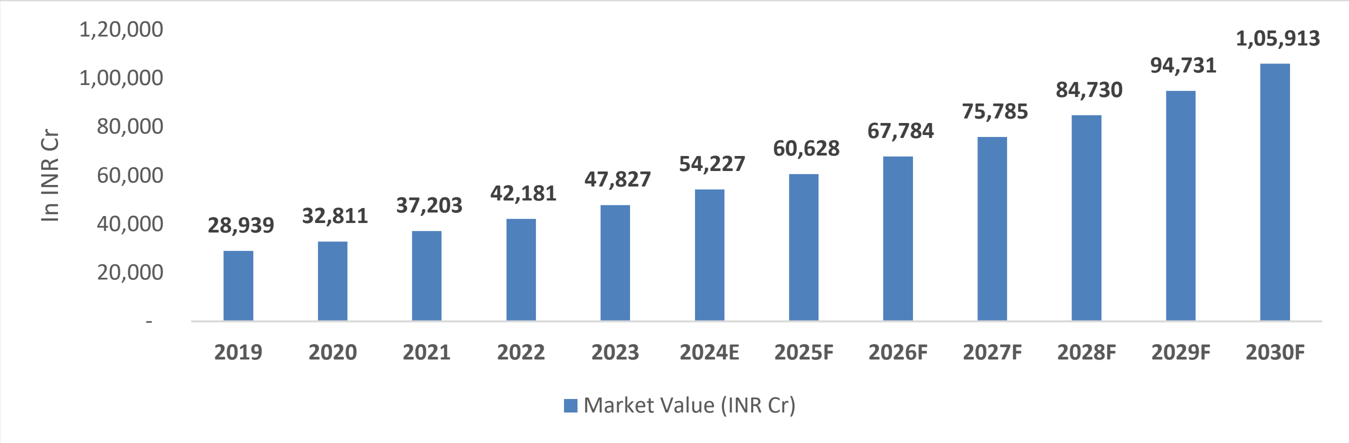
- USA is the leading country in railway network globally with 220,044 Kms, followed by China 159,000 Kms, Russia 105,000 Kms.
- India is positioned at fourth place in terms of Railway network with 68,584 Kms. Expansion of Railway network will drive the requirements of more locomotives and rail coaches which in turn will boost the growth of forged products such as Connecting rods, draw bars, Gears, Braking Systems, Structural and Couplings.

3.6.2 Indian Railways Overview:

- Indian railways span thousands of kilometers practically covering the entire nation, making it the fourth largest in the world after the US, China, and Russia. The Railways Board, which has a monopoly over the provision of rail services in India, oversees overseeing the whole infrastructure. Due to its low cost and effective operations, railways continue to be the most popular means of transportation for most Indians when travelling long distances.
- Forged Products such as **Gears, Draw Bars, Pinions, Connecting Rod, Couplings, shafts and cylinder heads, Gear Blanks, Pinions and Shafts, Rings, Profile Rings, Bearing Cap, Bevel Pinions and Yoke Forgings will experience a boost with the growth of the Railways in India.**
- The railway sector aims to contribute about **1.5% of GDP** by building infrastructure to support **45% of the modal freight share of the economy.**
- India is focusing on high-speed rails to accelerate the wheels of economy. India is following the Mantra "**Hungry for Cargo**" Indian Railways has continuously strived to simplify business and improve service delivery at competitive rates, resulting in new traffic on the railways for both conventional and non-conventional goods streams.
- Indian Railways marked **total revenue of INR 2.56 lakh Crores by the end of FY 24.** In 2022-23, Railways Indian railways earned 69% of its internal revenue from freight and 24% from passenger traffic. The remaining 7% was earned from other miscellaneous sources such as parcel service, coaching receipts, and sale of platform tickets.
- Indian Railways is developing and creating technology in areas such as signaling and telecommunication with 15,000 km being converted into automatic signaling and 37,000 km to be fitted with 'KAVACH', the domestically developed Train Collision Avoidance System.

India Rail Components Market: Railways, FY 2019-2030

Exhibit 186: India Rail Components Market Trend, Railways, INR Cr, FY 2019-30



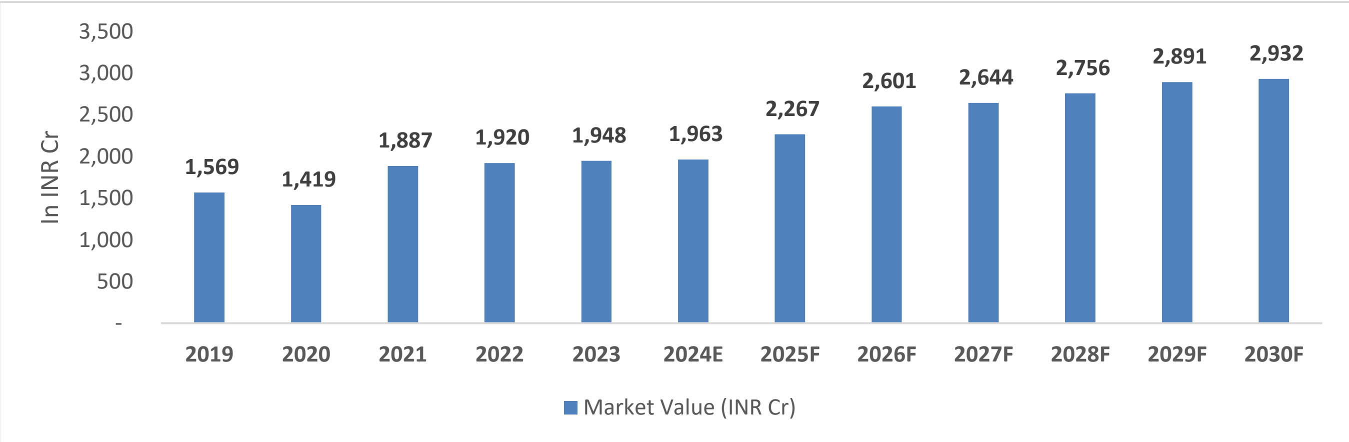
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Indian Rail Components Market was valued at **INR 54,227 Crores in FY 2024** and is projected to mark **INR 1,05,913 Crores by 2030** with a **CAGR of 11.8 % from FY 2024 to 2030** driven by Infrastructure expansion of Railways as per **National Rail Plan 2030**.

India Precision Forged Machined Components Market: Railways, FY 2019-2030

Exhibit 187: India Precision Forged Machined Components Market Trend, Railways, INR Cr, FY 2019-30



Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Indian Precision Forged Machined Components Market for Railways was valued at **INR 1,963 Crores in FY 2024** and is projected to mark **INR 2,932 Crores by 2030** with a **CAGR of 6.9 % from FY 2024 to 2030** driven by expansion of Railways as per **National Rail Plan 2030**.

Integration with High-Speed Rail (HSR)

Exhibit 188: Phasing of HSR Corridors

Sl No.	HSR Corridor	Proposed Year of Implementation
1	Mumbai Ahmedabad	2026
2	Delhi Varanasi Via Ajodhya	2031
3	Delhi Ahmedabad	2031
4	Varanasi to Patna	2031
5	Patna to Kolkata	2031
6	Hyderabad Bangalore	2041
7	Nagpur Varanasi	2041
8	Mumbai Nagpur	2051
9	Mumbai Hyderabad	2051
10	Patna Guwahati	2051
11	Delhi Chandigarh Amritsar	2051
12	Amritsar-Pathankot-Jammu	2051
13	Chennai to Mysuru via Bangalore	2051

Source: National Rail Plan 2030

- As per the HSR master plan, 13 (no.) corridors have been identified for the implementation as a part of the National Rail Plan. The corridors along with their phasing are given in the table above. These expansions will generate opportunities for a greater number of trains and eventually growth opportunities for forging manufacturers.

Investment in Railways in India

Exhibit 189: Summary of Investments Required in Coaches

Type of Coach	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2041	2051	Total
No. of Coaches													
Non-AC	8398	8398	8398	8398	8398	3716	3716	3716	3716	3716	26790	34464	121824
AC	1446	1446	1446	1446	1446	863	863	863	863	863	7521	11618	30684
MEMU/ DEMU	126	126	126	126	126	67	67	67	67	67	443	471	1878
Train Sets	20	20	20	20	20	9	9	9	9	9	70	92	306
Total	**9,990**	**9,990**	**9,990**	**9,990**	**9,990**	**4,655**	**4,655**	**4,655**	**4,655**	**4,655**	**34,824**	**46,645**	**1,54,692**
Investment Required (INR Crores)													
Non-AC	15116	15116	15116	15116	15116	6688	6688	6688	6688	6688	48222	62035	219277
AC	3109	3109	3109	3109	3109	1856	1856	1856	1856	1856	16170	24979	65974
MEMU/ DEMU	1010	1010	1010	1010	1010	533	533	533	533	533	3544	3768	15027
Train Sets	5000	5000	5000	5000	5000	2200	2200	2200	2200	2200	17500	23000	76500
Total	**24,235**	**24,235**	**24,235**	**24,235**	**24,235**	**11,277**	**11,277**	**11,277**	**11,277**	**11,277**	**85,436**	**1,13,782**	**3,76,778**

Source: National Rail Plan 2030

- **INR 1,77,560 crores** of investments could be required for the acquisition of coaches over the next **10 years till 2031**. About **61%** of this is estimated to be required for the purchase of non-AC coaches. About **20%** is expected for the purchase of train seats, and the balance for AC/MEMU/DEMU coaches.
- Beyond 2031, it is expected that another **INR 1,99,218 crore** of investments may be needed for acquisition of coaches up to **2051**. While these requirements would be subject to change based on various developments, about half of this amount is expected to be needed for the purchase of non-AC coaches, and the balance for mainly AC coaches and train sets.

Exhibit 190: Summary of Investments in Locomotives

Particulars	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2041	2051	Total
No. of Locomotives	2,205	2,205	2,205	2,205	2,205	929	929	929	929	929	13,510	16,837	46,017
Investments Required (INR Crore)	30,867	30,867	30,867	30,867	30,867	13,009	13,009	13,009	13,009	13,009	1,89,140	2,35,718	6,44,238

Source: National Rail Plan 2030

- INR **2,19,380 crores of investments** could be required for the acquisition of locomotives over the next 10 years till 2031.
- Beyond 2031, it is expected that another **INR 4,24,858 crore of investments** may be needed for acquisition of **locomotives up to 2051**. These requirements would however be subject to change based on various market and system developments such as demand variations, increased capacity, better speeds, heavier and longer trains.

Key Developments in Indian Railways

- As of April 1, 2024, Indian Railways has 488 railway infrastructure projects underway, including 187 new lines, 40-gauge conversions, and 261 doubling projects, **totaling 44,488 km and costing approximately Rs. 7.44 lakh crores.** Of this, 12,045 km has been commissioned, with an expenditure of around Rs. 2.92 lakh crores incurred by March 2024.
- Presently **61 Vande Bharat Service** Trains are running linking States with a Broad-Gauge electrified Network.
- Indian Railways is also working on upgrading its infrastructure, with a focus on electrification of lines, the construction of new lines, and the redevelopment of existing stations. The government has also announced plans to invest in high-speed trains, such as the Mumbai-Ahmedabad High-Speed Rail project, which is being implemented with the assistance of Japan.
- In June 2023, IRCON (formerly Indian Railways Construction Company Limited) signed a memorandum of understanding (MoU) with the National Investment and Infrastructure Fund Limited and Ayana Renewable Power Limited. This partnership will consider suitable opportunities for solar energy production for the Indian Railways as they intend to increase the share of renewables in their overall energy mix.

Government Initiatives

- As of January 2023, a total of 1724 kilometers of Dedicated Freight Corridor (DFC) had been commissioned, with 861 kilometers completed on the Eastern Dedicated Freight Corridor (EDFC) and 863 kilometers on the Western Dedicated Freight Corridor (WDFC).
- Government announced about the MoU signed with USAID India in June 2023 to achieve Net Zero Carbon Emission by 2030.
- The Ministry of Railways plans to monetize assets including Eastern and Western Dedicated Freight Corridors after commissioning, **induction of 150 modern rakes through PPP**, station redevelopment

through PPP, railway land parcels, multifunctional complexes (MFC), railway colonies, hill railways and stadiums.

Railway network expansion and inclusion of new coaches and locomotives will drive the forging components market in India.

Overview of New Government Schemes in Railways Sector

PM Gati Shakti

- PM Gati Shakti - National Master Plan for Multi-modal Connectivity, essentially a digital platform to bring 16 Ministries including Railways and Roadways together for integrated planning and coordinated implementation of infrastructure connectivity projects.
- The multi-modal connectivity will provide integrated and seamless connectivity for movement of people, goods and services from one mode of transport to another.
- The estimated outlay under the program is **INR 100 trillion** and it aims to reduce logistics cost and enhance export competitiveness of the country.
- Indian Railways have set up a separate directorate within the Railway Board to prioritize projects under the PM Gati Shakti scheme for handling rail cargos, a new 'Gati Shakti Multi-modal Cargo Terminal (GCT)' policy has been framed.
- It has been targeted to commission 100 Gati Shakti Cargo Terminals.

Exhibit 191: New Projects Sanctioned Under PM Gati Shakti

Sl No.	Name of the section for doubling	Length in Kms	Estimated Cost (INR Cr)	State
1.	Ajmer-Chanderiya	178.28	1813.28	Rajasthan
2.	Jaipur-Sawai Madhopur	131.27	1268.57	Rajasthan
3.	Luni-Samdari-Bhildi	271.97	3530.92	Gujarat & Rajasthan
4.	Agthori-Kamakhya with new Rail cum Road Bridge	7.062	1650.37	Assam
5.	Lumding-Furkating	140	2333.84	Assam & Nagaland
6.	Motumari-Vishnupuram and Rail over Rail at Motumari	99.68	1746.2	Telangana & Andhra Pradesh

Source: PIB

Dedicated Freight Corridor (DFC)

- The Dedicated Freight Corridor Corporation of India (DFCCIL) spearheads the DFC project, constructing dedicated freight railways across India.
- The Eastern and Western Dedicated Freight Corridors, with a combined length of **2,843 kilometers** are transforming freight movement in the country.
- The Objective of DFC is to reduce the logistic cost below 10% as per the National Logistic Policy.

Amrit Bharat

- The Amrit Bharat Station Scheme was launched in March 2023 for development of railway stations to upgrade and modernize the Railway Stations.
- Currently, **1,309 railway stations** have been identified for development. Budgetary funds and under Public Private Partnership Model are followed. Work on more than 500 stations is in progress.

Energy, Mineral and Cement Corridor, Port connectivity corridors and High traffic density corridors

- India is a strategic initiative aimed at developing a dedicated industrial corridor that leverages the country's vast reserves of energy, metals, and cement.
- 40,000 Km Rail tracks are expected to be laid under these corridors to enhance the network capacity by FY 2031.

High Speed Rail Projects

- To reduce the transit time, 12 high speed rail corridors with train speeds exceeding 250 km/hour have been proposed by the government, spanning approximately **7,200 Km**.
- The 508 Km Mumbai-Ahmedabad corridor has been taken up for construction at an expected capital expenditure of **INR 1.1 trillion**

Semi High-Speed Rail Projects

- The Government of India has taken various initiative under 'Make in India' campaign like **Semi**- **High-Speed train, Vande Bharat Express.**
- India has embarked on several semi-high-speed rail projects to enhance the speed, efficiency, and connectivity of its railway network. These projects aim to upgrade existing rail lines to support speeds of up to **160-200 km/h**, significantly reducing travel times between major cities and boosting economic growth.

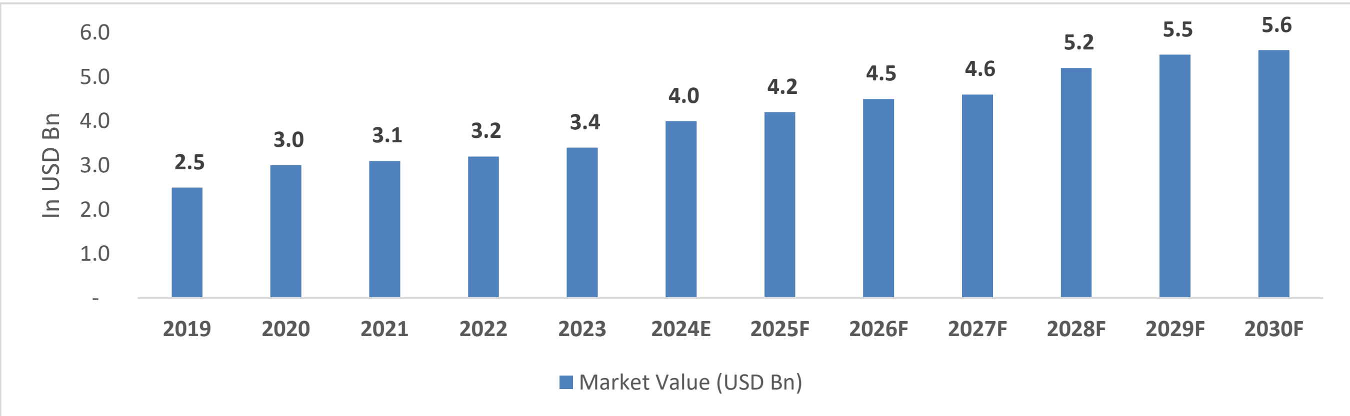
3.7 Other Segments:

3.7.1 Other Segments, Global

- Forged components crucial for construction and agricultural equipment and their growth trajectory is bolstered by government initiatives including easy financing for tractors and other agricultural equipment.
- This sector includes any general engineering segment such as manufacturing sector, Construction, Agricultural equipment and Spaceframes is expected to have a positive growth due to growing population, industrialization, investments in infrastructure development by the Government and urbanization.
- The demand for new structural forms along with the growing innovation in building techniques has resulted in the increasing adoption of space frames in various commercial & industrial infrastructures. The penetration of new & improved industrial structures coupled with increasing demand for lightweight materials is anticipated to further amplify the space frame industry growth.
- Space frames are gaining wide popularity across the globe and have been widely seen in exhibition pavilions, sports arenas, transportation terminals, assembly halls, warehouses, airplane hangars, and workshops. These frames are not only used on roof tops but also find applications in exterior walls, floors, and canopies.
- Furthermore, these structures also aid in hosting various concerts, sports tournaments, and mass assemblies with the advantage of extension and contraction as per gathering strength, which are the major advantages of space frames on concrete roofing systems.

Global Overall Forgings Market: Other Sectors 2019-2030

Exhibit 192: Global Overall Forgings Market Trend, Other Sectors USD Bn, 2019-30



Source: Frost & Sullivan Analysis

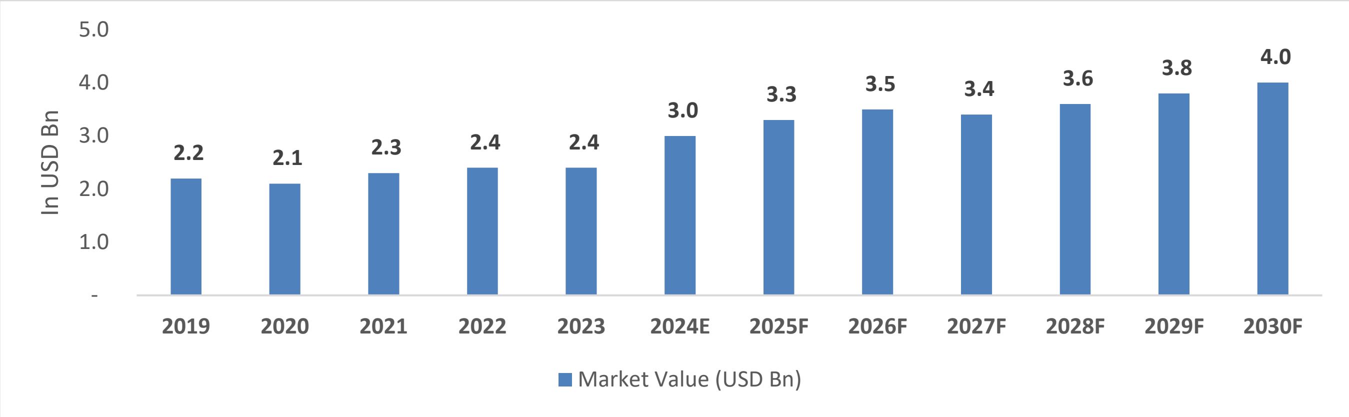
E-Estimated, F-Forecasted

Other sector includes general engineering segment such as manufacturing sector, Construction, Agricultural equipment and Spaceframes

- Global overall forgings market for other sectors was valued at **USD 3.4 Bn in 2023** and is projected to mark **USD 5.6 Bn by 2030** with a CAGR of **7.4 % from 2023 to 2030** driven by demand for new structural forms along with the growing innovation in building techniques has resulted in the increasing adoption of space frames in various commercial & industrial infrastructures

Global Precision Forged Machined Components Market: Other Sectors 2019-2030

Exhibit 193: Global Precision Forged Machined Components Market Trend, Other Sectors USD Bn, 2019-30



Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

Other sector includes general engineering segment such as manufacturing sector, Construction, Agricultural equipment and Spaceframes

- Global Precision Forged Machined Components Market for other sectors was valued at **USD 2.4 Bn in 2023** and is projected to mark **USD 4 Bn by 2030** with a **CAGR of 6.1 %** from **2023 to 2030 driven by demand for new structural forms along with the growing innovation in building techniques has resulted in the increasing adoption of space frames in various commercial & industrial infrastructures.**

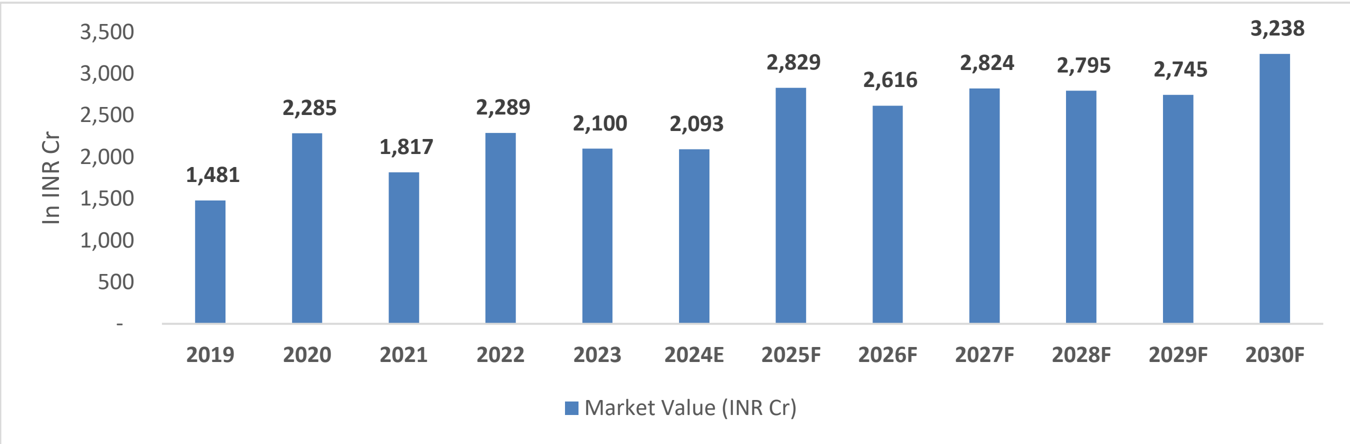
3.7.2 Other Segments, India

- This sector includes any general engineering segment such as manufacturing sector, Construction, Agricultural equipment, Spaceframes which is a high-end segment and is expected to have a growth due to growing population, industrialization, investments in infrastructure development by the Government and urbanization.

- Forged components crucial for construction and agricultural equipment and their growth trajectory is bolstered by government initiatives including easy financing for tractors and other agricultural equipment. The confluence of favourable financing options, government incentives, and policy reforms is expected to drive sustained growth and adoption of tractors across different segments in India's agriculture and rural development sector.

India Overall Forgings Market: Other Sectors, FY 2019-2030

Exhibit 194: India Overall Forgings Market Trend, Other Sectors, INR Cr, FY 2019-30



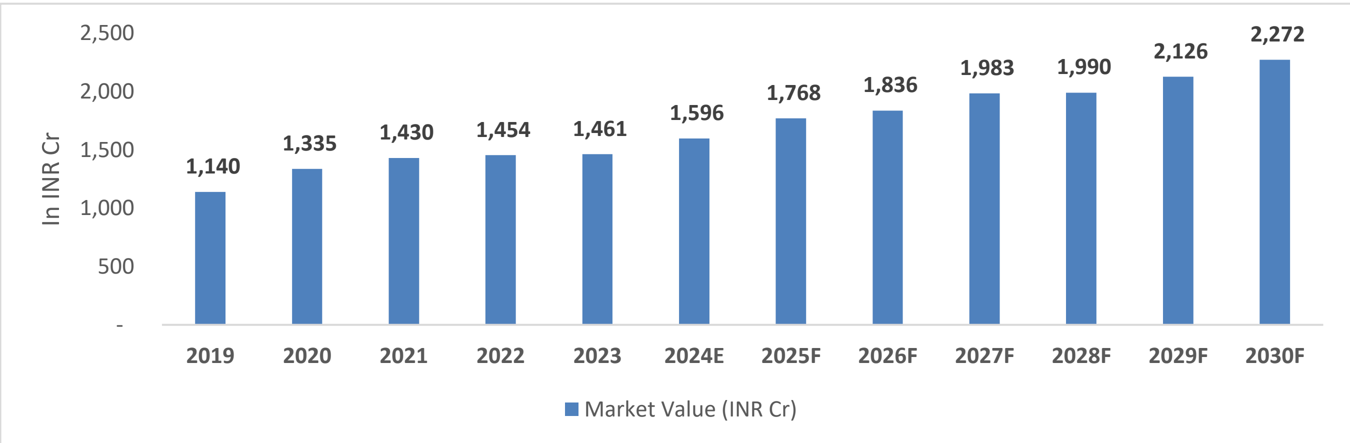
Source: Frost & Sullivan Analysis

E-Estimated, F-Forecasted

- Indian Overall forgings market for Other Sectors was valued at **INR 2,093 Crores in FY 2024** and is projected to **mark INR 3,238 Crores by 2030** with a **CAGR of 7.5 % from FY 2024 to 2030** driven by growing population, industrialization, investments in infrastructure development by the Government and urbanization.

India Precision Forged Machined Components Market: Other Sectors, FY 2019-2030

Exhibit 195: India Precision Forged Machined Components Market Trend, Other Sectors, INR Cr, FY 2019-30



Source: Frost & Sullivan Analysis

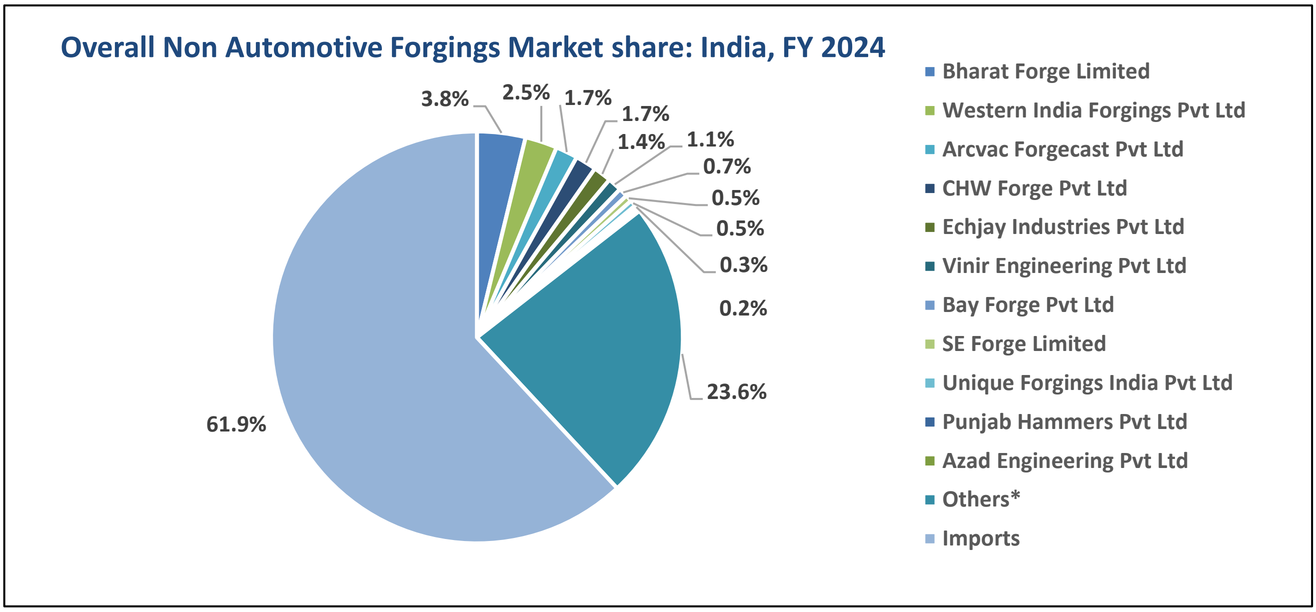
E-Estimated, F-Forecasted

- Indian Precision Forged Machined Components Market for Other Sectors was valued at **INR 1,596 Crores in FY 2024** and is projected to mark **INR 2,272 Crores by 2030** with a **CAGR of 6.1 % from FY 2024 to 2030** driven by growing population, industrialization, investments in infrastructure development by the Government and urbanization.

Competition Landscape of Non-Automotive Forgings in India

4.1 Competition Landscape of Overall Non-Automotive Forging Market in India

Exhibit 196: Competition Landscape of Overall Non-Automotive Forging Market in India, FY 24



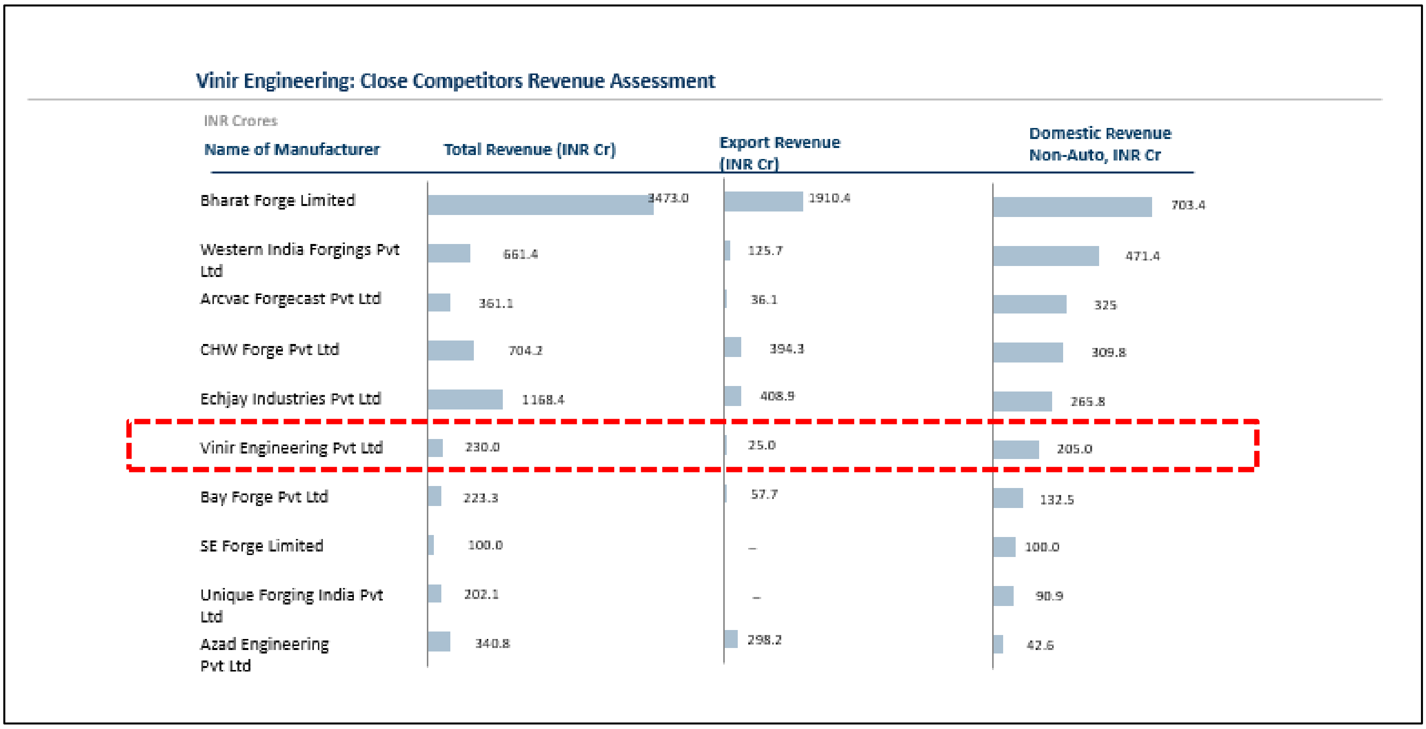
Source: Frost & Sullivan Analysis
The base year is FY 2024

- The Indian Overall Non-Automotive Forging Market was valued at **INR 18,738 Cr in FY 2024,** Domestic producers catered to **38.1% of the total demand followed by Imports of 61.9%.**

Domestic Supply:

- Bharat Forge Limited is the market leader with 3.8%, followed by Western India Forgings Pvt Ltd being the 2nd largest with 2.5%. Followed by Arcvac Forgecast Pvt Ltd (1.7%), CHW Forge Pvt Ltd (1.7%), Echjay industries Pvt Ltd (1.4%), Vinir Engineering Pvt Ltd (1.1%) which is one of the prominent players in this niche segment of precision-forged and machined components industry, especially for critical and heavy-duty applications, positioned under top 10 category and solely operates in the precision forged machined components segment of non-automotive end use segments such as energy (oil and gas), aerospace & defence, railways, earthmoving hydraulics and mining segment.
- Other smaller players are Bay Forge (0.7%), followed by SE Forge (0.5%) which mainly operates in Ring Rolling, Unique Forgings Pvt Ltd (0.5%), Punjab Hammers (0.3%), Azad Engineering (0.2%). 14.5% market demand of non-automotive forging in India is met by the above producers which are close competitors of each other.
- The remaining 23.6% demand is catered by the other* players which are spread across four forging clusters such as north, south, east and west.
- Key players among others category are Ramakrishna Forgings Ltd, Happy Forgings Ltd which are predominantly present into Automotive forgings, MM Forgings Pvt Ltd, Echjay Forgings Pvt Ltd, Ganga Forgings Ltd, Ambe Forge Pvt Ltd, Harika Industries, Happy Steel Pvt Ltd, JVR Forgings, Microtek Forgings Pvt Ltd, RB Forgings Pvt Ltd, Sadhu Forgings Pvt Ltd, Fine Forge limited, GSB Forge Pvt Ltd, AMIC Forgings Pvt Ltd, BMN Alloy Steel Pvt Ltd, BTM forgings Pvt, Ltd, Creative Forgings Pvt Ltd, Genova Forgings Pvt Ltd, Inno Forge Pvt Ltd, LBG Forge Limited, Phoenix Forge Pvt Ltd, Steel and Industrial Forgings Pvt Ltd, Unity Forge Pvt Ltd, Ambar Forge Pvt Ltd, Arora Forgings Pvt Ltd, Jeko Industries, Padmavati Forge Pvt Ltd, Sachin Forge Pvt Ltd, Varsha Forgings Pvt Ltd Unimech Aerospace and Manufacturing Ltd, MTAR Technologies and Balu Forge Industries Ltd.

Exhibit 197: Revenue Assessment of Close Competitors of Vinir Engineering, India, INR Cr, FY 24



Source: Company Annual Reports FY 2024 and Frost & Sullivan Primary Research

Imports:

- 61.9% of total non-automotive forging demand is met via imports, China is a major exporter of overall forgings to India with an overall share of 35-40%. Key exporters of forgings to India for Oil and Gas sector are China (46%), Japan (7%), USA (6%) and rest of the world contributing to (41%) Germany, Kingdom of Saudi Arabia (KSA), United Arab Emirates (UAE), Kuwait and United Kingdom (UK).
- For Earthmoving and hydraulic forged components major exporter to India are China (54%), South Korea (16%), Germany (4%) and 26% is rest of the world being United Kingdom, USA and Japan. For Aerospace forgings major exporter to India are Germany (22%), France (17%), USA (14%) and rest of the world comprising of 47% share Italy, Israel and Brazil. Defence forgings are imported to India from Italy (40-45%), Germany (15-20%), Israel (10-15%), rest of the world comprising between 30-35% contributed by USA, Russia and United Kingdom.
- The Non-Automotive Industry as a whole has a large addressable opportunity for import substitution to penetrate the domestic forging market by capturing the portion of imports and reduce the dependency and become a self-reliant country.

Exhibit 198 a: Capability Comparison Between Key Competitors of Vinir Engineering

Capability	Vinir Engineering	Unimech Aerospace and Manufacturing Ltd	MTAR Technologies Ltd	Azad Engineering Ltd	Balu Forge Industries Ltd
Closed Die Forging	Yes	No	Limited	Yes	Yes
Open Die Forging	Yes	No	No	No	No

Capability	Vinir Engineering	Unimech Aerospace and Manufacturing Ltd	MTAR Technologies Ltd	Azad Engineering Ltd	Balu Forge Industries Ltd
Ring Rolling	Yes	No	No	No	No
Radial Forging	Yes	No	No	No	No
Machining	Yes	Yes	Yes	Yes	Yes

Source: Company websites

Exhibit 198 b: Financial Comparison of Key competitors, INR Cr, FY 2022

Name of the company	Revenue (INR Cr)	EBITDA Margin (%)	PAT (%)	ROCE (%)	ROE (%)
Bharat Forge Limited	6,254.6	19.4%	17.2%	16.7%	15.2%
Western India Forgings Pvt Ltd	-	-	-	-	-
Arcvac Forge Cast Pvt Ltd	220.5	19.0%	18.4%	27.3%	35.1%
CHW Forge Pvt Ltd	389.8	5.4%	3.6%	5.9%	6.9%
Echay Industries Pvt Ltd	827.8	20.5%	16.3%	27.2%	7.3%
Vinir Engineering	153.7	-	10.1%	-	-
Bay Forge Pvt Ltd	174.9	20.9%	14.9%	11.3%	10.7%
SE Forge Ltd	481.0	-	2.1%	-	-
Unique Forging India Pvt Ltd	146.9	4.2%	3.1%	6.7%	9.2%
Azad Engineering	194.5	33.0%	15.2%	17.0%	12.2%
Balu Forge Industries Ltd	147.3	12.3%	5.2%	16.0%	18.8%

* **Blank spaces indicate data not reported or not available**

Source: Annual Report FY 2022, Financial Reports FY 2022

Exhibit 198 c: Financial Comparison of Key competitors, INR Cr, FY 2023

Name of the company	Revenue (INR Cr)	EBITDA Margin (%)	PAT (%)	ROCE (%)	ROE (%)
Bharat Forge Limited	7,572.7	19.8%	13.8%	16.2%	13.6%

Name of the company	Revenue (INR Cr)	EBITDA Margin (%)	PAT (%)	ROCE (%)	ROE (%)
Western India Forgings Pvt Ltd	-	-	-	-	-
Arcvac Forge Cast Pvt Ltd	306.6	14.3%	6.8%	13.3%	15.2%
CHW Forge Pvt Ltd	618.2	12.6%	3.5%	8.4%	9.5%
Echay Industries Pvt Ltd	1,112.7	23.3%	15.6%	35.5%	8.4%
Vinir Engineering	227.5	16.6%	12.3%	34.0%	34.0%
Bay Forge Pvt Ltd	200.1	22.2%	13.7%	10.9%	10.1%
SE Forge Ltd	473.0	-	-7.4%	-	-
Unique Forging India Pvt Ltd	179.6	9.1%	4.1%	9.7%	12.9%
Azad Engineering	251.7	28.7%	33.8%	13.0%	12.1%
Balu Forge Industries Ltd	339.3	19.1%	11.5%	23.1%	19.5%

* **Blank spaces indicate data not reported or not available**
Source: Annual Report FY 2023, Financial Reports FY 2023

Exhibit 198 d: Financial Comparison of Key competitors, INR Cr, FY 2024

Name of the company	Revenue (INR Cr)	EBITDA Margin (%)	PAT (%)	ROCE (%)	ROE (%)
Bharat Forge Limited	8,968.6	22.6%	15.8%	20.0%	13.1%
Western India Forgings Pvt Ltd	674.0	15.1%	15.1%	-	-
Arcvac Forge Cast Pvt Ltd	338.8	14.2%	6.5%	-	-
CHW Forge Pvt Ltd	592.2	14.4%	4.9%	-	-
Echay Industries Pvt Ltd	-	-	-	-	-
Vinir Engineering	229.5	19.3%	11.7%	40.0%	40.0%
Bay Forge Pvt Ltd	-	-	-	-	-
SE Forge Ltd	482.0	-	1.4%	-	-

Name of the company	Revenue (INR Cr)	EBITDA Margin (%)	PAT (%)	ROCE (%)	ROE (%)
Unique Forging India Pvt Ltd	-	-	-	-	-
Azad Engineering	340.8	34.0%	17.0%	21.0%	9.0%
Balu Forge Industries Ltd	570.3	22.8%	16.4%	16.3%	-

* **Blank spaces indicate data not reported or not available**
Source: Annual Report FY 2024, Financial Reports FY 2024

4.2 Brief Profile of Vinir Engineering

Ownership	Privately Held	Company Overview
Founded	1983	• Vinir Engineering is a leading, integrated engineering solutions company engaged in the manufacturing of specialised, critical and heavy, precision-forged and machined components for a wide range of industries and applications, including energy, energy turbines, defence, aerospace, railways, earthmoving, hydraulics and high-end engineering amongst others have stringent quality and performance requirements. • Vinir Engineering's products play a vital role in various systems and applications, such as armored vehicles, armaments and ammunition, combat equipments, military hardware, upstream and downstream oil & gas systems, cryogenics systems, aircraft propulsion systems, power turbines, gas turbines, railway locomotives and braking systems, nuclear energy infrastructure equipments, heavy duty excavation machinery, spaceframes, hydraulic components, wind turbine generators, high-pressure boilers, amongst others. • Vinir Engineering produces products for all types of forgings namely Closed, Open, Ring Rolling and Radial Forging for the niche precision forged and machined components market. • Vinir Engineering is backward integrated with raw material sourcing capabilities, inspection, testing and preparation, ensuring that only high-quality materials are used for the production process. These initial steps are critical to maintaining the integrity and performance of the final components, forming the foundation of their production efficiency and quality assurance. • Vinir Engineering specialises in producing critical and heavy precision-forged and machined components using a wide range of metals, including alloy steel, titanium, Hastelloy, carbon steels, stainless steels, duplex steels, special steels, Inconel, Monel, and aluminium, amongst others. **Market Position:** • Vinir Engineering is a pioneer in the niche non-automotive forging segments in India, with 89% of its total sales focused on the Indian Market, the firm has a large addressable market of INR 18,738 Crores i.e. Imports (61.9%) INR 11,606.18 Crores and Domestic Market addressable market of (38.1%) INR 7,131.82. • **Sector Wise Revenue Split**: Energy (56.08%), Aerospace and Defence (12.74%), Earthmoving, Hydraulics and Mining (7.59%), Railways (7.4%), Energy Turbines (4.52%) and others (11.67%) which includes Spaceframes, Manufacturing construction & agricultural equipment. Vinir Engineering is more focused on the emerging segments such as Energy and Aerospace and Defence. **Plant Capability:** • Vinir Engineering produces Open Die forgings upto 6,000 kgs/piece (rough, proof machined or full machined) • Vinir Engineering have three rolling mills which produces rings upto 4500 mm diameter on wagner RR at and upto 1500 mm diameter and 325 mm height on wagner RR machine.
Headquarters	Bangalore	
Manufacturing Facilities	3 Bangalore-1 Hosur -1 Kalukondanapalli-1	
Capacity (MTPA)	45,000	
Total Revenue, FY 24	INR 230 Crores	
Total Domestic Revenue (Non-Auto), FY 24	INR 205 Crores	
Export Revenue, FY 24	INR 25 Crores	

Ownership	Privately Held	Company Overview
		• Inhouse heat treatment, test labs Certified by National Accreditation Board for Testing and Calibration Laboratories (NABL) and machining facilities to finish machined parts. • Have forged based machined assemblies in ready to use condition duly tested and certified for all sectors including Energy (oil and gas), defence and aerospace. • Vinir Engineering have inhouse capability of design and manufacturing of precision dies tailored to produce the final precision components. Vinir Engineering has a portfolio of over 5,000 die designs. • The backward integration spanning raw material preparation to die design and production provides Vinir Engineering a significant competitive edge by ensuring superior quality control, optimizing cost and reducing process lead times. **Key Products Manufactured:** • **Energy:** Parts of valve bodies, Gates, Stem, Studded Tee, Crosses, Rings, Slip Bowls, coupling hub, clamp, body, adapters, flange, caps, blocks, Rings, Profile Rings, seat rings, Parts of surface well heads, slip bowls, flanges, Parts for subsea applications including adapter bodies, Parts of cryogenic applications including valve bodies, extended bonnets, Parts for chokes. • **Energy Turbines:** Rotor Shafts, Gear Box, Low and High-Speed Drive Shafts, Hubs, Turbine Discs, • **Aerospace:** Disks, Diffusers, Structural parts, Barrels, Swing arms, Hub, Turbine Discs • **Defence: Armoured Vehicles:** Parts for Engines, Suspension, turret, main body, track **Armaments and Ammunition:** Body, Extractors, ejectors, barrel **Military Hardware**: Parts for engines, suspension, main body, Track • **Railways:** Braking Systems, Connecting Rods, Gears, Pinions, Couplings, shafts and cylinder heads, Gear Blanks, Pinions and Shafts, Rings, Profile Rings. • **Earthmoving, Hydraulics and Mining:** Parts for Engine, Structural, Couplings, parts for track, Parts for boom, Connecting Rods, Gears, Hydraulic Cylinder parts, Parts for bucket and attachments • **Others:** Parts for space frames including node, cones, sleeves, Gears, shafts, connecting rods, crankshafts, hubs, rotors **Key Certifications:** • ISO 9001:2015, ISO 45001:2018, ISO 14001:2015, ISO 50001:2018, ISO 17025-NABL • AS 9100D • Certified Green Company (CII-GreenCo) • API 20C, AD 2000

Source: Frost & Sullivan Primary Research

4.3 Brief Profile of Western India Forge

Ownership	Privately Held
Founded	1980
Headquarters	Pune, Maharashtra
Manufacturing Facilities	3; WIF Bhosari, Kran Rader, WIF Sanaswadi, Pune
Capacity (MTPA)	-
Total Revenue, FY 24	INR 661.39 Crores
Domestic Revenue (non-auto), FY 24	INR 471.44 Crores
Export Revenue, FY 24	INR 125.66 Crores

Company Overview

- Western India Forge is one of the prominent players in the non-automotive forgings market in India and produces open die, closed die and ring rolled forgings under one roof in the weight range of 1kg to 10,000kgs.
- Western India Forge mainly serves industries such as oil and gas, earthmoving equipment, railways, energy, defence and other general engineering sectors under non-automotive segments.

Market Position:

- Western India Forge is one of the prominent players in the non-automotive Forging space in India and witness 2.5% market share in domestic non-automotive forgings market.
- **Sector Wise Revenue Split**: Energy (49%), Defence (8%), Earthmoving, Hydraulics and Mining (18%), Railways (17%), and others (8%) which includes manufacturing sectors, construction and agricultural equipment.

Plant Capability:

- Western India Forge have capability to produce Open Die forgings ranging from diverge raw materials such as carbon, alloy, stainless, tool and duplex steels. Under Open Die Forgings it produces small die forgings up to 300 kgs while other products range between 300kgs to 1 ton
- Downstream facilities are equipped with gas fired heat treatment setup qualified as per CQ19 and AMS 2750E and AMS 6875.Facilities have well defined QMS Integrating requirements of ISO, TS and API.
- Plant is equipped with 16-ton hammer which enables Western Forge to produce close die components up to 750 kgs and serves segments of Railways, Oil and Gas and Power.
- Capable of producing huge range of products from 35kgs to 10 tons.
- With the support of three Vertical Ring Mills and one Horizontal Ring Mill Western India Forge is capable of producing rings from 350mm OD to 3000 mm OD and weight range of 15Kgs to 3200 Kgs.

Key Products Manufactured:

- **Oil and Gas:** Bonnets, Body, Housing, Gates, Square Block, Cross, Studded Tees
- **Railways:** Gears, Trolley Wheel, Axle Arm, Bearing Cap, Bevel Pinions, Rings, Yoke Forgings
- **Energy:** Round Bar, Spring Plate, Rotor-Pole End Plate, Planet Bucket Ring, Gear Blank, Cross Head, Connect Flange
- **Earthmoving, Hydraulics and Mining:** Cone Forging, Coupler, Back Head, Drive Shafts, Handle Forgings, Rings, Shafts, Valve Forgings, Base Trunion, Bearing Yoke, Blank Pinion, Rings, Spindle, Cone Head Shaft, Spacers, Gears
- **General Engineering:** Shaft Forging, Inner Core Forging, Hub Forging, Chain Link, Coupling Sprocket, Thrust Plate, Clutch Body, Wheels Forgings

Ownership	Privately Held	Company Overview
		Key certification: • ISO 14001:2015 and OHSAS 18001:2007 • ISO / TS16949 from TUV SUD • PED 97/23/EC from DNV-GL • ABS approved Forging facility **Key Customers:** • Alstom, AAM, Andritz Hydro, GE Oil and Gas, Goodwin International Ltd, Mahindra, Siemens, Perkins, Wesco, Volvo

Source: Frost & Sullivan Primary Research

4.4 Brief Profile of Arcvac Forge Cast Private Limited

Ownership	Privately Held	Company Overview
Founded	2005	• Arcvac Forge Cast Private Limited is a specialized open die forging company strategically located in Eastern India operating in non-automotive segments such as Oil and Gas, Aerospace, Railways, Energy, Mining, Ship building, Heavy Engineering and Ports and Yards. **Market Position:** • Arcvac Forge Cast Private Limited is a key player in the non-automotive Forging space in India and witness 1.7% market share in domestic non-automotive forgings market. • **Sector Wise Revenue Split**: Energy (27%), Aerospace & Defence (15%), Earthmoving, Hydraulics and Mining (22%), Railways (15%) and others (21%) which includes manufacturing sectors, construction and agricultural equipment. **Plant Capability:** • Inhouse Electric Arc Furnace with Eccentric Bottom Tapping for slag free liquid metal, subsequently refined in Ladle Refining Furnace and Vacuum Degassed under 1 Torr. • Forge Shop with multiple Hydraulic Hammers and Manipulators to forge ingots upto 8 tonne single piece. • Inhouse machining facility equipped with more than 100 horizontal and Vertical Turning Lathes, Horizontal and Vertical Boring Machines for rough and precision machining. **Key Products Manufactured:** • Customized open die forgings up to 6 ton a piece. • Forge Shop with multiple Hydraulic Hammers and Manipulators to forge ingots upto 8 tonne single piece • Forge Shop with multiple Hydraulic Hammers and Manipulators to forge ingots upto 8 tonne single piece **Certification:** • ISO 9001:2000 • ISO 14001:2004 • Modern NABL (ISO:17025) accredited laboratory facilities • ABS Certified **Key Customers:** • Confidential
Headquarters	Kolkata, India	
Manufacturing Facilities	Kolkata	
Capacity MTPA	16,000	
Total Revenue, FY 24	INR 361.10 Crores	
Domestic Revenue (non-Auto), FY 24	INR 325 Crores	
Export Revenue, FY 24	INR 36.11 Crores	

Source: Frost & Sullivan Primary Research

4.5 Brief Profile of CHW Forge

Ownership	Privately Held	Company Overview
Founded	Founded in 1956 & started operation in 1960	• CHW Forge, formerly known as Chaudhry Hammer Works, was established in 1956. Key end-use sectors include **oil and gas, Aerospace & Defence, Shipbuilding, Nuclear power, Mining and Infrastructure.** The company also makes parts for **Construction, General Engineering, and Drilling Machines**. • CHW Forge manufactures a wide range of steel forging products which find application across diverse industries. **Market Position:** • CHW Forge is a key player in the non-automotive Forging space in India and witness 1.7% market share in domestic non-automotive forgings market. • **Sector Wise Revenue Split**: Energy (77%), Aerospace & Defence (23%) **Plant Capability:** • CHW Forge produces large diameter bearing rings in sizes ranging from external diameters of 500mm to 4800mm. • CHW Forge have electrically operated reheating furnaces and gas operated reheating furnaces. • Plant is equipped with inhouse heat treatment facility. • CHW Forge uses wide range of materials for Carbon & Special Steels, Alloy Steel, Stainless Steel, Aluminium Alloys, Titanium Alloys and Super Nickel Alloys. • CHW Forge is equipped with Fully Automatic hydraulic presses for Open Die Forging, Heat treatment and Machining facilities. • Plant is equipped with mobile forging manipulators ranging between 2 MT to 30 MT weight. **Key Products Manufactured:** • Key products manufactured by CHW Forge includes aluminium forgings, Forged Flanges, Tower Flanges for windmills, Seamless Rolled Rings, Rings for Slew Bearings, Gear Rings and Y Rings, Forged Disc, Forged Shafts and Stepped Shafts, Forged Gear Blanks and Crane Wheels **Rolling Infrastructure:** • CHW Forge has a fully integrated Ring Rolling Machine, automatic hydraulic press 4000T, and Automatic Hydraulic Open Die Forging Press 3800 MT for producing high-speed open die forging. They also use modern gas-fired and electric-operated furnaces to reduce energy costs and carbon emissions. • CHW Forge has heat treatment facilities for normalizing, hardening, tempering, annealing, and hydrogen flanking at high temperatures. They also have the latest manipulators from Dango & Dienenthal and an integrated ERP system for accurate material control and quality standards. **Key Certifications:** • CHW Forge is certified by world renowned certifying agencies for ISO 9001, ISO 14001, ISO 45001, API 6A, API 20B, API 20C, AD 2000-Merkblatt WO, EN 9100 & ISO 27001 **Key Customers:** • Hyundai Heavy Industries, Samsung Engineering Company Limited, National Petroleum Construction Company (NPCC), Technimont,
Headquarters	Ghaziabad, UP	
Manufacturing Facilities	Ghaziabad & Noida	
Capacity (MTPA)	40,500	
Total Revenue, FY 24	INR 704.18 Crores	
Domestic Revenue (Non-Auto), FY 24	INR 309.84 Crores	
Export Revenue, FY 24	INR 394.34 Crores	

Ownership	Privately Held	Company Overview
		Toyo Engineering India Limited, Komatsu India Ltd, KYB Conmat India Pvt. Ltd., Liebherr India Private Limited, Schwing Stetter India Pvt. Ltd. Kirloskar Brothers Limited, Larsen & Toubro (Power Division), Abu Dhabi National Oil Company (ADNOC), BPCL, HPCL, Voith Hydro Pvt. Ltd.

Source: Frost & Sullivan Primary Research

4.6 Brief Profile of Bharat Forge

Ownership	Public Listed	Company Overview
Founded	1961	• Bharat Forge Limited (BFL) is the flagship company of the Kalyani Group and a global provider of high performance innovative, safety & critical components and solutions to various sectors including Automotive, Railways, Defence, Construction & Mining, Aerospace, Marine and Oil & Gas sectors. It is the India's largest Forging company with the presence of world's largest forging facility located at Mundhwa in Pune, India. • Bharat Forge has the Business presence in Power, Oil and Gas, Automotive, Railways, Marine, Construction and Mining, Aerospace, Defence and E-Mobility. • Bharat Forge produces Green Forgings. It is one of the few companies in the world with majority of power being produced by renewable sources. **Market Position:** • Bharat Forge is a key player in the non-automotive Forging space in India and witness 3.8% market share in domestic non-automotive forgings market. • **Sector Wise Revenue Split**: Energy (Oil & Gas) (15.5%), Aerospace & Défense (26.7%), Railways (17.8%), Earthmoving Equipment (26.7%), Others (13.3%) which includes manufacturing sectors, construction and agricultural equipment. **Plant Capability:** • Bharat Forge's forging facilities consists of fully automated forgings press lines ranging from 1600T to 16000T. All the forging press lines are highly flexible, which gives the company the inherent advantage to simultaneously meet different customer demands and optimize production. This allows Bharat Forge to meet the growing demands of its customers continuously. • Produces Product Ranges from 0.2 Kg to more than 30 Ton Finished Weight • Plants are equipped with Material sourcing, design and simulation, Tools and Die Making, Forging and Precision Forging, Precision Machining, Specialized heat treatment and testing and validation all under one roof providing customers with one stop solutions. **Key Products Manufactured:** • **Energy:** Rotor Shaft, Generator, Welded Rotor, Disc, Thrust Block, Trunion, Bush, Main wind, Ring Wheel, Planet Wheel, Fast Wheel, High pressure valve bodies, Y Blocks, Spool body, Mandrel, Connectors, Rings, Gate valve body, Shell, Y Block • **Aerospace**: Fan Blades, Compressors, Turbine • **Defence:** parts of artillery gun systems, protected vehicles, small arms, Ammunitions, Marine • **Railways:** Crankshafts, connecting rod, Gear box support, Motor Support, Primary Support
Headquarters	Pune Maharashtra, India	
Manufacturing Facilities	6 Pune-1, Baramati-1, Satara-1, Chakan-1, Vadodra-1, Lonikand-1	
Capacity MTPA	4,23,750	
Total Revenue, FY 24	INR 3,473.36 Crores	
Domestic Revenue (Non-Auto), FY 24	INR 703.36 Crores	
Export Revenue, FY 24	INR 1910.35 Crores	

Ownership	Public Listed	Company Overview
		• **Earthmoving and Mining:** Machined Crankshaft, Injector body, front spindle, tracklink **Key certification** • ISO 9001 • ISO 14001 • TS 16949 • AS 9100 REV C • NADCAP • API Q1 • PED 97/23/EC **Key Customers:** Halliburton, Cummins, Boeing, Daimler, Caterpillar, John Derre, Baker Hughes, Schlumberger, BHEL, Siemens Gamesa, Indian Railway, HAL, Safran, IOF, Ministry of Defence

Source: Frost & Sullivan Primary Research

Conclusion: Vinir Engineering

5. Conclusion: Vinir Engineering

5.1 Key Drivers and Challenges in Indian Precision Forged and Machined Components Market

Indian Precision Forged and Machined Industries is mainly influenced by the dynamics of various end use segments where applications of forgings are prevailing.

Exhibit 199: Key Drivers and Challenges in Indian Precision Forged and Machined Components Market

Key Drivers	
Government's Initiatives	India's push for indigenization in aerospace & defence manufacturing and the "Make in India" program provide opportunities for domestic forging manufactures to expand their capabilities and cater the growing forging demand both domestically and internationally
Government Investments in Railways	India's significant investments in modernizing and expanding its railway infrastructure create a steady demand for high-quality components, enabling local forging manufacturers to expand their capabilities and diversify their portfolio.
Infrastructure Development	India's focus on large-scale infrastructure projects drives demand for earth-moving equipment, directly boosting the need for forged components manufactured by the local players. The growing demand for construction and mining equipment in India presents a steady market for forged and machined parts.
Technological Upgradation	Investments in automation and advanced machining is improving efficiency, reducing costs, and offering a competitive edge in the forging market for hydraulics and earthmoving segments.
Sectoral Growth in India	Rapid urbanization and industrial growth drive the demand for forged components in general engineering and infrastructure, creating business opportunities for the local manufacturers.
Challenges	
Oil and gas sector	Oil and gas sector is subject to global market fluctuations, affecting demand for forged products and services. Compliance with strict industry regulations for Oil and Gas sector can increase operational costs and complexity. Intense competition from global suppliers and low-cost manufacturers can pressure pricing and margins.
Stringent Quality and Compliance Requirements for Aerospace & Defence sector	Meeting the strict quality, certification, and compliance standards in aerospace and defence manufacturing can be challenging and time-consuming and impacts forging market.
High Entry Barriers for Aerospace & Defence Sector	Establishing trust and securing contracts in these sectors often requires extensive documentation, lengthy approval processes, and robust quality systems creating hesitation among players for venturing into these sectors
Dependency on Government Procurement	The defence sector in India is heavily reliant on government procurement, which can be influenced by budget constraints and policy shifts.

Raw Material Price Volatility	Fluctuations in the cost and availability of raw materials could impact production costs and delivery timelines, affecting profitability and customer relationships.
Cyclical Demand from Earthmoving and Hydraulics segment	The earth-moving sector is highly dependent on economic cycles and infrastructure spending, leading to fluctuating demand.
Technological Advancements	Rapid changes in hydraulic technology and equipment design may require constant innovation and upgrading of processes, adding to operational costs for the forging industries manufacturers.

5.2 Entry Barriers for New Entrants in Precision Forged and Machined Components Industry

Exhibit 200: Entry Barriers for New Entrants

Entry Barriers	
High Capital Investment	Setting up manufacturing facilities for precision forging and machining involves extensive financial resources due to the need for advanced infrastructure and specialized equipment. New entrants must acquire high-value machinery, including CNC machines for precision machining, open-die and closed-die forging presses for various forging applications, seamless ring rolling mills for producing high-strength rings, and temperature-controlled heat treatment facilities to enhance material properties, amongst others. Beyond equipment and machines, substantial costs are incurred in setting up auxiliary systems for testing, inspection, and material handling. Establishing backward integration, such as in-house die design and manufacturing, further compounds the financial requirements, as it necessitates specialized software, skilled personnel, and additional machinery like CAD/CAM systems and CNC die-manufacturing setups.
Technological Expertise	The precision-forged and machined components industry demands a comprehensive understanding of advanced forging and machining techniques. New entrants face a steep learning curve in mastering processes like closed-die forging, which requires intricate die design, and open-die forging, which involves manipulating large components with precise control. Processes such as seamless ring rolling and radial forging demand not only technical proficiency but also sophisticated machinery and process optimization. Additionally, the ability to work with diverse and challenging materials, such as Alloy Steel, Titanium, Hastelloy, Inconel, and Duplex Steels, requires expertise in material properties, heat treatment, and machining characteristics. Building this knowledge base and acquiring skilled personnel to execute these processes effectively takes years of experience and investment in training.

Long Customer Approval Cycles	Winning contracts in the precision-forged and machined components industry involves protracted approval and qualification processes. Customers in critical sectors require extensive testing, prototyping, and performance validation before awarding contracts. For example, aerospace and defense components undergo rigorous fatigue testing, metallurgical analysis, and dimensional accuracy checks to ensure compliance with strict safety and operational standards. These approval cycles can span months or even years, making it difficult for new entrants to achieve a steady revenue stream or build a track record. Moreover, established companies like Vinir Engineering often have pre-qualified vendor status, giving them a competitive edge that new players struggle to overcome.
Established Relationships and Reputation	The industry places a high value on trust and reliability, with customers often favoring suppliers that have demonstrated consistent performance over many years. Companies like Vinir Engineering benefit from long-standing relationships with customers across critical industries, which are built on a history of delivering quality, tailored solutions. For new entrants, establishing this level of trust is a significant challenge, as they lack a proven track record and the industry connections necessary to secure large contracts. Customers are also hesitant to shift to untested suppliers due to the risks and costs associated with validating a new source.
Economies of Scale and Vertical Integration	Established players in the industry achieve competitive advantages through economies of scale and vertical integration. Large-scale production allows players to distribute fixed costs over higher output volumes, reducing per-unit costs. Additionally, vertical integration such as in-house capabilities from raw material sourcing, inspection, and preparation to die design, forging, machining, heat treatment, and final testing enables them to streamline operations, reduce lead times, and maintain tighter control over quality. For new entrants, achieving similar economies of scale is challenging without significant upfront investment and a steady pipeline of orders. The lack of integrated capabilities also forces them to rely on external suppliers, increasing costs and lead times, further limiting their ability to compete with established players.

5.3 Exit Barriers for Customers in Precision Forged and Machined Components Industry

The precision-forged and machined components industry is characterized by significant exit barriers for customers, making it challenging for them to switch suppliers with ease for highly customized, critical, and heavy components for demanding applications. These exit barriers arise from a mix of factors including technical, economic, and operational, inherent in the industry, ensuring a strong and lasting relationship between suppliers and customers

Exhibit 201: Exit Barriers for Customers

Exit Barriers	
High Switching Costs	Customers in specialized and critical end user industries rely on components that must meet exact specifications and perform flawlessly under stringent conditions. Changing suppliers involves substantial switching costs, including requalification of new vendors, tooling adjustments, and the need to revalidate the production processes. This often requires significant investment of time, money, and resources, making it economically unfeasible for customers to move away from their existing suppliers.
Dependence on Tailored Solutions	Precision-forged and machined components are often designed and manufactured to suit the unique operational needs of each customer. Our Company, for example, delivers highly customized components, leveraging technologies and processes such as closed-die forging, open-die forging, and seamless ring rolling, coupled with in-house die design capabilities. This customization creates a high level of dependency, as transitioning to a new supplier would necessitate redesigning, retooling, and revalidating parts, potentially disrupting the customer's supply chain and operational schedules.
Quality, Reliability and Breach of Confidentiality Risks	The critical nature of components means that even minor deviations in quality can have catastrophic consequences. Customers place a high degree of trust in suppliers who have demonstrated consistent quality and reliability over time. Transitioning to a new supplier introduces the risk of quality issues, which can result in operational failures, increased downtime, and reputational damage. This risk further discourages customers from exploring alternative sources. Also, in industries where precision-forged and machined components are very critical, a significant amount of proprietary information, including design specifications, engineering data, and operational requirements, is shared between the customer and the supplier. This reliance on confidentiality creates a substantial exit barrier for customers, as the trust and secure systems established with an existing supplier cannot be easily replicated. As a result, customers are more inclined to maintain long-term relationships with existing trusted suppliers, where data security and intellectual property are safeguarded.
Integrated Supply Chain Relationships	Well established suppliers integrate closely into the customers' supply chains, offering end-to-end solutions that streamline the operations. From in-house die design and manufacturing to precision machining and rigorous quality assurance processes, such integration ensures seamless delivery and minimizes lead times. Shifting to a new supplier would require customers to rebuild this supply chain relationship, which is both time-consuming and operationally disruptive.

5.4 Overall Business Revenue: FY 2020-FY 2024

Exhibit 202: Vinir Engineering: Business Revenue, FY 20-24

Sector Focus	FY 20	FY 21	FY 22	FY 23	FY 24
Domestic Sales (INR Cr)	79.79	77.69	140.84	205.83	205
Export (INR Cr)	17.25	15.53	12.82	21.69	25
Total Sales (INR Cr)	**97.04**	**93.22**	**153.66**	**227.52**	**230**

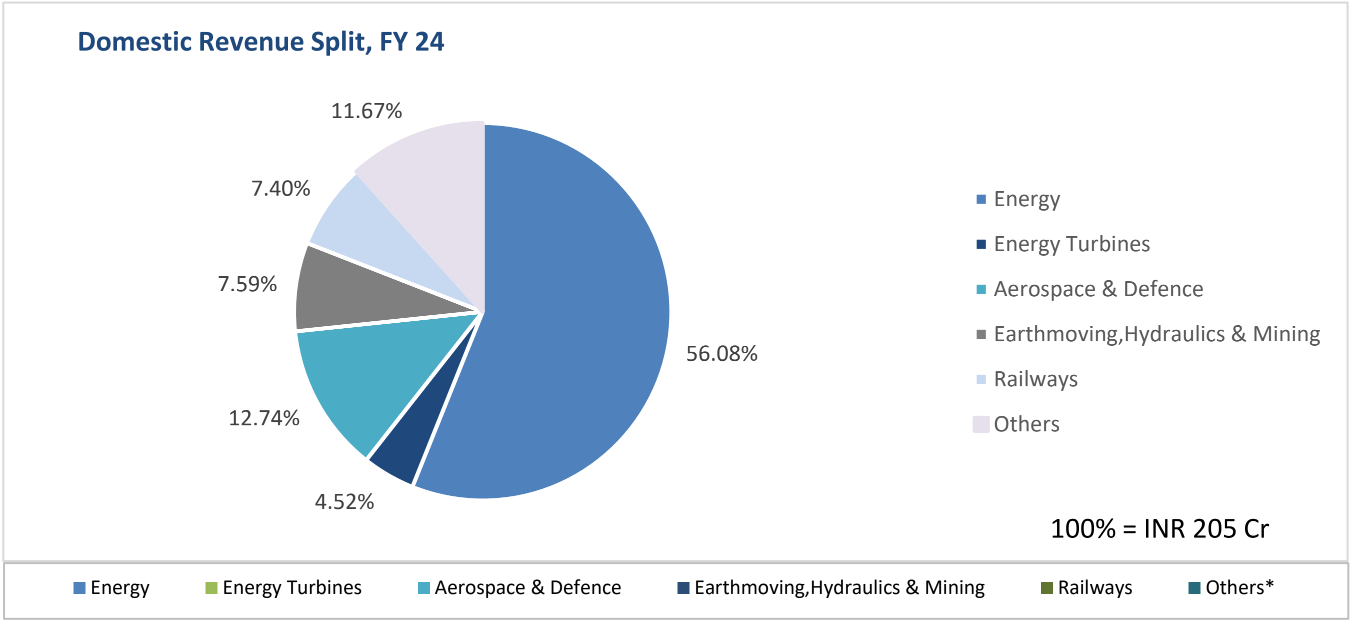
Source: Vinir Engineering

- **Vinir Engineering is well positioned with respect to business, and the overall revenue has grown from INR 97.04 Crores in FY 20 to INR 230 Crores in FY 24 with a CAGR of 24%. Vinir Engineering sales are majorly focused on domestic market, and the overall domestic revenue has grown from INR 79.79 Crores in FY 20 to INR 205 Crores in FY 24 with a CAGR of 27% in the last 5 years. Exports are growing at a CAGR of 10% from INR 17.25 Crores in FY 20 to INR 25 Crores in FY 24**.

In the last 40 years, Vinir Engineering have served Numerous clients across 18 countries.

5.5 Vinir Engineering Domestic Revenue Split by End Use Segments: FY 2023-24

Exhibit 203: Vinir Engineering: Domestic Revenue Split, FY 2023-24



Source: Vinir Engineering

Others includes any general engineering segment such as manufacturing sector, Construction, Agricultural equipment, Space Frames*

- Vinir Engineering's total revenue stood at **INR 230 Crore in FY 2023-24**, out of which 89.13% (INR 205 Crores) revenue was generated by the sales in the domestic market and the remaining 10.86% (INR 25 Crores) was contributed by the sales in the export market. Key export market for Vinir Engineering in FY 24 were USA (39%), Tunisia (26%), Mexico (25%), Canada (6%) and Malaysia (3%).

- Vinir Engineering is predominantly focused on precision forged and machined components market of non-automotive end use segments and focuses majorly on Energy, Energy Turbines Aerospace & Defence, Earthmoving, Hydraulics & Mining, Railways and others which includes any general engineering segment such as manufacturing sector, Construction, Agricultural equipment, Space frames.

- Vinir Engineering's Domestic revenue in FY 24 was majorly generated from Energy (56.08%), followed by Aerospace and Defence (12.74%), Earthmoving, Hydraulics & Mining (7.59%), Railways (7.4%), Energy Turbines (4.52%) and others (11.67%).

5.6 SWOT Analysis: Vinir Engineering

Exhibit 204: Vinir Engineering: High level SWOT Analysis

Strength	Weakness
• **Diversified Product Range:** Capable of manufacturing diverse products for industries such as Energy (Oil & Gas), Aerospace, Energy and more. Vinir Engineering has a broad market. • **Technical Proficiency:** Vinir Engineering is skilled in both forge-based and machine-based engineering solutions. A rare blend that gives us a competitive advantage. • **Green Certification:** Vinir Engineering is 'GreenCo' certified. An increasingly important credential in today's environmentally conscious business world. • **Family-Owned with Professional Management:** As a third generation 40-year-old company. Vinir Engineering blends family values with professional governance • **Well-Equipped Facilities:** State-of-the-art equipment and facilities for both forging and machining operations. • **Zero Debt** company	• **Geographical Concentration:** Currently have a large emphasis on the domestic market. However, Vinir Engineering's strategic business expansion plan to increase international footprints in Aerospace & Defence, Shipping and Hydraulics sector will ensure sectoral and Geographical diversification to Global customers. • **Dependence on Non-Renewable Energy Sectors:** Some of the sectors Vinir Engineering serves, such as Energy (Oil and Gas) are likely to shrink over time due to a global shift towards renewable energy source, hence a product diversification strategy needs to be adopted. However, Vinir Engineering's diversified service to sectors like Aerospace and Defence will reduce the risk of dependency on the Energy (oil and gas sector) for business growth and volatility in the demand due to global price fluctuations. Aerospace and defence sectors offer a steady demand, reducing reliance on other sectors like Energy (oil and gas). The global defence and aerospace market offers opportunities for exporting specialized components, expanding Vinir Engineering's International footprint.
Opportunity	**Threat**
• **Diversification:** Expanding into adjacent sectors such as wind, renewable energy, navy and shipping. • **Geographic Expansion:** Tapping into new markets, both within India and internationally, especially in regions with growing demand in non-auto sectors, could open new revenue streams. • **Technological Upgradation:** Investment in advanced manufacturing technologies (e.g., automation, Industry 4.0) can enhance efficiency and capacity. • **Partnerships and Alliances:** Collaborating with global companies in Energy (O&G), Defence & Aerospace etc or EPC contractors can create new business opportunities.	• **Market Volatility:** Fluctuating Energy (oil) prices and geopolitical tensions can directly impact client spending and project flow. • **Competition:** Local and international competitors offering faster, cheaper, or more technologically advanced services. • **Economic Slowdown:** A general economic downturn could reduce capital expenditure in most sectors, impacting demand for Vinir Engineering's services. • **Regulatory Changes:** Shifting environmental or industrial regulations, both domestically and internationally, may require costly operational adjustments. • **Competition from defence, Aerospace, and Earthmoving Industries:** These sectors require

• **Growing Environmental Focus:** Vinir Engineering's environmentally friendly operations can be leveraged as a differentiator as industries and governments increase their focus on sustainability.	similar capabilities in terms of heavy component production and precision machining, posing a potential threat as they may draw on resources or attract Vinir Engineering's target clients with more lucrative contracts.

Source: Frost & Sullivan Analysis and Primary Research

5.7 Unique Selling Proposition (USP) and Key Success Factors of Vinir Engineering

Unique Selling Proposition (USP)

- Engaged in the manufacturing of specialized, critical and heavy, precision-forged and machined components for a wide range of industries and applications, including energy, defence, aerospace, railways, energy turbines, hydraulics, earthmoving, high-end engineering, amongst others Vinir Engineering Specializes in low-volume high value parts production.
- Capable of producing heavy components in closed-die, open-die and ring rolling.
- Provides comprehensive solutions for ODF, CDF, and RR.
- Environmentally friendly operations and has **GreenCo certification**.
- Targets the Southern and Western regions of India where there are lesser suppliers.
- Offers free product development for the Oil & Gas sector depending upon the circumstances.
- Delivers products faster than typical industry lead times.
- Provides free engineering services on a case-to-case basis.
- In-house certified laboratory and various other certifications required for oil and gas, defence, railways, and shipping.
- Offers low-margin value-added machining services.
- Expertise in processing all steel grades including specials, Inconel and Duplex.
- Features an advanced in-house machine shop.
- Good strategic relations with legacy customers.

5.8 Key Success Factors

- **Specialized Industry Focus:** Vinir Engineering is an integrated engineering solutions company engaged in the manufacturing of specialized, critical and heavy, precision-forged and machined components for a wide range of industries and applications, including energy, defence, aerospace, railways, energy turbines, hydraulics, earthmoving, high-end engineering, amongst others and tailor its offerings to meet the specific needs of this industry, setting it apart from competitors.
- **Low-Volume, Heavy Component Production:** The ability to produce low-volume, heavy components efficiently is a critical advantage, as many clients in the Oil & Gas sector require such specialized manufacturing.
- **Comprehensive Solutions (ODF, CDF, RR):** Offering a full range of solutions under one roof ensures that clients can depend on Vinir Engineering for all their production needs, making the company a one-stop-shop for Oil & Gas sector clients.
- **Faster Delivery Times:** Delivering products faster than industry standards gives Vinir Engineering a significant competitive advantage, particularly in time-sensitive projects where delays can be costly.

- **Cost-Effective Services:** Providing product development and engineering services at no additional cost helps foster long-term partnerships with clients, making Vinir Engineering an attractive and value-driven partner.
- **In-House Capabilities:** With an in-house certified laboratory and machine shop, Vinir Engineering maintains high-quality control standards, reduces dependency on external suppliers, and ensures faster turnaround times.
- **Expertise in Steel Grades:** Deep knowledge of all steel grades and expertise in processing enables Vinir Engineering to cater to diverse and complex client requirements, further enhancing its market competitiveness.
- **Environmental Commitment:** Being environmentally friendly aligns with global sustainability trends and regulatory requirements, making Vinir Engineering a preferred partner for clients with similar values.
- **Strategic Market Targeting:** By focusing on the Southern and Western regions of India, Vinir Engineering is able to optimize its operations and logistics, catering to key Oil & Gas hubs in these regions.
- **Value-Added Services:** Offering machining and other value-added services ensures that clients receive comprehensive solutions, adding to customer loyalty and satisfaction.

Vinir Engineering's prospects are promising, supported by strategic diversification, technological upgrades, and quality-focused practices. While challenges exist, particularly from market volatility and economic factors, the company's proactive strategies and robust operational foundation position it well to capitalize on emerging opportunities and navigate potential risks.

5.9 Best Practices and Continuous Process Improvements of Vinir Engineering

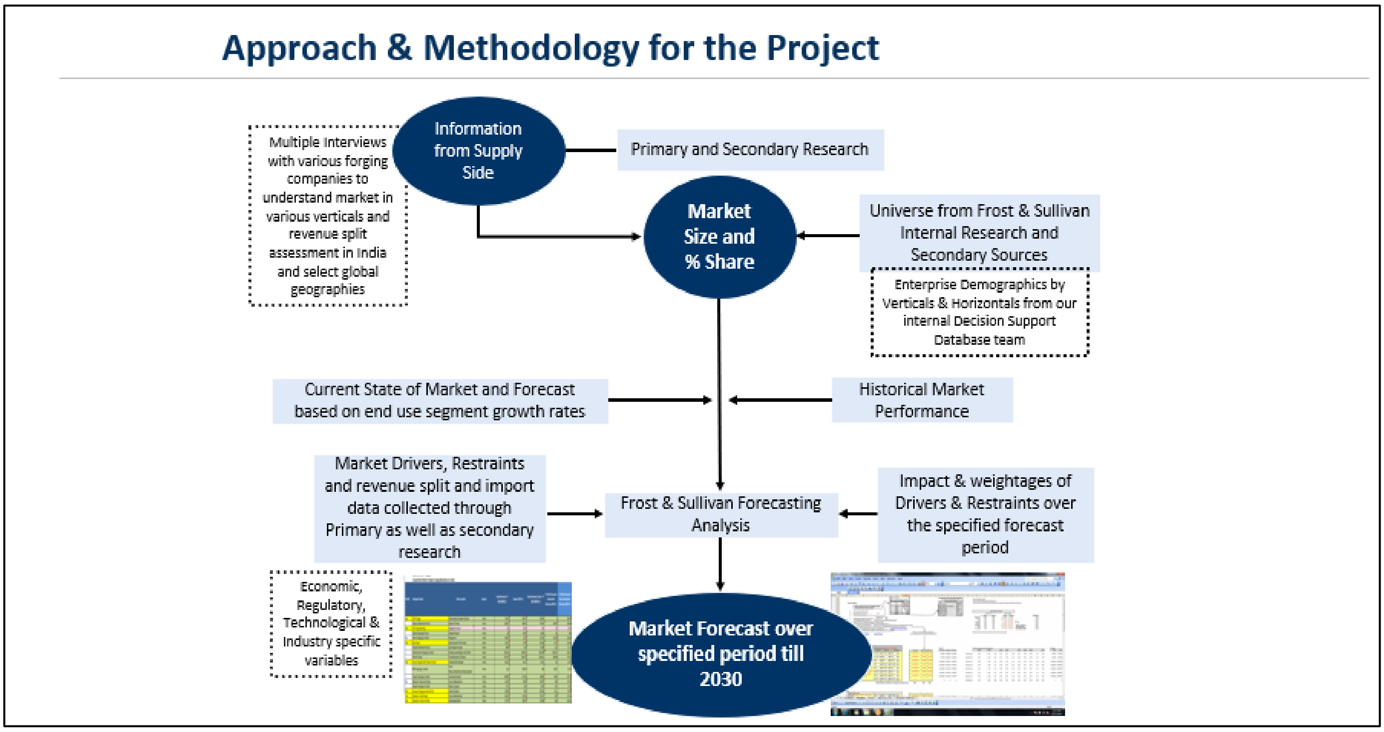
- **ISO 9001:** Ensures that Vinir Engineering's quality management systems meet international standards.
- **API 20C:** This is a certificate of authority granted to use the official API monogram on manufactured products by the American Petroleum Institute (API).
- **ISO 14001:** Demonstrates Vinir Engineering's commitment to environmental management systems.
- **ISO 45001:** Related to occupational health and safety management systems, ensuring a safe work environment.
- **Pressure Equipment Directive (PED):** Ensures equipment meets the standards required for fabrication of pressure equipment within the EU.
- **AD 2000:** German regulation for pressure vessels and other pressure equipment.
- **IBR Well Known Forge:** Indicates recognition under the Indian Boiler Regulations as a well-known forge.
- **AS 9100D:** Certification for quality management systems in the aerospace industry.
- **ISO 50001:** Pertains to energy management, helping organizations to continually reduce energy use, costs, and environmental impacts.
- **ISO 17025 - NABL:** Accreditation signifies the competence of testing and calibration laboratory.
- **'Greenco':** Reflects Vinir Engineering's adherence to environmentally sustainable practices.
- **ABS:** This is a certificate of forging facility and process approval granted by ABS for being considered capable of manufacturing steel forging components for marine applications.
- Vinir Engineering is presently using Piped Natural Gas (PNG) to meet it energy requirements at unit 1 located at Bangalore.

  These certifications showcase Vinir Engineering's dedication to maintaining the highest quality standards across diverse aspects, from environmental practices to industry-specific production quality, enhancing its credibility, focusing on sustainability and trustworthiness in international markets.

Annexure: Approach and Methodology

6. Approach and Methodology

Flow Diagram of Approach and Methodology Adopted



Steps of Approach and Methodology adopted in this project

F&S team have followed both top to bottom approach and then bottom to top approach to perform the Indian non-automotive forging market assessment for data validation. We have considered inputs from key market players for the revenue assessment and end-use wise revenue split for the companies considered for the assessment to size the market. Also, F&S team have done import assessment considering various HS codes to finalize the market size and obtain the market shares of the Vinir Engineering and other manufacturers.

- Relevant Data such as annual revenue of the companies, domestic sales, exports, split by forging types and split by end use segments has been collected from various primary interviews and credible secondary sources.
- Import data were collected from primary research and credible secondary sources with the end use segment specific HS Codes for forging products.
- Revenue assessment and analysis of the collected data was performed to obtain the domestic market share of Vinir Engineering and its other competitors.
- Historical trends were finalized basis the input from the primary and secondary sources and past growth of the end use segments.
- Forecast were performed by considering the drivers and restraints of each of the end use segments and potential growth rate and by considering weighted average of each of the end use segments.