Market Intelligence
& Analytics

CRISIL
An S&P Global Company

Assessment of the cryogenic equipment industry

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RAHUL PRITHIANI

Digitally signed by RAHUL PRITHIANI
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Table of contents

1 Overview of global economy

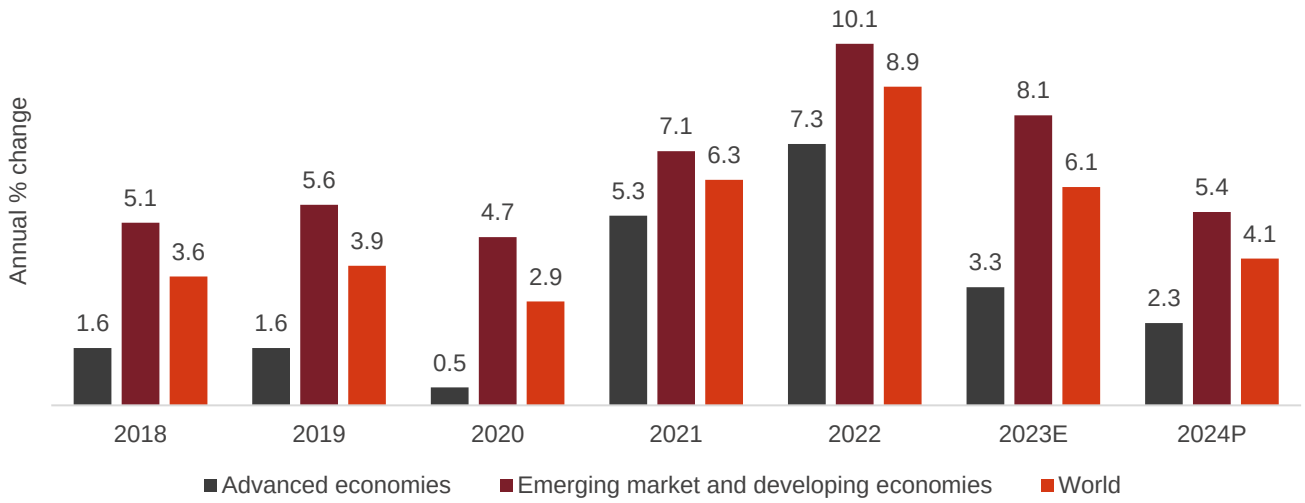
1.1 Review and outlook of economic growth and inflation in key global economies

In 2022, the world came out of the clutches of Covid-19 and was gradually shedding the impact of the pandemic and was on the way to recovery. However, Russia's invasion of Ukraine and the rise in energy and commodity prices have raised concerns on the strong recovery expected once the pandemic subsided. After initial outage, some improvement was noted in the global economic indicators in the second half of 2022 and by early 2023, the world economy began showing signs of stabilising. Increasing commodity prices, geopolitical tensions with Russia's war in Ukraine and China's reopening of economic activity has continued in 2023. The outlook for global economic growth remains subdued in the medium term due to elevated interest rates, widespread slowdown and increasing geopolitical uncertainties.

Global Inflation

Global inflation has been declining since second half of 2022. A fall in the fuel and energy commodity prices, particularly in the United States, the euro area and Latin America has contributed majorly to this decline. To dampen demand and reduce core inflation, major central banks around the world have been raising interest rates since 2021 at a faster clip than before. Monetary policy tightening, particularly by major economies, has led to a sharp increase in borrowings costs, raising concerns about the sustainability of debt in some economies. According to the International Monetary Fund (IMF), global growth projection in the first half of 2023 has improved due to better than expected consumer spending in developed economies, recovery in China and momentum in India.

Trend in inflation, average consumer prices (CY2018-CY2024)



Advanced economies – US, Japan, Euro area
Emerging market and developing economies – China, India, Russia, Brazil, Mexico, South Africa
Source: IMF (World Economic Outlook – April 2023 update), CRISIL MI&A

Global headline inflation has been declining since mid-2022 at a three-month seasonally adjusted annualised rate (Figure 1.3). A fall in fuel and energy commodity prices, particularly for the United States, the euro area and Latin America has contributed to this decline. .

In 2022, economic activity in Europe was more resilient than expected given the large negative terms of trade fallout from the Ukraine conflict and associated economic sanctions. The stinging hike in commodity prices that followed galvanised a reorientation of gas flows with marked increases in non-Russian pipelines and liquefied natural gas deliveries to Europe, alongside contraction of demand due to mild winter and adjustment by industries to substitute gas and to change production process where feasible. Oil and gas prices began trending downward from their peaks in mid-2022;these actions and channels have reduced the negative effect of the energy crisis in Europe, with better-than-expected levels of consumption and investment in the third quarter of 2022. A decline in food energy prices in the fourth quarter of 2022 (although prices are still high at previous levels) has brought some relief to consumers and commodity importers, contributing to a fall in headline inflation. Sustaining lower prices will depend on how supplies are.

In China, Covid-19 restrictions were ultimately lifted. Multiple large outbreaks had led to a decline in mobility and economic activity in the fourth quarter of 2022 because of the virus' direct effects on health and heightened fears of contagion. Supply disruptions also returned to the fore, even if temporarily, leading to a rise in supplier delivery times. The Chinese authorities responded with a variety of measures, including additional monetary easing, tax relief for firms, new vaccination targets for the elderly, and measures to encourage the completion and delivery of unfinished real estate projects. As Covid-19 waves subsided in January 2023, mobility normalised and high-frequency economic indicators such as retail sales and travel bookings started to pick up. With China absorbing about a quarter of exports from Asia, and between 5 and 10 percent from other geographic regions, the reopening and growth of its economy will likely generate positive spillovers, with even greater spillovers for countries with stronger trade links and reliance on Chinese tourism.

A return of the world economy to the pace of economic growth that prevailed before the bundle of shocks in 2022 and the recent financial sector turmoil is looking increasingly elusive. More than 20 months after the Russia-Ukraine conflict began and the outbreak of more contagious Covid-19 variants, many economies are still absorbing the shocks. The recent tightening in global financial conditions is also hampering the recovery. As a result, many economies are likely to experience slower growth in incomes in 2023, amid rising joblessness. Moreover, even with central banks having driven up interest rates to reduce inflation, the road back to price stability could be long. Over the medium term, the prospects for growth now seem dimmer than in decades.

Fuel and nonfuel commodity prices are expected to decline in 2023 amid slowing global demand. Crude oil prices are projected to fall by about 24 percent in 2023 and another 5.8 percent in 2024, while nonfuel commodity prices are expected to remain broadly unchanged. The financial stability risk has increased rapidly since October 2022, the global interest rates stay elevated for longer than expected. The central banks remain focused on returning inflation to targets while deploying tools to maintain financial stability as needed. Governments are on average expected to gradually withdraw fiscal policy support, including, as commodity prices decline, by scaling back packages designed to shield households and firms from the effects of the fuel and energy price spikes in 2022.

Inflation in the eurozone is expected to moderate to 6.1% from 7.0% in 2022, according to a flash estimate released by Eurostat. The softening in inflation is led by a 1.7% on-year fall in energy prices. Food inflation is expected to remain high at 12.5% compared with 13.5% in April 2023. Core inflation (inflation excluding energy, food, alcohol and tobacco) is also expected to soften to 5.3% from 5.6%.

The eurozone economy grew by a seasonally adjusted 0.3% in the second quarter of 2023 vis-à-vis no growth in the first quarter, according to a flash estimate released by Eurostat. However, the GDP print was mixed across the currency bloc major economies. Italy contracted 0.3% on-quarter, while Spain and France expanded 0.4% and 0.5%, respectively. Germany was flat after contracting for the previous two quarters. To tame inflation, the European Central Bank (ECB) hiked interest rates for the ninth successive time at its July meeting. It hiked rates by 25 bps, taking the marginal lending facility rate to 4.5%.

Inflation in the UK eased significantly in July, falling to 6.8% from 7.9% in June, cooled by falling energy prices. This is the slowest pace of on-year rise in prices since February 2022. Real GDP growth in the UK ticked up to 0.2% on-quarter from 0.1% in the previous quarter, led by strong household and government expenditure. Services output grew 0.1% in the second quarter, with accommodation and food services rising 1.6%. The Bank of England hiked interest rates for the 14th consecutive time, raising it 25 bps at its August meeting to 5.25%.

Japan's growth accelerated to an annualised 6.0% in the second quarter of 2023, compared with a revised 3.7% in the first quarter of 2023. Meanwhile, CPI inflation held steady at 3.3% in July, though food inflation accelerated to 8.8% from 8.4% in June. Inflation in housing remained unchanged at 1.1%. Prices of fuel, light and water fell 9.6% on-year in July, steeper than the 6.6% fall in June, led by sliding electricity prices. Notably, core inflation eased to 3.1%, the lowest print in the past four months, but still was above the central bank's target. Japanese trade balance was in deficit of ¥78.73 billion in July 2023 compared with a deficit of ¥1421.92 billion in July 2022, as imports fell 13.5% while exports fell a softer 0.3%.

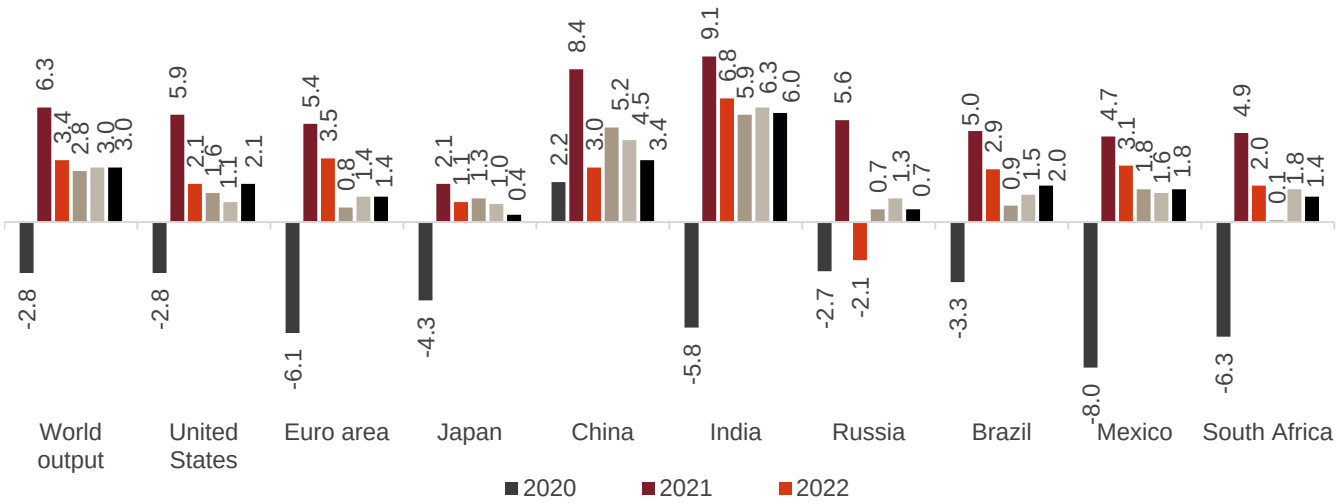
Global growth outlook

As per the International Monetary fund (IMF), the global economy was projected at 3.4% in 2022 and 2.8% in 2023.The forecast for 2023 is lowered to 2.7% in April 2023 Outlook, lower than predicted in the January 2023 outlook. This forecast for the coming years is well below what was expected before the onset of the adverse shocks since early 2022.

For advance economies, the growth was projected at 2.7% in 2022 and 1.3% in 2023. About 90 percent of advanced economies are projected to see a decline in growth in 2023. With a sharp slowdown, advanced economies are expected to see higher unemployment. For emerging and developed economies, economic prospects are on average stronger than for advanced economies but vary widely across regions. On average, growth is expected to be in 3.9 percent in 2023 and to rise to 4.2 percent in 2024. In low income developing countries, GDP is expected to grow by 5.1 percent, on average, over 2024 as compared to 2023.

India is expected to remain a growth outperformer over the medium run. CRISIL MI&A expects India's GDP growth to average 6.1% between fiscal 2025 and 2027, compared with 3.1% globally as estimated by IMF. India would also outpace emerging market peers such as China (4.2%) Indonesia (5.0%), Turkey (3.2%) and Brazil (1.8%) between fiscal 2025 and 2027.

IMF estimates of GDP growth for key economies



**Euro area includes 19 countries of the European union*

Source: IMF (World Economic Outlook – April 2023 update), CRISIL MI&A

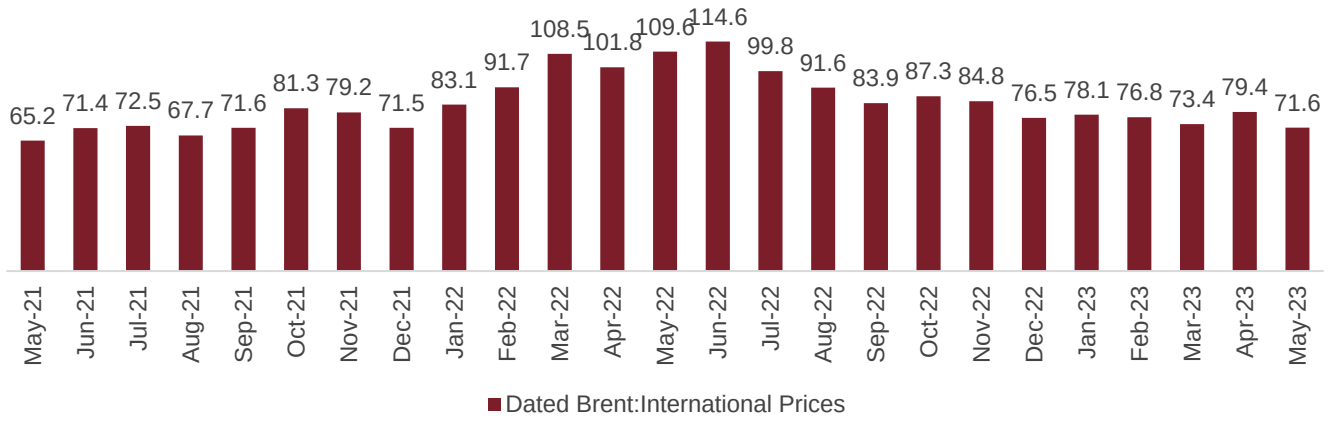
Brent crude falls

Crude oil prices decreased in the first half of 2023 primarily due to sustained high inflation coupled with slowdown in demand, which have significantly impacted the prices. A strong dollar along with sharp production cuts resulted in supply pressure pushing crude oil prices downward.

However, the prices remained elevated during 2022 due to demand-supply tightness. Geopolitical tensions because of the Russia-Ukraine conflict had major impact on energy prices and this, along with production outages in Libya and Norway, added pressure on prices.

Crude oil prices averaged $98-103 per barrel in 202 2 compared to $70.4 per barrel in 2021, which was an increase of 39-46% on year. However, increasing recessionary fears stemming from inflation coupled with interest rate hikes globally have led to significant shadow over consumption and economic growth, pushing prices downward. CRISIL MI&A expects price to stabilise in the $80-85 per barrel range in 2023, in line with the global decline owing to decelerating demand.

Brent crude oil price



Note: Dated Brent price is the price of physically delivered crude oil in the North Sea that has specific delivery date
Source: Industry, CRISIL MI&A

1.2 Global trade environment

The pace of global trade growth is estimated to taper from 5.1% in 2022 to 2.4% in 2023 owing to slowdown in global demand after two years of accelerated growth from the pandemic recession and shift in the composition of spending from traded goods back towards domestic services.

Rising trade barriers and the linger effects of US dollar appreciation in 2022 made traded products more expensive for several economies. And considering the dollar's dominant role in trading, this will add further pressure on trade growth in 2023.

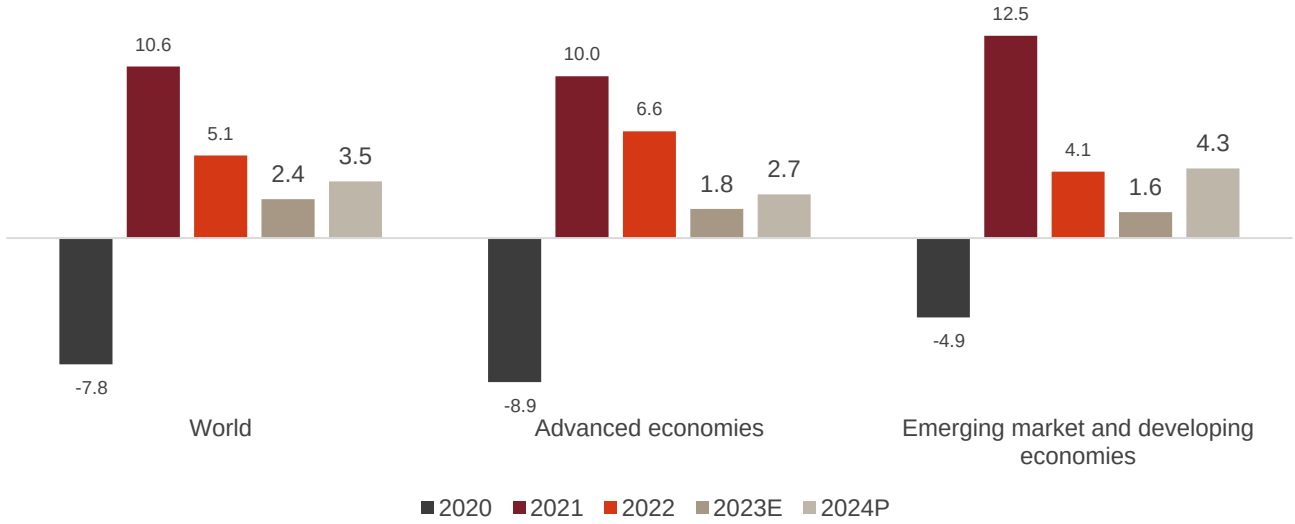
Amid delay in China's recoveries (post Covid-19) with substantial share of economies export absorbed by China, a weaker-than-expected recovery in China would have further significant cross border effects, especially for commodity exporter and tourism dependent economies. The ongoing weakness will have adverse impact on Chinese real estate market which can potentially lead to financial instability.

An escalation of the Russia-Ukraine conflict could prompt renewed energy crisis in Europe and amplify food security in low-income countries. During winter 2022-23, gas price crises were averted given ample storage at European facilities, higher liquified natural gas imports and lower gas demand — amid high prices. A possible increase in food prices from the failed extension of the Black Sea Grain initiative will add further pressure on food importing countries.

Further, geopolitical fragmentation risks have not only lowered cross-border flows of labour, goods and capital, but also reduced international activity in vital global public goods such as climate-change mitigation and pandemic resilience. Some countries may benefit from an associated arrangement in global production, but the overall impact on economic wellbeing is expected to be negative with costs particularly high in short-term as replacement of disrupted flows will take time.

The global economy is expected to be resilient in 2023 with tight labour markets in several economies and improved household consumption. Although this would be a challenge against high inflation, lower demand for import and lower commodity prices owing to weakening of activity in most of economies.

IMF estimates of world trade growth



Note: Volumes of exports of goods and services have been considered for the calculations
Source: IMF (World Economic Outlook – April 2023 update), CRISIL
Advanced economies – US, Japan, Euro area
Emerging market and developing economies – China, India, Russia, Brazil, Mexico, South Africa

2 Overview of the Indian economy

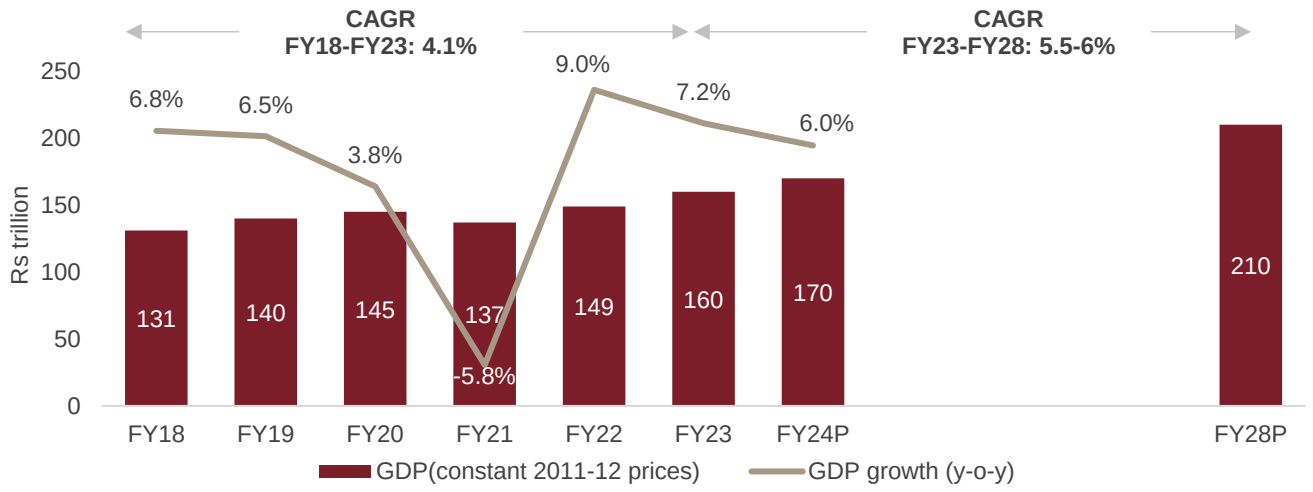
2.1 Review of real GDP growth over fiscals 2018-23 and outlook for fiscals 2023-28

The Indian economy logged a 4.1% compound annual growth rate (CAGR) over fiscals 2018-2023. It contracted 5.8% in fiscal 2021 due to the impact of Covid-19.

GDP growth between fiscals 2017 and 2019 was robust a CAGR of 6.6%, driven by rising consumer aspirations, rapid urbanisation, the government's focus on infrastructure investment and growth of the domestic manufacturing sector. The growth was supported by benign crude oil prices, softer interest rates and lower current account deficit. The Indian government also undertook key reforms and initiatives, such as implementation of the Goods and Services Tax (GST) and Insolvency and Bankruptcy Code (IBC); Make in India and financial inclusion initiatives; and gradual opening of sectors such as retail, e-commerce, defence, railways, and insurance for foreign direct investments (FDIs). As lockdowns were gradually lifted, economic activity revived in the second half of fiscal 2021. After a steep contraction in the first half owing to rising number of Covid-19 cases, GDP moved into positive territory towards the end of fiscal 2021. Subsequently, in fiscal 2022, India's real GDP grew 9.0% from the low base of fiscal 2021.

A large part of the lower print between fiscals 2018 and 2023 was because of the economy contracting 5.8% in fiscal 2021 owing to the fallout of Covid-19. The impact of the pandemic was more pronounced on contact sensitive services as social distancing norms affected services such as entertainment, travel, and tourism, with many industries in the manufacturing sector also facing issues with shortage of raw materials/components as lockdown in various parts of the world upended supply chains. Over the period, India's economic growth was led by services, followed by the industrial sector. In parts, though, growth was impacted by demonetisation, non-banking financial company (NBFC) crisis, slower global economic growth, and Covid-19.

GDP growth pace to slow down to 7.3% in FY23, long term growth expected at 5.5-6% CAGR



Note: P – Projected; E – Estimated, FY23 – Second advance estimate
Source: National Statistical Office (NSO), CRISIL MI&A estimates

Growing restrictions on the movement of people and lockdowns in the affected countries led to demand, supply and liquidity shocks, which resulted in major financial losses and bankruptcies of several players in different industries.

India saw one of the world's most stringent lockdowns in March 2020. The impact of Covid-19 was more pronounced on contact sensitive services as social distancing norms impacted many services such as entertainment, travel and tourism sector. While many industries in the manufacturing sector also faced issues with shortage of raw materials/components as lockdown in various parts of the world wrecked havoc on their supply chains. As lockdowns were gradually lifted, economic activity revived in the second half of fiscal 2021. After a steep contraction in the first half, owing to the rising number of Covid-19 cases, GDP growth moved into positive territory towards the end of fiscal 2021. India's real GDP grew 8.7% in fiscal 2022 from the low base of fiscal 2021.

According to the National Statistical Office (NSO) estimates released on May 31, 2023, GDP growth rose sharply to 6.1% on-year in the fourth quarter (January-March) of fiscal 2024. During the third quarter of the fiscal GDP had declined to 4.5%. The growth surpassed what was factored in the NSO's second advance estimate of February 2023. Annual growth for fiscal 2023 was revised up to 7.2% (provisional estimate) from 7.0% in the second advance estimate. The economy was first hit by the pandemic during the first quarter of fiscal 2021 and again affected in the second wave by the delta variant in the first quarter of fiscal 2022. In contrast, there was no pandemic-led disruption in the first quarter of this fiscal. Hence, first-quarter data of this 2023 continues to be statistically boosted by a favourable base-effect. Despite headwinds due to the Russia-Ukraine conflict, the growth momentum (in seasonally adjusted terms) improved sequentially during the quarter.

India's real gross domestic product (GDP) rose 6.3% on-year in the second quarter of fiscal 2023 vis-a-vis 13.5% in the previous quarter. The sharp deceleration was partly because of a high base effect, as GDP had printed 8.4% in the second quarter of fiscal 2022. That said, GDP was dragged down by weakening industrial growth as well, particularly in the manufacturing sector that was hit by slowing global growth and compressed margins.

On the supply side, gross value added (GVA) grew 6.5% on-year in the fourth quarter of fiscal 2023, much slower than the 4.7% growth in the previous quarter. Agriculture and allied activities surged to 5.5% from 4.7% as a result of a robust rabi output despite unseasonal rains towards the year-end.

Within the industry basket:

- Manufacturing grew a tad to 4.7%, from 4.5% in the previous quarter. Easing commodity prices and supply constraints, along with resilient domestic demand, supported production. However, declining goods exports dampened industrial prospects.
- Construction growth moderated (7.9% versus 10.4%), as a result of a decline in residential housing activity. But it grew faster than GDP over a high base and was positive for employment generation, as construction is a labour-intensive activity. There was a modest improvement in mining (5.8% vs 4.3%), while utilities' growth slowed down sharply (2.9% vs 6.9%)
- Agriculture and allied activities slowed down to 3.5% from 5.5%; sowing has started with a delay, in response to the delayed onset of monsoon in June

While services posted slowing on-year growth, it was primarily the result of an unfavourable base. In fact, activity continued to improve sequentially across all major components.

Private final consumption expenditure (PFCE) increased 2.8% in the fourth quarter compared with 2.2% in the previous quarter. It continued to contribute positively to growth.

Fixed investment had a good outing again (8.0% in first quarter of fiscal 2024 vs 8.9% previous quarter), as the growth momentum was maintained by the government's frontloading of capex at the start of the fiscal and a revival in private capex.

Meanwhile, the government's consumption spending, as measured by government final consumption expenditure (GFCE), turned negative 4.4% on-year in the second quarter vs. 1.3% in the previous quarter, reflecting ebbing of Covid-19-related spending. Also, real export growth of goods and services slowed sharply to 11.5% in the second quarter from 14.7% in the previous quarter. Exports slowed considerably to major destinations — the US and the EU — as tightening financial conditions weighed on the growth of these economies. In contrast, imports were strong at 25.7% in the second quarter (although lower than 37.2% in the first quarter) on relatively resilient domestic demand. Taken together, net exports continued to subtract from overall GDP growth.

Share in GDP expanded materially for PFCE (58.4% in the second quarter of fiscal 2023 vs. 56.6% in the second quarter of fiscal 2022) and imports (31.9% vs. 27%), while it fell for GFCE (8.8% vs. 9.8%), and was stable for GFCF (34.6% vs. 33.4%) and exports (23.3% vs. 22.2%).

Nominal GDP was much higher at 16.2% in the second quarter compared with real GDP. Also, while the GDP deflator moderated to 9.3% on-year in the second quarter from 11.6% in the previous quarter, it was higher than the pre-pandemic level (0.2% in the second quarter of fiscal 2020)

Domestic macroeconomic outlook for fiscal 2024

Macro variables	FY22	FY23	FY24E	Rationale for outlook
GDP (%, on-year)	8.7%	7.2%	6.0%	India's real gross domestic product (GDP) growth forecast to 6.0% for fiscal 2024 from 7.2% estimated previously. This is primarily because slowdown in global growth has started to impact India's exports and industrial activity. The domestic demand will also come under pressure owing to hike in interest rates, softening inflation and government capex will offer support in this fiscal. Monsoon and El Nino risks remain a swing factor. Interest rates are higher than their pre-pandemic five-year average (fiscal 2016-2020) this would moderate domestic demand, specifically in interest-sensitive segments such as automobile and housing. Consequently, CRISIL projected GDP growth to slow to 6.0% in fiscal 2024 and 6.2% in fiscal 2025.The risks to the forecast remain tilted downwards.
CPI-linked inflation (%, on-year)	5.5%	6.7%	5.5%	Decline in crude oil prices along with the export of other top commodities mainly due to slowdown in global growth. lowered the commodity prices in fiscal 2024, eased inflation during the year. CPI inflation moderated further in past few months in fiscal 2024. ;The downward growth trajectory is mainly due to strong base effect that will fade out the headline inflation. Another reason, a fall in global oil and commodity prices, easing supply pressures leading to better availability of inputs and therefore reduced the pressure on prices. Easier food inflation as rabi crop outlook were positive. CRISIL Projected CPI inflation to 5.5% for fiscal 2024 from 6.7% in the fiscal 2023. Supportive monsoon is key assumption underlying these forecasts. Slowdown in growth and moderated inflation may further cut rates by end of fiscal 2024.

Macro variables	FY22	FY23	FY24E	Rationale for outlook
10-year government security yield (%, March-end)	6.8%	7.4%	7.0%	Yields on 10-year G-secs yield has trended downward after the monetary policy committee unexpected halted the rate hike cycle in its April 2023 review. It continued to decline in May after the inflation print fell further on the back of fall in crude oil prices and rise in FPI debt purchases supported lower yields. Both global and domestic factor contributed towards softening of bond yield. Domestically, yield has fallen almost 50-bps lowest since August 2017 and well below the pre-pandemic five-year average of 95bps. 10-year G-sec to averaged 7.4% in March 2023, compared with 6.8% in March 2022. G-sec yields are expected to remain low till end of fiscal 2024 on the back of moderating inflation, lower crude oil prices and as the RBI takes a pause in its rate hike cycle, yield are expected to come down to 7% by March 2024.
CAD/GDP (%)	-1.2	-2.5	-2.0	India's exports are expected to face headwinds from the anticipated slowdown in global growth. Several key economies such as US and Euro area both are key export market for India reeling under pressure. Further, deceleration in domestic growth could lead to some softening in imports. However, India's robust growth and falling inflation, and easing trade deficit helped attract foreign investors. A sharp fall in crude oil prices ($75.7per barrel in May vs $84.1 in the April) also augurs well for the domestic economy. The foreign portfolio investor (FPI) inflows increased to $5.9 billion(net)in May, the highest in since September 2022.Most of the inflow directed towards equities and inflows are also improved for debt. Narrowing trade deficit had a salutary effect on India's CAD. CRISIL projects India's CAD at ~2% of GDP in the fiscal 2024, as exports continue to decline at a greater pace than imports.
Rs/$ (year-end)	76.2	82.3	83.0	The rupee continues to face headwinds amid global growth slowdown, heightened geopolitical tensions, elevated commodity prices, and aggressive rate hikes by the US Fed, which is continuing to strengthen the dollar as India's Trade deficit widen However, in calendar year 2023 so far, the rupee has depreciated a mere 0.5% on average against the dollar, remaining on the least depreciated emerging market currencies. The Rupee come under pressure against the US dollar strengthen in the last couple of months of this fiscal, from averaging 82.0 against dollar in April 2023, INR-USD exchange rate fell 0.4% on month to 82.3 against dollar in May 2023. Rupee has remained resilient this year. CRISIL expects the rupee to average 83 against the dollar in March 2024 compared with 82.3 in March 2023.A surge in Foreign Portfolio Investment (FPI)flows restricted the currency from falling further down.

Note: E: Estimated, P - Projected
Source: Reserve Bank of India (RBI), NSO, CRISIL

While growth was robust in fiscal 2023, a slowdown is inevitable in fiscal 2024, driven by rising borrowing costs. While central banks aggressively raised policy rates over the past 15 months, their transmission to broader lending rates is taking place with a lag. Rates are expected to peak in the fiscal, hitting both global and domestic demand. External demand will weaken more with major advanced economies facing the highest interest rates in over a decade. S&P Global expects United States GDP growth to slow to 0.7% in 2023 from 2.1% in 2022; Eurozone will

brake to 0.3% from 3.5%. These economies account for 33% of goods exports. Hence, exports will curb the growth in this fiscal. While the rise in domestic interest rates is relatively lower than in advanced economies, bank lending rates have reached the pre-pandemic five-year average. This is expected to moderate domestic demand, especially in interest-sensitive segments such as automobiles and housing.

However, falling commodity prices and slowing inflation augurs well for domestic demand this fiscal. We expect further support from the government's continuing infrastructure spend. The key swing factor is monsoon, which has a significant bearing on rural demand. While the India Metrological Department has forecast a normal monsoon, regional and temporal distribution will have a bearing on agricultural output. Downside risks from an expected El Niño remain.

Because of these factors, CRISIL MI&A projects GDP to grow 6% this fiscal, compared with 7.2% in fiscal 2023. Nominal growth will see a sharper slowdown to 10.6% from 16.1%, with falling inflation (particularly for WPI) narrowing the gap between real and nominal GDP.

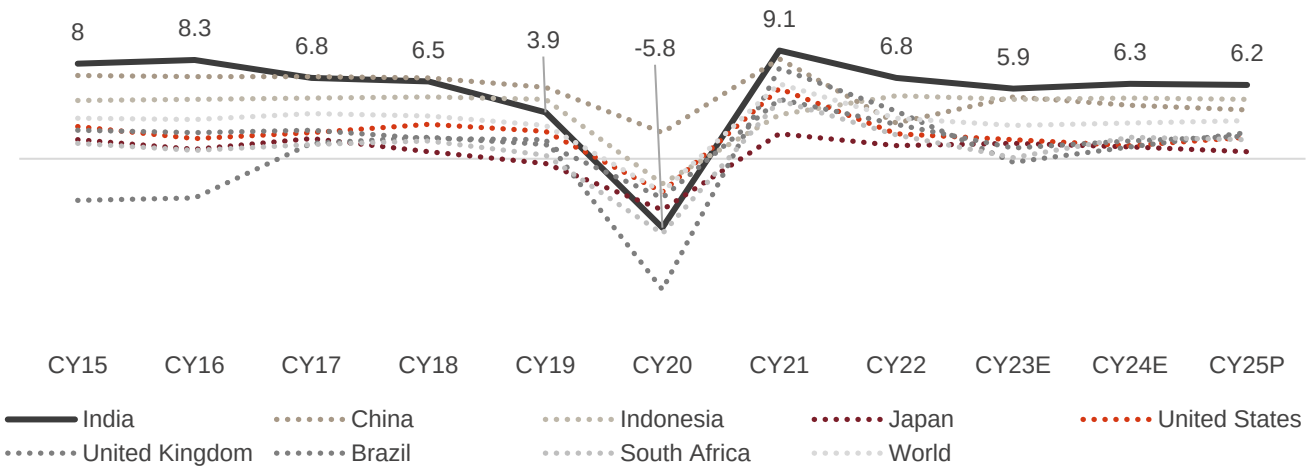
India to remain a growth outperformer globally

Despite the slowdown in near term, India is expected to remain a growth outperformer over the medium run. CRISIL MI&A expects GDP growth to average 6.1% between fiscal 2025 and 2027, compared with 3.1% globally as estimated by IMF.

Drivers for India's economic growth:

Stronger domestic demand is expected to drive India's growth premium over peers in the medium term Investment prospects are optimistic, given the government's capex push, progress of Production-Linked Incentive (PLI) scheme, healthier corporate balance sheets, and a well-capitalised banking sector with low non-performing assets (NPAs) India is also likely to benefit from its diversification of supply-chain for incoming FDI flows. As global supply chains get reconfigured with focus shifting from efficiency towards resilience and friend shoring Private consumption (~57% of GDP) will play a supportive role in raising GDP growth in the medium term.

India is one of the fastest-growing major economies (GDP growth, % on-year)



E: Estimated; P: Projected
Note: GDP growth is based on constant prices
Source: IMF (World Economic Outlook – April 2023 update), CRISIL

Factors that will shape growth in fiscals 2024 and 2025

Moderate household demand supported by service catch up and government capex:

Strong industrial growth led by manufacturing sector, the index of Industrial production accelerated to 4.2% on year in April 2023 from 1.7 in March majorly led by growth in manufacturing sector, which was supported by domestic oriented sectors, however certain export -oriented sector capped the gain. While manufacturing sector growth led by infrastructure and construction goods and consumer non-durables. However slow activity for primary, intermediate, and capital goods. Consumer non-durables comprising essential items such as food products — saw the sharpest rebound in growth relative to the previous month. Easing inflation in the past few months seems to be improving demand from poorer segments. Rural inflation fell more swiftly in the past few months, which helped increase real wages for their workforce. This, coupled with robust rabi production, seems to be hinting at improved rural demand

Infrastructure and construction goods growth rose in April after a three-month slowdown, reflecting a pickup in government capital expenditure with the start of the fiscal 2024. At 12.8%, it was the strongest contributor to IIP growth in April.

Industrial performance seems to be encouraged from easing inflationary pressures in the past few months. Falling commodity prices eased input cost pressures for producers, and softening retail inflation has boosted consumers' purchasing power. S&P's Purchasing Managers Index for manufacturing rose further to 58.7 in May 2023 from 57.2 in April, recording the strongest expansion since October 2020. This suggests healthy manufacturing performance in May as well.

Slowing external demand will inevitably also be a drag on domestic growth, considering major advanced economies are expected to slow down following the sharp rise in interest rates. While the rise in domestic interest rates is relatively lesser than in advanced economies, lending rates in India too are now higher than their pre-pandemic five-year average. This is expected to moderate domestic demand, especially in interest-sensitive segments such as automobiles and housing.

Global and domestic growth cycle:

The GDP growth has been resilient so far, with sharp uptick to 6.1% in the last quarter of fiscal 2023.However, recovery remained uneven, with private consumption being more subdued than other demand segments in the second half. Urban demand and services have been leading the recovery so far. Meanwhile, investment remains robust and net exports have become less of a drag on growth. Robust rabi production augurs well for rural prospects. Services and investments are expected to remain robust. However, weakening external demand and geopolitical risks are key downside risks to growth outlook.

The growth in key advanced economies was mixed, with the economy of the Euro area contracting on quarter, while US growth slowed down to an annualised 1.3% compared with 2.6%in the previous quarter. Japan's GDP growth accelerated to 2.7% in the first quarter compared to 0.4% in the last quarter 2022.China is showing an uneven recovery. Manufacturing activity contracted in China for the second consecutive month while inflation remained low in May due to sluggish demand.

The central bank lowered down the policy rate, the US policy rate decline by 1.6% point in 2023 and 1.8 % point in 2024 relative to the baseline. The global average of policy rate declines by 2.1 and 2.3%over the same period. However even after rate cuts in 2024 S&P global expect Fed rate to be at 4% until late 2024.The high interest rates

in major advance economies can significantly alter capital flow and asset prices, as stated by the IMF in its financial stability report of April 2023.

Monetary policy tightening and weakening growth momentum in advanced economies have already started to impact India in the form of slowdown in exports and volatility in foreign portfolio investment (FPI) inflows. India's core export which includes crude oil and gems, and jewellery exports shrank lower 4.0%, as healthy performance in core categories such as electronics, iron ore and select agriculture commodities. The impact of weakening global demand is visible in most other core export categories.

Exports are expected to face headwinds from the anticipated slowdown in global growth, largely premised on lower growth in advanced economies such as the US and the euro area both are key export markets for India. Further, deceleration in domestic growth could lead to some softening in imports.

Financial condition stabilises, broader economy to face elevated rates

The RBI is expected to further extend pause on rate hike, as it evaluates inflation trajectory and growth momentum. While inflation has fallen in the past four months, progress of monsoon and impact of El Nino will be monitorable. The impact of past rate hikes on growth will be the most prominent in fiscal 2024. As growth slows, CRISIL MI&A expect the RBI to initiate rate cuts in the last quarter of this fiscal.

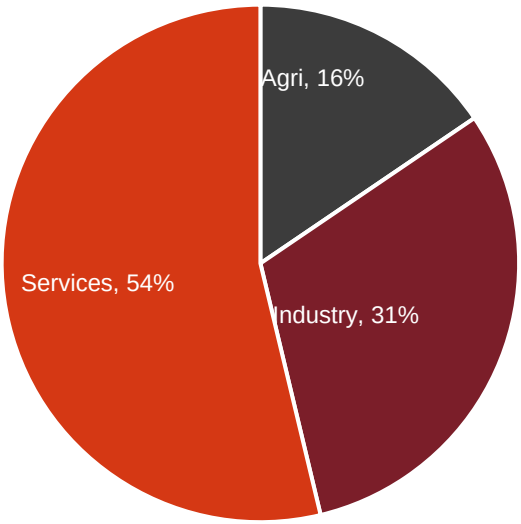
While the pause on rate hikes has augured well for financial markets, elevated bank lending rates could tighten financial conditions for some segments of the economy. Rates will rise further in real terms as inflation moderates. Even as the repo rate remained unchanged in May 2023, the 'real repo rate' (i.e., repo rate adjusted for CPI inflation) increased to 2.2%, the highest since August 2019. It is worth noting that tight financial conditions had contributed to growth slowdown in fiscal 2020. On the global front, the US Fed paused rate hikes in June, but remains on the edge as the economy continue to witness tight labour market conditions.

S&P Global expects the Fed rate to remain at peak levels in calendar year 2023. While the risk of tight and volatile global financial conditions persists, India's vulnerability to these shocks is expected to be lowered this year. India's current account deficit (CAD) anticipated to be declined in fiscal 2024 on the back of lower crude oil prices. This, coupled with the RBI's adequate forex reserves and the country's good growth prospects, should cushion the impact of a global spillover on overall macros.

2.1.1 Government policies to boost manufacturing in India

Indian economic output is majorly driven by the high productivity services sector which contributes 54% of the economic output. The share of industry is a distant second at 31% of which manufacturing account nearly 60%. Manufacturing sector growth can not only increase job in the sector but also reduce forex outgo on imported goods. Hence the government has introduced several incentives in the past decade in order to boost the manufacturing sector in India.

Sectoral GDP share FY2023



Source: CRISIL MI&A

Construction capex to rise 13-16% this fiscal on a high base of fiscal 2023

Growth momentum in capex for fiscal 2024 continued from fiscal 2023 with major focus on construction by infrastructure segment given the rising investment and focus by central and state government capex coupled with schemes such as NIP, NMP and Gati shakti initiatives on a rising pace. Although FY2022 had seen challenges due to second wave of coronavirus and other minor challenges like irregular monsoon in certain states, it showed sharp estimated rise of 35-40% to Rs 9.1-9.3 trillion over a low base of FY21.

Construction sector is projected to grow at 13-16% in fiscal 2024 with major contribution by infrastructure segment given the rising investments and focus by central and state government capex. Construction capex is projected to rise 15-17% on year in fiscal 2023 led by infrastructure segment to Rs.10.5 -10.7 trillion. The rise is in keeping with the Govt's focus on infrastructure as visible in rising central and state budget allocations to capex to meet the infra build out outlined in the NIP.

CRISIL MI&A estimates healthy growth of construction investments in FY22 due to effect of low base in FY21 where construction activities where highly impacted by lockdowns due to the outbreak of Covid-19 Pandemic.

Infrastructure to drive construction sector growth in the medium to long term

The share of infrastructure projects is expected to grow faster in the next five years compared to the past five years, as Government's focus on Infrastructure under the NIP, NMP and the Gati Shakti initiative. The Central government's focus on roads, urban infrastructure and railways will boost infrastructure investments.

Sector	FY18-FY22 CAGR	FY22E (Rs trillion)	FY23E (Rs trillion)	FY24P y-o-y growth	FY23-27P to FY18-22E ratio
Infrastructure (A)	**12%**	**5.7-5.9**	**6.9-7.1**	**18-20%**	**1.9x**
Roads	13%	2.7-2.8	3.1-3.3	20-25%	1.9x
Power	5%	0.2-0.3	0.3-0.4	10-12%	1.5x
Railways	17%	0.8-0.9	1.1-1.2	12-14%	2.1x

Sector	FY18-FY22 CAGR	FY22E (Rs trillion)	FY23E (Rs trillion)	FY24P y-o-y growth	FY23-27P to FY18-22E ratio
Urban Infra	17%	0.8-0.9	1.0-1.1	31-33%	2.4x
Irrigation	2%	0.7-0.8	0.8-0.9	7-9%	1.5x
Other Infra	5%	0.2-0.3	0.2-0.3	14-16%	1.6x
Industrial (B)	**8%**	**0.7-0.8**	**0.7-0.8**	**6-8%**	**1.2x**

Note: E-estimated, P- Projected;
Source: CRISIL MI&A

Of the total capex, the Centre is expected to contribute just one-third, with state capex accounting for the rest. However, actual state capex is lagging budgeted estimates. Private companies are primed and getting ready for scaling up investments but remain cautious in the current uncertain environment. Private consumption remains the weak link owing to reduced direct fiscal policy support. Roads and Railways dominated by public funds to lead growth in infrastructure.

The total budgetary allocation on capital expenditure in infrastructure for FY2023-24 saw a 14% rise over the revised estimates for FY 2022-23 to Rs 9.5 trillion with roads and railways being the biggest beneficiaries. Of this, Rs 5.4 trillion will be through budgetary support, with the remainder from internal and extra budgetary resources and grants in aid for capital creation. The share of infrastructure projects is expected to increase to 65-70% in the next five years as against 55-60% in the past five years, as Infrastructure investments are seen growing faster than the other two segments due to the to the Government's focus on Infrastructure under the NIP, NMP and the Gati Shakti initiative. The Central government's focus on roads, urban infrastructure and railways will boost infrastructure investments.

Make in India

The Make in India initiative was launched in September 2014, to give a push to manufacturing in India and encourage FDI in manufacturing and services. The objective of the initiative was to increase manufacturing share in GDP to 25% by 2020 by boosting investment, foster innovation, and intellectual property, and build best-in-class infrastructure for manufacturing across sectors including but not limited to automobile, auto components, aviation, biotechnology, chemicals, construction, defence manufacturing, electrical machinery, electronic systems, food processing, mining, oil and gas, pharmaceuticals, renewable energy, thermal power, hospitality and wellness.

To achieve this objective, a dedicated Investor Facilitation Cell (IFC) was setup to assist investors in seeking regulatory approvals, hand-holding services through the pre-investment phase, execution and after-care support. Key facts and figures, policies and initiatives and relevant contact details were made available through print and online media. The Indian embassies and consulates proactively disseminate information on the potential for investment in the identified sectors in foreign countries while domestically, regulations and policies were modified to make it easier to invest in India.

FDI inflows have seen a leg up, as India jumped to the 8th position in the list of world's largest FDI recipients in 2020compared to the 12th position in 2018, according to the World Investment Report 2022. FDI to India almost doubled to $83.6 billion in 2021-22 from $ 45.15 billion in fiscal 2015. India is on track to attract $100 billion FDI during fiscal 2023 according to Ministry of Commerce and Industry.

However, the share of manufacturing in GDP had not make a meaningful move since the introduction of the programme. Additional policies were announced, and targets rolled forward initially to 2022 and then to 2025. Domestically, there were multiple steps taken to improve to make sectors more attractive and ease investment processes. Some of the major steps taken were announcement of National Infrastructure Pipeline, reduction in corporate tax, various sectors such as defence manufacturing, railways, space, and single brand retail have been opened up for FDI. Measures to boost domestic manufacturing were also taken through Public Procurement Orders (PPO), Phased Manufacturing Programme (PMP) and Production Linked Incentives (PLI) schemes etc. Many states also launched their own initiatives on similar like to boost manufacturing their respective states.

Atmanirbhar Bharat

Atmanirbhar Bharat Abhiyan or the self-reliant India campaign was launched in May 2020 amid the Covid-19 pandemic, with a special and comprehensive economic package of Rs 20 trillion, equivalent to 10% of the country's GDP.

The scheme was launched with the primary intent of fighting the pandemic and making the country self-reliant based on five pillars: economy, infrastructure, technology-driven system, demography and demand. The stimulus package announced by the government under the scheme consisted of five tranches, intended to boost businesses including Micro, Small and Medium Enterprises (MSMEs), help the poor (including farmers), boost agriculture, expand the horizons of industrial growth, and bring in governance reforms in business and health and education sectors.

The mission emphasises the importance of encouraging local products and aims to reduce import dependence through substitution. It also aims to enhance compliance and quality requirements to meet international standards and gain global market share.

The government has also rolled out other reforms — namely, supply-chain reforms for agriculture, rational tax systems, simple and clear laws, capable human resource and a strong financial system.

Production Linked Incentive (PLI) scheme

The PLI scheme's prime objective is to make manufacturing in India globally competitive by removing sectoral disabilities, creating economies of scale and ensuring efficiency. It is designed to create a complete component ecosystem in India and make India an integral part of the global supply chain. Furthermore, the government hopes to reduce India's dependence on raw material imported from China. The scheme is expected to boost economic growth over the medium term and create more employment opportunities, as many of the sectors covered under the scheme are labour-intensive. It will be implemented over fiscals 2022-29.

Construction spends across Industrial investments in fiscal 2024 are seen rising 6-8% driven by expansion in oil and gas and metals segment. The growth is on a low base of FY23 where the sector face slight bump due to geopolitical issues in FY21 and FY22. However, The Production Linked Incentives (PLI) scheme is expected to provide the necessary boost to the sector

The stronger than expected pickup in demand and larger companies gaining share from smaller companies also led to revival of capex in FY22. Based on an analysis of eight key sectors, CRISIL MI&A estimates construction investment in the industrial segment at Rs -4.0-4.1 trillion between fiscals 2023 and 2027, rising 1.3 times over spends seen in fiscals 2018 to 2022. The rise in investments is projected due to inclusion of PLI scheme in the capex investments of industrial sector. While the PLI scheme entails 13 sectors, we have only considered 3 capex intensive sectors viz. Auto

Budgeted incentives for each sector under the PLI scheme

Sector	Segment	Budgeted (Rs bn)*	
Automobile	Advance chemistry cell (ACC) battery	181	751.4
	Automobiles and auto components	570.4	
Electronics	Mobile manufacturing and specified electronic components	409.5	545.15
	Electronic/technology products/IT Hardware	73.25	
	White goods (ACE and LED)	62.4	
Pharma and medical equipment	Critical key starting materials/drug intermediaries and active pharmaceutical ingredients	69.4	253.6
	Manufacturing of medical devices	34.2	
	Pharmaceuticals drugs	150	
Telecom	Telecom and networking products	122	122
Food	Food products	109	109
Textile	Textile products: man-made fibre (MMF) and technical textiles	106.8	106.8
Steel	Speciality steel	63.2	63.2
Energy	High-efficiency solar PV modules	240	240
Aviation	Drones and drone components	1.2	1.2
Total			**2,192**

**Approved financial outlay over a five-year period*
ACE: Appliance and consumer electronics; LED: Light-emitting diode
Source: Government websites, CRISIL

Increasing per-capita income

Per-capita income (per-capita NNI) is estimated to have grown 2.3% in fiscal 2020, compared with 5.2% in fiscal 2019. In fiscal 2021, per-capita income declined by 9.7% owing to GDP contraction amid the pandemic's impact on this lower base of fiscal 2021, per capita income rose 7.5% in fiscal 2022.

However, per-capita income is forecast to improve in line with GDP growth. This will be an enabler for domestic consumption. According to IMF estimates, India's per-capita income (at current prices) is expected to increase at a 10.5% CAGR over calendar years 2022-27.

2.2 Near-term outlook on agriculture, industrial and services GDP

2.2.1 The services sector is the main growth driver

In fiscal 2020, the services sector accounted for 55.3% of India's GDP, compared with 52.4% in fiscal 2015. However, its share dipped to 53.6% in fiscal 2021 due to the pandemic. Fiscal 2022 witnessed marginal improvement in its share with gradual normalization of market operations.

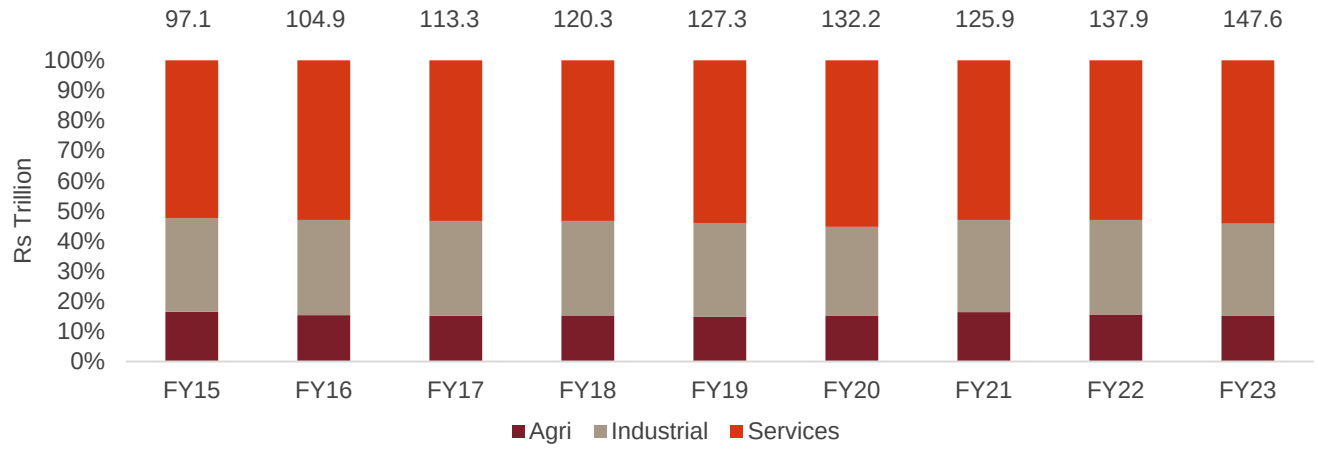
The industrial sector, which is the second-largest contributor, maintained its share in GDP, as the sector logged a 7.1% CAGR over fiscals 2015-19. Industrial contribution declined in fiscal 2020 with the slowdown in economic development. Before overall economic activity slowed down in fiscal 2020, India's industrial sector output growth was supported by the Make in India initiative, rising domestic consumption and GST implementation. The initiatives improved India's position on the World Bank's Ease of Doing Business index to 63 in fiscal 2019 from 142 in fiscal 2014.

The Covid-19 pandemic and subsequent lockdowns exacerbated the economic slowdown in fiscal 2021. The services segment was the worst affected and declined 7.8% on-year, followed by industrial, which declined 3.3% on-year. Agriculture was the only sector that grew 3.3% on-year and restricted the fall in GDP.

In fiscal 2021, the agriculture sector's share in GVA at constant prices expanded, while the share of services and industrial contracted.

Agriculture GVA continued to grow at a steady 4.0% in fiscal 2023. Faster GDP growth in fiscal 2023 saw the share of agriculture increased during the fiscal. The share of the industrial sector in GDP grew 4% in fiscal 2023, strongly by utility services with a respectable 8%, higher than above all other industrial sectors. Mining grew by 5% while manufacturing and construction added marginal growth momentum from a high base of fiscal 2022. The high base of fiscal 2022 led to moderate growth of the industrial sector in fiscal 2023. The services sector grew by 9% in fiscal 2023. Trade, hotel, transport, and communication THTC saw strong growth to 14% in fiscal 2023 compared to previous fiscal.

Share of sectors in GVA at constant price



Source: RBI, CRISIL MI&A

During fiscal 2023, the Agri sector is expected to continue its growth momentum of ~4% y-o-y, thereby contributing to 15.1% of the GVA. The services sector is expected to provide thrust to the economy with 7.2% growth and a share of 54.2% while the industry sector remains at 30.7% share in fiscal 2023, helping it maintain its contribution.

CRISIL expects the contribution of services to increase and the Agri sector to lose some ground during the year due to higher growth in the services sector.

2.3 Review and outlook on inflation

2.3.1 CPI inflation high on base effect

Inflation, as measured by the Consumer Price Index (CPI), moderated sharply to 4.3% on-year in May, from 4.7% in April. The downward trajectory is mainly because of fall in global oil and commodity prices. The global energy index fell an average 31.1% on-year in the last four months, while the metals index is down 17% on average. Also, the easing supply chain pressures leading to better availability of inputs and therefore reduced pressure on prices. As input cost pressures abate, though retail prices are higher than a year ago, month-on-month the increase is lesser, easier food inflation as the rabi crop enters the market, sequentially food inflation fell 0.2% on a seasonally adjusted on month basis, compared to 0.1%rise in the preceding month. Overall inflation is moderated, for instance food inflation has been easing from past few months and with the latest reading at 2.9%. Encouragingly, there is also easing of sequential momentum much of this is being led by fruits and vegetables, edible oils however pricey cereals and milk continue to exert pressure on overall inflation.

The biggest takeaway from the May 2023 CPI print was the persistent stickiness in core inflation, which stood at 5.1% in May, and same as April, Inflation in some essential categories remained broadly unchanged- health (6.2% vs 6.3%), transport and communication (1.1% vs 1.2%), housing (4.8% vs 4.9%)

Inflation in clothing and footwear moderated to 6.6% from 7.5%. On the other hand, inflation in personal care and effects accelerated sharply to 9.9% from 9.0% in the previous month as inflation in gold (18.2% vs 13.8%) and silver (13.0% vs 4.7%) accelerated.

Fuel inflation settled at 4.6% in May vs 5.5% previous month. The lowest rate since March 2021. A large part of this fall was due to a high base and moderating global crude oil prices. Price of brent crude oil decreased from $84.1/bbl to $75.7/bbl.

Food inflation fell to 2.9% in May from 3.8% in April driven by vegetables (-8.2% inflation), edible oils (-16%) however Pulses saw increase in inflation to 6.6% from 5.3%. Though inflation in cereals cooled, it remains in double digits at 12.7%. The easing in cereals inflation was led by cooling inflation in wheat (from non-PDS sources) (12.6% vs 15.4%). As inflation in wheat remains in double-digits, the government signalled that it would continue to ban exports of wheat. The government has also imposed stocking limits on wheat and some pulses till the next crop arrivals in March 2024 and October 2023, respectively for these crops.

WPI-linked inflation single again

Inflation based on the Wholesale Price Index (WPI) eased sharply again in May to -3.5 from -0.9% in April (and 1.4% in March). This is the twelfth consecutive month of moderation in WPI inflation. WPI inflation is easing largely on base effect, and some sequential easing of some food groups. WPI pressures eased for manufactured product such as foods, textiles, and chemicals however inflation is hardened in electrical material and pharmaceuticals.

Fuel and power WPI inflation also slipped into the deflation zone to -9.2% from 0.9%. Inflation in coal moderated (2.5% vs 3.2%), while prices of mineral oils fell by 16.2% on-year. Inflation in electricity moderated sharply to 9.7% from 20% .

Inflation outlook

CPI inflation may moderate in the coming months as base effect comes into play. Going ahead, food inflation falls led by edible oil, vegetables, and some softness in cereals. However elevated inflation rate in milk, cereals, species, and recent uptick in pulses remains a monitorable. In the months to come, rainfall conditions will play a key role in shaping food inflation.

Amongst the food category, inflation in milk has been elevated over the last year driven by higher procurement cost. Demand of milk remains high while stocks of dairy products are lower than the previous year prompting the government to consider importing milk and/or milk products. The easing in cereals inflation was led by cooling inflation in wheat. As inflation in wheat remains in double-digits, the government signalled that it would continue to ban exports of wheat. The government has also imposed stocking limits on wheat and some pulses till the next crop arrivals in March 2024 and October 2023, respectively for these crops.

Some relief on fuel inflation can be expected if the recent decline in Brent crude oil prices is sustained (which would bring down domestic fuel prices at the pump).

Considering these factors, CRISIL M&I Projects CPI inflation forecast at 5% for this fiscal, from 6.7% in FY2023. A supportive monsoon is a key assumption underlying this forecast. In this scenario, CRISIL expect the Monetary Policy Committee (MPC) to maintain a pause as it continues to watch the impact of past rate hikes. As growth slowdown seeps in and inflation moderates, we expect it to cut rates by the end of this fiscal.

The Indian Meteorological Department has predicted overall normal rains this year. However, timeliness and regional distribution are very critical for crop production, price signaling and hence inflation expectations. With rabi harvest entering the market, some respite for cereal and pulses prices could be felt in the next 2-3 months. However, any distortion in rains could bring a reversal of gains in categories experiencing low/easing inflation (vegetables and edible oils), or worse, keep inflation elevated in cereals. However, some recently announced policy measures (imposing stock limits on wheat and pulses, and possible imports of milk or milk products) could cap some of the upside to food inflation..

3 Global cryogenic equipment industry

3.1 Overview of cryogenic gases

Industrial gases are used in industrial processes for manufacturing products in a wide range of industries, including oil and gas, petrochemicals, chemicals, power, mining, metals, pharmaceuticals, electronics, glass and aerospace. Nitrogen, oxygen and natural gas are the major gases which would account for almost 80% of the cryogenic equipment demand. Other gases would include argon, helium, nitrous oxide, ethylene, and carbon dioxide.

These gases are produced by a gas production plant called an air separation unit (ASU), which filters and cools the atmospheric air to very low temperatures. As gases are cooled, they turn into liquids. However, each gas liquefies at a different temperature. This property enables the separation of gases by distillation with very high purity levels. The output of this process is available as a liquid at a very low temperature (below -150°C) and is called cryogenic gas.

Another major segment of cryogenic gases is the energy segment, which consists majorly of natural gas and, to a smaller extent, hydrogen. Liquefied natural gas (LNG) is produced by the oil and gas industry through exploration and extraction of underground gas reserves and cooling it to about -162°C which liquefies it making it convenient for storage and transportation. Hydrogen can be produced in many ways, including from fossil fuel sources such as LNG and from renewable sources through electrolysis of water.

As long as cryogenic gases are kept cool, they stay in liquid form and can be held at a lower pressure. Very large quantities can be contained in a smaller tank compared to their gaseous form, which requires high-pressure tanks that hold a lower amount of gases by weight. If the temperature of a cryogenic liquid increases by absorbing heat from its surroundings, it turns into gas, increasing the pressure inside the equipment. To prevent this, the equipment has to be properly insulated and it also requires some pressure build up based on its design. There are regulations developed and maintained as per the application and product to ensure the safety of people working with or around these gases, and the environment into which these gases might escape.

The equipment used to store, transport and handle the cooled gases in liquid form is collectively called cryogenic equipment. ASU's form about 58-62% of the demand for total global cryogenic equipment consumption in CY2021. The major cryogenic equipment includes tanks, valves, vaporisers and pumps. The other equipment includes pipes, regulators, freezers, storage dewars, strainers, samplers, heat exchangers, leak detection equipment, dispensers, and accessories (manifolds, fittings, vacuum jacketed/insulated piping, hoses, and connections). The market sizing of cryogenic equipment included below includes all cryogenic equipment used for storage, handling and distribution of industrial gases as well as gases used for energy such as a LNG and hydrogen and includes air separation units, liquefiers and LNG bulk carriers.

Not all gases require cryogenic equipment for storage and handling. The output of an ASU are gases in cryogenic state which also makes them convenient to transport as they take us less volume. LNG is also cooled to its liquid state as it allows for separation of impurities and unwanted gases. This process also reduces the volume required to 1/600th the volume compared to the gaseous form at atmospheric pressure which makes it convenient for transportation. For overseas transportation, LNG bulk tankers are used to transport LNG to an LNG terminal at the destination port. Distribution of cryogenic liquids needs to be done in special insulated tankers which keep the cryogenic liquids from boiling and escaping into the atmosphere. However, when these gases are to be put to use, they may be required to be converted to their gaseous form either due to the end-use requirement or lack of

cryogenic equipment at the end use location. For e.g., medical oxygen is required to be converted to a gas from its liquid form at a hospital where it might be stored in a cryogenic tank. However, in locations where cryogenic tank storage is not available, the gas is also distributed and stored in high pressure cylinders. This is usually the case at end use locations where the gas requirement is lower. High pressure cylinders are not included in market sizing of cryogenic equipment.

3.2 Cryogenic industry supply chain

There are four major groups in the cryogenic industry:

- Raw material manufacturers: They include metal and metal part manufacturers that produce large quantities of steel and steel products, which are the major raw materials for cryogenic equipment, along with other metals such as copper and nickel alloys, chromium, and titanium.
- Cryogenic equipment manufacturers: They manufacture equipment such as tanks, valves, and vaporisers, which enable storage and handling of cryogenic gases. The equipment is supplied to gas companies for manufacture, storage, and transportation of industrial or energy gases such as LNG or hydrogen. It is also supplied to end-users of such gases.
- Gas suppliers: They include industrial gas manufacturers operating air separation units, or oil and gas companies producing LNG.
- End-users: They are industries where such gases are used, e.g., steel, glass, semiconductor, and hospitals.

3.3 Regulations governing cryogenic gas equipment

Because of risks involved with malfunctioning cryogenic equipment, there are stringent regulations with regard to design, manufacture and operation of such equipment. These regulations vary based on type of equipment and area of operation, and also across regions to some extent.

Certification standards for each category of equipment is developed or maintained by an organisation with expertise in the area, such as American Society of Mechanical Engineers (ASME) and International Organization for Standardization (ISO), which specify specification/procedures for the manufacture of cryogenic equipment. These standards are usually required to be adopted by law in a country, and are enforced by one or more government bodies, based on the application of the equipment. Some standards could be accepted by a large number of countries, which allows for the equipment to be quickly imported and put into service, while some countries may provide expedited approvals of the equipment that already has approvals based on globally accepted standards.

Nevertheless, local laws could require additional approval for import, installation and use of cryogenic equipment from the local authority governing the application or industry. For e.g., in India, Petroleum and Explosive Safety Organisation is authorised to approve vessels to transport hazardous material, while US Department of Transport's approval is required for the transport of hazardous material in the US. The stringency related to design and manufacture and number of regulations in the segment is an additional barrier to entry for new players in the segment.

The major global organisations that specify and maintain standards related to cryogenic equipment across geopgraphies are:

- USA: American Society of Mechanical Engineers (ASME) provides the public and private sectors with a wide range of safety codes and standards. These are managed by the Board on Safety Codes and Standards (BSCS). In fact, the BSCS is responsible for the management of all ASME activities related to codes, standards, and accreditation and certification programmes directly applicable to safety codes, safety standards, and related accreditation and certification. For e.g., it develops and maintains eight major codes addressing safety. Of these, ASME Boiler & Pressure Vessel Code Section VIII details requirements applicable to the design, fabrication, inspection, testing, and certification of pressure vessels operating at internal or external pressures exceeding 15 pounds per sq inch, while ASME B31 is related to piping. Similar standards are present for other types of cryogenic equipment.
- EU: European Standards, which includes over 20 publishers of standards, including ISO and BS (British Standards) from the British Standards Institution, specify requirements for cryogenic equipment for use in the EU. For e.g., BS EN 1626:2008 specifies the requirement for cryogenic valves.
- Global: International Organization for Standardization (ISO) also maintains globally accepted standards. ISO21011:2008 is required for cryogenic valves, while ISO3834 specifies requirements for fusion welding of metallic materials that are part of a process in the manufacturing cryogenic equipment, such as tanks.
- Global: For devices running in environments with there could be a potential explosion possibility, additional certifications may be required such as ATEX/IECEx/PESO etc. ATEX, an initialization of the French term Apparels destinés à être utilisés en ATmosphères EXplosibles (French for "Equipment intended for use in explosive atmospheres"), is a set of European Union regulations that ensure products used in explosive environments are safe. Environments with flammable gases, mists or vapours or combustible dusts along with air and an ignition source could be a potential explosion hazard and are required to be tested and certified by the ATEX certification based on the categories of equipment and zones of operation. Similar to ATEX, IECEx (International Electrotechnical Commission Explosive Atmospheres) another certification is an internationally accepted method based on standards developed by IEC (International Electrotechnical Commission) in the field of electrotechnology. For e.g., these certifications are required for equipment used in auto fuelling stations since automobiles used electrical systems and can be an additional risk factor. In India the certification for equipment used in fuelling stations would fall under PESO.

Adhering to these standards are required to ensure that the certified equipment is fit to be used in a particular application from a safety point of view. The certification of the equipment is done by a qualified inspector authorised by a reputed organisation, such as the National Board of Boiler and Pressure Vessel Inspectors (NBBI), ASME, etc. Equipment meeting all requirements can be stamped with a mark from the standards organisations. For e.g., ASME U stamped equipment may be a requirement when installed in an area where people are present. It could also be an essential requirement by insurance companies in case the facility needs.to be insured.

Similarly, cryogenic equipment manufacturers could secure other accreditations based on quality and expertise of their plants for specific activities, such as design only, metallic or non-metallic repairs, and/or alterations, either only in the shop, only in the field, or in the shop as well as the field. For instance, NBBI provides certificates of authorisation to use the ‘R’ symbol stamp for repair or alteration of equipment.

Other institutions with specialised expertise may provide their own certification to suppliers that can meet their quality standards. For e.g, International Institute of Welding, which is a premier welding R&D and educational institute, provides certification on specific techniques that are used in the manufacture of cryogenic equipment.

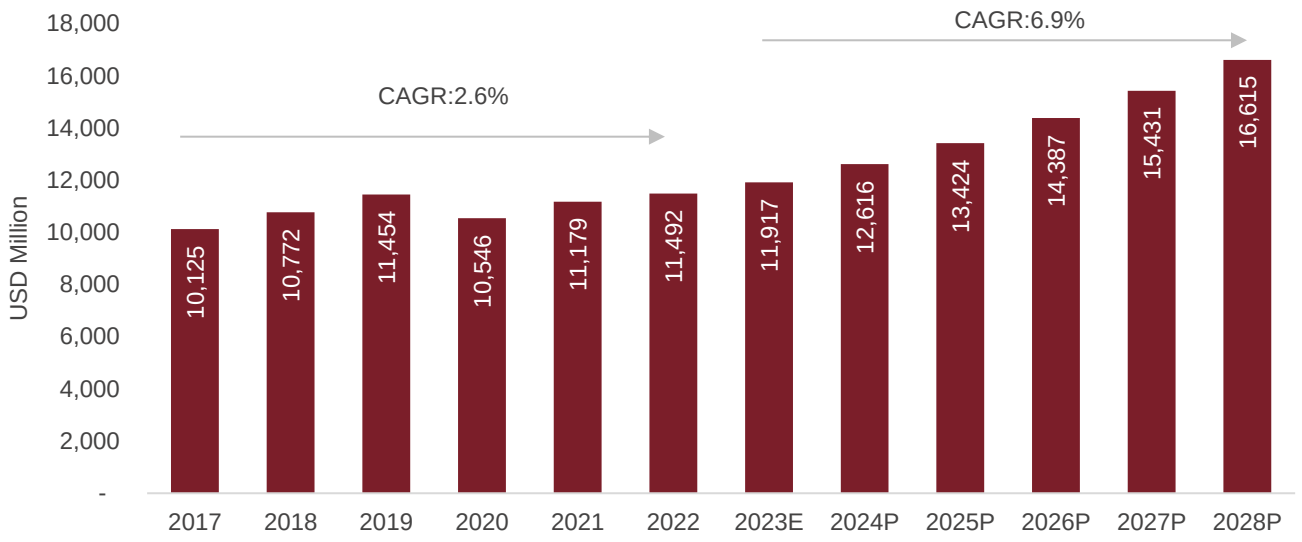
Many of the certifications are provided for a limited duration and need to be renewed periodically to ensure that the quality of the product / process is maintained.

3.4 Market size of global cryogenic equipment industry

The global cryogenic equipment market was valued at $11.5 billion in CY2022. Global cryogenic equipment demand clocked 2.6% compound annual growth rate (CAGR) between CY2017 and CY2022. Demand saw a dip during the Covid-19 period of CY2020 and CY2021, declining at 1.2% CAGR between CY2019 and CY2021, as economic activity slowed down. However in CY2022, demand surpassed pre-Covid-19levels marginally.

Global cryogenic equipment demand is projected to reach $16.6 billion by CY2028, logging 6.9% CAGR between CY2023 and CY2028. Demand for cleaner fuels such as LNG and hydrogen due to focus on reducing carbon emissions from conventional energy sources will drive the uptake of cryogenic equipment across geographies. Additionally, the increase in industrialisation in developing nations in Asia Pacific is expected to boost demand for industrial gases in segments such as electronics, space and satellite and in turn, increase demand for cryogenic equipment.

Global cryogenic equipment demand



E: Estimated; P: Projected
Source: Markets and Markets, CRISIL MI&A

3.4.1 Key applications of cryogenic equipment

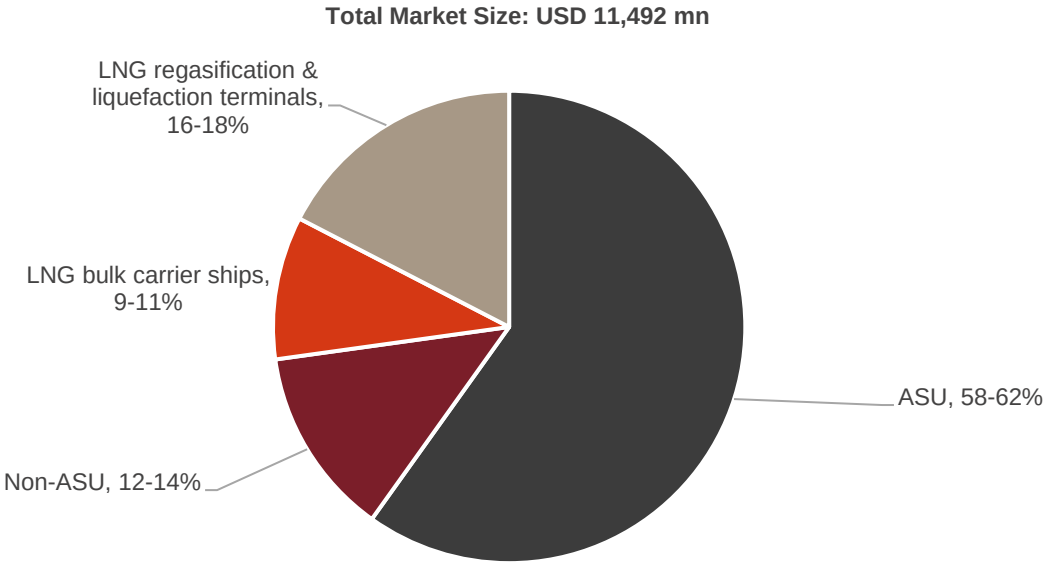
The equipment used to store, transport and handle the cooled gases in liquid form is collectively called cryogenic equipment. ASU's form about 58-62% of the demand for total global cryogenic equipment consumption in CY2022. The major cryogenic equipment includes tanks, valves, vaporisers and pumps. The other equipment includes pipes, regulators, freezers, dewars, strainers, samplers, heat exchangers, leak detection equipment, dispensers, and accessories (manifolds, fittings, vacuum jacketed/insulated piping, hoses, and connections).

LNG applications form another major market for cryogenic equipment due to the large volume of natural gas demand and the subsequent need for its transport, storage and distribution. Of these application LNG bulk carrier ships and LNG terminals for liquefaction and regasifications are the major demand segments. LNG bulk carrier

ships are marine vessels that enable the transportation of large quantities of liquified industrial gas which accounts for 9-11% of the total global cryogenic equipment demand while LNG liquefaction and regasification terminals are facilities that convert the industrial gas into its liquid and gaseous states, respectively, to facilitate storage and transporation of large volumes of natural gas economically over long distances. This segment accounted for 16-18% of the total cryogenic equipment demand in CY2022.

All other applications of cryogenic equipment are grouped under non-ASU segment, which includes rail and road transport, small-scale/temporary storage, cryopreservation, research studies, satellite launch facilities, cryogenic process technologies and cryogenic electronics, such as superconducting magnet systems, low-temperature detector systems and infrared array systems, among others.

Share of applications for cryogenic equipment CY2022

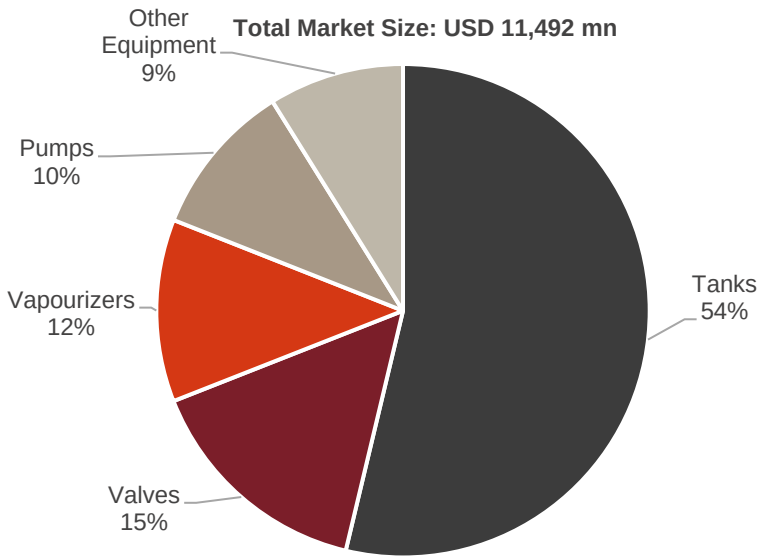


Source: Markets and Markets, CRISIL MI&A

3.4.2 Types of cryogenic equipment

Of the types of equipment used, tanks used for storage and transportation form a major share with over half of the total cryogenic equipment demand. The other major types of equipment are valves which are used to control flow and for safety at 15%, vapourisers which convert cryogenic liquids to gaseous form at 12% and pumps at 10%. The other equipment accounting for 9% includes pipes, regulators, freezers, dewars, strainers, samplers, heat exchangers, leak detection equipment, dispensers, and manifolds, fittings, vacuum jacketed / insulated piping, hoses, connections etc.

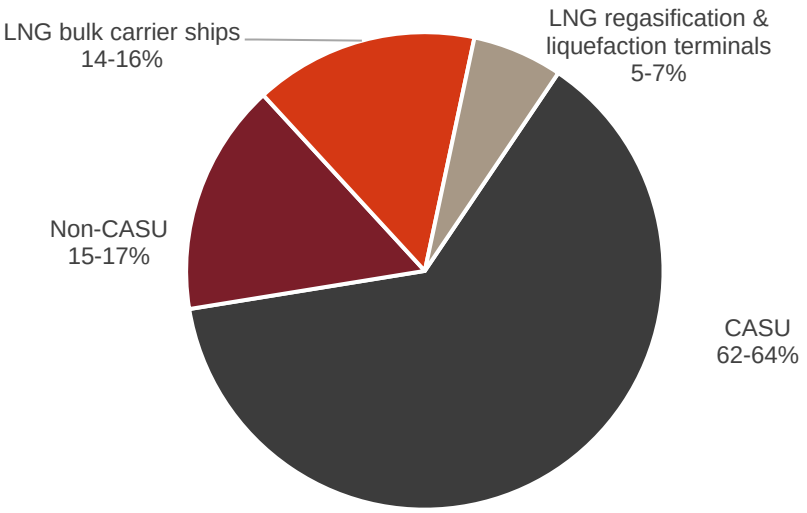
Share of type of cryogenic equipment CY2022



Source: Markets and Markets, CRISIL MI&A

At 54%, tanks account for an estimated $6,175 mn of the total global cryogenic equipment demand out of which ASU's for a major share of demand account for a little under 2/3^{rds} of the demand. LNG bulk carrier ships account for 14-16% of the demand while LNG terminals accounted for 5-7% of the demand. The rest of the demand for tanks from transport and storage accounted for 15-17% of the demand.

Share of applications for cryogenic tanks CY2022



Total Market Size: USD 6,175 mn

Source: Markets and Markets, CRISIL MI&A

3.4.3 Impact of Covid-19 on the cryogenic gas equipment industry

The pandemic had an adverse impact on the cryogenic gas equipment industry as restrictions on travel and non-essential activity across many regions reduced the demand for goods and services. Demand for industrial gases and energy was also impacted. The industries most impacted were oil and gas owing to travel restrictions, while many industries slowed down because of lack of supply of parts.

However, demand for medical oxygen rose sharply during peak of the Covid-19 waves. During the peaks, demand for cryogenic equipment rose sharply, especially for tanks and oxygen production plants, such as pressure swing adsorption units that can be smaller and produce oxygen at required level of purity for supply to hospitals. Demand for oxygen containers such as tanks also rose to the extent that supply was not able to cater to demand during peak requirement in some countries such as India where equipment for use in other industries had to be converted to make it suitable for use in the healthcare industry and was used to supply oxygen to hospital.

Although demand for liquid oxygen equipment declined in CY 2020 and CY 2021 as Covid-19 impacted industrial demand, demand from medical use cushioned a sharper fall. Hence, cryogenic equipment demand from the oxygen segment was affected to a lower extent compared with other cryogens. However, as share of medical oxygen demand comprises a smaller share of overall oxygen demand, at 15-20%, overall demand for cryogenic equipment from oxygen segment declined during CY 2020 and CY 2021 at a CAGR of 0.9% over 2019 peak as compared to a growth of 6.6% CAGR between CY 2016 and CY 2019.

With the readiness of medical oxygen supply tested, there has been increase in interest to ensure that the situation does not arise again in case of another Covid-19 wave, leading to a rise in medical oxygen infrastructure. Although Covid-19 subdued industrial gas and in turn cryogenic equipment demand, it had the opposite effect on semiconductor demand. As economies around the world went into lockdown with global air travel and local restrictions on non-essential travel came into force, people were reliant on digital and remote work technologies like never seen before. Demand for computing devices shot up while supply chains were clogged shooting up prices. People without access to fast internet and computing devices were at a huge disadvantage. The demand for routers, phones, tablets, laptops, desktops etc. drove demand for electronic chips. As people were locked down in their homes, home comfort became another essential increasing demand for consumer durables such as air conditioners, TV’s etc. while post-Covid boom for personal transport increased demand for automobiles and electronic chips which are also used in these vehicles. All of this combined has caused a shortage of semiconductor devices, thereby driving investments in the semiconductor sector for capacity expansion. Accompanied by increasing demand for digital technologies such as cloud, IoT, AI/ML etc, and improving productivity across industries, demand for cryogenic equipment from the electronics segment is expected to see the fastest growth across industries between 2023 and 2028.

3.4.4 Key demand drivers

High demand for gases from the metallurgy sector

The metallurgy industry uses industrial gases in processes such as metal forming, fabrication, welding and combustion — oxygen and nitrogen are the most commonly used industrial gases. Oxygen is an integral industrial gas used in the production of steel. According to the World Steel Association (WSA), ~73% of global steel production is done using the oxygen process (basic oxygen process). As demand for steel increases, demand for oxygen is likely to accelerate, creating demand for oxygen-related cryogenic equipment**.**

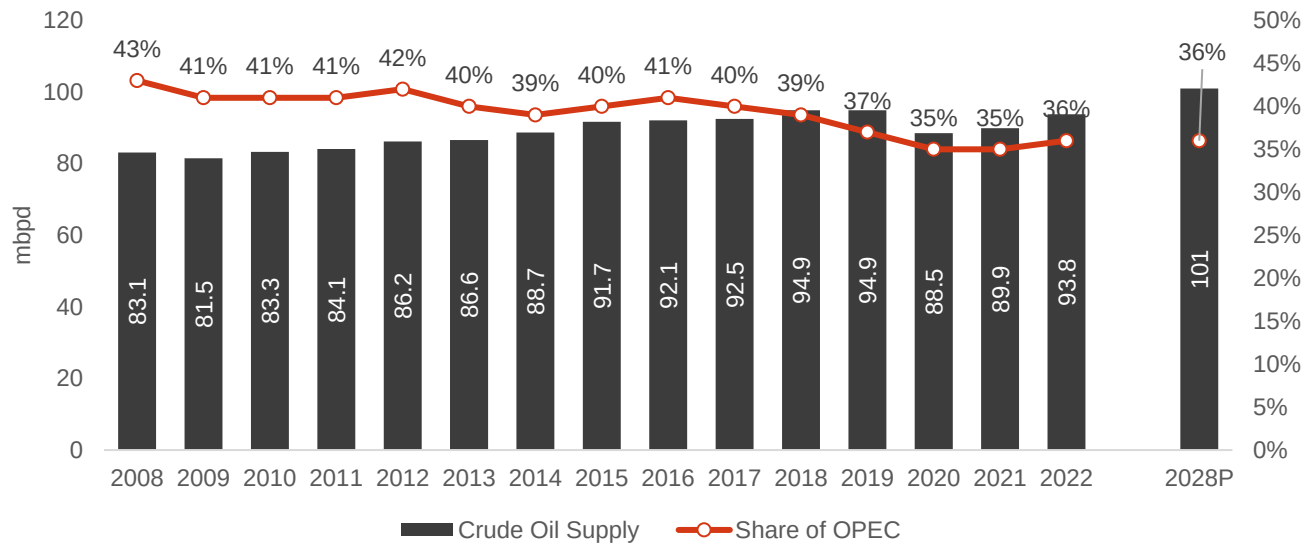
In the US, the Build Back Better Act has multiple provisions for public health, greenhouse gas reduction, and manufacturing. It also proposes building a supply chain for critical goods. The Act will increase spending on manufacturing plants, clean energy and green technologies, driving investments in electric vehicle production and charging infrastructure, along with hydrogen infrastructure and health infrastructure with a total outlay is estimated to be $1.64 trillion over 10 years. The demand for metals such as steel and aluminium and fabrication of metal products will support demand for cryogenic equipment required to handle gases such as oxygen, LNG etc.

China has been pushing its Belt and Road Initiative for improving connectivity from China to Europe, the Middle East and Africa, where up to $900 billion worth of projects are estimated to be under execution. In India, the National Infrastructure Pipeline (NIP), announced by the government to improve project preparation and attract investments into infrastructure, has up to $1.87 billion worth of projects in the pipeline as per the NIP portal on India Invest Grid. Such projects are expected to drive demand for metals, especially steel and aluminium supporting demand for cryogenic equipment.

Production of metals such as steel and aluminium is set to increase as infrastructure activity, automobile production (especially of electric vehicles) and consumer durables demand are expected to rise, driven by an increase in population, urbanisation, and rising consumption (especially in developing economies). Further, development of high-strength metal alloys with high rigidity and stiffness for emerging applications is expected to drive the growth of the metallurgy sector.

Demand from the oil and gas sector to rise with recovery in global economy

Global crude oil supply outlook



Source: CRISIL MI&A

In 2020, oil suppliers were forced to restrict production due to demand contraction on account of Covid-19. Global oil supply is estimated to have increased in 2022 led by easing of supply by the Opec+ members. In 2023, Supply is expected to grow further by 0-2 mbpd breaching pre-Covid-19levels. . Going forward, the share of the Organization of Petroleum Exporting Countries (OPEC) in global crude oil production is expected to decline by 2025. OPEC countries met over 40% of the world's crude oil supply over the past few years. But the share has been declining gradually. The cartel contributed to ~35% of overall production in 2021, down from ~41% in 2017. Considering the resistance from OPEC to increase crude oil production to restrict decline in crude price, we expect its share to remain below 40% by 2027. Further, production from non-OPEC countries such as the US is expected to increase. The share of OPEC in total oil production has fallen due to supply disruptions and production cuts in line with the market sentiments. On the other hand, production from non-OPEC countries have also increased, especially from the US.

CRISIL projects the global supply of crude oil rise to remain gradual and tepid during the five year forecast period. We expect supply to increase by 6-8 million barrels per day (mbpd) between the calendar years 2012 and 2027.

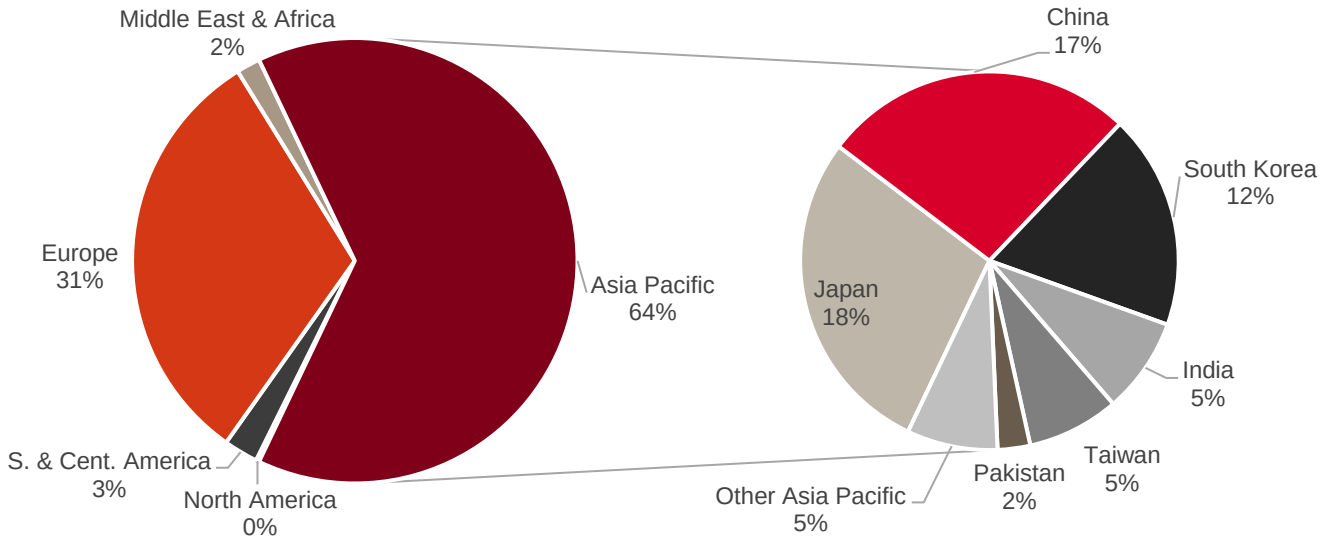
Crude oil prices have continued to be on an upward trajectory since the end of-2021. They became even higher with the Russia-Ukraine conflict, which led to the prices averaging $100 per barrel (bbl) in 2022. The prices averaged $106 per barrel in the first half of 2022 owing to the Russia-Ukraine conflict, which resulted in a significant shift in the overall crude oil supply chain. Going forward, with further de-escalation of the crisis and balancing of global crude oil trade, we expect prices to cool further, settling at $75-80 per barrel in 2023. .

CRISIL MI&A expects oil supply from the Middle East to increase by about 3-4 mbpd (million barrels per day) during CY 2022 - CY 2027. Countries, such as Iraq and the UAE, are expected to keep the oil flow strong post oil production cut deal valid up to 2023, and would together account for slightly over 1 mbpd of the incremental production.. Saudi Arabia and Kuwait will be the other major contributors. Overall crude oil production in US, including condensate production, increased by ~1% on-year to 16.59 mbpd in 2021. Going forward, the pace of production will increase 2-3 mbpd between 2020 and 2027. . As far as oil production from Canada is concerned, supply is expected to increase by 0.6-0.8 mbpd between 2021 and 2027. Over the next five years, North American oil production will likely see an increase of 3-3.5 mbpd between 2021 and 2027 as against ~4.6 mbpd added between 2015 and 2019.

In the oil and gas industry, the downstream processes require the use of industrial gases such as nitrogen, hydrogen, oxygen and carbon dioxide for chemical synthesis. Nitrogen and carbon dioxide are also used as injection fluids for enhanced oil recovery (EOR) and used widely for gas cycling, reservoir pressure maintenance and gas lift in the oilfield process. With the increase in demand for oil and gas as global economic recovery gains steam from an extended Covid-19 slump, oilfield operators are also increasing production to meet rising demand. Cryogenic equipment is required in these oilfields for the storage and handling of liquefied industrial gases and for converting them into useful gaseous form. Thus, growing oil production from existing mature wells through EOR and from newly drilled wells across the world is expected to drive growth of the cryogenic equipment market.

Shift to lower-carbon fuels to drive demand for LNG

Share of global LNG trade (CY2022)



Source: BP Stats, CRISIL MI&A

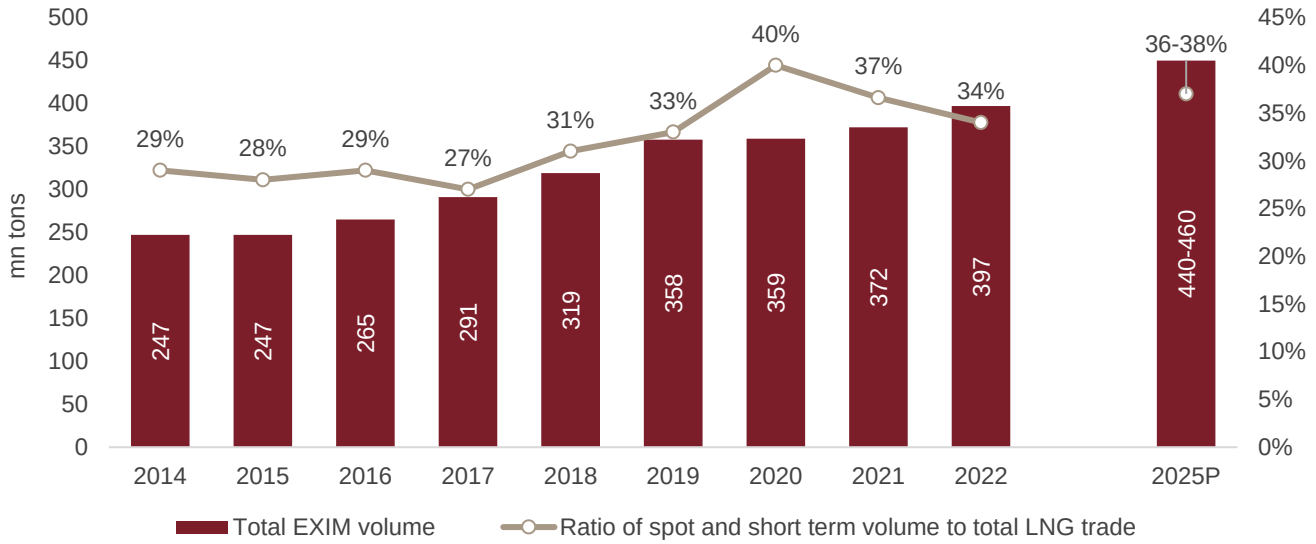
Global LNG trade posted a CAGR of ~7% between 2017 and 2022 to ~397 million tonne.. Demand was primarily driven by European nations post steep supply cuts from Russia. Asian nations, such as China, India, Japan and

South Korea, which increasingly shifted to gas from alternative energy sources, such as coal, crude oil and nuclear power.. LNG availability also improved because of large-scale capacity additions by Australia and the US, which accounted for the majority of new liquefaction capacities commissioned over the past five years. LNG liquefaction terminal capacity, also increased in 2021 with new capacities of 7.4 MTPA taking the total to 462 MTPA. In terms of LNG liquefaction terminal capacity, Australia and Qatar led with terminal capacities of 87.6 and 77.1 MTPA, respectively, as of 2020.

Asian economies account for over 70% of the total LNG trade. China and Japan are the largest markets for LNG trade accounting for about one fifth of the global LNG trade volume. China overtook Japan as the top LNG importer recoding a 15% increase imports driven by a shift to low carbon sources. Japan, though, is expected to remain the one of the largest importers of LNG, although the restart of the country's nuclear reactors would lower import volumes. Also, Chinese LNG demand is expected to grow significantly to over 110 MTPA by 2025, as the country aggressively shifts from coal to natural gas, in line with its long-term plan to combat rising pollution. China has aggressively replaced coal with gas in industries and households, which is evident from the shutdown of coal-based power plants and replacement of coal with gas for residential heating.

The below chart show the LNG trade volume which indicates the supply of natural gas, as generally, natural gas is liquefied to get LNG when it is required to be transporter overseas in LNG container ships while, domestic demand is met though pipelines in gaseous form. Whereas, the demand for LNG is indicated through the ratio of LNG procured in the spot market over and above the contracted LNG volumes which indicates the additional demand for LNG. The demand for LNG has increased with LNG trade volume increasing by ~7% in CY2022 of which the total volume of spot and short term demand reached 135.0 MT in CY2022 accounting for 34.0% of the total trade, lower than 40% seen in CY2020 as demand for spot LNG increasing caused the prices for LNG to increase impacting demad from cost sensitive economies.

Global LNG demand versus supply



P: Projected

Source: CRISIL MI&A

The procurement for LNG in spot market is expected to remain moderate through CY 2025 as higher prices dent the demand in the spot market however, overall LNG demand including contracted volumes are expected to continue to increase through CY 2025. In the long run, CRISIL projects global liquefied natural gas (LNG) demand

to grow at a healthy pace of 5-6% CAGR up to 2025 to 480-500 million tonne per annum (MTPA). Demand would mainly be driven by Asian economies, such as China, India and South Korea, along with emerging demand centres, such as Europe, Bangladesh and Pakistan. CRISIL expects significant new LNG export capacity additions over the next five years, leading to a surge in global LNG supply. In 2020, 19.95 MTPA of liquefaction capacities were added, taking the total global installed capacity to ~450.5 MTPA. This included commissioning of States Freeport LNG and States Cameron LNG in the US. In CY 2021, LNG liquefaction terminal capacity, also increased in 2021 with new capacities of 7.4 MTPA taking the total to 462 MTPA. This included 1.5 MTPA Petronas Floating Liquified Natural Gas (PFLNG) Dua floating offshore liquefaction unit at Sabah, Malaysia, and a new large-scale, 5 MTPA capacity installed at Sabine Pass liquefaction train in the US. In 2023, new supplies of 5.8 MTPA are expected to be commissioned. Between 2021 and 2025, we expect 7-8 MTPA of liquefaction terminals to be commissioned each year. These capacity additions will be led by the US. Owing to surging domestic gas production and low prices, the US started exporting LNG in 2016 - it began exports with the commissioning of the first train (4.5 MTPA) of the 18 MTPA Sabine Pass LNG terminal. Over the next five years, we expect new terminals of ~140 MTPA capacity to start operations across the globe, driven by the US.

The recent growth in the LNG market is proportionately boosting demand for cryogenic equipment in this industry. While renewable energy is cleaner, it does not produce power at a steady rate; in the case of solar, power is only produced during the day. LNG-based supplementary power producing systems aid in reducing emissions while maintaining power supply during peak demand. These factors are driving demand for cryogenic equipment in the energy and power industry. Opportunities for cryogenic equipment in decarbonisation are expected to be significant as countries try to meet their decarbonisation goals. For example, to achieve the France 2030 plan, the government has allocated a total of ~$6.14 billion (EUR 5.6 billion) to decarbonise industrial sectors such as steel, cement, chemicals and metallurgy. Such efforts are likely to benefit LNG and hydrogen demand and, in turn, drive demand for cryogenic equipment.

Chemicals industry's decarbonisation and transition to more sustainable process to fuel growth

In the chemicals industry, industrial gases such as nitrogen, argon, hydrogen and helium are used for various applications such as polymerisation, synthesis of intermediates, freeze drying, storing biological samples and drugs, and preparation of laboratory and pilot production-scale cold baths. The chemicals industry had been facing cyclical pressures before the Covid-19 pandemic began, and this scenario had become worse post the pandemic. Going forward, strong demand for both commodity and specialty chemicals is expected due to the recovery of many economies from the pandemic. One of the major areas of focus for chemical companies in the near future will likely be sustainability and decarbonisation. Many chemical companies are expected to increase investment in research and development (R&D) capabilities and leverage advances in decarbonisation and recycling technologies to lower their and their customers' carbon footprint, as well as reduce plastic waste. Further, the recovery in global economic growth coming out of the Covid-19 period with easing of restrictions will increase demand for industrial gases in the chemicals industry, consequently driving demand for cryogenic equipment.

3.4.5 Opportunities in the cryogenic equipment market

Hydrogen demand from multiple industries to surge as cost of green hydrogen falls driven by need to reduce carbon footprint

There has been increasing interest in hydrogen in recent years as it is considered to be a versatile green energy source when produced from renewable sources though electrolysis. The newest applications of hydrogen, such as fuel cells in the transportation and energy-related industries, are also gaining momentum. Several countries are

beginning to experiment with hydrogen as a source of power for industries such as transportation, steel and fertilisers to reduce carbon emissions.

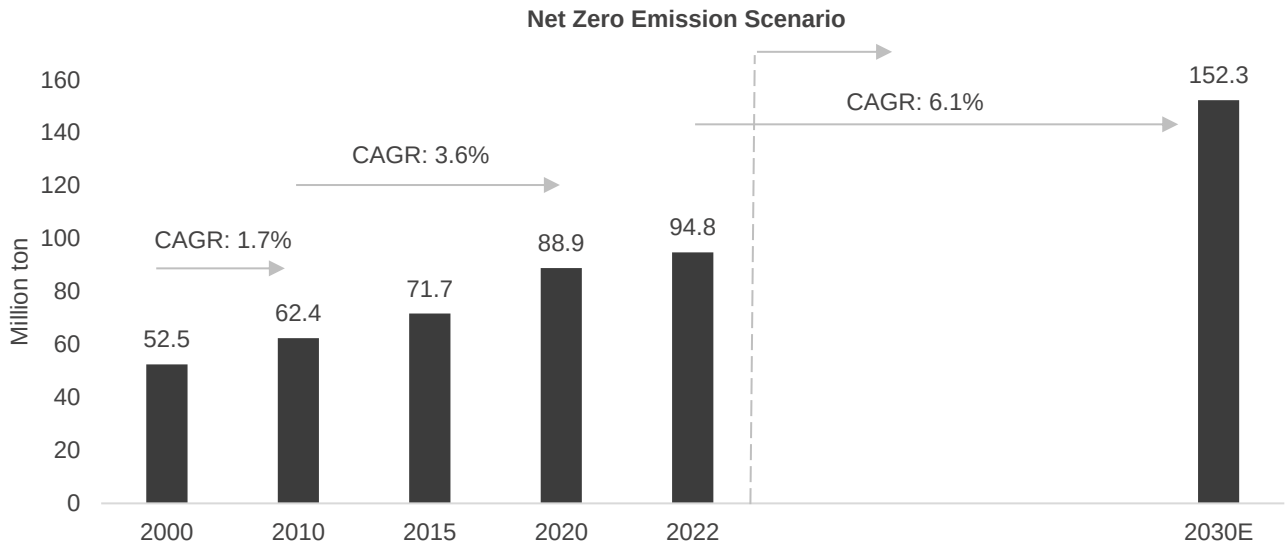
Steel is one of the most energy-intensive industries. According to a WSA study in CY 2020, every tonne of steel produced emits about 1.85 tonne of carbon dioxide into the atmosphere. In CY2020, 1,860 MT of steel was produced, which resulted in total direct emissions of 2.6 billion tonne, representing between 7% and 9% of global anthropogenic carbon dioxide emissions. The urgency to move to a lower carbon footprint by steel-consuming industries has resulted in steel manufacturers looking for alternatives such as 'green steel' made using 'green hydrogen', i.e., hydrogen produced from renewable energy sources.

In Sweden, steel giant SSAB and mining company LKAB have a joint venture named HYBRIT (Hydrogen Breakthrough Ironmaking Technology), which has already started commercial deliveries of steel made from green hydrogen. In India, Vedanta's Sesa Goa Iron Ore Business is seeking a tie-up with IIT Bombay to develop processes for manufacturing green steel.

However, the high cost of hydrogen and the equipment utilising hydrogen (such as fuel cells) poses challenges. Secondly, infrastructure for hydrogen distribution is almost nil. Hydrogen, especially green hydrogen, is prohibitively expensive to produce and distribute. These challenges are being worked on to make hydrogen economically and technologically viable.

According to International Energy Agency (IEA), demand for hydrogen had been growing at a tepid 1.7% CAGR between CY2000 and CY2010 which has increased in the next decade to 3.6% CAGR between CY2010 and CY2020. Global hydrogen use reached 95 Mt in 2022, a nearly 3% increase from 2021, continuing the growing trend that was only interrupted in 2020 as a consequence of the Covid-19 pandemic and the economic slowdown. As per International Energy Agency (IEA) estimates, in the next zero emission scenario the demand for hydrogen can increase at a rapid pace at a CAGR of 6.1% between CY2022 and CY2030. However, IEA estimates that even this pace is below what is required to meet the net zero emission scenario by CY2050.

Hydrogen demand (MT)



Source: IEA (2023), Hydrogen, IEA, Paris https://www.iea.org/reports/hydrogen, CRISIL MI&A

Hydrogen can be produced in multiple ways, including through fossil fuels such as natural gas, where hydrogen and carbon are separated through a process call steam methane reformations — this hydrogen is called 'grey

hydrogen', while that produced from coal is called 'black hydrogen' or 'brown hydrogen'**.** However, when the carbon content produced during hydrogen production is captured and utilised or stored instead of being released into the environment, it is called 'blue hydrogen'. This can provide similar benefits as green hydrogen, which is the cleanest form of hydrogen, produced from electrolysis of water. The by-products of electrolysis are hydrogen and oxygen when produced using power from renewable sources such as wind, solar and hydro. However, the cost of producing green hydrogen is very high for it to be considered viable against currently used fossil fuels. Another challenge with hydrogen is the way it is utilised to produce electric power though fuel cells. These are also nascent technologies that needs to be further refined to improve its operating characteristics; moreover, they are expensive to operate.

Additional applications for hydrogen such as jet fuel, fuel for ICE vehicles, and use in industrial processes as an alternative to fossil fuel-based sources are likely to emerge in the long term as innovation in process and technologies take place driven by a need to achieve net zero emissions.

As per IEA the cost of production of hydrogen from natural gas ranges from $0.5 to $1.7 per kg and cost of blue hydrogen produced using carbon capture technologies is expected to range between $1 to $2 per kg while green hydrogen, produced from renewable sources to cost in the range of $3 - $8 per kg in CY2021 based on region.

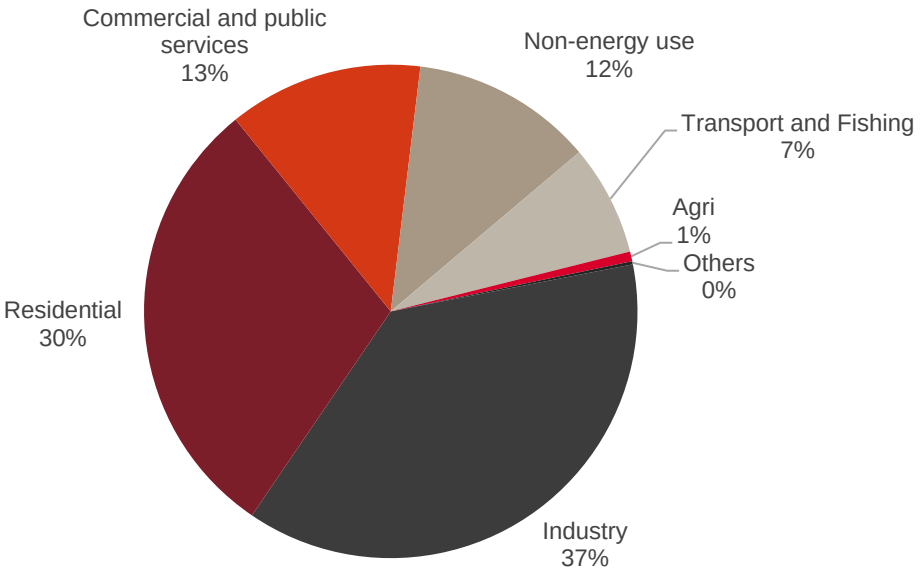
Based on IEA's assessment, there is potential for green hydrogen cost to fall as low as $1.6 per kg in regions with excellent renewable resources which will be comparable to blue hydrogen by 2030. The reduction in cost of producing green hydrogen can significantly improve adoption of hydrogen across industries as hydrogen can become more cost competitive w.r.t to fossil fuel while reducing the carbon footprint for organisations using green hydrogen.

Development of alternative technologies to reduce transport emissions

The transportation industry is one of the largest sources of carbon emissions globally. To reduce emissions, both pollutants and greenhouse gases, there is a shift underway towards electric vehicles. However, for large power requirements, such as for heavy loads and long-distance transport, the size of batteries needed increases significantly. This affects the cost competitiveness of battery vehicles for such applications due to higher capital costs for larger batteries as well as loss in payload capacity due to additional weight of batteries.

The demand for natural gas is dominated by the industrial and residential sectors with over 2/3rd of the demand.

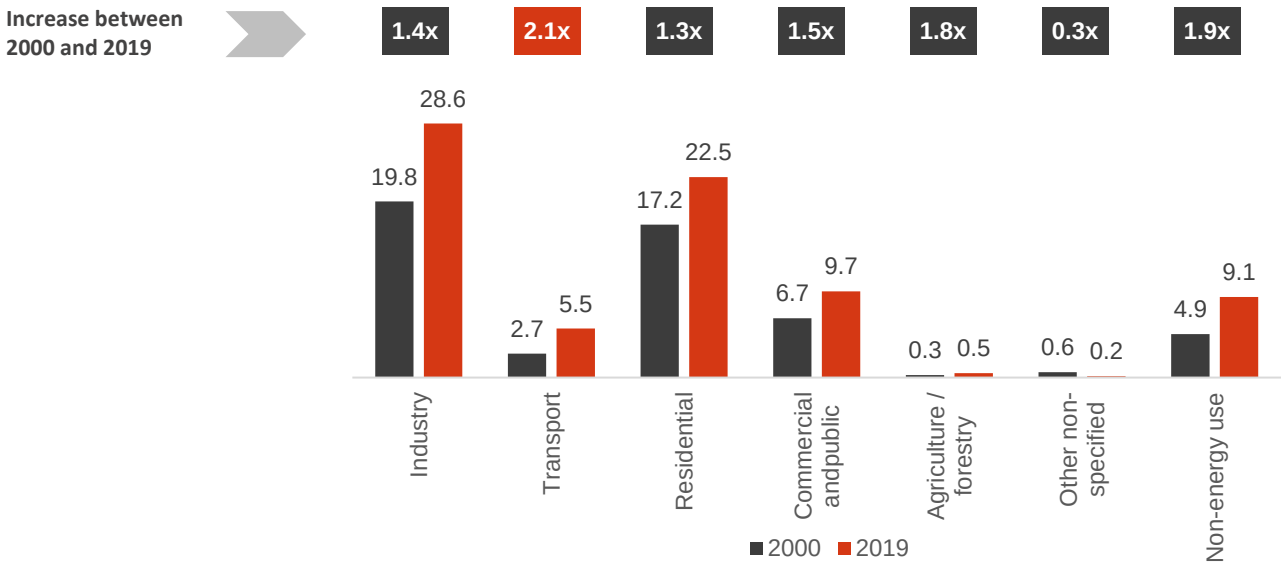
Share of natural gas demand CY2019



Source: IEA, CRISIL MI&A

However, with rising demand for cleaner fuels, the demand for natural gas has been steadily increasing. Over the last two decades the demand for natural gas from transport and fishing (including shipping vessels) has been the fastest growth end-use sector for natural gas.

Natural gas demand (million terra joules)



Source: IEA, CRISIL MI&A

Ships that burn highly polluting fuel oil face entry restrictions in some regional waters, which has caused an increase in demand for LNG for powering ships.

In the short term, LNG is expected to be the most technologically and economically viable option as it is a cleaner burning fuel with lower carbon emissions than crude derivatives. The lower volume occupied by LNG allows for a much larger volume of the fuel to be carried in a given size of fuel tank. This is beneficial for long-haul transportation allow for fewer fuel filling stops and they can also be refuelled relatively quickly. A lower need for fuelling infrastructure can also lower fuel costs. However, the infrastructure for LNG dispensation, especially for

road transport, is still inadequate in most countries. Expansion of the LNG distribution network for transportation is expected to drive demand for cryogenic equipment from the transportation sector.

In the long term, there is a concerted effort by many leading companies to make products that can run on hydrogen, which can be produced from fully renewable sources. Toyota and Hyundai are two major automakers pioneering the use of fuel cells and have also launched commercial products in the passenger vehicle segment. They are also collaborating with companies and governments to bring their technology to other segments. For example, Toyota has collaborated with truck makers Hino and Kenworth for heavy-duty trucks such as Class 8 trucks (heaviest class of trucks) in the US. Airbus is testing hydrogen-powered planes with its Zero concept. Storage of breathing oxygen in liquid state for high-altitude military aircraft was one of the earliest of such use cases. Other aircraft applications include cabin pressurisation and cooling, along with the generation of auxiliary power. Liquid hydrogen is also being considered as a fuel for hypersonic aircraft.

Space propulsion depends on propellants that are normally gaseous in nature but are carried in the condensed form as liquids facilitated by the use of cryogenic systems. These applications of industrial gases in the aerospace industry are expected to drive demand for cryogenic equipment.

Rise in space and satellite applications

Applications of liquid oxygen in the aerospace industry are increasing in the Asia Pacific region. In India and Russia, liquid oxygen demand is expected to get a boost from growth of cryogenic space engines. Cryogenic engines would usually use another gas along with oxygen such as LNG or hydrogen which are stored in their liquid state in cryogenic tanks. This allows the space vehicle to reduce the size of the fuel tanks required to be carried allowing for better efficiency of the cryogenic engine. When used with hydrogen, it doesn't create any pollution in the atmosphere unlike fossil fuel-based engines. Hydrogen sourced from renewable energy can further help greenify space activities. Increasing investment in space missions is the major driving factor for cryogenic gases and associated equipment demand in India. Further, the government set up a new body IN-SPACe (Indian National Space Promotion and Authorisation Centre) in June 2020 to regulate and promote private-sector participation in space activities. The government is also planning to revise the foreign investment policies in the space sector to facilitate foreign direct investment in the sector. In addition, Indian private players, along with foreign companies, have also shown interest in participating in the country's aerospace and defence sector. These developments across India's aerospace industry are expected to drive demand for cryogenic equipment in the country. Thus, increasing space missions are also likely to create opportunities for oxygen-related cryogenic equipment in the near future.

Evolving electronics applications requiring cryogenic gases

Cryogenic gases cater to an array of applications in the electronics industry, such as fibre optics, flat panel displays, integrated circuit packaging, assembly and testing, LED technologies, photovoltaics, printed circuit board (PCB) assembly and testing, and semiconductors.

Manufacture of semiconductions require multiple types of cryogenic gases. Some of these gases used to create the chemical reactions to produce the electrical properties of the device are required to be produced at very high qualities with no impurities as even a small amount of impurities could reduce the output of the plant (due to defective products) which will cost a lot due to the chip making process being very capital intensive. Another purpose of gases in semiconductor manufacturing is the use of "purge" gases which are used to flush out other gases in the pipeline, containers etc. Nitrogen, oxygen, argon and hydrogen are some of the major gases used in the semiconductor manufacturing process.

Often electronic devices are required to be tested after production in varying climatic conditions as specified in the safe operating ranges for the devices — this also requires cooling with nitrogen. Demand for electronic chips for computing devices has increased due to remote work adoption. The increased demand has led to an increased demand for computing devices, increasing prices of devices and driving investments in the semiconductor sector. This has impacted other sectors as well such as consumer durables and automobiles as chip fabrication plants have been facing capacity constraints with a sudden rise in demand.

Digital technologies such as cloud, the internet of things (IoT), and artificial intelligence (AI)/ machine learning (ML) are improving productivity across industries, and the hybrid/ remote work culture is taking hold. Therefore, demand for cryogenic equipment from the electronics segment is expected to rise as many countries, including the US, China and India, are making efforts to ensure that supplies of components that are critical for productivity growth and technological advancement are available as per requirements.

Cryogenics and its uses in cryo-scientific research

Cryogenics is the production and behaviour of materials at very low temperatures. The low temperatures modify the behaviour of materials to produce distinct effects which are found in a range of applications in research and technology. For e.g., one of the best known and used phenomenon - super conductivity has been put to use for production of powerful magnets which are used in varying fields such as electronics, medicine and biological research. In medicine, cryosurgery is performed to treat many types of diseases, such removal of tumours and other malignant skin conditions. Cryoelectronics is a field where electronics phenomena are studied at low temperatures where electrical resistance is next to negligible. Cryobiology involves the study of low temperatures on living organisms. Cryotherapy for the treatment of inflammation, managing pain etc. is also another new field under study whose benefits are yet to be fully understood.

Some of the most challenging problems in science are being tackled with the help of cryogenic phenomena which are not seen under normal conditions. Cryogenic fluids are used to cool magnets for the Large Hadron Collider which contains the world’s most powerful particle accelerator. ITER project (“Iter” meaning "The Way" in Latin), which is a collaboration of 35 nations, are building the world’s largest tokamak, a magnetic fusion device which will be used to study nuclear fusion which can be a large source of clean energy. The ITER cryostat is a large stainless steel high-vacuum pressure chamber which provides a high vacuum, ultra-cool environment for the ITER vacuum vessel and superconducting magnets.

The requirements for cryo-scientific research can be very demanding depending on the application. Requirements for extremely pure gases, clear environments and very low temperatures such as near absolute zero may be required which may not have commercial viability but could be essential in research.

3.4.6 Challenges for cryogenic equipment

Cryogen leakage from equipment leading to health hazards

Some gases can be dangerous when inhaled even at normal temperatures. Due to cryogenic gases being stored at very low temperatures, their leakage poses health hazards and has two major risks. First, prolonged exposure to cryogen can cause frostbite and damage to the lungs. Second, discharge of the cryogen into an enclosed area can lead to oxygen deficiency in the area, posing a health risk. These necessitate extra care in designing, testing and maintaining cryogenic equipment, which can be a hindrance to adoption of cryogenic equipment.

Well-to-wheel emissions of LNG lower benefit of shifting from other fossil fuels

Well-to-wheel emissions are calculated by looking at emissions for the entire value chain, instead of just at the end-use locations. Some studies have pointed out that although replacing other fossil fuels with clean burning LNG can benefit at the location of use, there are potential emissions then negate some of the benefit elsewhere. The main reason being that LNG, which is basically liquefied methane, is a very potent greenhouse gas, estimated to be 34-40 times more greenhouse effect producing than carbon dioxide. Tiny amounts of fugitive emissions (unintentional emissions) can nullify the benefits at a value-chain level. This can happen during nozzle coupling, valve and pump leakage, etc. in industrial use. LNG vehicles that do not have their engine running will usually require venting of boil-off gases from the fuel tank if pressure increase beyond safe limits and it absorbs heat from its surroundings; lower efficiency engines also add to unburnt methane emissions. Pipeline/tank ruptures due to mechanical failure or accidents can also leak methane into the atmosphere are another source of emission. These require tight regulations and adherence to these regulations with proper controls to get the desired benefit of shifting to LNG.

Electric vehicles could hurt CNG, LNG and hydrogen demand

Long-haul transport of heavy goods via roads, ships and airlines requires a significant amount of energy. To cater to these segments with batteries alone can be economically unviable due to the current high upfront costs of the batteries and lower energy density (amount of energy contained in a given size of battery). Hence, electric vehicles, at least in the present scenario, are mostly used in the short-haul or light-vehicle categories. However, efforts are underway to make battery vehicles more efficient, including the battery technology and the powertrain and physical characteristics of the vehicle. These improvements could enable battery vehicles to capture a larger share of the market, which would hurt CNG, LNG and hydrogen demand. The extent to which battery vehicles can compete with CNG, LNG and hydrogen-based vehicles will depend on technological breakthroughs. While there is no consensus on this topic, there are highly committed voices on both sides of the argument. Tesla, a pioneer in electric vehicle technology, believes hydrogen vehicles could be unviable and is solely focused on battery vehicles. Meanwhile, Toyota, a pioneer in fuel-cell technology, has largely abandoned battery technology and is primarily focused on fuel-cell vehicles.

Introduction of stringent emission norms and zero emission vehicle (ZEV) targets could impact the CNG uptake over long term.

While CNG can be considered as a cleaner fuel alternative to traditional fossil fuels, they are still not emission free. Combustion of CNG produces carbon dioxide (CO2) emissions, however, fewer compared to gasoline or diesel. With governments across the world introducing stringent emission standards, for example, proposed migration from Euro 6 to Euro 7 standards by 2025, plans to phase out traditional engines along with ZEV targets would impact the uptake of CNG powered vehicles. Further, OEMs must invest in the R&D for developing technologies for lowering the emission as per standards which would result in increase of the vehicle price for end user. This might result in customers preferring alternate fuel vehicles owing to the TCO benefits.

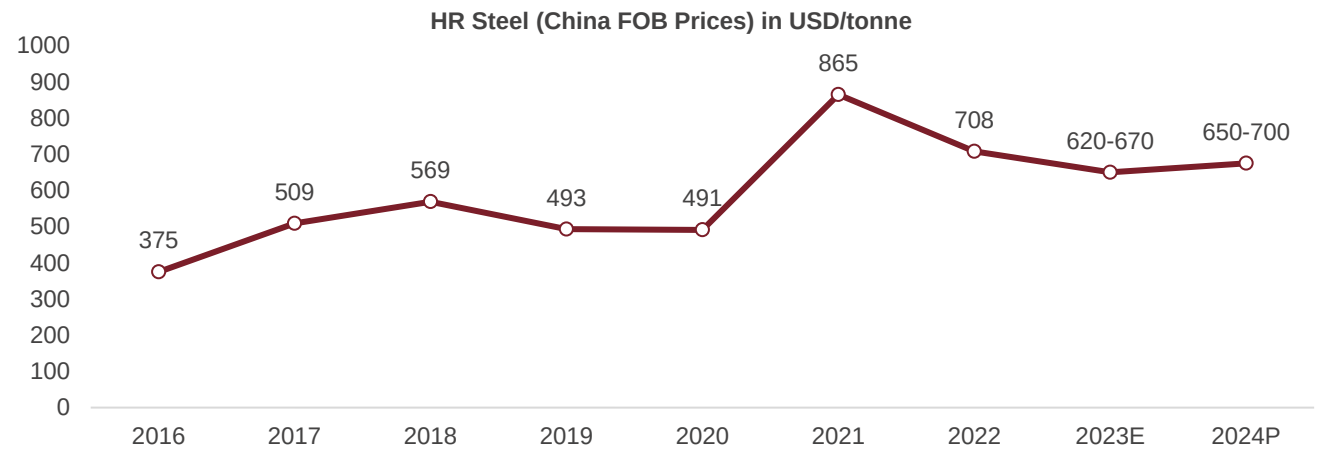
Volatility in raw material prices impact costs for cryogenic equipment suppliers

After an impressive rally last year, when global steel prices (China HR FOB) rose 76%, prices fell in January February 2022 on weak demand in China as it cut its manufacturing output in lieu of the Winter Olympics and Lunar New Year. However, the recent rise in raw material prices and the Russia-Ukraine war, rising covid-19 cases have again led to an upward rally in prices. However, since mid-May, coking coal prices have started to correct massively and panic procurement of steel in global market has subsided. Consequently, prices have seen a rapid

downward trend. China HR FOB prices are already below $700 per tonne level. Even EU and US prices are hovering in the $800 per tonne level.

Recovery in demand on last year's low base, high input costs of iron ore, coal, ferro alloys, gas and other key raw materials, coupled with rising steel prices in both the global and domestic market, led to a significant rise in steel and other commodity prices. Therefore, we foresee continued volatility over the next quarter as global geo-political tensions, recent outbreaks of new Covid-19 variants in China, and disruptions in coking coal market keep prices elevated.

Global Steel price trend



Note: HRC – Hot Rolled Coil
Note: E: Estimate; P: Projected
Source: CRISIL MI&A

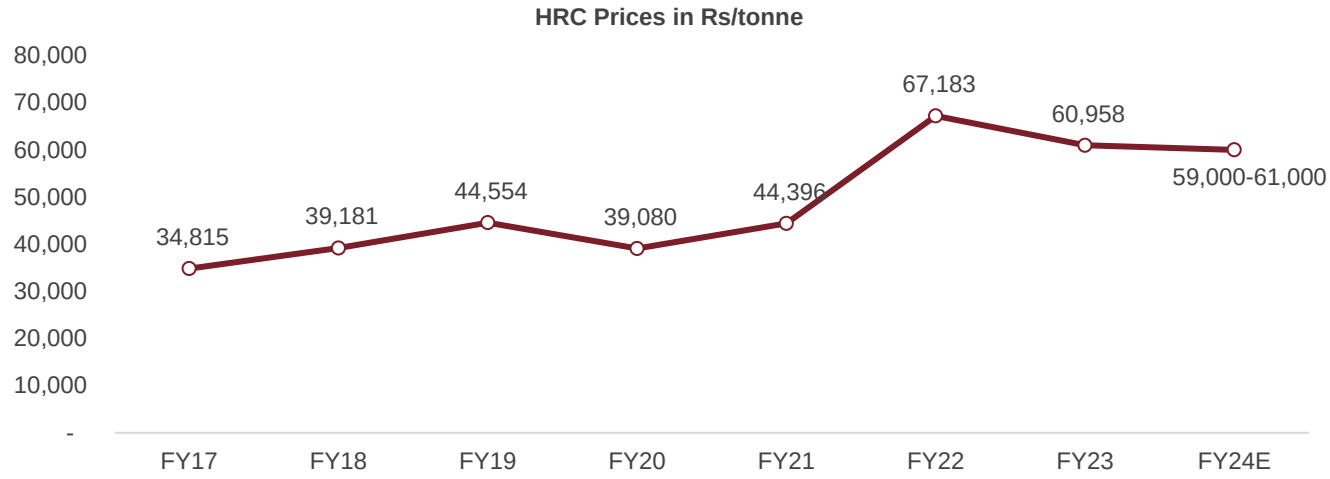
After an impressive rally last year, global steel prices (China HR FOB) fell 18%. Weak demand in China because of the underperforming real estate sector and zero-Covid lockdowns caused supply-chain constraints, leading to this fall. Overall, China HR FOB prices averaged $708 per tonne in calendar year 2022.. With the break-out of war, panic buying started in the EU, causing a huge surge in pricing that crossed the 1250 EUR/tonne mark in Mar'22. But demand from end-user segments was not as expected, causing steel mills to stop production. By the end of Dec'22 as stock depleted, nations in the EU started operating mills amid speculations of healthy demand, making the price rise justified. Mills are claiming good orderbooks and citing a further rise in prices. Also, with Turkey hit by an earthquake in Feb'23 and Asian orders with longer lead times, demand is primarily met through the domestic market. CY23 to see growth assuming improvement in the energy crisis, supply chain issues, and coming out of recessionary headwinds. This will lead to healthy prices, but not to the levels of the calendar year 2022..

In fiscal 2019, domestic steel prices rose 13.7%, mirroring the trend in global steel prices, led by strong domestic demand and rupee depreciation. Domestic HRC prices surged 20% in the first half of fiscal 2019 owing to elevated global prices and weakening rupee. However, prices started moderating in the third quarter of fiscal 2019 due to trend reversal in the aforementioned factors. Flat steel prices rose 14% on-year in fiscal 2021 to average at Rs 44,396 per tonne. Long steel prices rose 12% on-year to average at Rs 45,175 per tonne in fiscal 2021. Fiscal 2022 saw steel prices surge on account of pent-up demand in global market paired with logistics and supply-chain challenges and rising input cost. Flat steel prices rose a whopping 51% on-year to average at Rs. 67,183. Meanwhile, long steel prices rose by 26% to average at Rs. 56,941. Long steel prices averaged to Rs 59,146 per

tonne in fiscal 2023 and flat prices to Rs 60,958 per tonne. Moving ahead, with cooling of raw material prices, long to average at Rs 53,000-55,000 per tonne and flat to average Rs 59,000-61,000 per tonne..

Steel is a major raw material for cryogenic equipment. The changes in steel prices directly impact the gross margins of the cryogenic equipment suppliers. Rapid increase in steel prices will impact the ability of suppliers to complete projects undertaken profitability and increase the cost of new projects.

Domestic steel price trend

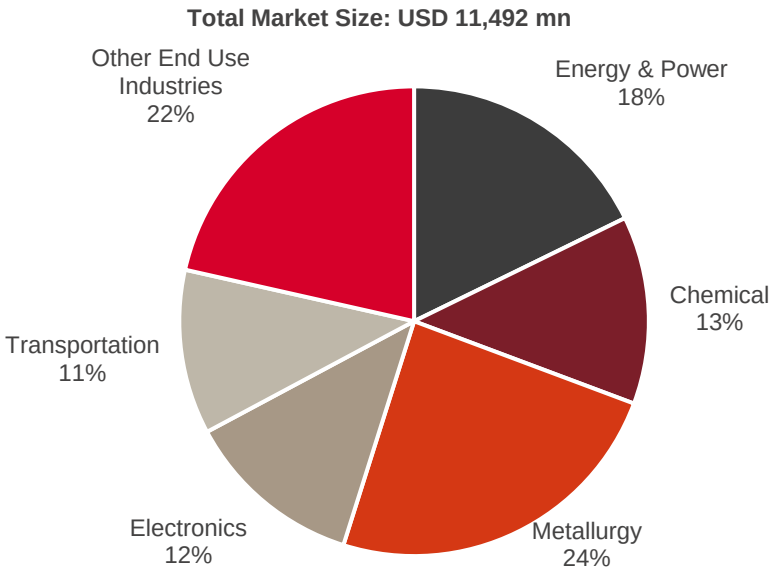


Note: HRC – Hot Rolled Coil
Note: E: Estimate; P: Projected
Source: CRISIL MI&A

3.5 Market size of global cryogenic equipment by end-use industry

Metallurgy is the largest demand segment for cryogenic equipment, with a 24% share of overall demand in CY2022. During the year, demand from the segment was $2.8 billion. The large market share can be attributed to rapid industrialisation and favourable government policies globally benefitting the manufacturing and industrial sectors.

Share of cryogenic equipment by end-use industry in CY2022

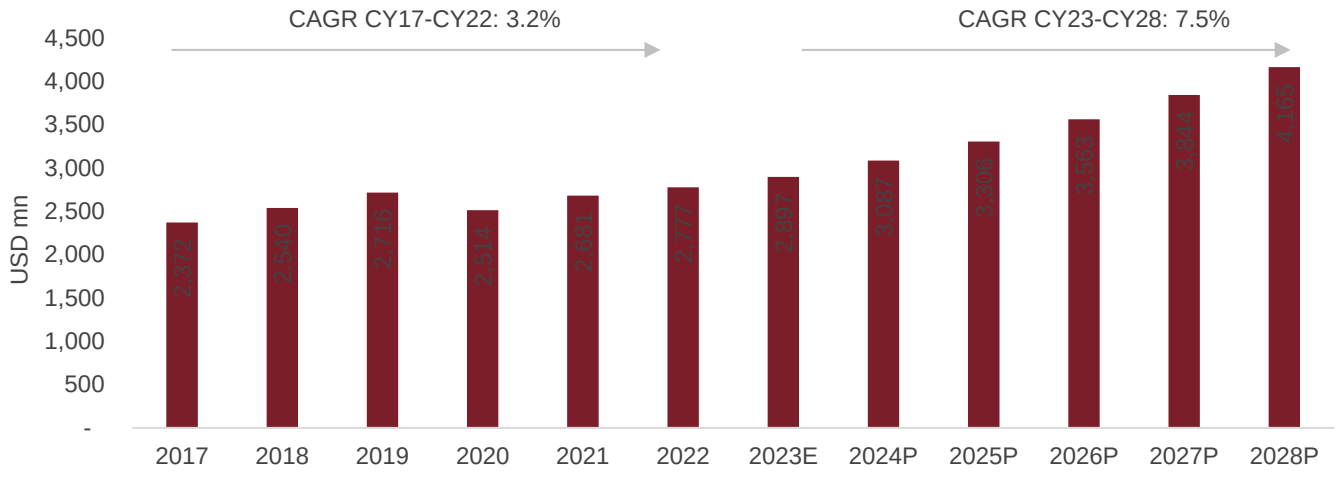


Source: Markets and Markets, CRISIL MI&A

Within the metallurgy industry, processes such as metal forming, fabrication, welding, and combustion require industrial gases, and therefore cryogenic equipment, with oxygen and nitrogen the most commonly used gases. Other gases such as argon and hydrogen are used to a lesser extent.

Between CY2023 and CY2028P, demand for cryogenic equipment from the metallurgy industry is expected to grow at 7.5% CAGR mainly driven by demand for steel and aluminium from infrastructure, automobile and consumer goods.

Demand for cryogenic equipment from metallurgy industry

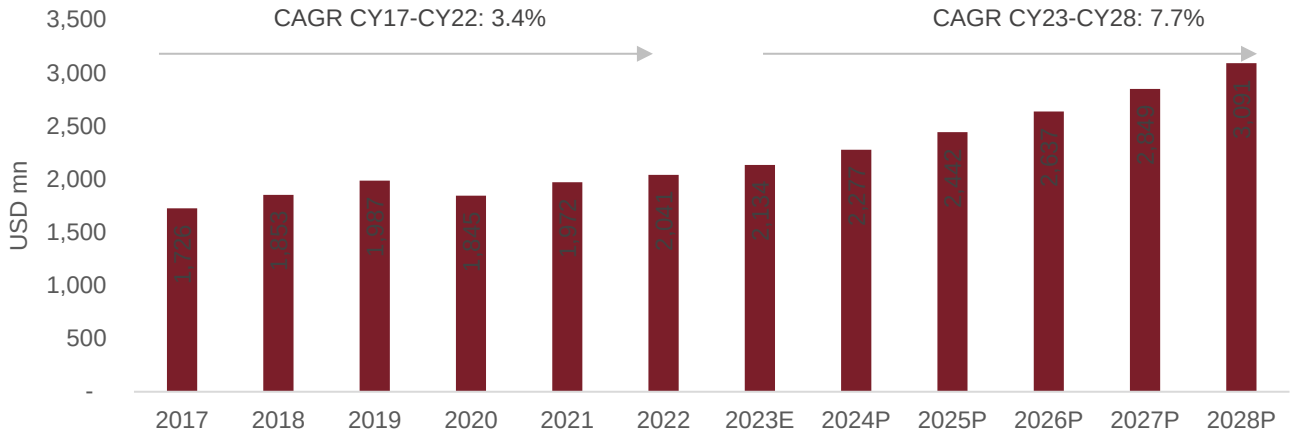


E: Estimated; P: Projected
Source: Markets and Markets, CRISIL MI&A

Energy and power, which was the second-largest demand segment for cryogenic equipment in CY2022, is also projected to continue to rise, fuelled by rising population and economic expansion. Cryogenic equipment is used for various industrial gases across energy and power applications. Cryogenic equipment is also used by the energy and power industry for supply of some of its products (LNG and hydrogen) to other end-use industries.

Between CY2023 and CY2028P, demand for cryogenic equipment from the energy and power industry is expected to grow at 7.7% CAGR. Metallurgy processes are typically energy intensive. As per the World Steel Organisation, every tonne of steel produced leads to 1.85 tonnes of carbon dioxide emission which translated into 2.6 bn tonnes of carbon dioxide emission in 2020 for the 1.86 bn tonnes of steel produced in 2020. Demand for cryogenic equipment from the metullargy industry are expected to be driven by investments in R&D to make processes cleaner with climate change in focus and building of cleaner fuel capacities such as LNG and hydrogen while reducing the carbon footprint of existing processes.

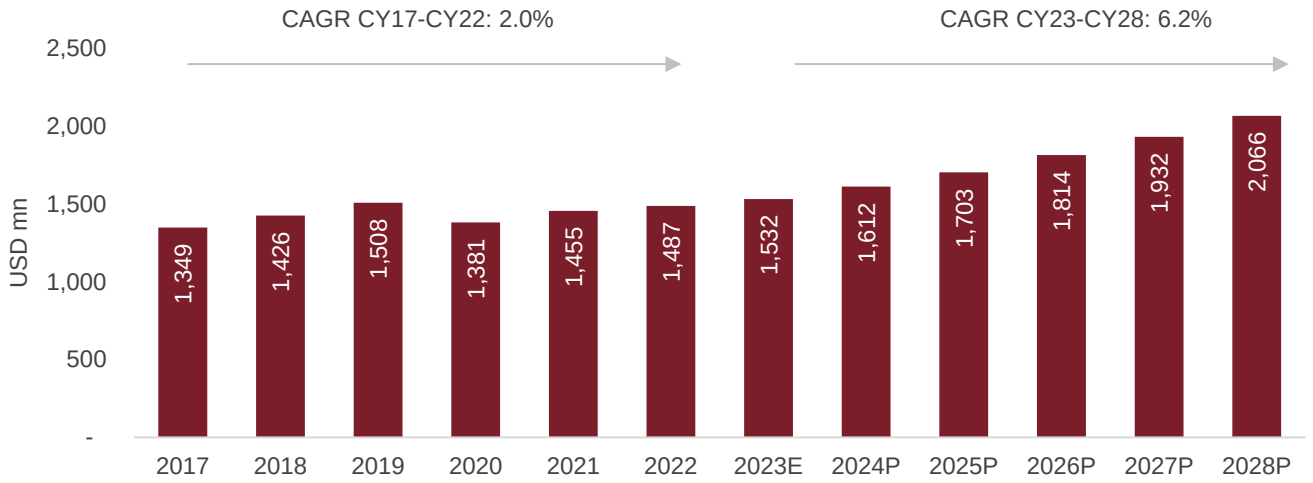
Demand for cryogenic equipment from the energy and power industry



E: Estimated; P: Projected
Source: Markets and Markets, CRISIL MI&A

In the chemicals segment, industrial gases are used for polymerisation, synthesis of intermediates, synthetic gases, specialty chemicals etc. The cryogenic equipment demand from the segment has recovered from the low during the peak of the pandemic, with demand estimated to grow at 6.2% CAGR between CY2023 and CY2028 driven by increased consumption demand and a shift to lowering emissions by the sector.

Demand for cryogenic equipment from the chemicals industry



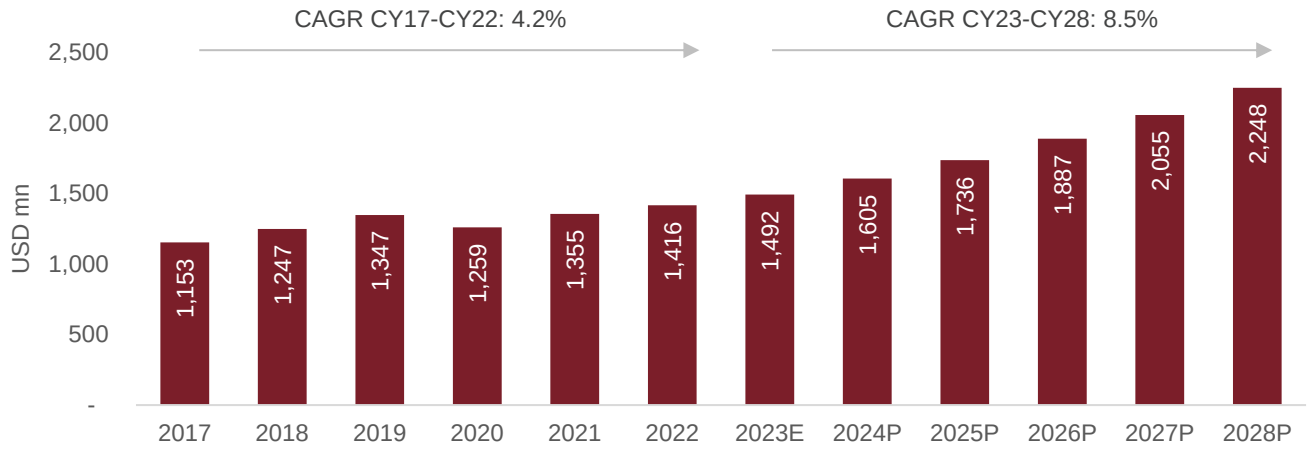
E: Estimated; P: Projected
Source: Markets and Markets, CRISIL MI&A

While the electronics segment was the fourth-largest cryogenic equipment demand centre in CY2022, the semiconductors and consumer electronics sectors within the electronics segment are expected to post high growth. Cryogenic gases cater to an array of applications in the electronics industry, such as fibre optics, flat panel displays, integrated circuit manufacturing, packaging, assembly and testing, LED technologies, photovoltaics, printed circuit board (PCB) assembly and testing, and semiconductors.

Hence, the overall segment is expected to rise the sharpest in the cryogenic equipment basket at 8.5% CAGR over CY2023 and CY2028. Continued demand from remote working, technologies such as AI/ML, IoT, and cloud/edge computing will provide lift.

In fact, demand for cryogenic equipment from the electronics industry was not just the fastest during the pre-pandemic period, but the segment was also the least impacted during the peak of the pandemic in CY2020 and CY2021 as demand for computing devices rose sharply owing to companies shifting to work-from-home during the lockdowns. Even post lifting of restrictions, companies have continued to provide remote or hybrid work options, thereby requiring the use of multiple electronic devices, such as workstations as well as internet equipment, and for telephonic/video conferencing purposes.

Demand for cryogenic equipment from the electronics industry

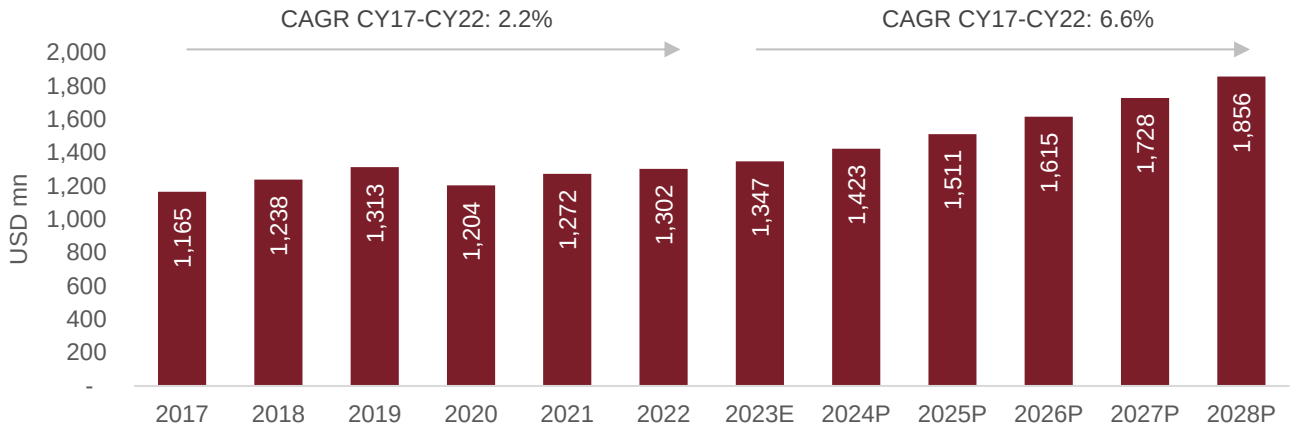


E: Estimated; P: Projected
Source: Markets and Markets, CRISIL MI&A

Owing to the large amount of emission of pollutants as well as greenhouse gases from trucks, buses, ships, and airplanes, the transport industry has come under increasing pressure to shift to low carbon alternatives. While for smaller vehicles such as two-wheelers and cars, electric or CNG are fast becoming alternative fuels, in the case of heavy transport, such as a long haul trucks, ships and airplanes, there are limitations due to the size of the batteries as well as the size/number of CNG tanks required, which increases costs and also takes up additional space and weight, leading to low utilisation. This is particularly pronounced in airplanes as weight is an important factor for efficiency. However, even for a low-margin business such as trucking, large batteries are financially prohibitive.

Hence, for long haul heavy transport fuel will need to be contained more densely (higher amount of fuel taking up less space) in smaller tanks such as LNG or hydrogen. Hence, demand for cryogenic equipment from the transportation industry is expected to grow at 6.6% CAGR between CY2023 and CY2028, with increasing shift to LNG and hydrogen fuel.

Demand for cryogenic equipment from the transport industry



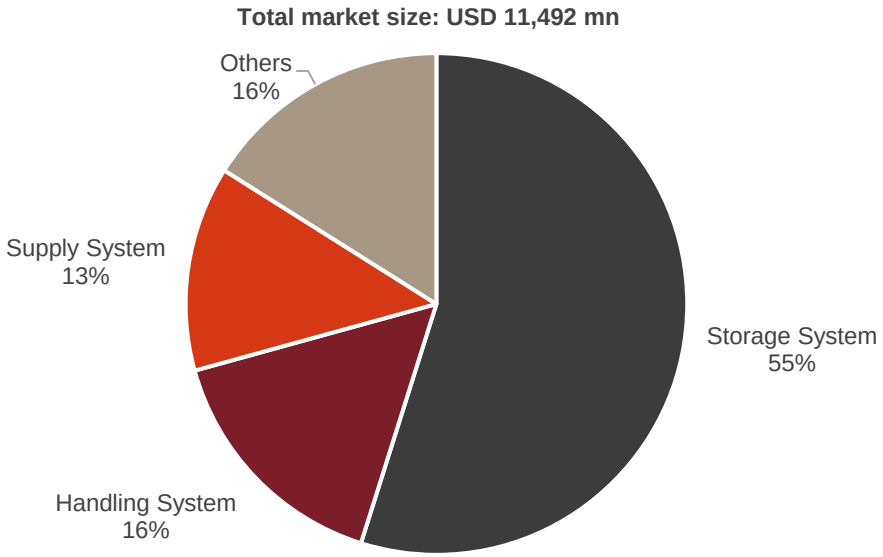
E: Estimated; P: Projected
Source: Markets and Markets, CRISIL MI&A

3.6 Market size of global cryogenic equipment by type of system

The cryogenic equipment market can be segmented on the basis of storage system, handling system, supply system, and others.

Storage systems facilitate the preservation of industrial gases at cryogenic temperatures, either to be used on site or transported to the site of operation. Handling systems facilitate the movement and transfer of cryogenic fluids. A cryogenic supply system is cryogenic equipment used to feed, return, or deliver cryogenic fluids to be used in an application.

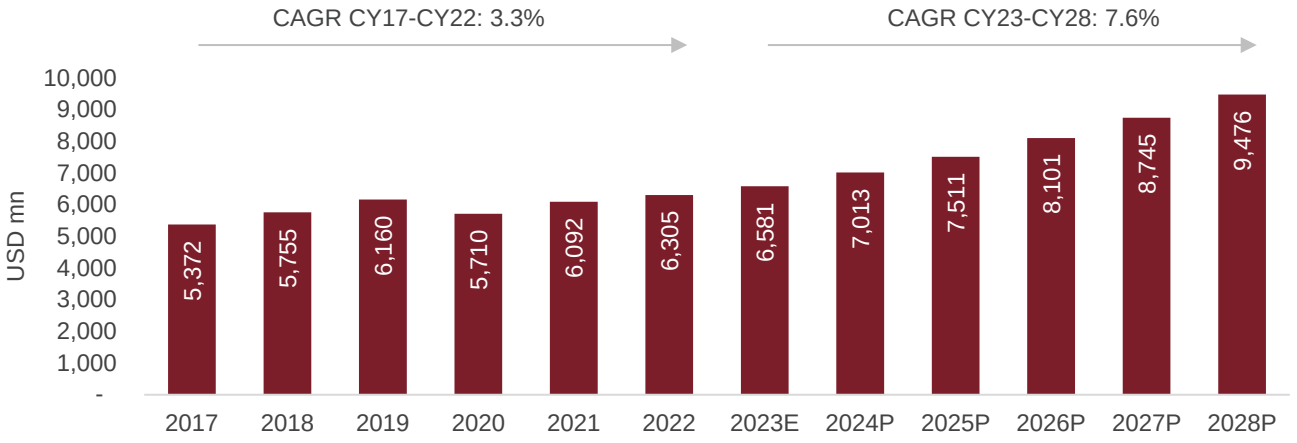
Share of cryogenic equipment by type of system in CY2022



Note: Other Equipment includes vaporisers, strainers, heat exchangers, samplers, leak detection equipment, tunnel freezers and liquifiers
Source: Markets and Markets, CRISIL MI&A

The storage system, which includes cryogenic tanks, dewars and pressure vessels, accounted for the largest share of cryogenic equipment market with 55% share in CY2022. Within the segment, while various types of cryogenic equipment are required for use with cryogenic gases, tanks are the primary component, wherein demand will increase proportionally with the increase in demand for cryogenic gases as tanks are used at both the production and end-use locations of cryogenic gases. Dewars facilitate dispensing or transporting cryogenic fluids in relatively small quantities with most of the applications in the healthcare industry and research and experimentation stages such as in superconductivity domain of the electronics industry. Going forward demand for cryogenic equipment from storage systems is expected to grow at a CAGR of 6.8% between CY2023 and CY2028.

Global demand for cryogenic storage equipment

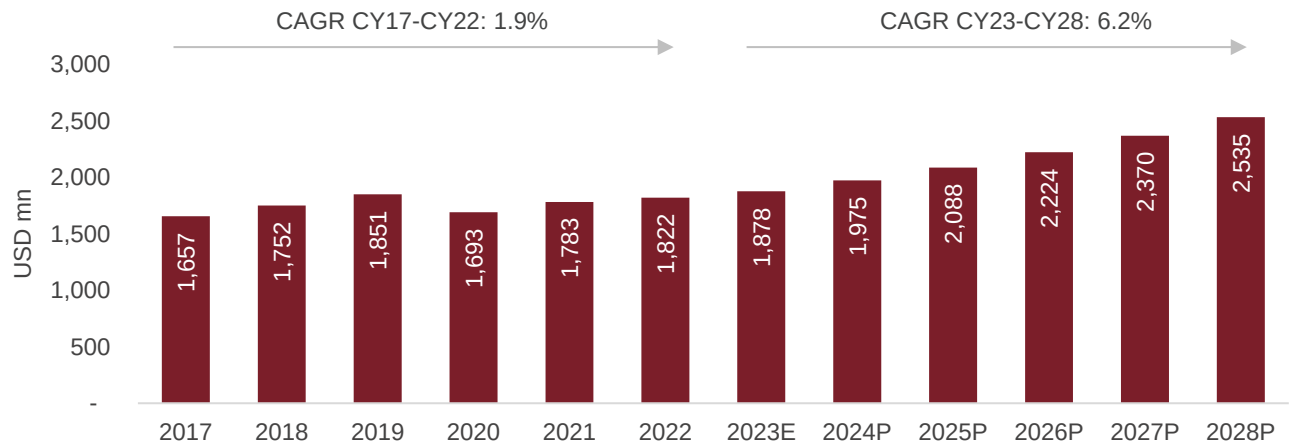


E: Estimated; P: Projected

Source: Markets and Markets, CRISIL MI&A

The handling system segment accounted for 16% of the cryogenic equipment market in CY2022. Handling systems facilitate the movement and transfer of cryogenic fluids to cater to the respective application. These systems are primarily constituted by valves, regulators, and gauges, and are used in tandem with the other cryogenic systems. Going forward demand for cryogenic equipment from the handling systems industry is expected to grow at a CAGR of 6.2% between CY2023 and CY2028P.

Global demand for cryogenic handling equipment

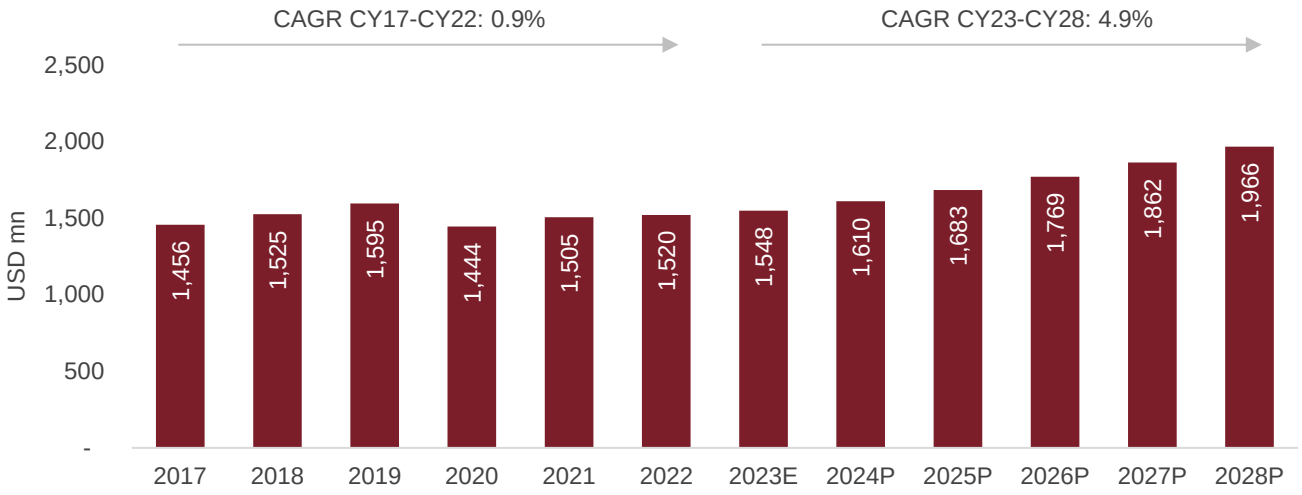


E: Estimated; P: Projected

Source: Markets and Markets, CRISIL MI&A

The supply system segment accounted for 13% of the cryogenic equipment market in CY2022. A cryogenic supply system is a set of cryogenic equipment used to feed, return, or deliver the cryogenic fluids to be used in the respective application. These systems are composed of components/equipment such as pumps, pipes, hoses, and flanges. These components are designed and assembled to maintain consistent pressure, required flow, and purity requirements. Going forward demand for cryogenic equipment from the handling systems industry is expected to grow at a CAGR of 4.9% between CY2023 and CY2028P.

Global demand for cryogenic supply equipment



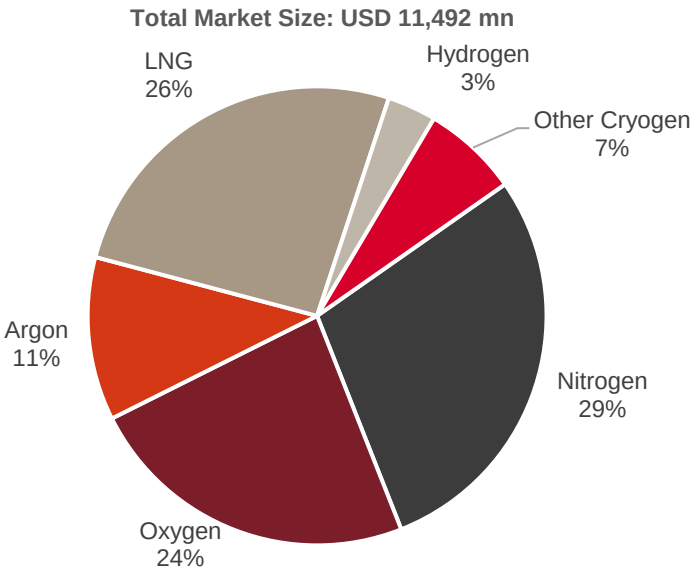
E: Estimated; P: Projected
Source: Markets and Markets, CRISIL MI&A

3.7 Market size of global cryogenic equipment by cryogen

The major sources of cryogenic gases are atmospheric air, which is separated into its constituents such as nitrogen, oxygen, argon etc. by air separation units, and energy gases, such as LNG and hydrogen. While LNG, a fossil fuel, is extracted from drilling, hydrogen can be produced from renewable and non-renewable sources. While most of the hydrogen produced currently is from fossil fuels, in the long-term hydrogen produced from renewable sources i.e., “green hydrogen” is expected to increase as cost for producing green hydrogen declines. This is expected to drive demand for hydrogen as a source of clean fuel as it would be produced from fully renewable sources and also emits no pollutants during use.

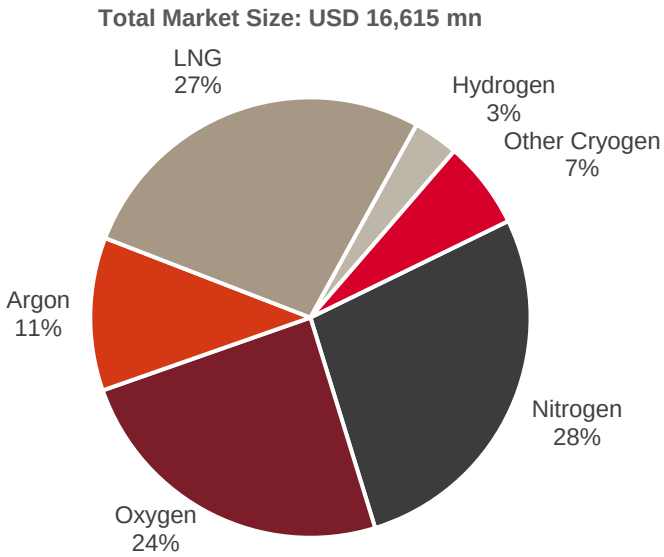
That said, nitrogen is the most widely used cryogen across industries. However, LNG, which is used as a fuel source, is seeing rising adoption as a cleaner fuel source in the global shift towards low carbon sources. Other gases that form 7% of the total demand for cryogenic equipment are helium, nitrous oxide, ethylene, and carbon dioxide.

Share of cryogenic equipment by cryogen in CY2022



Source: Markets and Markets, CRISIL MI&A

Share of cryogenic equipment by cryogen in CY2028

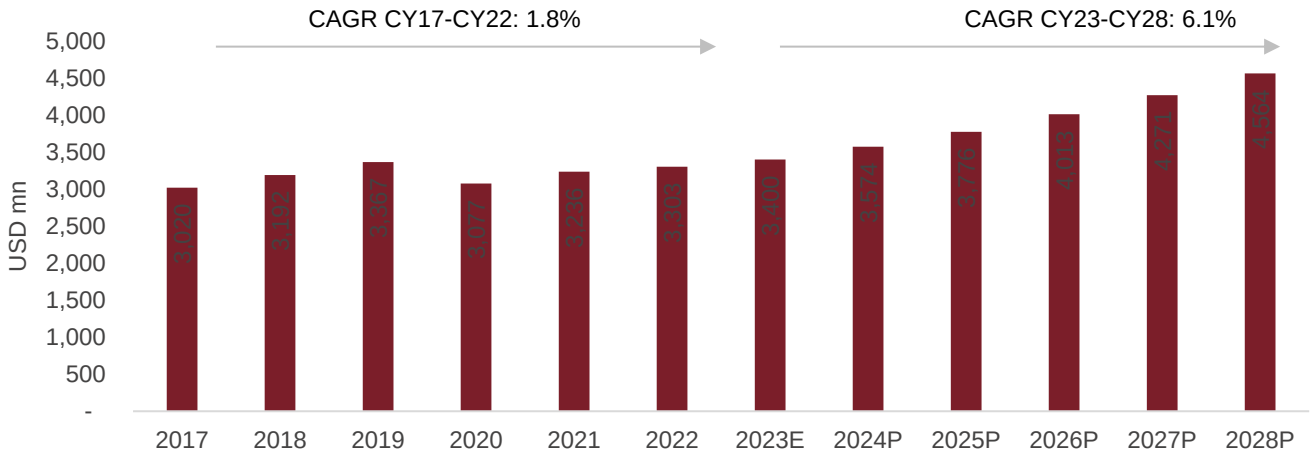


Source: Markets and Markets, CRISIL MI&A

Nitrogen, which comprised 29% share of the cryogenic equipment market in CY2022, has wide application in industries and for medical use owing to its high availability in the atmosphere and its inert nature. Nitrogen is used in the energy and power industry for enhanced oil recovery. It is also used in fertilisers as a feedstock and chemical industries. Demand for liquid nitrogen equipment, though, dipped during peak of the pandemic in CY2020 and CY2021 as industrial demand slowed.

However, between CY2023 and CY2028P, demand for cryogenic equipment from liquid nitrogen is expected to grow at 6.1% CAGR. Demand for liquid nitrogen equipment is expected to be driven by the electronics, energy and power, and chemical industries. Regionally, growth is expected to be faster in the Asia-Pacific and North American regions.

Global demand for cryogenic equipment from nitrogen segment

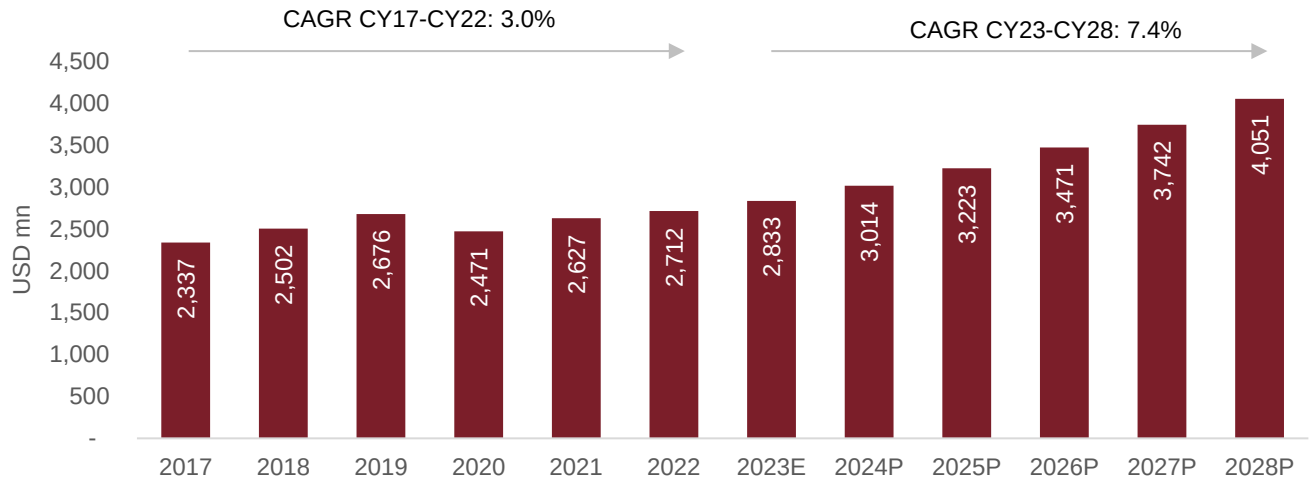


E: Estimated; P: Projected
Source: Markets and Markets, CRISIL MI&A

Oxygen is also abundantly available in the atmosphere and has a key role in combustion and the oxidation processes in industries such as metallurgy. It also finds use in aerospace, petrochemical, and medical applications. In CY2022, gas accounted for the second largest market share of the global cryogenic equipment market.

Between CY2023 and CY2028P, demand for cryogenic equipment of liquid oxygen is expected to grow the second-fastest, at 7.4% CAGR. Electronics and metallurgy industries are projected to be the key demand drivers for oxygen-related equipment.

Demand for cryogenic equipment from oxygen segment



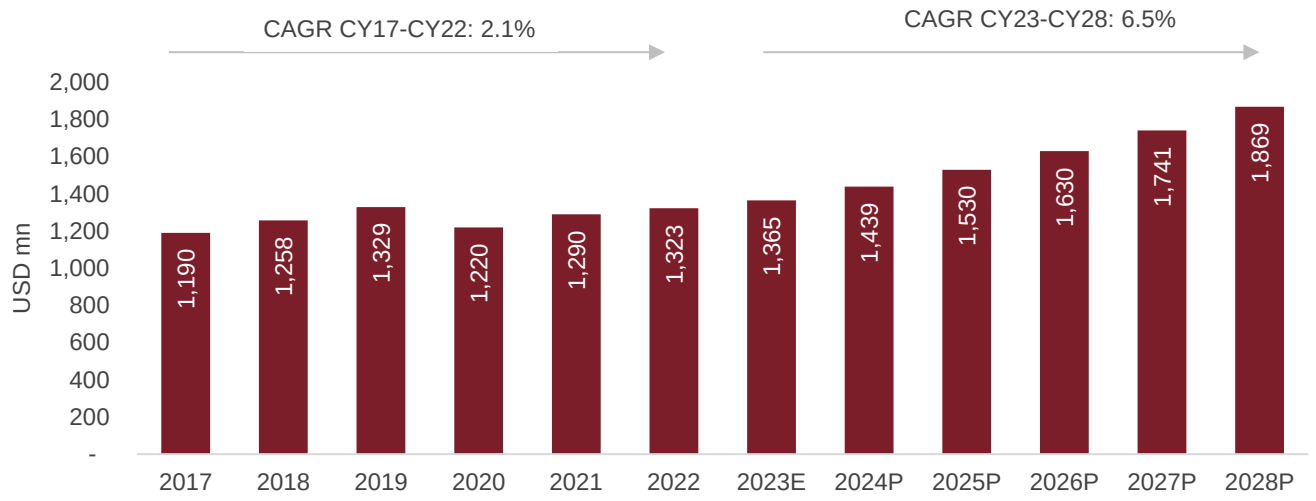
E: Estimated; P: Projected
Source: Markets and Markets, CRISIL MI&A

Argon is an inert gas and is rarely found in the atmosphere, thus making it expensive to produce. Argon is used in critical industrial processes, such as manufacturing of high-quality stainless steel and production of impurity-free silicon crystals for manufacturing electronics. In fact, liquid argon is extensively used in the semiconductors industry. Other applications of liquid argon include fabrication of specialty alloys, lasers, and metals. It has medical

applications as well, specifically in cryosurgery and situations that require an inert environment. The gas also provides an environment inert from oxygen and nitrogen for annealing processes.

From CY2023 to CY2028, demand for cryogenic equipment from the liquid argon segment is expected to grow at 6.5% CAGR. Rising demand for electronics will drive demand for argon and hence, demand for cryogenic equipment. Asia-Pacific and North America are expected to be key regions driving demand for liquid argon.

Demand for cryogenic equipment from argon segment



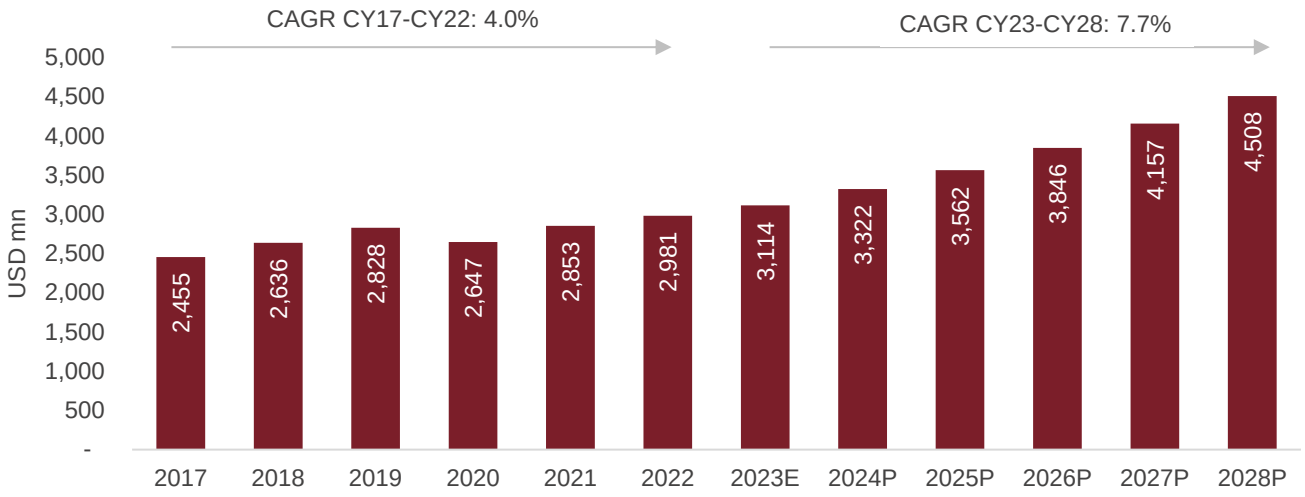
E: Estimated; P: Projected
Source: Markets and Markets, CRISIL MI&A

Cryogenic equipment demand from the LNG segment was $3 billion in CY2022. Natural gas, which is largely methane, is cooled, thereby converting into a liquid, also known as LNG. The cooling reduces natural gas' volume by 600 times, thereby making it cheaper to transport. While LNG is reasonably costly to produce, advances in technology are reducing costs associated with liquefaction and regasification. LNG is primarily used as an energy source for heating and electricity generation. It also has other uses such as feedstock in fertiliser and hydrogen production.

But with rising investments in LNG infrastructure, both for use as a fuel and as a source of 'blue hydrogen' – hydrogen produced from fossil fuels, but with carbon produced in the process captured and stored instead of releasing it into the environment – the demand for cryogenic equipment from LNG is expected to post the fastest growth among cryogens over the long term.

Between CY2023 and CY2028, demand for cryogenic equipment from LNG is expected to grow at 7.7% CAGR. While shift to cleaner fuels is expected to drive demand in developed regions like the EU and the US, higher growth is expected from Asia-Pacific, in line with fast growing developing economies with rising need for electricity.

Demand for cryogenic equipment from LNG segment



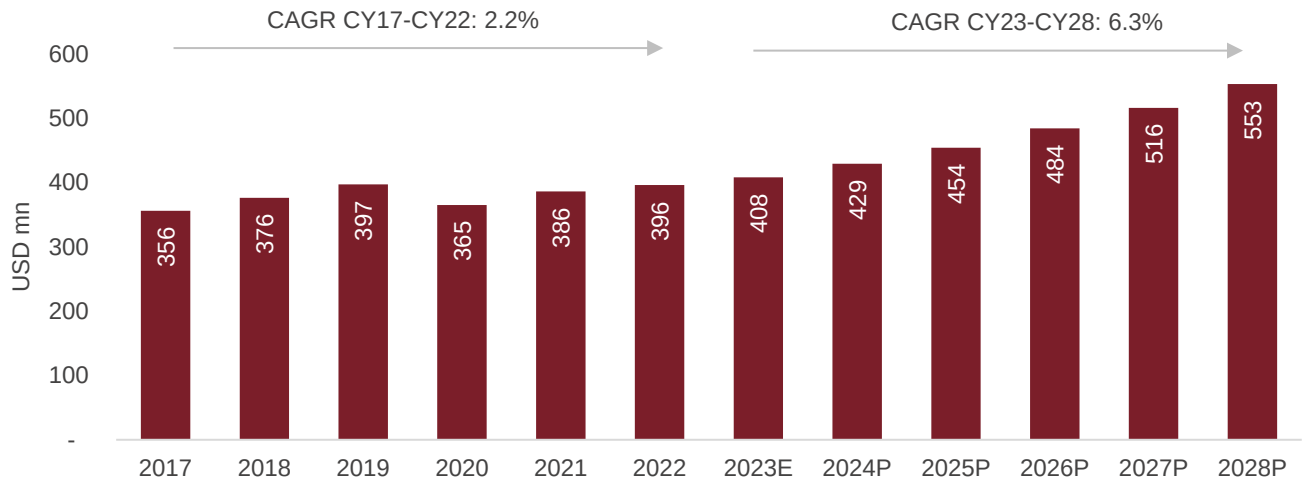
E: Estimated; P: Projected
Source: Markets and Markets, CRISIL MI&A

Hydrogen is the lightest gas and, hence, occupies substantial volume under standard pressure conditions; liquefaction by cooling the gas can significantly reduce the volume. Storing in cryogenic tanks maintains the temperature of liquid hydrogen. Hydrogen is widely used in chemical and petroleum refining industries.

While demand for cryogenic equipment from the hydrogen segment accounted for 3.5% share of the global cryogenic equipment market in CY2022, given the potential for hydrogen applications and investments in R&D to reduce the cost of producing hydrogen as well as investments in processes to make use of greener sources of fuel, the share of demand for cryogenic equipment from the hydrogen segment is likely to continue to expand.

Between CY2023 and CY2028, cryogenic equipment from liquid hydrogen is expected to grow at 6.3% CAGR, driven by the electronics, metallurgy, and energy and power segments.

Demand for cryogenic equipment from hydrogen segment

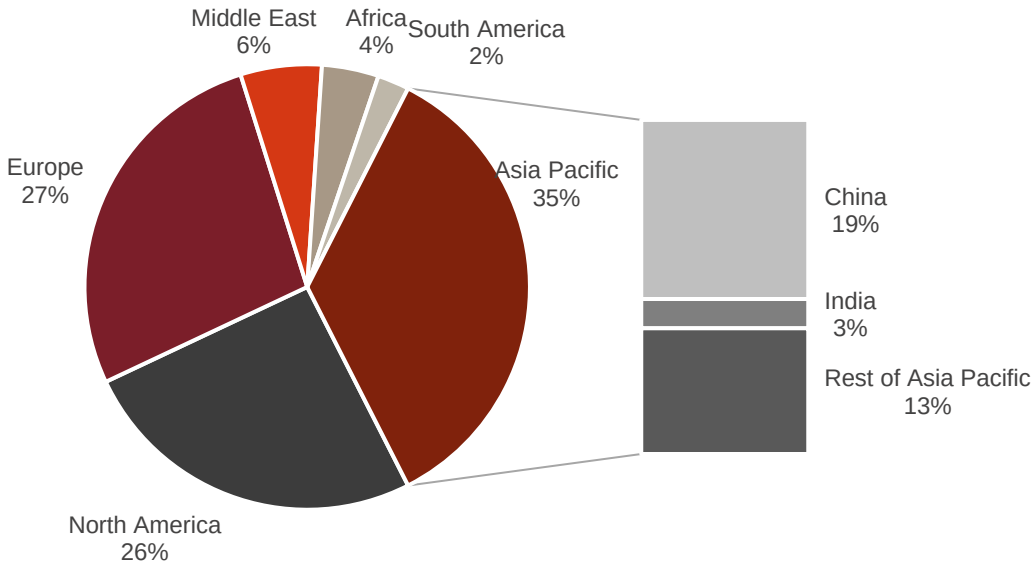


E: Estimated; P: Projected
Source: Markets and Markets, CRISIL MI&A

3.8 Market size of global cryogenic equipment by region

Asia-Pacific is the largest market for cryogenic equipment, with a 35% share. About half of this is from China owing to its large industrial sector, which requires considerable volume of industrial gases, as well as significant investments in LNG infrastructure.

Share of demand for cryogenic equipment region-wise in CY2022

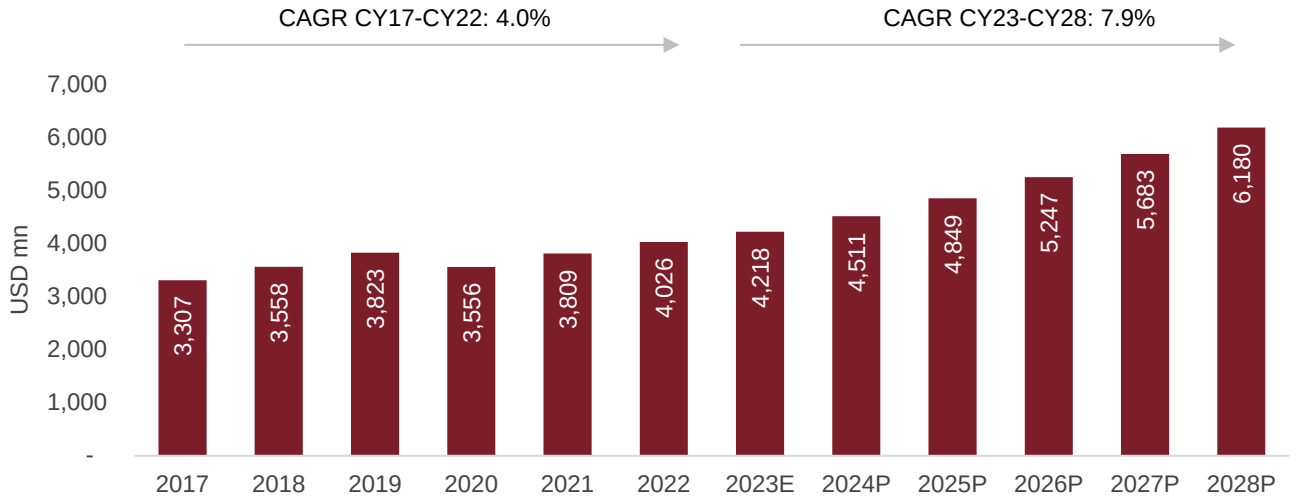


Source: Markets and Markets, CRISIL MI&A

The Asia-Pacific region is not only the largest market for cryogenic equipment, but also projected to be the fastest growing between CY2023 and CY2028. Demand is expected to be driven by China and Japan, followed by India.

Demand for cryogenic equipment in the region is majorly driven by LNG demand with increasing focus on shift to low carbon technologies in industry as well as transportation. The market in China is driven by development of LNG infrastructure projects, rising LNG demand in Japan and natural gas production operations in Australia. Increase in production of metals for infrastructure development is driving demand for gases such as oxygen in China and India. Rising demand for semiconductor manufacturing in China and India is expected to drive demand for nitrogen, oxygen, argon and hydrogen which are used in electronics manufacturing. Investments in space and satellite applications in India are expected to drive demand for oxygen, hydrogen and LNG. Hence demand for cryogenic equipment from Asia Pacific is expected to grow at a CAGR of 7.9% between CY2023 and CY2028.

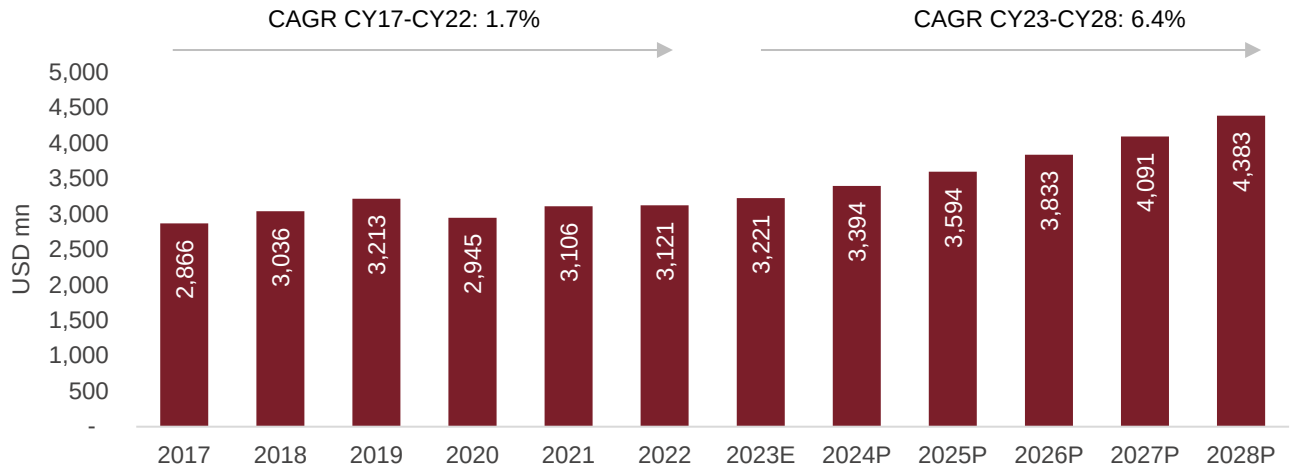
Demand for cryogenic equipment in Asia-Pacific



E: Estimated; P: Projected
Source: Markets and Markets, CRISIL MI&A

Europe is the second largest region for cryogenic equipment. Growth in the region between CY2023 and CY2028 is expected to be strong at 6.4% CAGR, though slightly lower than Asia-Pacific and North America. Developments in LNG gas infrastructure in Europe, modernisation of Germany's healthcare industry, and European nations' efforts to achieve net zero emission will drive demand for LNG and Hydrogen cryogenic equipment. Overall, demand for cryogenic equipment is expected to be driven by the electronics, metallurgy and energy and power segments.

Demand for cryogenic equipment in Europe



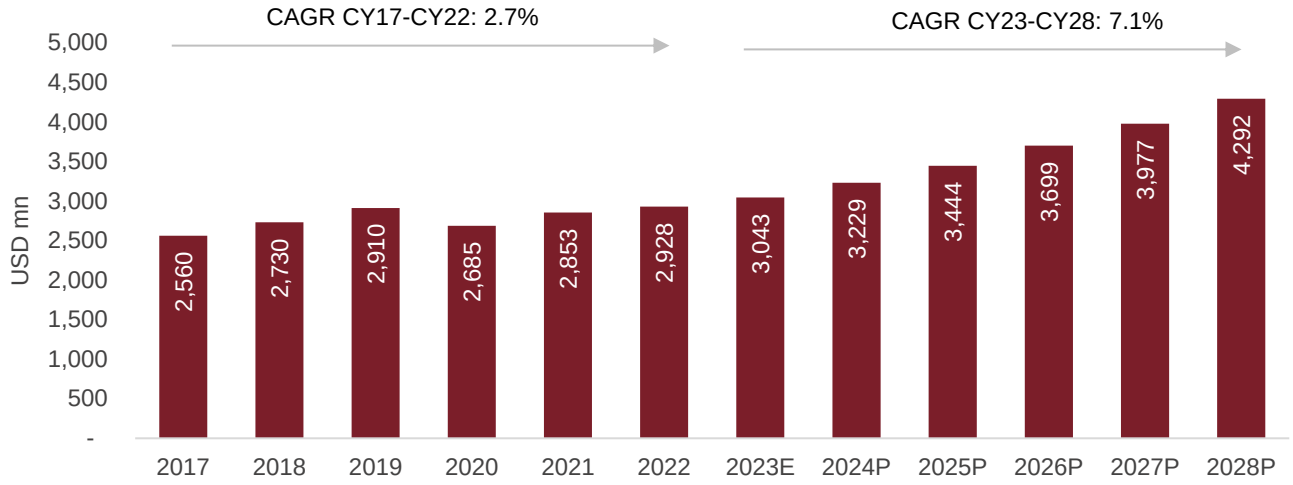
E: Estimated; P: Projected
Source: Markets and Markets, CRISIL MI&A

In the case of North America, the cryogenic equipment market is expected to be driven by demand from the electronics, and energy and power sectors. There have been significant investments in the clean energy space in the region, with several start-ups and industrial and energy majors looking to find solutions to the climate change issue. Also, the severe chip shortage owing to the fallout from the pandemic has highlighted the need to be self-

reliant for high-tech industries to maintain technological and economic leadership, with many discussions between political leaders and the electronics industry to bring critical processes such as chip manufacturing to the US.

With rising production of natural gas, the volume of natural gas exports (majorly LNG) has grown significantly as well. Also, the shale boom and reshoring of manufacturing in the US, growing chemicals and plastics sectors in Canada, and demand from onshore and offshore fields in the Gulf of Mexico are expected to propel growth of the cryogenic tanks market in the region.

Demand for cryogenic equipment in North America



E: Estimated; P: Projected
Source: Markets and Markets, CRISIL MI&A

4 Domestic cryogenic equipment industry

4.1 Regulations and government policies impacting demand for cryogenic gases

4.1.1 Regulation driving shift towards cleaner fuels

The Paris Agreement, which has been ratified by India, set an objective of limiting global temperature rise this century to well below 2^0 Celsius over pre-industrial levels, and to pursue efforts to limit temperature increase further to 1.5^0 Celsius. To achieve this target would require a significant increase in the share of zero or low emission vehicles.

This target, combined with growing environmental and sustainability awareness among the population, is expected to transform the global auto industry from internal combustion engines to green mobility, such as hybrid vehicles, electric vehicles, fuel cell vehicles, and alternative-fuel vehicles.

Regulations on fossil fuel can have two types of impact:

- Direct impact: where the regulations mandate use of cleaner fuels such as ban on diesel commercial vehicles in Delhi that cause an abrupt shift to alternate fuels
- Indirect impact: where the regulations on emission control or monitoring such as fuel efficiency and Bharat Stage (BS) emission norms which increases cost of ownership of such devices / vehicles reducing their economic competitiveness via-a-vis other fuel options which cause a gradual shift towards alternatives.

While the natural gas demand for smaller vehicles such as cars, UVs, 3W, small commercial vehicles and intermediate commercial vehicles is mostly in compressed natural gas (CNG) form the demand for natural gas is likely to increase and any shortfall is likely to be met with LNG imports driving demand for cryogenic equipment for LNG transport and handling.

4.1.2 CAFE norms for passenger vehicles to increase fuel efficiency

While Bharat Stage (BS) norms target pollutant emissions such as hydrocarbons, nitrous oxide, particulate matter etc, fuel efficiency norms target carbon emission by limiting the CO_2 emissions from vehicles. In India, fuel standards for vehicles came into force in April 2017 for petrol, diesel, liquefied petroleum gas and CNG PVs. These standards are based on the corporate average fuel efficiency (CAFÉ) system rather than specific vehicle level emission limits, and targets to improve the fuel consumption of PVs by 2022 gradually over a period of time.

The first phase of the regulation was implemented on April 1, 2017 with the introduction of BS-IV emission norms. It was decided that the highest permissible carbon footprint would be 130 gm per km till March 2022. In the second phase, starting April 2022, it would be reduced to 113 gm per km. The investment required to make the vehicles more fuel efficient will add to the cost of vehicles to the end users eventually. This is expected to incentivise the shift towards greener technologies such as natural gas and electric vehicles as OEMs will find it increasingly difficult to meet the norms with petrol and diesel vehicles alone, which in turn, will increase demand for natural gas.

4.1.3 Transition from BS-IV to BS-VI

BS emission standards are issued by the government to regulate the output of air pollutants from motor vehicles. In January 2016, the government decided to skip BS-V and transition directly to BS-VI norms. It fixed the deadline of April 1, 2020 for manufacturers to commence vehicle production compliant with the BS-VI emission norms.

BS-VI regulations demand major reduction in PM and NOx levels for passenger vehicles

Type of Vehicle	Unit	BS IV	BS VI	Change
Diesel				
HC	gm/km	0.3	0.17	**-43%**
NOx	gm/km	0.25	0.08	**-68%**
PM	gm/km	0.025	0.0045	**-82%**
Petrol				
NOx	gm/km	0.08	0.06	**-25%**
PM	gm/km	-	0.0045	**Newly added**

HC: Hydrocarbon, NOx: Nitrogen oxides, PM: Particulate matter
Note: HC, NOx, and PM refer to pollutants from the vehicle exhaust
Source: ARAI

Addition of devices and subsystems in a BS-VI compliant vehicle

Pollutant	Devices / Subsystems to be included to reduce the Pollutants
NOX- Nitrous oxide	▪Exhaust Gas Recirculation ▪Selective Catalytic Reduction ▪3 way catalyst ▪Lean NOx Trap
HC- Hydrocarbons	▪Secondary Air Injection ▪3 way catalyst ▪Diesel Oxidation Catalyst ▪Purge Control Valve ▪Canister
PM- Particulate matter	▪Diesel Particulate Filter ▪Gasoline Particulate Filter

Source: CRISIL MI&A

BS-VI compliant PV prices increased 2-4%, with the cost of diesel variants rising more than other fuel variants. Adding of devices and systems to reduce emission levels adversely affected prices of such vehicles driving a shift towards natural gas vehicles increasing natural gas demand. From April 1, 2023, all new vehicles passenger vehicles, two wheelers, and commercial vehicles have to comply with the new BS VI phase 2 emission norms. Vehicles will be required to meet actual driving emission requirements rather than just laboratory tests. To make this possible, automobiles must come equipped with OBD2 (On-board Diagnostics).

4.1.4 CV emission norms

In February 2016, the government decided to skip the BS-V emission standards and move directly to BS-VI norms by April 2020. The stringent BS-VI norms incorporate substantial tightening of nitrogen oxides (NOx) and

particulate matter (PM). These emission standards pushed vehicle prices higher — diesel trucks and buses segment witnessed a higher rise in costs due to the significant upgradation of engines and exhaust systems.

According to our estimates, implementation of the BS-VI norms will result in a 12-15% hike in the cost of diesel trucks. Percentage increase in vehicle price for BS-VI models over BS-IV was more pronounced in LCV trucks and buses and relatively lower for tractor trailers and MAVs. As the BS-VI norms were implemented in April 2020, the increase in vehicle prices and subdued finance availability resulted in a sudden increase, both in the initial cost of acquisition and total cost of ownership of vehicles running on diesel. This has been driving a shift towards more economical natural gas vehicles, increasing the demand for natural gas. BS-VI phase 2 implemented from April 2023, entailed an addition of on-board self-diagnostic device (OBD2) to monitor real time emissions. The addition of OBD2 will also require upgrades to hardware and software of the vehicles to comply with the new norms which resulted in a price hike of 2-4%.

4.1.5 Fuel efficiency norms of heavy commercial vehicles likely to be enforced in fiscal 2023

To make heavy-duty trucks and buses more fuel efficient, the Ministry of Petroleum and Natural Gas, MoRTH, and the Ministry of Heavy Industries are in talks to notify fuel efficiency norms. Based on talks with various stakeholders, BS-IV compliant diesel vehicles of categories M3 and N3, with GVW of 12T and above, will have to comply with these norms. Vehicles are expected to meet the 'target diesel fuel consumption' value for a specific set of speeds, which is dependent on the vehicle’s GVW, axle configuration, and category (N3/M3). Unlike the CAFÉ system for passenger vehicles, commercial vehicles are required to meet the 'target diesel fuel consumption' value for a specific set of speeds, which is dependent on the vehicle’s GVW, axle configuration, and category. While the implementation system is different the increasing pressure to reduce carbon emissions by increasing fuel efficiency is likely to increase the cost of such vehicles reducing their competitiveness vis-à-vis natural gas and electric vehicles.

4.1.6 Types of gas pricing in India

Natural gas pricing in India has undergone a sea change from being fixed by the government in the early 1970s to greater market determination (based on formulas linked to international prices) of prices. There are broadly two pricing regimes for gas in the country - domestically produced gas and imported LNG.

4.1.7 Domestic gas pricing mechanism

Administered Pricing Mechanism (APM) gas is produced from gas fields awarded by the Government to entities on nomination basis prior to the Production Sharing Contract (PSC) regime. The prices of gas produced from these fields were administered by the Government. Landfall price of APM gas was fixed at $1.79 per mmbtu (on Net Calorific Value (NCV) basis) till May 2010, post which it was increased by the government to $4.2 per mmbtu (on NCV basis).

On October 18, 2014, the Cabinet Committee on Economic Affairs (CCEA) approved a new mechanism for determining the price for domestic natural gas where, the domestic price of natural gas is the volume weighted average of gas prices at Henry Hub, Alberta Gas Reference Point, NBP and Russia. Prices at the three trading hubs/Russian domestic price will be deducted by $0.5 per mmbtu to account for transportation and treatment charges.

Gas prices are determined on a half-yearly (April and October) basis and based on trailing four quarter prices at these hubs, with a one quarter lag. For instance, prices for April to September will be based on the average prices over January to December in the previous year.

Based on the new pricing mechanism, domestic gas prices were revised downward for the October 2015-March 2016 period, to $3.82 per mmbtu (on Gross Calorific Value (GCV) basis) from $4.66 per mmbtu (on GCV basis) earlier. Post that, prices were further downward revised to $3.06 per mmbtu (on GCV basis) for the April 2016-September 2016 period, reflecting weakness in global gas prices. The prices for the period, April-September 2017 had been fixed at $ 2.48 per mmbtu. The prices were further revised to $ 3.36/mmBtu from October 2018 - March 2019, compared with $3.06 from April 2018 - September 2018, reflecting a recovery in global market. Currently, domestic gas prices are at $2.39 per mmbtu, revised for the period April-September 2020.

Also, new discoveries (made post October 2014) in deep and ultra-deep-water areas and areas with high temperature-high pressure would be allowed a premium over this base price. Gas produced from such fields would be allowed marketing and pricing freedom, however its price will be capped based on the price of substitute fuels such as fuel oil, imported coal, naphtha and imported liquefied natural gas (LNG). For the period April 2020-September 2020, the price ceiling for gas produced from these fields is fixed at $5.61 per mmbtu (on GCV basis). Price ceiling on gas price prevents price shocks to gas customers who will find it beneficial to use gas during energy price volatility.

Government appointed Parikh committee to review the gas pricing formula for domestically produced gas in India, which is currently based on international benchmark prices. Thus, in April 2023 this mechanism was approved by the cabinet. The committee mulled ways to boost natural gas production and ensure availability and affordability for end-users. As per the new mechanism, the dynamic APM prices will have a floor of $4 per mmBtu and a ceiling of $6.5 per mmBtu for fiscals 2024 and 2025. The ceiling will be raised by $0.25 per mmBtu every year after completion of two years. However, price mechanism for difficult field gas price remained unchanged.

4.1.8 R-LNG pricing

In India, at present, Petronet LNG is the only player in the regasified liquefied natural gas field with long-term contract, for sourcing 8.5 mtpa LNG from RasGas Qatar. Until December 2009, the FOB price of LNG from RasGas was capped at $2.53 per mmbtu after which, the price has been linked to the price of Japanese Crude Cocktail (JCC) and was to be determined as per an agreed formula. As a result, FOB prices of long-term LNG increased gradually to $13.7 per mmbtu in 2014-15.

However, on December 31, 2015, Petronet LNG (PLL) renegotiated the terms of its long-term LNG supply contract with Rasgas, Qatar. Rasgas agreed to modify the formula for calculating the LNG price, which led to the reduction of the LNG price by half; it also waived off the penalty for low volume offtake in 2015. On the other hand, Petronet LNG committed to increase the volume of LNG to be purchased from Rasgas.

As per the renegotiated contract, the basis for calculating the LNG price has been modified to make it more responsive to recent crude oil price (Dated Brent) movements. Under the earlier contract, the cap and floor price for crude oil was set based on the average price for the preceding 60 months. While this mechanism limited volatility in the contracted LNG price, it also prevented a sharp correction in the contracted LNG price in 2015, despite crude oil price declining by almost half.

From January 2016 onwards, the average crude oil price of only the previous three months is considered to calculate LNG price. While this has made LNG price much more volatile compared to the earlier formula, it has also led to almost a 50% decline in LNG price.

Domestic gas prices averaged at $7.34 per mmBtu in fiscal 2023. Prices rose by more than 200% on-year. The rise in prices was attributable to a steep rise in international hub prices owing to lower inventory levels, energy crisis in Europe and supply constraints owing to realignment of global trade key reasons. Domestic gas prices averaged at $2.1 per mmBtu (metric million British thermal unit) in fiscal 2021 compared to $2.5 per mmBtu in fiscal 2020. The decline in prices was due to subdued gas prices at different international gas hubs. For the first half of fiscal 2022 i.e. from April-September 2021, domestic natural gas price was at $1.8/ mmBtu, due to lower prices at international gas hubs as a result of supply glut. Considering the sustained over-supply, lower prices and lower demand due to Covid-19 restrictions, prices in second half (October 2021-March 2022) settled at $2.9/ mmbtu mark.

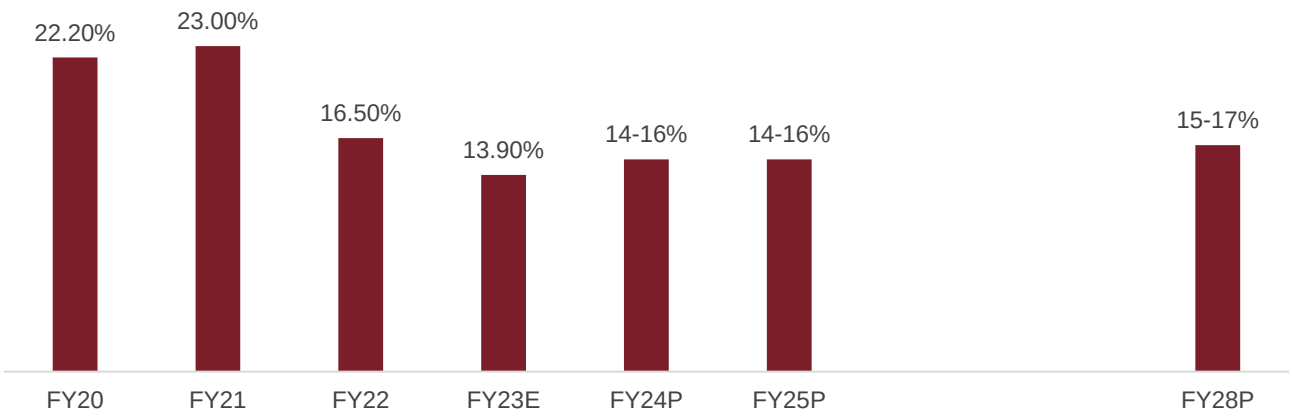
In fiscal 2023, spot gas prices have risen by ~26% on-year to $26.8 per mmBtu owing to lower inventory levels amid Russia-Ukraine conflict. However, spot LNG prices are expected to remain lower in fiscal 2024 owing to substantial inventory levels coupled with demand destruction from the European markets to keep prices lower. Therefore, we expect spot prices to remain in range of $10-15 per mmBtu depending on scenarios based on Russian gas supplies, winter and injection demand from Europe, outages at liquefaction terminals etc..

Impact on R-LNG pricing on demand for power from natural gas

With declining domestic gas production and power not being a priority sector any more for domestic gas, the generation from gas plants has become costlier owing to high prices of re-gassified liquid natural gas (RLNG). The variable cost of generation from RLNG would be more than Rs 11-12.5 per kWh as against Rs 5-6 per kWh for coal-based plants.. Even after the government's initiative to support RLNG-based power generation until March 2017, the average plant load factor (PLF) for gas-based plants remained low at 22.5% over the past three years. Thus, in fiscal 2022, gas consumption from the power sector declined, as PLF declined to 16.5% owing to higher LNG prices. Due to continued higher gas prices in fiscal 2023, gas-based power plant's PLF is estimated to have remained low at 13-14%.

In fiscal 2024, PLF to increase to the tune of 14-16% with cooling of LNG and domestic gas prices. Therefore, gas consumption from this sector is expected to remain subdued. .

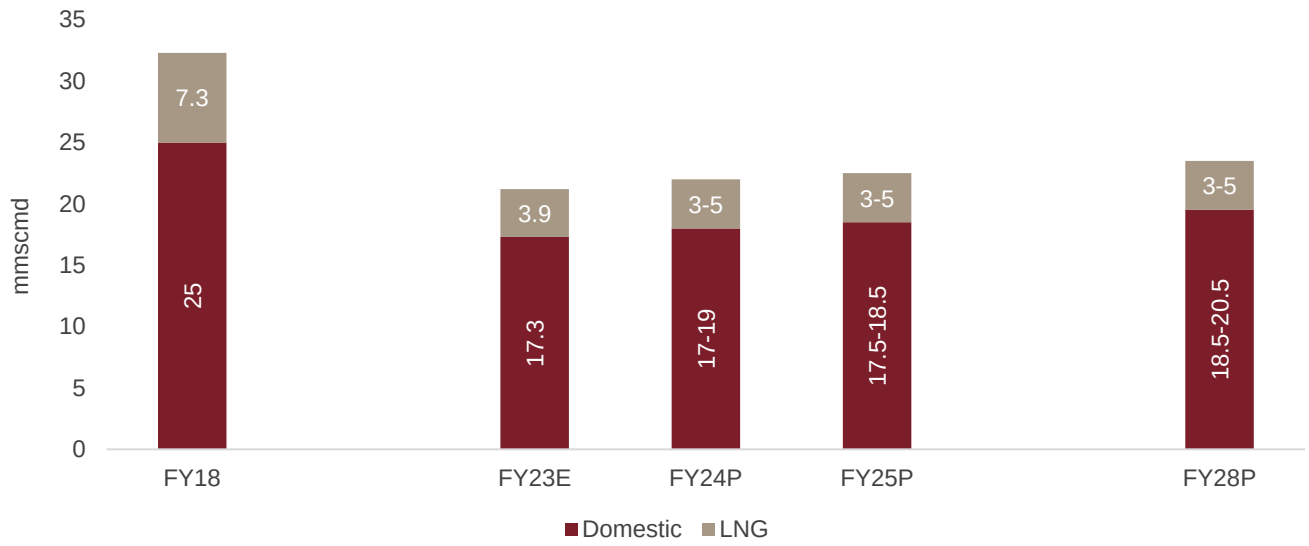
Plant load factor for gas-based power plants



Note: E: Estimated; P: Projected
Source: CRISIL MI&A

Over long term, we expect gas demand to increase marginally at 2-6% CAGR between fiscals 2023 and 2028, to 23-25 MMSCMD. In the long run, gas-based power plants' PLF is expected to increase marginally from low levels of fiscal 2022. Therefore, demand is expected to increase, but average PLF of gas-based plants is expected to remain low at below 18%. Lower PLF, given the lower competitiveness of gas against its alternates, will lead to lower demand from the power segment.

Plant load factor for gas-based power plants



Note: E: Estimated; P: Projected
Source: CRISIL MI&A

4.1.9 LNG as auto fuel, fuelling infrastructure key to LNG adoption by the auto sector

In 2017, the government notified the use of LNG as an auto fuel by amending the Central Motor Vehicle Rules (CMVR), which paved the way for manufacturers to develop vehicles using LNG. Further in 2018, the Gas Cylinder Rules were amended to include Auto LNG (LNG meant for automotive fuel) under its regulatory framework. Trials for the first LNG bus was held in November 2016 to test the feasibility of LNG powered vehicles. However, there has not been any significant market development on this till now either on the auto-LNG dispensing station or on LNG vehicle availability side. This is a chicken and egg story as LNG vehicles can't operate without auto-LNG dispensing stations hence LNG vehicles are unlikely to be launched commercially. While auto-LNG dispensing station setup without vehicles to supply to will be a loss-making affair.

This deadlock was broken in November 2020 with the Government of India kicking off construction of 50 LNG fuel stations along the golden quadrilateral connecting the four corners of the country. In phase-I, 50 LNG stations have been awarded of which, Indian Oil will set up 20 LNG Stations, while Bharat Petroleum and Hindustan Petroleum will set up 11 LNG stations each while the rest are being set up by Gujarat Gas and JV of GAIL with OMC's. These are mostly expected to be setup on the western side of the golden quadrilateral on the Delhi-Mumbai, Mumbai-Bangalore, Bangalore-Kochi and Chennai-Kolkata route. This will serve as an important first step to developing an LNG ecosystem for automobiles.

In phase-II, 50 more stations are expected to be awarded which are expected to be along the Delhi-Kolkata and Mumbai-Indore route. Further, 900 more stations connecting the major highways are expected to be awarded to ensure that the major freight carrying routes along the length and breadth of the country will be covered over the

next three years. A total of 1,000 stations are planned with a total expenditure of Rs.100 bn to setup with LNG stations along the national highway network, industrial corridors, and mining areas of the country.

Auto-LNG dispensing station are being setup in phases along the golden quadrilateral as these stations will require LNG to be supplied though LNG tanker trucks which will carry LNG from large LNG terminals located along India's coastline which are supplied with LNG from LNG bulk tanker ships. Unlike CNG stations which can operated with piped natural gas, LNG stations will not be able to do so as cost of liquefying piped natural gas will add to cost significantly. One major benefit of setting up LNG fuel stations along the Golden Quadrilateral especially along the coastline is that the closer they are to the LNG terminals lower will be the cost of transporting fuel to these stations.

Existing LNG terminals

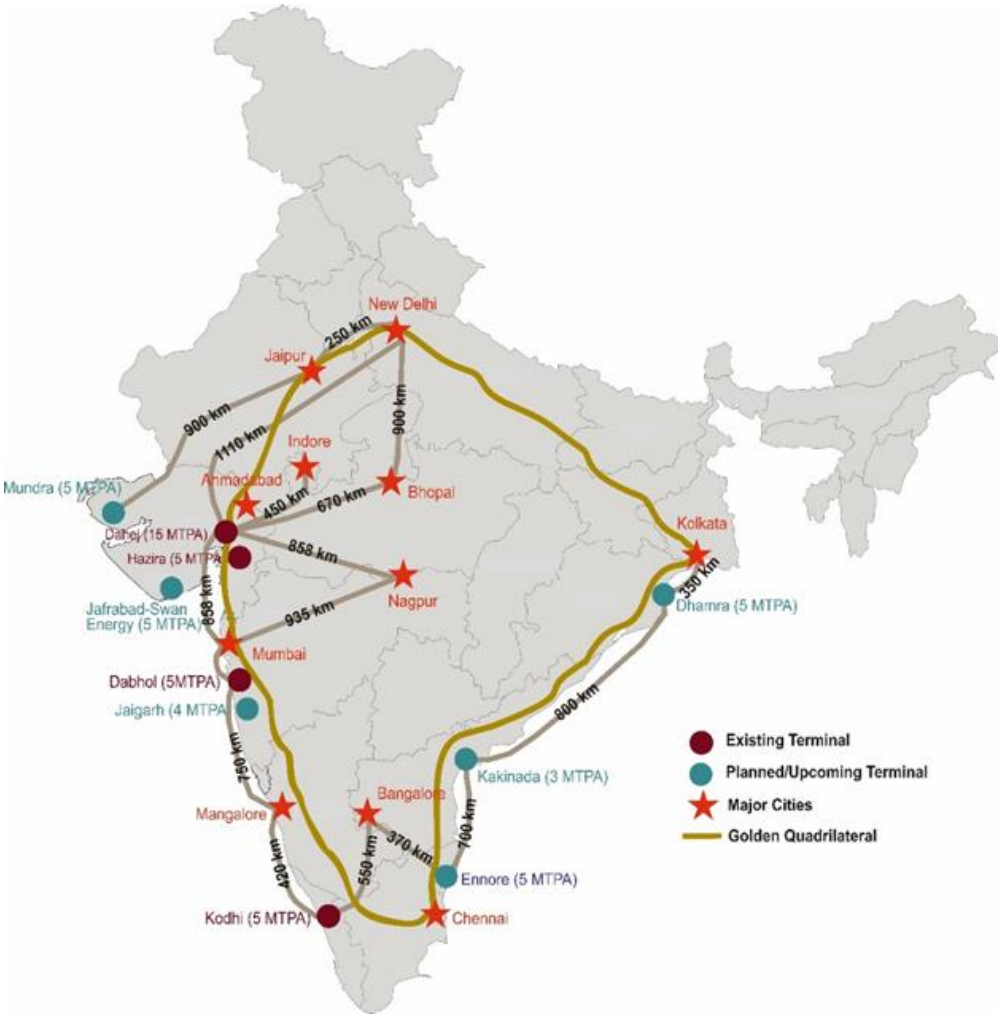
LNG Terminal	Entity/promoter	Capacity	Utilisation			
			FY21	FY22	FY23E	Apr-Jul'23
Dahej	Petronet LNG	17.5	94%	88%	78%	96%
Hazira	Shell Energy	5.2	77%	47%	37%	33%
Dabhol	Konkan LNG	5	76%	85%	39%	49%
Kochi	Petronet LNG	5	17%	21%	19%	20%
Ennore	IOC	5	13%	13%	11%	11%
Mundra	GSPC LNG	5	35%	19%	16%	19%

Source: CRISIL MI&A

Upcoming LNG Terminals

LNG Terminal	Entity/promoter	Capacity	Expected Commissioning
Dhamra	Adani Total Group	5	FY24
Jaigarh	H-Energy	5	FY24
Chhara	HPCL and Shapoorji Energy	10	FY24
Jafrabad	Swan Energy	5	FY24
Dahej	Petronet LNG	5	FY25
East coast	Petronet LNG	4	FY27

Existing and planned/upcoming LNG terminal locations



Source: CRISIL MI&A

While mainstream OEMs are yet to launch LNG commercial LNG vehicles the infrastructure being put in place will give confidence to the other stakeholders in the industry such as transporters and financers to transition to LNG. Blue Energy Motors, launched India's first Liquefied Natural Gas (LNG) fuelled green truck in September 2022. Company rolled out their 100th LNG truck in May 2023 showcasing the potential for LNG trucks in long haul applications.

LNG auto fuelling stations can be of two types, LNG stations and LCNG stations. The main difference being that while LNG stations only dispense LNG, LCNG stations can also provide fuel for LNG as well as CNG vehicles using equipment to convert LNG to CNG. This is an important distinction as in the current scenario, there are no LNG vehicles on road in India. Hence, till LNG vehicle population builds up LCNG stations can cater to CNG vehicles such as passenger vehicles, three wheelers and light and intermediate commercial vehicles where a rapid shift from diesel to CNG is seen with rise in diesel prices.

With the government is pushing the use of LNG as fuel for long-haul transportation, along with PSU oil and gas majors such as IOCL, HPCL, BPCL etc private companies such as Shell and H-Energy are also looking to setup LNG stations to cater to LNG demand from long distance heavy commercial vehicle traffic.

4.1.10 Share of natural gas vehicles likely to increase going forward

Maruti Suzuki already offers CNG models in Alto, Swift, Brezza and Ertiga. Other OEMs have started offering CNG option at least in entry level cars as well. Recently,. Tata Motors also has launched CNG variants for Tiago, Punch and Altroz. With more cities being connected to gas networks, penetration of CNG is expected to increase. With petrol prices now, in May 2023 at ~Rs 97 per litre, CNG is 25-30% cheaper after the new price mechanism currently at Rs 73.59 per kg, thus the switchover would be easier. This, along with new model launches focussed on CNG by OEMs, will further accelerate the transition towards CNG vehicles.

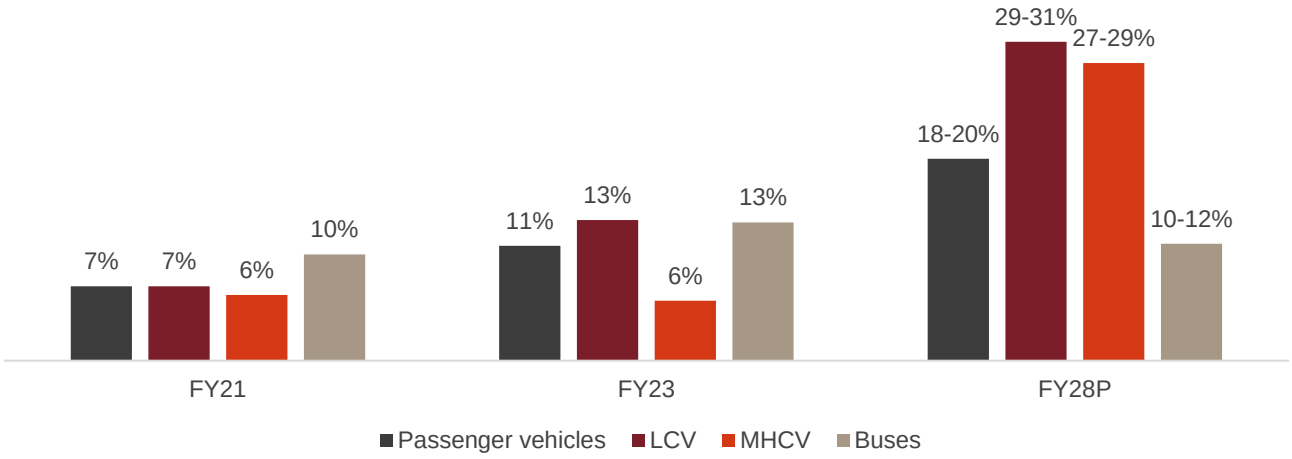
That said, currently, CNG is primarily available in major metros and tier-I cities. Long waiting time to refill CNG vehicles has led to low buyer preference for CNG variants. However, the CNG network is expanding rapidly. The total number of stations is set to reach 12,000-13,000 by fiscal 2028.. The industry is also exploring measures to boost the CNG ecosystem with mobile refilling CNG facilities, wherein CNG refilling is set up in shopping malls, offices, etc.

Diesel variants posted the sharpest decline owing to most manufacturers phasing out diesel variants in passenger vehicles on account of increase in the cost of the vehicle due to BS-VI, making the powertrains unviable. Traction in CNG variants was seen because of better cost economics as compared with other fuel types.

Share of CNG has seen a sharp increase in LCV and passenger vehicle segment in the last five years. The major shift has been post BS-VI norms implementation. Share of natural gas vehicles is expected to continue to increase due to favourable cost economics due to lower gas prices compared to diesel and expansion in city gas distribution (CGD) network across the country.

In MHCV segment, diesel still accounted for more than 90% share in FY2023 while CNG saw an increase to about 6% from less than 1% in FY2016. However, for large power requirements, such as for heavy loads and long-distance transport, the size/number of CNG tanks required increase significantly. This affects the cost competitiveness of vehicles as it results in lower payloads and limited running distances. Time taken to fuel CNG vehicles is another deterrent as many CNG stations are more catered towards smaller vehicles which use smaller nozzles for filling CNG as the amount of CNG required for smaller vehicles such as cars and smaller commercial vehicles is much lower than required for trucks. Also, the cost of CNG fuel plays a critical role in uptake of CNG vehicle. In FY23, the Russia-Ukraine conflict impacted the CNG fuel prices. As the price of CNG was higher, adoption almost was flat in FY2023 as the total cost of ownership (TCO) benefits were lower. Hence the price difference between CNG and fossil fuel would play a critical role in CNG adoption, Further, the pricing mechanism suggested by Parikh committee would lower the CNG fuel prices, driving the adoption. For longer distance transport LNG is expected to gain favour as large amounts of gas can be stored in liquefied form which is ideal for heavy duty trucks on long trips. Currently all natural gas vehicles are CNG variants however with the government notifying LNG as an auto fuel and plans underway to setup a national LNG dispensation grid the share of LNG vehicles is also likely to increase especially in the medium to heavy commercial vehicle (MHCV) segment.

Historical share of natural gas (CNG/LNG) vehicles across segments



Source: CRISIL MI&A

Emission norms of other segments

Emission norms for tractors and construction equipment have been renamed to agricultural tractor and other equipment (TREM) norms and construction equipment vehicles (CEV) norms by the government in a notification dated 5th Oct 2020.

Tractors with over 50 horsepower (hp) will be required to comply with the new TREM IV emission norms once they come into effect, to reduce the emission of pollutants. While the share of > 50 hp tractors is limited at about 10% of the sales, the emission regulations are on a tightening trend not just for on-road vehicles but all other vehicles such as tractors and construction vehicles.

TREM-V and CEV-V are notified to be applicable from FY2025 which will further increase the stringency in emissions. The broader goal is to reduce emission of pollutants and greenhouses gas and this will keep manufacturers looking for alternatives to reduce emissions.

Similar norms are also applicable for emissions from gensets used for power generation. In 2002, the standards were developed for diesel engines over 800kW and were phased in between 2003 and 2005. Emission limits for <800kw gensets were introduced in 2005 and further strengthened in 2013. In 2016 emission standards for smaller <19kw spark ignition engines using petrol/natural gas were introduced. These regulations targeting lower emissions from emissions from will increase costs of genset operating on diesel and petrol. Gas based genset are seeing demand especially in areas where air quality is poor. For e.g., the Delhi government had banned the use of diesel gensets when AQI index hit ‘very poor’ in the city. This has potential to increase demand for natural gas-based equipment increasing demand for natural gas.

Indian Space Policy and Defence Acquisition Procedure to support domestic manufacturing of rocket and missiles

The governments’ thrust in developing the space sector can be seen with the activity in the sector such as, Department of Space after allowing the private companies to enter the Indian space sector in June 2020, had also proposing a policy to enable the private Indian companies to develop new systems as well as sell services to foreign companies, allowing FDI and supporting domestic companies in the space sector with access to ISRO

facilities and expertise. Around 75 start-ups have registered under space technology category in the Startup India portal since the time private participation was allowed and allowing of FDI in the sector can further boost the investment and development of the sector. The development of cryogenic space engines by startups will increase demand for liquid oxygen at it one of the key ingredients along with either liquid hydrogen or LNG.

Hydrogen policy introduction by central and state governments

In January 2023, Union Government has approved a Rs 197.44 billion National Green Hydrogen mission that aims to make India a global hub for using, producing and exporting green hydrogen.. It aims to develop India as a global hub for manufacturing hydrogen and fuel cell technology across the value chain. The Mission will support the replacement of fossil fuels and fossil fuel-based feedstocks with renewable fuels and feedstocks based on Green Hydrogen. This will include replacement of Hydrogen produced from fossil fuel sources with Green Hydrogen in ammonia production and petroleum refining, blending Green Hydrogen in City Gas Distribution systems, production of steel with Green Hydrogen, and use of Green Hydrogen-derived synthetic fuels (including Green Ammonia, Green Methanol, etc.) to replace fossil fuels in various sectors including mobility, shipping, and aviation. The mission also aims to aid the government in meeting its climate targets and making India a green hydrogen hub. PLI schemes are also offered for manufacturing of electrolysers in India along with offering incentives for hydrogen production.

Along the lines of the Nation Hydrogen mission, the central government has introduced the Green Hydrogen and Green Ammonia Policy in Feb 2022. The policy aims at boosting the domestic production of green hydrogen to 5 MTPA by 2030. It has provided open access, grid finance and charted out a favourable regulatory environment to provide fast approvals for green hydrogen and green ammonia projects. Due to the high cost of production of green hydrogen currently, it has provided free inter-state transmission system for 25 years for capacity install by June 2025 which will lower the cost of green hydrogen. It has also authorised 30-day renewable energy banking at limited charges set by state commissions. State governments too are looking to draft state level hydrogen policies to support the hydrogen sector within the state. Gujarat and Tamil Nadu governments have already announced that they are working on coming out with a hydrogen policy.

As per a study by Rocky Mountain Institute (RMI), the prices of green hydrogen to halve from the current $1.7-$2.4/kg in 2030 to $0.6-$1.2/kg by 2050. The current cost of green hydrogen is estimated to be between $4.1-7/kg. The significant reduction in prices is expected to drive demand for green hydrogen.

RMI estimates, from the basis of price parity alone, the share of green hydrogen in overall hydrogen demand can increase from 16% in 2030 to 94% in 2050 while currently the share of green hydrogen is estimated to be miniscule. This implies a cumulative electrolyser capacity of 20GW in 2030 and 226GW by 2050 which is an 11x increase in 20 years translating to about 13% CAGR of green hydrogen production capacity over the period. The report estimates a cumulative value of the green hydrogen market in India of $8 billion by 2030 and $340 billion by 2050. The key industries driving the demand for hydrogen would be refining, ammonia and methanol in the near term while steel production and heavy duty trucking are expected to drive demand toward the latter end of the period accounting for over 50% of the demand for green hydrogen. The forecast of demand for green hydrogen is done without assuming any policy intervention. Hence, support from central and state governments can further accelerate the trend.

RMI estimates the rise in demand for green hydrogen to benefit the environment by an estimated 3.6 giga tonnes of cumulative CO2 emission between 2020 and 2050 while the financial saving accounting from reduced energy

import costs are estimated to be to the tune of $246 billion to $358 billion in the same period while providing other benefits such as energy security and lesser impact of energy prices on India's foreign exchange situation.

Regulations for cryogenic equipment in India

In India, Petroleum & Explosives Safety Organization (PESO) is the nodal agency covering cryogenic equipment manufacturing and operations such as tanks for cryogenic gases. PESO is responsible for formulation of framework and safety guidelines for industries/equipment associated with compressed gases. PESO certification essentially proves that the company adhere to rules and regulations associated with safety while manufacturing, transporting and storage of cryogenic gases and other hazardous chemicals. ATEX, IECEx, ASME, PED, or TPED certificates including corresponding test reports verified by certified independent agencies must be submitted for the PESO certification. Ideally, these documents should be up to date, meeting latest standards (such as ISO standards) and preferably not older than 2 years. In addition to the required documents, the company must nominate an Indian representative Authorized Indian Representative (AIR) which should be a company registered in India such as the own subsidiary or a reliable local sales partner. For successful certification from PESO, product information with valid certificates, and company information pertaining to sales and AIR needs to be submitted.

Cryogenic equipment rules are governed by the Static & Mobile Pressure Vessel (Unfired) Rules, 2016. The licenses required to design, manufacture, repair such equipment are provided by PESO for a period of 3 years and are renewed if all requirements are met. These licenses cannot be transferred from one person/company to another person/company. Equipment manufactured will require testing every year for safety relief values, two years for pressure vessels containing toxic and corrosive gases and every five years for other vessels. Getting PESO approvals can be difficult due to the nature of products governed by PESO. The process can be very stringent, and a large number of documents / information may be required based on the type of approval required. Cryogenic systems have stringent certification requirements and engage the products in rigorous testing and quality checks and hence customer stickiness can be high.

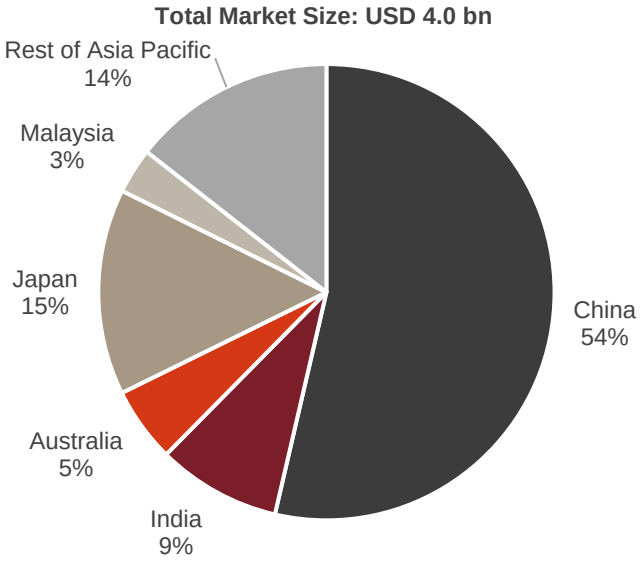
As per the Legal Metrology Act, 2009 weighing and measuring instruments have to be approved as specified in The Legal Metrology (Approval of Models) Rules, 2011 to ensure the security and accuracy of the weighments and measurements. These regulations are applicable for fuel dispensing equipment such as petrol, diesel, LNG dispensers etc. As of November 2022, only two LNG dispenser manufacturers have received the certificate of approval under the rules. One is Cetil Dispensing Technology which is based in Madrid, Spain and Inox India based in Vadodara, India which is the first Indian manufacturer of LNG dispensers to get the approval.

4.2 Market size of domestic cryogenic equipment industry

Asia Pacific is the largest share of cryogenic equipment demand by region due to large share of production in sectors such as metallurgy, chemicals and electronics. It accounts for 35% of the global cryogenic equipment demand. The Asia-Pacific region is not only the largest market for cryogenic equipment, but also projected to be the fastest growing between CY2023 and CY2028

The largest market in the Asia Pacific region is China which has a large manufacturing industry and has become one of the key suppliers of a variety of products to the world. The market in China is primarily propelled by development of LNG infrastructure projects. Japan is also having many high-tech industries such as electronics and heavy engineering but is also one of the largest LNG importers in the world which drives demand for cryogenic equipment. India is the third largest market for cryogenic equipment in the Asia Pacific regions account for 8-10% of the demand for cryogenic equipment.

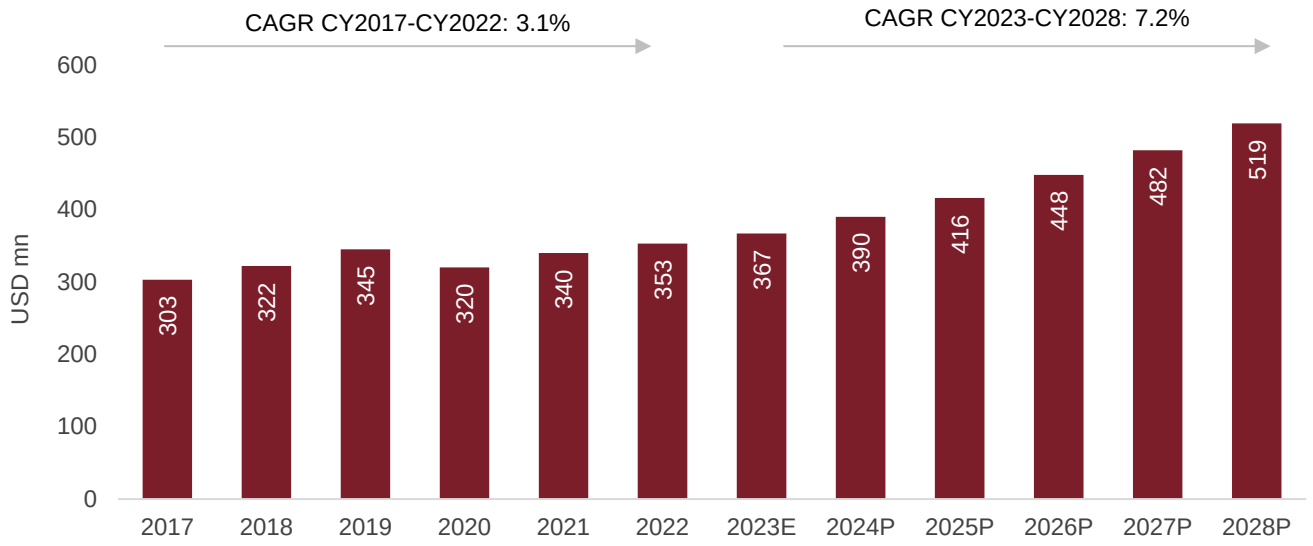
Share of demand for cryogenic equipment in Asia Pacific by country in CY2022



Source: Markets and Markets, CRISIL MI&A

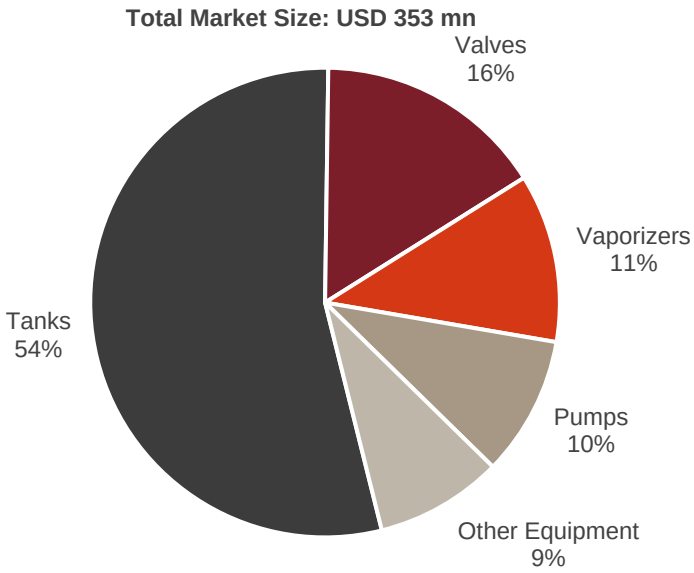
The domestic cryogenic equipment market size was estimated to be USD 353 mn in CY2022. The demand for cryogenic equipment was steadily growing at a rate of 6.8% CAGR between CY2017 and CY2019 before being impacted by the Covid-19 pandemic. The ensuing lockdown and travel restrictions saw the demand growth for cryogenic equipment stall for two years between CY2019 and CY2021. Going forward demand for cryogenic equipment is expected to grow at a CAGR of 7.2% between CY2023 and CY2028. Driven by increase in industrial output, investments in electronics and space sectors and shift towards cleaner fuel sources such as LNG and hydrogen in the industrial and transport sector.

Domestic cryogenic equipment demand



E: Estimated; P: Projected
Source: Markets and Markets, CRISIL MI&A

Share of types of cryogenic equipment in domestic market in CY2022



E: Estimated; P: Projected
Source: Markets and Markets, CRISIL MI&A

Of the types of equipment used, tanks used for storage and transportation form a major share with over half of the total cryogenic equipment demand. The other major types of equipment are valves which are used to control flow and for safety at 16%, vapourisers which convert cryogenic liquids to gaseous form at 11% and pumps at 10%. The other equipment accounting for 9% includes pipes, regulators, freezers, dewars, strainers, samplers, heat exchangers, leak detection equipment, dispensers, and manifolds, fittings, vacuum jacketed / insulated piping, hoses, connections etc.

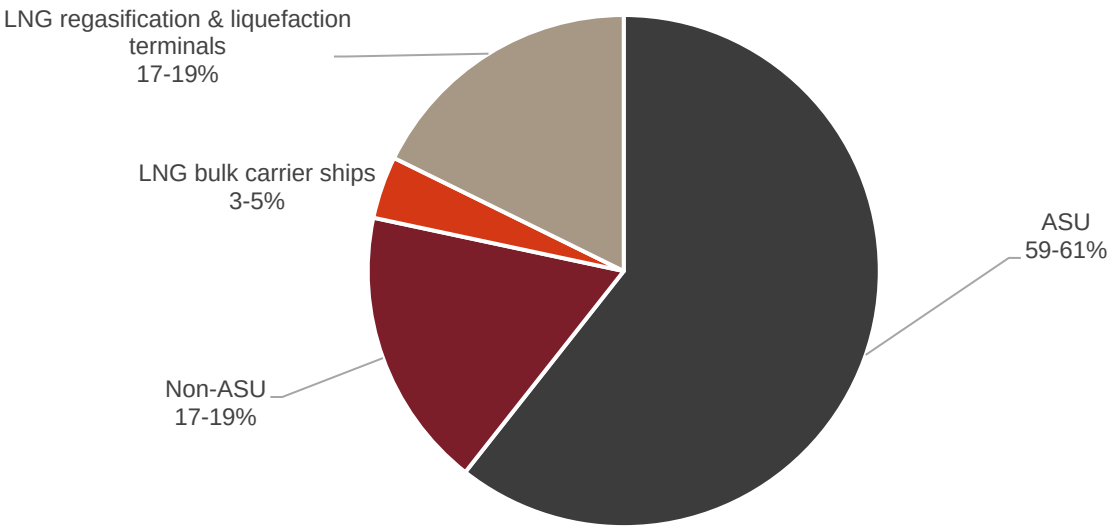
4.2.1 Key applications of cryogenic equipment

The equipment used to store, transport and handle the cooled gases in liquid form is collectively called cryogenic equipment. ASU's form about 59-61% of the demand for domestic cryogenic equipment consumption in CY2022. The major cryogenic equipment includes tanks, valves, vaporisers and pumps.

LNG applications form another major market for cryogenic equipment due to the large volume of natural gas demand and the subsequent need for its transport, storage and distribution. Of these application LNG bulk carrier ships and LNG terminals for liquefaction and regasifications are the major demand segments. LNG bulk carrier ships are marine vessels that enable the transportation of large quantities of liquified industrial gas which accounts for 3-5% of the domestic cryogenic equipment demand while LNG liquefaction and regasification terminals are facilities that convert the industrial gas into its liquid and gaseous states, respectively, to facilitate storage and transporation of large volumes of natural gas economically over long distances. This segment accounted for 17-19% of the total cryogenic equipment demand in CY2022.

All other applications of cryogenic equipment are grouped under non-ASU segment, which includes rail and road transport, small-scale/temporary storage, cryopreservation, research studies, satellite launch facilities, cryogenic process technologies and cryogenic electronics, such as superconducting magnet systems, low-temperature detector systems and infrared array systems, among others.

Share of applications for domestic cryogenic equipment CY2022

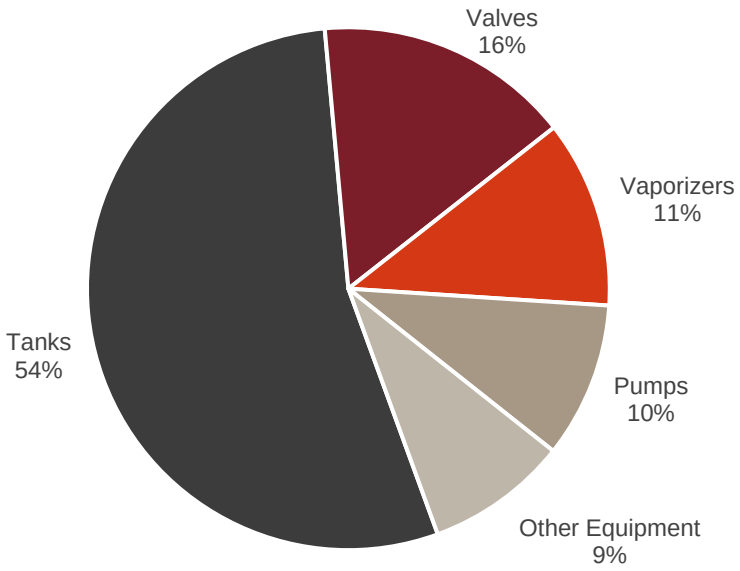


Source: Markets and Markets, CRISIL MI&A

4.2.2 Types of cryogenic equipment

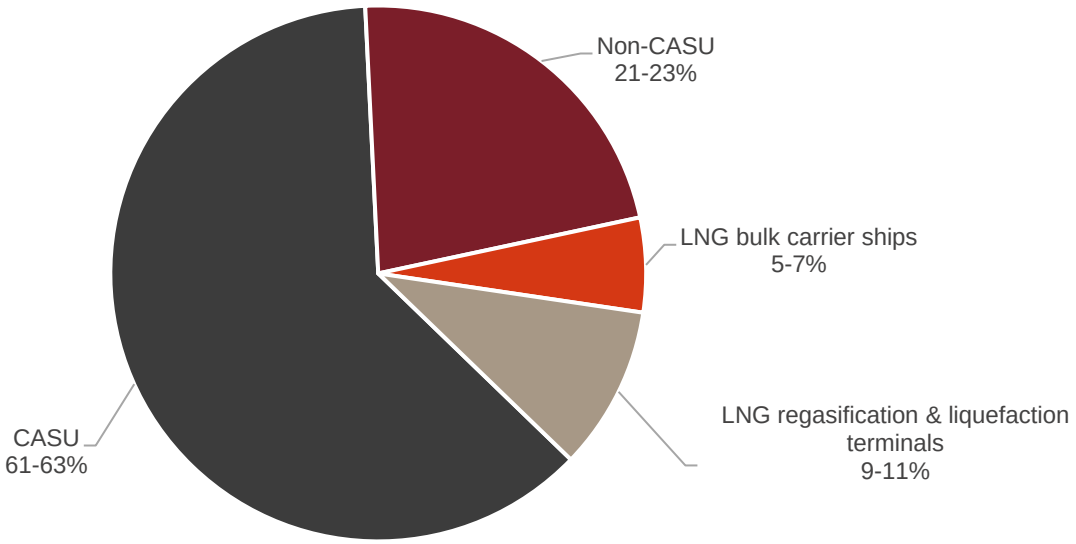
Of the types of equipment used, tanks used for storage and transportation form a major share with over half of the total cryogenic equipment demand. The other major types of equipment are valves which are used to control flow and for safety at 16%, vapourisers which convert cryogenic liquids to gaseous form at 11% and pumps at 10%. The other equipment accounting for 9% includes pipes, regulators, freezers, dewars, strainers, samplers, heat exchangers, leak detection equipment, dispensers, and manifolds, fittings, vacuum jacketed / insulated piping, hoses, connections etc.

Share of type of cryogenic equipment CY2022



Source: Markets and Markets, CRISIL MI&A

At 54%, tanks account for an estimated $191 mn of the domestic cryogenic equipment demand out of which ASU's for a major share of demand account for a little under 2/3rds of the demand. LNG bulk carrier ships account for 9-11% of the demand while LNG terminals accounted for 5-7% of the demand. The rest of the demand for tanks from transport and storage accounted for 21-23% of the demand.



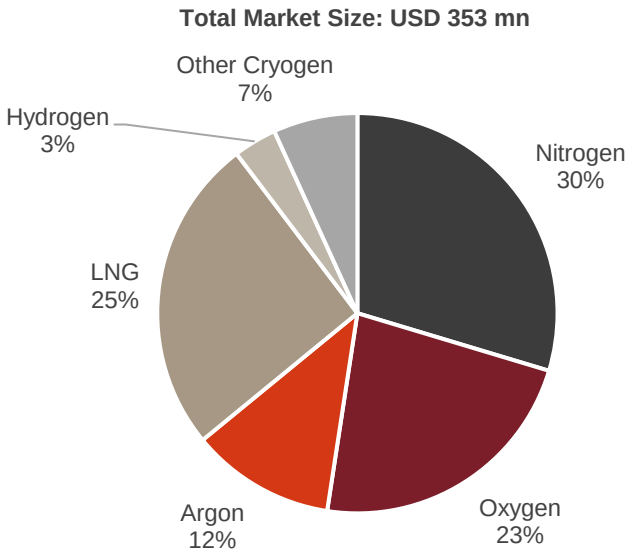
Source: Markets and Markets, CRISIL MI&A

4.3 Market size of domestic cryogenic equipment by cryogen

The major sources of cryogenic gases are atmospheric air, which is separated into its constituents by air separation units, and energy gases, such as LNG and hydrogen. While LNG, a fossil fuel, is extracted from drilling, hydrogen can be produced from renewable and non-renewable sources. While most of the hydrogen produced currently is from fossil fuels, in the long-term hydrogen produced from renewable sources i.e., "green hydrogen" is expected to increase as cost for producing green hydrogen declines. This is expected to drive demand for hydrogen as a source of clean fuel as it would be produced from fully renewable sources and also emits no pollutants during use.

That said, nitrogen has wide application across industries. However, LNG, which is used as a fuel source, is seeing rising adoption as a cleaner fuel source and is expected to see the fastest growth across cryogens. Other gases that form 7% of the total demand for cryogenic equipment are helium, nitrous oxide, ethylene, and carbon dioxide.

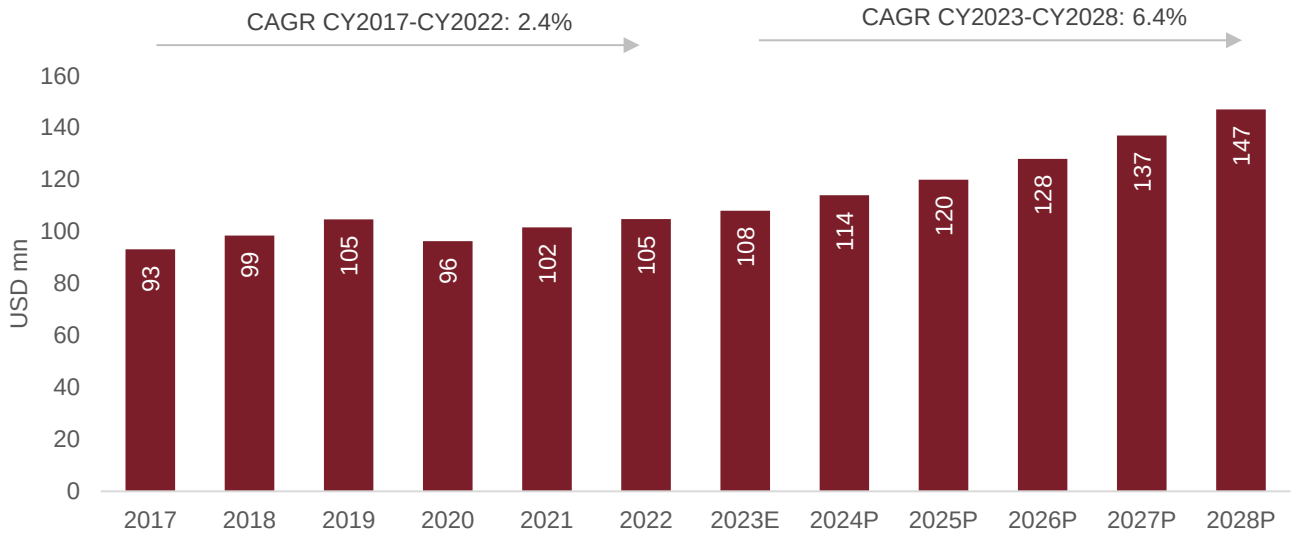
Share of cryogenic equipment demand by cryogen in CY2022



Source: Markets and Markets, CRISIL MI&A

Nitrogen is the most abundantly available gas in the atmosphere. Demand for cryogenic equipment from nitrogen is estimated to account for 30% of the total cryogenic equipment demand in India. It has wide application in industries such as fertiliser and chemical industries and for medical use owing to its high availability in the atmosphere and its inert nature. Going forward demand for cryogenic equipment from liquid nitrogen is expected to grow at a CAGR of 6.4% between CY2023 and CY2028

Domestic demand for cryogenic equipment from nitrogen segment



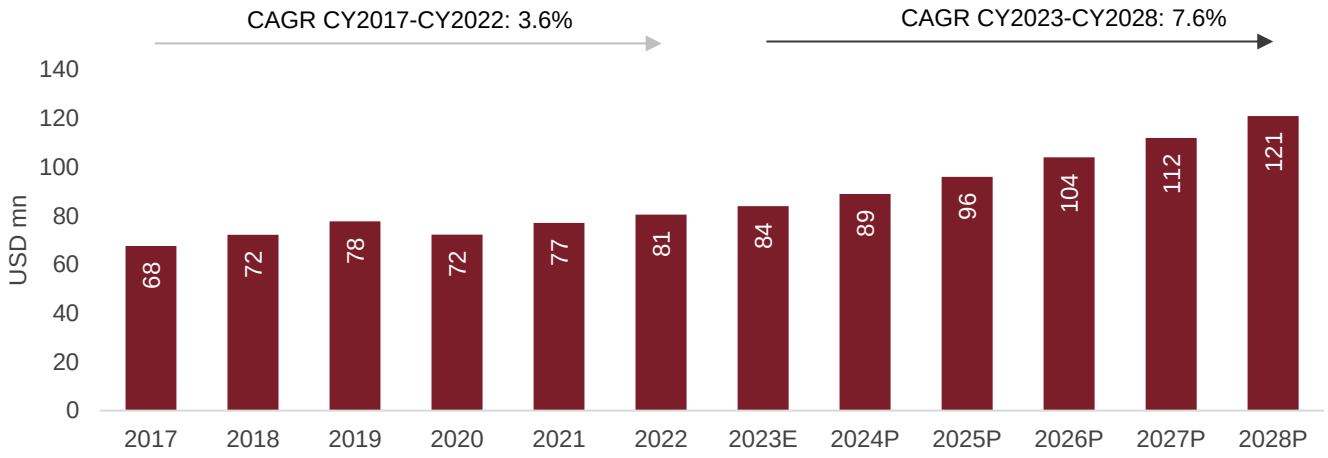
E: Estimated; P: Projected
Source: Markets and Markets, CRISIL MI&A

Demand for cryogenic equipment from oxygen is estimated to account for 23% of the total cryogenic equipment demand in India. Oxygen is also abundantly available in the atmosphere and has a key role in combustion and the

oxidation processes in industries such as metallurgy for production of steel and metal fabrication. It also finds use in petrochemical, medical and aerospace applications.

Between CY2023 and CY2028, demand for cryogenic equipment of liquid oxygen is expected to grow the second-fastest, at 7.6% CAGR. Electronics and metallurgy industries are projected to be the key demand drivers for oxygen-related equipment.

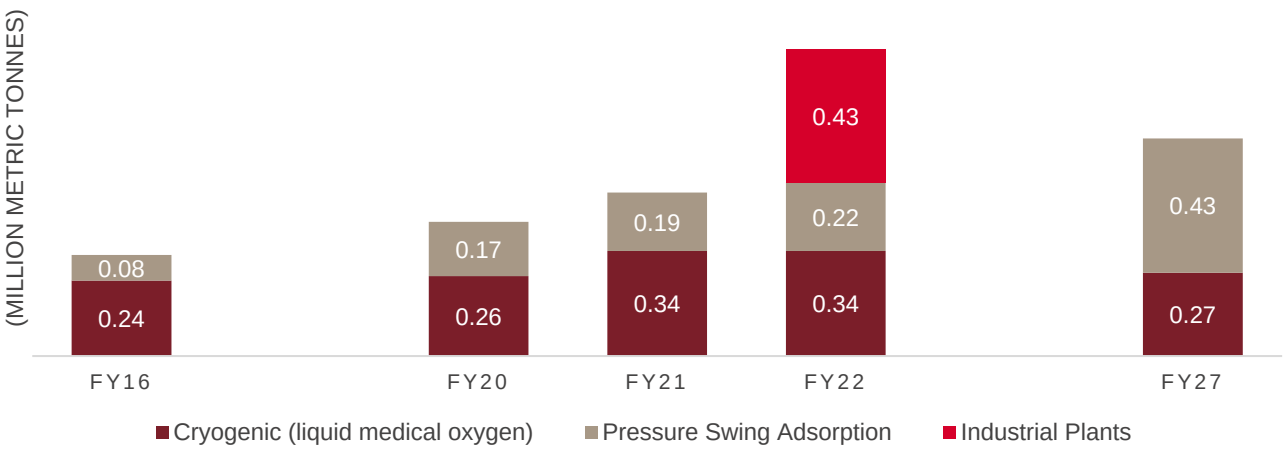
Domestic demand for cryogenic equipment from oxygen segment



E: Estimated; P: Projected
Source: Markets and Markets, CRISIL MI&A

Out of the total demand for liquid oxygen, about 20% of the liquid oxygen demand is for medical applications. The oxygen supplied to the medical segment called liquid medical oxygen (LMO) has additional standards to adhere to over and above what is required for industrial applications which is monitored by Central Drugs Standard Control Organisation (CDSCO).

Domestic medical oxygen demand from cryogenic vs non-cryogenic sources



Source: CRISIL MI&A

The demand for medical saw a surge in CY2020 and CY2021 due to the Covid-19 pandemic and the need for concentrated oxygen for some patients suffering from extreme symptoms of Covid-19 with breathing issues. Due to

the lockdown across the world there were many supply issues in meeting the demand for cryogenic equipment for LMO. The huge surge in cases in a short period necessitated the diversion of industrial equipment to meet the medical segment during the waves of infection with as each new variant emerged. However, the highest demand was seen during the second wave (Delta variant) which spread fast and caused a much higher peak case load in a short span of time.

The demand for cryogenic equipment saw a surge from the medical segment during CY2020 and more so in CY2021 however, due to shortage of cryogenic equipment availability and difficulty in quickly transporting liquid oxygen from the air separation unit plant to hospitals in remote locations many pressure swing adsorption (PSA) plants were setup to meet the additional demand which do not require cryogenic equipment as the oxygen is produced in gaseous form.

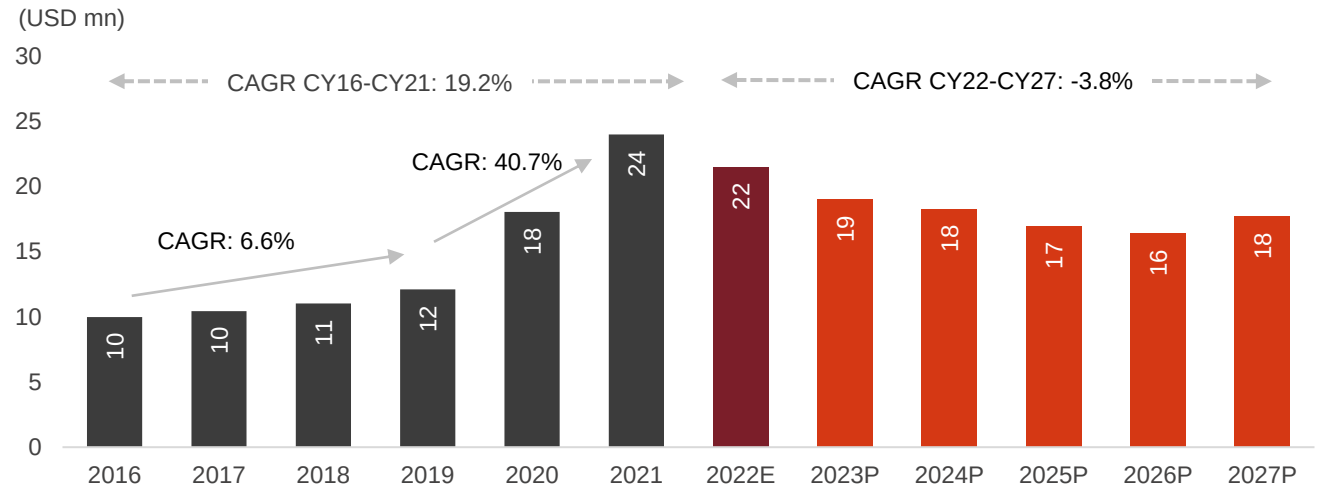
Pressure swing adsorption (PSA) is a type of technique to separate gases by using an adsorbent material such as zeolite which is used as a trapping material for gases under high pressure and later when the process swings to low pressure the trapped gas is released and captured.

PSA plants are cheaper to operate and also produce a continuous stream of oxygen from the atmosphere as long as there is a continuous source of power. This is ideal in cases where the requirement is far away from an air separation unit (ASU). It also produces oxygen directly in gaseous form and no vaporisers are required.

The downside of PSA plants is that the purity of oxygen produced is lower than that of ASU's, about 93% vs >99.5% from ASU's. However, for respiration purposes highly concentrated oxygen cannot be used. High purity oxygen of greater than 99% needs to be diluted before supplying it to the patient's lungs. This drawback is not an issue for PSA plants for medical applications however, for industrial used highly pure oxygen may be required based on application which can only be produced from ASU. Secondly, PSA plant will continuously produce oxygen as long as power supply is available and disruption in power supply will impact oxygen production.

In the wake of the Covid crisis, there has been an effort to increase the readiness to meet oxygen demand. The number of PSA plants are likely to increase and cater to most of the incremental oxygen demand and demand for LMO transported to hospitals is likely to remain stagnant over the next five years as oxygen produced by PSA plants are in gaseous form. Hence, the demand for cryogenic equipment from medical applications is expected to see a marginal decline in the post-Covid scenario as most of the cryogenic equipment demand going forward from the medical segment is likely to be from replacement demand rather than new capacity additions.

Domestic demand for cryogenic equipment from liquid medical oxygen (LMO) segment

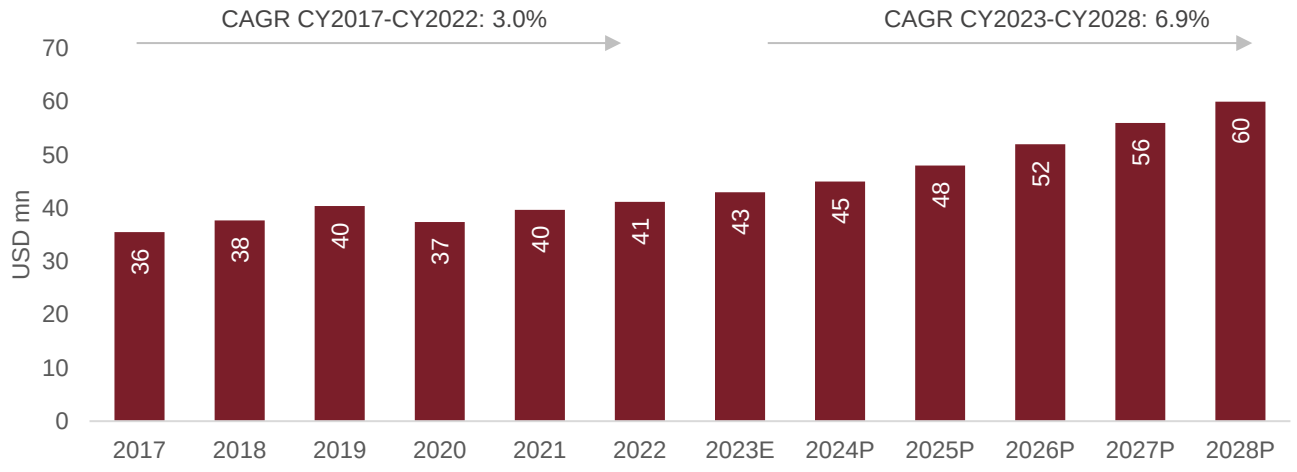


E: Estimated; P: Projected
Source: CRISIL MI&A

Argon is an inert gas and is rarely found in the atmosphere, thus making it expensive to produce. Argon is used in critical industrial processes, such as manufacturing of high-quality stainless steel and production of impurity-free silicon crystals for manufacturing electronics. In fact, liquid argon is extensively used in the semiconductors industry. Other applications of liquid argon include fabrication of specialty alloys, lasers, and metals. It has medical applications as well, specifically in cryosurgery and situations that require an inert environment.

From CY2023 to CY2028, demand for cryogenic equipment from the liquid argon segment is expected to grow at 6.9% CAGR. Increasing investments in the semiconductor and electronics space and support from policies such as India Semiconductor Mission, demand for argon and, hence, demand for cryogenic equipment from the segment is likely to increase.

Domestic demand for cryogenic equipment from argon segment

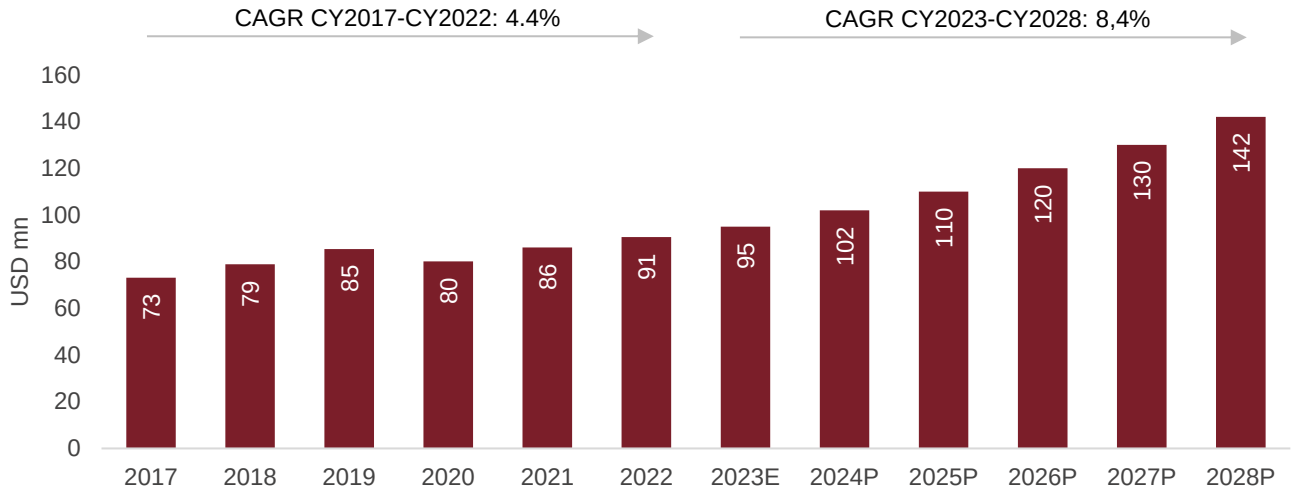


E: Estimated; P: Projected
Source: Markets and Markets, CRISIL MI&A

Domestic natural gas demand declined 6% in fiscal 2023. The decline in demand was attributable owing to steep rise in prices and constrained supplies under long term LNG contracts. The demand remained subdued from power, refinery and petrochemicals sector as these sectors are dependent on imported gas pushed the demand downwards. In fiscal 2024, demand from natural gas is projected to grow at 8-10% driven by city gas distribution (20-25%), refinery (20-25%) and petrochemicals (40-45%). Lowered gas prices domestically and globally along with improved domestic availability will aid demand growth for fiscal 2024. . Gas demand from fertilisers is also estimated to grow by 10% in fiscal 2023 and marginally in fiscal 2024 owing to weak demand for fertilisers due to uneven rainfall.

The growth trajectory of gas consumption went off-track in fiscal 2021 due to Covid-19-related challenges owing to constrained transportation and industrial activities. Subsequently, overall demand of gas was stable.. Domestic natural gas production is expected to increase over the next 4-5 years; however, reliance on LNG would continue because of continued demand-supply mismatch i.e., as gas demand increases, the shortfall will be required to be met through LNG imports. CRISIL MI&A expects LNG demand to clock 10-12%% CAGR between fiscals 2023 and 2028. However, because installed regasification capacity is forecast to almost double to 72.0-77.0 mtpa in fiscal 2028 from 43 mtpa in fiscal 2023, average utilisation of LNG terminals is set to range between 45-50% in fiscal 2028, lower than ~74% in fiscal 2018. While demand for cryogenic equipment for LNG storage, distribution and handling is expected to increase at a rate of 8.4% CAGR between CY2023 and CY2028.

Domestic demand for cryogenic equipment from LNG segment

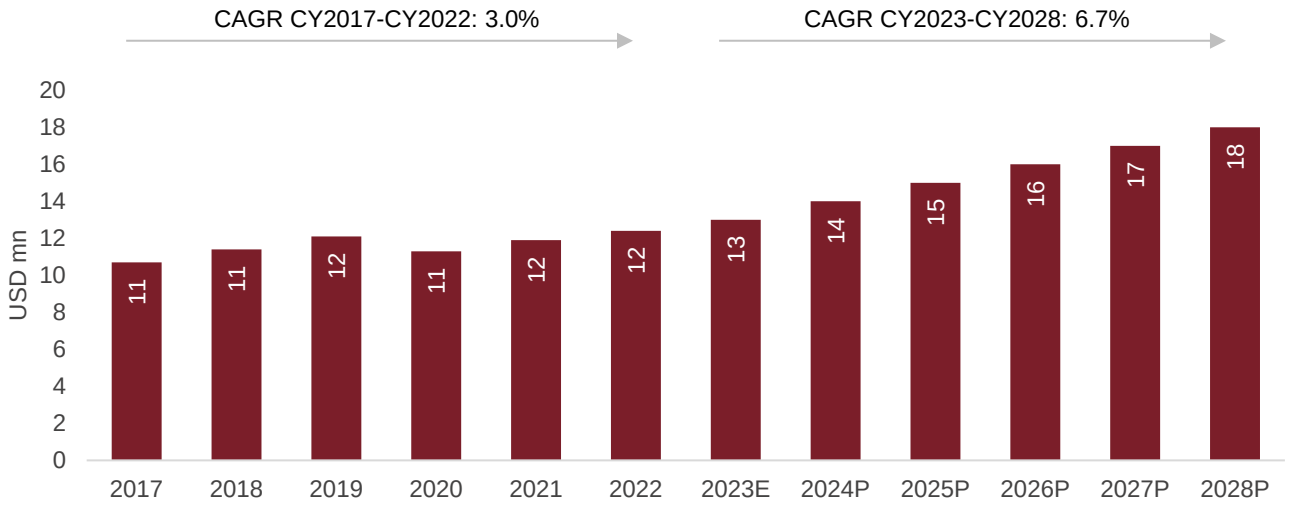


E: Estimated; P: Projected
Source: Markets and Markets, CRISIL MI&A

The hydrogen segment in India is expected to see a strong growth with government's emphasis on developing a hydrogen economy in the country. The major issue with hydrogen is the volatile nature of the gas which is easily combustible and also more complicated to transport and handle. The infrastructure to handle the gas is being rapidly developed and on the other side the cost of producing hydrogen is also being worked on to make it more competitive against other fuel types given its potential to be a completely green fuel produced from renewable sources alone. However, due to applications such as fuel cells are still in their nascent stages widespread use of hydrogen is expected to be at least a decade away. The current demand for hydrogen is likely to be from industries such as steel and fertilisers which may shift to hydrogen in a bid to reduce their carbon footprint.

Reliance Industries Ltd has announced its plans to become a net zero carbon firm by 2035. RIL has plans to invest in INR 600 billion to build a 5000-acre green energy complex in Jamnagar, Gujarat. The complex will house an electrolyser plant to produce green hydrogen. Vedanta's Sesa Goa Iron Ore Business is seeking a tie-up with IIT Bombay to develop processes for manufacturing green steel. In April 2022, Indian Oil Corporation, Larsen & Toubro along with ReNew Power announced a joint venture to develop the hydrogen sector in India. In April 2023, Tata Steel commenced the trial injection of hydrogen gas using 40% of the injection systems in E Blast Furnace at its Jamshedpur Works. This is the first time in the world that such a large quantity of hydrogen gas is being continuously injected in a blast furnace. The trial has the potential to reduce the coke rate by 10%, translating into around 7-10% reduction in CO2 emissions per ton of crude steel produced. Refining, steel and fertiliser sectors will be the focus of the JVs' initial efforts as these are expected to account for a major share of the hydrogen demand currently. Going forward demand for cryogenic equipment from liquid hydrogen is expected to grow at a CAGR of 6.7% between CY2023 and CY2028.

Domestic demand for cryogenic equipment from hydrogen segment



E: Estimated; P: Projected

Source: Markets and Markets, CRISIL MI&A

5 Domestic Industries driving demand for cryogenic gases

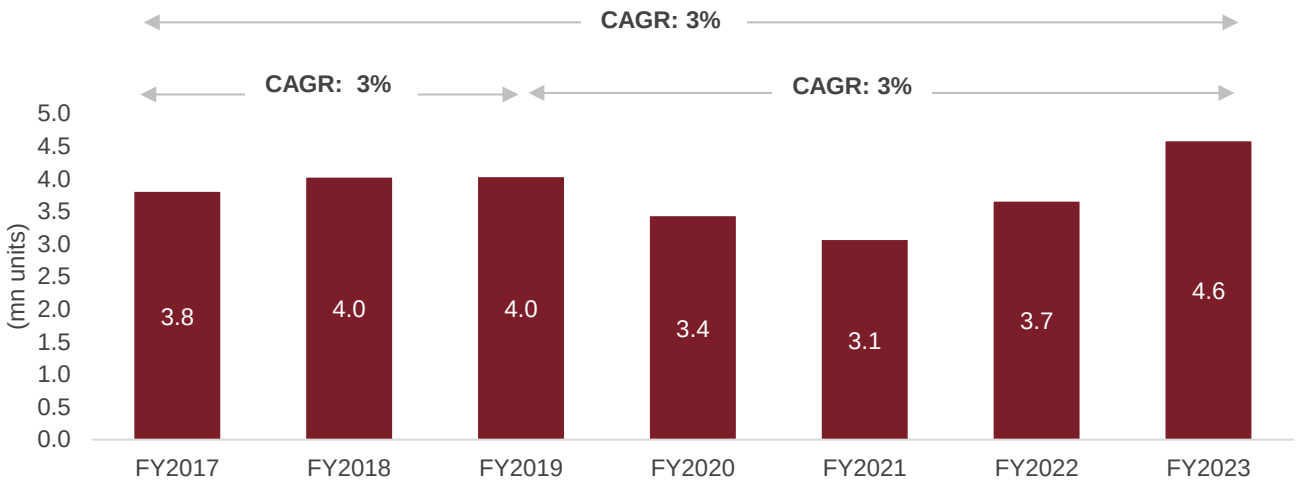
5.1 Review and outlook of the Indian automobile industry

Demand for automobiles drives demand for cryogenic gases as metals such as steel and aluminium are key inputs for manufacture of automobiles and also fabrication of metal parts will require gases such as oxygen for cutting and welding. Besides inputs, there has been a surge in demand for CNG vehicles post implementation of BS-VI norms as there has been a sharp increase in vehicle prices for emission control equipment which are required to be installed in automobiles in order to meet the stringent emission norms under BS-VI standards in both passenger and commercial vehicles. Also, BS-VI phase 2 implemented from April 2023, entailed an addition of on-board self-diagnostic device (OBD2) to monitor real time emissions. The addition of OBD2 will also require upgrades to hardware and software of the vehicles to comply with the new norms. Another factor supporting sales of CNG vehicles is the increase in crude prices which has made the prices of petrol and diesel rise to record highs increasing the cost of owning such vehicles. As of April 2023, petrol prices of Rs.96.7/ltr are 29% higher than CNG at Rs.75.2/kg. As of January 2023, petrol prices are Rs.96.7/ltr, a 22% higher than CNG at Rs. 79.6/kg. In fiscal 2024, with the Kirit Parekh committee recommendations on CNG pricing, CNG prices have declined by 4% to Rs 74/kg. This decline in prices will open up the difference in total cost of ownership between petrol/diesel and CNG favouring CNG transition. CNG being a cleaner fuel and also lower in cost has benefited which many OEM's also launching CNG variants of their vehicles. While in the passenger vehicles CNG variants were offered on some vehicles directly from factory the trend has seen an increase post BS-VI implementation. Even on the commercial vehicle side there have been many CNG variant launches. Although CNG vehicles do not require cryogenic equipment, the rising demand for CNG will support demand for LNG as shortfall will be met with increase in LNG import driving demand for cryogenic equipment for LNG transport, storage and handling.

5.1.1 Review of Indian passenger vehicle industry (FY2017 to FY2023)

Production of passenger vehicles (PVs) in India rose at a healthy 2.9% CAGR between fiscals 2017 and 2019, with domestic demand as well as exports providing support. Domestic demand was driven by expansion of the addressable market, development of road infrastructure, and stable cost of vehicle ownership as crude oil prices remained low, except for a few months when global output declined because of US sanctions on Iran. In fiscal 2019, 4 million PVs were manufactured, of which 3.4 million were sold in the domestic market and 0.7 million were exported. But in fiscal 2020, low private consumption owing to slowdown in economic growth and inventory adjustment because of change in emission norms from Bharat Stage (BS)-IV to BS-VI and outbreak of Covid-19 resulted in a 15% on-year decline in production. During the year, domestic sales fell 18% on-year whereas exports remained flat. Further, a second wave of Covid-19 infections also affected PV production at the beginning of fiscal 2022, with a semiconductor shortage further buffeting the industry.

PV production



Source: Society of Indian Automobile Manufacturers (SIAM), CRISIL MI&A

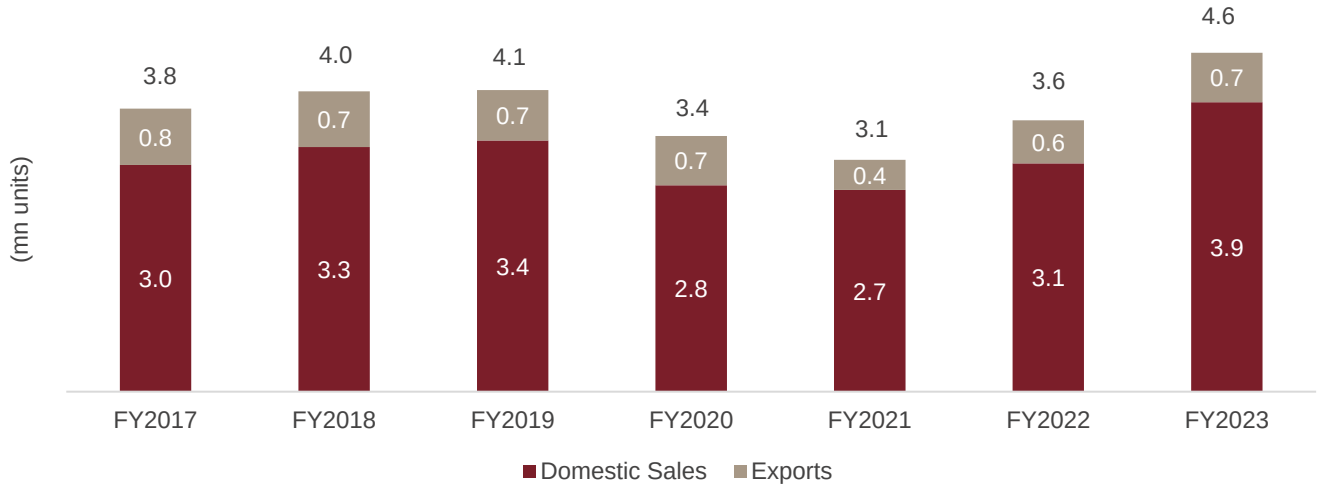
The semi-conductor shortage dented passenger vehicle production in the first three quarters of fiscal 2022. However, due to the improvement in supply of chips and agile production strategies adopted by OEMs, the fourth quarter of fiscal 2022 saw an improvement in volume. Also, several headwinds in the form of multiple waves of Covid-19 limited overall growth to 13% in fiscal 2022. However, with recovery in economy backed by strong orderbook as a result of pent-up demand, improving supply chain and new model launches to increase overall growth by ~27% in fiscal 2023.

Domestic PV sales vs exports

The Indian PV market is domestic-focused, comprising over 85% of sales in fiscal 2023. In fact, the share of exports vis-à-vis overall sales contracted from 20% in fiscal 2017 to 15% in 2022. This could be attributed to slowdown in the global automobile industry as well as major OEMs focusing on catering to the fast-growing domestic market.

In fiscal 2020, though, the export share had risen to 19% as OEMs refocused on export markets. Stagnating domestic sales over the past three years resulted in foreign automobile manufacturers such as Ford, General Motors, and Volkswagen increasing their focus on exports, thereby improving utilisation by using spare capacity and boosting revenue. These players are developing India as an export hub, as evidenced by the consistent increase in the proportion of exports to their total production share. However, with the exit of GM and Ford, and impact of Covid-19 and major OEMs prioritising fast-growing domestic markets over foreign markets, the export volumes declined through fiscal 2021. Following a ~39% on-year drop in fiscal 2021, exports improved drastically by ~43% in fiscal 2022and fiscal 2023 recorded an exports growth of ~15% owing to demand from emerging countries supported from push from major OEMs. Exports are projected to grow marginally by 1-3% in fiscal 2024 due to the moderation in trade across global economies, which is directly linked to the slowdown in economic growth. .

PV industry by domestic sales and exports

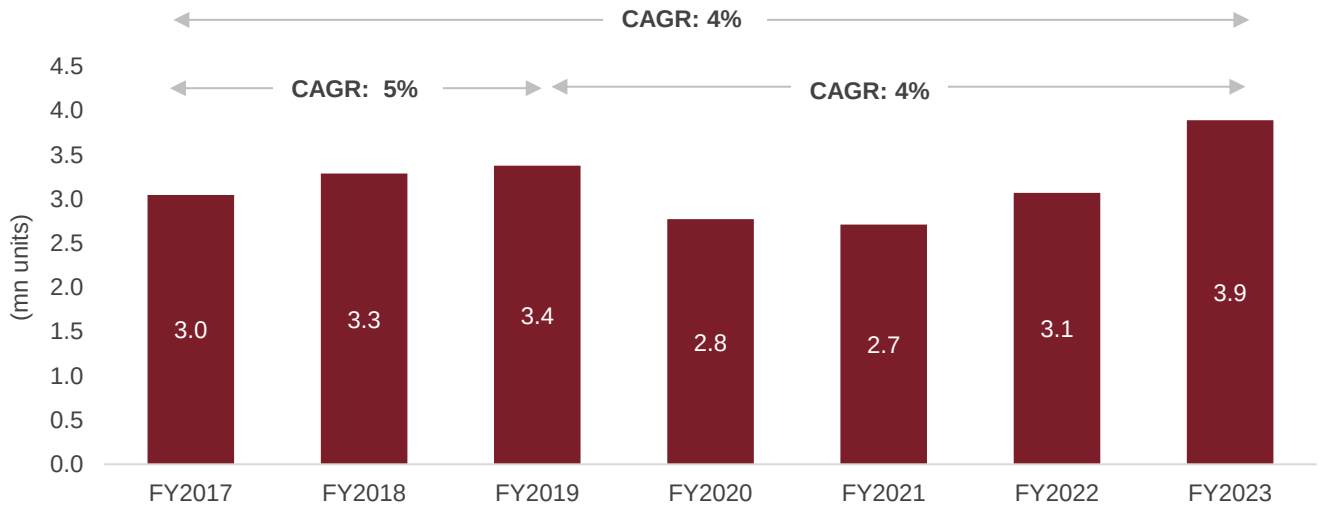


Source: SIAM, CRISIL MI&A

On the domestic front, the PV industry grew 5.3% CAGR between fiscals 2017 and 2019, led by strong growth in utility vehicles (UVs), which rose 14.9% CAGR vs cars, which grew 3.1% CAGR. Improving economic scenario, higher affordability, and new model launches drove demand during the period. The semi-conductor shortage dented passenger-vehicle production in the first three quarters of fiscal 2022. However, due to the improvement in supply of chips and agile production strategies adopted by OEMs, the fourth quarter of fiscal 2022 saw an improvement in volume. Accordingly, fiscal 2022 saw a growth of ~13% in wholesale volume. In fiscal 2023, PV industry grew by 27% on year due to healthy pent-up demand created by two years of slump in sales volumes owing to a pandemic induced disrupted supply chain. We expect volumes growth of 6%-8% in fiscal 2024 due to demand confirmed by healthy order books along with multiple new models launches in the growing UV segment backed by eased up semiconductor shortage to provide support to domestic volume growth in fiscal 2024. CRISIL expects semiconductor shortage to gradually improve over the year as semiconductor supplies and the associated parts supply chain improves..

In fiscal 2020, though, domestic demand fell 18% on-year because of weak consumer sentiment owing to a slowing economy and inventory correction because of the change in emission norms. Moreover, acquisition costs increased on account of implementation of safety norms, such as mandatory anti-lock braking system, airbags, etc. In fiscal 2021, domestic sales are estimated declined a further 2% on-year as the pandemic and subsequent lockdowns impacted supply chains. The shift towards personal mobility to maintain social distancing, though, arrested a sharper fall in PV sales. Lifting of lockdown measures and improving economic activity in fiscal 2022 resurrected the demand. As a result, the overall growth was restricted to 13% in fiscal 2022.

PV domestic sales



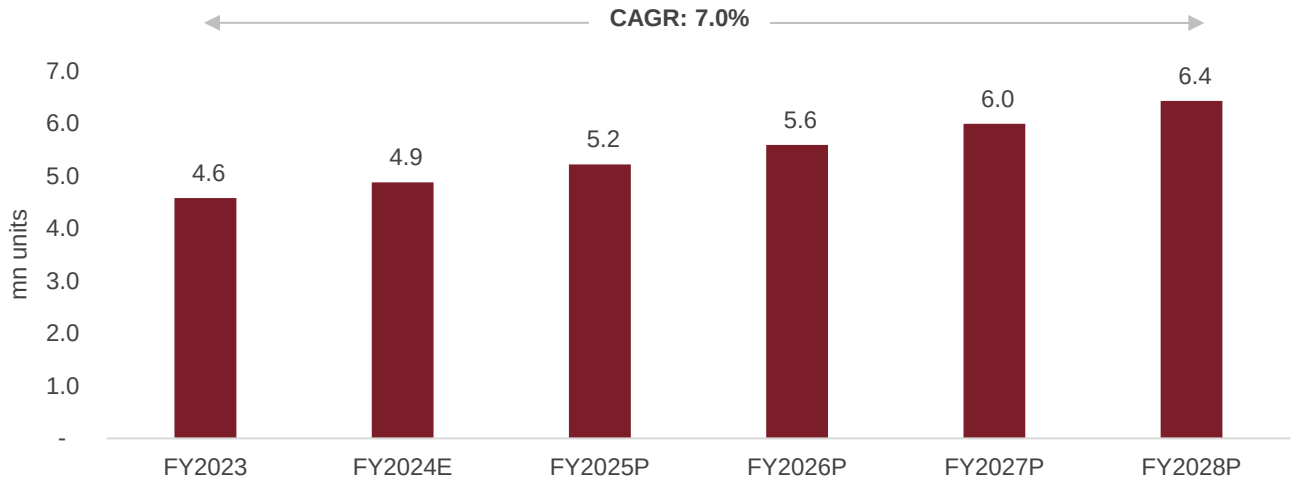
Source: SIAM, CRISIL MI&A

5.2 Outlook of the Indian PV industry (FY2023 to FY2028)

5.2.1 Production outlook

CRISIL MI&A projects PV production to grow at 7% CAGR between fiscals 2023 and 2028 to 6.4 million units. Post a drop in production in fiscals 2020 and 2021, PV production is expected to increase sharply over the next five fiscals, with domestic sales as well as exports driving growth. Rising domestic demand will be on the back of continued expansion of the addressable market, fast-paced infrastructure development, and relatively stable cost of vehicle ownership as crude oil prices are expected to stabilise at lower levels.

PV production



P: Projected
Source: SIAM, CRISIL MI&A

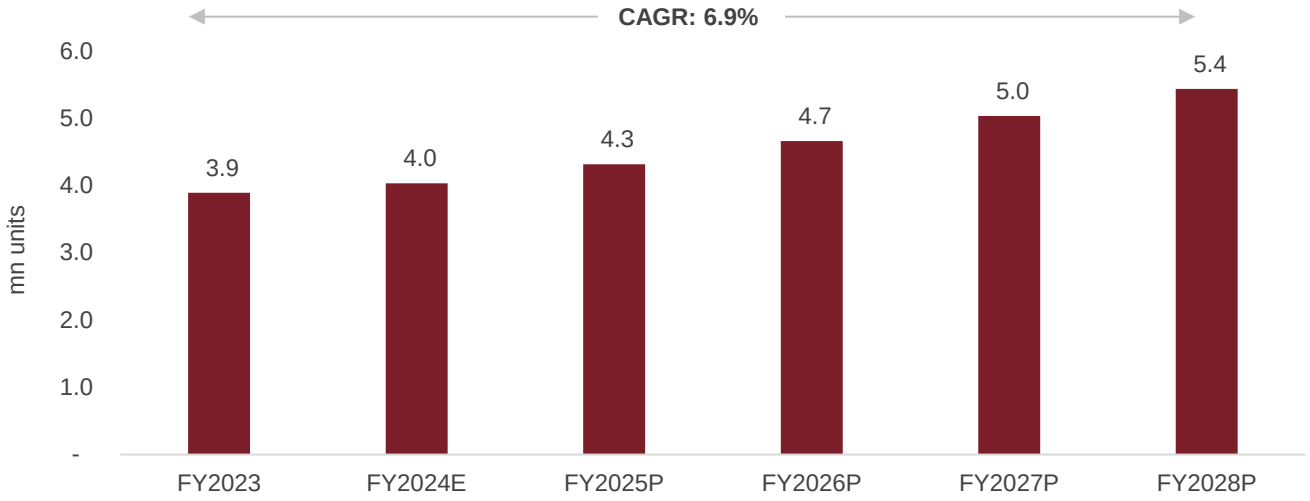
However, in fiscal 2022, because of the semiconductor shortage, CRISIL MI&A expected PV production to be impacted. The semi-conductor shortage dented passenger-vehicle production in the first three quarters of fiscal 2022. However, due to the improvement in supply of chips and agile production strategies adopted by OEMs, the fourth quarter of fiscal 2022 saw an improvement in volume. Thereafter, exports could drive industry growth on efforts by manufacturers to penetrate newer geographies and the Production Linked Investment (PLI) scheme, which incentivises them to export. CRISIL forecasts exports to clock 2.6% CAGR between fiscals 2023 and 2028.

Unlike most developed economies and some developing countries, India's car market is highly underpenetrated. As of fiscal 2020, India had ~24 PVs per 1,000 people. This is significantly lower than developed countries and even other nations in the BRIC block (Brazil, Russia, and China), based on per capita gross domestic product (GDP) – Brazil, Russia, and China had 173, 307 and 99 PVs per 1,000 people, respectively, in 2015. Thus, the country holds tremendous potential for automobile manufacturers. Also, in penetration of cars and UVs vis-à-vis per capita GDP across countries, India is still behind most countries.

Total Cost of Acquisition (TCA) is calculated considering down payment, registration and upfront insurance costs for a buyer. We see that the cost of acquisition of small cars increased by 4.5% CAGR and UVs by 7.7% between fiscal 2018 and 2023 on account of price hikes by OEMs on account of increase in raw material prices, safety norms, an increase in registration costs as well as an increase in upfront insurance costs and the early launch of BSVI models. Going ahead we expect TCA to increase by 2% as most of the price hike related to raw material increase and transition to BSVI stage 2 has already been incorporated by OEMs. During fiscals 2018-2023, petrol and diesel prices increased by 36% and 41% respectively leading to very high cost of operation. While EMI expenses will rise in fiscal 2024 due to high interest rates, lower fuel expenses from highs of first half of fiscal 2023, is expected to translated to lower TCO growth. Going ahead we expect TCO to grow modestly by 4.8% and 3.7% in cars and UVs between fiscal 2023-2028 as compared to previous 5 year CAGR of 5.2% and 5.6%between fiscals 2018-2023.

Domestic PV sales are expected to increase 6.9% CAGR between fiscal 2023 and 2028.. In fiscal 2022 as well, sharp rise in Covid-19 cases during the second wave disrupted the supply chain, thereby elongating the waiting periods of fast-moving models. Over the short-to-medium term, Covid-19-induced demand for personal mobility is likely to support PV sales. Over the long-term horizon, healthy macroeconomic growth, increasing disposable income, a modest increase in the cost of vehicle acquisition, favourable financing scenario, as well as a deeper reach in the rural markets, tier-III and tier-IV cities will support this growth. Moreover, intermittent feature rich competitively priced vehicle launches will provide an additional kicker to the industry demand. Other factors that would aid demand are increasing urbanisation, government support to farm income, lowering of vehicle holding period and electrification. However, increasing congestion in cities and rising popularity of shared mobility services are likely to restrict car sales in the long term.

PV domestic sales



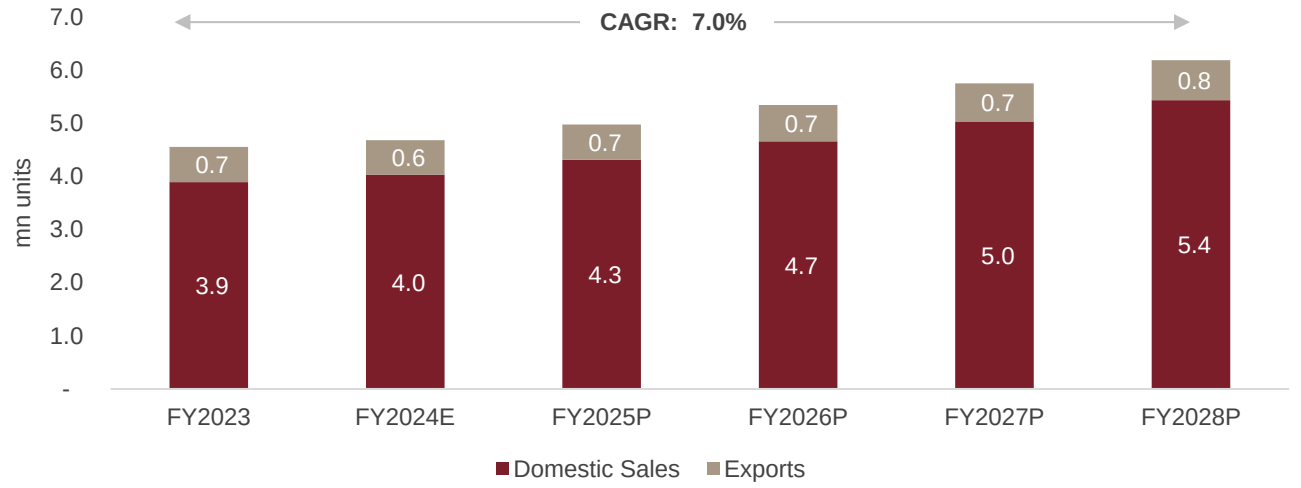
P: Projected. E: Estimate
Source: SIAM, CRISIL MI&A

The previous five years, that is fiscals 2017 and 2023, witnessed a moderate growth of 4.2% CAGR. We expect sales to log in 6.9% CAGR during fiscals 2023-2028P, anticipating continuous improvement of economic activities, increasing average income and affordability of vehicles.

Domestic PV sales vs exports

Domestic sales, which formed 85.0% of overall production in fiscal 2023, are expected to grow at 6.9% CAGR between fiscals 2023 and 2028P. Over the period, exports are forecast to grow at 2.6% CAGR on a low base of fiscal 2023.

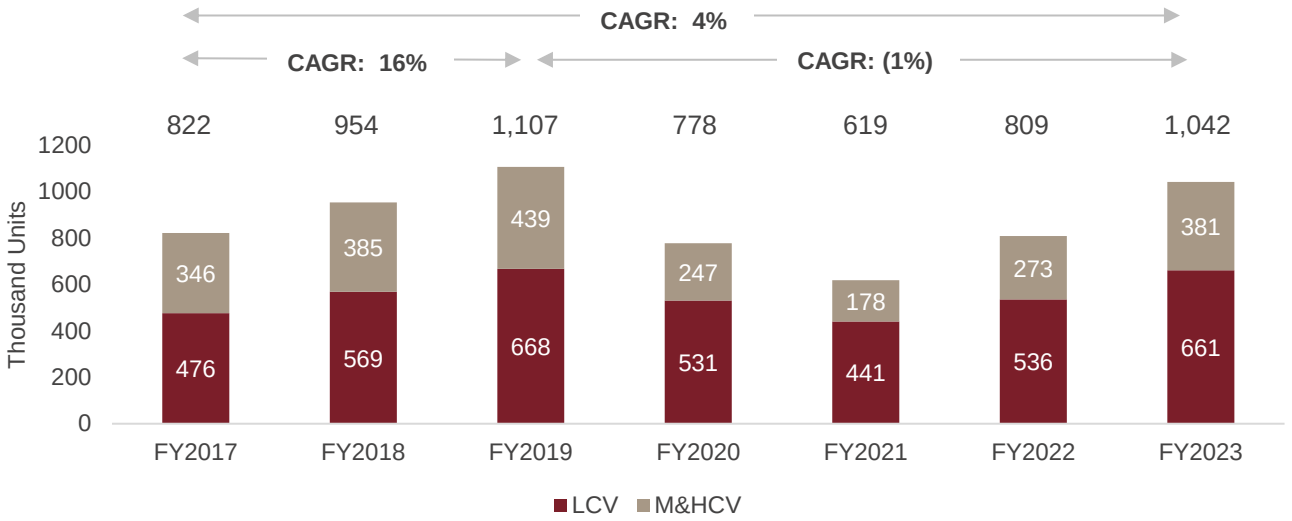
PV industry by domestic sales and exports



P: Projected E: Estimate
Source: SIAM, CRISIL MI&A

5.2.2 Review of Indian commercial vehicle industry (FY2017 to FY2023)

CV production by vehicle segments



Note: LCV includes vehicles with gross vehicle weight (GVW) less than or equal to 7.5 tonne; MHCV includes vehicles with GVW greater than 7.5 tonne

Source: SIAM and CRISIL MI&A

Over fiscals 2017 to 2019, production grew at 16% CAGR, driven by pick-up in rural and industrial activity, and the government's focus on infrastructure investment. A large portion of the production increase was on robust demand for goods carriers, which clocked 19.4% CAGR. Passenger carrier production, though, declined 0.3% CAGR.

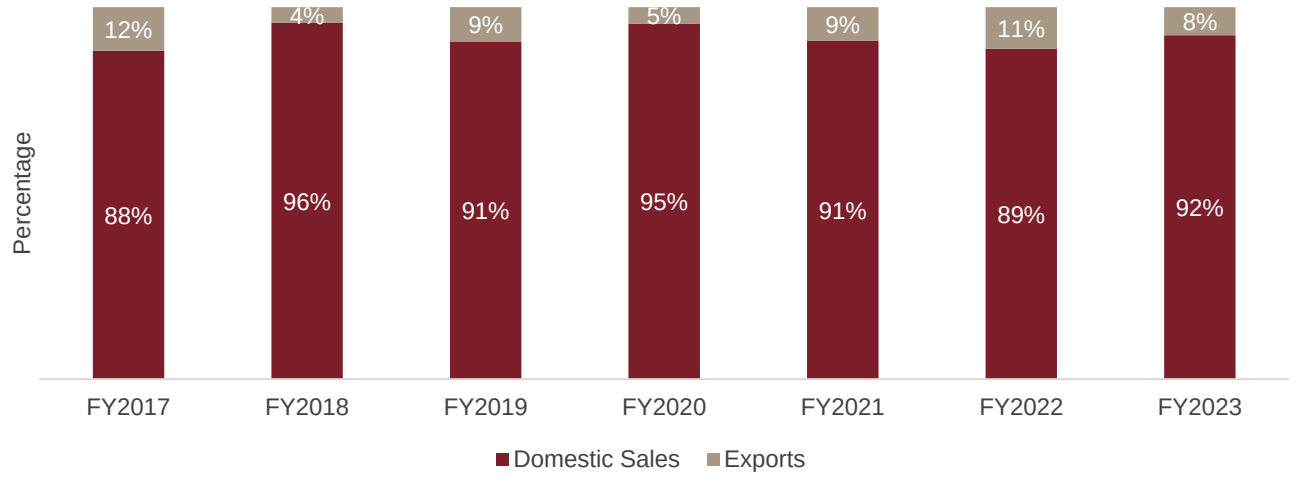
In fiscal 2020, production fell on account of inventory correction as the industry transitioned from BS-IV to BS-VI and a tepid demand for CVs owing to slowdown of the economy and lower government infrastructure spending post the general election. In addition, policy changes in Sri Lanka, one of the major industry export markets, considerably affected exports.

Overall, CV production have shown a growth of 4.0% CAGR over fiscals 2017 to 2023. Within the space, medium and heavy commercial vehicle (MHCV) production marginally increase 1.6% CAGR whereas light commercial vehicle (LCV) improved by 5.6%. However, over fiscals 2017 to 2019, industry production in fact grew at 16% CAGR because of a sharp 18.4% CAGR in LCVs and 12.6% CAGR in MHCV.

Faster growth in LCV production was on account of strong domestic demand, supported by high replacement demand over fiscals 2018 to 2020, improved rural sentiment, and growing e-commerce penetration. Even during the pandemic, improved rural sentiment and less impact of the pandemic in rural areas resulted in LCVs outperforming MHCVs.

Split by domestic sales and exports

CV sales – domestic and exports



Source: SIAM, CRISIL MI&A

CRISIL MI&A expects CV domestic sales volume for fiscal year 2024 to grow by 4-6%, surpassing the pre-pandemic levels recorded in fiscal year 2019. This is supported by increased government spending and robust replacement demand. Key end-user sectors, notably construction and mining, are anticipated to sustain their strong demand, contributing to this upward trend.

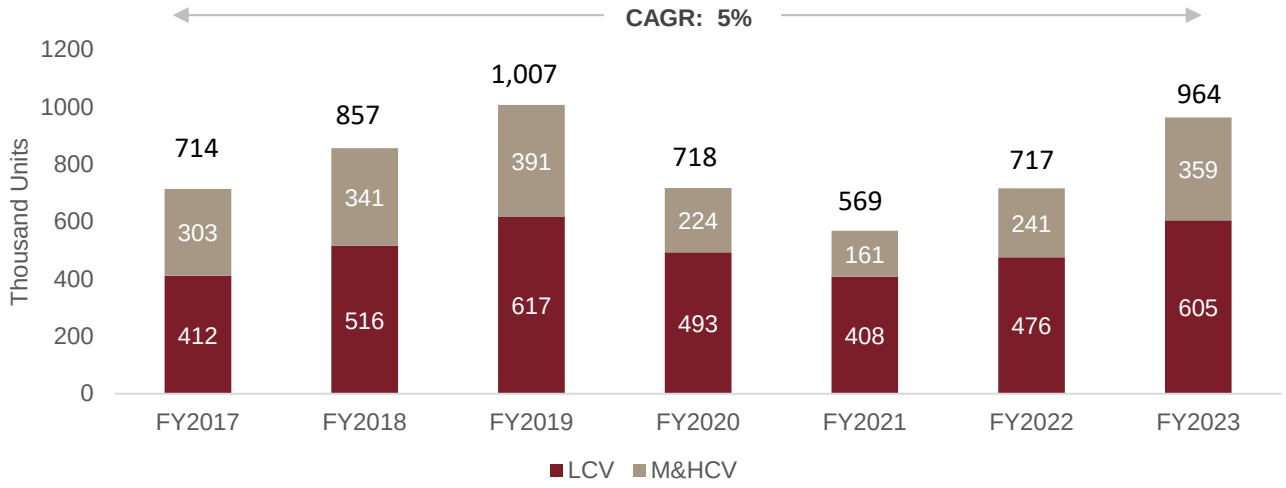
In the initial quarter of fiscal 2024, overall CV sales experienced a marginal decline of 3% compared to the corresponding period of the previous year. This downturn was influenced by prebuying activity that occurred in the fourth quarter of the fiscal 2023, ahead of the implementation of BS VI stage II, which entailed a price hike of 3-5%. Moreover, supply-related constraints emerged because of the technological transition undertaken by Original Equipment Manufacturers (OEMs) to comply with the new standards.

The CV industry exhibited noteworthy recovery in fiscal year 2023, achieving a remarkable growth rate of 34% and reaching 96% of the pre-pandemic levels attained in fiscal year 2019. This resurgence can be attributed to pent-up replacement demand that had been hampered during the preceding 2-3 years due to economic stagnation and the disruptive impact of the pandemic.

Split by CV categories

In fiscal year 2023, the LCV sales recorded an impressive growth of 27%, rebounding to 98% of pre-Covid levels. The surge in sales can be attributed to robust replacement demand, particularly in the sub-one-tonne category, which was deferred due to economic challenges and the pandemic. Similarly, MHCV volumes registered 49% increase over a base fiscal 2022 but to remain below pre-pandemic levels. The pre-buying (shift in sales from fiscal 2024) happening in Q4 fiscal 2023 made a dent in sales in Q1 fiscal 2024, leading to a moderation in volume growth of ~4-8% in the coming fiscal.

Review of CV segment-wise domestic sales



Note: LCV includes vehicles with gross vehicle weight (GVW) of less than or equal to 7.5 tonne; M&HCV includes vehicles with GVW > 7.5 tonne

Source: SIAM, CRISIL MI&A

Over the past five years, the industry weathered major challenges on account of events such as demonetisation, the NBFC crisis, implementation of axle load norms, changes to insurance norms and the transition to BS-VI. A culmination of these factors, particularly post second half of fiscal 2019, resulted in a dampening of demand for CVs. Between fiscals 2017 and 2021, MHCV goods vehicles sales saw a negative CAGR of 16% in the MHCV segment.

Demand for buses in fiscal 2020 was impacted by safety regulations (emergency exit doors, fire detection and suppression, escape hatches and emergency lighting) that led to an increase in cost of ownership of ~Rs 50,000. This was after a price hike of ~Rs 15,000 due to mandatory installation of vehicle tracking system and panic buttons in January 2019.

After the price rise, demand for buses in fiscal 2020 was also hit by weakening private consumption, hampering demand from tourist bus and inter-city travel operators. Weak corporate hiring and production cuts in manufacturing also impacted demand for corporate staff buses. However, schools and route permit buses have shown some resilience in fiscal 2020. Demand from state transport undertakings (STU) ramped up in the second half of the fiscal, as STUs looked to replace much of their older fleet before the BS-VI price rise. Also, increased demand for inter-city/state travel, aided by improved road infrastructure, and higher personal disposable incomes will drive growth

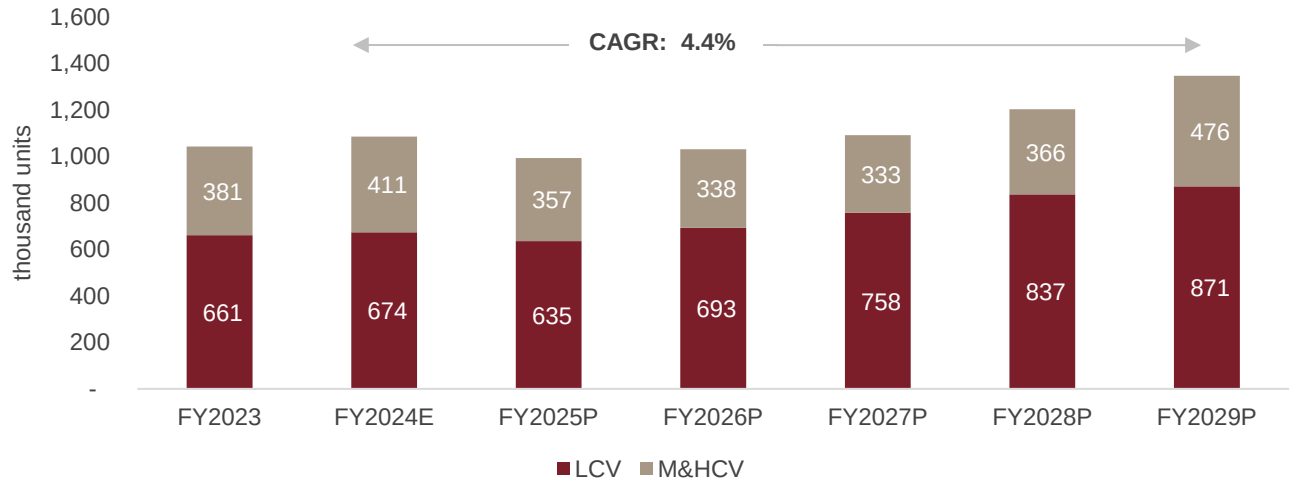
Recently, the pandemic brought the entire economy to a grinding halt, affecting profitability and sustainability of transporters due to lack of availability of freight demand. The industry is, however, now witnessing a gradual pick-up in quarterly sales as consumption demand and industry activity have started gaining pace.

5.3 Outlook on the Indian CV industry for the next five years

5.3.1 Production outlook

Production of CVs in India is expected to increase at 4.4% CAGR between fiscals 2024 and 2029. MHCV production is expected to grow at 3% as sales are expected to improve on the back of improving industrial activity, steady agricultural output, and the government's increasing focus on infrastructure. LCV production is expected to grow at a 5.3% CAGR over the same period to cater to demand driven by higher private consumption, lower penetration, greater availability of redistribution freight and improved finance.

CV production outlook



Note: LCV includes vehicles with GVW of less than or equal to 7.5 tonne; MHCV includes vehicles with GVW > 7.5 tonne; P – Projected

Source: SIAM, CRISIL MI&A

Projected split by domestic sales and exports

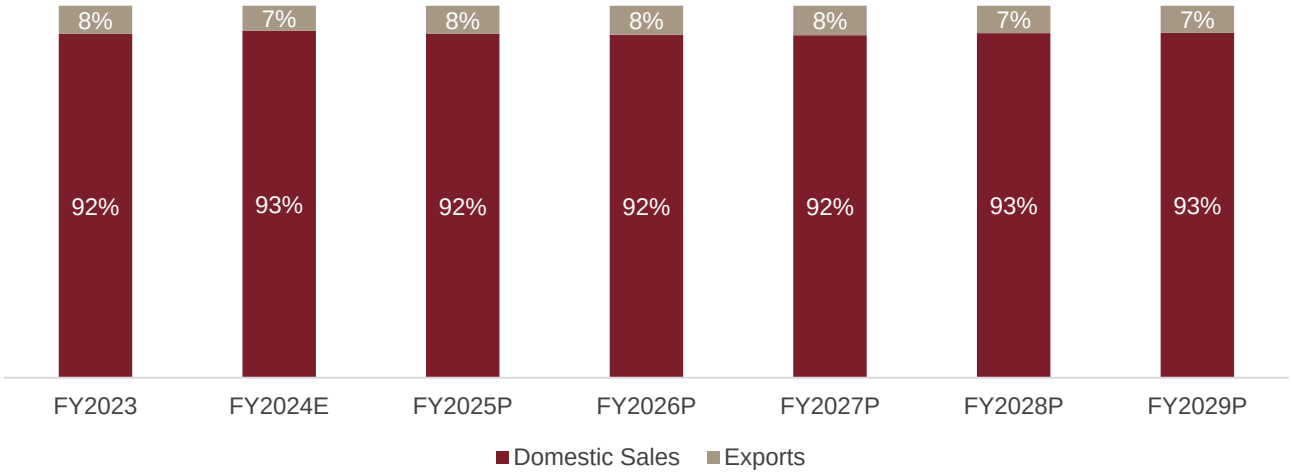
The Indian CV industry is expected to remain domestic-focused, with domestic sales comprising ~93% share of production even in fiscal 2029. However, with exports projected to grow at 5-7% CAGR between fiscals 2024 to 2029, its contribution in overall production is likely to remain flat.

The second Covid-19 wave resulting in lockdowns in key affected areas in the first quarter of fiscal 2022 impacted domestic sales across segments, post a healthy fourth quarter in fiscal 2021. Consequently, LCV and MHCV volumes declined ~42% and ~63% sequentially (on-quarter) and overall CV volumes by ~50%. Also, with a significant share of loans under moratorium amid low fleet utilisation and freight rates, risk-averse financiers limited wholesale offtake. In FY22, LCV and MHCV sales improved by ~17% and 50% and on-year respectively over a low base of FY21. As mobility restrictions were relaxed and economic activities started picking up after the second wave abated in Q1 FY22, CV sales have picked up. The CV industry exhibited noteworthy recovery in fiscal year 2023, achieving a remarkable growth rate of 34% and reaching 96% of the pre-pandemic levels attained in fiscal year 2019. This resurgence can be attributed to pent-up replacement demand that had been hampered during the preceding 2-3 years due to economic stagnation and the disruptive impact of the pandemic.

On the exports front, manufacturers are directing their investments into expanding presence to other Asian countries from neighbouring countries such as Bangladesh, Nepal, and Sri Lanka to Africa and the Middle East.

Domestic players are also considering setting up of assembly operations across multiple markets. Also, going forward, new product line-ups and technology upgradation will allow domestic players to enter relatively advanced markets of south-east Asia. The economic slowdown is anticipated to lead to reduced consumer spending and investment in various regions, subsequently impacting merchandise trade volumes and posing significant challenges for India's export prospects. .

CV industry split by domestic sales and exports (projected)



Note: P – Projected E: Estimate
Source: SIAM, CRISIL MI&A

CRISIL MI&A expects sales of commercial vehicles to grow at a CAGR of 4.3% between fiscals 2024 and 2029 aided by healthy industrial growth, focus on infrastructure and higher mining production. CV sales has plummeted ~29% in fiscal 2020 and further by ~21% in fiscal 2021. The fall in sales had created a low base over which volumes have witnessed growth of ~26% in fiscal 2022. In the last three years (FY2020-FY2023), the industry demonstrated a strong CAGR of 10%. The rise in tonnage addition is expected to be driven by an improved product mix, with a notable surge in demand for Multi-Axle Vehicles (MAV) and T-Trailer despite a shift to lower tonnage vehicles due to axle norm regulations. .

5.4 Key trends and developments affecting commercial vehicle demand

5.4.1 Healthy Industrial growth

The overall Indian industry’s gross value add (GVA) had been growing tepidly, averaging b~3-4% between fiscals 2017 and 2022. After consecutive weak fiscals of 2020 and 2021 due to the Covid-19 outbreak, industrial GVA is estimated to have grown by ~20-25% in fiscal 2022 and is up by ~7% on-year in fiscal 2023. Over the fiscal 2023-2028, industry GVA is expected to be robust driven by the government's focus on 'Make in India'. Moreover, improvement in infrastructure and higher expected corporate expenditure is likely to support the capex cycle going forward post fiscal 2023..

CRISIL MI&A also expects coal production to expand at ~4.5-5.5% CAGR between fiscals 2023 and 2028, driven by rising demand for electricity and the onset of commercial mining, while iron ore mining will also likely grow at a healthy pace 3.5-4.5% CAGR during this period, aiding tipper demand.

5.4.2 Government's focus on infrastructure

The National Infrastructure Pipeline (NIP) proposes to spend Rs 111 trillion of capital expenditure in infrastructure sectors in India over fiscals 2020 to 2025.

Infrastructure investment from fiscal 2013 to 2019 was Rs 57 trillion. Power, roads and bridges, urban, digital infrastructure and railways together constituted over 85% of the total infrastructure investment. The centre and states were the major funding sources for sectors such as power and roads and bridges, with moderate participation from the private sector. Digital sector investments were largely driven by the private sector, while investments in the irrigation sector were predominantly made by the state governments.

The NIP thus aims to double infrastructure investment annually from the current average of Rs 10 trillion per year to Rs 22 trillion. Of the total NIP investments of Rs 111 trillion, 40% worth of projects are under implementation, 30% at the conceptualisation stage, and 20% under development. Almost 83% of project allocation indirectly benefits the commercial vehicle sector in India, and this push for infrastructure is a major driver of growth.

5.4.3 Scrappage policy

The MoRTH, in August 2018, considered incentivising the scrapping of vehicles sold before April 2005 (15 years old). After deliberations on the modalities on implementation of the norm, the government currently aims to promote vehicle scrapping by exempting registration charges for truck purchases made after scrapping older trucks. To scrappage of older vehicles, the government has increased the registration charges for older vehicles and increased stringency of fitness tests. These will entail higher costs for owners of older vehicles. Hence, by disincentivising the ownership of older vehicles, the government expects the scrappage of older vehicles to increase. We believe the impact of the norms to be limited on additional scrappage (apart from vehicles scrapped in the normal course of business). If, through higher incentives from the government and OEMs, transporters are able to be incentivised to scrap vehicles older than 15 years, we expect 6,00,000- 6,50,000 MHCVs to be available for scrapping.

5.4.4 Commissioning of dedicated freight corridors to affect road freight and CV sales

The dedicated freight corridor (DFC) is intended to help the Indian Railways regain lost freight share by cutting turnaround times between importing and consuming destinations, compelling several industries to realign their logistics strategies. The DFC and associated logistics parks can significantly reduce plant-level inventory, enabling huge savings in working capital. Not only will the DFC bring about faster freight movement, but it will also aid the economy by decongesting major highways due to the increased shifting of freight to rail. It will also allow for faster evacuation of cargo from ports, improving efficiency. Thus, roads, which have outperformed rail over the past decade, will lose some share to rail once the DFC is commissioned.

5.4.5 Enhanced operations due to better road infrastructure to lower truck demand

Improvement in road infrastructure is expected to increase the average speed of trucks, leading to efficiency gain of ~10%. Hence, fewer trucks will be required to move the same quantity of goods, lowering truck demand. On the other hand, increased running of trucks will help improve the competitiveness of the road transportation industry, helping attract more freight.

Demand for goods carrying medium & heavy commercial vehicle to lead in the next five years

MHCV sales are likely to rise by ~2%-4% compound annual growth rate (CAGR), , from fiscal 2024 to 2029 (five-year CAGR), as compared to the previous five-year (FY18-23) CAGR of 1.1%%. Moreover, tonnage addition is expected to improve in-line due to a better product mix (higher growth in MAV and T-Trailer demand despite a shift to lower tonnage vehicles due to axle norm). Factors driving long-term MHCV sales will be the improving industrial activity in the country, steady agricultural output, and the government's focus on infrastructure. However, volume growth will be limited due to efficiencies achieved from the goods and services tax (GST), better road infrastructure along with the commissioning of the dedicated freight corridor (DFC).

Factors driving long-term MHCV sales will be industrial growth aided by 'Make in India' initiatives, focus on infrastructure and higher mining production. However, factors such as the Commissioning of DFC would restrict road freight growth and enhanced operations due to better road infrastructure would lower truck demand

LCV sales to grow at a modest pace in the long run

Light commercial vehicle (LCV) demand is expected to expand at ~5-7% CAGR from fiscal 2024 to 2029, due to higher private consumption, lower penetration, greater availability of redistribution freight and improved finance. Upper-end light commercial vehicles (ULCVs) offer the transporter lower returns, as compared with ICVs, and are most suited for captive use. Entry restriction on ICV trucks and higher tonnage MHCVs is expected to keep demand from this segment buoyant. However, higher toll on ULCV trucks vs. pickups will limit growth in the segment. Replacement demand was positive in fiscal 2023 as some replacement sales that was expected in FY20 and FY21 would have got deferred to subsequent years. Improving volumes up for replacement in the terminal years would aid demand growth.

5.5 Review and outlook of the Indian cement industry

Cement production is an energy intensive process with a lot of energy required for crushing, grinding and heating raw materials. Cement plants use coal, pet coke or diesel in the manufacturing process creating a lot of emissions of greenhouses gases and other pollutants. With rising focus on environmental damage such as global warming and sea level rise, harmful effect of pollution on humans as well as wildlife, there is an increasing pressure on companies to shift to greener processes. Use of natural gas can significantly reduce the pollution caused from cement manufacturing process.

5.5.1 Review of the Indian cement industry (FY2016 - FY2022)

Cement is a high-volume and low-value commodity. Transporting cement beyond a distance, therefore, makes it unviable for end-users. Cement consumption varies region-wise because the demand-supply balance, per capita incomes and levels of industrial development differ in each state, and consequently, in each region. Hence, supply and capacity utilisation in the cement industry is influenced by demand growth and level of consolidation in the region. In fiscal 2023, cement demand grew 12% (by volume)after witnessing ~8% growth in fiscal 22.In Q1FY23, demand witnessed robust growth of ~18% on-year on a low base and was driven by pickup in infra-activities as well as a strong recovery in individual housing – both rural and urban. However, Q2FY23 witnessed some moderation sequentially on back of seasonal weakness but grew by ~9% on-year. Further, as monsoon receded and with easing inflationary sentiments, traction in real estate and affordable housing, as well as pickup in infra execution ahead of elections in 2024 boosted healthy ~10% on-year demand growth in Q3FY23. In the last quarter of the fiscal, demand is estimated to have grown by robust ~12% on-year growth largely driven by year-end volume push by players to meet fiscal end targets..

In 2022-23, the eastern region accounted for the largest share of demand (~25%), followed by south (~23%), north and west (~18% each) and central (~15%).

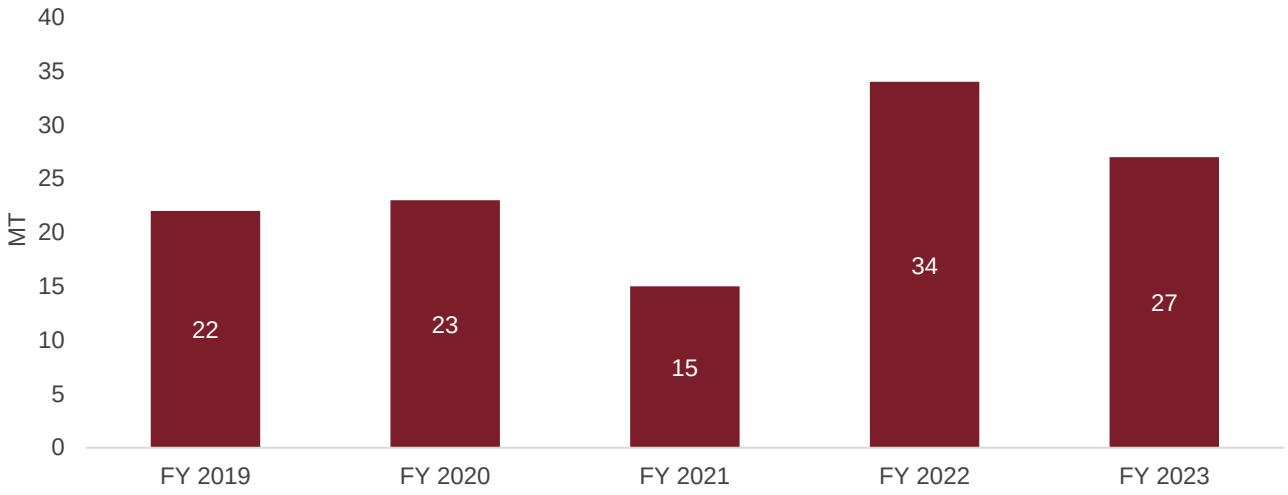
CRISIL MI&A estimates overall installed capacity of cement at 596 million tonne per annum (MTPA) as of fiscal 2023. Improving demand expectation, tight market situation in select regions and increasing utilisation had triggered a wave of new capacity announcements, especially by large players.

However, due to adverse macroeconomic conditions and significant impact of first and second waves of the Covid-19 pandemic on the underlying business, players had delayed or cancelled their ongoing/upcoming/new expansion projects in first half of fiscals 2021 and 2022. Further, extended local lockdowns and manpower unavailability impacted the construction activities in the ongoing expansion projects, leading to delay in capacity additions.

In fiscal 2022, 34 mtpa of capacity was commissioned. Further, a robust capacity addition of over 36-38 MT is expected in fiscal 2024. Improving demand outlook over the medium term and push to gain market share have triggered a wave of capacity addition announcements by cement manufactures, especially large players.

After witnessing healthy additions in fiscal 2022, capacity additions slowed down during fiscal 2023 to 26-28 MT (inclusive of grinding and integrated units). Higher input costs, led by elevated power, fuel and freight prices, which rose further in the first half of the fiscal 2023, affected the industry's profitability, thereby slowing down capex execution of players. However, higher capacity addition of 36-38 MT is expected in fiscal 2024 amid easing cost pressure and revival of player's margins..

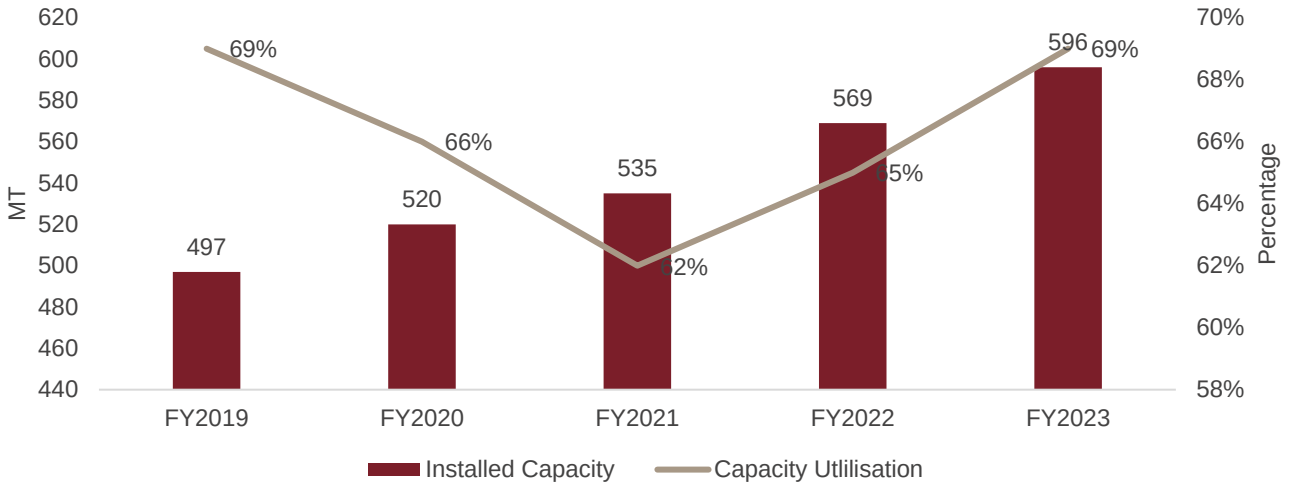
Review of capacity additions (FY2019 – FY2023)



Source: CRISIL MI&A

CRISIL MI&A expects operating rates of cement players to rise to 71-73% on-year this fiscal, after recovering to ~69% in the previous fiscal from ~65% in fiscal 2022. Utilisation levels improved in fiscal 2023 from ~62% in fiscal 2021 and ~65% in fiscal 2022, amidst a healthy demand uptick. Higher utilisation levels were supported by strong tailwind of higher demand from housing and infra segment coupled with capacity additions of 26-28 MT during FY23.

Trend in capacity utilisation (FY2019 – FY2023)



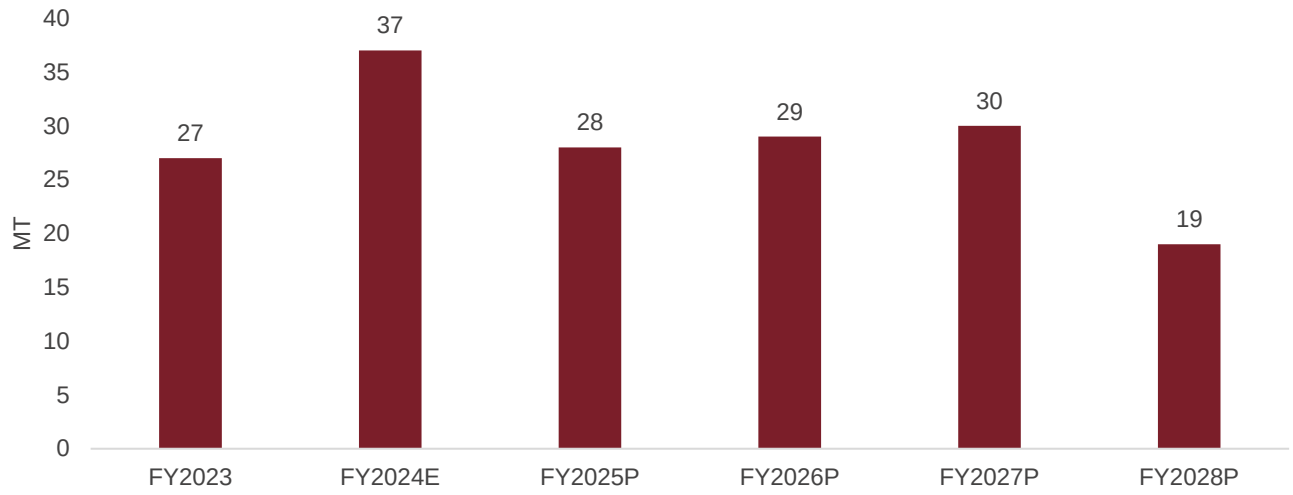
Source: CRISIL MI&A

Cement demand grew by a healthy ~12% in fiscal 2023. High construction costs, which impacted demand in the early months, witnessed some cooling off in the second half of the fiscal. Demand was supported by tailwinds from strong demand for rural housing and infrastructure. The individual housing segment, especially rural, which was expected to bear the brunt of inflation in the early months of the fiscal, fared well in the second half amidst cooling construction costs, higher rural income owing to healthy yields and increase in crop prices, thereby supporting demand growth from the rural housing segment. Infrastructure continued its strong growth momentum, led by the government's spending, primarily across its flagship schemes, such as PM Gati Shakti and the National Infrastructure Pipeline..

5.5.2 Indian cement industry outlook (FY 2021 - FY 2027P)

After witnessing healthy additions in fiscal 2022, capacity additions slowed down during fiscal 2023 to 26-28 MT (inclusive of grinding and integrated units). Higher input costs, led by elevated power, fuel and freight prices, which rose further in the first half of the fiscal 2023, affected the industry's profitability, thereby slowing down capex execution of players. However, higher capacity addition of 36-38 MT is expected in fiscal 2024 amid easing cost pressure and revival of player's margins. Players resumed capex plans in the latter half of fiscal 2021, which ran well into the next fiscal, leading to 26-27 MT capacity addition in fiscal 2022. The second wave of the pandemic in the first quarter of fiscal 2022 induced short-term demand hiccups and a delay in execution. However, this did not materially affect the capex plans. Various players have announced long-term growth plans with healthy capacity addition amid increasing comfort and visibility of positive demand outlook in the long term, despite near-term headwinds due to cost inflation.

Outlook on capacity addition (FY 2024E – FY 2028P)



E: Estimate P: Projected
Source: CRISIL MI&A

In fiscal 2024, pan-India utilisation levels are projected to reach71-73%, with rising demand. Utilisation levels improved in fiscal 2023 from ~62% in fiscal 2021 and ~65% in fiscal 2022, amidst a healthy demand uptick. Higher utilisation levels were supported by strong tailwind of higher demand from housing and infra segment coupled with capacity additions of 26-28 MT during FY23. With continued momentum of demand growth, utilisation levels are expected to improve further in this fiscal reaching to 71-73% in FY24, crossing ~70% operating levels, last seen in the industry before a decade.. Over fiscals 2024-28, CRISIL MI&A Research expects the industry to add 140-150 million tonne per annum (MTPA) of grinding capacities, taking the country's total installed capacity to 735-745 MTPA by fiscal 2028.Over fiscals 2024 to 2028, operating rates are forecast to average 71-73%, higher than the ~66% in the previous five years due to robust capacity additions to the tune of 140-150 MT over the next five years. Healthy demand growth of 5-6% CAGR over the next five years (fiscals 2024 to 2028) vis-a-vis 6% CAGR between fiscals 2019 and 2023 will aid utilisation levels, but higher capacity additions will limit further growth in operating rates.

Outlook on installed capacity levels (FY 2024E – FY 2028P)

P: Projected E: Estimate
Source: CRISIL MI&A

CRISIL expects demand to witness further 8-10% growth in fiscal 2024 after two consecutive years of healthy demand uptick, primarily led by the government's thrust to boost infrastructure development before the Lok Sabha election in 2024. Although, agri-profitability to remain a key monitorable on back of expected El Nino condition and weak monsoons in fiscal 2024. The infrastructure segment is expected to be the major demand driver for cement demand in near term, led by ~24% rise in the Centre's budgeted spending on key infra sectors against FY 2023. The highest traction is expected from roads, where the total outlay for the Ministry of Road Transport and Highways and the National Highways Authority of India has risen by 25% and 15%, respectively, on-year. Construction pace under PMAY-U scheme is expected to drive demand from urban housing this fiscal as scheme nears closure. However growth from real estate expected to be moderate on account of rise in capital values and higher interest rates. On the other hand, pre-election boost will spur growth in fiscal 2024 at 8-10%, led by the government's push to bolster the infra and housing segments. Demand witnessed a growth in the first quarter fiscal 2023 driven by pickup in infrastructure construction and a strong recovery in individual housing, both rural and urban. However, demand in the second quarter is expected to have declined because of seasonal weakness as monsoons hamper construction activities across regions. Ffurther, as monsoon receded and with easing inflationary sentiments, traction in real estate and affordable housing, as well as pickup in infra execution ahead of elections in 2024 boosted healthy ~10% on-year demand growth in Q3 fiscal 2023. CRISIL MI&A Research expects cement demand to log a CAGR of 5-6% over the next five years (fiscals 2024 to 2028) against ~6% CAGR in the past five years (fiscals 2019 to 2023), driven by a raft of infrastructure investments and a healthy support from housing demand.

5.6 Review and outlook of the Indian fertiliser industry

Natural gas is a key input for the fertiliser industry. It is used as a feedstock for production of ammonia from which most of the fertiliser such as urea is produced. The high amount of hydrogen that can be generated from natural gas is preferred compared to other fossil fuels. Natural gas is also cleaner and reduces the complexity vis-à-vis other fossil fuels. However, going forward there is also a view that ammonia can be produced from greener sources of fuel such as hydrogen which is produced using CCUS (Carbon Capture, Utilisation and Storage) technologies which doesn't emit carbon into the atmosphere or even from hydrogen produced from renewable sources such as solar and wind which can significantly reduce the carbon footprint of the industry.

Review of the Indian fertiliser industry (FY 2016 – FY 2022)

Fertilisers are vital for sustaining and increasing food production to meet the increasing food requirement. Fertilisers can broadly be categorised into nitrogenous, phosphatic, potassic, and complex. Application of fertilisers varies from region to region based on nutrient requirements, cost of fertilisers and farmer preferences. In India, nitrogenous fertilisers account for the bulk of consumption followed by phosphatic fertilisers.

The different chemical fertilisers differ from each other based on their nutrient content. For example, urea has 46% nitrogen and no phosphate or potassium, while DAP has 18% nitrogen, 46% phosphate and no potassium). Their application as well differs for different crops.

Different crops require different proportions of N, P and K. For instance, one tonne of paddy absorbs 9.74 kg of nitrogenous nutrient, 3.12 kg of phosphatic nutrient and 3.26 kg of potassic nutrient from the soil, while one tonne of wheat extracts 15.96 kg of nitrogenous nutrient, 1.89 kg of phosphatic nutrient and 3.43 kg of potassic nutrient from the soil.

The quantum of nutrient absorption also varies across different kinds of soil. In India, the ideal NPK usage ratio is supposed to be 4:2:1. In reality, the usage ratios differ from region to region, due to variations in soil types, crops grown and farmer price preferences. This discrepancy in the usage ratio is driven primarily by farmer preferences. For instance, the consumption of nitrogenous fertilisers in India is much higher than that of phosphatic and potassic fertilisers. This is because the impact of nitrogenous fertiliser consumption is immediately visible and the cheaper availability of urea as compared to the other fertilisers.

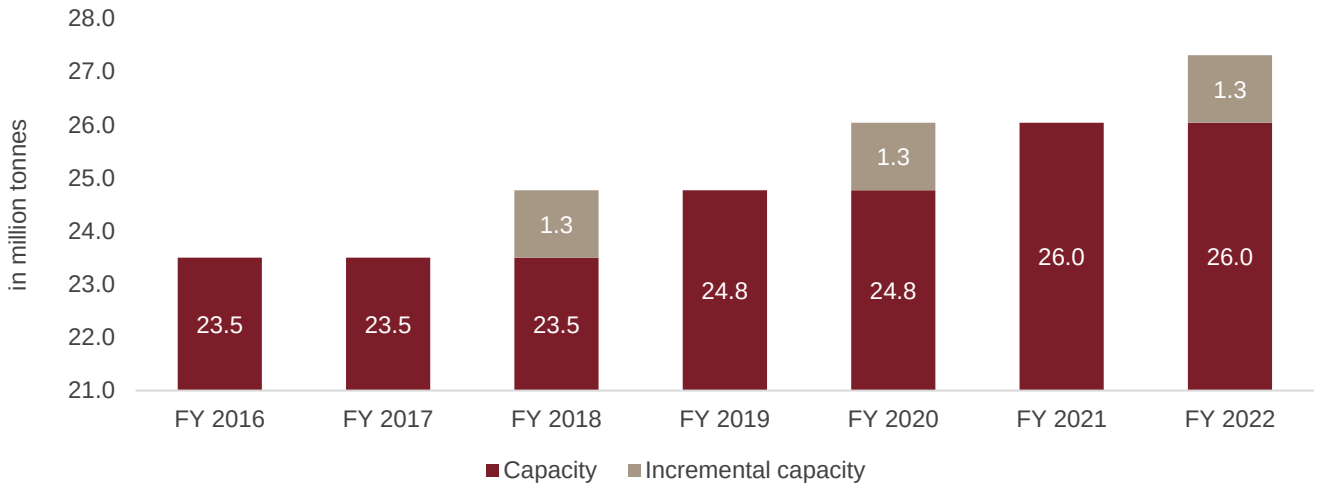
In the past decade, there has not been any significant technological advancement in the basic manufacturing process of fertilisers. The focus has largely been on refining existing processes to reduce power consumption, increase efficiency, develop better autoclave materials to enable production at a higher temperature and pressure, and improve the choice of catalysts.

The manufacture of ammonia and urea (nitrogenous fertilisers) is highly technology intensive as compared with the manufacture of complex fertilisers. The processes and equipment for almost all fertilisers (except for single super phosphate) are procured from overseas technology licensors. The basic process designs in the fertiliser industry are patented and most countries use them under a licensing system.

To reduce dependence on imports and increase domestic urea production to keep pace with demand, the government introduced the Urea Investment Policy, 2014. With the government aiming to revive sick urea plants, major capacities are likely to be commissioned in the next few years.

Urea capacity increased in fiscal 2018 on account of the commissioning of the Rangan plant by Matix Fertilisers (1.3 MT). The plant, which started operations in October 2017, is not operational due to inadequate supply of feedstock till fiscal 2022. The plant had been operationalised in Q2 of fiscal 2022.. Another capacity addition of 1.27 MT happened in fiscal 2019 with the commissioning of Chambal Fertilisers' Gadepan III plant in January 2019. The plant operated at optimal capacity in fiscals 2020 and 2021.

Review of fertiliser capacity additions (FY2016 - FY2022)



Source: CRISIL MI&A

To address the players' concerns over setting up new capacities based on relatively higher priced liquefied natural gas (LNG), the government has extended the applicability of its gas-pooling mechanism to new plants from fiscal 2019. Pooling of domestic gas and LNG has made the cost of gas for all urea plants uniform. This has benefitted

new plants, which would have otherwise relied on LNG. Natural gas prices had soared high during FY21-23, and there had been a tremendous spike in the gas pooled price during the period, owing to increase in prices under the three kinds of allocation – contracted, spot and APM. Also, hike in prices of natural gas in FY 23 was mainly attributed to Russia-Ukraine Crisis, as the Russia is one of the largest global exporters of natural gas. Further, trade restriction of natural gas by Russia resulted in natural gas crisis in Europe and consequently price hiked significantly.

At the expected gas cost of $6.5 per metric million British thermal unit, floor and ceiling prices are set at $305 per tonne and $335 per tonne, respectively. Hence, with international urea prices projected to be in the $280-300 range over the next five years (on account of a fall in capacity utilisation rates), return on net worth could be lower or might be capped at 12% in the initial few years.

Meanwhile, in the absence of the assured offtake clause, if the landed cost of international urea price is below the reimbursed price, the government may import urea to reduce its subsidy burden instead of procuring urea from domestic players. This would compel players to either lower their utilisation rates or sell excess urea in international markets at a discount, which would impact their returns.

The weak financial position of some urea companies and removal of the assured offtake clause are therefore restricting players from setting up new plants.

5.6.1 Review of domestic demand for fertilisers

CRISIL expects domestic fertiliser demand to grow by 3-4 % on year in fiscal 2024P. In FY23, fertiliser consumption reportedly increased by ~1.5%, out of which urea increased by a significant 5.4%, while non-urea fertilisers declined by 2.9%. In FY23, growth in urea consumption was supported by its increased availability during key cropping seasons and improved realisation from agri-commodities which led to higher acreage under crops in FY23.

On the other hand, the overall decline in non-urea fertiliser consumption was led by dip in MOP following a significant spike in prices, inadequate availability during key seasons and complexes sales. Minimal price hike in DAP following Government's support coupled with increased availability resulted in a significant increase in DAP consumption by ~14% on the year, on a low base of the previous year.

Fiscal 2022 and 2023 witnessed a historical spike in international prices of fertilisers such as urea, DAP, and MOP. Prices of DAP had started spiking since the beginning of FY22 due to shortage at the global level, which was further aggravated by the export ban of DAP by China to meet their domestic requirements. The Russia-Ukraine war led to the worsening of the situation and as a result, prices of Urea, DAP, and MOP increased steeply during Q4 FY22.

In FY22, fertiliser consumption had declined by ~7% due to erratic monsoon in key months of rabi and kharif. In addition, a supply crunch for key fertilisers was witnessed on the back of elevated international prices, and limited availability of fertilisers in the global market following export curbs from key countries. Although rainfall during the season was 99% of the long period average (LPA), it was unevenly distributed at 110%, 93%, 76% and 135% of the LPA during June, July, August and September, respectively. This affected the sowing of kharif crops. In addition, there was a supply crunch in key fertilisers on the back of elevated international prices and limited availability of fertilisers in the international market following export curbs from key countries.

In fiscal 2021, the domestic demand for fertilisers increased by 7.5% (volume terms). Demand for urea and non-urea grew by 4.4% and 11.2%, respectively. Demand remained buoyant in the first half on account of timely arrival of monsoon, migration of labourers to hometowns, increased kharif acreage, improved reservoir levels, and government norms. In the second half, fertiliser demand growth moderated to 1% on-year over a high base of 10%.

Indian fertiliser industry outlook (FY2023 – FY2026P)

CRISIL MI&A expects overall domestic capacity to increase ~1.3 MT by fiscal 2025. It takes between three and three-and-half years for a brownfield plant and four years for a greenfield plant to be commissioned from the date of commencement of construction.

The deadline to commission the Ramagundam revival plant was initially planned for December 2019; however, the project was delayed further to March 2020. The plant, which is expected to add 1.3 MT of urea capacity, was ready for commissioning activities as of April 2020. However, unavailability of contract labour due to Ramagundam being a Covid-19 hotspot area delayed the plant commissioning. The plant finally came on stream in August 2021. RFCL started commercial operation in March 2022.

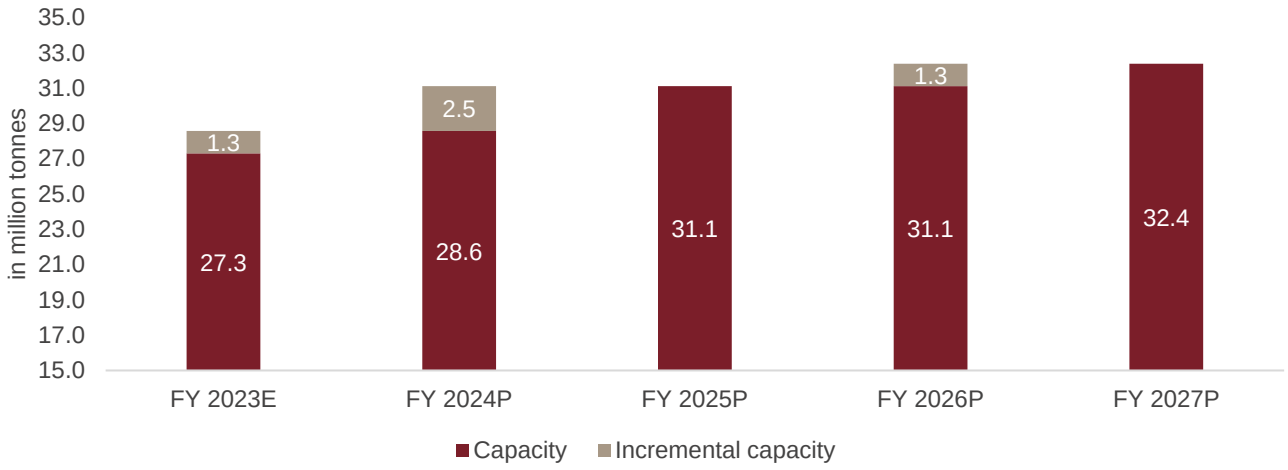
Further, the government has been trying to revive sick urea units in Sindri, Gorakhpur, Talcher, and Barauni in addition to the Ramagundam plant. The schedule for the Gorakhpur unit of Hindustan Fertilisers and Chemicals Limited has been completed. Until November 2021, Sindri and Barauni fertiliser plants achieved 92.8% and 92.5% of progress, respectively. National Fertilisers Ltd (NFL) and Rashtriya Chemicals and Fertilisers Ltd (RCF) have acquired 11% stake each in FCIL's Sindri unit. Production in Barauni and Sindri plants also started in October and November 22 respectively. Talcher plant is also expected to get commissioned in fiscal 25 and produce at full capacity by FY26P.

In complex fertilisers, with existing plants already operating below ~75% capacity utilisation, CRISIL MI&A expects only one greenfield project in the next five years (by Krishak Bharati Cooperative Ltd with a capacity of ~1 MT).

In the case of phosphatic fertilisers, Paradeep Phosphates Ltd is in the process of enhancing production capacity of its non-urea fertilisers, including DAP (di-ammonium phosphate) and NPK (nitrogen-phosphorus-potassium) by nearly 50% to 1.8 MT from the present 1.2 MT.

Over the years, production of urea had been falling short of the consumption demand for urea, thus giving rise to imports. However, in FY23, imports declined by ~25% supported by increased domestic production due to operationalization of revived urea producing units of Matix (Oct'21), HURL Gorakhpur (Dec'21),RFCL (Mar'22), HURL Barauni (Oct'22) and Sindri (Nov'22). Subsequently, with expected increase in urea producing capacity, dependency on imports is expected to further reduce. Along with enhancement of indigenous capacity introduction of nano- urea is expected to replace granular urea imports gradually over the years. In fiscal 2021 and 2022, urea imports have been almost the same in volume terms. However, rising international prices of urea and increasing natural gas prices are now big concerns in front of the Government as well as manufacturers. Soaring prices of coal in China, the main feedstock for ammonia production, forced fertiliser factories to cut production, which led to a supply crunch eventually contributing to the increased urea prices. The Russia-Ukraine crisis has worsened the situation. Amid this global issue, domestic production of urea is set to increase by 2.54 million tons with the planned commissioning of Sindri and Barauni plants of Hindustan Urvarak & Rasayan Ltd. Overall urea capacity in India is projected to increase by ~6.35 million tons by fiscal 2026. With increasing domestic production and global turmoil situation, import is expected to decline by ~25% in fiscal 2024.

Outlook on fertiliser capacity additions (FY 2023E – FY2027P)



E: Estimate P: Projected
Source: CRISIL MI&A

5.6.2 Outlook on demand (FY2023 – FY2028)

From fiscals 2023 to 2028, demand for overall fertilisers is expected to witness a compound annual growth rate (CAGR) of 3-4%% to ~73 million tons. Urea is expected to grow at ~1% CAGR to reach 37 -38 million tons by end of fiscal 2028. Urea will continue to have a dominant share in fertilisers owing to a higher preference among marginalised farmers (constituting ~85% based on holding size) and middle-income farmers. However, growth is expected to be slower than the fifteen-year (till FY 22) CAGR of ~2.5% due to increasing awareness among farmers regarding soil fertility.

On the other hand, non-urea fertilisers are expected to register 4-5% CAGR to reach 36 million tons by fiscal 2028. Initiatives taken by the government (soil health card scheme) towards increasing awareness among farmers and training programs conducted by fertiliser companies will be the key growth drivers. As part of the scheme, a total of 107 million and 115 million soil health cards were distributed in the first (2015-17) and second cycle (2017-19) of the scheme, respectively. The adoption of non-urea fertilisers is projected to increase in the long term driven by such awareness programs and Govt has set up a task force to promote it.

5.7 Review and outlook of the Indian oilfield equipment and services industry

In oil & gas refining and other downstream processes, industrial gases such as nitrogen, hydrogen, oxygen, and CO2 are consumed for chemical synthesis. In addition, nitrogen and CO2 have been effectively used as injection fluids for enhanced oil recovery (EOR) and widely used in oil field processes for gas cycling, reservoir pressure maintenance, and gas lift. Demand for oilfield equipment and services is likely to also increase demand for cryogenic gases as higher production of crude oil will increase the demand for cryogenic gases from the downstream petrochemical industry where a variety of chemicals and other intermediates are manufactured which require industrial gases.

5.7.1 Review of the Indian oilfield equipment and services industry (CY2016–CY2023)

Domestic exploration & production spending to increase in CY2021 as demand improves

The exploration and production (E&P) industry is dependent on the energy security requirements of countries. Any fluctuation in demand for crude oil can impact the industry. Over the years, growth in crude oil demand and the subsequent increase in oil prices provided momentum to drilling operations. However, a sharp decline in crude prices in the past years and budget cuts by oil and gas exploration companies have impacted drilling adversely, affecting oilfield services companies. With crude oil prices rising to $100 per barrel levels in the first half of 2022 after recovering from lows of 2020, drilling operations were witnessed revival. However, crude oil prices have moderated since then and currently range between $75-85 per barrel. This has supported a gradual uptick in demand post the covid-19 pandemic is resulting in improvement in utilization of rigs.

Oilfield equipment and services form the core of the drilling industry and investments in this form the largest capital expenditure by E&P players. With upstream players trying to curtail their operating costs by optimising usage of oilfield services and re-negotiating contract prices, oilfield equipment providers will see an erosion in their profitability.

E&P capital expenditure recovered in CY2021, investments to increase further in CY2022 and CY2023

Crude oil prices surged in 2022 as the Russia-Ukraine conflict directly impacted oil supply from restricting movement. Healthy demand from industries also witnessed revival as manufacturing and transportation segment returned to normalcy. Despite increasing recessionary fears, production cuts announced by OPEC+ provided some support to the falling oil prices in H2 2023.

Subsequently, investments in the E&P sector grew post the multi-year low oil prices rendered many projects and players, especially those operating in tough terrain, economically unviable. In fact, many majors such as Shell, Total, British Petroleum and Chevron cut capex for 2020 by 15-20%. Evidently, the number of rigs in operation globally has also come down.

The situation improved in 2022 and is expected to improve further in 2023 and 2024 with recovery in demand and economic activities. However, the players may remain cautious about their capex and postpone any significant and long-term investment until demand is clearly visible. We expect global E&P spending to increase 3-5% on-year in 2023.

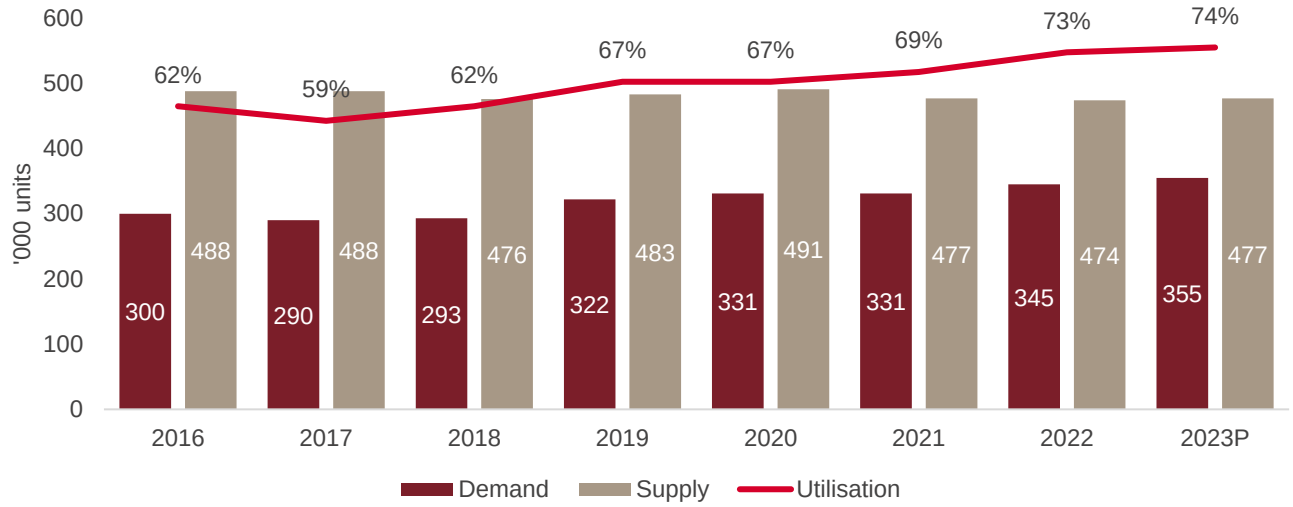
We expect the capital expenditure of domestic E&P players to also increase a further 8-12% on-year in 2023. Overall upstream investments are expected to increase to ~Rs 377-400 billion over the next couple of years. Only projects that are in the advanced stage of commissioning or are viable at low crude oil prices will get funds. Others will either be postponed or shelved until the prices recover.

Aggregate revenue of the domestic oilfield equipment and services industry declined ~6% on-year in fiscal 2022. Under the current market circumstances, with major E&P players announcing a significant increase in their spending budget, we expect more opportunities for these players in terms of new rig contracts. However, they may face difficulties in bagging new contracts, particularly because of their worsening financial condition, aging fleet and fierce competition from domestic and international rivals

Leading charter rates to remain high in CY2021

Leading charter rates for jack-up rigs, semi-subs and drill ships have increased in 2021, due to higher retirement of rigs. This is expected to increase in 2023 due to higher retirement of rigs as well as increased demand for drilling. Considering the sharper decline in upstream investments and lower rig demand, retirement of older rigs and postponement of new deliveries was seen in 2020. Even in 2021, retirements were higher vis-a-vis deliveries. In 2023, we do expect elevated prices to support demand and retirement of older units to keep charter rates high. Furthermore, E&P players tried to charter advanced jack-up rigs, such as premium jack-up and harsh weather rigs, in offshore oil fields instead of semi-submersible and drill ship, wherever possible. This supported charter rates of jack-up rigs.

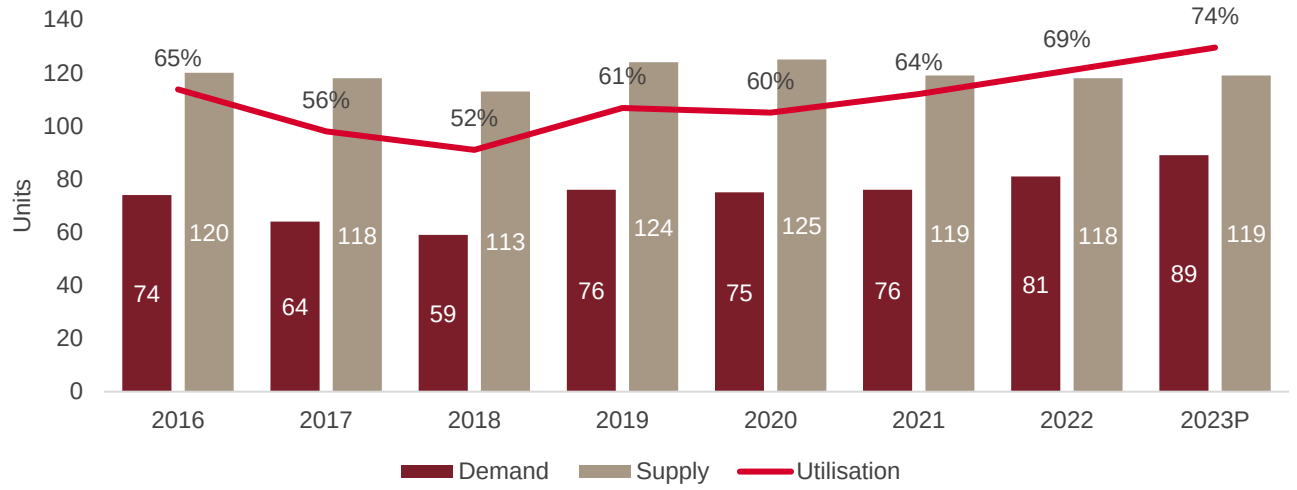
Demand, supply and utilisation rates for jack-up rigs (CY2016–CY2023)



Source: Industry, CRISIL MI&A

The jack-up rigs market has improved in 2022 as E&P activities increased. However, more than one-fifth of current jack-up supply is 35 years of age or older, leading to high retirements in 2021 as well as 2022, with Valaris and Borr Drilling retiring their older fleet. Total fleet is expected to reverse the declining trend due to reduced retirals as well as deliveries of new units. Subsequently, utilisation rates are estimated to have increased to ~74% amid increase in immediate requirement to boost crude production Leading charter rates of 300+ WD jack-ups are expected to remain elevated with increased demand for premium and modern rigs. Similar trend was seen in 2020 and 2021 as well. The jack-ups market is expected to see an improvement in 2023 as E&P activities see an increase due to soaring crude oil prices. Utilisation rates are estimated to increase to ~79% amid an increase in immediate requirement to boost crude production.

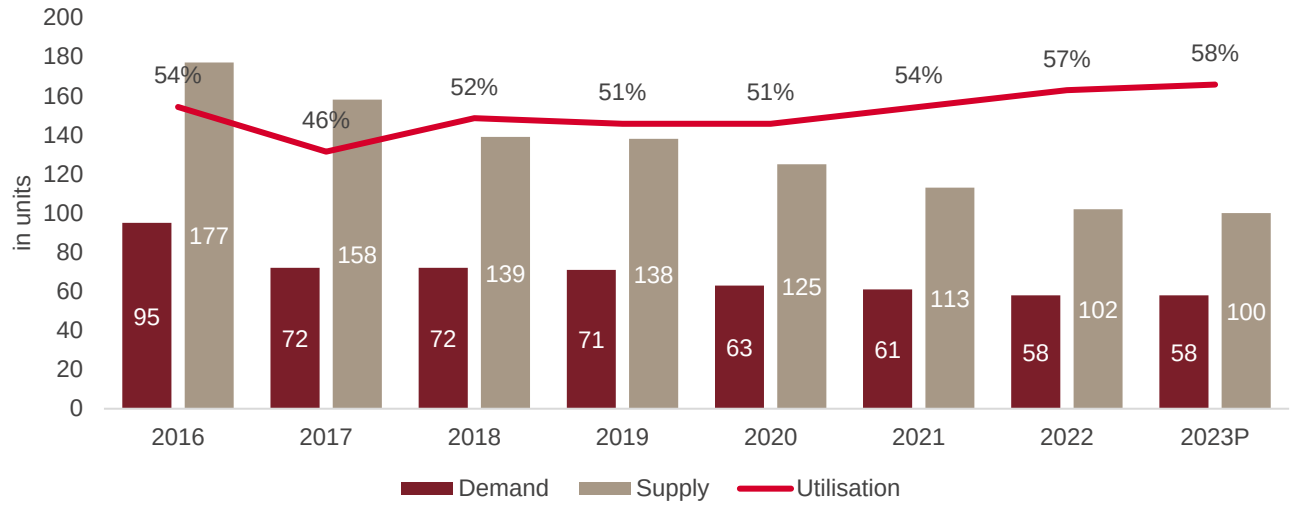
Demand, supply and utilisation rates for drill ships (CY2016 –CY2023)



Source: Industry, CRISIL MI&A

Despite the pandemic, drillship demand remained stable in 2021, with demand further expected to grow in 2022. However, increased preference for drill ships vis-à-vis semi submersibles will support higher growth in the future. In the medium term, utilisation rates are expected to range at 65-70%. Drillship rates are expected to increase in 2022 and 2023– primarily driven by increased E&P activities supported by surging oil prices.

Demand, supply and utilisation rates for semi-submersibles (CY2016–CY2023)



Source: Industry, CRISIL MI&A

Demand for semi-subs declined ~11% on-year in 2020, due to reduction in drilling activities as crude oil prices declined amid the pandemic. Given the decline in oil prices in 2020, many players postponed or even shelved their investment plans for deeper and geologically challenging oil wells, as it was economically unviable for them to open, develop and operate such wells and fields at sub-$50 per barrel levels. However, elevated crude oil prices in 2022 and 2023 is expected to push activities in these difficult fields. Thus, demand for semi-subs was estimated to witness a growth of 1-3% on-year in 2022 and expected to remain stable in 2023. Also, in 2022, five submersible ships are expected to retire against a delivery of two. This would lead to an increase in utilisation levels given a

reduction in the total fleet. However, charter rates to increase in 2022 due to an increase in retirement of fleets as well as increase in demand.

Charter rates for offshore support vessels to increase marginally

Demand for offshore support vessels (OSVs) is linked to the demand for rigs and thus in 2022, with pick up in rig demand, demand for OSV is likely to improve. It is estimated to have moderated as more rigs equipped with dynamic positioning systems kept the requirement for AHTS (anchor handling tug supply) lower in 2022 and 2023. However, the retirement of OSVs would decline amid the oil price crisis and it will have an adverse impact on the charter rates. The decline will be restricted due to higher usage of PSVs (platform support vessels) for oil storage as the pandemic-induced lockdown has lowered oil demand, resulting in an over-supply in 2020. In 2022 and 2023, we expect a marginal uptick in demand for OSV, leading to an increase in charter rates in 2022 but a marginal decline in 2023. in 2023, higher crude oil prices are expected to reverse the trend of retirals and thus increase supply marginally, thus leading to a slight reduction in charter rates of OSVs.

5.8 Review and outlook of the India consumer durables & electronics industries

The Covid-19 pandemic sharply increased the demand for computing and connectivity devices such as laptops and mobile phones as well as home comfort products such as AC's as people were restricted to their homes during the lockdown period. The ensuing shortage of products using electronic semiconductor devices also known as electronic chips have put the spotlight on the concentration of industry as well as the global supply chain. The shortage in such electronic devices have had an adverse impact not just on computers but also on other industries which are increasingly using newer digital technologies such as IoT, AI/ML, cloud/edge computing to become more efficient and increase productivity.

As major economies are looking to become self-sufficient / reduce their dependence on foreign supplies of essential products the Government of India too has stepped up efforts in this regard. India is already a leader in the software field but is lagging in the hardware side. The Government of India has embarked on a mission to strengthen the domestic electronics industry as well and had introduced many policies to support the sector.

Cryogenic gases cater to an array of applications in the electronics industry, such as fibre optics, flat panel displays, integrated circuit manufacturing, packaging, assembly and testing, LED technologies, photovoltaics, printed circuit board (PCB) assembly and testing, and semiconductors which are sub-components of consumer durables. The increase in electronics devices and appliances demand will drive the demand for cryogenic gases from the sector.

5.8.1 Review of consumer durables and electronics industry (FY2016 - FY2022)

The domestic consumer durables industry – comprising colour televisions (CTV), refrigerators, washing machines (WM) and room air conditioners (RAC) – is estimated to have grown 10-13% in fiscal 2023. Rising inflation and reduced discretionary spend is expected to limit growth of household appliances sector. Among all the appliances, AC is expected to grow fastest while CTV will grow at the slowest pace. Soaring temperatures during summer coupled with low base of the first quarter of previous fiscal will drive growth for air conditioners. Consumption is expected to witness moderation next fiscal, which will have an impact on household appliances growth. Domestic demand could come under pressure as interest rate hikes gets transmitted more to consumers. CRISIL thus expects sector to grow 6-8% in fiscal 2024.

The household appliances sector witnessed 13-15% growth in fiscal 2022 on a low base of previous fiscal, increase in discretionary spend and waning impact of pandemic. Second lockdown (partial/ full), restriction on sale of non-essentials; even through online mode in some states impacted demand during the first quarter of fiscal 2022. Air-conditioner sales witnessed higher impact as it’s a peak season for them and around 30-35% of the sales happen during the first quarter. Higher product prices due to rising raw material prices also impacted demand. Demand improved with the onset of festive season in the second half of fiscal 2022. People's focus on hygiene and higher storage capacity pushed demand for washing machine and refrigerator..

After increasing on a low base in fiscal 2022, demand for CTV is expected to grow at a slower pace of 6-7% in fiscal 2023., The preference for larger screen sizes is expected to drive the demand while higher discretionary spending and waning impact of the pandemic. Demand slowdown following Covid-19 impacted television (TV) sales in fiscal 2021. Lockdown during the first quarter impacted sales significantly. However, with education going online, there was increased demand for CTVs to meet the need of online classes for children. Further, with people remaining at home, consumption of OTT content is being preferred on large screen. Also, with films being released on streaming services and fear of visiting multiplexes led to demand for CTVs post lockdown. Festive season fared well for CTVs. Sales improved through the online route with social distancing norms in place because of pandemic and customer's preference of having contactless buying. However, significant decline during the first quarter weighed on overall demand. Thus, sales declined ~16% in fiscal 2021.

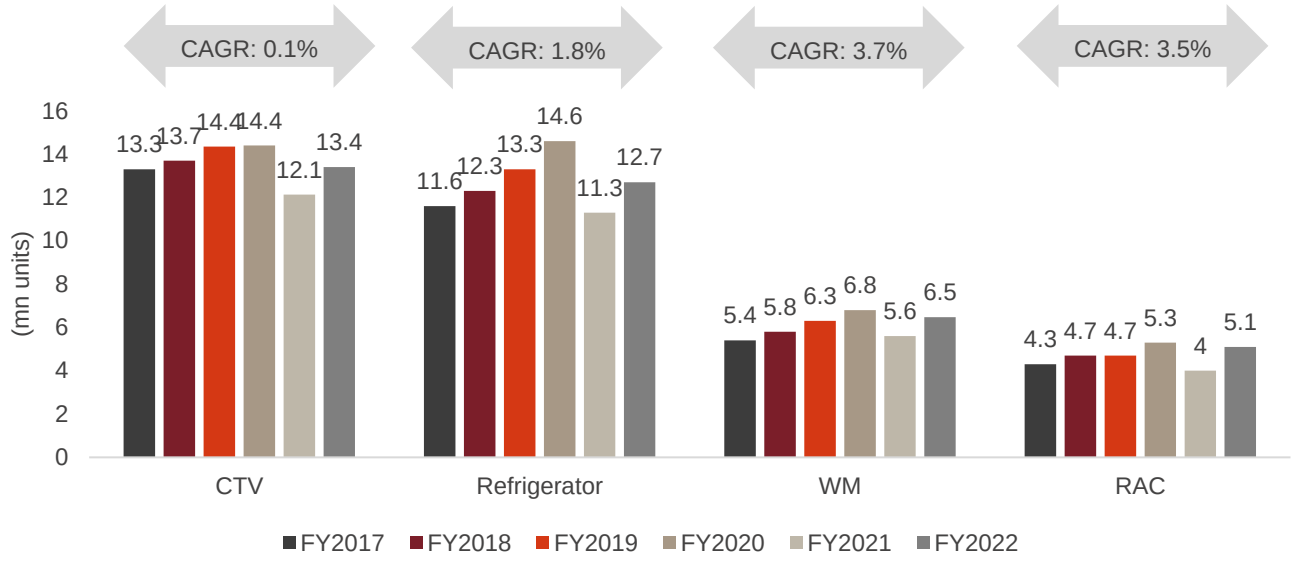
Fiscal 2023 started well with demand for cooling products improving during month of April. However, rising inflation took toll on demand post mid-May. However, on a significantly low base of last year owing to second wave of Covid, demand grew during the first quarter. Demand for the mass segment is expected to be impacted amid rising inflation. However, growth will be driven by the premium segments. Overall, the sector is estimated to grow 14-16% on-year in fiscal 2023 on a low base of previous fiscal. Consumption is expected to witness moderation next fiscal, which will have an impact on refrigerator growth. Domestic demand could come under pressure as interest rate hikes gets transmitted more to consumers. We expect the segment to grow 6-8% in fiscal 2024. A slump was witnessed in the demand during the first quarter of fiscal 2022 on account of lockdown/ curbs and restriction on sale of non-essentials in some parts of the country. Demand improved during the second half of the fiscal with onset of festivals. Thus, a low base, higher discretionary spending, no rating revision and good festive growth will help demand grow by 12-14% in fiscal 2022. and refrigerator household penetration is estimated at ~40% in India. While the segment fares relatively better than RACs and washing machines, it still significantly lags the CTV segment.. Unlike the RAC and washing machine segments, growth in the refrigerator segment is expected to be driven by higher demand from both urban and rural areas. \

A good summer in fiscal 2018 aided a growth of ~9% in the RACs segment. The Bureau of Energy Efficiency (BEE) revisions led to rise in AC prices in fiscal 2019 and impacted growth. Demand slowdown following Covid-19 impacted AC sales in fiscal 2021. Sales are estimated to have witnessed a decline of around 70% in the first quarter owing to lockdown. First quarter forms around 35-40% of overall sales during the year. Thus, sales decline during the first quarter weighed heavily on the whole fiscal. With first quarter being most productive for AC, demand slowdown following impact of Covid-19 in fiscal 2021. While sales improved during the second half of the fiscal especially during festivals, overall, AC demand declined by ~25% in fiscal 2021.With second wave of pandemic, restriction on sale of non-essentials; even through online mode in some states impacted demand during the first quarter of fiscal 2022. However, demand improved during the second half of the fiscal with onset of festivals. Thus, from a low base of previous fiscal, demand rose by 25-28% in fiscal 2022. Further, demand for room air conditioner is expected to be more resilient as compared to refrigerator this fiscal. Overall, CRISIL expects demand to rise by 20-25% in fiscal 2023. In fiscal 2024, CRISIL expect the segment to grow 11-13% as the domestic demand could

come under pressure as interest rate hikes gets transmitted more to consumers. Further, after witnessing growth on a low base in fiscal 2024, demand growth is expected to normalise in fiscal 2024.

The Washing Machine segment is expected to witness 14-16% growth in fiscal 2022 on account of a low base, people's focus on hygiene and a higher discretionary spending. Lockdown (partial/ full), restriction on sale of non-essentials; even through online mode in some states impacted demand during the first quarter of fiscal 2022. However, with increasing focus on hygiene and people staying at home, washing machine witnessed good demand during fiscal 2022. Demand for semi- and fully automatic machines largely from urban and semi-urban areas. While the former caters to price-sensitive consumers in semi-urban areas, demand for fully automatic (FA) machines comes from the metros and mini metros. Although the FA segment has outpaced the semi-automatic (SA) segment in growth, over the past five years, higher prices and the requirement of continuous running water have curtailed growth of the former in semi-urban areas. Among household appliances, the penetration level of washing machines is low in India, lagging far behind CTVs and refrigerators. Penetration level in India is estimated at ~19% of total households in fiscal 2022. Urban markets, account for the bulk of sales. In contrast, rural markets remain significantly under-penetrated, due to lower electrification, consumer perception that washing machines do not clean the collars and cuffs of shirts, and easy availability of manual labour at cheap rates.

Review of domestic consumer durable sales trend (FY2016 – FY2022)



Source: Industry, CRISIL MI&A

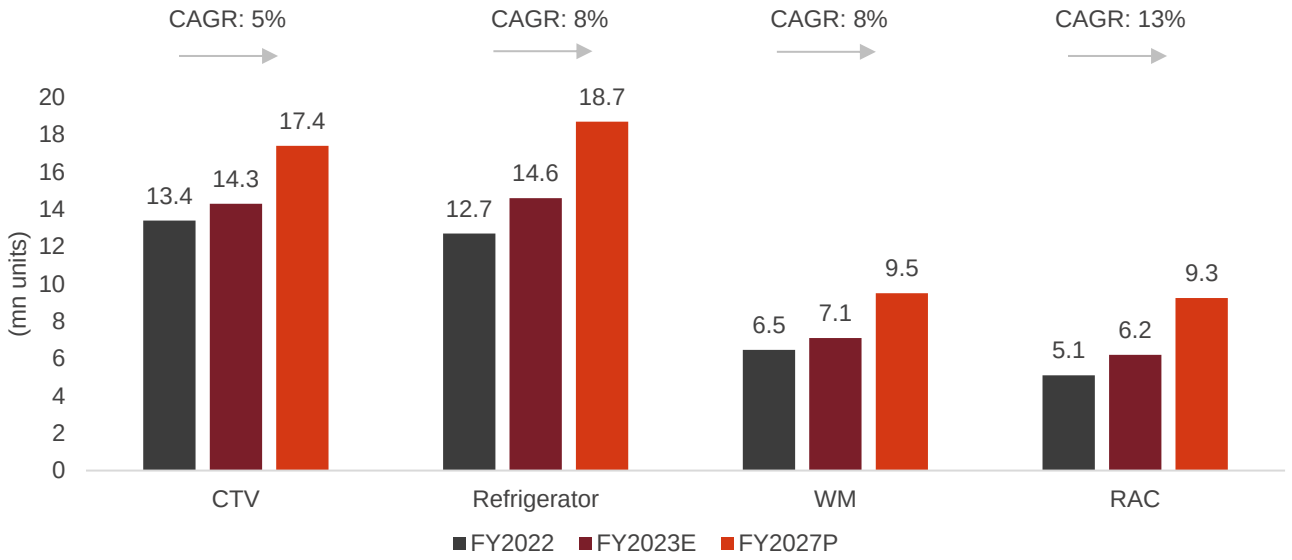
5.8.2 Outlook of the consumer durables and electronics industry (FY2023E - FY2027P)

CRISIL MI&A projects long-term demand for consumer durables and electronics to witness healthy growth on increasing affordability because of stable product prices, easy financing options, increased government spending on rural infrastructure amid higher economic growth, and assuming moderate inflation. Volume growth will be driven by better affordability, shorter replacement cycles, multiple ownership (in the case of CTVs) and current low penetration levels (in the case of other appliances). Between fiscals 2022 and 2027, revenue of the household appliances industry is forecast to grow at 10-12% CAGR.. The sector is expected to witness 7-9% volume growth in long term.

Although CTVs had the highest penetration among household appliances in fiscal 2021 (60% of total households), rural penetration is still low at ~38%. Rising demand in under-penetrated rural areas and replacement demand, as

well as multiple ownership in urban areas could drive long-term growth. The overall TV market is projected to clock 5-6% CAGR in volume terms in long term from fiscal 2022 till fiscal 2027. In refrigerators, direct-cool and frost-free segments are likely to post CAGR of 7.5-8.5% and 8.5-9.5% respectively in volume terms between fiscals 2022 and 2027. While urban areas will drive demand for frost-free refrigerators, semi-urban and rural areas will mainly lean on direct cool refrigerators, with rural consumers now considering refrigerators as a necessity as well. The refrigerator market is expected to grow at a CAGR of 8% from fiscals 2022 to 2027. In washing machines, growth in demand in volume terms for fully automatic (FA) machines could outpace semi-automatic (SA) machines over the next five years. The growth in FA and SA machines is expected to grow at 9-10% CAGR and 6-7% CAGR respectively. While urban areas are likely to drive demand for fully automatic machines, with growing number of working women and rising disposable incomes, price-sensitive consumers in semi-urban areas will drive demand for semi-automatic machines. In fiscal 2022, washing machine penetration was only 19% of total Indian households. Over the next five years from fiscal 2022, the segment is expected to record 8% CAGR in volume terms.. In fiscal 2022, RAC penetration is only ~12% of total Indian households. Over the next five years, the segment is expected to record 12-14% CAGR in volume terms. The segment will grow riding on low penetration, growing multiple ownership and increased perception among consumers about RACs being a necessity. It is expected to penetrate 15-17% of total Indian households by fiscal 2027. Within the segment, split ACs are likely to log 14-16% CAGR in volume terms over the period fiscal 2022 and fiscal 2027 vis-a-vis ~1% growth in window AC sales volume. The urban markets are more likely to drive RAC sales, as price-sensitive rural consumers are still reluctant to purchase RACs. The RAC market is estimated to grow at a CAGR of 13% from fiscals 2022 to 2027

Domestic consumer durable sales trend (FY23E-FY27P)



P: Projected
Source: Industry, CRISIL MI&A

Key trends and developments in the electronics and consumer durables industry

To enable the growth and development of the industry the government has taken many steps such as launch of the India Semiconductor Mission, Rs. 760 billion budget to support manufacturing, PLI scheme, SemiconIndia conference to encourage interaction amongst stakeholders and catalyse the growth of the industry. As per the governments' semiconductor vision document India will consume semiconductors of around USD 70-80 billion to manufacture electronics products worth $300 billion by 2026 with $120 billion of export. The government aims to double India's electronics output by FY2026 from FY2020 levels.

5.8.3 India Semiconductor Mission (ISM)

To achieve self-sufficiency in electronics & semiconductors Union Cabinet has approved the Semicon India programme with a total outlay of INR 760 billion for the development of semiconductor and display manufacturing ecosystem in the country. The programme aims to provide financial support to companies investing in semiconductors, display manufacturing and design ecosystem.

India Semiconductor Mission (ISM) has been setup as an independent business division within Digital India Corporation with administrative and financial autonomy to formulate and drive India's long-term strategies for developing semiconductors and display manufacturing facilities and semiconductor design ecosystem. ISM will serve as the nodal agency for implementation of the schemes announced by the government to support the electronics manufacturing ecosystem in India:

- Scheme for setting up of semiconductor fabs in India provides fiscal support to eligible applicants and is aimed at attracting large investments for setting up semiconductor wafer fabrication facilities in the country. Following fiscal support has been approved under the scheme:
  - 28nm or Lower - Up to 50% of the Project Cost
  - Above 28 nm to 45nm - Up to 40% of the Project Cost

  - Above 45 nm to 65nm - Up to 30% of the Project Cost
- Scheme for setting up of Display Fabs in India provides fiscal support to eligible applicants and is aimed at attracting large investments for setting up TFT LCD / AMOLED based display fabrication facilities in the country. The Scheme provides fiscal support of up to 50% of Project Cost subject to a ceiling of INR 120 billion per fab.
- Scheme for setting up of Compound Semiconductors / Silicon Photonics / Sensors Fab and Semiconductor Assembly, Testing, Marking and Packaging (ATMP) / OSAT facilities in India provides a fiscal support of 50% of the Capital Expenditure to the eligible applicants for setting up of Compound Semiconductors / Silicon Photonics (SiPh) / Sensors (including MEMS) Fab and Semiconductor ATMP / OSAT facilities.
- Design Linked Incentive (DLI) Scheme offers financial incentives, design infrastructure support across various stages of development and deployment of semiconductor design for Integrated Circuits (ICs), Chipsets, System on Chips (SoCs), Systems & IP Cores and semiconductor linked design. The scheme provides “Product Design Linked Incentive” of up to 50% of the eligible expenditure subject to a ceiling of ₹150 million per application and “Deployment Linked Incentive” of 6% to 4% of net sales turnover over 5 years subject to a ceiling of ₹300 million per application.

5.8.4 Launch of SemiconIndia

Government has launched the SemiconIndia conference with the aim to make India a global hub for Semiconductor Design, Manufacturing and Technology Development which will help propel the vision of India Semiconductor Mission. The Conference aims to bring together leaders from industry, academia and research institutions to catalyse the growth of India’s semiconductor and electronics manufacturing ambitions.

The conference serves as the formal launch pad of India’s semiconductor strategy and policy which envisions making India a global hub for Electronics System Design and Manufacturing. The maiden conference of SemiconInda was held in 2022 from April 29th to May 1st. The second conference, SemiconIndia was held in 2023 between 28th July and 30th July.

5.8.5 PLI scheme for the white goods industry

- The PLI scheme for white goods (air conditioners and LED lights) has been implemented for fiscals 2022-2029, with a budgetary outlay of Rs 62.4 billion
- The scheme intends to remove sectoral disabilities, create economies of scale, enhance exports, create a robust component ecosystem and employment generation
- The scheme for ACs covers high-value intermediates (copper tubes, aluminium foils, and compressors) and low-value intermediates (PCB assembly for controllers, BLDC motors, service valves and cross flow fans for AC and other components)
- The scheme for LED lights covers core components, such as LED chip packaging, resistors, ICs, fuses, large-scale investments in other components and lighting products such as LED chips/ drivers/ engines, mechanicals, packaging, modules, wire-wound inductors and other components
- The scheme will extend an incentive of 4-6% on incremental sales of goods manufactured in India to manufacturers of ACs and LED lights

5.8.6 PLI scheme for large-scale electronics manufacturing

- The PLI scheme for electronic systems (laptops, mobile phones, tablets, PCs, servers and specified electronic

components) has been implemented for fiscals 2021-2025, with a budgetary outlay of Rs 409.5 billion

- The scheme intends to boost domestic manufacturing and attract large investments in the electronics manufacturing industry, including electronic components and semiconductor packaging
- The scheme will extend an incentive of 4-6% on incremental sales of goods manufactured in India to companies engaged in manufacturing of goods covered under target segments.

The government has received proposals from five companies for setting up the electronic chip and display manufacturing plants with an investment of Rs 1.53 trillion under the SemiCon India Programme. Vedanta Foxconn JV, IGSS Ventures and ISMC have proposed to set up electronic chip manufacturing plants with USD 13.6 billion investment and Vedanta and Elest have proposed to set up display manufacturing units.

5.9 Review and outlook of the consumer foods industry

The consumer foods industry used many cryogenic gases such as liquid nitrogen and carbon dioxide (as dry ice) used as refrigerants, owing to their versatile nature and their wide performance range. These gases are commonly used for the preservation, cooling, and freezing of products in the industry. In addition, these gases are used in the research and laboratory applications of the consumer foods industry.

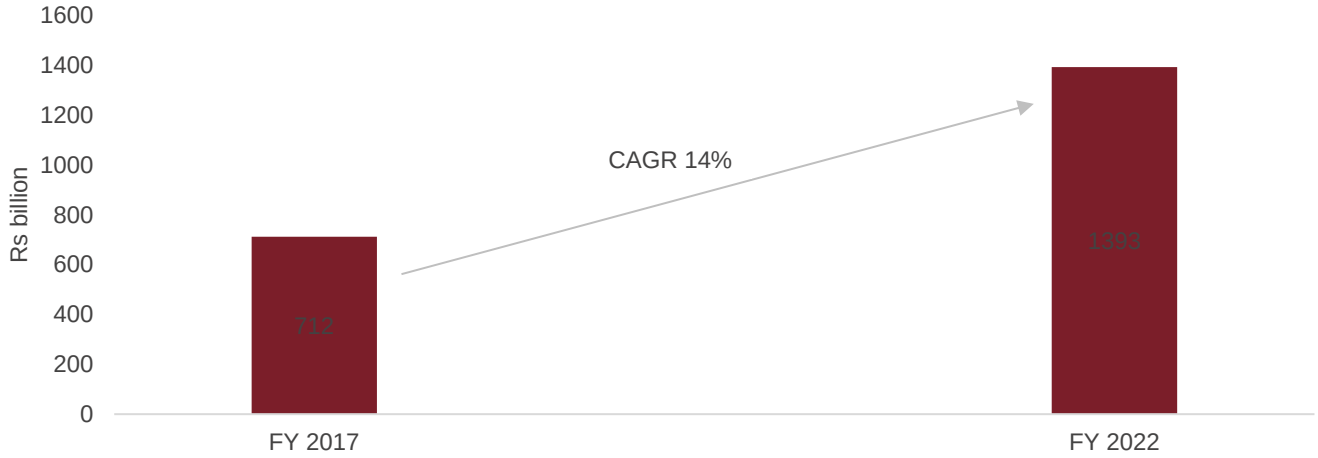
5.9.1 Review of the consumer foods industry (FY2017 - FY2022)

CRISIL MI&A estimates the market size of the Indian organised consumer foods industry to be about 1.6 trillion in fiscal 2023. We expect the industry to slightly moderate but continue its growth trajectory in fiscal 2024 led by strong rural demand, favourable population demographics, rising incomes and transition towards premium, healthy and nutritious products. According to CRISIL MI&A, the domestic consumer foods industry manufactures products through two main routes – contract and standalone. Standalone manufacturing is most preferred for high-value products, as the technology control is retained by the parent company; 55-60% products are manufactured through this route. Contract manufacturing is usually employed by large players, especially in the biscuits and bakery items segment, when a large multinational company wants to expand reach/penetration within a region rapidly and the market volumes are sizeable, while incurring minimal capex.

Organised consumer food industry which grew by 14% between fiscal 2017 and fiscal 2022 is expected to grow by 15-17% in fiscal 2023. The sales growth is expected to marginally improve to 13-15% in fiscal 2024. Rapidly growing modern retail shops (supermarkets and hypermarkets) in urban areas, owing to consumers increasingly preferring to buy 'all under one roof', are expected to drive sales of packaged foods. Online sales are estimated to have risen from 1% share in fiscal 2019 to more than 5% share in fiscal 2022 with more people preferring to order from the convenience of their home. Ease in mobility restrictions, increased social gatherings, recovery in institutional sales and improved activity in key sales points (such as railway stations, bus stations, markets and highways) propelled demand. With rising incomes and rapid urbanisation, consumers appear to prefer premium, nutritious, and healthy foods.

Prices of palm oil, potato and milk which had risen significantly in fiscal 2022. In fiscal 2023, elevated wheat, milk, sugar and maize prices compelled the players to pass on the increase in cost to the consumers thereby impacting volumes negatively.

Review of the Indian consumer foods industry (FY2017 – FY2022)



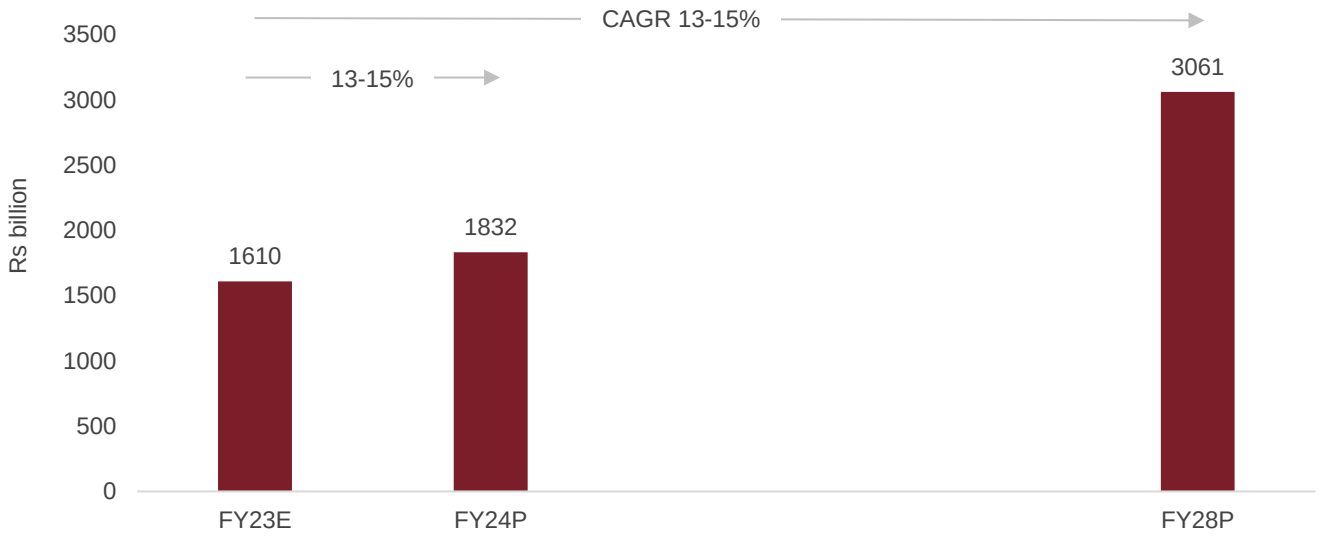
Source: Industry, CRISIL MI&A

5.9.2 Outlook of the consumer foods industry (FY2023 - FY2028P)

The consumer foods industry is expected to grow 15-17% y-o-y in fiscal 2023 and improve marginally to 13-15% y-o-y in fiscal 2024. Bakery products are expected to register stable growth in the two fiscals, on account of better volume growth in biscuits led by premium and healthy categories after a sales lull in fiscal 2022. With ease in mobility restrictions, the out-of-home consumption of snacks increased, resulting in strong revenue growth in fiscal 2022. Improved penetration of the organised sector amid the pandemic and new bakery products in regional flavours will drive growth of the industry in 2024. Chocolates and confectionery items, being impulse products, witnessed an uptick in fiscal 2022. Reopening of schools, colleges and increased opportunity of celebrations will help the industry surpass the pre-pandemic growth rate in fiscal 2023. Ready to eat/ ready to cook (RTE/RTC) food products are expected to witness strong demand from the B2C channel due to convenience and increase in demand from key sectors such as Horeca (hotels, restaurant, and catering), railways and airlines. The B2B channel will aid RTE/RTC products in fiscal 2024.

Margins of the packaged food segment players are expected to expand in fiscal 2024 as raw material prices soften coupled with healthy demand. The biscuit segment's margins are estimated to shrinking fiscals 2023, on account of rising of raw material prices, and limited ability to pass on to the end customer. The bread segment's margin is expected to remain stable in fiscals 2023 and 2024, led by steady demand amid softening of raw material prices. Input prices grew at higher pace than what the industry anticipated, resulting in margin contraction of bread products in fiscal 2022. Rise in input cost, fuel prices, freight cost to lead to price hikes which will contribute towards higher revenue for the segment. For chocolates segment, margins are expected to show a sustained expansion in fiscal 2023, due to increasing demand for high value products. Due to limited ability of sugar based confectionary players to pass on the increased cost, their margins are expected to be impacted in fiscal 2023 It is expected to remain stable in fiscal 2024. Despite strong rebound in sales of snacks on account of increased out-of-home consumption, margin contracted in fiscal 2022 due to 36% on-year hike in palm oil prices. We expect margin to expand in fiscals 2023 and 2024, as prices of key raw materials, such as palm oil, cools down amid steady demand. The RTE/RTC segment's margin was impacted by higher freight costs as the industry has significant exposure to exports. Revival in global demand, as the pandemic subsides, will keep margins stable. Changing lifestyles and paucity of time among the working population is expected to drive faster growth of RTE/RTC despite a slowdown in economy. In fiscal 2023, price hikes taken for LUPs (lower unit packs) by large players amid rising raw material cost is estimated to have impacted demand.

Outlook on the Indian consumer foods industry (FY23-FY28P)



Source: Industry, CRISIL MI&A

PLI scheme for food processing

- The scheme was announced on March 31, 2021, with an outlay of Rs 109 billion over fiscals 2022-2027
- It was intended to support Indian brands in the markets abroad and create global food manufacturing champions in India
- The scheme covers RTC/RTE foods, processed fruits and vegetables, marine products and mozzarella cheese
- It targets expansion of food processing capacity by nearly Rs 300 billion and creation of additional direct and indirect employment opportunities for 0.25 million persons by fiscal 2027
- Additionally, the PLI Scheme for Millet-based Products (PLISMBP) was launched in FY 2022-23 with an outlay of ₹800 crore, utilisng savings from PLISFPI.

5.10 Review and outlook of the dairy & milk products industry

Dairy products can quickly deteriorate in quality due to microbial growth and fermentation of products. To prevent this from happening and extend shelf life a variety of gases are used for cooling and packaging of dairy products. Rising dairy intake is likely to increase demand for industrial gases from the dairy industry.

5.10.1 Review of the dairy & milk products industry (FY2018 - FY2024P)

India is the highest producer and consumer of milk globally and among the fastest growing dairy markets. Domestic milk production has averaged 25-30% share in global milk production since 2015. However, limited quantities of milk left for exports and government regulations, such as regular bans on exports of high-volume products like milk powder and imports limited to premium varieties of butter and cheese, have kept India's share in the milk trade low.

Milk production in India was ~188 million tonne in fiscal 2019 and is estimated to have been 198 million tonne in fiscal 2020. Domestic milk production logged a compound annual growth rate (CAGR) of 6% between fiscals 2018 and 2022 reaching 221 million tonne. Uttar Pradesh, Rajasthan, Andhra Pradesh, Gujarat, Punjab, Maharashtra, Madhya Pradesh and Tamil Nadu collectively accounted for much of the country's total milk production in fiscal 2022. Although dairy farming is the primary profession of many in rural areas, milk production is concentrated in 10

states that account for over 80% of total milk production in India. Uttar Pradesh is the largest milk producer and Punjab has the highest per capita availability.

Domestic milk production logged a CAGR of 6.3% between fiscals 2016 and 2020. However, in fiscal 2021, it fell 3% as Covid-19 affected artificial insemination services in the first quarter. Further, a sharp fall in milk procurement price left limited funds with farmers to invest in their animals. A rise in fodder prices added to the cash crunch, leading to a fall in milk production. In the absence of lockdown restrictions, artificial insemination grew 4% in fiscal 2022, compared with a decline of 2% in fiscal 2021, which will increase milk production this fiscal. Further aided by an expected normal monsoon, milk production is set to grow 6.5-7% this fiscal.

In fiscal 2022, Covid-19 infections in rural regions of the country were more severe, and farmers incurred high medical expenses, which, in turn, hampered their investment in animals. As in fiscal 2021, artificial insemination services saw obstructions again as plants producing liquid nitrogen were directed to produce oxygen. Liquid nitrogen is a key element used in storing animal semen. The short supply of liquid nitrogen is expected to have impacted artificial insemination adversely, slowing down milk production. Also, production is expected to fall in fiscal 2023 with substantial decrease in fodder consumption led by 22% rise in fodder costs. Along with that, spread of lumpy skin disease in the months of June to November, especially in high milk producing states like Rajasthan and Gujarat led to decrease in milk production and lesser fat and SNF content in the procured milk.

This year, demand from the institutional and HORECA (hotel, restaurant and cafe) segments is up because of an increase in social gatherings, outings and travel, and reopening of schools and institutions. Companies that had resorted to selling their products such as ice cream, cheese, SMP and khoa, in smaller packages for retail consumption in fiscals 2021 and 2022 have seen demand rebound for wholesale packs. With changes in eating habits after the lockdown, household consumption of cheese and paneer had increased substantially by about 20%.

The milk demand is expected to remain steady at 10% in fiscal 2023, and grow by 8% in fiscal 2024.. With lockdown restrictions removed, educational institutions, tourism, and social gatherings are back to their normal course leading to higher demand for value-added products in the institutional and hotels, restaurants, and cafes (Horeca) categories. Household consumption will continue growing at a steady pace in fiscal 2024 as well. While household demand for milk increased during the pandemic in fiscal 2021, demand from the hotels, restaurants and catering (HORECA) segment picked up in fiscal 2023. That said, as restaurants and cafes were still not operating at their full capacity, household demand drove the 5% growth in fiscal 2022, while in fiscal 2023, the growth is driven by institutional and HORECA segments.

Highly fragmented and unorganised

The organised segment of the domestic dairy sector comprises cooperatives, private companies, and producer companies (companies set up with the help of the National Dairy Development Board), while the unorganised segment comprises local vendors and dairy farmers selling within their area of production.

As of fiscal 2022, unorganised players dominated the Indian dairy industry with ~58% share in the retail market of dairy products. Going forward, the organised segment is expected to grow at a faster pace of 16-18% than the unorganised segment's 12-13%. This is expected boost the share of organised players in the near future. Rising consumerism, growing urbanisation, and preference for branded packaged foods will primarily drive this trend.

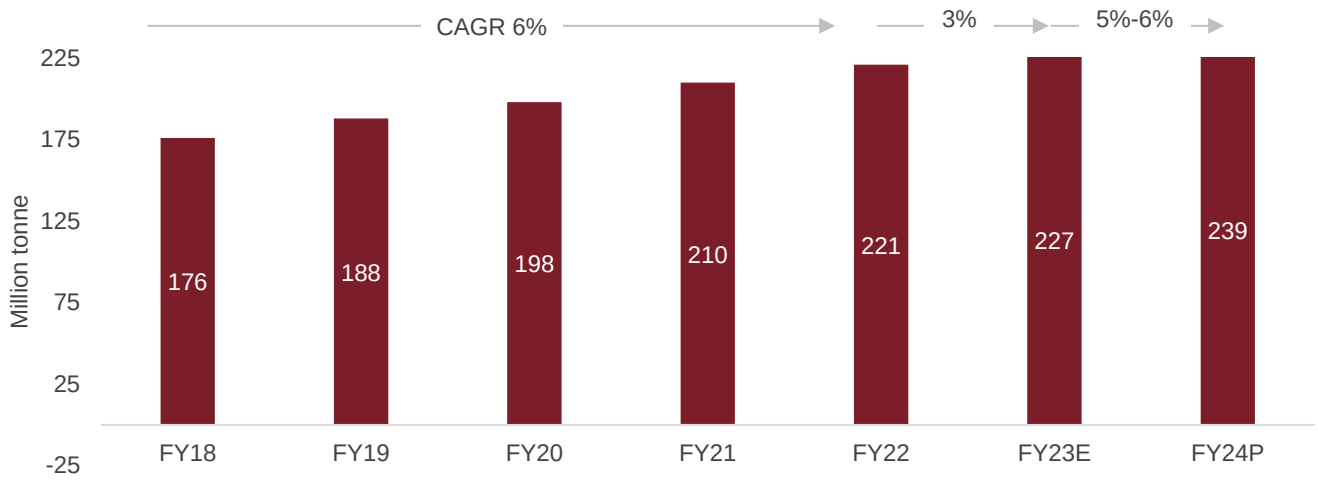
Also, private players are expected to increase their capital investment, which will help them wrest market share from unorganised players. The presence of cooperatives is the highest in Gujarat across the value chain, with the

Gujarat Co-operative Milk Marketing Federation (owner of the Amul brand) alone enjoying a whopping market share of 90-95% at the retail level. It procures 85-90% of milk available for marketing in the state.

Co-operatives have upper hand in milk procurement owing to subsidies in a few states. Milk co-operatives in the country have a strong procurement and storage capacity with a wide network of collection and chilling centres at the village level. They also have vehicles that travel door to door across many villages to collect milk. Also, a few state governments such as Karnataka, Telangana, and Haryana offer subsidies of Rs 3-5 per litre to farmers for supplying milk to co-operatives. Hence, they enjoy an upper hand in milk procurement, especially in these states.

On the other hand, private players are investing heavily to strengthen their procurement and distribution network by setting up chilling centres at the village level and building relations with farmers. With the government allocating Rs. 150 billion to incentivise private dairy processing, select states where private players have a strong hold are expected to benefit.

Review and outlook of milk production growth (FY18-FY24P)



Source: NDDB, industry, CRISIL MI&A

5.11 Review and outlook of the Indian ceramic tiles industry

5.11.1 Review and outlook of the Indian ceramic tiles industry (FY2018 – FY2024P)

The ceramics industry majorly uses natural gas in the ceramic production process. The ceramic industry is broadly classified under ceramic tiles, glazed vitrified tiles and polished vitrified tiles. Ceramic tiles are used in residential and commercial spaces, primarily for flooring purposes. They are also used for covering walls. The ceramic tiles industry is classified under ceramic and vitrified tiles, and further divided into glazed vitrified and polished vitrified tiles. It is marked by intense competition, due to large presence of the unorganised sector and availability of cheaper Chinese imports.

Ceramic tiles are manufactured by both large players, and small and medium enterprises, with wide variance in type, size, quality and standard. In terms of production, India ranks third in the world in the ceramic tiles and sanitaryware sector.

Lower-end ceramic tiles face competition from mosaic tiles, whereas the higher-end polished and glazed vitrified tiles face competition from marble flooring.

The Morbi region in western Gujarat is the largest manufacturing hub of ceramic tiles in the country. With over 600 unorganised players along with several joint ventures (JVs) of large players such as Kajaria and H&R Johnson, this region accounts for 80% of India's total ceramic production. This cluster and the adjoining areas are rich in red soil - a basic raw material needed for manufacturing China clay. Other raw materials such as quartz (source of silica) and feldspar are also available, else transported from Rajasthan.

Organised players have outpaced unorganised smaller players over the past few fiscals and hold over 50% market share in value terms since fiscal 2019. Larger players would continue to wrest more market share from smaller players on the back of a higher degree of innovation, wider product range, better distribution network, premiumisation and greater spending on advertising and marketing initiatives. NGT ban on coal gasifier starting April 2019, along with stricter implementation of E-way bill regulations have helped large players to increase their market share so far.

Liquidity issues due to the NBFC crisis was in the favour of organised players further. As builders faced liquidity issues, receivable days for tile players spiked. Organised players with better liquidity positions were able to operate freely, while SME players were stretched in meeting their working capital needs.

In fiscal 2021, the domestic industry witnessed a 15-20% contraction in volume as well as revenue, while the organised segment largely defended any contraction in volume or value and gained market share. This is also partially attributed to significant rise in exports demand across the globe post imposition of anti-dumping duty on China by the US and China's focus on less carbon footprint from polluting industries such as ceramic tiles, which led to unorganised players focusing only on exports.

Further, continued widening of the dealership network with net dealer addition, as well as rapid penetration into tier 3/4/5 markets and rural markets by organised players left little room for unorganised players in the domestic market.

In fiscal 2022 as well, while the overall market is estimated to have reached its pre-pandemic levels in volume and value terms, organised players are further strengthened their position in the domestic market at the cost of unorganised set following expansion of distribution network, better product offerings and higher brand recall.

Going forward, in fiscal2024, we expect the domestic market to continue to witness rising dominance of organised players as lucrative export opportunities (due to subdued exports from China and tapping into new markets by Indian exporters) in the international markets continue to keep unorganised players engaged in those segments.

Slew of capacity additions expected by fiscal 2023; key organised players eyeing premium segments, unorganised players to add capacities in wall and floor segments.

Over the past few years, financials of unorganised players had remained moderate; several players had been under financial stress. This provided large players an opportunity to acquire plants at attractive valuations. The average cost of acquisition is significantly lower at Rs 70-75 million per million square metres (msm), as compared to the cost of setting up a greenfield / brownfield plant. This has led to several joint ventures between large players such as Kajaria, Somany and HR Johnson with small players located in Morbi, Gujarat. The main objective of entering into joint ventures is to add capacity without the gestation period at low cost. It also helps the players expand their footprint. Over a period of time, JVs have become the backbone of capacity expansion, in fact, JVs and contract manufacturing accounted for ~52% of the sales of these players in fiscal 2021 and fiscal 2022.

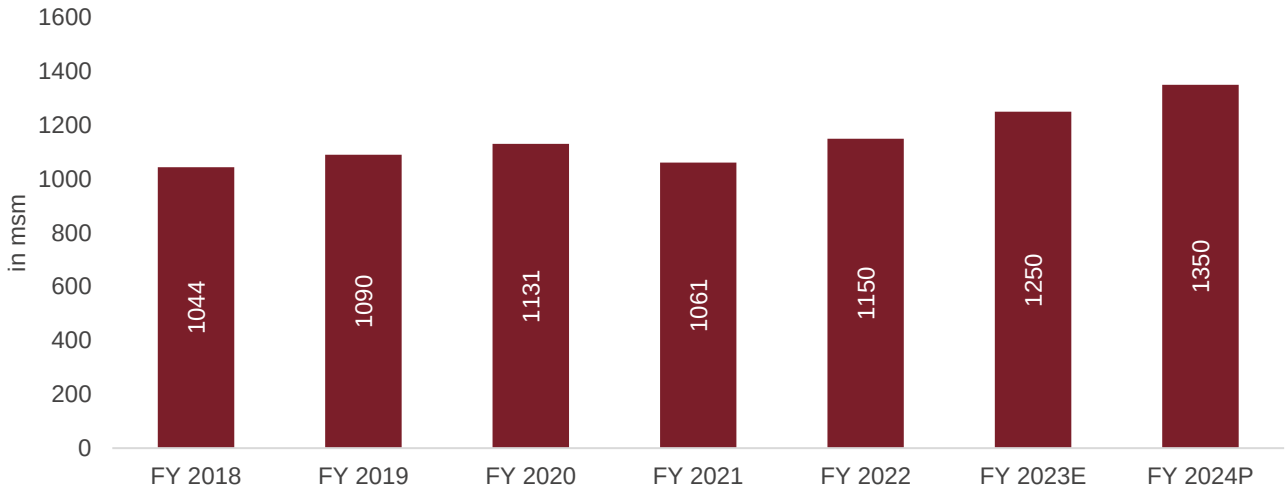
In fiscal 2021, large companies such as Kajaria, Somany and Asian Granito announced their capex plans and new capacity augmentation would come into effect in end-fiscal 2022 or early fiscal 2023. Kajaria and Somany are

together expected to add up to 24-25 MSM of capacity over the next 2-3 quarters, a combination of both greenfield as well as brownfield expansion. The enhanced capacity additions are set to take place in premium segments such as GVT and PVT.

This capacity expansion and consequent higher sales volumes shall lead to these players further strengthening their hold in the industry. Stronger brand equity, better distribution network, and higher awareness owing to more ad spending are expected to aid major brands in registering robust growth going forward. Also, organised players mostly cater to the faster-growing segments - vitrified and polished tiles - which will also help them grow faster in value terms and provide increased profitability.

The unorganised segment, on the other hand, had refrained from making any significant capex plans and capacity expansion over the past few fiscals. However, with unprecedented growth in the export markets and favourable near-to-medium term dynamics, the unorganised segment has also announced capacity expansion plans. The segment is likely to add more than 50 new plants with an estimated aggregate capacity of over 125 MSM of ceramic tiles (floor and wall). These plants are likely to be export-oriented plants and are expected to be commissioned by fiscal 2023.

Trend in ceramic tiles production (FY2018 – FY2024P)



E: Estimated; P: Projected
Source: Industry, CRISIL MI&A

Domestic demand outlook

The market size of the Indian ceramic tile industry (domestic consumption) is estimated at Rs 280-300 billion for the fiscal 2023. The organised segment accounts for more than ~65% of the total market in value terms, largely because of significant market share gains from the unorganised players post the pandemic.. According to CRISIL MI&A overall industry volumes are expected to see ~4% growth in fiscal 2023, value growth seen at ~14% amid increase in realisations as players partially pass on increase in input costs. In fiscal 2024, the Indian ceramic tiles industry is expected to grow at 4% in terms of value and 14% in terms of volume largely driven by demand from the domestic segment. The organised segment is expected to witness a growth of 16-19% in value terms in the domestic market in fiscal 2023. The organised set witnessed a ~22% increase in sales volumes of ceramic tiles and ~28% increase in value terms in fiscal 2022 on-year basis. This healthy performance was also attributed to widening of dealership network, penetration into tier 3/4/5 markets, introduction of a few new products and low base of fiscal 2021 etc.

After posting a sharp de-growth of ~18% in demand over one year i.e., fiscal 2021, due to the pandemic-induced lockdown and demand disruption in the domestic market, the ceramic tiles industry is estimated to exhibit a healthy recovery and growth of ~15% in fiscal 2022, largely on a low base of last fiscal and resumption of real estate project completions and is expected to rise by 6-9% in volume terms in fiscal 2023 and reach 750-780 MSM and breach pre-pandemic levels of fiscal 2020. Pent up demand from the construction segment and replacement demand to drive domestic demand in fiscal 2023, value to grow by ~10-14% to exceed fiscal 2020 levels.

The volume growth will largely be led by a strong rebound in real estate construction activities as well as real estate sales across key states and cities. States such as Maharashtra, Karnataka and Gujarat have shown a faster-than-envisaged rebound in home sales and completions, thereby leading to higher demand for ceramic tiles. Due to increased affordability following multi-year low interest rates, demand in the real estate sector witnessed a strong revival. Consequently, demand for tiles started gaining momentum. In fiscal 2022, we estimate real estate completions upward of around 320-325 million sq. ft as they got deferred by a year owing to the pandemic. Furthermore, replacement or renovation demand is estimated to continue its upward trajectory in fiscal 2022 as continued work from home in the services sector continues to drive overall demand for tiles.

Also, construction and completion of PMAY Urban units remained buoyant during the period as the government focused on completing the programme before the stipulated timeline. This also partially supported demand recovery in the second half of the fiscal.

Demand from the commercial segment remained moderately healthy as transaction and leasing activities increased moderately through the first half of fiscal 2022. Also, within the commercial segment, co-working or flexi working space gained momentum. Incremental demand from tier 2/3/4 cities as well revived strongly as some portion of the urban workforce chose to work from their hometown and the segment which lived in rented apartments took the advantage of increased affordability to buy a house in fiscal 2022.

A gradual recovery in the macroeconomic environment as well as higher penetration and usage of tile products is likely to bode well for the sector. As a result, CRISIL MI&A expects the demand for ceramic tiles to increase by 6-9% y-o-y in volume terms to reach close to 750-770 MSM and breach pre-Covid-19levels in fiscal 2023.

With normalcy returning in the near to medium term i.e., fiscals 2023 and 2024, gradual recovery in economic activities, and the PMAY Urban programme reaching the deadline for completion, growth in volumes and value growth are expected to remain firm. As a result, we expect demand for ceramic tiles in India (volume) to grow at 8-10% in fiscal 2024 respectively. Furthermore, low penetration of tiles as an application in India and expected increased propensity to spend on home improvements shall continue to drive growth, going forward. Also, a gradual favourable product mix change i.e., shift to higher value PVT & GVT segments will ensure value growth outpaces volume growth.

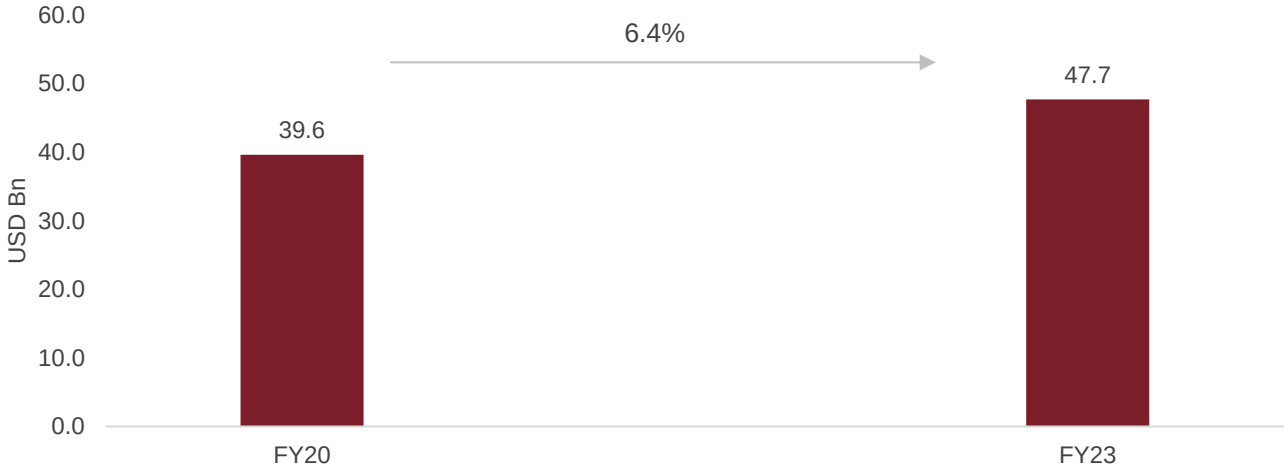
5.12 Review and outlook of the Indian pharmaceutical industry

A wide range of cryogenic gases are required by the pharmaceutical industry. These could be used in the synthesis of and producing chemicals used in drugs, sterilisation, and preservation of products by driving out oxygen and moisture that would otherwise reduce the quality of the product in storage or transit.

5.12.1 Review of the Indian pharmaceutical industry (FY2020 – FY2023)

Historical production (FY2020 – FY2023)

Market size of the Indian pharmaceutical industry (FY2020 – FY2023)



Source: Industry, CRISIL MI&A
Note: USD INR exchange rate assumed to be 79 in FY2023

Domestic market has shown a high growth of ~15% in fiscal 2022 over a low base of fiscal 2021. Demand for anti-infective and other Covid related drugs helped the industry growth fiscal 2021 and 2022. The domestic market is expected to grow 8-10% in fiscal 2024 over a base of ~9% growth during the fiscal 2023. Growth will be driven by a rise in prices, while volume is likely to remain moderate this fiscal. Exports have grown at ~8% CAGR between fiscal 2017 and fiscal 2022. For fiscal 2022, India's exports were flat on a high base of fiscal 2021. The export market is projected to grow 8-10% (in rupee terms) this fiscal after recording a healthy growth of ~11% in the fiscal 2023. Growth is likely to be driven by new product launches, entry into products having low competition and diversification into untapped markets. Formulation exports grew by ~10% during fiscal 2023 after witnessing a high base-led flat growth during fiscal 2022. The pharma industry continued to witness pricing pressure in the US, the main export market, during fiscal 2022 and fiscal 2023. However, strong exports to European market helped offset this to an extent.

Exports have been the cornerstone of growth of the Indian pharmaceutical industry, with the global market offering strong opportunities. Healthcare expenditure is spiralling the world over, with developed markets in the US and Europe seeing the steepest rise. These markets traditionally contribute the largest share to global medicine sales. Given India's strengths of cost-competitiveness and advanced process chemistry skills, domestic players are well-placed to tap into this opportunity and increase their presence in the generics market.

Renewed regulatory interest a positive for the sector

The recent supply disruption in the wake of the pandemic has resulted in the government taking proactive steps to boost domestic manufacturing and bring down costs. A regulatory boost, along with strong process chemistry skills, will continue to help the Indian bulk drugs industry garner a big share of the global bulk drug exports pie. We expect growth to pick up in the coming years on account of product diversification and increased global demand.

The Union Cabinet, on March 21, 2020, approved the below schemes for the development of the Indian bulk drug sector.

Scheme	Salient features
Production-linked incentive scheme	• Tenure of scheme – Fiscal 2021 to fiscal 2030 • Financial outlay – Rs 69 billion • Applicable for greenfield projects • Financial incentive to be provided for 41 identified key products, which cover all 53 identified active pharmaceutical ingredients (APIs) • The net worth of the applicant (including that of group companies), as on the date of application, should not be less than 30% of the total proposed investment • Maximum number of selected applicants – 136 • The incentive under the scheme will be applicable to domestic manufacturers only on the sales of the eligible product
Creation of bulk drug parks	• Tenure of the scheme – Fiscal 2021 to fiscal 2025 • Financial outlay – Rs 30 billion • Three bulk drug parks will be supported under the scheme • Maximum grant-in-aid for one bulk drug park will be limited to Rs 10 billion • Minimum 50% of land area for bulk drug manufacturing units • Three states to be selected through challenge method

Source: PIB

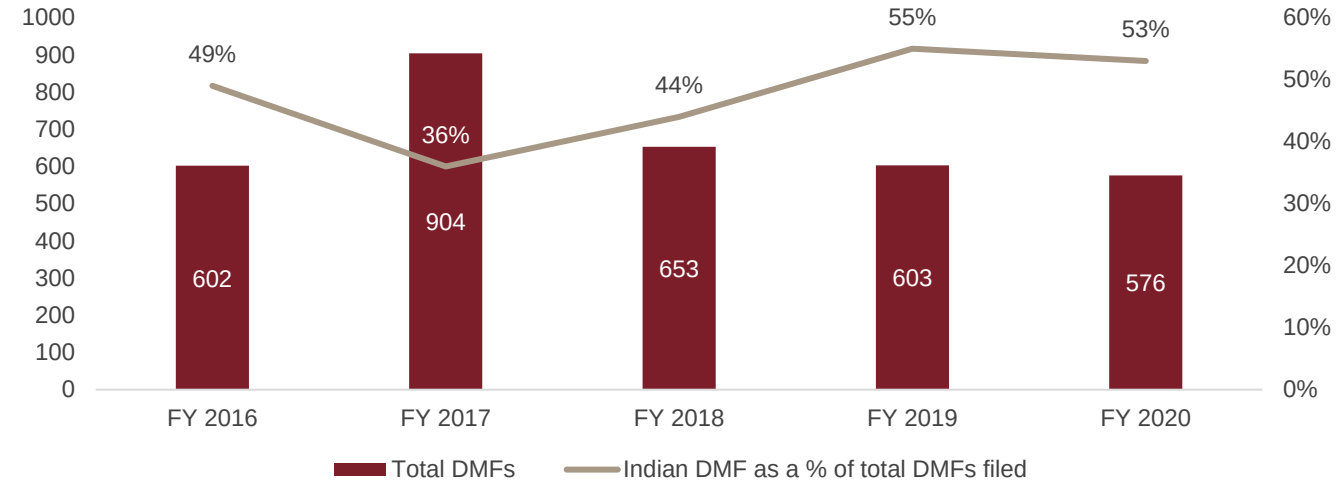
Indian pharma companies are largely clustered in Maharashtra, Gujarat and Andhra Pradesh. However, after the government imposed a maximum retail price-based excise duty system in 2005, many players shifted their manufacturing bases to excise-free zones such as Baddi (Himachal Pradesh), Haridwar (Uttaranchal) and Sikkim.

Unlike commodities, capacity expansion in the domestic pharmaceutical industry does not bunch up due to a low capital-intensity and gestation period. Hence, companies expand capacities in line with demand patterns. Setting up a US Food and Drug Administration (FDA)-approved formulations manufacturing plant costs more than that required for an unapproved facility. Units compliant only to the GMP (good manufacturing practices) have a shorter gestation period. The average gestation period for a US FDA-approved manufacturing facility is 18-24 months compared with 6-12 months for other facilities.

India has the highest number of US FDA-approved facilities outside the US. The country also has skilled manpower and advanced process chemistry skills. Some bulk drug manufacturers have forward integrated into pre-formulations (pelletisation/ granularisation of bulk drugs before they are converted into finished dosages) as well.

Though China is a major destination for bulk drug manufacturing, it has a major share primarily in the manufacturing of bulk drug intermediates. India has consistently maintained its leadership in drug master file (DMF) submissions. This proves the capability of Indian players to meet required export quality standards for regulated markets. A DMF is an indicator of the bulk drug manufacturing capabilities of players (in terms of quality standards maintained at their facilities for processing, packaging, storage of drugs, etc.), which is used by global pharmaceutical companies that are outsourcing production activities (innovators).

Review of DMFs (FY2016 – FY2020)

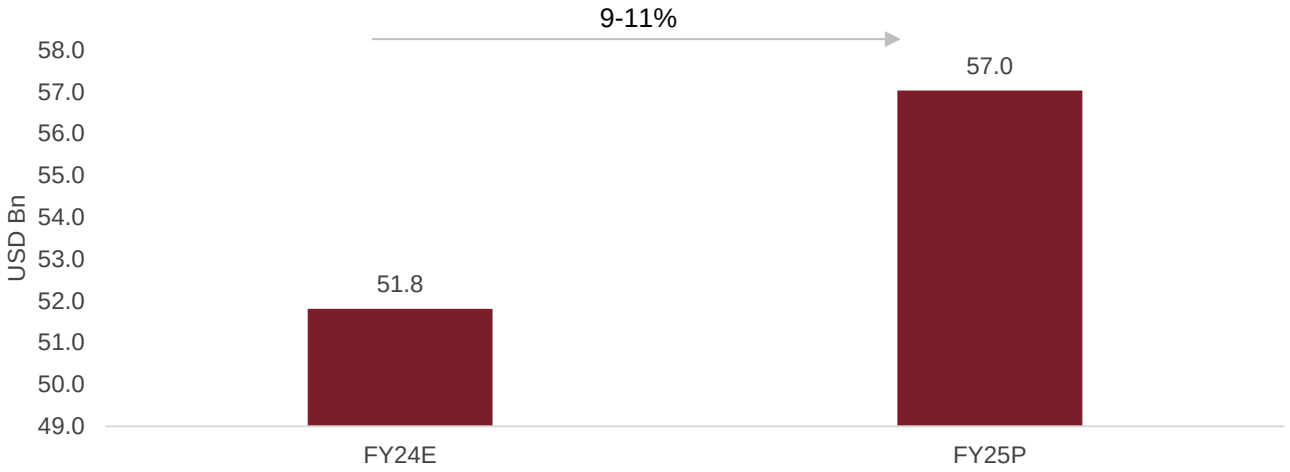


E: Expected
Source: USFDA, CRISIL MI&A

India is considerably ahead of its competitors in terms of the total number of DMFs.

5.12.2 Outlook of Indian pharmaceutical industry (FY2024 – FY2025P)

Outlook of the market size of the Indian pharmaceutical industry (FY2024E – FY2025P)



Note: USDINR exchange rate assumed to be 79 in FY24 and FY25
E: Estimate; P: Projected
Source: Industry, CRISIL MI&A

The India pharmaceutical industry has shown a high growth of ~15% in fiscal 2022 over a low base of fiscal 2021. High growth in the H1 fiscal 2022 due to high demand for the Covid related drugs like anti-infective and vitamins. Going forward, the industry is expected to grow at 9-11% between FY2024 and FY2025.

Focus on niche and specialty products to aid growth

Indian pharma players have a healthy pipeline of complex generics and limited competition products, which are difficult to manufacture but command a higher premium. The pricing pressure is also expected to normalise in regulated markets in the coming years.

Further, the supply disruption from China is expected to aid business opportunities for bulk drug players in the global market. Also, recent quality issues related to Chinese APIs have slightly dented the country's image globally, which would in turn boost business for India, the next largest and cost-effective API supplier after China. Some multinational corporations (MNCs) are looking at alternative sources for bulk drug procurement following Chinese issues.

Outsourcing of bulk drugs from MNCs to continue

In view of high operating expenses, CRISIL MI&A believes MNCs will look at bulk drug outsourcing to control cost and improve profitability. Margins of global innovator players dipped substantially from 2015 to 2018. Going ahead as well, MNCs are likely to continue outsourcing bulk drugs manufacturing to India.

Major players look to improve capacities to reduce China dependence

Players such as Aurobindo, Divis Labs, and Aarti Industries are looking at expanding their API capacities with an aim to reduce dependence on China.

Recent supply and quality issues in China have resulted in disruptions. Indian players are now looking at capitalising the opportunity as even some global MNCs are moving away from China as they consider alternate sourcing of APIs.

- Aurobindo has invested Rs 5 billion in setting up a Penicillin G (Pen G) plant in Andhra Pradesh, with an overall project cost of Rs 20 billion
- Aarti Industries had announced a capex plan of Rs 30 billion over the next two years to increase market share and diversify its product portfolio.
- Divis Laboratories has invested Rs 25 billion in capex since FY18. the company announced new capex at Kakinada, with an investment of Rs 6 billion to be spread over 2–3 years. Apart from this, the company has several other investments in line.
- Aarti Drugs has guided for a capex in the range of Rs 10-12 billion annually for next couple of years. The new production-linked incentive scheme announced by government will also see new greenfield projects coming up, which will boost bulk drug production in the country.

However, dependence on Chinese imports (key starting materials / intermediates) is likely to continue. This is because unless the government provides continued support in the form of infrastructure and tax subsidies, it would be difficult for Indian players to match the manufacturing costs of Chinese counterparts.

5.13 Review and outlook of the Indian hospitals and healthcare delivery industry

Apart from pharmaceuticals, cryogenic gases also have applications in medical procedures such as medical oxygen for respiration, liquid nitrogen used in cauterisation, helium can be used as a mixture with pure oxygen for respiration, etc. As healthcare facilities improve, demand for cryogenic gases in medical/ pharmaceutical

applications will also increase. Use of any product in healthcare applications have more stringent norms over and above regular safety norms. Similarly, gases and equipment used in health care applications are also required to adhere to higher safety standards.

5.13.1 Review of the Indian hospitals and healthcare delivery industry (FY2018 – FY2023)

The hospitals sector is capital intensive owing to high per bed cost. Hospitals mainly incur capital expenditure on land and equipment. The capital cost to build a hospital is typically Rs 8-10 million per bed (excluding land cost) for a tertiary care super-specialty hospital, whereas the cost for secondary-care hospitals is lower. High technology and equipment cost keeps the total capital cost of super-specialty tertiary care hospitals at the higher end. The use of imported equipment can further drive equipment cost up. The ratio of beds to individuals in India is, thus, still a meagre 14 beds per 10,000 people (as against a global median of 29).

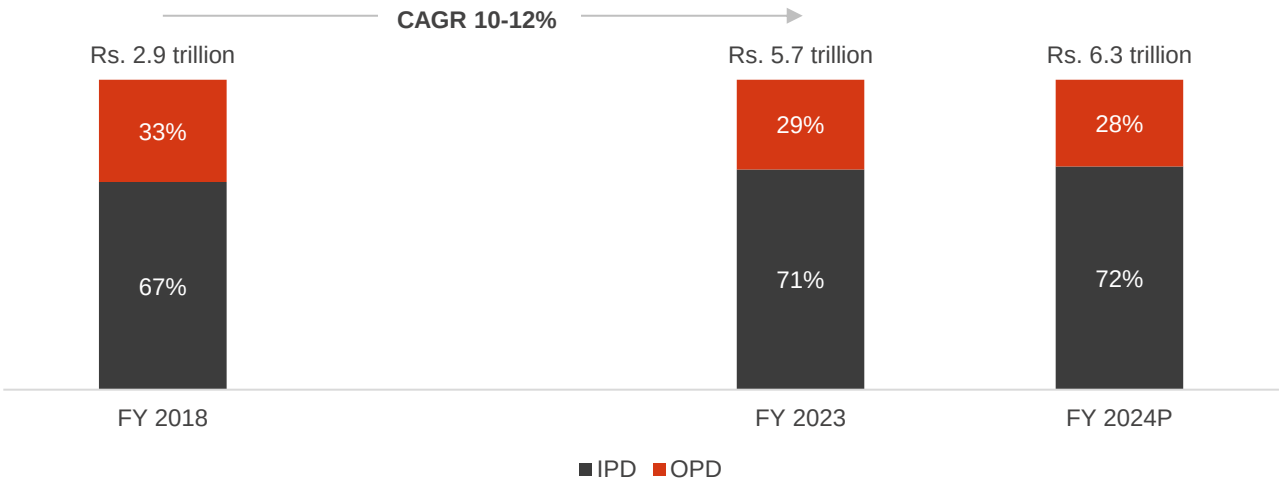
Hospitals are also highly labour-intensive. They require skilled manpower such as doctors, nurses and para-medical staff comprising lab technicians, radiologists, and therapists. While India has a large medical workforce, the country has just ~7.4 physicians per 10,000 people (as against a global median of 16) and 18 nurses and midwives per 10,000 (as against the global median value of 40).

In India, healthcare services are provided by the government and private players, and these entities provide both in-patient department (IPD) and out-patient department (OPD) services. However, the provision of healthcare services in India is skewed towards the private players (both for IPD and OPD). This is mainly due to the lack of healthcare spending by the government and the high burden on the existing state health infrastructure.

CRISIL MI&A estimates the healthcare delivery industry size at around Rs 5.7 trillion in fiscal 2023 and around Rs 6 - 6.5 trillion in fiscal 2024.. This includes both inpatient treatments forming almost 70% in value share and outpatient consultations contributing the rest 30%. In fiscal 2023, while government’s share is estimated at 30-32%, private sector is expected to contribute the lion’s share at 68-70%. Within the private sector, large hospitals form only 25-35% of the industry with the rest of the market dominated by small and medium hospitals, clearly indicating the fragmented nature of the industry. During the last three years the industry had grown at a CAGR of 10-12%, with major contribution from structural factors like improving penetration of healthcare insurance, increasing incidence of non-communicable diseases, increasing urbanization & awareness, booming medical tourism, etc. Going forward, too, these favourable socioeconomic demographics are expected to continue. However, tailwinds in the form of focused expansion of large corporates with adjusted business models in tier-II locations and demand impetus on account of Ayushman Bharat are expected to aid momentum, leading to an industry growth of 13-14% over the medium term.

In terms of supply creation, major hospital chains are now looking at brownfield expansion at existing facilities and have also expanded into the next level of creamy Tier-2 and -3 locations (with ~70% aggregate bed additions in these areas by the 10 largest hospital players in the past four years). Given the significantly lower revenue per bed in these locations, players had to adjust their business models such as a hub and spoke model of operation, tight control on operating costs with a no-frills model, etc. But a common observation has been that players with focus on limited specialties have been able to remain region agnostic in terms of locational impact on returns and margins.

Review of healthcare delivery market (FY2018 – FY2023)



P: Projected
Source: CRISIL MI&A

Over the past four years, major hospital chains have added supply (~70% of their incremental supply during the period) in tier II and III locations, to create a referral network into their main centre by tapping into the underserved creamy tier II areas. The government is also expected to augment this via a scheme in the pipeline (PM Atmanirbhar Swasth Bharat) for strengthening primary, secondary and tertiary healthcare infrastructure in the country.

Structural factors such as an increase in lifestyle-related ailments, increasing medical tourism and changing demography, etc. are expected to contribute to demand. Also, growth in household incomes, and consequently, disposable incomes, is critical to the overall growth in demand for healthcare delivery services in India. The share of households falling in the income bracket above Rs. 0.2 million is expected to have gone up to 35% in fiscal 2022 from 23% in fiscal 2017, providing potential target segment (with more paying capacity) for hospitals.

5.13.2 Outlook on Indian hospitals and healthcare industry (FY2023 – FY2027P)

Robust growth is expected in fiscal 2023 as the underlying fundamental growth factors remain strong. Regular demand drivers such as OPD, elective surgeries and regular treatments stabilise and demand drivers such as high realisation from the medical tourism business picks up as international travel restarts gradually. Margins are expected to remain rangebound as compared to the previous fiscal. With long term structural factors supporting growth, renewed impetus from PMJAY and government focus shifting onto healthcare sector, the healthcare delivery market is expected to grow at 9-11% compounded annual growth rate (CAGR) and reach Rs 8.4 trillion in fiscal 2027.

Outlook on healthcare delivery market (FY2024P - FY2027P)

Source: CRISIL MI&A

Factors affecting demand

A combination of economic and demographic factors is expected to drive healthcare demand in the country. CRISIL MI&A believes that the PMJAY scheme launched by the government would be an addition to these drivers.

With improving life expectancy and changing demographic profile, healthcare services is a must

India lags behind the global benchmarks in healthcare infrastructure, both in terms of physical infrastructure as well as personnel. However, the picture is bleak even on the healthcare indicators front. With the Indian population expected to grow to ~1.4 billion by 2026, the need to ensure healthcare services to this vast populace is an imperative. But this also provides a big opportunity to expand into a space that bears huge potential.

Rising income levels to make quality healthcare services more affordable

Growth in household incomes, and consequently, disposable incomes is critical to the overall growth in demand for healthcare delivery services in India. The share of households falling in the income bracket above Rs. 0.2 million is expected to have gone up to 35% in fiscal 2022 from 23% in fiscal 2017, providing a potential target segment (with more paying capacity) for hospitals.

Increasing health awareness to boost hospitalisation rate

Majority of the healthcare enterprises in India are more concentrated in the urban areas. With increasing urbanisation (migration of population from rural to urban areas), awareness amongst the general populace regarding presence and availability of healthcare services for both preventive and curative care would increase.

CRISIL MI&A, therefore, believes that the hospitalisation rate for in-patient treatment as well as walk-in out-patients will improve with increased urbanisation and rising literacy.

Government policies to improve healthcare coverage

The government has kept its healthcare budget flat in fiscal 2023 at Rs 1,02,547 crore from Rs. 1,02,294 crore in fiscal 2022and fiscal 2022 is more for Covid-related expenditure (emergency aid and vaccination drive). Nonetheless, the focus seems to shift from curative aspect to preventive health and well-being under the ambit of

holistic healthcare. The long-term goal is to raise its healthcare spending to 2.5% of GDP by 2025 under the National Health Policy 2017 from the current 1.3% of the GDP.

Pradhan Mantri Jan Arogya Yojana (PMJAY)

With the intention of providing affordable healthcare, the Pradhan Mantri Jan Arogya Yojana (PMJAY) was launched on September 23, 2018. The scheme primarily has three objectives -

Upgrading sub-centres under physical health infrastructure: Upgradation of 0.15 million 'Health and Wellness' centres to provide comprehensive healthcare, including coverage of non-communicable diseases and maternal and child health services. These centres would also provide essential medicines and diagnostic services free of cost. Inclusion of new ailments under the ambit of the scheme would go a long way in ensuring focus on preventive care as opposed to only curative care. A strong referral network is vital in providing a continuum of care.

Strengthening government hospitals under physical health infrastructure: Setting up 24 new government hospitals and medical colleges and upgrading existing district hospitals. The intention is to have at least one medical college for three parliamentary constituencies. The government already has a scheme in place - Pradhan Mantri Swasthya Suraksha Yojana (PMSSY) to correct the geographical imbalance in the availability of tertiary healthcare. Six AIIMs, each at Patna (Bihar), Raipur (Chhattisgarh), Bhopal (Madhya Pradesh), Bhubaneswar (Odisha), Jodhpur (Rajasthan) and Rishikesh (Uttarakhand) have been set up and 16 new ones announced by the government are under various stages of construction and are expected to be operational by fiscal 2025. Tackling issues of inadequate physical and personnel infrastructure is targeted via this objective.

Expansion of health insurance coverage - Ayushman Bharat: Provision of Rs. 0.5 million assured healthcare coverage to each family that is eligible, selected based on inclusion under the Socio-Economic Caste Census (SECC) list. Nearly 107.4 million families will be covered under the scheme. All existing central and state health insurance schemes will be subsumed under Ayushman Bharat. However, the model of the scheme to be implemented (via insurance company, trust or mixed model) is the prerogative of the states.

However, healthcare delivery at affordable prices would require a shift in focus towards capitalising on the volumes (with nearly 1,65 million new people coming under a healthcare scheme) rather than on value (via margins). The government has started an initiative of National Digital Health Mission on the lines of the proposed National Health Stack (NHS). A shared digital framework for both private and public hospitals, it is expected to digitalise all health records and keep track of all details pertaining to healthcare enterprises in the country. The scheme holds huge potential for healthcare delivery and allied industries but the mechanism for quality control and monitoring along with raising resources for implementation will be a key monitorable.

Non-communicable diseases: A silent killer

As opposed to the decreasing rate in communicable diseases, lifestyle-related illnesses or non-communicable diseases (NCDs) have been increasing rapidly in India over the last few years. The contribution of NCDs to the disease profile has risen from 30% in 1990 to 55% in 2016. Statistics show that these illnesses accounted for nearly 62% of all deaths in India in 2016. As per the World Economic Forum, the world will lose nearly 30 trillion USD by 2030 for NCD treatments and India's burden from this will be $5.4 trillion.

Growing health insurance penetration to propel demand

With health insurance coverage in India set to increase, hospitalisation rates are likely to go up. In addition, health check-ups, which form a mandatory part of health insurance coverage, are also expected to increase, boosting the demand for a robust healthcare delivery platform.

5.14 Review and outlook of the Indian paper industry

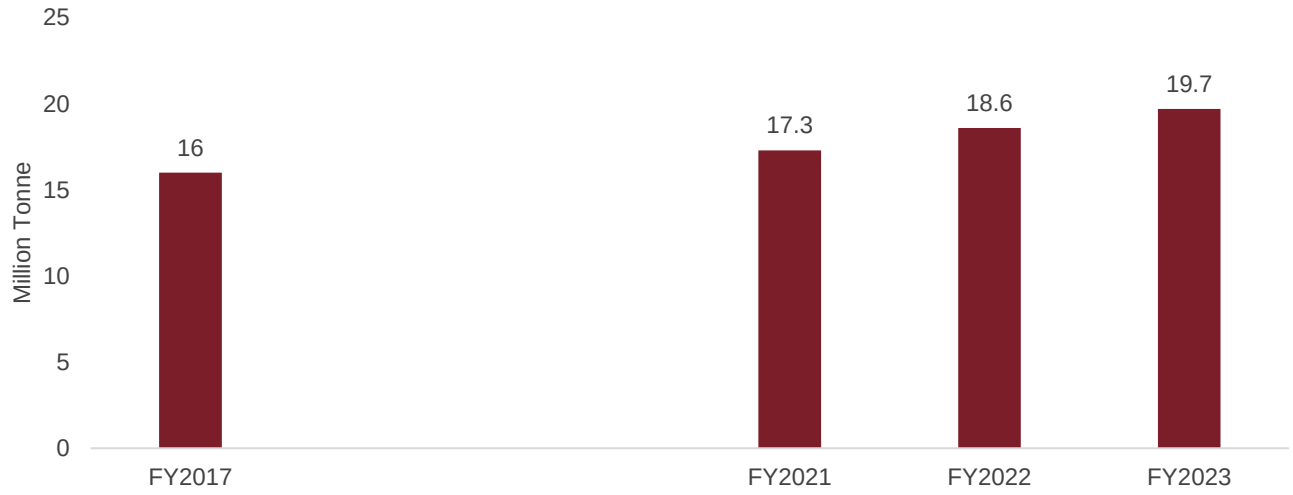
The paper industry requires steam in the production process which uses natural gas.

5.14.1 Review of the domestic paper industry (FY2017 – FY2023)

The paper industry is categorised into writing and printing (W&P), paperboard and newsprint, of which, paperboard accounts for the largest share of the market in volume terms, while W&P is the largest segment in value terms. This industry is highly fragmented. Wood-based pulp, wastepaper and agri-residues are the main raw materials used to manufacture paper. Domestic wood supply is inadequate compared to demand, and the wastepaper recovery mechanism is not very robust. Inadequate raw material availability remains a constraint for the paper industry.

CRISIL MI&A expects paper demand to grow moderately in fiscal 20243 after witnessing a revival in fiscal 2023. The paperboard segment is expected to drive demand in the near and long term due to healthy demand from end-use industries. W&P paper demand is expected to witness a sharp growth in fiscal 2024 as schools, colleges and office spaces are being opened up. The paper and paperboard (including newsprint) demand is estimated to grow by 5-7% on-year in fiscal 2024, after a rise of 6-8% in fiscal 2022. In fiscal 2023, Segment-wise, W&P segment posted a moderate growth of 3-5% on-year post recovery in the previous fiscal. Whereas the paperboard segment Is estimated to grow by a robust 6-8% growth rate (FY24-26) on back of healthy demand from the end use industries. The newsprint segment witnessed a de-growth of (0-5) % in fiscal 2023 after witnessing a steep 18-20% rise in fiscal 2022. Specialty paper is estimated to grow at a healthy pace of 13-15% (FY24-26). .

Trend in domestic consumption of paper (FY2017 - FY2023)



E: Estimate
Source: Industry, CRISIL MI&A

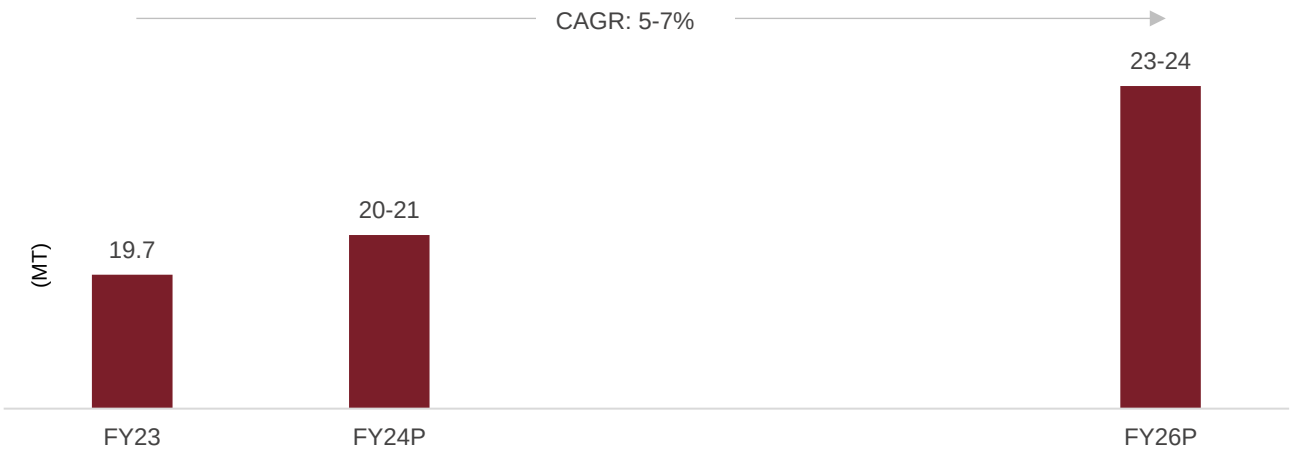
Domestic paper demand (including newsprint) is estimated to reach 20.0-21 million tonnes in fiscal 2024. The expansion was on the back of increased industrial activity and corporate spending on office stationery and

advertisements following improving economic growth. The newsprint segment continues to drag down overall demand due to decline in English paper circulation on account of shift towards digitised versions of newspapers with proliferation of digitisation and smartphones. Even though the domestic W&P segment demand witnessed moderate demand in the fiscal, healthy exports demand is likely to have driven player utilisation. Paperboard players are likely to continue to operate at higher levels due to strong demand recovery from end-use industries. In fiscal 2023, utilisation levels fell to 81-83% with healthy demand and muted capacity additions.. Even though the domestic W&P segment demand witnessed moderate demand in the fiscal, healthy exports demand is likely to have driven player utilisation. Paperboard players are likely to continue to operate at higher levels due to strong demand recovery from end-use industries. Going forward, over fiscals 2023 to 2026, we expect capacity utilisation to pick up to 91-93% in the paper and paperboard segment, and the newsprint segment to witness utilisation levels of 95-98% as a result of falling capacities..

5.14.2 Outlook on the domestic paper industry (FY2023 – FY2026)

We expect demand to recover and grow at a healthy two-year CAGR (FY24-FY26) of 4-6% to ~21-23 million tonne by fiscal 2026 driven by paperboard demand.. Demand will be led by healthy growth in paperboard volume, which is expected to clock 6-8% CAGR over fiscal 2024 to fiscal 2026. This growth would be driven by increased volumes in end-user segments such as household appliances, fast-moving consumer goods (FMCG), ready-made garments, pharmaceuticals, e-commerce, etc. W&P demand is expected to increase at a modest 2-4% CAGR over fiscal 2024 to fiscal 2026, compared to growth of 3-5% over fiscal 2021 to fiscal 2024., on account of steep demand fall owing to pandemic due to closure of educational institutes & offices. Specialty paper (majorly tissue and thermal paper) is expected to continue to log a robust 13-15% CAGR over fiscal 2024 to fiscal 2026..

Outlook on domestic paper consumption (FY2023 – FY2026P)



E: Expected; P: Projected
Source: Industry, CRISIL MI&A

CRISIL MI&A expects paper and paperboard capacity to by 0.5-1.5 million tonne (MT) by fiscal 2026. Key organised players (Best paper, TNPL, West Coast Paper Mill, Nepa, Seshasayee Paper and Boards and Yash Pakka Ltd) are expected to add an aggregate of 1-2 MT of capacities over the next five years in the paper and paperboard segment. On account of a sudden plunge in the demand environment in fiscal 2021, some players deferred or postponed their capacity additions. Emami Paper deferred setting up of 0.225 MT of paperboard

capacity in fiscal 2021, and Ruchira Papers also went slow on expansion in the fiscal. However, small players are expected to increase kraft paper capacity on the back of strong demand expectation.

Within the paper segment, we expect paperboard and specialty to witness healthier growth compared with other segments, and capacity additions in the paperboard segment are expected to rise through fiscal 2027 due to healthy demand prospects, largely from unorganised players. Moreover, capacity additions in the paperboard segment will be driven by its lower capital intensity and non-requirement of technical expertise.

Along with capacity additions, consolidation in the domestic paper industry has gained traction over the past 2-3 years, with around five cases with stressed liability of about Rs 8.6 billion being resolved under the Insolvency and Bankruptcy Code, 2016. The recovery amount was about Rs 4.3 billion, resulting in a 50% haircut by financial and operational creditors. Further, four cases are awaiting resolution approval by the National Company Law Tribunal. Additionally, West Coast Paper acquired majority controlling stake in International Paper APPM. Mergers and acquisitions among domestic players are expected to result in higher competition and smooth backward integration for raw materials.

5.15 Review and outlook of the Indian glass industry

Glass manufacturing is an energy intensive process which uses natural gas as an energy source.

5.15.1 Review and outlook

Glass is an inorganic product produced by melting a mixture of silica sand, soda ash, limestone and other ingredients by heating the mixture at a very high temperatures and followed by gradual cooling. The glass industry comprises four key segments — flat glass, container glass, fibre glass and specialty glass. The flat glass segment is sub-divided into float glass, solar glass, figured glass and sheet glass. In this report, CRISIL MI&A has focused on the float glass and solar glass market in India.

Flat glass produced through a float process is known as float glass. The float process was developed and patented in the 1960s, and licensed throughout the world by Pilkington Brothers Ltd, UK. More than 90% of the global flat glass is produced through the float process.

Float glass is produced in wide-ranging dimensions, and is available in sizes of 0.4 mm-25 mm thickness. Apart from aesthetic utility, it serves functional utility, such as privacy, energy conservation, safety, protection against fire, and noise insulation.

Float glass is largely being used as a material in the building and construction industry. It directly or indirectly competes with other building materials such as paints, plywood, and laminates and ceramic tiles.

Float glass is expected to be among the fastest-growing building materials in India.

Float glass manufacturing process

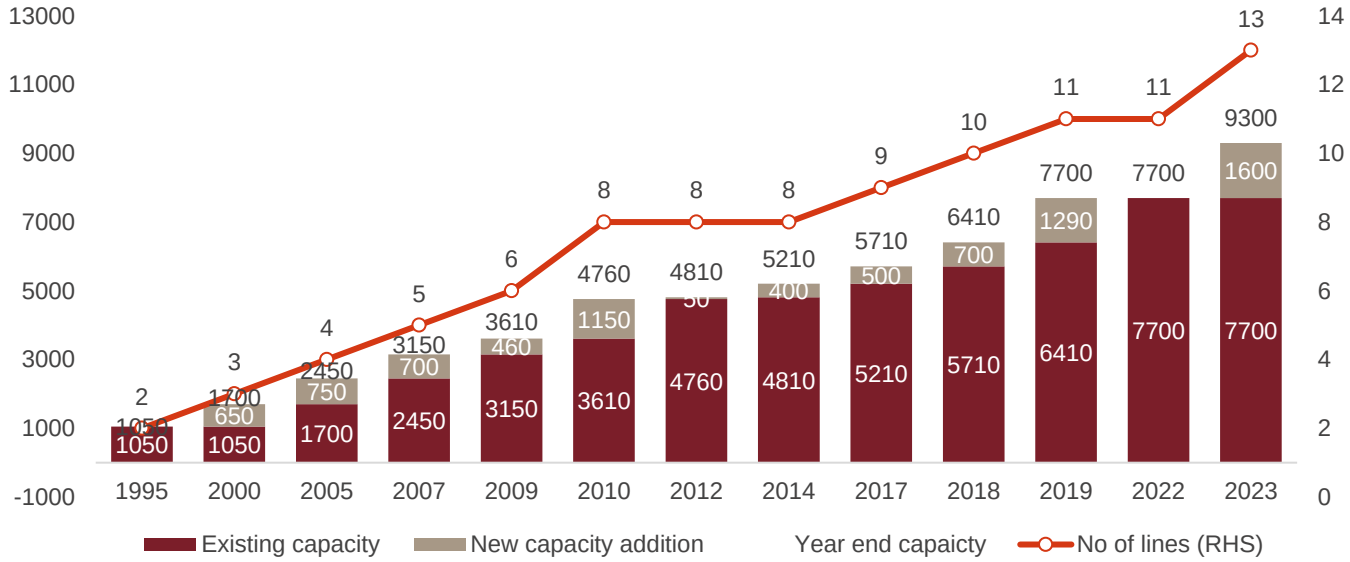
Float glass is primarily a soda-lime glass manufactured using sand, soda ash, limestone, dolomite and other minor elements. The production of float glass also includes usage of cullet glass, i.e., recycled glass, to reduce energy consumption as well as CO_2 emissions. Glass manufacturing is a highly energy-intensive process, with natural gas and electricity being major energy sources.

The float glass industry is characterised by high entry barriers because of its capital-intensive nature, long gestation period, need to cater to the entire range of products, and a large distribution network that is required to be set up before the commencement of operations.

Development of the float glass industry in India

- Pre-1995 – Gujarat Guardian was the first company to set up a float glass line in India. It set up its maiden float glass line with a capacity of 550 TPD.
- Asahi India Glass, since its incorporation, has undertaken expansion projects, and now operates ~1,200 TPD capacity.

Domestic float glass industry capacity additions

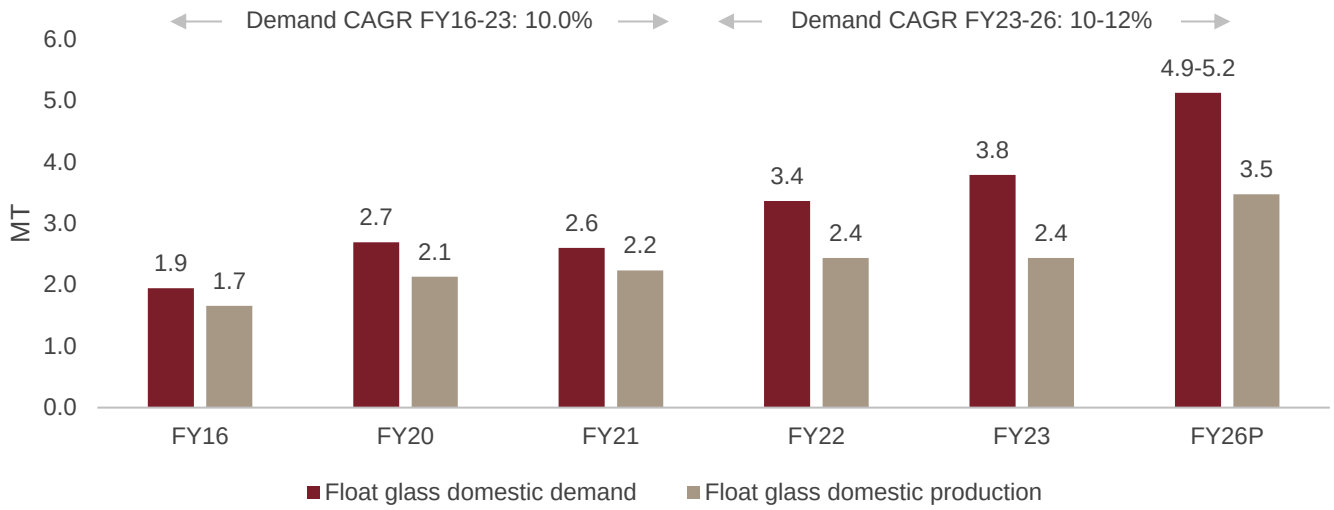


Note: Industry capacity for the current year (CY)
Source: CRISIL MI&A

Float glass market in India

Indian float glass manufacturing is a highly consolidated industry with only five organised players and no unorganised players. CRISIL estimates demand for float glass at 3.8 MT in India in fiscal 2023. CRISIL MI&A has considered unprocessed, clear, tinted, mirror, reflective, lacquered and frosted glass as part of the float glass market. Demand for float glass is estimated to have grown from 1.9 MT in fiscal 2016 to 3.8 MT in fiscal 2023, at a 10.0% CAGR. The domestic demand is estimated to have logged a healthy 8.5% CAGR over fiscals 2016-20, even as Covid-19 hurt demand sentiment in fiscal 2021, posting a marginal decline of ~4%. The demand grew in fiscal 2022 on the back of a sharp recovery, driven by pent-up demand and a faster-than-anticipated recovery in the buildings and construction segment. Secular tailwinds in place supporteding domestic glass manufacturers. Imports historically have been high historically due to limitation in domestic capacity limitations, the imports which and typically ranged from addressed 20% to -30% of domestic demand till fiscal 2022, and shoot up to 42% in fiscal 2023, where the A majority of this import was of with clear glass accounting for a majority of imports. .

Indian float glass market (MT) (FY2016 – FY2026)



Note: The float glass market includes clear and value-added glass
Fiscal 2026 production is projected based on capacity expansion plan announced by Gold Plus Glass and Asahi
Source: CRISIL MI&A

Demand for float glass is expected to rise to 4.9-5.2 MT in fiscal 2026 from 3.8 MT in fiscal 2023, at a high CAGR of 10-12%. Demand revival after the pandemic and faster economic growth should support demand for float glass through fiscal 2026 and beyond. Domestic demand is significantly higher than domestic supply, translating into a growth opportunity for domestic manufacturers.

In value terms, demand for float glass is estimated to have increased at a ~7.1% CAGR over fiscals 2016 to 2023, to Rs 116 billion. Value growth for the industry was suboptimal due to the pricing pressures because of cheaper imports from Malaysia. CRISIL estimates demand for float glass to expand at a 15-17% CAGR to Rs 175-185 billion by fiscal 2026. Imports are expected to continue to increase due to the continued demand-supply gap even after the proposed capacity additions by key players such as Gold Plus Glass and Asahi. Imports as a percentage of demand is expected to decrease from 42% in fiscal 2023 to 33% by fiscal 2026.

For most part of fiscals 2016- to 2021, demand for float glass from the building and construction sector remained under pressure, as demand for housing in the major cities was sluggish over fiscals 2018-2021 owing to multiple shocks such as demonetisation, GST implementation, establishment of the Real Estate Regulatory Authority (RERA) and Covid-19pandemic-induced economic slowdown over fiscals 2019 and 2020, in general. Over fiscals 2018 -2021, demand for housing declined at a CAGR of 9% on a compound annual growth rate (CAGR) basis. Demand declined significantly in fiscal 2021, by ~22% in fiscal 2021 because of due to the pandemic. Demand is estimated to have bounced back sharply by 35 - 40% y-on-year in fiscal 2022, albeit on a lower base of fiscal 2021. Fiscal 2023 Demand witnessed a moderate recovery post revocation of after certain state government revoked pandemic restrictions initiatives which propelled demand last fiscal,; partially offset by rising interest rates and capital values to remain detrimental to incremental demand partially. Meanwhile, higher demand for office spaces by from MNCs, the entry of foreign players in office space, expansion of the e-commerce sector, expansion of commercial retail projects, emergence of the concept of shared office spaces and a growing preference for green buildings supported demand for float glass .

Brownfield capacity expansions across Bangalore, Delhi, Chennai and Hyderabad airports have provided the boost to float glass demand since fiscal 2019.

5.16 Review and outlook of the Indian metal industry

The metallurgy industry is a major consumer of industrial gases. The production of metals from ore is an energy intensive process which can use natural gas for power. Besides, steel making also requires large amounts of oxygen in the process.

5.16.1 Review and outlook

Aluminium is the most abundant metallic element in the earth's crust and the most widely used non-ferrous metal. It is highly reactive and does not occur in the free metallic form in nature, but its compounds are present in almost all rocks, vegetation and animals. Aluminium is used in numerous applications in a variety of industries, such as transport, food packaging, architecture and electrical applications.

Domestic aluminium demand

Domestic demand for secondary aluminium revived by 19.2% in fiscal 2023 to reach 2.0 MT.. Between fiscal 2018 and fiscal 2020, the demand for secondary aluminium grew by 8.5% CAGR reach 1.3 MT in fiscal 2020 owing to its improving quality of secondary aluminium. However the growth was limited owing to slowdown in automobile segment, which is a major demand segment for secondary aluminium. Between fiscal 2020 and fiscal 2022, the demand for secondary aluminium grew by 11.1% CAGR despite pandemic in fiscal 2021 owing to revived automobile production along with other demand segment shifting to secondary aluminium amid sharp rise in primary aluminium prices

Domestic demand for primary aluminium revived by 9.9% in fiscal 2022 after declining 13% in fiscal 2021 due to the pandemic's impact. Revival in fiscal 2022 would have been higher if not for the incidence of the second wave, which resulted in lockdowns in all major Indian states in April and May 2021. Moreover, any further increase in domestic demand was limited by semiconductor shortage, which impacted automobile production. Domestic demand for aluminium grew by 12.3% in fiscal 2023 to reach 2.52 MT owing to reviving automobile production and strong construction activities after reviving by 9.9% in fiscal 2022. .

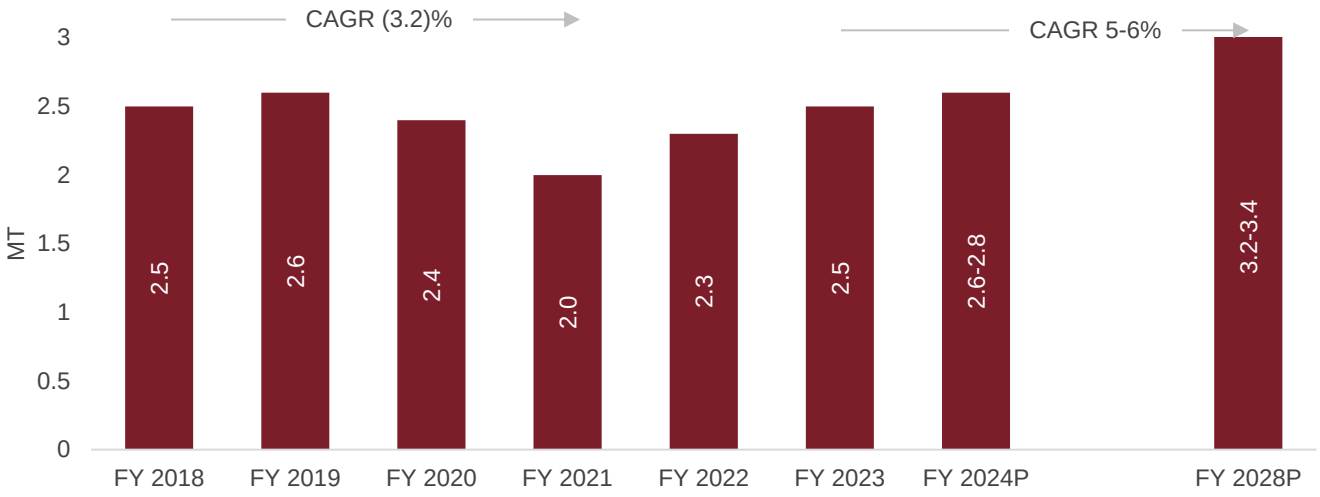
We forecast demand to increase at an annualised growth rate of 5-6% through fiscals 2024-28, led by higher ordering by PGCIL and a steady addition to transmission lines by state transmission companies, along with a pick-up in growth in key sectors such as automobile (domestic and exports), consumer durables and packaging.Healthy aluminium demand from the construction sector is estimated as aluminium penetration is likely to increase across all segments, which is otherwise currently limited to premium urban projects. Additionally, the segment is expected to be supported by industrial construction fueled by the PLI scheme. Continued growth will be seen in automotive sector demand, as domestic production of cars and two-wheelers is expected to increase by 5–7% over fiscal years 2024–28,, led by increase in penetration of primary aluminium in this segment. Also, inreasing acceptance of electric vehicles and government incentives around the same may also help propel demand, as this category has a higher intensity of aluminium than internal comustion engine (ICE) vehicles.

Strong consumer durable demand growth of 4-6% over fiscal 2024–2028. Robust growth in demand from the packaging industry, led by the rising sale of aluminium foil in the wake of restrictions on plastic usage, will also boost the demand for primary aluminium. However, higher usage of secondary aluminium in packaging and limited foil capacity of primary aluminium manufacturers will limit growth from the segment in the near term.

The demand from the power sector is expected to rise by 5–7% over the medium term, driven by the RDS scheme. The demand is also expected to increase further owing to rapid renewable energy capacities, especially in solar,

which uses 15-20 tonnes of aluminium (primary and secondary) per MW capacity. The power sector will continue to drive more than 50% of total primary demand..

Trend in domestic aluminium demand (FY2018 – FY2028P)



Source: CRISIL MI&A

Marginal capacity additions, moderate demand boost global utilisation in 2022

Global primary aluminium production grew 4.1% on-year in CY2022 to ~68.5 MT, with a utilisation rate of 86.4%. The global production was aided by 4.1% on-year growth in Chinese aluminium output.

Aluminium supplies have been under significant pressure since the second half of 2021, and the prices on the London Metal Exchange (LME) have remained elevated. Major production cuts across China and Europe owing to a severe energy crisis after coal shortages and gas price spike have cut supplies. Overall production in China slowed down to 3% on-year in the second half of 2021, compared with 9% on-year in the first half.

Global primary aluminium is estimated to grow further by 3-3.5% on year in CY 2023 to 69.5-71.5 MT owing to healthy output from China. The production from China is estimated to grow by 3.3-3.8% owing to production ramp up with healthy domestic and global demand while RoW is estimated to increase by 3-3.5% for the same period. In CY 2023, Chinese production is expected to grow by 3-4% on year owing to improving domestic demand driven by renewable energy investments and electric vehicle production. We expect the production resumption from North America after production cuts as gas supply is expected to ease in CY 2023. The supply is also expected to resume from Brazil owing to restart of aluminium smelter by Alcoa. Thus, the production increase from the rest of the world to 3-3.5%. .

CRISIL MI&A expects utilisation rates of global primary aluminium players to gradually increase to 94.5-96.5% by CY2027, provided capacity expansions are as expected. This year, Chinese capacity addition are expected to be stable as China has already reached 45 MT capacity. Thus, the capacity swapping is expected by major smelters in the country.. Therefore, these capacity additions are replacement additions. Elsewhere, too, capacity additions are likely to be limited as players have an ESG target and any capacity addition will have to be within that. Thus, capacity additions until CY2027 will be 1.5-2.5 MT as against the 9 MT added between 2015 and 2020.

India's utilisation rate to surge due to production ramp-up at Vedanta

Domestic utilisation rate, which hovered between 86% and 89% over fiscals 2018-2021, increased to 97% in fiscal 2022 due to quick production ramp-up at Vedanta and further remained at 98% in fiscal 2023. This is primarily on account of a ramp-up in production at Line IV Jharsuguda by Vedanta. The company produced 2.3 MT, compared with 1.9-1.95 MT from fiscal 2018 to fiscal 2021, thus pushing the overall industry production to 4.0 MT compared with 3.6 MT in fiscal 2021.

Capacity utilisation in the Indian primary aluminium industry has always been healthy. The industry operated at 90-95% between fiscals 2010 and 2014, driven by healthy domestic demand and tepid capacity addition. However, capacity expansion and ramp-up of existing facilities by Hindalco, Vedanta and Balco led to a fall in capacity utilisation in fiscal 2015, when it reached ~85%. However, as players gradually ramped up production at new facilities, utilisation rates inched up closer to ~88% until fiscal 2019..

However, in fiscal 2020, overall utilisation dipped marginally to 87% due to disruption caused by Cyclone Fani and poor coal supply from Mahanadi Coalfields Ltd, leading to a temporary shutdown of multiple potlines by Nalco. Also, Vedanta was operating at ~80% utilisation as it had not started operating the Line IV smelter at Jharsuguda. The company had lower utilisation rates through fiscals 2019-2021. However, given the higher metal prices and healthy export demand, Vedanta began quickly ramping up its smelter lines. In fact, the company recorded production growth of ~15% on-year in fiscal 2022. Thus, the industry utilisation rate in the fiscal 2022 increased to 97%, significantly higher than the 87% seen in fiscal 2021. The capacity utilisation rate is elevated to 98% in fiscal 2023 despite falling exports amid slowdown in importing countries owing to robust domestic demand. Going forward, the capacity utilisation is expected to remain between 97-98%.

Domestic capacity is expected to reach ~5.1 MT in fiscal 2028, led by expansions by Nalco and Balco. Nalco is expected to add brownfield capacity of 0.5 MT at its Angul facility and another 0.1 MT by debottlenecking its existing facility by fiscal 2027. The company has also announced another greenfield smelter of 0.5 MT, the timeline for which has not been provided. While work on the unit is yet to commence, we expect partial addition by the end of fiscal 2024 and completion by fiscal 2025. Any development on this front will be a key monitorable. Balco is expected to add 0.4 MT per annum (MTPA) to reach 1 MTPA by fiscal 2024. Hindalco is expected to add brownfield capacity of 180 KTPA at Aditya or Mahan smelters basis ofthe success of its 100 MW round the clock renewable energy project at Aditya smelter.

5.17 Review and outlook of the Indian steel industry (FY2016 – FY2028P)

Steel is an alloy containing a high proportion of iron with some carbon. Other alloying elements may also be present in varying proportions. Steel properties are dependent on the proportion of alloying elements and also on the heat treatment the metal is subjected to. Steel is characterised by high strength, low weight, durability, flexibility and corrosive resistance. It is widely used in the construction, automobile and consumer durables industries.

5.17.1 Domestic steel demand

After printing a stellar growth of 8-9% in fiscal 2018 and fiscal 2019, the demand momentum fizzled out in fiscal 2020 to 1.4% growth. The domestic steel industry grew a moderate 1.4% in fiscal 2020, with non-alloy steel demand growth of 3.3%. On the contrary, alloy steel consumption declined ~21% during the same period, because of declining automobile production. Flat steel saw a ~3% decline in consumption, while long-steel demand grew 5.5% in fiscal 2020.

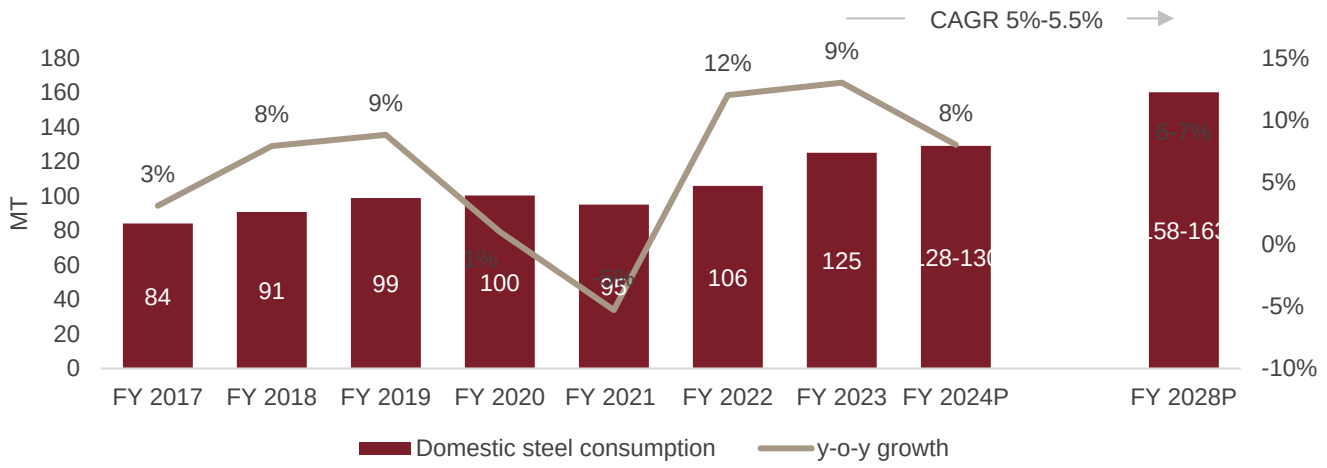
Domestic steel demand rose a healthy 8.8% in fiscal 2019, primarily led by a rise in construction activity and modest growth in consumption sectors. Low base of the first half (GST implementation in the preceding year) also cushioned growth to a certain extent.

Steel demand increased by 13.3% in FY23 after having seen a 11.4% recovery in FY22 on low-base of covid-impacted fiscal 2021. While growth is moderating, demand is already much higher than pre-Covid-19levels. Demand is expected to be spearheaded by infrastrcuture projects housing and construction demand and pent up demand from auto sector. Momentum in projects like PMAY and NIP will sustain momentum endsuring steady demand. FY23 was tumultuous with the Outbreak of Russia-Ukraine war in Q1FY23, impacting prices of coking coal, iron ore, pig iron, and steel they all rallied to reach new all-time highs, hurting domestic demand. Consequently, export volumes saw surge causing effect on prices to elevate. The effect of elevated prices directly impacted procurement decisions among end-use segments in the first quarter of fiscal 2023. However, we saw a recovery coming in strong in the remaining months of this fiscal since prices have corrected swiftly on the government's intervention of cutting exports of finished steel. Further, the post-monsoon demand revival and festive season have ensured demand growth this fiscal.

Going ahead, demand in fiscal 2024 will see growth of 7-9% with robust demand from allied sectors and capital expenditure push by government.Long steel segment will augur well on infra push and housing executions as elections approach and flat steel will see relief as semi-conductor shortage steadily alleviates. Further, healthy urban housing progress is ensuring and continue to push flat demand (in applications like railings, doors, staircases and outdoor construction)

The healthy domestic demand growth projected this fiscal year 2024 is driven by a 11-13% rise in infrastructure, a decent 5-7% rise in housing driven by government housing construction, and private demand. Also, the auto production rise by 6-8% driven by both Passenger and commercial vehicle production rise would aid demand growth.

Trend in domestic steel demand growth (FY2017 - FY28P)



E: Estimated; P: Projected
Source: Joint Plant Committee, CRISIL MI&A

5.17.2 Utilisation to rise on recovery in domestic demand and exports, but new capacities will limit further improvement

Fiscal 2023 saw utilisation levels of 80% owing to the healthy domestic demand from the infrastructure, construction, and auto sectors. Fiscal 2024 will see the utilization levels rise further with gradual production ramp-up of planned capacity additions and a healthy demand scenario, reaching to the range of 82-84%.

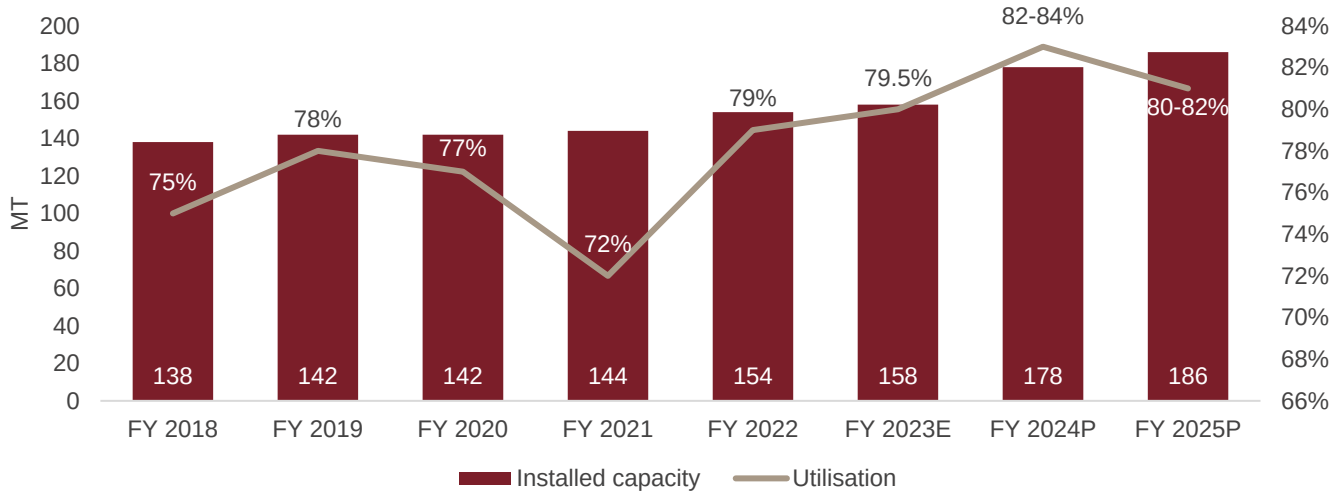
In the medium run, utilization levels are set to stay elevated due to a strong demand trajectory, but any major uptick will be limited by continued capacity additions.

Several new capacities are expected to come on-stream over the next five years (90-95% of capex by large players), the pace of which has been accelerated after blockbuster profitability in the past two quarters. We expect a net capacity addition of 60–67 MT in this period, owing to healthy profitability and debt reduction seen in the past two fiscals. Share of large players is expected to rise to 60-63%% in fiscal 2028 from 65% in fiscal 2023, driven by increased capex activities on healthy profitability and strong revenue. Ramp-up of acquired assets will also help drive capacities up.

Share of BF/ BOF (Blast Furnace/Blast Oxygen Furnace) through 2028 is expected to rise to 47-49% from 42% currently with greenfield / brownfield capacity expansions of large integrated players like Tata (Kalinganagar), JSW (Dolvi), and AMNS.

Geo-political conflict induced volatility and supply chain disruption shot-up prices across the value chain. To curtail hikes, Government of India imposed export duty from May-Nov'22 on steel and its raw materials to support the domestic market. Also, weak global demand further dampened export volumes. Fiscal 2023 saw utilization levels of 80% owing to the healthy domestic demand from the infrastructure, construction, and auto sectors. Fiscal 2024 will see the utilization levels rise further with gradual production ramp-up of planned capacity additions and a healthy demand scenario, reaching to the range of 82-84%.

Capacity utilisation levels for the Indian steel market (FY2017 – FY2026P)



E: Estimated; P: Projected
Source: Joint Plant Committee, CRISIL MI&A

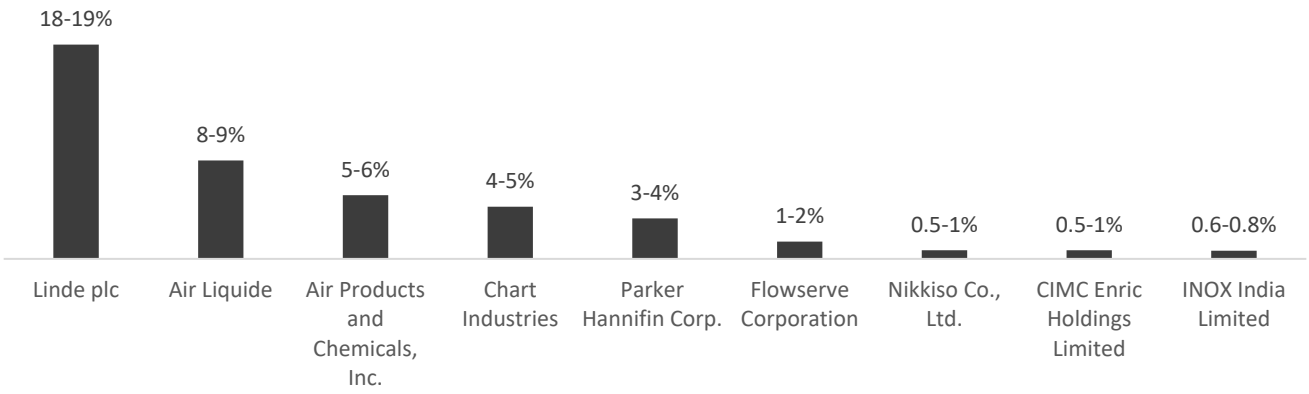
6 Competitive Landscape

6.1 Global market share of cryogenic equipment

As many cryogenic equipment suppliers have multiple business segments and can also offer a wide range of industrial solutions such as production of cryogenic gases, transport and distribution businesses, the market share of players in the global cryogenic equipment industry is calculated based on estimates of the revenue related to their cryogenic equipment business.

Linde Plc is the largest global player, with a market share of about 18-19%, followed by Air Liquide, which has a market share of 8-9%.

Market share of key cryogenic equipment suppliers globally (CY2022):



Source: Markets and Markets, CRISIL MI&A

At the global level, the top 9 companies account for about 35-48% of the cryogenic equipment market. Total cryogenic market includes all cryogenic equipment including air separation units, liquefaction plants and LNG bulk carrier ships. According to a report of Markets & Markets commissioned by CRISIL Market Intelligence & Analytics (MI&A) for the proposed IPO of INOX India Ltd, the report stated that Inox India Ltd. is amongst the top 10 cryogenic equipment manufacturers in the world by revenue in CY2022. It is the first Indian company to manufacture trailer mounted hydrogen transport tank designed jointly with Indian Space Research Organisation (ISRO). Other major cryogenic tank manufacturers in India are VRV Asia pacific and Cryolor.

Domestically, INOX India is the largest supplier of cryogenic equipment with a revenue of Rs. 9.65 billion (approx. USD 116.1 mn) in FY2023. Company has a dominant position in the Indian market with approx. three times the sale revenue of VRV Asia Pacific in fiscal 2022. It also designs and manufactures cryogenic equipment which can meet international norms which can be exported to the US and Europe. About ~46% of its sales came from exports in FY2023. Inox India is the largest exporter of cryogenic tanks from India in terms of revenue in fiscal 2023. In the LNG tank segment, Inox India has supplied over 60% of the tanks in both the stationary tank segment which includes all LNG applications including LCNG stations and trailer mounted mobile LNG tanks in India which have a valid PESO license as of 4th May 2022, for tanks supplied between 1996 to May 2022. Inox India has also received orders for supply of equipment for multiple auto-LNG dispensing stations from IOCL, BPCL and HPCL between March-2021 and March-2022 for the Phase-I of auto-LNG station rollout.

6.2 Player Profiles

6.2.1 INOX India Private Limited

Key facts	Brief profile
HQ: **Vadodara, Gujrat, India** Company type: **Private** No. of Employees: **NA** Revenue (INR million): **9,659**	Incorporated in 1992, INOX India acquired US based Cryogenic Vessel Alternatives Inc., a (CVA), a cryogenic transportation equipment manufacturer in 2009 to form INOXCVA. INOX India is a global manufacturer of equipment used for the transportation, storage, and distribution of cryogenic liquid and gases. The company engages in design engineering, manufacturing, supply, and commissioning of cryogenic storage, vaporisation, and distribution systems for industrial gases, LNG and cryo-scientific segments.

6.2.2 Geographic presence (locations)

INOX India has three manufacturing plants in India (Gujrat) and a sales office each in India, Brazil and the Netherlands.

6.2.3 Equipment product portfolio

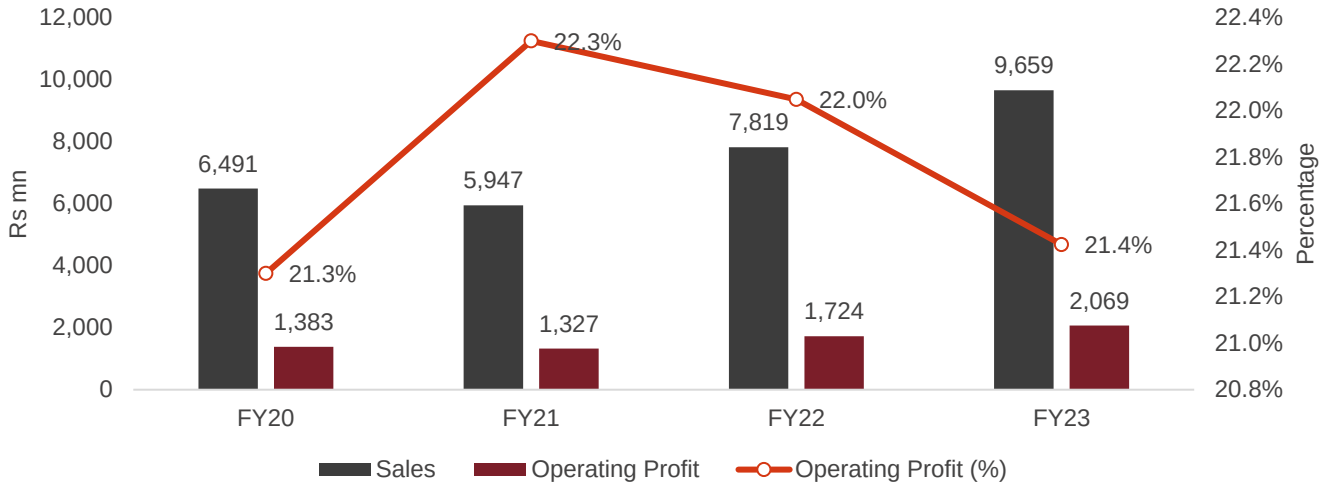
INOX India product portfolio includes cryogenic-standard products, cryogenic engineered tanks and systems for industrial gases as well as LNG and hydrogen, cryo-biological products, Cryolines, disposable cylinders, vaporisers and LNG dispensation stations.

Source: RoC, Company reports, CRISIL MI&A

Sharp rise in sales, Profit margins remained near stable during fiscal 2023

INOXCVA's revenue rose by 24%during the fiscal 2023. Operating profits also registered nearly 20% y-o-y growth in absolute terms.

Operating as well as net margins remained nearly steady during the year.



Source: Registrar of Companies, Company reports, CRISIL MI&A

Financial parameters (In Mn INR)

	FY2020	FY2021	FY2022	FY2023
Revenue	6,491	5,947	7819	9,659
Operating profit	1,383	1,327	1724	2,069
Operating Margin	21.3%	22.3%	22.0%	21.4%
Net profit	973	975	1279	1,547
Net profit Margin	15.0%	16.4%	16.4%	16.0%
Equity	2,794	3,721	5,338	5,854
Debt	917	604	512	60
Debt to Equity ratio	0.33	0.16	0.10	0.01

Note: Debt include lease liabilities

Source: Registrar of Companies, Company reports, CRISIL MI&A

6.2.4 Air Liquide Inc.

Key facts	Brief profile
HQ: **Paris, France** Company type: **Public** No. of Employees: **67,100** Revenue ($ million): **31,559**	Established in 1902, Air Liquide is a world leader in offering services, technologies, and gases for Healthcare and Industrial End users. The company operates its business through three segments, namely, Gas & Services segment, Engineering & Construction and Global Markets & Technologies. Under its Engineering & Construction segment Air Liquide design, construct and manufacture plants and equipment's for the group and third-party customers.

6.2.5 Geographic presence (locations)

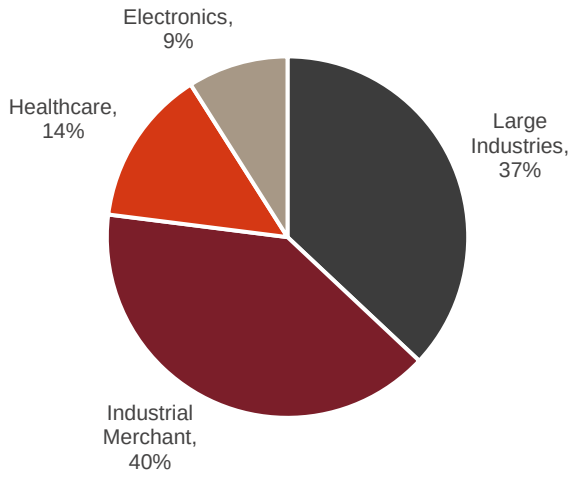
The company operates in approximately 73 countries and serves more than 3.8 million patients and customers.

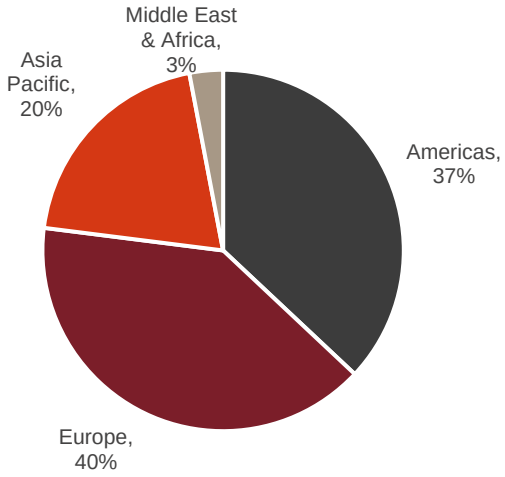
6.2.6 Equipment product portfolio

The company offers a wide range of cryogenic equipment, such as Cryocap H2, Cryocap Oxy, Helium Recovery and Liquefaction, Hydrogen, Nitrogen, and Argon Recovery, Large Air Separation Unit.

The large industries have grown fastest among the business line

In CY2022, Large industries business segment grew by 51% which resulted increase in share from 31% to 37%. Whereas both Industrial merchant and electronics grew by 22% respectively.

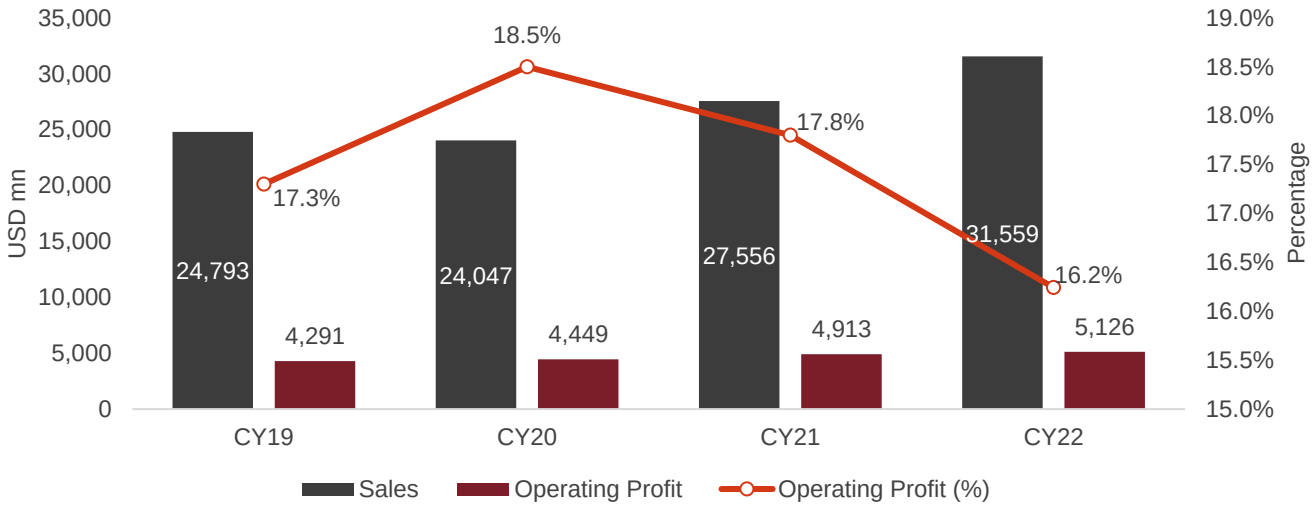




Source: Company reports, CRISIL MI&A

Air Liquide's operating profit grew by 10% but operating margin declined from 17.8% to 16.2%

In CY2022, Air Liquide's revenue grew by 15%, whereas operating profit grew only 4% because of rising costs. However, Air Liquide is able to manage a decent operating margin due to inflation-adapted pricing policy and high efficiency gains.



Source: Company reports, CRISIL MI&A

Financial parameters (In Mn USD)

	CY2019	CY2020	CY2021	CY2022
Revenue	24,793	24,047	27,556	31,559
Operating profit	4,291	4,449	4,913	5,126
Operating Margin	17.30%	18.50%	17.80%	16.2%
Net profit	2,536	2,858	3,037	2,909
Net profit Margin	10.23%	11.89%	11.0%	9.2%

	CY2019	CY2020	CY2021	CY2022
Equity	21,874	22,341	26,026	25,906
Debt	13,995	12,454	12,338	10,721
Debt to Equity ratio	0.6	0.56	0.47	0.41

Note: In debt, only non-current portion of the debt is considered

Source: Company reports, CRISIL MI&A

6.2.7 Linde Plc

Key facts	Brief profile
HQ: **Dublin, Ireland** Company type: **Public** No. of Employees: **65,010** Revenue ($ million): **33,364**	Established in 1879, Linde plc is a global industrial gas and engineering company. The principal business activities of the company are production of industrial gases along with designing, engineering, and manufacturing of the equipment used in the production of industrial gases. The company operates its business through segments, namely, healthcare, manufacturing, chemicals and refining, metals, electronics, food and beverage, and others along with an engineering division named Linde Engineering.

6.2.8 Geographic presence (locations)

Linde Plc operates in more than 80 countries. The company has facilities across the globe, but its cryogenic equipment manufacturing facilities are in China and Germany.

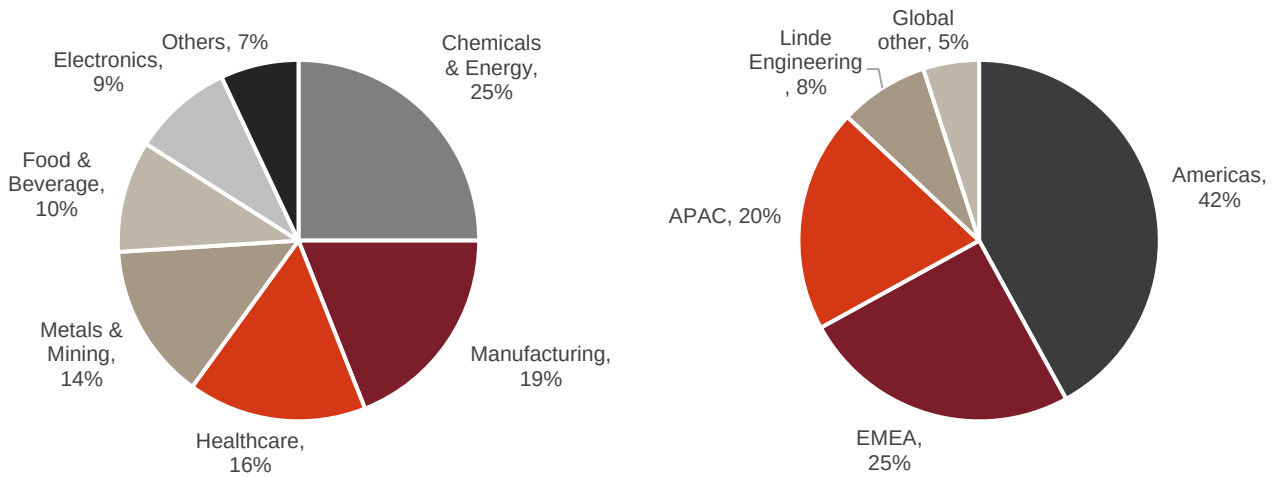
6.2.9 Equipment product portfolio

The cryogenic equipment manufactured includes plant components, such as cryogenic tanks, cryogenic portable tanks, vaporisers, pipes, and heat exchangers.

Source: Company reports, CRISIL MI&A

Engineering segment's revenue is $2.8 bn, which includes the manufacturing of cryogenic tanks (CY2022)

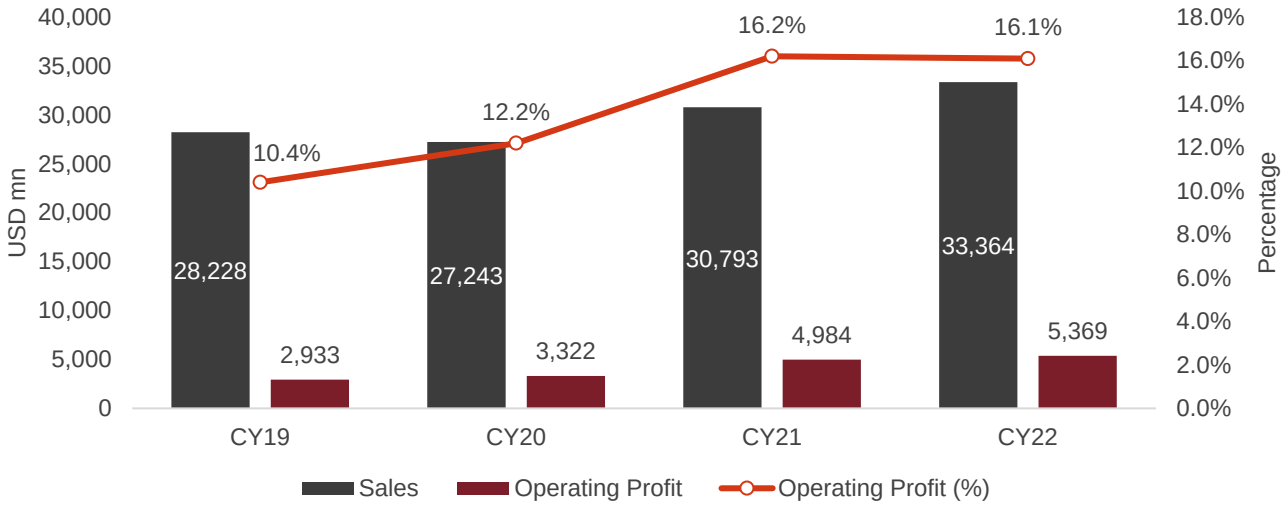
The engineering segment, which accounts for 8% of global revenue, includes products such as cryogenic tanks, cold boxes, packaged units, and cryogenic columns, plate-fin heat exchangers, coil-wound heat exchangers and water bath vaporisers.



Source: Company reports, CRISIL MI&A

Linde Plc has been improving its revenue and margin gradually

Linde Plc, being the largest player in the sector, has been improving its revenue along with operating margin. In the last couple of years, operating margin improved from 10.4% in CY19 to 16.2% in CY21 and remained stable in CY2022 at 16.1%.



Source: Company reports, CRISIL MI&A

Financial parameters (In Mn USD)

	CY2019	CY2020	CY2021	CY2022
Revenue	28,228	27,243	30,793	33,364
Operating profit	2,933	3,322	4,984	5,369
Operating Margin	10.4%	12.2%	16.2%	16.1%
Net profit	2,285	2,501	3,826	4,147
Net profit Margin	8.09%	9.18%	12.4%	12.4%
Equity	51,522	49,569	45,428	41,374
Debt	34,977	38,647	36,164	38,271
Debt to Equity ratio	0.7	0.78	0.80	0.93

Source: Company reports, CRISIL MI&A

6.2.10 Chart Industries, Inc.

Key facts	Brief profile
HQ: **Georgia, US** Company type: **Public** No. of Employees: **5,178** Revenue ($ million): **1,612**	Established in 1992, Chart Industries is a manufacturer of cryogenic equipment, which are used across the liquid-gas supply chain. The company operates its business through four segments, namely, cryogenic-tank solutions, heat-transfer system, specialty products, repair, services and leasing. Its distribution & storage west segment is involved in designing, manufacturing, and services related to the storage and delivery of cryogenic liquids used in industrial gas and LNG applications.

6.2.11 Geographic presence (locations)

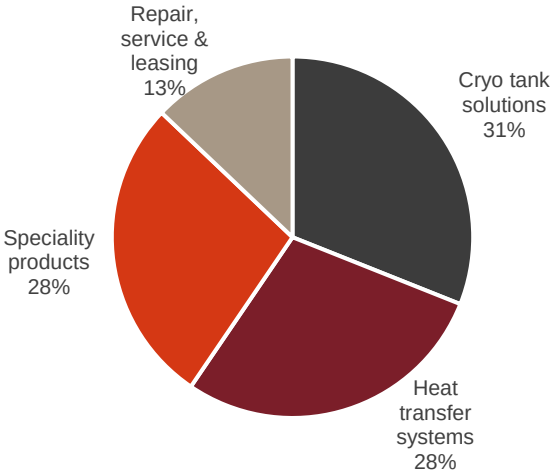
The company has offices in more than 10 countries in Asia-Pacific, Europe, and North America. Chart's engineering and manufacturing facilities are located in U.S, India, China, the Czech Republic, Italy, Germany, and France.

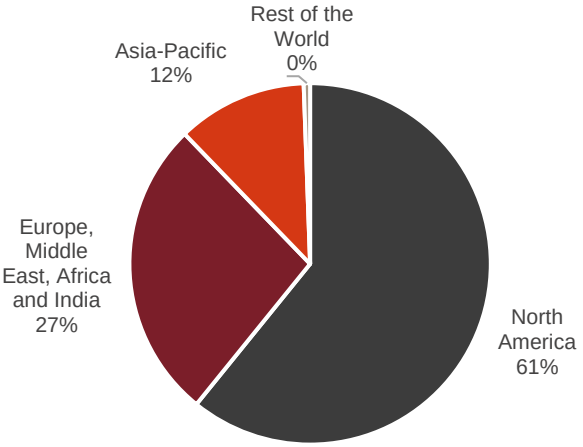
6.2.12 Equipment product portfolio

The company offers a wide range of cryogenic equipment, such as heat exchangers, vacuum-insulated containment vessels, liquefaction process units, other cryogenic components, gas processing equipment, cold boxes, and ambient temperature fans.

Cryogenic-tank solutions account for a third of the revenue for the company

Revenue from the cryogenic-tank solutions revenue accounts for $500 million, which includes manufacturing of tanks for bulk CO_2, bulk storage tanks, cannabis and CBD oil, and cryogenic transport trailers.

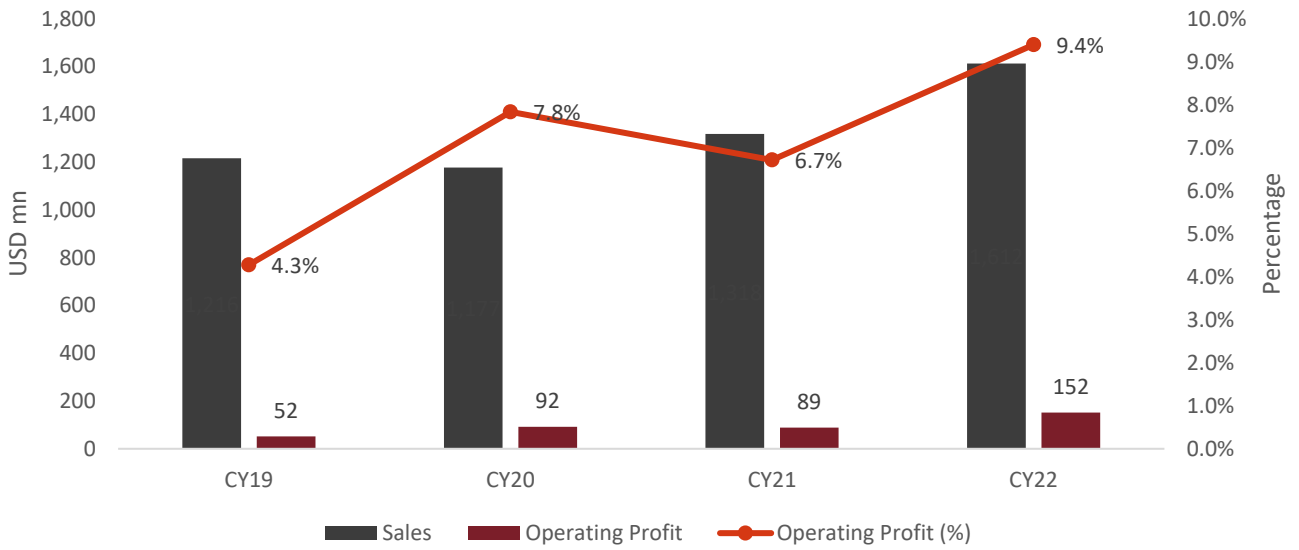




Source: Company reports, CRISIL MI&A

Chart industries operating margin dipped in CY2022

Chart industries operating margin declined although Heat transfer systems and Repair, service and leasing margins were positive compared to last year. For Heat transfer systems operating margin improved from (4.5%) in CY2021 to 11.2% in CY2022. On the other hand, repair, service and leasing business operating margin improved from 12.5% to 24.3% in calendar year 2022. However margins dipped for cryo tank solutions and specialty products. .



Source: Company reports, CRISIL MI&A

Financial parameters (In Mn USD)

	CY2019	CY2020	CY2021	CY2022
Revenue	1,216	1,177	1,318	1,612
Operating profit	52	92	89	152
Operating Margin	4.3%	7.8%	6.7%	9.4%
Net profit	32	70	61	83
Net profit Margin	2.6%	5.9%	4.6%	5.1%
Equity	1,232	1,579	1,625	2,684
Debt	1,249	991	1,419	3218
Debt to Equity ratio	1.01	0.63	0.87	1.20

Note: Net profit is net income from continuing operations
Source: Company reports, CRISIL MI&A

6.2.13 Air Products and chemicals, Inc.

Key facts	Brief profile
HQ: **Pennsylvania, US** Company type: **Public** No. of Employees: **21,900** Revenue ($ million): **12,699**	Established in 1940, Air products is a global industrial gases company that is principally involved in the development, engineering, building, owning, and operating of industrial gas projects. The company has five business segments, namely, Industrial Gases - Americas, Industrial Gases - EMEA, Industrial Gases - Asia, Industrial Gases - Global, and corporate and others. Under its industrial gases equipment segment, the company designs and manufactures storage and transportation cryogenic equipment for air separation, hydrocarbon recovery and purification, natural gas liquefaction, liquid helium, and liquid hydrogen.

6.2.14 Geographic presence (locations)

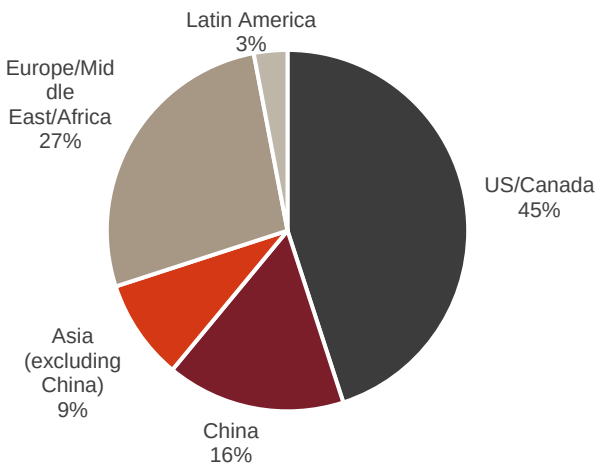
Air Products has manufacturing facilities for industrial gases equipment in the US. The company has a presence in 45 countries.

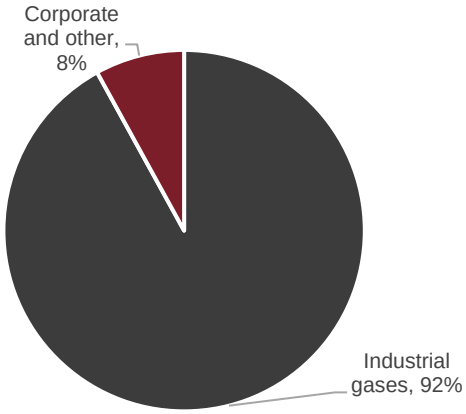
6.2.15 Equipment product portfolio

The cryogenic equipment product portfolio of the company includes tanks, vaporisers, and pressure regulators.

Limited presence in the cryogenic market (CY2022)

Air Products is mainly focused on industrial gases, which accounts for 92% of global revenue, whereas corporate and others segment includes cryogenic equipment.

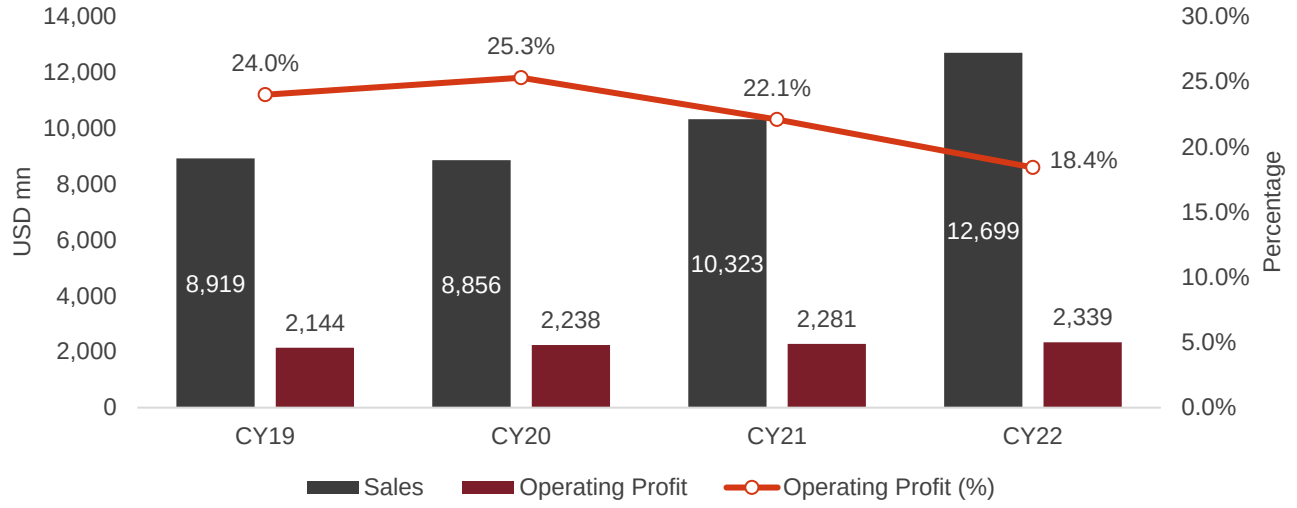




Source: Company reports, CRISIL MI&A

Operating margin declined however operating profit increased marginally

Air Products operative margin declined in CY2022 to 18.4% from 22.1%..



Source: Company reports, CRISIL MI&A

Financial parameters (In Mn USD)

	CY2019	CY2020	CY2021	CY2022
Revenue	8,919	8,856	10,323	12,699
Operating profit	2,144	2,238	2,281	2,339
Operating Margin	24.00%	25.30%	22.1%	18.4%
Net profit	1,809	1,931	2,115	2,267
Net profit margin	20.29%	21.81%	20.5%	17.8%
Equity	11,388	12,443	14,088	13,702
Debt	7,555	12,725	12,771	13,490
Debt to Equity ratio	0.66	1.02	0.91	0.98

Source: Company reports, CRISIL MI&A

6.2.16 Emerson Electric Co.

Key facts	Brief profile
HQ: **Missouri, USA** Company type: **Public** No. of Employees: **85,500** Revenue ($ million): **19,629**	Established in 1890, Emerson Electric Co. is a manufacturer and solution provider for industrial and commercial markets. The company operates through two business segments, namely, automation solutions and commercial and residential solutions. The company offers cryogenic equipment under its valves category of products. The principal business activities of the company are production of industrial gases, along with designing, engineering, and manufacturing of the equipment used in the production of industrial gases. The company operates its business through segments, namely, healthcare, manufacturing, chemicals and refining, metals, electronics, food and beverage, and others.

6.2.17 Geographic presence (locations)

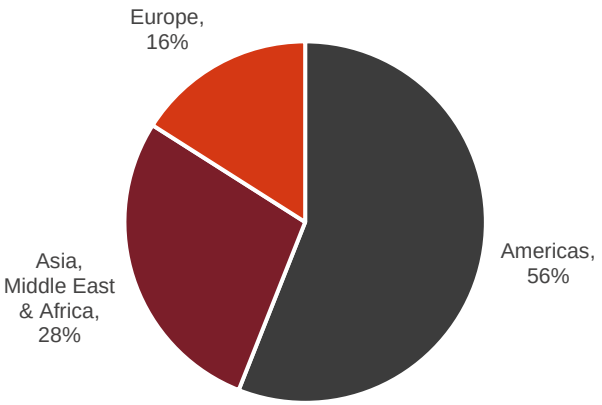
The company has a strong presence in Asia, Latin America, Eastern Europe, and the Middle East and Africa.

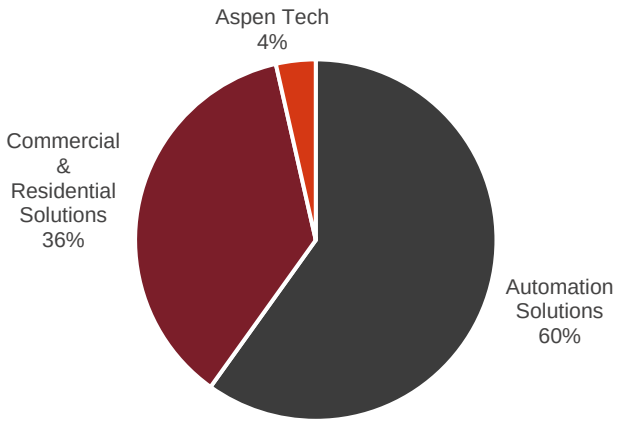
6.2.18 Equipment product portfolio

Emerson Electric Co. has a wide range of cryogenic valves that are used at air-separation plants, LNG terminals, aerospace engines, and other cryogenic applications.

Emerson Electric is more focused in American market (CY2022)

Emerson Electric gets around 56% of revenue from the Americas, whereas Asia, Middle East and Africa cumulatively account for 28% of revenue.

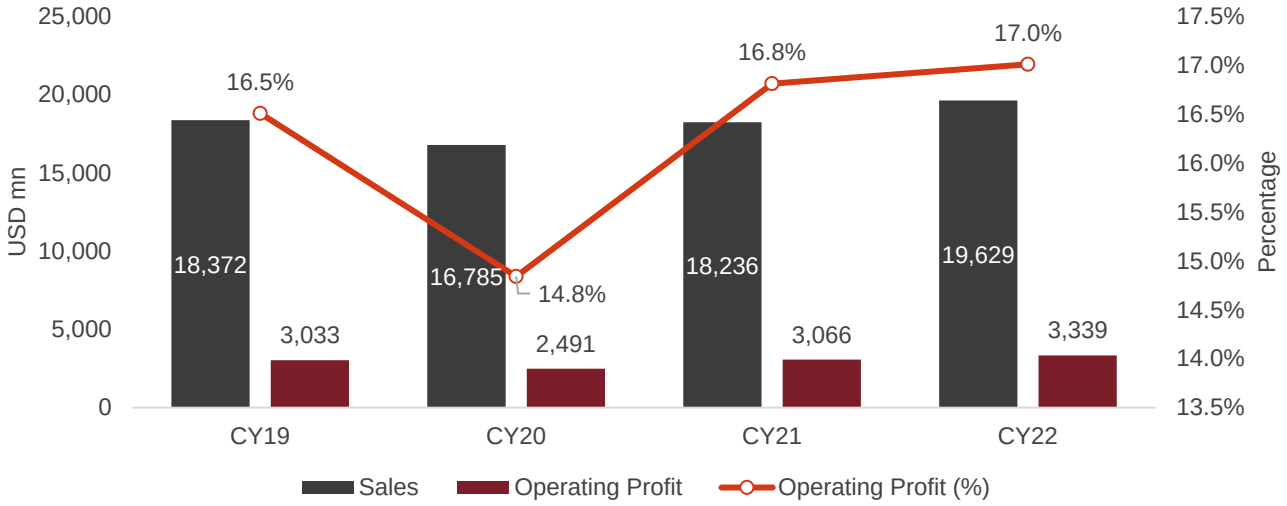




Source: Company reports, CRISIL MI&A

Emerson Electric operating margin improved to pre-Covid-19level (CY2021)

Emerson Electric operating margins improved marginally to 17.0%% in CY2022 from 16.8%.



Source: Company reports, CRISIL MI&A

Financial parameters (In Mn USD)

	CY2019	CY2020	CY2021	CY2022
Revenue	18,372	16,785	18,236	19,629
Operating profit	3,033	2,491	3,066	3,339
Operating Margin	16.5%	14.8%	16.8%	17.0%
Net profit	2,328	1,990	2,327	3,230
Net profit margin	12.7%	11.9%	12.8%	16.5%
Equity	8,273	8,447	9,923	16,316
Debt	6,248	8,650	8,546	11,579
Debt to Equity ratio	0.76	1.02	0.86	0.71

Source: Company reports, CRISIL MI&A

6.2.19 Shijiazhuang Enric Gas Equipment Company Ltd.

Key facts	Brief profile
HQ: **Shijiazhuang, China** Company type: **Public** No. of Employees: **10,500** Revenue ($ million): **2,920**	Founded in 2004, CIMC ENRIC Holdings Limited, one of the members of the CIMC Group and is a global leading manufacturer of high-pressure and cryogenic pressure vessel manufacturer. The company serves storage and transportation requirements for clean-energy industries of CNG/LNGs and hydrogen, semiconductor and photovoltaics industries, and petrochemical industry. ENRIC designs and manufactures products by complying with the standards or regulations of GB, ISO, EN, PED/TPED, ADR, USDOT, KGS, PESO, OTTC to meet the tailored requirement of target counties.

6.2.20 Geographic presence (locations)

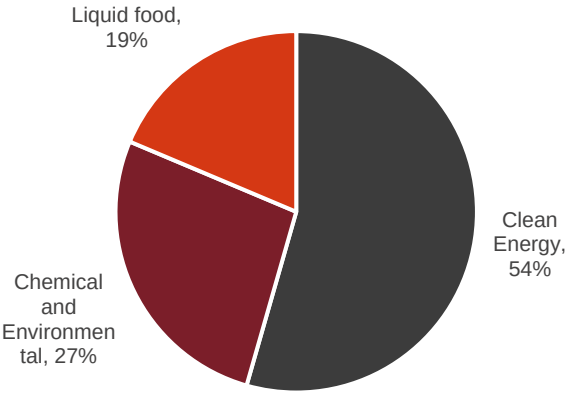
The Company has built a global marketing network and has over 20 domestic and overseas subsidiaries located in China, the Netherlands, Germany, Belgium, the United Kingdom, and Canada that operate production bases and advanced R&D centers.

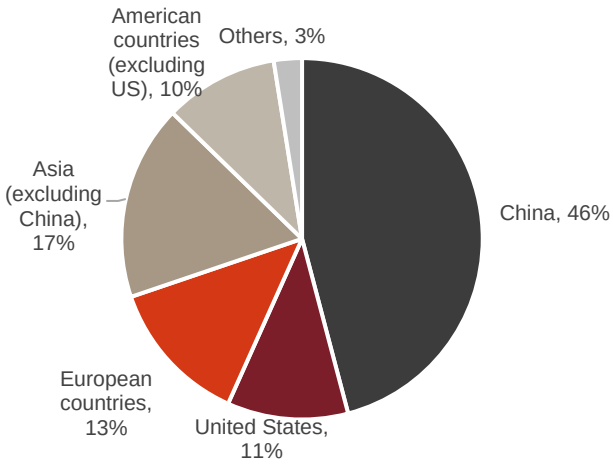
6.2.21 Equipment product portfolio

CIMC ENRIC has been innovatively developing and manufacturing high-quality seamless steel cylinders and various types of storage tanks and trailers for gas energy and petrochemicals.

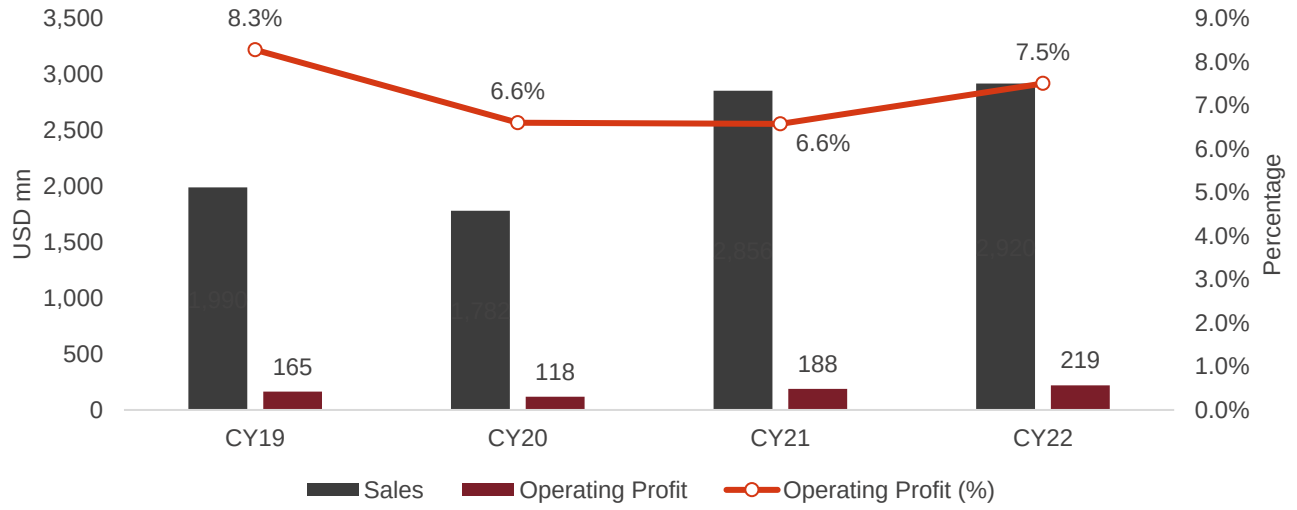
CIMC ENRIC is more focused in domestic market (CY2022)

About 46% of revenue is generated from China; only additionally, 17% of revenue is generated from other Asian markets. The American countries (including USA) contribute about 21% of overall revenue.





Source: Company reports, CRISIL MI&A



Source: Company reports, CRISIL MI&A

Financial parameters (In Mn USD)

	CY2019	CY2020	CY2021	CY2022
Revenue	1,981	1,820	2,857	2,920
Operating profit	164	120	188	219
Operating Margin	8.3%	6.6%	6.6%	8%
Net profit	130	84	141	162
Net profit	6.56%	4.61%	4.93%	6%
Equity	1,065	169	1,318	1,419
Debt	1,228	195	1,632	1,890
Debt to Equity ratio	1.2	1.2	1.2	1.3

Note: Debt=Current liabilities+Non-current liabilities

Source: Company reports, CRISIL MI&A

6.2.22 Taylor-Wharton

Key facts	Brief profile
HQ: **Texas, US** Company type: **Private** No. of Employees: **NA** Revenue ($ million): **NA**	Established in 1742, as a metal working company, it entered the cryogenic equipment space in 1925. However, the company ran into trouble and filed for Chapter 11 bankruptcy protection in 2009 in the US. It emerged from bankruptcy protection in 2010 but five years later had to file for bankruptcy protection again in 2015. Air Water Inc., an industrial gasses company, acquired Taylor-Wharton; however, Air Water decided that Taylor-Wharton would operate in its brand name. Taylor-Wharton manufactures a wide range of cryogenic storage, transportation, and regasification equipment for industrial gases, life sciences, and LNG applications. The company operates its business through three segments, namely, mega tanks and transports, commercial cryogenic storage, and cryogenic freezer applications.

6.2.23 Geographic presence (locations)

The company has presence in the US, Belgium, Poland, the UAE, Malaysia, Japan, Australia, and Colombia.

6.2.24 Equipment Product Portfolio

The cryogenic equipment products portfolio of the company includes bulk-storage vessels, micro-bulk tanks, liquid cylinders, transport vessels, LNG vessels, vaporisers, freezers, and vacuum insulated piping.

Source: Company reports, CRISIL MI&A

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