



# GLOBAL MARKET OVERVIEW OF THE INDUSTRIAL GASES

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## Disclaimer

The market research process for this study has been undertaken thorough secondary / desktop research as well as primary research, which involves discussing the status of the market with leading participants and experts. The research methodology used is the Expert Opinion Methodology. Quantitative market information was sourced from interviews by way of primary research as well as from trusted portals, and therefore, the information is subject to fluctuations due to changes in the business and market climate. Frost & Sullivan's estimates and assumptions are based on varying levels of quantitative and qualitative analyses, including industry journals, company reports and information in the public domain.

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Frost & Sullivan has prepared this study in an independent and objective manner, and it has taken adequate care to ensure its accuracy and completeness. We believe that this study presents a true and fair view of the Global and Indian industrial gases segment within the limitations of, among others, secondary statistics, and primary research, and it does not purport to be exhaustive. Our research has been conducted with an "overall industry" perspective, and it will not necessarily reflect the performance of individual companies in the industry. Frost & Sullivan shall not be liable for any loss suffered because of reliance on the information contained in this study. This study should also not be considered as a recommendation to buy or not to buy the shares of any company or companies as mentioned in it or otherwise. For calculation of market size of industrial gases, F&S has excluded captive production of gases which is not catered by industrial gases players. E.g. If hydrogen is produced at oil & gas facility and further captively utilized for exploration process, it will be a non-addressable market for an industrial gases player and thus, we have excluded the same from market size estimation."

## **ABBREVIATIONS**

AMRUT: Atal Mission for Rejuvenation and Urban Transformation

APAC: Asia Pacific

AP: Andhra Pradesh

ASEAN: The Association of Southeast Asian Nations

Bn: Billion

CAGR: Compound Annual Growth Rate

CY: Calendar Year

F&B: Food and Beverage

FY: Financial Year

GDP: Gross Domestic Product

INR: Indian Rupees

MCA: Ministry Of Corporate Affairs

PESO: Petroleum and Explosives Safety Organization

PLI: Production Linked Incentives

PMAY: Pradhan Mantri Awas Yojana

PSA: Pressure Swing Adsorption

R&D: Research and Development

UDAN scheme: Ude Desh ka Aam Nagarik scheme

USD: United States Dollar

WB: West Bengal

## INDUSTRY AND BUSINESS-RELATED TERMS

Term	Description
Argon Oxygen Decarburization	The argon oxygen decarburization process is a steelmaking method that reduces carbon content in molten steel by injecting argon and oxygen to refine the steel.
ASU	Air separation units for production of oxygen, nitrogen and argon
Coal gasification	Process that converts coal into syngas through high-temperature reactions, from which hydrogen is extracted
Cryogenic distillation	It is a process that separates gases, such as air, into its components by cooling them to extremely low temperatures until they liquefy, allowing the different components to be separated based on their boiling points.
EOR	Enhanced oil recovery is a technique used to increase the amount of oil extracted from a reservoir by injecting substances like water, gas, or chemicals to boost oil flow and production beyond what traditional methods achieve
Green Hydrogen	Green hydrogen is hydrogen produced through the electrolysis of water using renewable energy sources, such as wind or solar, without emitting carbon dioxide
Metal fabrication	Metal fabrication is the process of cutting, shaping, and assembling metal materials to create structures, components, or products
MIG welding	Metal Inert Gas is a welding process that uses a continuous wire electrode and inert gas to join metals
Route of synthesis	The route of synthesis refers to the step-by-step sequence of chemical reactions and processes used to produce a specific material from starting substances
SMR	Steam Methane Reforming is a process that produces hydrogen by reacting natural gas (primarily methane) with steam at high temperatures
TIG welding	Tungsten Inert Gas welding uses a non-consumable tungsten electrode and inert gas for more precise, high-quality welds to join metals



# 1 Global & Indian Macro-Economic Review

## 1.1 Economic Outlook – Global

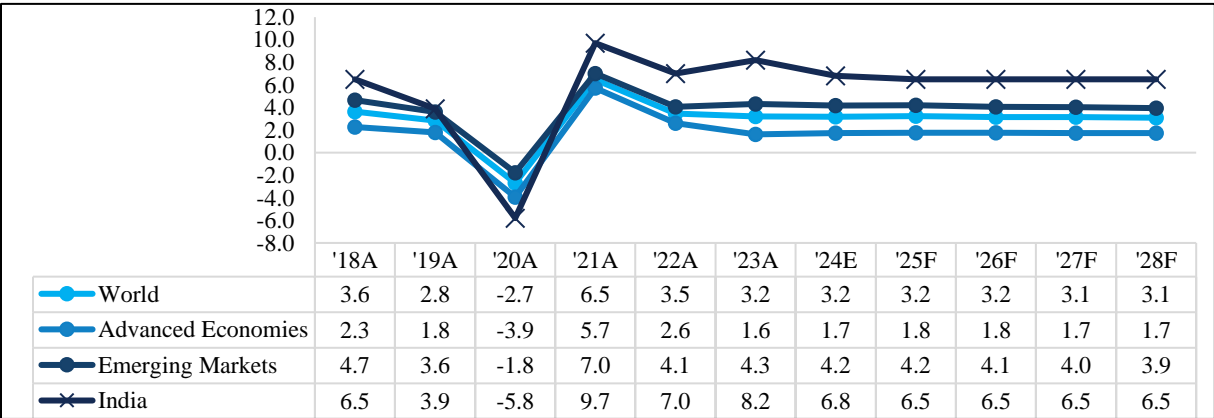
### 1.1.1 Global GDP – Outlook & Growth

From CY2011 to CY2018, the global economy experienced steady growth, driven by strong consumer demand, technological advancements, and stable global trade, etc. From CY2018 to CY2023, global GDP growth demonstrated resilience despite unprecedented challenges, including the COVID-19 pandemic and supply chain disruptions. The global economy quickly rebounded post-CY2020, driven by technological advancements, strong fiscal policies, and rapid recovery in key sectors like digital services, manufacturing, and renewable energy. Emerging markets, particularly in Asia, continued to play a pivotal role in global growth during this period, while advanced economies showed steady recovery.

Looking ahead from CY2023 to CY2028, the outlook remains optimistic. As global markets adapt to new economic realities, including the transition to greener economies and further digital transformation, sustained growth is expected. Innovation in areas like AI, clean energy, and biotechnology, along with increasing globalization and trade partnerships, are anticipated to fuel expansion. Emerging markets, particularly in Asia and Africa, are set to drive a significant portion of this growth, supported by rising middle-class populations and investment in infrastructure and industry. The world economy is poised for steady, positive growth in the coming years. Structural reforms, fiscal and monetary policy prudence, and growing adoption of digital and green energy initiatives will act as tailwinds to the world economy.

The graph below illustrates the real GDP growth performance during last 5 years and projected growth through CY2028.

**Graph 1.1.1-1 Real GDP Growth (%) CY2018 - CY2028F**



Note: A: Actual, E: Estimate, F: Forecast, India’s data is represented in fiscal years. For e.g. 2022 stands for FY2023 i.e. 1 April 2022 to 31 March 2023; Source: International Monetary Fund (IMF) May 2024 Update, Moody’s Outlook, Frost & Sullivan

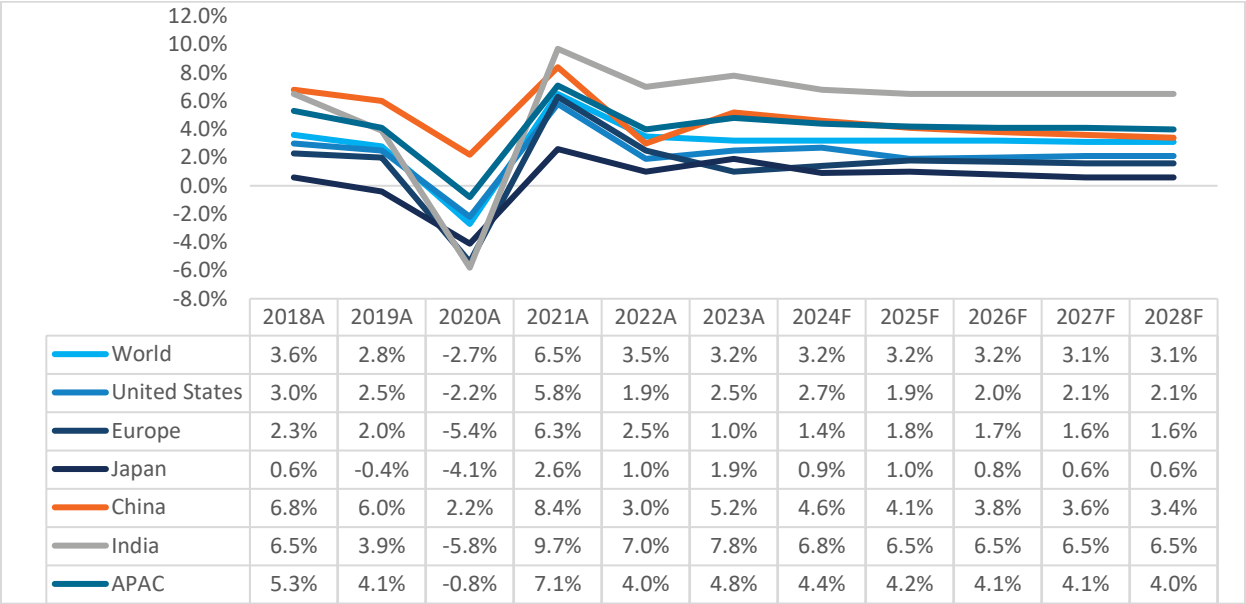
**Advanced economies** are projected to grow slower than the global average over the forecast period.



**Emerging market and developing economies** will witness divergent growth in CY2024. China’s economic recovery will continue to face setbacks as falling domestic demand, deflationary concerns, a property market crisis, and soft external demand will cause significant setbacks. The Association of Southeast Asian Nations (ASEAN) and India will be growth bright spots, as robust domestic economic fundamentals, strong labour market conditions, and fiscal stability will contribute towards economic growth.

The graph below illustrates the Real GDP growth performance in key economies during the last 5 years and projected growth through CY2028

**Graph 1.1.1-2 Real GDP Growth (%) in Key Economies (CY2018 - CY2028F)**



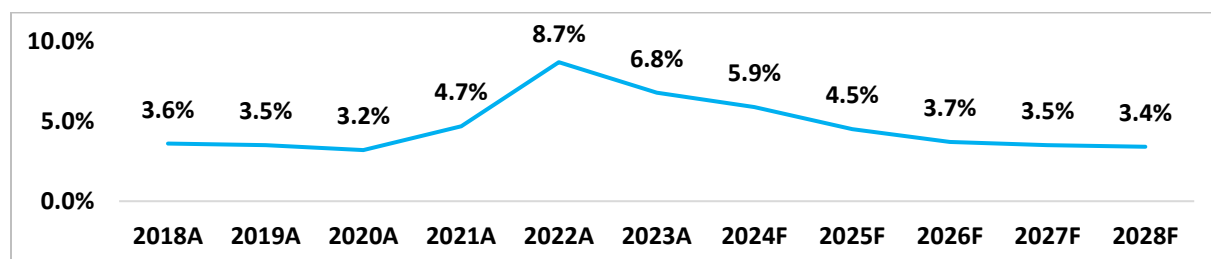
*Note: A: Actual, F: Forecast, Source: International Monetary Fund (IMF) May 2024 Update, Frost and Sullivan Research and Analysis*

In conclusion, the global economic landscape is set to experience varied growth trajectories over the coming years. While advanced economies will grow at a slower pace, emerging markets such as India, China and APAC are expected to drive global economic growth. The ongoing challenges and opportunities across different regions underscore the complex and dynamic nature of the global economy.

### 1.1.2 Review and Outlook of Global Inflation

Global inflation rates remained relatively stable between CY2011 and CY2019. In developed countries, inflation rates were around 1.5% while it was around 5% for emerging and developing economies. The graph below illustrates the global inflation rate, average consumer prices (in annual % change) during last 5 years and projected change in dynamics through CY2028:

**Graph 1.1.2-1 Global Inflation Rate (Average Consumer Prices) in Annual % Change, CY2018-2028F**



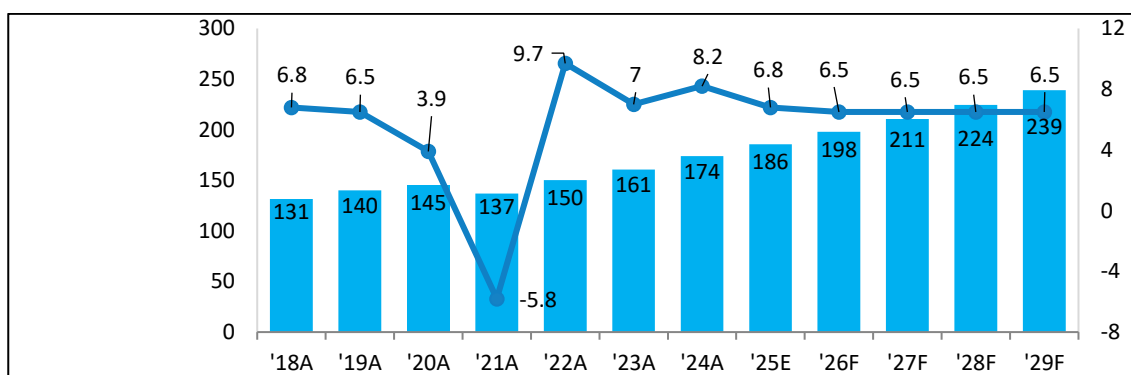
Note: A: Actual, F: Forecast, Source: International Monetary Fund (IMF) May 2024 Update, Moody’s Outlook, Frost & Sullivan

### 1.2 Economic Outlook – India

The Indian government as part of its proactive fiscal and monetary policies introduced several stimulus measures such as loan moratoriums, credit guarantees, and direct cash transfers to support businesses and households. These measures helped sustain domestic consumption and mitigate the economic impact of the pandemic in FY2022. Recovery within manufacturing as well as the services industry – particularly within segments such as information technology, healthcare, and e-commerce – provided further impetus.

Over the forecast period, the Indian economy is likely to grow by more than 6%. Consistent public expenditure on building and upgrading infrastructure and connectivity, boosting the scalability and uptake of the digital economy, strengthening domestic green energy generation capabilities, and undertaking economic policies that foster inclusive social development will be at the forefront of India’s long-term economic vision.

**Graph 1.2-1: Real GDP Value, at Constant Price (INR 000’Bn) and Growth %, India, FY2018 to FY2029F**



Note: A: Actual, E: Estimate, F: Forecast, Source: Moody’s Outlook, IMF Estimate, Dun and Bradstreet, IMF World Economic Outlook October 2023, IMF World Economic Outlook April 2024 Update, Frost & Sullivan

**India's strong growth path: Conducive policy support & strong fundamentals will drive long-term investment attractiveness**

In the past decade, the Indian government has extensively focused on boosting domestic manufacturing capabilities. Initiatives like Make in India, Atmanirbhar Bharat, and Production Linked Incentive (PLI) schemes are playing an active role in establishing India as a manufacturing powerhouse, especially with the rising focus on China+1 strategies post-pandemic.

Continued policy support has started garnering positive results. For instance, since inception until November 2023, the PLI schemes brought in INR 1.03 lakh crore worth of investments, which further drove output of INR 8.06 lakh crore, and generated 6.87 lakh direct and indirect jobs.

The steel industry is a backbone of India's industrial sector, contributing significantly to GDP through construction, infrastructure, and manufacturing. It generates substantial employment and has a high multiplier effect on the economy. The government of India is ambitious to increase steel production by CAGR 20% through FY2030. The PLI scheme encourages the production of specialty steel by providing financial incentives for incremental production.

The Indian healthcare industry is poised for significant growth, driven by favourable government policies and a strong economic foundation. Programs like Ayushman Bharat aim to expand healthcare access, fuelling industry expansion. The sector is expected to grow at a CAGR of 18% through FY2028, supported by increasing domestic demand and medical tourism. Investments in healthcare infrastructure and incentives for pharmaceutical manufacturing further enhance the industry's growth prospects. The strong fundamentals and conducive policy environment make India an attractive destination for long-term investment in healthcare.

The pharmaceutical industry is a major contributor to India's GDP, driven by exports and domestic consumption. The government of India provides incentives for manufacturing bulk drugs and critical drug intermediates.

The Indian infrastructure sector is set for substantial growth, propelled by strategic government initiatives and robust economic fundamentals. Major programs such as the Smart Cities Mission, Bharat Mala Pariyojana, and the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) aim to modernize urban infrastructure and enhance connectivity across the country. The sector is expected to grow at a CAGR of 11% through FY2028, supported by large-scale investments in highways, railways, ports, and urban development projects.

The government has also launched the National Infrastructure Pipeline (NIP), which aims to invest INR 111 lakh crore in infrastructure projects by 2025, spanning sectors like energy, transportation, and water & sanitation. This initiative is expected to create significant employment opportunities and boost economic activity. Furthermore, the implementation of the Gati Shakti Master Plan aims to streamline infrastructure projects and reduce logistics costs, enhancing overall efficiency.

The government has also set a vision for the chemicals and petrochemicals sector. By 2034, the aim is to bolster domestic production capabilities, reduce imports dependence, and attract foreign investments.

To conclude, with real GDP growth momentum forecast to remain above ~6.0% in the long-term, India will remain a global growth frontrunner and enter the league of the top 3 largest economies by FY2030. Moreover, the FY2019-FY2027 manufacturing value add is forecasted to grow at a CAGR of 10.8% as compared to China's 6.9%, as the Chinese economy loses steam, and global firms prioritize diversification of sourcing and production lines to reduce overdependency on China. Hence, India's PLI scheme, solid

GDP growth, as well as demographic dividend advantages will help attract more manufacturing investments.

### **1.2.1 Impact of GDP on Industrial Gases Segment**

The industrial gases industry in India encompasses the production and supply of gases such as oxygen, nitrogen, hydrogen, carbon dioxide, argon, etc. These gases are critical to many industries, including electronics, steel, chemicals and fertilizer, manufacturing, healthcare, and food and beverage.

The industrial gases industry is directly and significantly impacted by economic growth, as indicated by GDP. Industrial output normally rises with GDP, which raises the need for industrial gases used in welding, cutting, and purging operations. Growth in the steel and aluminum sectors, which are significant users of gases like oxygen and nitrogen for operations like smelting and refining, is frequently correlated with GDP growth. The growth of India's GDP has led to a surge in steel production, significantly increasing the demand for oxygen and other gases used in steel manufacturing.

The demand for medical gases like oxygen and nitrous oxide rises as a result of improved healthcare infrastructure and higher investment in medical facilities brought about by economic expansion.

As the pharmaceutical sector grows, the use of nitrogen and specialty gases in drug manufacturing and research becomes more critical, supporting the overall development of the industry.

The oil and gas and chemical industries, which employ a range of industrial gases for processes including synthesis, inerting, and blanketing, are supported by expanding GDPs. As economies grow, the demand for energy and chemical products increases, driving up the need for industrial gases. In the oil and gas industry, gases like hydrogen, nitrogen, and carbon dioxide are essential for refining processes, enhanced oil recovery, and maintaining safety standards through inerting and blanketing. Similarly, in the chemical industry, these gases play a crucial role in various synthesis reactions, improving product yields and ensuring process efficiency.

A stronger economy encourages urbanization and changes in consumer behavior, which could result in a rise in the consumption of packaged goods. As people migrate to urban areas, their lifestyles and dietary habits evolve, leading to increased demand for convenient, ready-to-eat, and packaged foods. This surge in consumption necessitates the use of more industrial gases for various applications within the food and beverage industry.

Government policies and regulatory frameworks that promote industrial development are frequently strengthened as a result of economic expansion. This involves providing tax benefits, subsidies, and expedited project approval procedures to overall industry.

The industrial gases industry in India is impacted by the GDP growth in a number of ways, including increased demand across all segments, investment, and innovation. Economic expansion serves as a major force behind the growth and development of India's industrial gases sector.

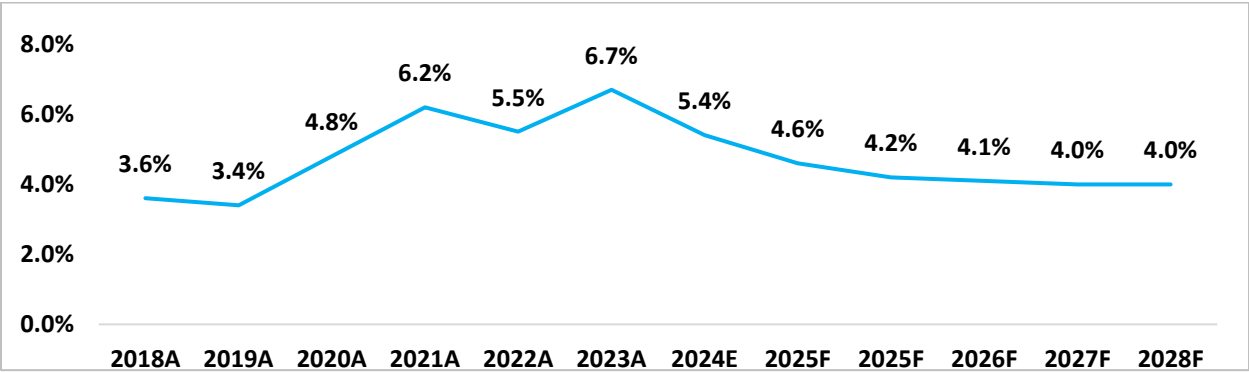
### **1.2.2 Near Term Inflation Review and Outlook**

Through FY2028, India's inflation is expected to reduce to about 4% each year, depending on a number of factors. Key factors that will contribute to lowering inflation in India includes the easing of disruptions to the world's supply chains, the RBI's ongoing vigilance over inflation expectations, the stabilization of commodity prices globally, the country's business-friendly climate because of government assistance, etc.

Market Overview of the Industrial Gases

The graph below illustrates India’s inflation rate (average consumer prices) in annual % change during the last 5 years and projected change in dynamics through FY2028:

**Graph 1.2.2-1 India’s Inflation Rate (Average Consumer Prices) in Annual % Change, FY2018-2028F**



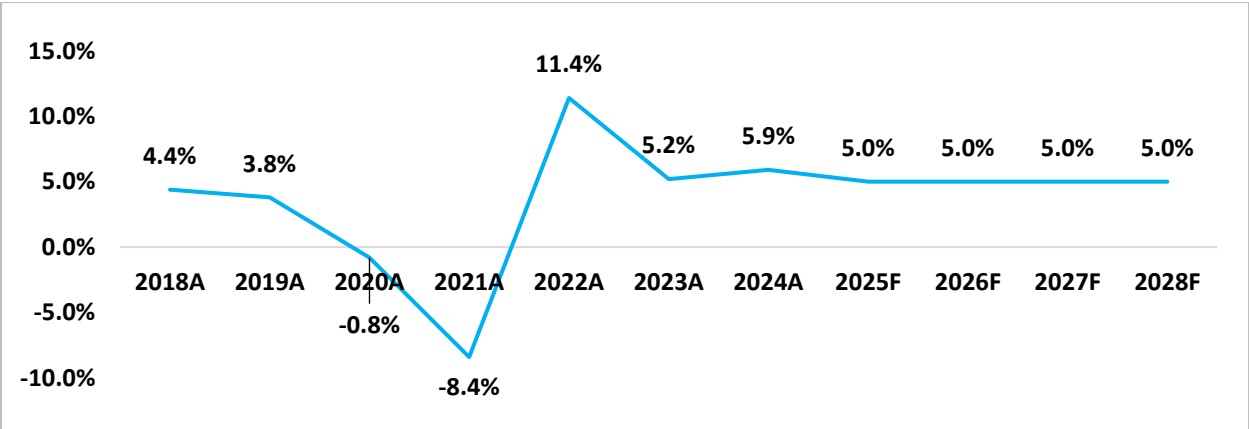
Note: A: Actual E: Estimate, F: Forecast, Source: International Monetary Fund (IMF) May 2024 Update, Moody’s Outlook, Frost & Sullivan

**1.2.3 Near Term IIP (Index of Industrial Production) Review**

For FY2024, IIP has increased by 5.9%. From FY2025 onwards, IIP is forecasted to grow at about 5%. The key driving factors would be the growth of infrastructure, sustained policy assistance (PLI schemes), and robust domestic demand, among others. Supply chain diversification, growing emphasis on green manufacturing, and technological advancements will be key parameters for high pace growth of IIP in India for coming 10 years.

The graph below illustrates India’s IIP (in annual % change) during last the 5 years and projected change in dynamics through FY2028 :

**Graph 1.2.3-1 India’s IIP in Annual % Change, FY2018-2028F**



Note: A: Actual, F: Forecast, Source: Ministry of Statistics & Programme Implementation 2024 Update, Frost & Sullivan

## 2 MARKET OVERVIEW

### 2.1 Global Industrial Gases Market Overview

Industrial gases encompass gases or gas combinations employed across various industries for several manufacturing operations and processes. These gases play a crucial role from the initial extraction of raw materials, through their intermediate processing for manufacturing metals, chemicals, pharmaceuticals, and ceramics, to the production of intricate industrial, consumer, and food items. The key industrial gases include Oxygen, Hydrogen, Nitrogen, Carbon Dioxide, Inert Gases (Argon, Xenon, Helium) and others.

With the expansion of various end industries dependent on industrial gases, and the wide array of products offered within the segment, it is anticipated that this segment will sustain its rapid growth trajectory well into the foreseeable future.

Industrial gas	Major application segments
Oxygen	Steel, healthcare, manufacturing, chemical, water and wastewater treatment, pharmaceutical, pulp and paper, oil & gas, etc.
Nitrogen	Chemicals, oil & gas, food & beverage, steel and other metal manufacturing, electrical and electronics, mining, manufacturing, pharmaceutical, etc.
Hydrogen	Chemicals and fertilizers, oil & gas, manufacturing, steel & other metal manufacturing, power industry, float & sintered glass, telecom towers, etc.
Carbon dioxide	Chemicals and fertilizers, oil & gas, food & beverage, manufacturing, electrical & electronics, construction, etc.
Argon	Manufacturing, electrical & electronics, steel & other metal manufacturing, healthcare, automotive, aerospace, chemicals, etc.

#### 2.1.1 Global Market Size

The worldwide industrial gases market is set for substantial expansion across its entire product spectrum. Population expansion, coupled with swift urbanization and technological progress is fueling a surge in demand for various end-products, with a heightened focus on quality and cost-efficiency. If companies' dependent on these essential gases faced shortages in restocking their supplies, it would have a significant impact on their bottom line, resulting in considerable costs. This trend is expected to fuel strong growth in the demand for industrial gases which are crucial raw materials in manufacturing processes. During the COVID-19 pandemic, the healthcare sector's surge in demand for oxygen was largely met by the industrial gas sector. Industrial gas manufacturers quickly pivoted their operations to supply medical-grade oxygen to healthcare facilities, ensuring a rapid response to the crisis. After the peak of the pandemic, the demand for these gases stabilized. During the COVID-19 pandemic, the average prices of key industrial gases saw an increase. This led to a growth in the overall global market size for industrial gases by value.

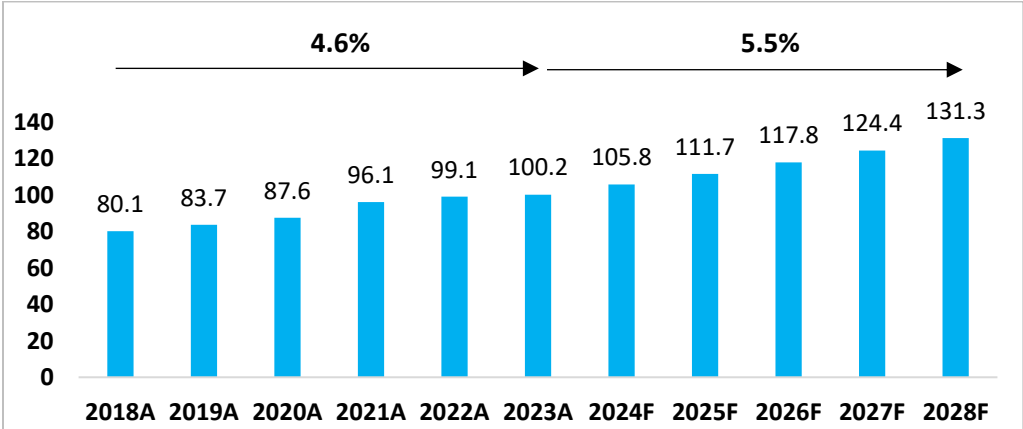
Market Overview of the Industrial Gases

While healthcare needs remained elevated compared to pre-pandemic levels due to enhanced medical preparedness and expanded healthcare infrastructure, the overall demand for oxygen and other gases returned to a more consistent, steady state, reflecting a balance between medical, industrial, and commercial requirements.

In CY2023, the global demand for Industrial gases was around USD 100.2 billion. The market is expected to grow at a CAGR of 5.5% between CY2023 - CY2028, with demand reaching USD 131.3 billion in CY2028.

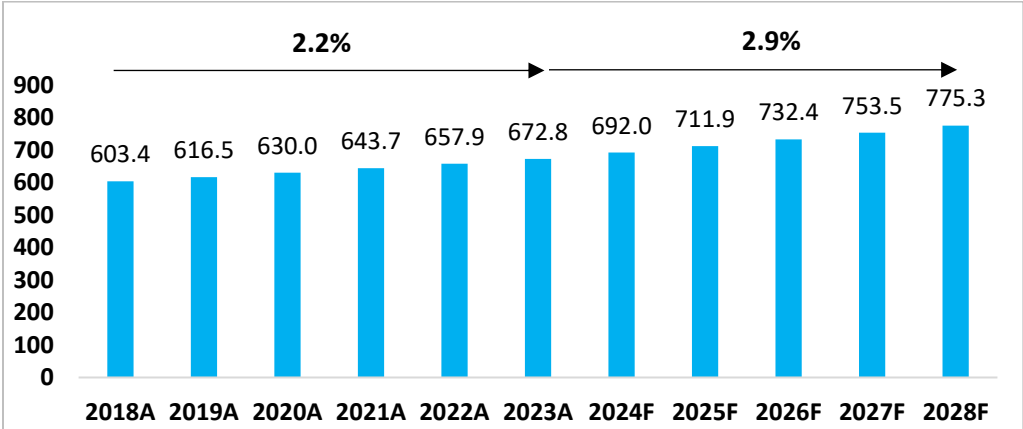
The graphs below illustrate the demand for Global industrial gases market between CY2018 and CY2028:

**Graph 2.1.1-1 Global Industrial Gases Market, by Value (USD Billion), CY2018-2028F**



Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis

**Graph 2.1.1-2 Global Industrial Gases Market, by Volume (Million tons), CY2018-2028F**



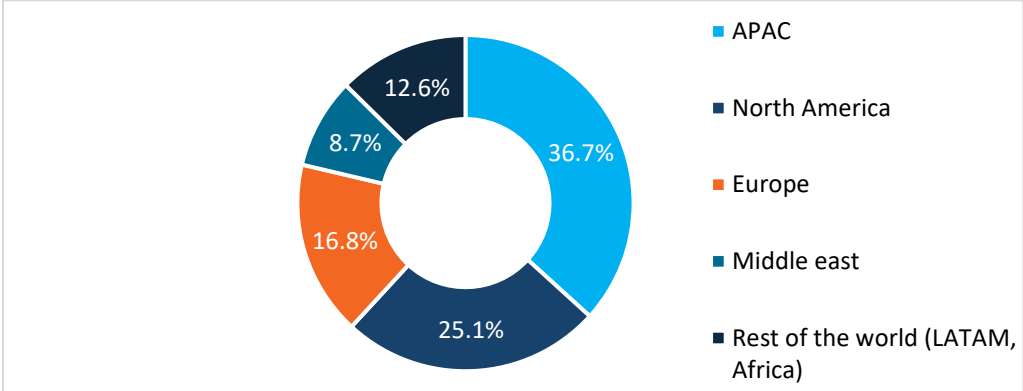
Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis



### 2.1.2 Regional Market Trends

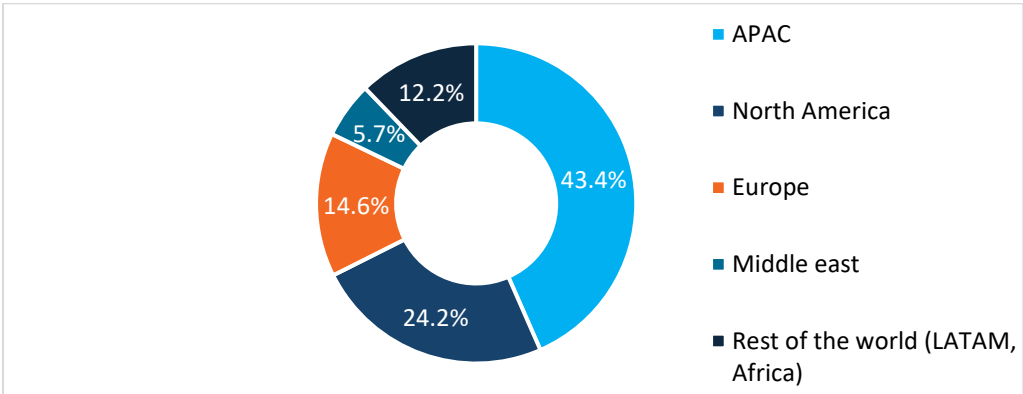
The graphs below show the regional segmentation for industrial gases in CY2023:

**Graph 2.1.2-1: Global Industrial Gases Market - Regional Segmentation by Value (USD 100.2 billion, CY2023)**



Source: Frost & Sullivan Research & Analysis

**Graph 2.1.2-2: Global Industrial Gases Market - Regional Segmentation by Volume (672.8 Million tons, CY2023)**



Source: Frost & Sullivan Research & Analysis

### 2.2 India Industrial Gases Market Overview

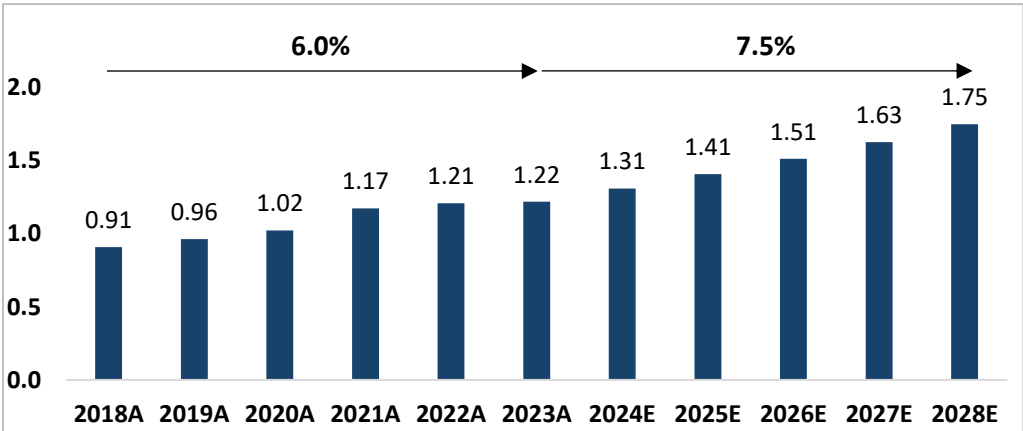
The Indian industrial gases industry plays a pivotal role in supporting various sectors such as steel and other metal manufacturing, oil and gas, general manufacturing, healthcare, pharmaceuticals, chemicals and fertilizers, and food and beverage production. Prominent manufacturers in this industry include Linde, Inox Air Products, Air Liquide, Ellenbarrie, Air Water, Goyal MG Gases, etc.

**2.2.1 India Market Size**

The market size of industrial gases in India was valued at USD 1.2 billion in CY2023. The demand has been increasing at a CAGR of 6% over the last five years, driven by rapid industrialization and infrastructure development, a growing emphasis on hydrogen as a clean energy source, and innovations in gas production, storage, and distribution that enhance efficiency and reduce costs. In India, during CY2021 and CY2022, the market size by value for industrial gases increased due to the higher prices driven by the COVID-19 pandemic. From CY2023 onwards, the market size for industrial gases in India stabilized. The large domestic market is driven by government initiatives such as 'Make in India' and the increasing call for import substitution, as well as demand from sectors such as steel, pharmaceuticals, manufacturing, defence, chemicals, healthcare, energy, pharma and electronics, and their growth prospects. The demand is projected to reach USD 1.8 billion by CY2028 with CAGR of 7.5%.

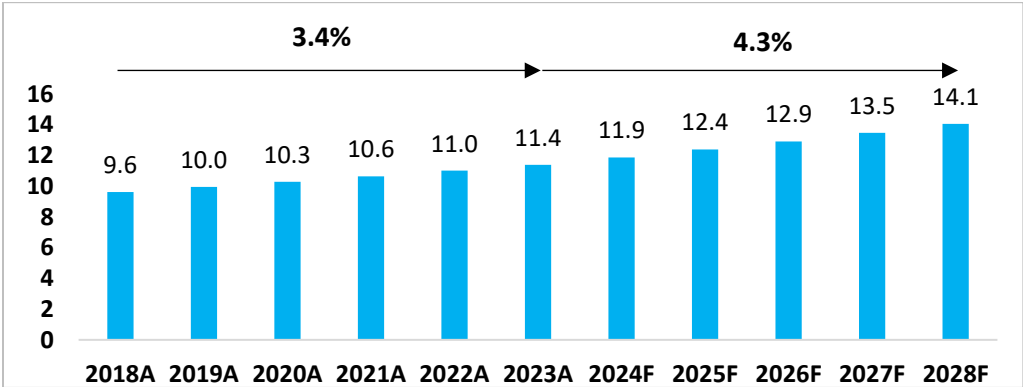
In terms of volume, the Indian industrial gases market grew from 9.6 million tons in CY2018 to 11.4 million tons in CY2023. The graphs below illustrate the demand for industrial gases in India over the past five years and the projected demand through CY2028:

**Graph 2.2.1-1 Industrial gases Market in India, by Value (USD billion), CY2018-2028F**



Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis

**Graph 2.2.1-2 Industrial Gases Market in India, by Volume (Million tons), CY2018-2028F**



Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis

## 2.2.2 Growth Drivers

### 2.2.2.1 Growth in End Use Industries

The industrial gases market in India is experiencing robust growth, driven primarily by the burgeoning end-use industries such as steel, pharmaceuticals, petrochemicals, healthcare, manufacturing, etc.

- **Steel:** The steel industry is a major consumer of industrial gases, particularly oxygen, nitrogen, and argon, which are critical in various stages of steel production. Oxygen is extensively used in blast furnaces to improve combustion efficiency and reduce coke consumption, leading to cost savings and lower emissions. Nitrogen is employed for inerting and purging processes to prevent oxidation, while argon is used in refining and casting to produce high-quality steel. The growth of the steel industry, driven by increasing demand in construction, automotive, and infrastructure projects, significantly boosts the demand for industrial gases. In February 2024, the government implemented various measures to promote self-reliance in the steel industry. Export duty of 30% has been levied on iron ore (lumps and fines) to ensure supply to the domestic steel industry.
- **Chemicals:** The chemicals and petrochemicals sector is one of the largest consumers of industrial gases like hydrogen, oxygen, and nitrogen. Hydrogen is essential in refining processes, including hydrocracking and desulfurization, to produce cleaner fuels. Oxygen is used in oxidation reactions and as a feedstock for various chemical syntheses. Nitrogen is crucial for creating inert environments to prevent unwanted reactions. The expansion of the chemicals and petrochemicals industry, fueled by rising demand for plastics, fertilizers, and specialty chemicals, continues to drive the need for industrial gases.
- **Pharmaceutical:** In the pharmaceutical industry, industrial gases play a vital role in ensuring product quality and process efficiency. Nitrogen is used for inerting, blanketing, and purging to maintain an oxygen-free environment, crucial for the stability of sensitive compounds. Carbon dioxide is employed in supercritical fluid extraction to obtain pure and high-quality active pharmaceutical ingredients. Oxygen is used in fermentation processes for antibiotic production. The growth of the pharmaceutical industry, driven by increased healthcare spending and innovation in drug development, leads to a higher demand for industrial gases.
- **Healthcare:** Healthcare facilities are significant users of medical grade gases such as oxygen, nitrous oxide, etc. Oxygen is critical for respiratory therapies, anesthesia, and life support systems. Nitrous oxide is used for its anesthetic properties during surgeries and dental procedures. Medical oxygen is utilized in ventilators and as a carrier gas for anesthetics. The expanding healthcare sector, with a focus on improving medical infrastructure and patient care, drives the demand for industrial gases in hospitals.
- **Infrastructure:** The infrastructure sector relies on industrial gases for various construction and maintenance activities. Oxygen and acetylene are used in oxy-fuel welding and cutting operations, essential for constructing and repairing metal structures. Nitrogen is used for concrete cooling and as an inert gas in tunneling operations. India's infrastructure sector is experiencing robust growth, driven by significant government initiatives aimed at enhancing the country's transportation, urban

## Market Overview of the Industrial Gases

development, and industrial capacities. Some of the major government initiatives include Smart Cities Mission, UDAN scheme, Pradhan Mantri Awas Yojana (PMAY) and Dedicated Freight Corridors among others.

- Electronics:** The electronics industry utilizes high-purity industrial gases such as nitrogen, argon, and hydrogen in manufacturing processes. Nitrogen is used for creating inert atmospheres in semiconductor fabrication to prevent oxidation. Argon is employed in plasma etching and sputtering processes to produce thin films and coatings. Hydrogen is used in annealing and as a reducing agent in various production steps. Additionally, it is also used in the doping stage to help control decomposition as the gases that are used for this process are extremely toxic. India's electronics industry has seen several recent achievements that will drive the demand for industrial gases. The PLI scheme for large-scale electronics manufacturing has been a significant success, attracting global giants like Apple, Samsung, and Foxconn to set up or expand their manufacturing facilities in India. The government has approved the setting up of new Electronic Manufacturing Clusters (EMCs) to provide world-class infrastructure for electronics manufacturing.
- Food and Beverage:** The food and beverage industry uses industrial gases for applications such as refrigeration, packaging, and carbonation. Carbon dioxide is used for carbonating beverages and in modified atmosphere packaging (MAP) to extend the shelf life of perishable products. Nitrogen is used for freezing and chilling foods, as well as in MAP to displace oxygen and prevent spoilage. The growth of the food industry, driven by increasing consumer demand for processed and convenience foods, along with advancements in food preservation technologies, fuels the demand for industrial gases.

The below table shows the historic growth of the market sizes of the key end industries from FY2018 to FY2023 and the projected market sizes till FY2028.

**Table 2.2.2.1-1 Market Landscape of End Industries in India**

End Use Industries	Market size by value (USD billion)			CAGR	
	FY2018A	FY2023A	FY2028F	Historical (FY18-23)	Forecast (FY23-28)
Steel	110.83	126.30	161.19	2.6%	5.0%
Chemicals	162.26	254.30	340.31	9.4%	6.0%
Pharmaceuticals	17.50	52.00	99.68	24.3%	13.9%
Healthcare	66.39	99.00	131.24	8.3%	5.8%
Infrastructure (Budgetary Outlay)	47.70	90.36	152.26	13.6%	11.0%
Electronics	188.54	364.00	783.00	14.1%	16.6%
Food and Beverage	537.04	814.26	1,213.72	8.7%	8.3%

*Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis*

Given the significant growth expected in key end-use industries such as steel, chemicals, pharmaceuticals, healthcare, infrastructure, electronics, food and beverage and considering the critical role industrial gases play as raw materials in these sectors, the market for industrial gases is poised for substantial expansion. This growth will be driven by increasing demand for high-quality, efficient production processes and advancements in these industries.

### **2.2.2.2 Impact of PLI on Indian Industrial Gases Market**

Introduced by the government of India, the PLI (Production Linked Incentives) scheme aims to boost domestic production by providing incentives to companies for additional sales of manufactured goods compared to a baseline year. Launched initially in March 2020 with three schemes, it expanded to 14 sectors in August 2023. The PLI Schemes for 14 key sectors have been launched with a financial outlay of ₹1.97 lakh crore (over USD 26 billion), aimed at boosting India's manufacturing capabilities and export potential. As demand from end-use industries increases, the demand for industrial gases will also go up.

### **2.2.2.3 New Opportunities in Steel Industry**

Steel manufacturers are increasingly offloading their industrial gases production and management to specialized industrial gases players in India. The major objective of steel manufacturers is to focus more on the core operations of steel production without the complexities of managing industrial gases production and distribution. Industrial gases players can leverage economies of scale and specialized expertise to optimize gas production, storage, and distribution, leading to cost efficiencies for steel manufacturers. Industrial gases players can effectively manage risks associated with gas supply, storage, and safety compliance, ensuring uninterrupted supply and regulatory adherence for steel manufacturers. Overall, this shift towards outsourcing industrial gases operations to specialized providers not only enhances operational efficiency and cost-effectiveness for steel manufacturers but also unlocks growth opportunities and innovation in the industrial gases sector.

### **2.2.2.4 Government Policy Impact on Liquid Medical Oxygen Infrastructure in India**

Medical oxygen plays a vital role in the healthcare sector since it is necessary for both surgical procedures and the treatment of numerous respiratory disorders. The COVID-19 pandemic highlighted the significance of having a strong infrastructure for medical oxygen supply. Medical oxygen serves as a respiratory assistance gas that is used for patients requiring supplemental oxygen. India's capacity to produce medical oxygen has expanded due to investments from the public and private sectors. In order to improve distribution and manufacturing, it also promoted cooperation between the public and private sectors.

Important initiatives like the National Oxygen Supply Program and the Pradhan Mantri Jan Arogya Yojana (PMJAY), among others, has aided in the establishment of new oxygen plants, the renovation of existing facilities, and the promotion of investment and involvement from the private sector. Technology advancements have increased the generation and storage efficiency of oxygen.

The Indian government also started programs such as the PM CARES Fund to increase the number of oxygen plants in medical facilities. A faster growth of production capacity has been made possible by streamlined regulatory procedures and expedited permissions for the establishment of oxygen plants.

Government's enhanced transportation planning has helped to guarantee that oxygen gets to isolated locations. This included the use of the Indian Railways' 'Oxygen Express' trains and the Indian Air Force airlifting oxygen containers.

### 2.2.2.5 Recent Investments in India by Key Players:

Investments by key gas manufacturers in India are significantly driving the demand in the industrial gases market by enhancing production capacity, expanding distribution networks, and fostering innovation:

- **Linde:** One of the largest industrial gases company of the world has plans to invest USD 1 billion in India in coming 3-5 years. The company has already invested billions of dollars for production of key industrial gases such as nitrogen, oxygen, hydrogen, argon, etc. Recently, the organization announced to invest USD 60 million for expansion of capacity of Steel Authority of India plant.
- **Inox Air Products:** In FY2021, Inox Air Products announced plans for greenfield investment of USD 240 million by FY2024. The focus is towards building 8 new Air Separation Units across the country to expand capacity of liquid gases to 4,800 TPD by FY2024. In May FY2023, Inox increased these investment targets to USD 360 million by FY2025 for 10 facilities.
  - In FY2023, the company announced plans to invest up to USD 60 million to establish ultra-high purification facilities for gases essential in semiconductor fabrication.
  - Awarded contract of USD 150 million by Tata steel for setting up 2 Air Separation Units (ASUs) at Tata Steel's Meramandali Plant, Odisha
  - It has invested USD 500 million at Kochi facility to supply high quality gas to BPCL
  - The company is looking for the right opportunity for investment in India. It may invest up to USD 5-10 billion in India for coal gasification projects.
- **Air Liquide:** The company has invested over USD 210 million in India for the construction of 6 industrial gases plants with over capacity of 1,400 tons per day.
  - Announced to invest USD 40 million in Kosi, Uttar Pradesh for the development of new Air Separation Unit (ASU) dedicated to Industrial Merchant market with capacity of 350 ton per day.
  - Invested over USD 14 million in Nagpur, Maharashtra for development of ASU with capacity of 70 tons per day.
- **Air Water:** In FY2019, the company invested USD 194 million to acquire the South India business of Linde India. In the same year, the company also acquired Praxair India's business of manufacture, sale and distribution of oxygen, nitrogen and argon operated in East India. In FY2022, it invested USD 26 million for development of 3<sup>rd</sup> production plant in southern India.
- **Yingde Gases:** It invested USD 60 million to set up gas manufacturing plant in India in FY2019. The company plans to invest USD 1 billion in India in the near future to expand the business.

- **Ellenbarrie:** The company has announced investment of about USD 60 million for setting up plants in Kurnool, AP (with capacity of 600 tons per day), Uluberia, WB (with capacity of 220 tons per day) and expansion of capacity at Tata steel plant in Kharagpur.

### 2.2.3 Key Challenges and Threats

The industrial gases market in India faces several challenges that could impact its growth and sustainability:

- **Supply chain challenges:** The supply chain for industrial gases is fraught with several challenges that affect their availability and distribution. The sector suffers from inadequate storage and handling infrastructure, leading to bottlenecks and increased costs. Poor road infrastructure, specialized transportation needs for cryogenic and high-pressure gases, and fragmented distribution networks result in delivery delays and higher costs. A shortage of skilled professionals and the need for continuous training affect operational efficiency. Geopolitical tensions and pandemics can disrupt the supply chain. The COVID-19 pandemic highlighted vulnerabilities in supply chains for companies like Linde India, which had to navigate disruptions in logistics and transportation. The unavailability of cylinders and containers were affecting the supply of oxygen to impacted parts of the nation.
  - Logistical challenges may arise from stringent laws concerning the shipping of hazardous chemicals. Strict safety regulations, which can be difficult to implement logistically, must be followed when transporting gases like hydrogen. Use of specialized vehicles is also required along with expertise in the operation and maintenance of specialized vehicles used to transport cryogenic gases. Complying with transportation rules, maintaining temperature and pressure control throughout transit, and comprehending the workings of cryogenic tankers and cylinders are all crucial.
- **Safety and environment:** When it comes to handling, storing, and transporting industrial gases, strict safety and environmental standards are crucial. Proper training is essential for anyone handling industrial gases. This includes understanding the properties of different gases, safe handling procedures, and emergency protocols. Users must follow safety guidelines, store gases properly, and use appropriate equipment. One has to secure the cylinders upright, using chains or straps to prevent tipping, and keep them away from heat sources and ignition. Meeting emissions standards and minimizing environmental impact requires investment in cleaner technologies and sustainable practices. Complete knowledge of the safety procedures and legal requirements for working with cryogenic gases is mandatory. Knowledge of national and international safety standards, such as PESO laws in India is must. The capability to conduct risk assessments and put safety precautions in place is also crucial.
- **Regulatory compliance:** Industrial gases are subject to stringent safety, environmental, and quality regulations. It is necessary to obtain clearances from the regulatory authorities like the Petroleum and Explosives Safety Organization (PESO), and the Central Pollution Control Board



(CPCB), each with its own set of standards, to build up new gas production facilities. Compliance involves paperwork, audits, and monitoring and this process can be time-consuming. The Gas Cylinder Rules, FY2016, under the Indian Explosives Act, 1884, were established to ensure safe handling, transportation, storage, and use of gas cylinders. License is mandatory for manufacturing gas cylinders, valves, or regulators. For cryogenic storage tanks, the manufacturers need to get PESO accreditation, guaranteeing that the tanks and cylinders meet safety requirements in terms of construction, testing, and operation. PESO certification is also required for trailers and cylinders that are used to transport liquid gases in order to guarantee that they adhere to safety and operational regulations.

- **Energy intensive process:** Producing industrial gases involves energy-intensive processes, such as air separation, compression, and purification. These steps require significant electricity or fuel. Fluctuations in energy prices, whether due to geopolitical events, supply-demand dynamics, or seasonal variations, directly impact production costs. Sudden spikes can strain profitability. Some industrial gases companies enter long-term energy contracts to stabilize costs. However, these contracts may not always align with market fluctuations. Investing in energy-efficient technologies and practices can reduce consumption. Upgrading equipment, optimizing processes, and using renewable energy sources are effective strategies.

### 2.3 Regulatory Landscape

There are many regulations in India that are required to be followed by industrial gases players. The Gas Cylinders Rules 2016, The Factories Act 1948, The Environmental Protection Act 1986, The Hazardous and Other Wastes (Management and Transboundary Movement) Rules 2016, are few examples of such regulations. Some of the important considerations for the industrial gases producers are:

- The Gas Cylinder Rules, FY2016, under the Indian Explosives Act, 1884, were established to ensure safe handling, transportation, storage, and use of gas cylinders. License is mandatory for manufacturing gas cylinders, valves, or regulators. The application must be submitted to the Chief Controller of Explosives. The storage license is required for storing gas cylinders beyond prescribed quantities.
- The foundation for environmental regulation and protection is provided by the Environmental Protection Act, 1986, which was further extended in 2022. In order to minimize the influence on the environment, it enforces stringent environmental standards and requires the installation of pollution control measures.
- The management and disposal of hazardous wastes are governed under the Hazardous and Other Wastes Act of 2016. By ensuring that industrial gases containers, cylinders and associated debris are disposed of and recycled properly, it reduces environmental risks.

## Market Overview of the Industrial Gases

- Health, safety, and welfare regulations as well as labor laws are enforced in industries by The Factories Act, 1948. In industrial gases plants, ensuring safe working conditions, lowering occupational dangers, and advancing worker welfare are the main priorities.
- The Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989, defines Hazardous Chemicals under Section 2(e) by laying down certain criteria in the Schedules of the Rules. Hydrogen forms a part of the list, and the manufacturer has to identify and report major accidental hazards and take adequate steps to prevent such major accidents and to limit their consequences to persons and the environment and provide to the persons working on the site with the information, training and equipment including antidotes necessary to ensure their safety.
- For cryogenic storage tanks, the manufacturers need to get Petroleum and Explosives Safety Organization (PESO) accreditation, guaranteeing that the tanks and cylinders meet safety requirements in terms of construction, testing, and operation. PESO certification is required for cryogenic tankers, trailers, cylinders that are used to transport liquid gases in order to guarantee that they adhere to safety and operational regulations.
- Apart from above important regulations, there are many standards set by Bureau of Indian Standards which are relevant for gas manufacturers. One such example of BIS standard is IS18149:2023 Transportation of Dangerous Goods which guides for the safe handling and transportation of hazardous materials across the country.

### 3 Market Segmentation

#### 3.1 Segmentation by Product

Based on product, the global industrial gases market can be segregated into 6 key product categories – oxygen, hydrogen, nitrogen, carbon dioxide, argon, and others (includes acetylene & non-argon noble gases).

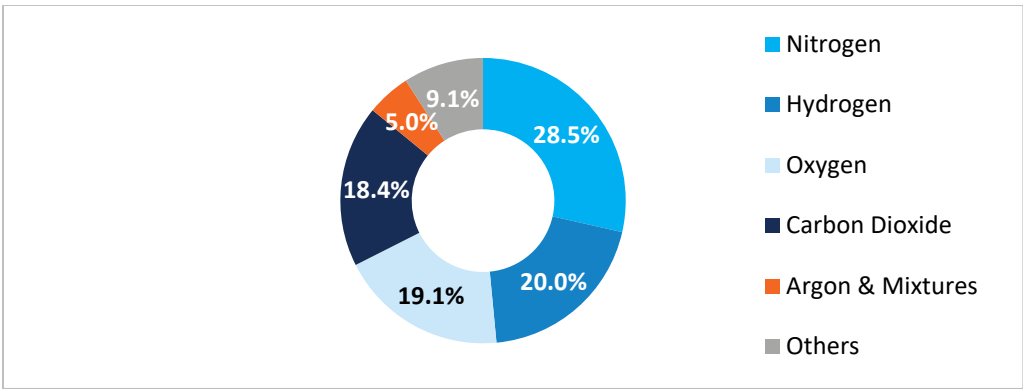
- **Nitrogen** – It accounted for 28.5% of the global industrial gases market by value and 23.6% of the Indian industrial gases market by value in CY2023 owing to its utilization in food & beverage industry, chemical production, steel and other metal manufacturing, etc. It is utilized for preservation, packaging, and freezing in food & beverage applications. In steel and other metal manufacturing, it is utilized in processes like annealing and sintering applications. In petroleum refining, it is used for purging, blanketing, and pressure transferring to enhance safety and efficiency, etc. Nitrogen demand was around 255 million tons and accounted for 37.9% of global industrial gases demand in terms of volume in CY2023. In India, nitrogen demand was around 4.5 million tons in CY2023.
- **Hydrogen** – In value terms, hydrogen accounted for 20% share of global industrial gases market in CY2023. In India, it accounted for 16.2% market share in CY2023. The avg. price of hydrogen ranges from USD 1,000 to 2,000 / ton which is 4 to 8 times higher than oxygen with avg. price of USD 200-300 / ton. The demand in terms of volume of hydrogen accounted for 2.3% of the global industrial gases with demand of 15.4 million tons in CY2023. In India, the demand in terms of volume of hydrogen was 0.15 million tons in CY2023. The consumption of hydrogen takes place in steel manufacturing, oil & gas industry, manufacturing industry, chemical production like ammonia, methanol, etc.
- **Oxygen** – It accounted for 19.1% of the global industrial gas market by value in CY2023. The demand for oxygen was around USD 19.1 billion in terms of value and 68.3 million tons in terms of volume in CY2023. In India, the demand for oxygen was around 2.2 million tons and USD 0.4 billion in CY2023 and forms a lion share of 35.9% of the total industrial gases market by value. The major utilization of oxygen is for the steelmaking process, exclusively in blast furnaces and basic oxygen furnaces. It is also essential in medical applications such as respiratory therapy, anesthesia, life support, among others. Oxygen is used as raw material in the production of chemicals like ethylene oxide, methanol, etc. Other applications include manufacturing, pharmaceutical, pulp and paper, oil & gas, water and wastewater treatment, etc.
- **Carbon dioxide** – It accounted for 18.4% of the global industrial gases market by value while it accounted for 11.2% of Indian industrial gases market by value in CY2023. The consumption of carbon dioxide is into food & beverage, manufacturing, chemicals, oil & gas industry, etc. It is most important feedstock for the production of urea fertilizer around the world. The total demand for CO<sub>2</sub> was more than 263 million tons globally at value of USD 18.4 billion in CY2023. In India, the demand for CO<sub>2</sub> was around 4 million tons and USD 0.14 billion in CY2023.

Market Overview of the Industrial Gases

- Argon and argon mixtures** – It accounted for 5% market share of the global industrial gases demand in terms of value in CY2023. The market size by value for argon and argon mixture was USD 5 billion in same year. In volume terms, the market was around 10 million ton globally. The major utilization of this gas is for metal fabrication application for welding purposes. Other important applications for argon are electrical and electronics, steel & other metal manufacturing, healthcare, etc. In India, argon accounted for 10.2% of total industrial gases demand in terms of value in CY2023.
- Other gases like acetylene, helium & other specialty gases accounted for 9.1% of the global industrial gases demand in terms of value in CY2023. In India, other gases accounted for 2.9% of the industrial gases demand in terms of value in CY2023. Acetylene is widely used in oxy-acetylene welding and cutting processes due to its high flame temperature. It also serves as a raw material in the chemical synthesis of various organic compounds, including plastics, solvents, and pharmaceuticals. Helium is used in medical imaging equipment such as MRI (Magnetic Resonance Imaging) machines, where it serves as a coolant for superconducting magnets. It is also used in aerospace industry as a purge gas in rocket engines and fuel tanks. Helium is employed in semiconductor fabrication processes, particularly in the production of microchips and optical fibers. The demand is driven by growth in end use industries. Specialty gases typically refers to calibration gases, zero gases, carrier gases, span gases, instrumentation gases and bump test gases, which may be either pure gases or gas mixtures containing components at concentrations extending from the per cent range down to part per billion and sometimes even part per trillion. Specialty gases are commonly used in analytical laboratories to conduct analysis and quality controls on raw materials, end products and industrial emissions to detect the trace and quantity of different components and impurities. In addition, specialty gases are used in industries such as steel, pharmaceuticals, cement, semiconductors, glass, lighting, in medical applications and in laboratories.

The graph below illustrates the global market segmentation by product (value terms):

**Graph 3.1-1 Global Market Segmentation by Product, by Value (USD 100.2 Billion, CY2023)**

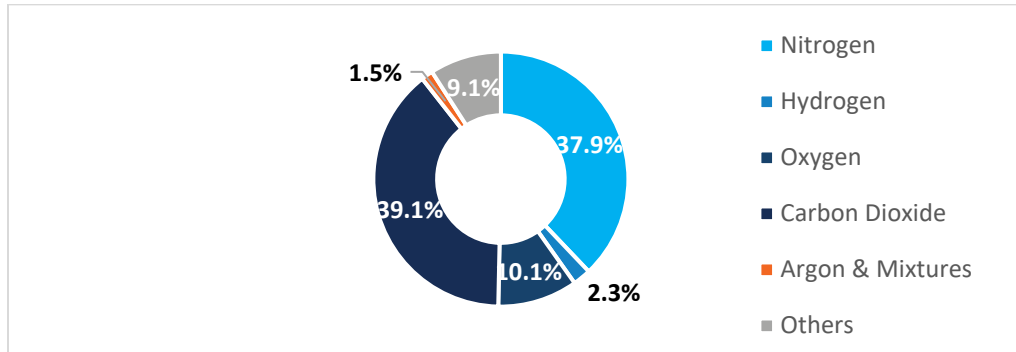


Source: Frost & Sullivan Research & Analysis

## Market Overview of the Industrial Gases

The graph below illustrates the global market segmentation by product (volume terms):

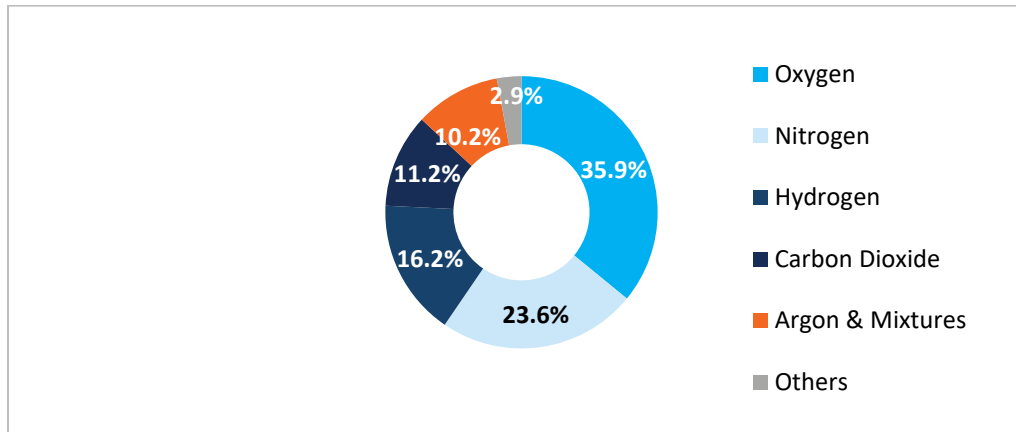
**Graph 3.1-2 Global Market Segmentation by Product, by Volume (672.8 Million Tons, CY2023)**



Source: Frost & Sullivan Research & Analysis

The graph below illustrates the market segmentation by product in India (value terms):

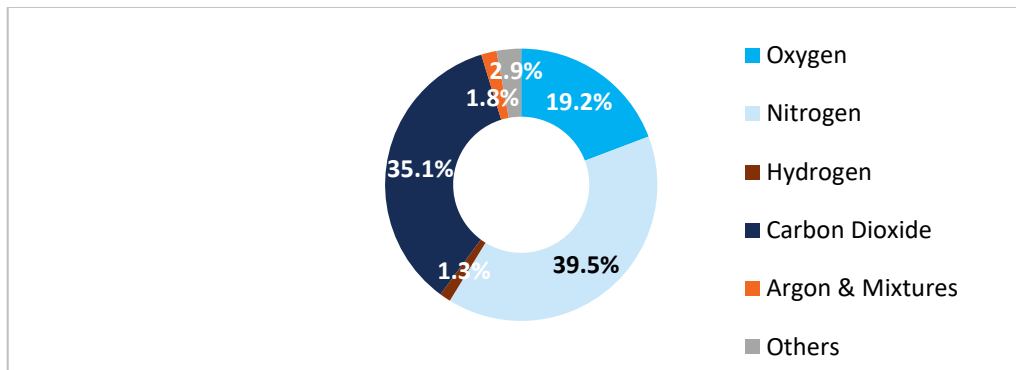
**Graph 3.1-3 Market Segmentation by Product in India, by Value (USD 1.2 Billion) in CY2023**



Source: Frost & Sullivan Research & Analysis

The graph below illustrates the market segmentation by product in India (volume terms):

**Graph 3.1-4 Market Segmentation by Product in India, by Volume (11.4 Million Tons) in CY2023**



Source: Frost & Sullivan Research & Analysis

## 3.2 Segmentation by Supply Mode

### 3.2.1 On-Site

Industrial gases are continuously required by large-scale industries including oil refining, chemical processing, and steel manufacturing, among others.

Globally, on-site production accounted for 28.3% of the total industrial gases demand, valued at USD 28.4 billion in CY2023. In India, the on-site production supply mode constituted 16.7% of the total industrial gases demand by value in the same year. Almost 3.2 million tons of gas was supplied through on-site production in India in CY2023.

The industrial gases industry is characterized by high customer stickiness, particularly for large customers, as gas generated is directly supplied by pipelines based on long-term contracts, typically ranging from 15 to 20 years. This arrangement makes transitioning suppliers cumbersome, inconvenient from an integration perspective, and financially onerous. Additionally, customers are highly selective in choosing new suppliers for industrial gases due to the critical role these gases play in the overall manufacturing process across industries, and the high costs and risks associated with switching suppliers, especially where product reliability and uninterrupted supply are essential.

Obtaining and maintaining the necessary qualifications and meeting internal supplier selection procedures is time-consuming and capital-intensive, constituting a significant barrier to entry for new industry players. The on-site business model provides unique advantages in terms of infrastructure integration with customers, reducing their inclination to seek alternative suppliers. This model ensures a clear demand pipeline and assured cash flows for suppliers.

The supply of industrial gases to government organizations, typically undertaken through a tender process, involves stringent qualification criteria, further acting as a barrier to entry for new entrants in the market.

### 3.2.2 Bulk Containers

In CY2023, bulk container supply, including tankers, accounted for 31.8% of the global industrial gases demand by value. In India, this mode constituted 41.3% of the total industrial gases demand by value, with approximately 4.1 million tons of gas supplied through bulk containers.

For medium to large-scale consumers who require substantial quantities of gases but lack the resources or demand for on-site production, bulk containers (including tankers) provide an affordable option. By reducing the frequency of smaller deliveries, this method minimizes environmental impact and lowers transportation costs related to gas supply logistics.

Bulk gas supply involves transporting gases in liquid form via cryogenic tankers to the consumer's site, where they are stored in large cryogenic storage tanks. These storage systems maintain the gases at extremely low temperatures to keep them in a liquid state, which is more economical for transportation

## Market Overview of the Industrial Gases

due to the higher density of liquid gases. At the point of use, the liquid gases are converted back into their gaseous form through vaporizers. This process ensures a steady and dependable supply of gases for sectors such as petrochemicals, automotive production, and food and beverage processing.

Bulk gas deliveries are convenient and efficient, as many companies already have the necessary infrastructure to handle them, integrating well with their current operating and supply chain procedures. This method is particularly advantageous for industries requiring a continuous and high-volume gas supply, ensuring operational efficiency and cost-effectiveness.

### 3.2.3 Cylinders

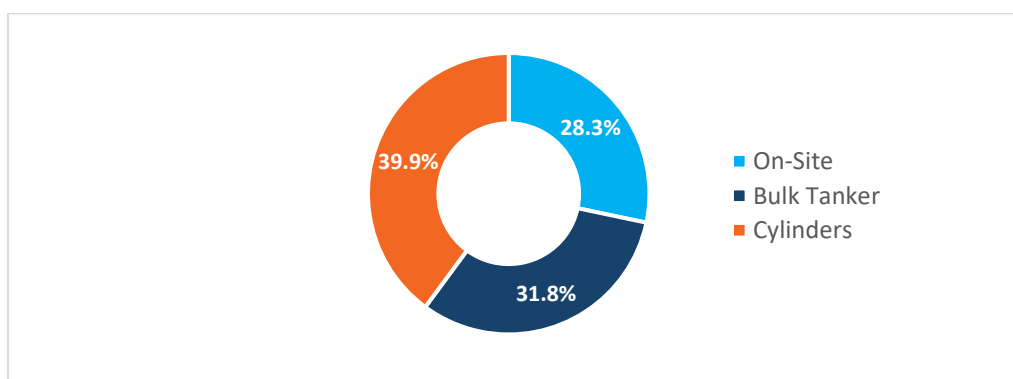
In CY2023, the supply through cylinders accounted for 39.9% of the total industrial gases demand by value globally. In India, cylinders constituted 42.0% of the total industrial gases demand by value, with almost 4.2 million tons of gases supplied through cylinders.

Cylinders are preferred for specialized and smaller-scale applications due to their versatility in handling different types of gases and varying demand levels. Firms can avoid the high capital costs associated with bulk storage systems or on-site manufacturing facilities by using cylinders. This makes them a practical option for both suppliers and end users, as they are easy to distribute and handle.

For package customers, the seamlessness of the supply chain, controlled transportation conditions, familiarity with suppliers, and safety and quality control concerns limit the extent to which customers are willing to switch suppliers of industrial gases. The package business is geographically limited due to the risks associated with transporting industrial gases over long distances and the high transportation costs involved.

The graph below illustrates the global market segmentation by supply mode (value terms):

**Graph 3.2-1 Global Market Segmentation by Supply Mode, by Value (USD 100.2 Billion) in CY2023**

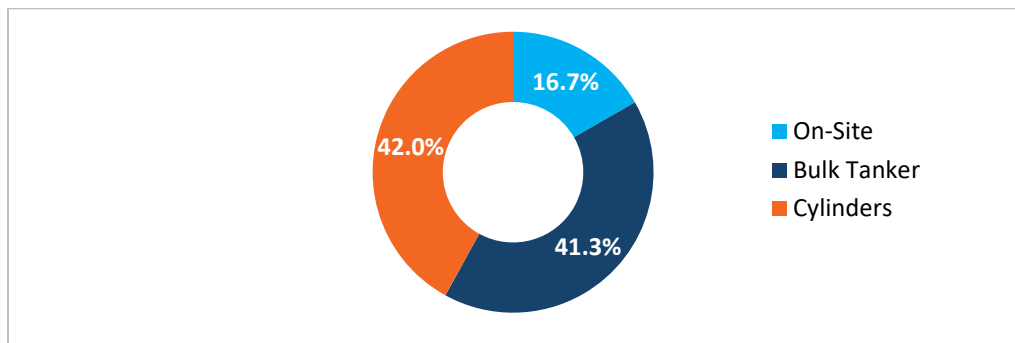


Source: Frost & Sullivan Research & Analysis



The graph below illustrates the India market segmentation by supply mode (value terms):

**Graph 3.2-2 India Market Segmentation by Supply Mode, by Value (USD 1.2 Billion, CY2023)**



Source: Frost & Sullivan Research & Analysis

### 3.3 Segmentation by Application

Industrial gases are used across diverse industry sectors. Following are the major ones:

- **Chemicals** – The chemical industry accounted for 19% of the global industrial gases demand by value in CY2023, and 16.3% in India during the same period. Industrial gases like oxygen, nitrogen, and carbon dioxide are essential for various chemical production processes, supporting the manufacture of high-volume essentials such as ammonia and urea. For example, ammonia production, which is a key component of fertilizers, relies heavily on nitrogen. The Haber-Bosch process, used to synthesize ammonia from nitrogen and hydrogen, requires significant volumes of these gases. Moreover, industrial gases play a role in ensuring safety and efficiency in chemical plants. Nitrogen, for instance, is used for purging and blanketing to prevent unwanted chemical reactions and maintain inert atmospheres in storage tanks and reactors. This is crucial for maintaining product quality and ensuring operational safety.
- **Steel and Other Metal Manufacturing** – This sector accounted for 18.2% market share of global industrial gases market in CY2023. In India, the market share of steel industry was 23.3%. All the gases play an important role in steel manufacturing process. Oxygen is blown into the molten pig iron to remove impurities like carbon, silicon, manganese, and phosphorus by oxidation, which is essential in converting pig iron into high-quality steel. Nitrogen has a solid solution strengthening effect and enhances steel's hardenability. In nitrogen-containing ferritic steel, precipitation hardening occurs due to ultra-microscopic nitrides during tempering. N<sub>2</sub> is commonly used as an alloying element in steel.
- **Healthcare** – The healthcare industry accounted for 11.9% of the global industrial gases industry by value in CY2023. Gases like oxygen, nitrogen, carbon dioxide, helium, etc. find important functions in healthcare sector. Oxygen therapy is fundamental in medical settings to treat conditions such as hypoxia (low blood oxygen levels) and respiratory distress. Nitrous oxide has several medical uses, primarily in anesthesia and pain management. Carbon dioxide is used in procedures like laparoscopy,

## Market Overview of the Industrial Gases

etc. Helium is used in medical imaging and respiratory therapies. In India, healthcare industry accounted for 9.8% of the industrial gases market by value in CY2023.

- **Oil and Gas** – The oil and gas industry accounted for 11.2% market share of global industrial gases demand by value in CY2023. In India, the oil & gas industry accounted for 6.1% share of Indian industrial gases market by value in CY2023. Key gases like hydrogen, carbon dioxide, nitrogen are essential for various refining processes. Hydrogen is very important for hydrocracking, hydrotreating, desulfurization, etc. Nitrogen is used for inerting and blanketing, purging, etc. applications. Carbon dioxide is utilized for enhanced oil recovery, pH control, cooling and fire suppression, etc.
- **Manufacturing** – The manufacturing industry accounted for 10.1% of global industrial gases demand by value in CY2023. In India, it represented 12.9% of the total industrial gases demand in terms of value. Industrial gases such as oxygen, nitrogen, and argon play critical roles in various manufacturing processes, significantly contributing to the efficiency and quality of production in metal fabrication, engineering, and general manufacturing sectors. Oxygen is widely used in cutting, welding, and brazing operations. It enhances combustion efficiency, enabling precise cutting and welding, which are essential in the fabrication of steel structures, automotive components, and machinery. In the engineering sector, nitrogen is utilized for its inert properties, which are crucial in preventing oxidation and contamination during the production of sensitive electronic components and precision instruments.
- **Food and Beverage** – The food and beverage industry accounted for 9.8% of the industrial gases market by value globally in CY2023. In India, the market share of F&B segment was around 9.2%. For better food preservation, high concentrations of nitrogen gas is required within food packaging. Nitrogen is also preferred for gas flushing which is helpful in longer food storage.
- **Electrical and Electronics** – The electrical and electronics industry accounted for 4.9% of the global industrial gases demand by value in CY2023. Nitrogen is used in wave soldering machines and blanketing applications. Oxygen supports high temperature cutting processes used for shaping metals and alloys in manufacturing electronic components. In some electrical equipment, such as high-voltage switchgear and circuit breakers, argon is used as an insulating gas to improve dielectric strength and performance. Hydrogen is used in controlled atmospheres for annealing and heat treatment processes in semiconductor manufacturing. In India, electrical and electronics industry accounted for 4.1% of the industrial gases market by value in CY2023.
- **Infrastructure** – The infrastructure industry accounted for 4% of the global and Indian industrial gases demand by value in CY2023. Industrial gases like oxygen and acetylene are used in oxy-fuel welding and cutting applications. Argon and carbon dioxide are utilized as shielding gas in welding processes like tungsten inert gas welding and metal inert gas welding.
- **Pharmaceutical** – The pharma industry accounted for 3% of the global industrial gases demand by value in CY2023 and for India, it accounted for 4.9% of the demand as per value in the same year.

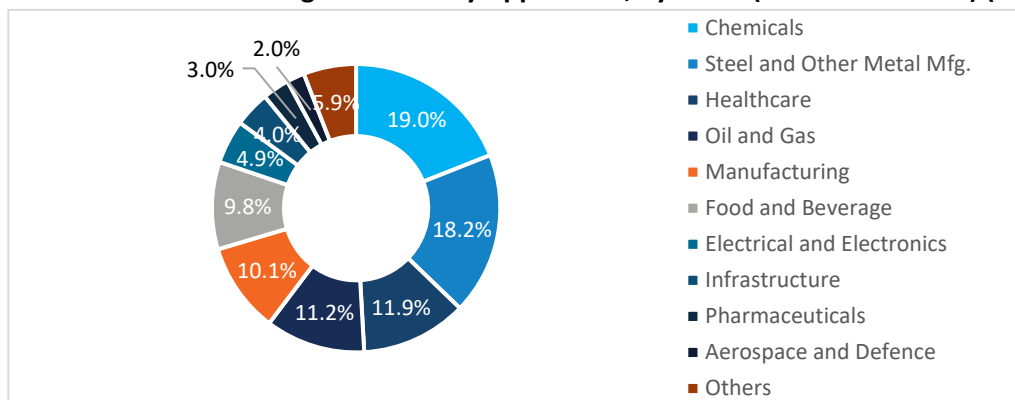
## Market Overview of the Industrial Gases

Nitrogen is used for inerting, blanketing, and purging to maintain an oxygen-free environment, crucial for the stability of sensitive compounds. Carbon dioxide is employed in supercritical fluid extraction to obtain pure and high-quality active pharmaceutical ingredients. Oxygen is used in fermentation processes for antibiotic production. The growth of the pharmaceutical industry, driven by increased healthcare spending and innovation in drug development, leads to a higher demand for industrial gases.

- Aerospace and Defence** – The industries together accounted for 2% of the global industrial gases demand by value in CY2023 and for India, it accounted for 2.3% of the demand in terms of value in the same year. Oxygen, argon, and helium are used in metal fabrication and welding applications. Hydrogen is utilized in rocket propulsion systems as a fuel source. Oxygen is also used as an oxidizer in rocket engines to support combustion of fuels.

The graph below illustrates the Global market segmentation by application by value:

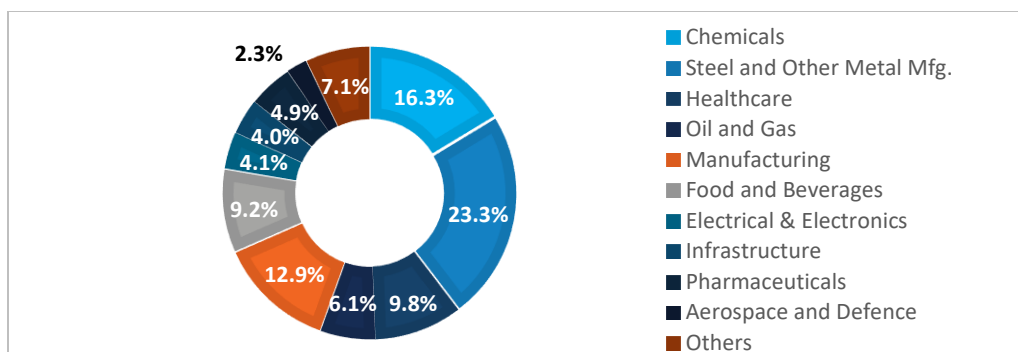
**Graph 3.3-1 Global Market Segmentation by Application, by Value (USD 100.2 Billion) (CY2023)**



Note: Manufacturing includes automotive, textile, general engineering and metal fabrication, machinery & equipment, etc. industries. Source: Frost & Sullivan Research & Analysis

The graph below illustrates the Indian market segmentation by application by value:

**Graph 3.3-2 India Market Segmentation by Application, by Value (USD 1.2 Billion) (CY2023)**



Note: Manufacturing includes automotive, textile, general engineering and metal fabrication, machinery & equipment, etc. industries; Source: Frost & Sullivan Research & Analysis

## 4 Product Segment Analysis

We have analyzed the industrial gases to recognize the global and regional market dynamics, market segmentation by application and region followed by industry trends and drivers.

### 4.1 Hydrogen

Hydrogen is a flexible energy carrier and not considered a primary energy source. It can be generated from various feedstocks, including biomass, natural gas, coal, nuclear power, and renewable energy sources like solar and wind. When used as a fuel in a fuel cell, hydrogen is a clean fuel that produces only water as a byproduct. Energy generated from other sources can be transported, stored, and delivered using hydrogen as an energy carrier. These benefits make hydrogen a desirable fuel choice for energy production and transportation applications.

**Route of synthesis:** There are various production methodologies for hydrogen, including steam methane reforming (SMR), coal gasification, water electrolysis, biological methods, and partial oxidation of hydrocarbons.

#### 1. Steam Methane Reforming (SMR):

**Process:** SMR is the most widely used technique for hydrogen production. It involves reacting methane ( $\text{CH}_4$ ) with steam ( $\text{H}_2\text{O}$ ) at high temperatures (700-1,000°C) in the presence of a nickel catalyst to produce hydrogen ( $\text{H}_2$ ), carbon monoxide (CO), and a small amount of carbon dioxide ( $\text{CO}_2$ ).

**Benefits:** High commercialization, large-scale production capabilities, and high efficiency of the production process.

**Challenges:** High  $\text{CO}_2$  emissions, high capital investment

#### 2. Coal Gasification:

**Process:** In coal gasification, coal is reacted with oxygen and steam at high temperatures to produce syngas.

**Benefits:** Utilizes abundant coal resources and can produce hydrogen from low-quality coal.

**Challenges:** High  $\text{CO}_2$  emissions, complex technology, and environmental concerns related to coal use.

#### 3. Water Electrolysis:

**Process:** Water electrolysis is considered a clean technology for producing green hydrogen. Water is split into hydrogen and oxygen using electrical energy.

## Market Overview of the Industrial Gases

**Benefits:** Produces high-purity hydrogen and can be powered by renewable energy sources, making it environmentally friendly.

**Challenges:** Currently not cost-competitive; targeted R&D is required to reduce production costs.

These methodologies offer diverse pathways for hydrogen production, each with its own set of benefits and challenges, contributing to the versatility and potential of hydrogen as a flexible energy carrier.

### 4.1.1 Global Hydrogen Market

The global demand for hydrogen is primarily driven by the oil and gas industry for enhanced oil recovery and the chemical industry for fertilizer production. Hydrogen is considered a versatile energy carrier that can help address various energy-related challenges. The demand for hydrogen was around 15.4 million tons in CY2023, increasing at a CAGR of 3.1% since CY2018.

With leading industrial participants announcing shifts towards low-emission hydrogen like blue and green hydrogen, it is estimated that by CY2050, two-thirds of the demand will be met by low-emission hydrogen.

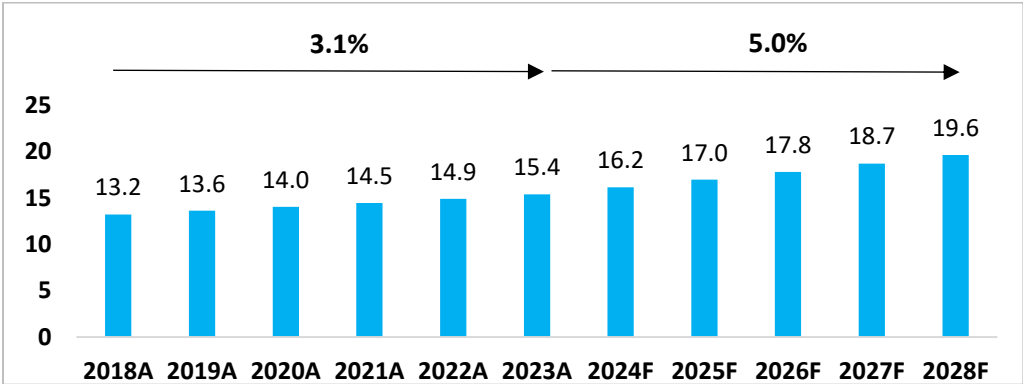
Hydrogen is essential for achieving sustainable energy systems and reducing greenhouse gas emissions as nations and industries focus on decarbonization. It is estimated that the demand for hydrogen will grow at a CAGR of 5.0% from CY2023 to CY2028, reaching 19.6 million tons by CY2028. In the future, the production of low-emission hydrogen is expected to grow rapidly.

China is currently a major consumer of hydrogen. The nation has introduced a crucial policy known as the "Medium- and Long-Term Plan for the Development of the Hydrogen Energy Industry (CY2021–CY2035)," which supports hydrogen-related developments and the deployment of fuel cell vehicles in urban areas. With this plan, China aims to make the transportation industry a major driver of hydrogen development. China has more than 30% of the world's electrolyzer capacity, making it a leader in green hydrogen plans. However, issues such as inflation and rising costs affect project bankability and government support for implementation.

Market Overview of the Industrial Gases

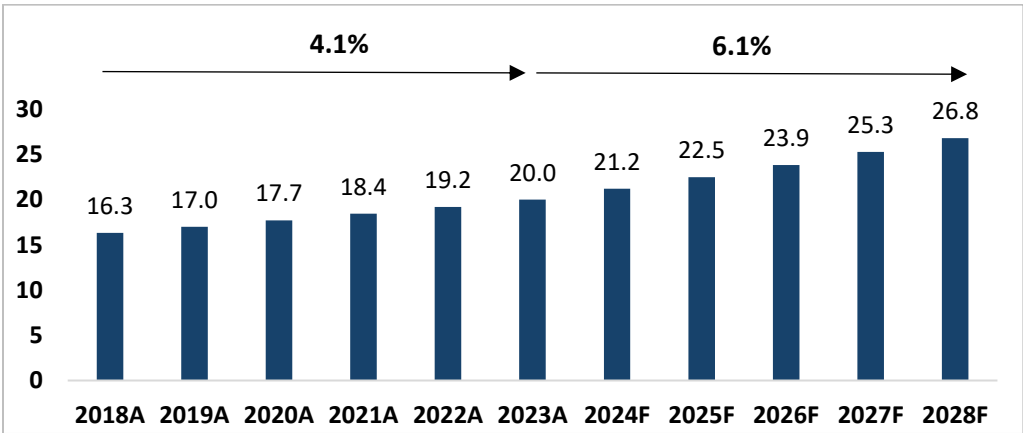
The graphs below illustrate the global demand for hydrogen during last 5 years and projected demand through CY2028.

**Graph 4.1.1-1 Global Hydrogen Market, by Volume (Million tons), CY2018-2028F**



Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis

**Graph 4.1.1-2 Global Hydrogen Market, by Value (USD Billion), CY2018-2028F**



Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis

**4.1.1.1 India Hydrogen Market**

In CY2023, India's annual hydrogen demand was 0.15 million tons, and it is estimated to increase to 0.23 million tons by 2028, growing at a CAGR of 9.0%. Grey hydrogen accounted for over 99% of the total hydrogen supply in India, with a small portion of blue and green hydrogen.

The market size for hydrogen in India increased from USD 0.15 billion in CY2018 to USD 0.20 billion in CY2023. This growth was driven by steady demand from the steel and oil & gas sectors, high traction from the fertilizer industry due to the rising population, and the utilization of hydrogen in new applications such as automotive and power.

## Market Overview of the Industrial Gases

With the declaration of energy independence by FY2047, India has shifted its focus towards developing a hydrogen economy. It is estimated that the market size by value will grow from USD 0.20 billion in CY2023 to around USD 0.32 billion in CY2028, at a CAGR of 10.1% over the next five years.

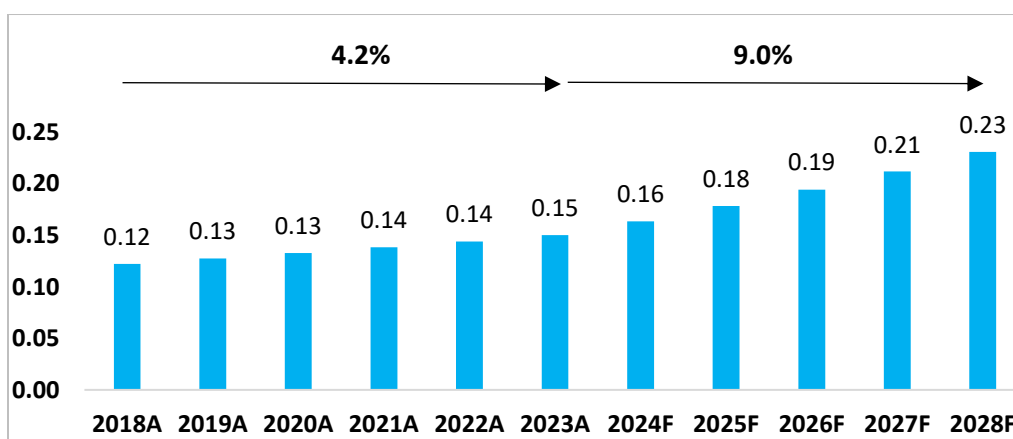
**Green Hydrogen Potential:** Green hydrogen is considered a clean energy solution, produced using renewable energy and electrolyzers to split water into hydrogen and oxygen. It offers dual benefits of carbon emission reduction and the potential to replace fossil fuels in applications such as power, fertilizers, the shipping industry, and oil & gas.

The market by value for hydrogen in conventional applications has been steadily increasing at a CAGR of 5.2% over the past five years. However, with the introduction of clean energy solutions, it is estimated that new applications will account for 30% of the overall hydrogen demand in the next ten years.

Linde, Grasim Industries, Inox Air Products, and Ellenbarrie are the top players, accounting for over 80% market share in CY2023. Air Liquide, Tata Chemicals, GHCL, and Bhuruka Gas are also noteworthy suppliers of hydrogen in India. These companies play a crucial role in meeting India's hydrogen demand and driving the transition towards a sustainable hydrogen economy.

The graphs below illustrate the demand for hydrogen in India during last 5 years and projected demand through CY2028:

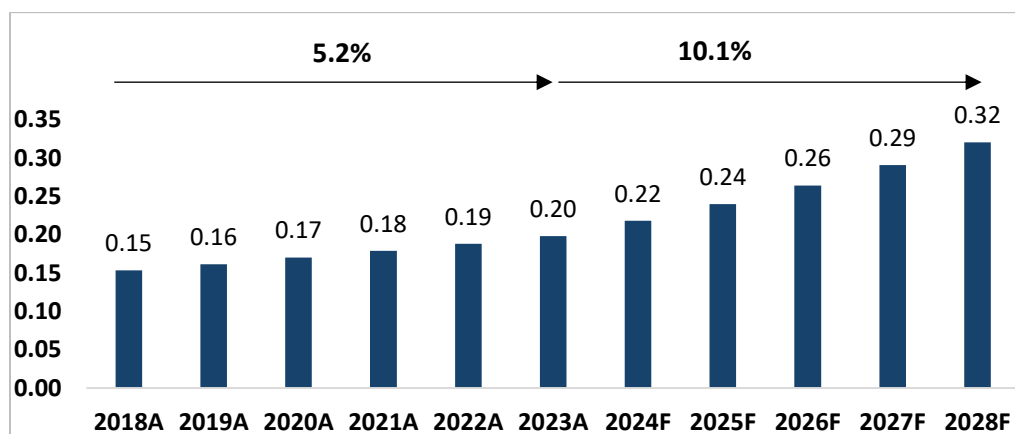
**Graph 4.1.1.1-1 Hydrogen Market in India, by Volume (Million tons), CY2018-2028F**



Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis



**Graph 4.1.1.1-4 Hydrogen Market in India, by Value (USD Billion), CY2018-2028F**



Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis

### 4.1.2 Hydrogen Market Split by Application (India)

**Steel and Other Metal Manufacturing:** In India, steel and other metal manufacturing accounted for 30% market share of total hydrogen demand in terms of value in CY2023. Hydrogen is used as a reducing agent in steel production. It is also used in the processing and refining of non-ferrous metals such as aluminum, copper, and nickel. To prevent oxidation and decarburization of steel and other metals, it is used in heat treatment processes. It is considered as excellent alloy material.

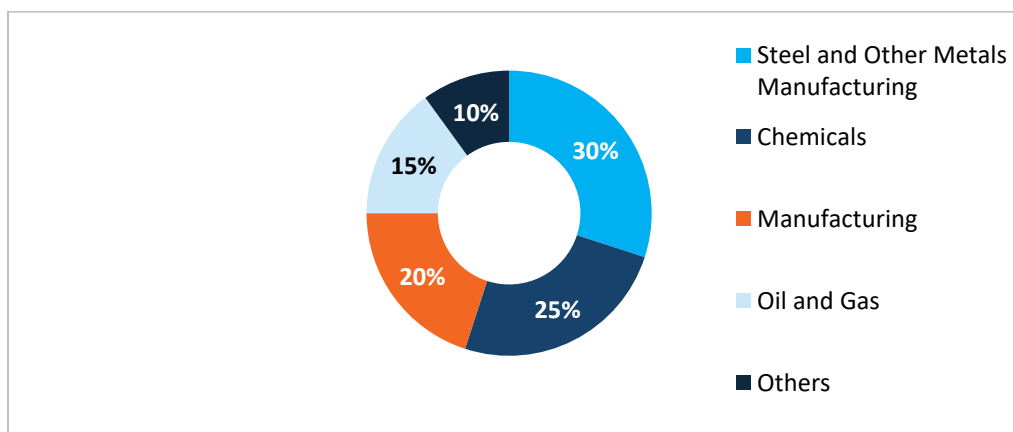
**Chemicals:** For chemical industry, hydrogen is the most important feedstock for production of ammonia. Ammonia is widely used as a fertilizer. Chemicals industry accounted for 25% market share in India hydrogen market by value in CY2023.

**Manufacturing:** For manufacturing sector (incl. metal fabrication & glass production), hydrogen is used for heat treatment and metal reduction processes. It is used as fuel for glass melting furnaces. In power plants, hydrogen is used in turbine cooling due to its superior thermal properties. Manufacturing industry (incl automotive) accounted for 20% market share in India hydrogen market by value in CY2023.

**Oil and Gas:** Hydrogen plays a fundamental role in refining industry, contributing to the effective fuel manufacturing and continuous operations. Hydrogen is prominently used for desulphurization of fuels where it is used to remove sulfur from fuels they produce. Another important function of hydrogen is hydrogenation where it involves breaking down large hydrocarbon molecules into smaller ones. It is used to convert heavy crude oil fractions into lighter, more valuable products such as gasoline, diesel, and jet fuel. Another function of hydrogen is to be used as catalyst to stimulate chemical reactions within the refinery. Oil and gas industry accounted for 15% market share in India hydrogen market by value in CY2023.

The graph below illustrates the market segmentation by application in India for hydrogen by value:

**Graph 4.1.2-1 Hydrogen Market Segmentation by Application in India, by Value (USD 0.2 Billion) (CY2023)**



Others includes power industry, optic fiber, float & sintered glass, telecom towers, etc. Manufacturing includes glass, automotive, general engineering and metal fabrication, machinery & equipment, etc. industries

Source: Frost & Sullivan Research & Analysis

### 4.1.3 Hydrogen Market Split by Region (India)

The concentration of refineries, steel plants, manufacturing industries, and fertilizer units is high in west Indian region and thus it accounted for more than 30% of the total demand of hydrogen in India in CY2023. In western India, there are refineries of Reliance Industries, Nayara Energy, IOCL, etc. in Gujrat and BPCL, HPCL in Mumbai, Maharashtra. Also, the fertilizer companies such as IFFCO, RCF, Krishak Bharati, Gujarat State Fertilizers & Chemicals, GNFC, Deepak Fertilizers, etc. has production facilities in states like Gujrat and Maharashtra. The other industries like steel production, manufacturing, power, etc. has significant presence in western India. Thus, demand of hydrogen is very high in this part of India.

The eastern region contributed to 30% of the hydrogen demand in India in CY2023. There are notable examples of steel manufacturing plants at Bokaro Steel City, Jamshedpur, Ranchi, Durgapur, Asansol, etc. which drives the demand of hydrogen. There are fertilizer plants at Paradeep (Odisha) by IFFCO and Paradeep Phosphates in this region. Also, refineries like Oil India at Assam, IOCL at Odisha, Bihar and West Bengal, etc. is driving the hydrogen demand.

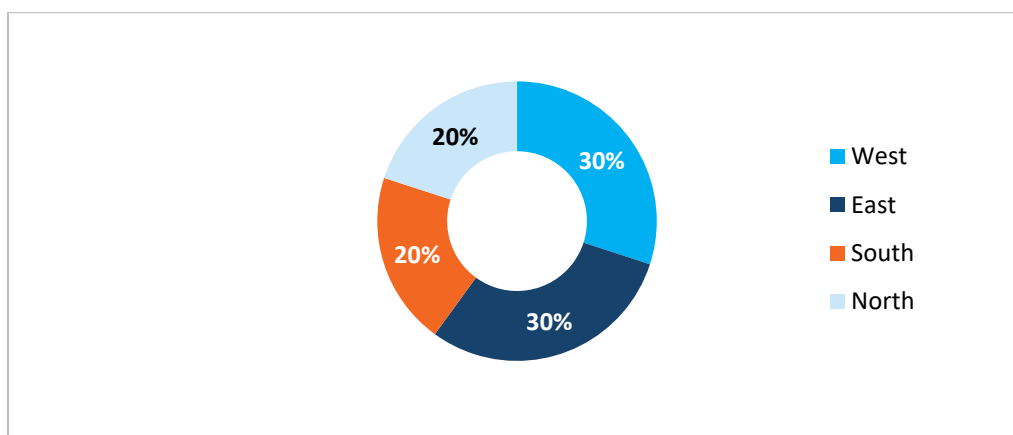
The Northern region accounted for 20% market share for the demand of hydrogen in CY2023 owing to the production plants of fertilizer companies such as IFFCO, Chambal Fertilizers and Chemicals, Krishak Bharati Cooperative Limited, etc. in Northern part. Also, presence of key refineries by IOCL at Haryana, Bihar and Uttar Pradesh, HPCL-Mittal Energy Limited at Punjab, BPCL at MP, etc. catered to the hydrogen demand in the region. North India also has presence of manufacturing and steel industry which drives the traction for hydrogen demand.

## Market Overview of the Industrial Gases

The southern part of country holds refineries at Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, etc. and key fertilizer plants at Andhra Pradesh, Tamil Nadu, Kerala which is driving the demand of hydrogen in southern region. It accounted for 20% of the total demand in CY2023. There are steel manufacturing plants in southern India at Vizag, Bellary, Bhadravati, Salem, etc. which accounted for significant share of hydrogen.

The graph below illustrates the market segmentation by region in India for hydrogen by value:

**Graph 4.1.3-1 Hydrogen Market Segmentation by Region in India, by Value (USD 0.2 Billion) (CY2023)**



Source: Frost & Sullivan Research & Analysis

### 4.1.4 Hydrogen - Growth Drivers and Market Trends (India)

- Energy security:** India has pledged to become energy independent by FY2047 with investment in renewables, electric vehicles, and green hydrogen. The country's strategic focus is on reducing reliance on crude oil and natural gas imports by developing domestic alternatives. The adoption of green hydrogen and electrified industrial production could decrease industrial coal imports by 95%, fostering energy independence and sustainability. The government of India has launched policies and initiated programs which support the development of hydrogen economy. This has provided boost to the demand of hydrogen.
- Decarbonization efforts:** There is urgent requirement of reduction in carbon emissions and to tackle climate change. Hydrogen is predominantly produced through the Steam Methane Reforming (SMR) process, which results in significant carbon emissions. By replacing grey hydrogen with blue or green hydrogen, the dual purpose of carbon reduction and providing alternative to the conventional fuels can be achieved. The decarbonization push has been effectively driving investments by key industry participants and has boosted the demand for hydrogen.
- Growth in key applications:** Owing to the introduction of low carbon hydrogen like blue or green hydrogen, new applications have emerged for the consumption of H<sub>2</sub> including transportation, power industry, fuel cells, etc.

4. **Research and development:** Indian government has allocated substantial budget of ₹400 crore for the research and development under national green hydrogen mission. The objective of this investment is to foster robust research ecosystem in the country and accelerate the commercialization of green hydrogen technologies. The country also aims to offer competitive pricing and capture a significant share of the global hydrogen demand by exporting green hydrogen globally.
5. **Decarbonization of energy intensive industry sectors:** The sectors like fertilizer & chemicals, power industry, transportation, etc. accounted for significant carbon emissions. The value chain participants are taking strides towards decarbonization of these sectors using green hydrogen. There has been active participation from the players to invest in technology, manufacturing set up, manpower, supply chain essentials, etc. for the acceptance of green hydrogen. Industry sectors like cement and steel where extensive energy requirements go beyond solar and wind energy, green hydrogen is standing out as preferred solution for achieving cleaner operations.
6. **Collaborations and partnerships:** India is actively engaging in international activities pertaining to green hydrogen and working with other nations. These collaborations improve information exchange and technological advancement. Examples include Total energy partnership with Adani, Ohmium partnership with Tata projects for plant setups, India-Australia Green Hydrogen Taskforce, Quad's (India, US, Japan, and Australia) Climate Working Group for Clean Energy, etc.

## 4.2 Nitrogen

All living things are composed of nitrogen, a colorless, odorless, and tasteless gas that is the most abundant element in the Earth's atmosphere. Nitrogen is produced with the aid of air separation equipment.

**Route of synthesis:** There are various air separation processes for nitrogen production such as cryogenic distillation, pressure swing adsorption, membrane separation, among others.

- 1. Cryogenic distillation process:** The compressed air is cooled to near its dew point using heat exchangers to achieve the low temperatures required. The cooled air is purified to remove moisture, carbon dioxide, and hydrocarbons, typically using molecular sieves. The purified air is introduced into a distillation column where it is separated into its components like nitrogen, oxygen, and argon based on the boiling points. The major benefits of this process are production of high-purity nitrogen, capability of large-scale production, etc.
- 2. Pressure swing adsorption process:** The atmospheric air is compressed to about 5-8 bar and passed through filters to remove particulate matter and impurities. The compressed air is then passed through a bed of adsorbent material, usually zeolite, which selectively adsorbs oxygen, water vapor, and carbon dioxide, allowing nitrogen to pass through. The process relies on the different adsorption properties of gases under pressure. The adsorbent material is regenerated by reducing the pressure in the adsorption beds. The previously adsorbed gases are desorbed and vented out, making the bed ready for the next cycle. The nitrogen-enriched stream, typically with purities ranging from 95% to 99.999%, is collected and stored for use.
- 3. Membrane separation process:** Atmospheric air is compressed and filtered to remove particulate matter. The compressed air is passed through a polymer membrane. The membrane allows smaller molecules like oxygen, water vapor, and carbon dioxide to permeate through it more quickly than nitrogen. This selective permeability is due to differences in the molecular sizes and diffusion rates of the gases. The nitrogen-enriched stream is collected on the non-permeate side. The purity levels typically range from 90% to 99.9%.

**4.2.1 Global Nitrogen Market**

The market size by value of nitrogen has increased from USD 23.4 billion in CY2018 to USD 28.6 billion in CY2023, growing at a CAGR of 4.1% owing to increase in demand from fertilizer industry, growing population and urbanization, increasing utilization in food packaging, etc. factors. The global demand in volume terms was estimated to be around 255.0 million tons in CY2023 and has been growing with CAGR of 2.0% since last 5 years.

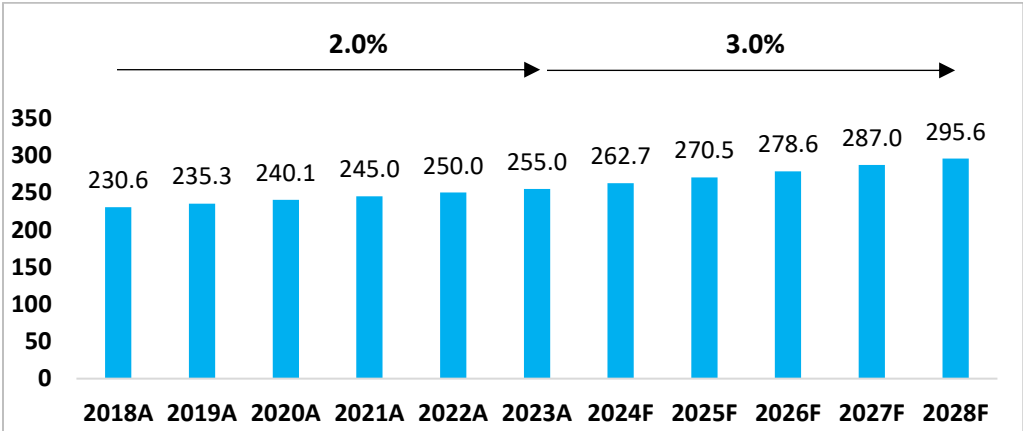
Asia pacific is a major contributor to the demand of nitrogen globally owing to high demand from fertilizer (chemicals) industry in China and India with consistent growth of agricultural production. The food industry in APAC region is also growing at an elevated pace where nitrogen is used in food packaging, bottling, and sparging for preventing spoilage, maintaining freshness, and enhancing product quality.

The demand for nitrogen is expected to reach 295.6 million tons in CY2028 from 255.0 million tons in CY2023. In terms of market size by value, the demand will grow at a CAGR of 5.1% to reach USD 36.6 billion by CY2028.

There are 2 major forms of nitrogen – gas and liquid form. Nitrogen gas has become an integral element of many industrial and medical processes such as chemicals, food & beverages, healthcare, steel industry, oil & gas, fabrication, etc.

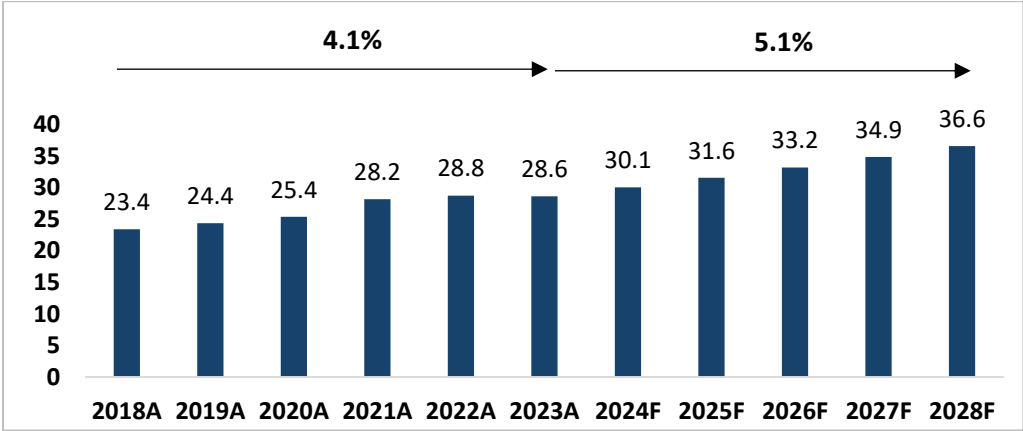
The graphs below illustrate the global demand for Nitrogen during last 5 years and projected demand through CY2028:

**Graph 4.2.1-1 Global Nitrogen Market, by Volume (Million tons), CY2018-2028F**



Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis

**Graph 4.2.1-2 Global Nitrogen Market, by Value (USD Billion), CY2018-2028F**



Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis

**4.2.1.1 India Nitrogen Market**

The demand of nitrogen in India has increased from 3.9 million tons in CY2018 to become 4.5 million tons in CY2023 with CAGR of 3.1% owing to expansion in fertilizer production, rapid growth of food packaging industry, consistent consumption in steel production, etc. In terms of market size by value, the demand has increased from USD 0.22 billion in CY2018 to USD 0.29 billion in CY2023 with CAGR of 5.2%.

Nitrogen in gas form is readily used for different applications across the country. The Pressure Swing Adsorption (PSA) based nitrogen generator is popularly used for nitrogen production in India. Due to its high purity output, advanced technology, cheaper cost, etc., it is preferred over other types of nitrogen generators.

Another technology of nitrogen generators is membrane separation technique. It is preferably used in oil & gas industries in India for under-balanced drilling, pipeline purging and pigging, coiled tubing operations, reservoir pressure maintenance, and fracturing. It is also used in mining, shipyards, etc.

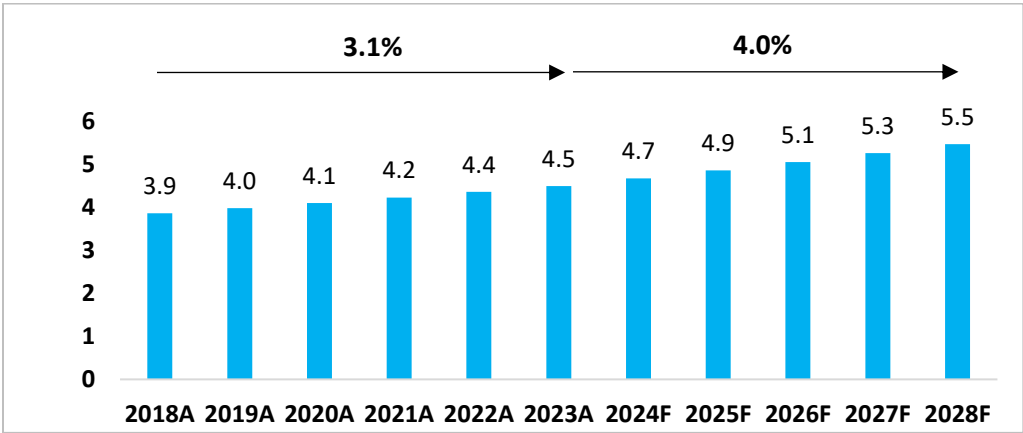
It is estimated that the demand for nitrogen will grow at a CAGR of 6.1% in next 5 years and will become USD 0.39 billion by CY2028. The major driving factors for such advances are India’s push for self-sufficiency in fertilizer sector, rapid improvement in population and urbanization that has increased the crop yield demand, innovations and advancements in emerging applications, investments in manufacturing sector owing to immense support from government in terms of incentives, etc.

The top players are Linde, Inox Air Products and Ellenbarrie. The top players accounted for over 60% market share in nitrogen supply in CY2023. The other players include Air Water, Air Liquide, Taiyyo Nippon Sanso India, Bhuruka Gas, Goyal MG Gases, etc.

Market Overview of the Industrial Gases

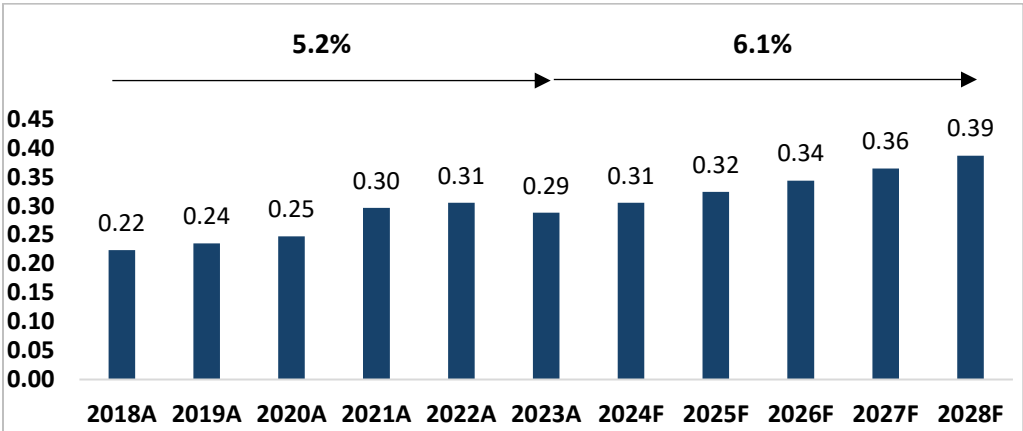
The graphs below illustrate the demand (volume and value) for Nitrogen in India during last 5 years and projected demand through CY2028 (CY2018 and CY2028):

**Graph 4.2.1.1-1 Nitrogen Market in India, by Volume (Million tons), CY2018-2028F**



Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis

**Graph 4.2.1.1-2 Nitrogen Market in India, by Value (USD Billion), CY2018-2028F**



Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis

**4.2.2 Nitrogen Market Split by Application (India)**

**Food and Beverage:** It accounted for 25% of the total demand in terms of value of nitrogen in India in CY2023. For better food preservation, high concentrations of nitrogen gas is required within food packaging. Nitrogen is also preferred for gas flushing which is helpful in longer food storage.

**Chemicals:** It is the 2<sup>nd</sup> largest consuming industry of nitrogen in India. The world’s most populous country also is one of the leading producers of agriculture output majorly dependent on urea-based fertilizers. The production of ammonia has rapidly increased in the last few years owing to government support and policies. The chemical industry accounted for 15% of the total nitrogen demand in the country in CY2023. In chemical industry, Nitrogen is also used as an inert gas, preventing oxidation or deterioration of chemical products during storage.



**Steel and Other Metals Manufacturing:** Another application with consumption of nitrogen is steel and other metal manufacturing. It accounted for 15% of the total demand in India in CY2023. Nitrogen has a solid solution strengthening effect and enhances steel's hardenability. In nitrogen-containing ferritic steel, precipitation hardening occurs due to ultra-microscopic nitrides during tempering. It is commonly used as an alloying element in steel.

**Manufacturing:** This accounted for 10% of the Indian demand in terms of value in CY2023. It is used in heat treatment processes such as annealing, sintering, and brazing to prevent oxidation and decarburization. It is also used in gas-assisted injection molding.

**Oil and Gas:** This industry accounted for 10% of the total demand for nitrogen in India in CY2023. Nitrogen is used to increase well pressure for better throughput of oil during oil exploration. In oil refining, nitrogen is used extensively to purge the hydrocarbons in pipelines and tanks and maintain a positive pressure so that oxygen does not come in contact with the hydrocarbons. Enhanced oil recovery with nitrogen injection helps in recovering additional oil and gas from depleted reservoirs. It ramps up existing production by stimulating flow. It utilizes nitrogen for increasing oil recovery and productivity.

**Pharmaceuticals:** In pharmaceuticals, nitrogen is used to create an inert atmosphere within storage tanks, reactors, and packaging, preventing oxidation and degradation of sensitive products. It protects active pharmaceutical ingredients and final products from oxidative degradation. It also purges air and contaminants from production equipment, pipelines, and containers, ensuring a clean and contamination-free environment. Liquid Nitrogen is also used in the pharmaceutical industries for reactor cooling in case of exothermic reactions. Pharmaceutical industry accounted for 7% of Indian nitrogen demand in terms of value in CY2023.

**Electrical and Electronics:** This industry accounted for 5% of Indian nitrogen demand in terms of value in CY2023. It is used to create an inert atmosphere in soldering and reflow processes to prevent oxidation and improve solder joint quality. Ultra-high purity nitrogen gas is used in the electronics industry and requires special technical acumen. Ellenbarrie offers such ultra-high purity nitrogen gas for electrical and electronics industry.

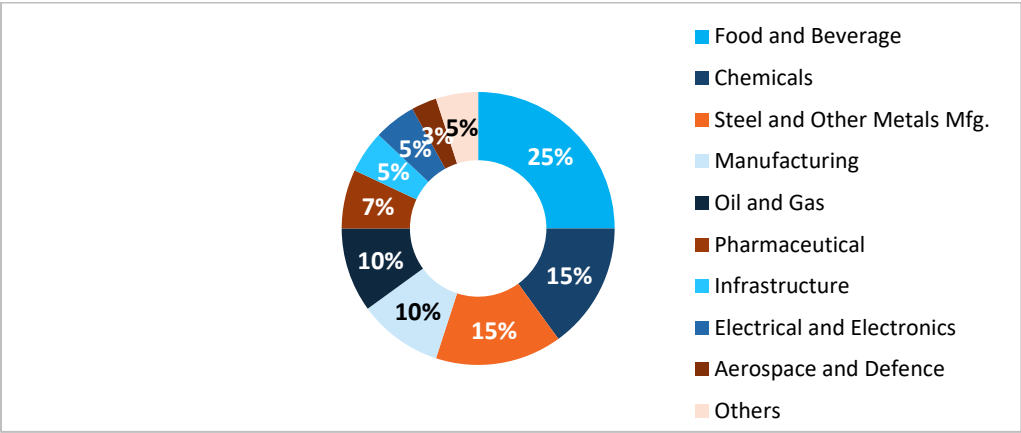
**Infrastructure:** It accounted for 5% of Indian nitrogen demand in terms of value in CY2023. Nitrogen is used to purge pipelines, storage tanks, and other vessels to prevent oxidation, contamination, and moisture buildup, ensuring a clean and safe environment for construction processes.

**Aerospace and Defence:** Aerospace and defence industries together accounted for 3% of Indian nitrogen demand in terms of value in CY2023. Nitrogen is used to create inert atmospheres during the production, storage, and transportation of ammunition and explosives, preventing accidental ignition and enhancing safety. It is also used to pressurize fuel tanks in missiles and rockets, ensuring consistent fuel delivery and optimal propulsion performance. Nitrogen is utilized in heat-treating processes to enhance the properties of aerospace metals and alloys, ensuring they meet stringent performance standards.

Market Overview of the Industrial Gases

The graph below illustrates the market segmentation by application in India for Nitrogen by value:

**Graph 4.2.2-1 Nitrogen Market Segmentation by Application in India, by Value (USD 0.29 billion) (CY2023)**



Others includes mining, animal resource, power, etc. Manufacturing includes automotive, textile, general engineering and metal fabrication, machinery & equipment, etc. industries

Source: Frost & Sullivan Research & Analysis

### 4.2.3 Nitrogen Market Split by Region (India)

The western region dominates the demand for nitrogen with market share of 35% in India. Owing to the strong presence of various fertilizer manufacturers such as IFFCO, RCF, KB Co-op Ltd, GSFC, GNFC, DF, etc. the demand for nitrogen is high. Also, packaged food producers such as HUL, Parle agro, Nestle, AMUL, etc. has presence in western region that drives the demand for the gas. Other manufacturing plants are also located in western region. The key refineries of Reliance industries, Nayara energy, IOCL, etc. in Gujrat and BPCL, HPCL in Mumbai, Maharashtra are also driving demand of nitrogen in western India.

Eastern India accounted for 25% market share for Nitrogen demand in India in CY2023. Owing to presence of steel and other metal manufacturing players such as Tata Steel at Jharkhand, SAIL at West Bengal, Jharkhand, Chhattisgarh, Jindal at Chhattisgarh, etc. the demand is moderate in this part of the country. There are various food and beverage manufacturers located in this region. There are fertilizer plants at Paradeep (Odisha) by IFFCO and Paradeep Phosphates. Also, refineries like Oil India at Assam, IOCL at Odisha, Bihar and West Bengal, etc. are well known consumers of nitrogen in eastern part of the country.

South India accounted for 20% of the total nitrogen demand in the country in CY2023. It has fertilizer plants of Fertilizer and Chemicals & Travancore, Madras Fertilizer, Nagarjuna Fertilizers and Chemicals, Coromandel International, Greenstar Fertilizer, etc. The fertilizer plans are driving the demand of nitrogen in southern region. It also has packaged food plants by Nestle and MTR Foods in Karnataka, ITC, Godrej Consumer Products and Dabur at Tamil Nadu, ITC at Andhra Pradesh, etc. which possess the requirement for high quality nitrogen at continuous intervals. It has presence of general manufacturing industry along with electronics industry. It also has refineries at Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, etc.

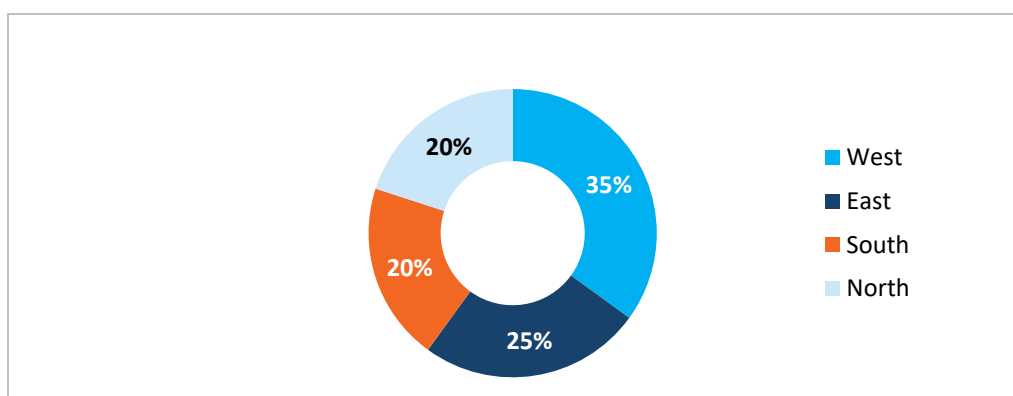
## Market Overview of the Industrial Gases

There are steel manufacturing plants in southern India at Vizag, Bellary, Bhadravati, Salem, etc. which accounted for significant share of nitrogen.

North India accounted for 20% of the nitrogen demand in CY2023. It has production plants of fertilizer companies such as IFFCO, Chambal Fertilizers and Chemicals, Krishak Bharati Cooperative Limited, etc. Few steel manufacturing plants like Ankur Industries are also located at North region. Packaged food companies like Patanjali, Godrej Consumer Products, Dabur India, ITC, Nestle, etc. has production factories in northern region which drives the demand of nitrogen. It also has presence of key refineries by IOCL at Haryana, Uttar Pradesh, HPCL-Mittal Energy Limited at Punjab, BPCL at MP, etc. which requires nitrogen on regular basis.

The graph below illustrates the market segmentation by region in India for Nitrogen by value:

**Graph 4.2.3-1 Nitrogen Market Segmentation by Region in India, by Value (USD 0.29 Billion) (CY2023)**



Source: Frost & Sullivan Research & Analysis

### 4.2.4 Nitrogen Growth Drivers and Market Trends

- 1. Fast-paced lifestyle:** Convenient, pre-packaged food options are in greater demand as busy lifestyles become more common. This has increased the market for packaged food which requires packaging with the utilization of nitrogen. The change in lifestyle has positively impacted the nitrogen market.
- 2. Increase in production capacities of steel sector:** India accounted for 7.6% of global steel production in CY2023. It is 2nd largest manufacturer of steel with domestic finished steel production at 89.71 million tons in CY2023. There has been significant investment by public and private players for boosting the production capacities in India. The government support through Production Linked Incentive Scheme has boosted steel sector investments where >25 firms have signed MoUs with total investment of ₹ 29,530 crore. The improvement in production capacities has been driving the demand for nitrogen in this sector. The China+1 strategy, which involves diversifying supply chains away from China, presents a significant opportunity for India's steel production. As global companies seek to reduce their reliance on China, India stands to gain a

substantial share of the market that China might lose. This strategic shift offers India considerable headroom for growth, even as it already ranks as the second-largest steel producer in the world.

3. **Growing demand for nitrogenous fertilizers:** The India nitrogenous fertilizers market is witnessing growth owing to rising food demand and the need for higher crop yields from farmers. Administration efforts to encourage the use of nitrogenous fertilizers for improvement in crop yields also contributes to the progress.
4. **Government policies and support:** The government of India has ambitions to become 'Aatmnirbhar' in fertilizer production in India. The urea production has increased from 22.5 million tons in FY2014 to 31 million tons in FY2023 owing to push from government through incentives and policies in place, expansion in capacities by existing players and investments for new plant set up. The improvement in ammonia and urea production capacities has driven the demand for feedstock like nitrogen in India
5. **Shift of pharma and chemical global supply chains from China to India:** Government support, cost competitiveness, adherence to stringent quality standards, skilled workforce, etc. factors are driving the shift in global supply chain from China to India. The shifting of pharma and chemical supply chain to India has positively impacted the nitrogen market.

### 4.3 Oxygen

With a volume percentage of over 20%, oxygen makes up the second largest component of the atmosphere. Pale blue in color, liquid oxygen is extremely cold. Despite not flaming, oxygen has a high oxidation potential. Life necessitate oxygen for survival.

**Route of synthesis:** There are various air separation processes for oxygen production such as cryogenic distillation, pressure swing adsorption, vacuum swing adsorption, among others.

The production process remains the same for nitrogen, oxygen and argon. In cryogenic distillation process, the oxygen is separated at boiling point  $-183^{\circ}\text{C}$  from nitrogen ( $-196^{\circ}\text{C}$ ) and argon ( $-186^{\circ}\text{C}$ ).

The pressure swing adsorption process is used to produce nitrogen and oxygen. The working principle remains the same while selective adsorption is used to produce target gas.

In vacuum swing adsorption, the compressed air is passed through adsorbent beds that selectively adsorb nitrogen, allowing oxygen to pass through. The adsorbent material is regenerated by creating a vacuum, which desorbs the adsorbed gases. The oxygen-enriched stream, with purities typically around 90-95%, is collected.

#### 4.3.1 Global Oxygen Market

The global market for oxygen was around 68.3 million tons in CY2023 and has been growing with CAGR of 4.3% since CY2018. The major drivers for improvement in demand is growth of steel production, increase in population and urbanization, rapid increase in demand from medical sector through pandemic, etc.

In terms of market size by value, the demand has increased from USD 14.7 billion in CY2018 to USD 19.1 billion in CY2023 at a CAGR of 5.4%.

Oxygen service equipment needs to adhere to strict cleaning specifications, and systems need to be built from materials that are nonreactive with oxygen under service circumstances and has high ignition temperatures.

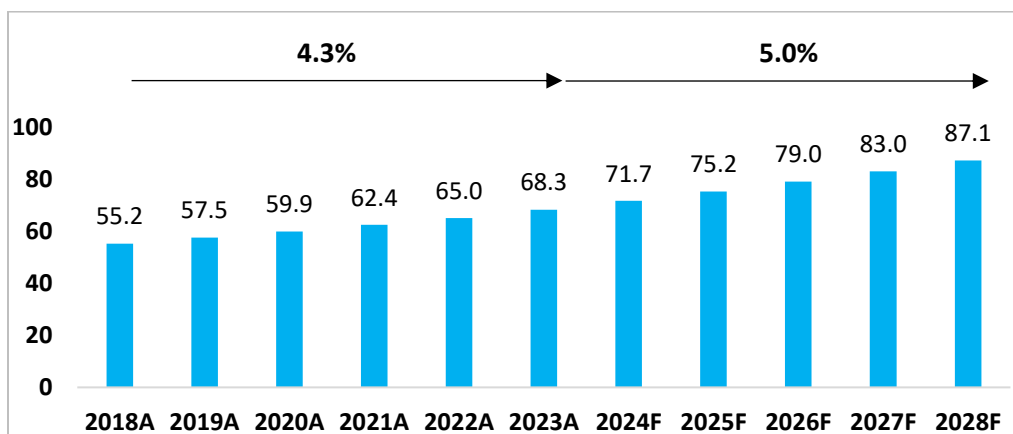
The demand for oxygen is estimated to grow at a CAGR of 5.0% in coming 5 years through CY2028 and the demand will be of 87.1 million tons in CY2028. In terms of market size by value, the demand will be around USD 25.6 billion in CY2028.

In order to store and transport oxygen more effectively, it is typically liquefied. However, oxygen is used in the majority of applications after it has evaporated to a gaseous state.

## Market Overview of the Industrial Gases

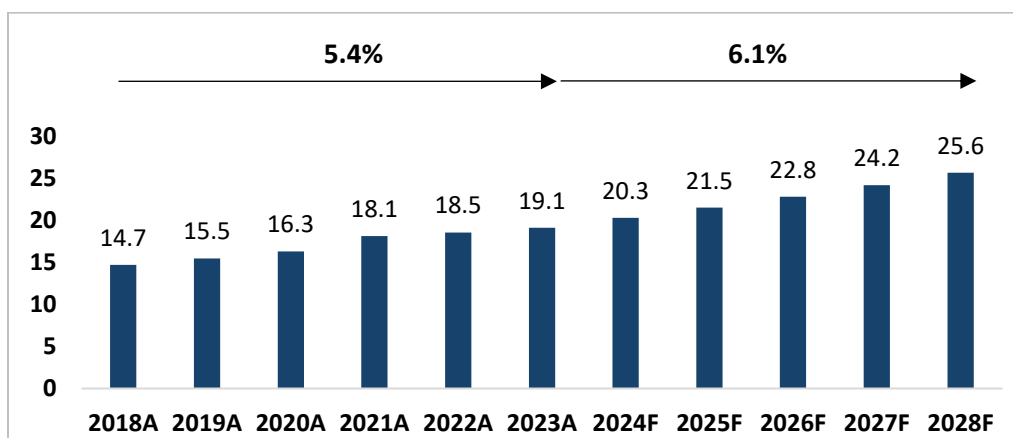
The graphs below illustrate the global demand for oxygen during last 5 years and projected demand through CY2028 (CY2018 and CY2028):

**Graph 4.3.1-1 Global Oxygen Market, by Volume (Million tons), CY2018-2028F**



Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis

**Graph 4.3.1-2 Global Oxygen Market, by Value (USD billion), CY2018-2028F**



Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis

### 4.3.1.1 India Oxygen Market

India oxygen demand has increased from 1.8 million tons in CY2018 to 2.2 million tons in CY2023 owing to expansion of healthcare facilities, government support for increase in manufacturing output through PLI schemes, increase in production capacities of steel & other metals in the country, steady demand from manufacturing sector, etc. In terms of market size by value, the demand has increased from USD 0.32 billion in CY2018 to USD 0.44 billion in CY2023.

In India, the most common method for producing oxygen is cryogenic distillation, which involves the separation of oxygen in air separation units (ASUs). It accounted for over 80% of the total production in the country. The process of fractional distillation is used to extract pure oxygen from ambient air. Using this technique, air gases are cooled to a liquid condition, divided into different components, and liquid

## Market Overview of the Industrial Gases

oxygen is then extracted. Ultra-high purity oxygen gas is extensively used in laboratories for various research and development activities, as well as in solar cells, semiconductors and other emerging applications.

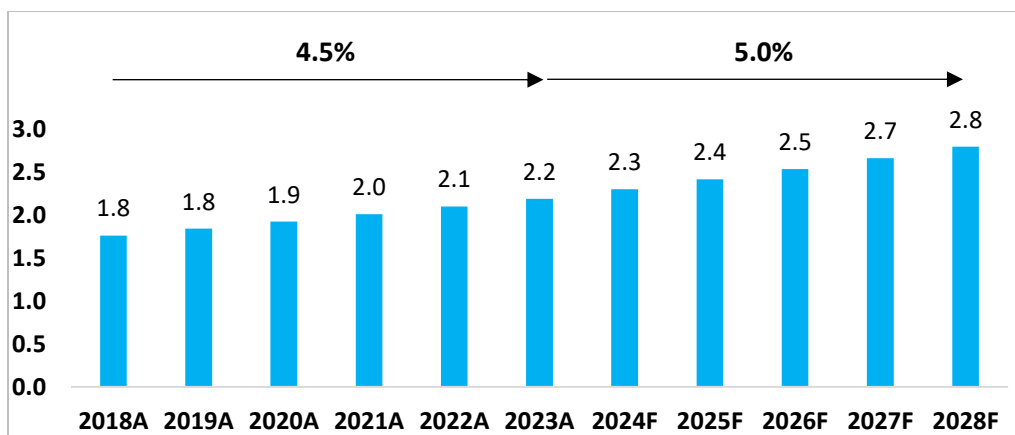
Oxygen prices surged during the COVID-19 pandemic, leading to an increase in the market size by value in CY2021. Starting from CY2023, the market size by value has been gradually improving. It is estimated that the demand of oxygen in India will grow up to 2.8 million tons by CY2028 with CAGR of 5.0%. In terms of market size by value, it is expected to grow around USD 0.62 billion in CY2028 with CAGR of 7.1%.

The top players include Linde, Inox Air Products, Air Liquide, Ellenbarrie, Air Water, etc. These top players accounted for over 60% market share in Indian oxygen demand in terms of value in CY2023. Other players include National Oxygen Limited, Goyal MG Gases, Bhuruka, etc.

Ellenbarrie operates one of the largest oxygen plant (in terms of capacity – 1250 ton per day) in the country and has strong presence in the steel and other metal manufacturing application segments. Ellenbarrie’s expertise in combustion technology, O<sub>2</sub> enrichment, heat treatment, etc. are time tested and proven in the industry.

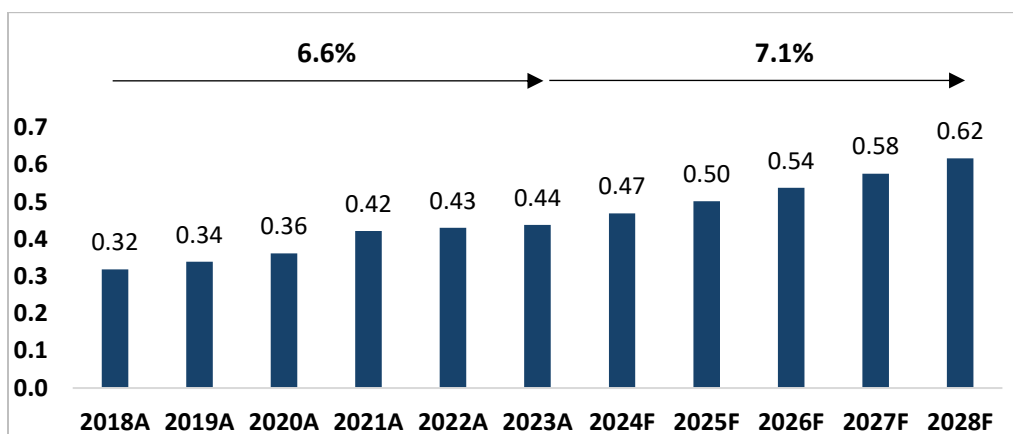
The graphs below illustrate the demand for Oxygen in India during last 5 years and projected demand through CY2028:

**Graph 4.3.1.1-1 Oxygen Market in India, by Volume (million tons), CY2018-2028F**



Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis

**Graph 4.3.1.1-2 Oxygen Market in India, by Value (USD billion), CY2018-2028F**



Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis

### 4.3.2 Oxygen Market Split by Application (India)

**Steel and Other Metal Manufacturing:** It is the leading consuming industry of oxygen in India. It accounted for 35% of the total demand of oxygen in CY2023. Oxygen increases furnace combustion efficiency throughout the steel-making process. By eliminating impurities and encouraging accurate cutting and welding procedures, it improves the grade of steel.

**Healthcare:** Another contributor to the demand of oxygen in India is healthcare and medical industry. It accounted for 22% of the market share in CY2023. Oxygen is essential for medical purposes. It helps patients who have difficulty inhaling, helps with anesthesia during operations, and is utilized in oxygen therapy for a number of medical illnesses. It is estimated that the demand will degrow in healthcare industry by 3% in coming years. The decline in medical oxygen demand is primarily due to the abnormally high demand experienced during the COVID-19 pandemic. Despite this temporary degrowth, the healthcare and medical sectors have a robust long-term outlook, ensuring a stable future for medical oxygen demand.

**Chemicals:** This industry accounted for 18% of the total oxygen demand in India in CY2023. Oxygen is an effective oxidizing agent. It combines with certain substances in a variety of industrial processes to start oxidation reactions. Desired chemical compounds are synthesized as a result of these reactions. It is also preferred in combustion process. In order to ensure that fuels burn efficiently and under control, oxygen is supplied to combustion systems. The enhanced oxygen also has applications in diverse chemical reactions, encompassing the synthesis of compounds such as sulfuric acid, nitric acid, and ethylene oxide.

**Manufacturing:** In manufacturing industry, oxygen is used with a fuel gas to achieve high-temperature flames for cutting metals. It is used to increase the efficiency of combustion processes in glass furnaces, resulting in higher-quality glass products. The manufacturing industry accounted for 8% of Indian oxygen demand in terms of value in CY2023.



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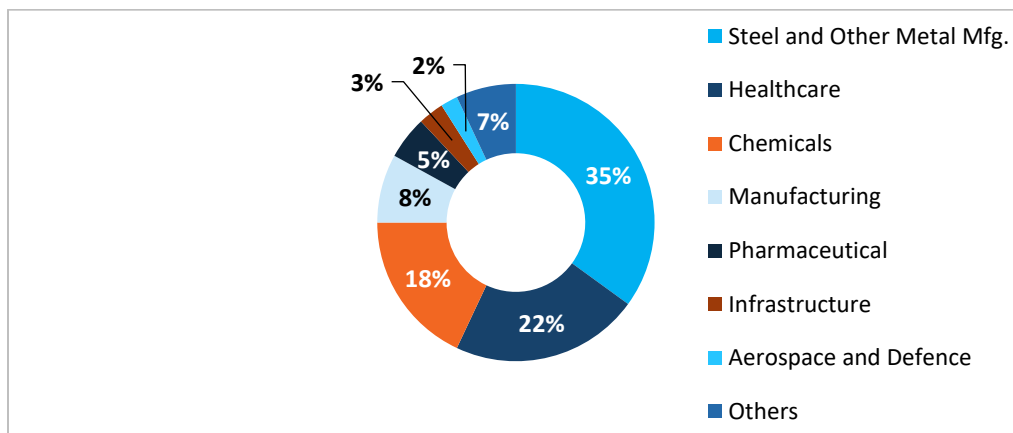
**Pharmaceuticals:** In pharmaceuticals industry, oxygen is used for sterilization and fermentation processes. It is used in various oxidation reactions that are part of the synthesis of active pharmaceutical ingredients. It is also used in the aerobic treatment of wastewater generated during pharmaceutical manufacturing, promoting the breakdown of organic contaminants. The pharmaceutical industry accounted for 5% of Indian oxygen demand in terms of value in CY2023.

**Infrastructure:** Oxygen is used in combination with fuel gases like acetylene for cutting and welding metals, essential in construction and maintenance of infrastructure. The infrastructure industry accounted for 3% of Indian oxygen demand in terms of value in CY2023.

**Aerospace and Defence:** Liquid oxygen is used as an oxidizer in rocket propulsion systems, combining with fuels like liquid hydrogen to produce the high thrust needed for space launches. Oxygen is also used in welding and cutting operations for the construction and maintenance of aerospace components and structures. The aerospace and defence industries together accounted for 2% of Indian oxygen demand in terms of value in CY2023.

The graph below illustrates the market segmentation by application in India for oxygen by value:

**Graph 4.3.2-1 Oxygen Market Segmentation by Application in India, by Value (USD 0.4 Billion) (CY2023)**



Others includes pulp and paper, oil & gas, water and wastewater treatment, etc. Manufacturing includes automotive, general engineering and metal fabrication, machinery & equipment, etc. industries

Source: Frost & Sullivan Research & Analysis

### 4.3.3 Oxygen Market Split by Region (India)

In 2023, the eastern part of the India accounted for 35% of the total demand of oxygen in India, the highest in comparison to other regions. Owing to presence of large steel and other metal manufacturing facilities like Tata steel at Jharkhand, SAIL at West Bengal, Jharkhand, Chhattisgarh, Odisha, Jindal at Chhattisgarh, etc. the demand for oxygen is high in this region. Oxygen is utilized for various applications including improving furnace combustion efficiency.

Market Overview of the Industrial Gases

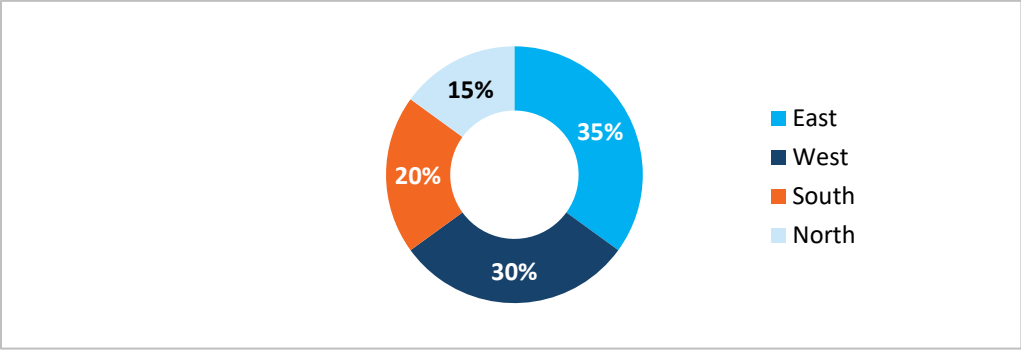
Western India accounted for 30% of the demand of oxygen in India in CY2023 owing to the rising demand from key industries like steel & metal manufacturing, healthcare, chemical manufacturing, pharmaceutical, pulp and paper, oil & gas, etc. The region has steel manufacturing plants of JSW, Essar Steel, among others which has been driving the demand for oxygen. The manufacturing plants of chemical companies like Tata chemicals, UPL, BASF, Aarti industries, Gujarat heavy chemicals, Gujarat Alkalies and Chemicals, Deepak Nitrite, Vinati Organics, etc. are located at west region.

South Indian region accounted for 20% of the total oxygen demand in India in CY2023. The southern states hold manufacturing plants of key steelmakers such as Vizag Steel, Rashtriya Ispat Nigam, MS Life Steel, etc. It also has presence of notable chemical manufacturers such as Thirumalai Chemicals, TGV SRAAC, Pandy Oxides & Chemicals, etc. which consumes oxygen on regular basis.

The northern region of India accounted for 15% of the total demand of oxygen in CY2023. The limited presence of steel and metal manufacturing plants in the region is the biggest inhibitor of oxygen demand. The demand majorly accounted from healthcare and medical industry, chemical plants like India Glycols, Gujarat Fluorochemicals, etc., pharmaceutical and automotive industry plants, etc.

The graph below illustrates the market segmentation by region in India for oxygen by value:

**Graph 4.3.3-1 Oxygen Market Segmentation by Region in India, by Value (USD 0.4 Billion) (CY2023)**



Source: Frost & Sullivan Research & Analysis

### 4.3.4 Oxygen Growth Drivers and Market Trends

- Increase in underlying respiratory conditions and disorders:** The O<sub>2</sub> therapy becomes crucial for managing respiratory distress in older adults, driving the demand for oxygen concentrators and related equipment. The rising incidence of respiratory disorders, such as chronic obstructive pulmonary disorder, asthma, and sleep apnea, has led to a surge in demand for oxygen concentrators.
- Rising demand from water and wastewater treatment plants:** Oxygen is a critical element in both water and wastewater treatment processes due to its role in supporting aerobic biological processes, oxidizing pollutants, and ensuring proper chemical reactions. Rising urbanization has been leading to growth of water purification demand leading to higher oxygen consumption. Government initiatives

## Market Overview of the Industrial Gases

such as Jal Jeevan Mission, the Atal Mission for Rejuvenation, National Mission for Clean Ganga, and community drinking water schemes, contribute to the growth of the Indian water and wastewater treatment market. This has direct positive impact on the oxygen consumption.

3. **Energy and power generation:** Growing population, increase in disposable income, rising middle class incomes, etc. has driven the growth in power generation, coal gasification, power plant operations. Oxygen is actively used in combustion process and thus demand is directly increasing in energy sector.
4. **Increasing demand in chemical and petrochemical industry:** Oxygen is an effective oxidizing agent. It reacts chemically with some compounds to initiate oxidation reactions in a range of industrial operations. Because of more stringent environmental regulations, cleaner combustion techniques are required. In industrial burners, oxygen enrichment plays a crucial role in growth by lowering emissions.
5. **High paced growth of steel industry:** The government of India has ambitious plans to increase steel capacity in India with CAGR of 20% through FY2030. Growing industrialization and urbanization is driving the demand of steel and other metals. Oxygen is an important gas for the production of steel. The rapid growth in steel production is likely to drive the demand of oxygen in India.

## 4.4 Argon & Argon Mixtures

In the atmosphere, argon (AR) is a monatomic, tasteless, odorless, and non-hazardous gas that is found in small amounts—less than 1% by volume. It belongs to a unique class of gases called noble gases. The gas is mildly soluble in water and heavier than air. Argon's complete inertness is valued, particularly during high temperatures.

**Route of synthesis:** Cryogenic distillation is mostly used production process for argon. The production process remains the same for nitrogen, oxygen, and argon. In cryogenic distillation process, the argon is separated at boiling point  $-186^{\circ}\text{C}$ . A further rectification step is employed to increase the purity of argon. The argon-rich fraction from the distillation column undergoes additional separation to remove residual oxygen and nitrogen.

Membrane separation is another method for air separation, though it is less effective for argon production due to the similar permeation rates of argon and nitrogen.

### 4.4.1 Global Argon Market

Argon being colorless, has a high melting point of over  $-186$  degree Celsius and is commonly used in metal fabrication industry for welding application. Argon's inertness, density, and stability make it vital across diverse sectors. Whether it is welding, electronics, or medical applications, it plays a crucial role in manufacturing.

The demand of argon has grown at a CAGR of 4.2% from 8.1 million tons in CY2018 to 10.0 million tons in CY2023. In terms of market size by value, it is estimated that the demand has increased from USD 3.9 billion in CY2018 to USD 5.0 billion in CY2023 with a CAGR of 5.3%. The major factors driving the demand are increasing demand from manufacturing industry, rising demand in India from expanding electronics industry, growing industrial output in Middle east, steady requirements from Europe and US regions, etc.

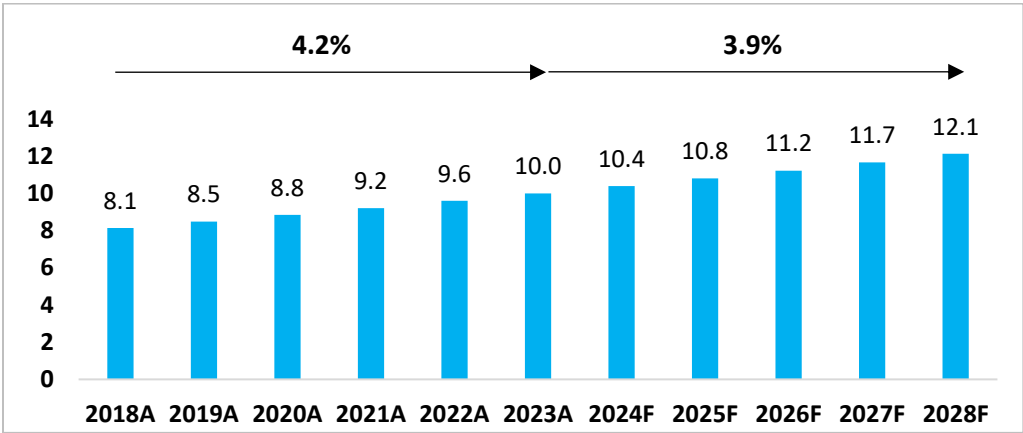
It is estimated that the demand of argon will grow from 10.0 million tons in CY2023 to 12.1 million tons in CY2028 at a CAGR of 3.9% owing to high pace growth of metal fabrication industry, innovative utilization in healthcare industry, increase in production capacities, etc. In terms of market size by value, it is estimated to become USD 6.7 billion with CAGR of 6.0%.

The prices of argon and argon mixtures has been steady since last 5 years and the similar trend is estimated through next 5 years. There were disruptions in the prices owing to global pandemic, crisis in Ukraine, conflicts in middle east, etc. which created volatile environment for the business and thus, huge surge and decline in prices were observed for couple of years.

Market Overview of the Industrial Gases

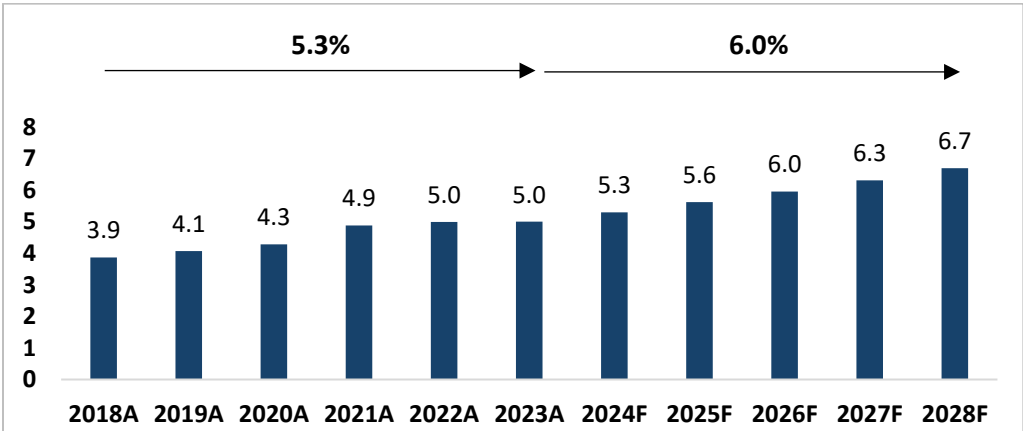
The graphs below illustrate the global demand for Argon during last 5 years and projected demand through CY2028:

**Graph 4.4.1-1 Global Argon Market, by Volume (million tons), CY2018-2028F**



Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis

**Graph 4.4.1-2 Global Argon Market, by Value (USD billion), CY2018-2028F**



Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis

**4.4.1.1 India Argon Market**

The Indian argon industry is growing rapidly owing to its applications in welding for manufacturing industry, steel industry, automotive industry, etc. It is estimated to have increased from USD 0.08 billion in CY2018 to USD 0.12 billion in CY2023 with CAGR of 8.7%. In terms of volume, the gas consumption has increased to 0.21 million tons in CY2023 from 0.16 million tons in CY2018. Argon sees extensive application in welding procedures such as resistance welding and metal inert gas welding. An increasing number of industries, including aerospace, automotive, and construction, need welding gases, including argon.

It is estimated that the demand for argon will increase at a CAGR of 9% through CY2028 and will become USD 0.19 billion in CY2028. In terms of volume, the demand will increase by CAGR 5.8% and will continue

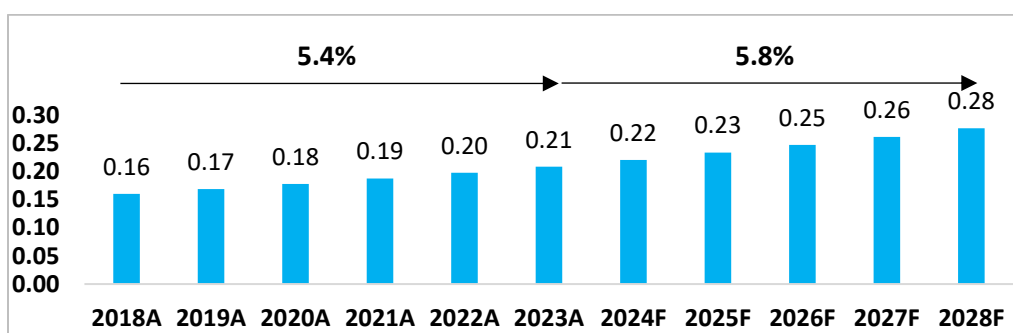
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to grow up to 0.28 million tons through CY2028. The major driving factors for argon are consistent growth in metal fabrication industry owing to rapid urbanization, innovative utilization in healthcare sector, growing consumption as replacement for helium, increasing demand from electronics and semiconductor industry, etc.

The top players include Linde, Inox Air Products, Air Liquid, Ellenbarrie, etc. These players accounted for 70% market share of Indian argon gas demand in terms of value in CY2023. Other players include Axcel Gases, Steelman Gas, Pavan Gases, Goyal MG Gases, National Oxygen Limited, etc.

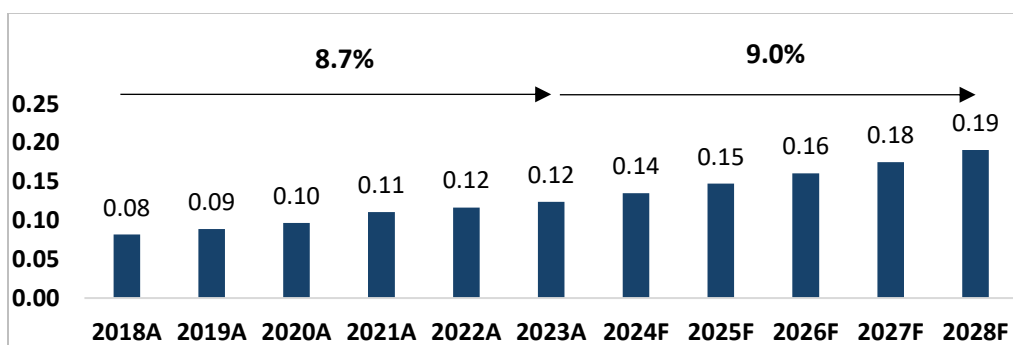
The graphs below illustrate the demand for Argon in India during the last 5 years and projected demand through CY2028:

**Graph 4.4.1.1-1 Argon Market in India, by Volume (million tons), CY2018-2028F**



Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis

**Graph 4.4.1.1-2 Argon Market in India, by Value (USD billion), CY2018-2028F**



Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis

### 4.4.2 Argon Market Split by Application (India)

**Manufacturing:** Manufacturing industry accounted for 22% of the argon demand in India in CY2023. Argon is commonly used as a shielding gas in MIG welding. It protects the weld pool from atmospheric contamination, ensuring high-quality welds. It is also used in resistance welding processes.

**Electrical and Electronics:** Electrical and Electronics industry accounted for 20% market share for argon demand in India in CY2023. The gas is used for creating a controlled environment during semiconductor

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fabrication. In lighting application, it is a common filling gas in fluorescent tubes. It also prevents the tungsten filament from corroding by creating an oxygen-deficient atmosphere in incandescent bulbs. It is used in the production of solar cells. In microelectronic devices, it helps in manufacturing microchips and other electronic components. For flat panel displays, argon is useful gas.

**Steel and Other Metals Manufacturing:** Argon is essential to the production of stainless steel in the steel industry. The Argon Oxygen Decarburization process (developed by Linde) is used to produce more than 70% of the stainless steel used worldwide. AOD offers a cost-effective method of producing stainless steel with little loss of valuable components. Among other things, silicon steels, tool steels, nickel-base alloys, and cobalt-base alloys are also produced using argon. 20% of the demand for argon in India comes from the steel and other metal producing industry.

**Healthcare:** The healthcare industry accounted for 10% of the Indian argon demand in terms of value in CY2023. In innovative solutions like argon lasers for surgeries, cryosurgery, etc., argon gas is utilized. In gas chromatography small amount of argon is needed. Though the current demand from this industry is low, the demand in application like gas chromatography is getting traction in India.

**Pharmaceuticals:** Pharmaceuticals industry accounted for 8% of Indian argon demand in terms of value in CY2023. Argon is used to create inert atmospheres in pharmaceutical manufacturing processes to prevent oxidation and contamination, especially during the production of sensitive active pharmaceutical ingredients. It is also used to blanket pharmaceutical products in vials and ampoules to protect them from air and moisture.

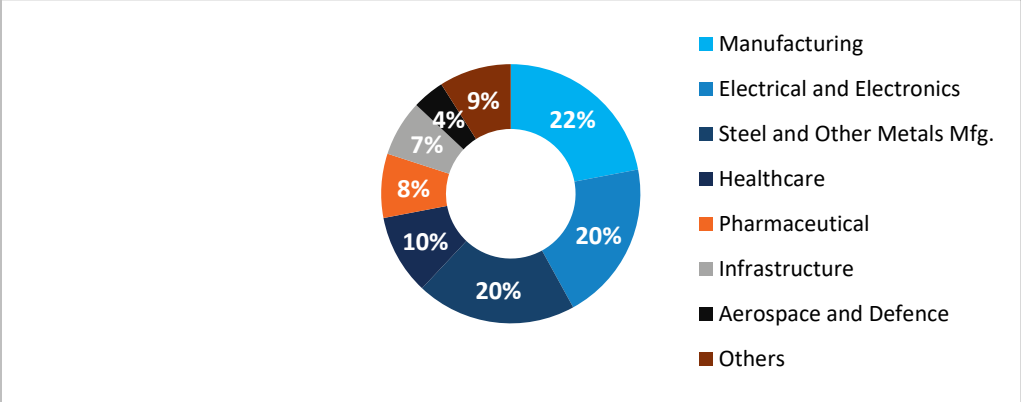
**Infrastructure:** This industry accounted for 7% of Indian argon demand in terms of value in CY2023. Argon is commonly used as a shielding gas in various welding processes, including MIG and TIG welding. It protects the weld area from atmospheric gases like oxygen and nitrogen.

**Aerospace and Defence:** These industries together accounted for 4% of Indian argon demand in terms of value in CY2023. Argon is extensively used in the aerospace industry for welding components of aircraft and spacecraft. It is also used in welding and cutting processes for the fabrication and repair of military vehicles, equipment, etc.

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The graph below illustrates the market segmentation by application in India for argon by value:

**Graph 4.4.2-1 Argon Market Segmentation by Application in India, by Value (USD 0.12 Billion) (CY2023)**



Others includes chemicals, oil & gas, beverage, etc.  
Manufacturing includes automotive, textile, general engineering and metal fabrication, machinery & equipment, etc. industries.

Source: Frost & Sullivan Research & Analysis

### 4.4.3 Argon Market Split by Region (India)

The western part of India accounted for 35% of the total argon demand in India in CY2023. Owing to the presence of a large number of metal fabrication plants in states like Maharashtra and Gujarat, the demand for argon has increased at a significant pace. The region also has state of art manufacturing facilities for semiconductor manufacturing players such as Tata Electronics and CG Power in Gujarat which has been driving the demand for argon. RRP Electronics, in collaboration with a consortium of European companies, is set to establish a state-of-the-art semiconductor facility in Maharashtra. Total investment outlay will be around ₹5,000 crore which will drive the demand for argon in the region.

The eastern region accounted for 30% of the argon demand in CY2023. The major reason for the same is traction from steel and metal manufacturing industries. With steel and other metal manufacturing facilities like Tata Steel at Jharkhand, SAIL at West Bengal, Jharkhand, Chhattisgarh, Odisha, Jindal at Chhattisgarh, etc. the region holds significant demand from metal fabrication industry.

The southern region accounted for 20% of the market share in Indian argon market in CY2023. Owing to presence of automotive value chain in the region, the metal fabrication and ancillary industry is getting traction and thus, demand for argon is increasing moderately. Demand from electronics industry for argon is rapidly getting traction in southern states. Renowned companies like Foxconn, Wingtech, Voltas, TCL, Sunny Opotech, and Dixon are associated with production facilities in Andhra Pradesh (current + announced). In Tamil Nadu, Tata Electronics is planning to invest ₹4,700 crore in a mobile phone component plant at Krishnagiri. Another upcoming investment in Tamil Nadu is investment of ₹1,100 crore by Pegatron near Chennai. In Karnataka, Tata Group is expanding its presence in the electronics segment by acquiring Taiwanese contract manufacturer Wistron’s iPhone manufacturing plant in Kolar district.

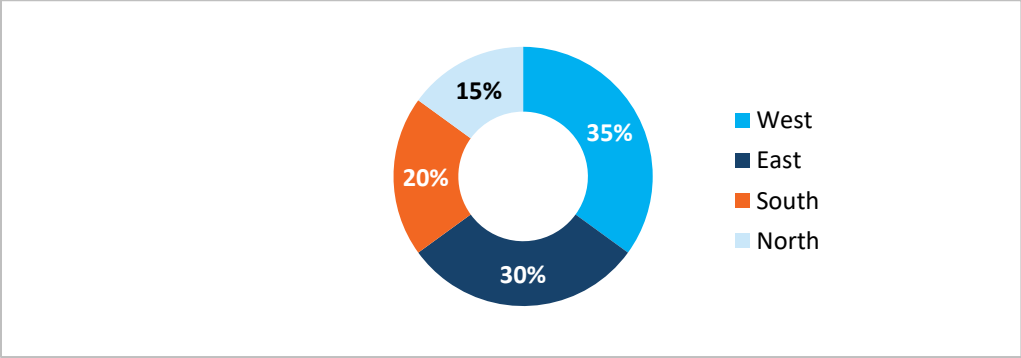


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The northern region accounted for 15% of the total argon demand in India in CY2023. The region has limited presence of electronics plants, steel & other metal manufacturing plants, etc. in comparison with Western or eastern region. However, the demand from metal fabrication industry which is catering to automotive industry in the region is driving the demand for argon. The region also has a good presence of automotive, chemicals, beverage industry, etc.

The graph below illustrates the market segmentation by region in India for argon by value:

**Graph 4.4.3-1 Argon Market Segmentation by Region in India, by Value (USD 0.12 Billion) (CY2023)**



Source: Frost & Sullivan Research & Analysis

**4.4.4 Argon Growth Drivers and Market Trends**

- High pace urbanization and industrialization:** India’s rising population is driving urbanization and industrialization across regions. The demand for finished steel is estimated to grow at CAGR 7.5% during FY2023 to FY2028. Argon plays an important role in steel production, especially stainless steel production.
- Growing demand for metal fabricated products for automotive industry:** The automotive industry is also estimated to grow significantly during next 5 years owing to increase in middle class economy and improvement in disposable income. Due to the strong push by the Government, the EV market is estimated to grow at a CAGR of 49% through FY2030 in India. Argon is used in welding processes for manufacturing high-performance and lightweight automotive components, especially in electric vehicles (EVs) and luxury cars. Metal fabrication industry is expected to flourish owing to rising demand in automotive industries.
- Significant investment in semiconductor and electronics industry** by global and Indian players such as Foxconn, Wingtech, Voltas, TCL, Sunny Optotech, Dixon, etc. is going to drive the demand for industrial gases like argon in India.
- Government policies and support:** The government of India has launched Production Linked Incentive (PLI) schemes for several industries including automotive, electronics, etc. The government expects major investments through PLI scheme with an outlay of USD 25 billion in 14 sectors. The

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push from government for industry growth will drive the demand for metal fabrication, steel manufacturing, healthcare, automotive, etc. sectors and thus will drive the demand for argon.

5. **Growing demand from defence and other manufacturing industry:** The Indian defence industry is focusing on indigenization and self-reliance, leading to increased manufacturing of aircraft, missiles, and other advanced defence equipment. The precise and high-quality welds required in these applications depend on argon to prevent oxidation and contamination. Argon is also used in welding and cutting processes for manufacturing armored vehicles and naval vessels. The rising demand from defence and other manufacturing sector is going to positively boost the argon demand in India.

## 4.5 Carbon Dioxide & Other Gases

Atmospheric quantities of carbon dioxide (CO<sub>2</sub>) are roughly 370 parts per million by volume, making it a trace gas. It is released as a by-product of aerobic respiration. Plants use photosynthesis to absorb CO<sub>2</sub> and release oxygen. Acid gases include carbon dioxide, hydrogen sulfide, hydrogen chloride, sulfur dioxide, and some oxides of nitrogen. They are responsible for the sour nature of fuel gases from various sources.

**Route of synthesis:** Carbon dioxide can be produced using various processes such as combustion of fossil fuels, fermentation, natural gas processing, and as a by-product of certain chemical processes.

It is a by-product of the combustion of fossil fuels, such as coal, oil, and natural gas. This method is widely used in power plants and other industrial settings. The exhaust gases, which contain CO<sub>2</sub>, water vapor, and other pollutants, are collected from the combustion chamber. The exhaust gas is passed through scrubbers and filters to remove particulates and other impurities, such as sulfur oxides and nitrogen oxides. CO<sub>2</sub> is separated from the exhaust gas using methods like amine scrubbing, where an amine solution absorbs CO<sub>2</sub>, which is then released upon heating. The purified CO<sub>2</sub> is compressed and stored in liquid or gaseous form for industrial use.

Fermentation is a biological process where microorganisms convert organic materials into CO<sub>2</sub>, ethanol and other by-products. CO<sub>2</sub> is often removed from natural gas to meet pipeline specifications and improve fuel quality. This method involves separating CO<sub>2</sub> from natural gas streams.

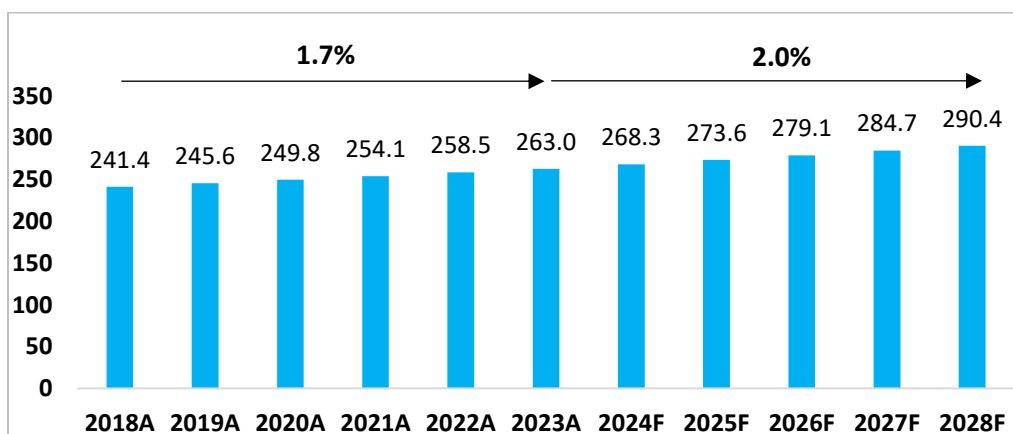
### 4.5.1 Global Carbon Dioxide Market

Carbon dioxide plays an essential role in production of the urea fertilizer, the most important chemical for agriculture industry. The demand of carbon dioxide was around 263 million tons in CY2023 and has been increasing at a CAGR of 1.7% since CY2018 owing to a steady growth of demand of urea in agriculture industry and growth in demand from refineries for oil recovery and beverage industry for carbonation purposes. The market size by value has increased from USD 14.5 billion in CY2018 to USD 18.4 billion in CY2023 with a CAGR of 4.9%. The market is projected to increase from 263 million tons in CY2023 to 290.4 million ton in CY2028 with CAGR of 2.0%.

## Market Overview of the Industrial Gases

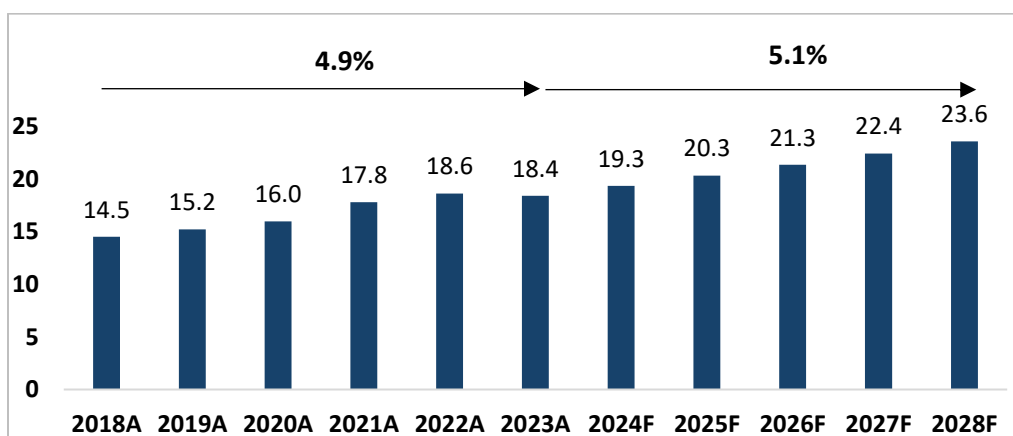
The graphs below illustrate the global demand (volume and value) for carbon dioxide during last 5 years and projected demand through CY2028 (CY2018 and CY2028):

**Graph 4.5.1-1 Global Carbon Dioxide Market, by Volume (million tons), CY2018-2028F**



Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis

**Graph 4.5.1-2 Global Carbon Dioxide Market, by Value (USD billion), CY2018-2028F**



Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis

### 4.5.1.1 India Carbon Dioxide market

There has been a steady demand for CO<sub>2</sub> in urea production. Additionally, the demand for CO<sub>2</sub> in refineries for enhanced oil recovery systems and the beverage industry has progressively expanded over the last five years. The food and beverage industry is the largest contributor to carbon dioxide demand in India. Due to perpetual demand from end-use industries, the demand for CO<sub>2</sub> has increased at a CAGR of 3.1% since CY2018, rising from 3.4 million tons in CY2018 to 4.0 million tons in CY2023.

In terms of value, the demand has increased at a CAGR of 5.2% in last 5 years and has reached USD 0.14 billion in CY2023 from USD 0.11 billion in CY2018.

## Market Overview of the Industrial Gases

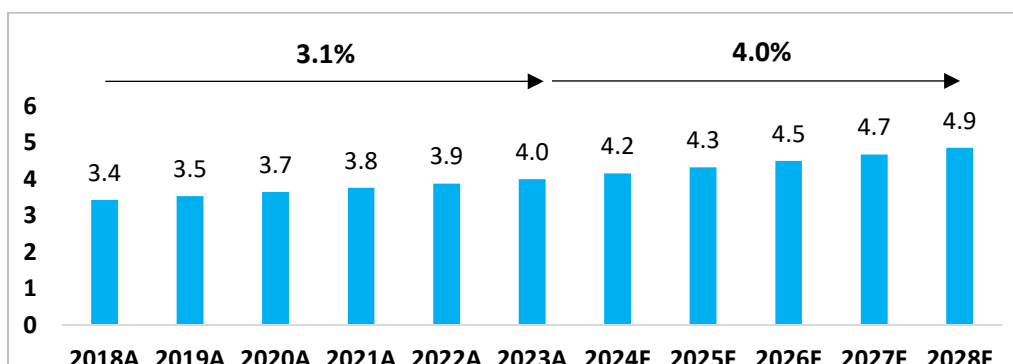
India is the fourth largest refining hub after the US, China, and Russia, with a refining capacity of approximately 250 million tons per annum. The country has 23 refineries: 18 in the public sector, 2 in joint ventures between the private and public sectors, and 3 in the private sector. These refineries are well-distributed geographically and connected by cross-country pipelines. There has been substantial use of CO<sub>2</sub> in the refinery industry, with sustained growth over the last five years.

Emerging applications for CO<sub>2</sub> include the production of fuels (methane and methanol), manufacturing plastic components, fire extinguishers, pharmaceuticals, soda ash, food and beverages, and building materials, among others. This boost towards emerging applications is expected to increase the demand for CO<sub>2</sub> at a CAGR of 6.1% over the next five years, reaching USD 0.18 billion by CY2028. In terms of volume, the demand is projected to grow from 4.0 million tons in CY2023 to 4.9 million tons in CY2028.

The top players include Linde, Inox Air Products, Ellenbarrie, etc. and accounted for major market share of carbon dioxide in India in CY2023. The top players had market share of over 50% in India.

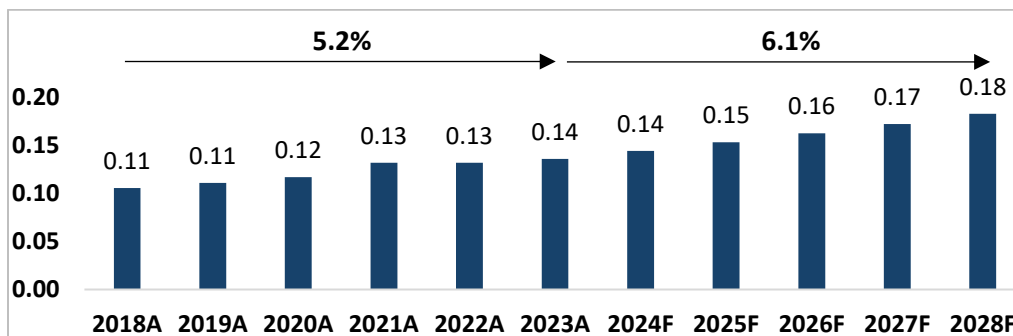
The graphs below illustrate the demand for carbon dioxide in India during last 5 years and projected demand through CY2028:

**Graph 4.5.1.1-1 Carbon Dioxide Market in India, by Volume (million tons), CY2018-2028F**



Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis

**Graph 4.5.1.1-2 Carbon Dioxide Market in India, by Value (USD billion), CY2018-2028F**



Note: A: Actual, F: Forecast, Source: Frost & Sullivan Research & Analysis

## 4.5.2 Market Split by Application (India)

**Food and Beverage:** Food and beverage industry is the leading end use sector for carbon dioxide in India with a market share of 30% by value. An important functionality of CO<sub>2</sub> is that it is used to carbonate soft drinks, beer, sparkling water, etc.

**Chemicals:** The chemical industry accounted for ~15% of the demand of CO<sub>2</sub> in India in CY2023 with direct use in production of urea, methanol, etc.

**Manufacturing:** Manufacturing industry accounted for 12% market share in Indian carbon dioxide demand in terms of value in CY2023. CO<sub>2</sub> is used as a shielding gas to protect the weld area from atmospheric contamination. CO<sub>2</sub> lasers are used for precision cutting of metals, plastics, and other materials.

**Oil and Gas:** This industry accounted for 10% of Indian carbon dioxide demand in terms of value in CY2023. Enhanced oil recovery is the most prominent use of CO<sub>2</sub> in the oil and gas industry.

**Infrastructure:** This industry accounted for 8% of Indian carbon dioxide demand in terms of value in CY2023. Carbon dioxide is used to cure concrete, a process known as carbonation. This can improve the strength and durability of the concrete by forming calcium carbonate within the material. It is also used as a shielding gas in welding processes.

**Pharmaceuticals:** The Pharmaceutical industry accounted for 6% of Indian carbon dioxide demand in terms of value in CY2023. It is utilized for extraction of active ingredients, cleaning and sterilizing pharmaceutical equipment, carbonation of certain pharmaceutical solutions, etc.

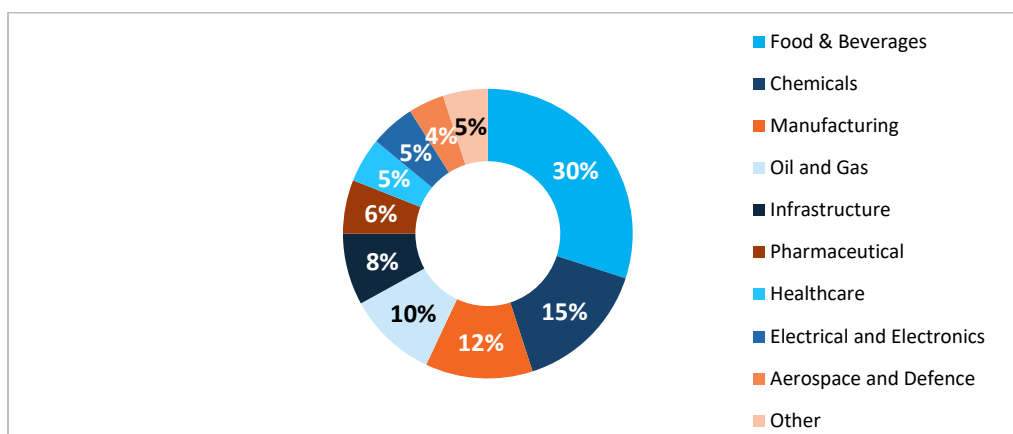
**Healthcare:** In healthcare, CO<sub>2</sub> is used to inflate the abdominal cavity, providing a clear view and space for surgeons to operate during laparoscopy. In endoscopy, it is used to insufflate the gastrointestinal tract, improving visibility and access during diagnostic and therapeutic procedures. It is also used in certain medical imaging techniques. Healthcare industry accounted for 5% in Indian carbon dioxide market by value in CY2023.

**Aerospace and Defence:** Aerospace and defence industries together accounted for 4% of Indian carbon dioxide demand in terms of value in CY2023. Carbon dioxide extinguishers are used in military vehicles, ships, and facilities to quickly suppress fires without damaging sensitive equipment. It is also used in cryogenic cooling systems for various defence applications, including the preservation of biological samples and cooling of electronic equipment. Carbon dioxide can be used as a propellant in cold gas thrusters for attitude control in small satellites and spacecraft, offering a simple and reliable propulsion method.

## Market Overview of the Industrial Gases

The graph below illustrates the market segmentation by application in India for carbon dioxide by value:

**Graph 4.5.2-1 Carbon Dioxide Market Segmentation by Application in India, by Value (USD 0.14 Billion) (CY2023)**



Others includes mining, entertainment, etc.

Manufacturing includes automotive, general engineering and metal fabrication, machinery & equipment, etc. industries

Source: Frost & Sullivan Research & Analysis

### 4.5.3 Market Split by Region (India)

Western India accounted for 35% market share of Indian carbon dioxide demand in terms of value in CY2023 owing to presence of end use industry plants such as food and beverage, general manufacturing, chemicals, oil & gas refineries, electronics, etc.

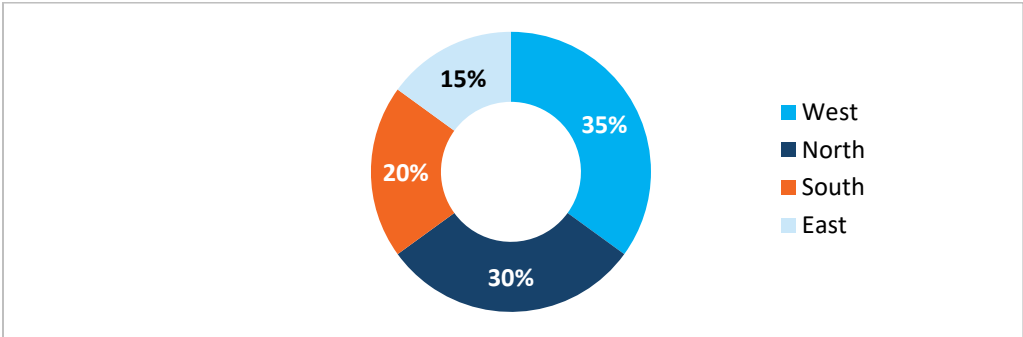
Northern region has presence of many food and beverage manufacturers such as Hindustan Foods, PepsiCo, Coca-Cola, etc. and chemical plants like India Glycols, Gujarat Fluorochemicals, etc. which are driving the demand of carbon dioxide in this region. North India accounted for 30% market share of Indian carbon dioxide demand in terms of value in CY2023.

South India has presence of various metal fabrication industry plants which directly serves the automotive industry and accounted for 20% of the demand for carbon dioxide in India for CY2023. There are many food and beverage manufacturing plants at Andhra Pradesh, Karnataka, Tamil Nadu, Telangana, etc. which is driving demand of carbon dioxide in the region.

In eastern India, there is presence of metal fabrication industry. The general manufacturing industry is leading driver of carbon dioxide in this region. This region accounted for 15% market share of Indian carbon dioxide demand in terms of value in CY2023.

The graph below illustrates the market segmentation by region in India for carbon dioxide by value:

**Graph 4.5.3-1 Carbon Dioxide Market Segmentation by Region in India, by Value (USD 0.14 Billion) (CY2023)**



Source: Frost & Sullivan Research & Analysis

### 4.5.4 Growth Drivers of Carbon Dioxide and Market Trends

- Emerging applications:** Emerging applications for carbon dioxide such as production of fuels (methane and methanol), plastic components, fire extinguishers, pharma, soda ash, building materials, etc. are driving the demand of carbon dioxide. There has been high investments by value chain participants in R&D to explore utilization of CO<sub>2</sub> in new applications.
- Steady growth in existing applications:** The existing industries like fertilizers, oil refineries, food & beverage, manufacturing, healthcare, etc. has a steady demand of carbon dioxide in India since last few years. The demand of CO<sub>2</sub> from these industries has increased at a CAGR of ~3% from CY2018.
- Government policies:** The Government of India has set up policies of Aatmnirbhar Mission to promote self-sufficiency in nitrogenous urea fertilizer production. Within last 10 years, urea production has risen to 310 lakh metric tons in FY2023 from 225 lakh tons in FY2014. The increase in production capacities for urea production has positively impacted the demand of carbon dioxide in last 10 years. The government policies are driving the growth of the industry.
- Decarbonization needs:** The country aims to achieve carbon neutrality by FY2070, with specific targets to reduce carbon emissions in the fertilizer industry. Industry participants, including the government, are planning to utilize captured carbon for urea production. Green hydrogen will be produced to create green ammonia, which, combined with captured carbon, will serve as feedstock for green urea. This initiative will positively impact the demand for carbon dioxide.



## 5 Competition Overview

### 5.1 Global Competitive Landscape

Globally, the leading manufacturers of industrial gases are Linde, Air Liquide, Air Products, Taiyo Nippon Sanso, Messer, Air Water, etc.

A few major businesses dominate a consolidated market owing to the industry's high capital requirements, substantial technological competence, and stringent regulatory standards. Over the past few decades, the industrial gases business has witnessed tremendous consolidation, mostly due to mergers and acquisitions. A small number of multinational giants with a sizable market share have become dominant because of this consolidation. Below are few examples:

- Air Liquide and Airgas Acquisition (CY2016): For USD 13.4 billion, Air Liquide purchased Airgas, greatly increasing its market share and foothold in the US.
- Linde and Praxair Merger (CY2018): This merger combined Linde's substantial market position in the Europe and Asia with Praxair's strong presence in the Americas to create one of the largest industrial gases firm in the world.
- Taiyo Nippon Sanso Corporation (TNSC) and Praxair's European Assets (CY2018): Praxair sold its European assets to TNSC in order to meet regulatory criteria for the Linde-Praxair merger, enabling TNSC to bolster its footprint in Europe.
- Air Products acquisition of Shell's coal gasification technology (CY2018): By acquiring Shell's patents and coal gasification technology business, Air Products improved its technology portfolio and solidified its position in the syngas industry.
- Messer Group acquisition of Linde-Praxair's US business (CY2019): To enable Messer's re-entry into the US market, Messer Group and CVC Capital Partners bought a sizable chunk of Linde's and Praxair's US business, which was sold to comply with regulatory requirements.
- Air Products and General Electric's gasification business (CY2019): Air Products acquired General Electric's gasification business including technology, patents, and equipment, to bolster its position in the gasification market and expand its technology portfolio for hydrogen economy.
- Air Water acquisition of Linde's India Business (FY2020): In a strategic decision to increase its worldwide reach and strengthen its presence in the Indian market, Air Water purchased Linde's and Praxair's south Indian industrial gas business.

In CY2023, the top 3 players, Linde, Air Liquide and Air Products accounted for 75.09% of market share globally. The annual revenue of Linde was USD 32.85 Billion while revenue of Air Liquide was USD 29.82 billion, and revenue of Air Products was USD 12.60 Billion.

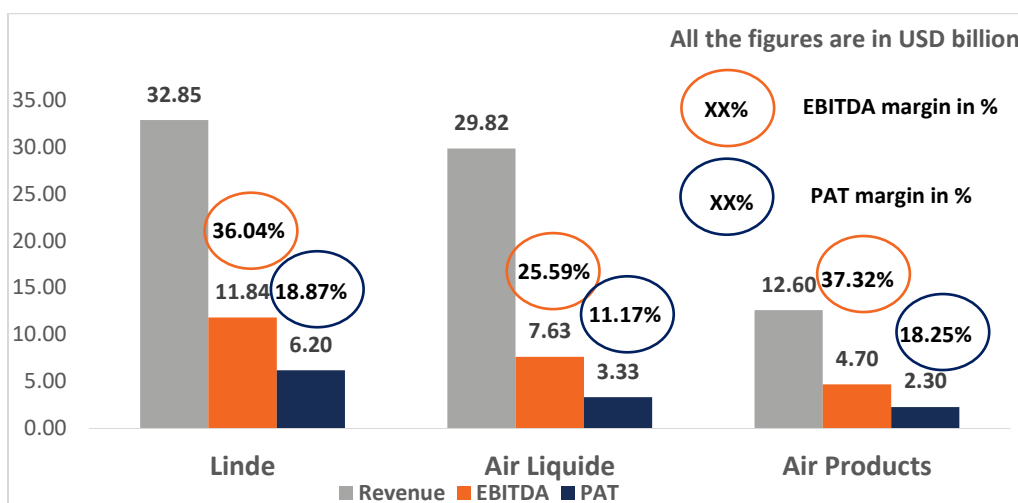
The performance of Linde was exceptional in CY2023 and reported EBITDA of USD 11.84 billion with EBITDA margin of 36.04%. Air Liquide had EBITDA margin of 25.59% and reported EBITDA was USD 7.63 billion in the same year. Air Products EBITDA margin was better than Air Liquide and was around 37.32%. It has reported EBITDA of USD 4.70 billion in CY2023.

## Market Overview of the Industrial Gases

The PAT for Linde, Air Liquide and Air Products was USD 6.20 billion, USD 3.33 billion, and USD 2.30 billion respectively in CY2023. PAT margin for Linde, Air Liquide and Air Products was 18.87%, 11.17%, and 18.25% respectively in CY2023.

The graph below illustrates the comparison of financial performance by global top 3 players:

**Graph 5.1-1 Comparison of Financial Performance by Top 3 Players (CY2023)**



Source: Annual reports, Frost & Sullivan Research & Analysis

## 5.2 Competitive Landscape in India

The industrial gases segment in India is a vital sector supporting various industries, including manufacturing, healthcare, steel, chemicals, energy, and more. The industry is witnessing significant changes driven by economic growth, infrastructure development, technological advancements, and regulatory changes. This segment is characterized by the dominance of a few key players such as Linde, Inoxx Air Products, and Air Water. High barriers to entry, including substantial capital expenditure and established customer relationships, are expected to benefit existing manufacturers of industrial gases.

The market for supply of industrial gases in India is characterised by its fragmented nature, with a long tail of small companies that presently service requirements. These companies typically operate at small scales and serve customers with limited capacities. Consequently, the sector is ripe for consolidation by the limited number of large players.

Following are the parameters that are critical for dominance of key players:

- **Capital intensive industry:** Establishing production facilities, air separation units, and distribution networks requires significant capital investment. Large companies benefit from economies of scale, reducing their production costs and enabling competitive pricing, which smaller companies find hard to compete with.

## Market Overview of the Industrial Gases

- **Technological expertise:** Leading companies invest heavily in R&D to develop efficient and innovative solutions, creating a technological gap that new entrants find challenging to bridge. Continuous innovation in gas applications, production processes, and digitalization further entrenches the position of established players.
- **Regulatory compliance:** The industrial and medical gas sector is subject to strict safety and environmental regulations. Established players have the resources and expertise to ensure compliance with these regulations, while smaller firms may find it financially and operationally burdensome.
- **Extensive distribution network:** Leading companies have extensive and well-established distribution channels, including pipelines, storage facilities, and logistics networks. Established players have a broad customer base and long-term relationships with key industries, making it difficult for new entrants to penetrate the market.
- **Focus on sustainability:** Leading companies are investing in sustainable technologies and practices, such as hydrogen production and carbon capture, aligning with global trends towards sustainability. This focus not only complies with regulations but also attracts environmentally conscious customers.
- **Strategic mergers and acquisitions:** The industry has seen significant consolidation through mergers and acquisitions. This has enabled leading companies to expand their market presence, acquire new technologies, and achieve operational efficiencies. One of the notable example of this would be acquisition of Linde's south Indian business by Air Water in FY2020. Through strategic acquisitions, companies can eliminate competition and strengthen their market position.

**Financial analysis – Key competitors:**

- **Annual revenue:**

**Table 5.2-1 Annual Revenue of Industrial Gases Manufacturers in India**

Company Name	Revenue INR Million				Revenue CAGR
	FY21	FY22	FY23	FY24	FY21-23
Linde India Ltd.	14,711.24	21,119.58	31,355.20	27,686.69	45.99%
Inox Air Products Pvt. Ltd.	17,573.95	20,904.19	21,918.26	NA	11.68%
Air Water India Pvt. Ltd.	8,697.30	9,344.10	10,358.70	NA	9.13%
Air Liquide India Holding Pvt. Ltd.	1,410.29	1,915.89	2,073.38	NA	21.25%
Ellenbarrie Industrial Gases Ltd.	1,751.50	2,445.76	2,051.07	2,694.75	8.21%
Taiyo Nippon Sanso India Pvt. Ltd.	2,224.31	2,295.47	2,006.19	NA	-5.03%
Goyal MG Gases Pvt. Ltd.	1,655.46	2,123.64	1,946.62	NA	8.44%

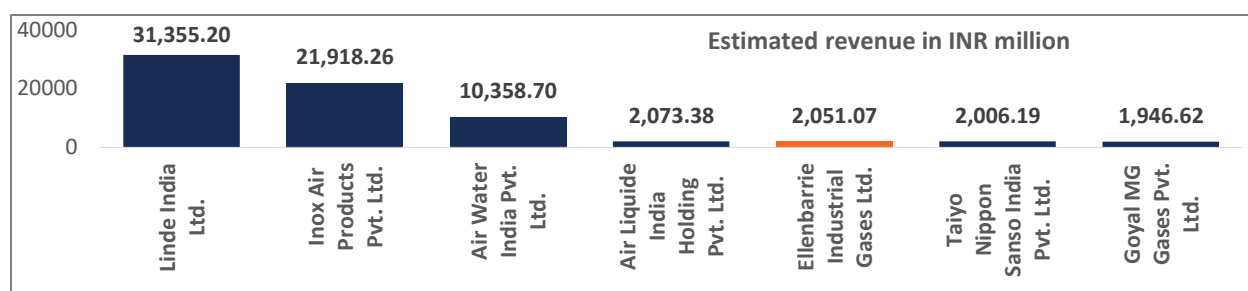
Note 1: NA = Not Available

Note 2: We have used consolidated figures for all players, except when only standalone numbers were available.

Note 3: For Linde India Ltd., FY21 and FY22 numbers represent CY20 (Jan'20-Dec'20) and CY21 (Jan'21-Dec'21) as the Company followed calendar year accounting till 2021. FY23 numbers represent the 15 months period Jan'22-Mar'23.

Source: Annual reports, MCA filings, Frost & Sullivan Research & Analysis

**Graph 5.2-1 Revenue Of Industrial Gas Manufacturers in India (FY2023)**



Note 1: For Linde India Ltd., FY21 and FY22 numbers represent CY20 (Jan'20-Dec'20) and CY21 (Jan'21-Dec'21) as the Company followed calendar year accounting till 2021. FY23 numbers represent the 15 months period Jan'22-Mar'23.

Note 2: We have used consolidated figures for all players, except when only standalone numbers were available.

Source: Annual reports, MCA filings, Frost & Sullivan Research & Analysis

- **EBITDA:**

**Table 5.2-2 EBITDA of Industrial Gases Manufacturers in India**

Company Name	EBITDA in INR Million				EBITDA margin %			
	FY21	FY22	FY23	FY24	FY21	FY22	FY23	FY24
Linde India Ltd.	3,748.46	5,465.88	7,648.37	7,023.23	25.48%	25.88%	24.39%	25.37%
Inox Air Products Pvt. Ltd.	8,352.98	10,479.25	9,963.16	NA	47.53%	50.13%	45.46%	NA
Air Water India Pvt. Ltd.	1,527.20	1,987.60	2,196.10	NA	17.56%	21.27%	21.20%	NA

## Market Overview of the Industrial Gases

Air Liquide India Holding Pvt. Ltd.	57.15	283.30	139.08	NA	4.05%	14.79%	6.71%	NA
Ellenbarrie Industrial Gases Ltd.	459.00	804.59	335.88	615.30	26.21%	32.90%	16.38%	22.38%
Taiyo Nippon Sanso India Pvt. Ltd.	255.43	121.17	82.21	NA	11.48%	5.28%	4.10%	NA
Goyal MG Gases Pvt. Ltd.	304.78	304.87	442.54	NA	18.41%	14.36%	22.73%	NA

Note 1: EBITDA is calculated as Revenue from Operations minus Total Expenses, plus Finance Costs and Depreciation and Amortisation expenses, EBITDA Margin = EBITDA / Revenue from operations, NA = Not Available.

Note 2: We have used consolidated figures for all players, except when only standalone numbers were available.

Note 3: For Linde India Ltd., FY21 and FY22 numbers represent CY20 (Jan'20-Dec'20) and CY21 (Jan'21-Dec'21) as the Company followed calendar year accounting till 2021. FY23 numbers represent the 15 months period Jan'22-Mar'23.

Source: Annual reports, MCA filings, Frost & Sullivan Research & Analysis

**Table 5.2-3 PAT of Industrial Gases Manufacturers in India**

Company Name	PAT in INR Million				PAT margin %			
	FY21	FY22	FY23	FY24	FY21	FY22	FY23	FY24
Linde India Ltd.	1,510.99	5,072.18	5,380.59	4,340.86	10.05%	23.41%	16.61%	15.25%
Inox Air Products Pvt. Ltd.	4,728.40	7,077.46	6,654.02	NA	25.90%	31.76%	28.42%	NA
Air Water India Pvt. Ltd.	-2,457.10	1,407.50	1,315.80	NA	-28.22%	14.95%	12.59%	NA
Air Liquide India Holding Pvt. Ltd.	-233.97	157.59	1,476.08	NA	-15.97%	7.42%	69.33%	NA
Ellenbarrie Industrial Gases Ltd.	240.50	671.55	281.42	452.89	13.38%	26.24%	12.58%	15.61%
Taiyo Nippon Sanso India Pvt. Ltd.	143.67	-66.88	-121.46	NA	6.26%	-2.91%	-6.05%	NA
Goyal MG Gases Pvt. Ltd.	67.41	119.02	351.43	NA	3.87%	5.27%	15.86%	NA

Note 1: PAT Margin = PAT / Total Income, NA = Not Available.

Note 2: We have used consolidated figures for all players, except when only standalone numbers were available.

Note 3: For Linde India Ltd., FY21 and FY22 numbers represent CY20 (Jan'20-Dec'20) and CY21 (Jan'21-Dec'21) as the Company followed calendar year accounting till 2021. FY23 numbers represent the 15 months period Jan'22-Mar'23.

Source: Annual reports, MCA filings, Frost & Sullivan Research & Analysis

- **Return on Equity Ratio:**

**Table 5.2-4 Return on Equity Ratio of Industrial Gases Manufacturers in India**

Company Name	RoE in %			
	FY21	FY22	FY23	FY24
Linde India Ltd.	6.76%	18.68%	17.14%	12.52%
Inox Air Products Pvt. Ltd.	14.03%	17.42%	14.10%	NA
Air Water India Pvt. Ltd.	-9.59%	5.21%	4.64%	NA
Air Liquide India Holding Pvt. Ltd.	-11.04%	6.87%	39.16%	NA
Ellenbarrie Industrial Gases Ltd.	16.29%	19.85%	7.75%	11.05%
Taiyo Nippon Sanso India Pvt. Ltd.	16.76%	-8.72%	-19.54%	NA

## Market Overview of the Industrial Gases

Goyal MG Gases Pvt. Ltd.	1.81%	3.10%	8.38%	NA
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Note 1: RoE = PAT / Total Equity, NA = Not Available.

Note 2: We have used consolidated figures for all players, except when only standalone numbers were available.

Note 3: For Linde India Ltd., FY21 and FY22 numbers represent CY20 (Jan'20-Dec'20) and CY21 (Jan'21-Dec'21) as the Company followed calendar year accounting till 2021. FY23 numbers represent the 15 months period Jan'22-Mar'23

Source: Annual reports, MCA filings, Frost & Sullivan Research & Analysis

### 5.3 Key Competitor Profiling

Please refer to below profiles of Linde, Inox Air Products, Air Water India, Ellenbarrie, Air Liquide. Key details such as establishment year, end use industries catered, range of product offerings, geographical positioning, Indian market share, etc. are reported.

#### 5.3.1 Linde India

<b>Establishment year (India)</b>	1935
<b>End use / industries catered</b>	Chemicals, electronics, construction, food and beverage, healthcare, steel and other metal manufacturing, oil & gas, metal fabrication, etc.
<b>Range of products offered</b>	Carbon dioxide, argon, oxygen, hydrogen, nitrogen, helium, mixtures, etc.
<b>Geographical positioning</b>	Market leader in industrial gases business in India.
<b>India market share (FY23)</b>	30.80%
<b>Supply capability</b>	Supply through on-site production, pipeline supply, bulk tankers and cylinders
<b>Distribution</b>	Dedicated owned fleet of tankers, cylinders along with third party distribution companies

#### 5.3.2 Inox Air Products

<b>Establishment year (India)</b>	1963
<b>End use / industries catered</b>	Chemicals, automotive, food & beverages, aerospace, oil & gas, healthcare, metal fabrication, steel & other metal manufacturing, etc.
<b>Range of products offered</b>	Argon, hydrogen, carbon dioxide, nitrogen, oxygen, helium, syngas, etc.
<b>Geographical positioning</b>	2 <sup>nd</sup> highest market share in India
<b>India market share (FY23)</b>	21.53%
<b>Supply capability</b>	Supply through on-site production, pipeline supply, bulk tankers and cylinders
<b>Distribution</b>	Dedicated owned fleet of tankers, cylinders along with third party distribution companies
<b>Total production capacity in India</b>	3,400 ton per day for merchant sales through bulk containers and cylinders
<b>Tech &amp; Innovations activities</b>	<ul style="list-style-type: none"> <li>Inox Air products is planning to establish a 190 ton green hydrogen project in Chittorgarh, Rajasthan, supplying clean energy to Asahi India Glass Limited by FY2025</li> </ul>

- The company is planning to set up green ammonia plant of USD 3 billion in Maharashtra in next 5 years.

### 5.3.3 Air Water

<b>Establishment year (India)</b>	2014
<b>End use / industries catered</b>	Steel, healthcare, electronics, chemicals, automotive, oil & gas, metal fabrication, etc.
<b>Range of products offered</b>	Oxygen, nitrogen, argon, and carbon dioxide
<b>Geographical positioning</b>	One of the top 3 player in India
<b>India market share (FY23)</b>	10.18%
<b>Supply capability</b>	Supply through on-site production, bulk tankers and cylinders
<b>Distribution</b>	Dedicated owned fleet of tankers, cylinders along with third party distribution companies

### 5.3.4 Ellenbarrie

<b>Establishment year (India)</b>	1973
<b>End use / industries catered</b>	Steel, pharmaceuticals and chemicals, healthcare, engineering and infrastructure, railways, aviation, aerospace and space, petrochemicals, defence, semi-conductors, etc.
<b>Range of products offered</b>	Oxygen, nitrogen, argon, hydrogen, carbon dioxide, acetylene, dry ice, helium, mixtures, etc.
<b>Geographical positioning</b>	One of the largest manufacturers of industrial gases in East India and South India, and the market leader in the states of West Bengal, Andhra Pradesh and Telangana, each in terms of installed manufacturing capacity, as of March 31, 2024
<b>India market share (FY23)</b>	2.01%
<b>Supply capability</b>	Supply through on-site production, bulk tankers and cylinders
<b>Distribution</b>	Dedicated owned fleet of tankers, cylinders

### 5.3.5 Air Liquide

<b>Establishment year (India)</b>	1992
<b>End use / industries catered</b>	Healthcare, electronics, chemicals, automotive, water treatment, oil & gas, metal fabrication, steel & other metal manufacturing, etc.
<b>Range of products offered</b>	Carbon dioxide, argon, oxygen, hydrogen, nitrogen, helium, mixtures, etc.
<b>Geographical positioning</b>	One of the top 5 player in India
<b>India market share (FY23)</b>	2.04%
<b>Supply capability</b>	Supply through on-site production, pipeline supply, bulk tankers and cylinders
<b>Distribution</b>	Dedicated owned fleet of tankers, cylinders along with third party distribution companies

## 6 Growth Potential for Ellenbarrie

In an industry dominated by multinational organizations, Ellenbarrie Industrial Gases Ltd (EIGL) is one of the oldest operating industrial gases companies in India, with a rich legacy of over 50 years. It is the largest 100% Indian owned industrial gases company in terms of installed manufacturing capacity, revenue and profitability in Fiscal 2024. EIGL operates one of the largest oxygen plants in India, with a capacity of 1250 TPD as of March 31, 2024. In Fiscal 2024, the company had a market share of approximately 2.65% in terms of revenue.

EIGL manufactures a wide variety of industrial gases, including oxygen, nitrogen, argon, helium, hydrogen, carbon dioxide, nitrous oxide and acetylene, through which it services a diverse set of industries, with its products finding use in ship building, glass manufacturing, steel manufacturing, pharmaceuticals, welding, fabrication, among others, rendering their consistent supply critical to different industries. It has been one of the key suppliers to India's space and defence program. EIGL also offers synthetic air, which is a mixture of oxygen and nitrogen, produced by controlled, homogenized mixing and is used as zero gas in the running and calibration of test equipment for environmental monitoring, owing to its limited impurities.

EIGL is one of the largest manufacturers of industrial gases in East India and South India, and the market leader in the states of West Bengal, Andhra Pradesh, and Telangana, each in terms of installed manufacturing capacity as of March 31, 2024. It was the first company to set up a hydrogen electrolyzer in Eastern India. As of March 31, 2024, EIGL had one of the highest number of customers out of any gas company in India, indicating a highly diversified customer base with limited concentration risk.

EIGL is one of the few companies to have dedicated plants for each type of gas delivery system - pipeline, merchant liquid and cylinder filling. It has a robust distribution network, with the third highest number of transport tankers, cylinders, and customer installations in India. In terms of bulk distribution capability, EIGL's fleet of cryogenic transport tankers in circulation is one of the largest in India as of March 31, 2024.

During the COVID-19 pandemic, Ellenbarrie's leadership was particularly evident. The company played a critical role in addressing the urgent demand for medical oxygen, with their tankers being routinely airlifted by the Indian Air Force from Hyderabad to Odisha. This rapid response not only highlighted Ellenbarrie's operational agility but also its dedication to public welfare during a national crisis. By consistently prioritizing innovation, operational excellence, and customer-centric solutions, Ellenbarrie Industrial Gases Ltd. continues to lead and shape the industrial gas landscape in India.

**[END OF REPORT]**



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