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OPPORTUNITIES IN HEATING EQUIPMENT, WASTE GAS HANDLING / EMISSION CONTROL SYSTEMS, AND RENEWABLE ENERGY SYSTEMS

SUBMITTED TO

JNK India Ltd.

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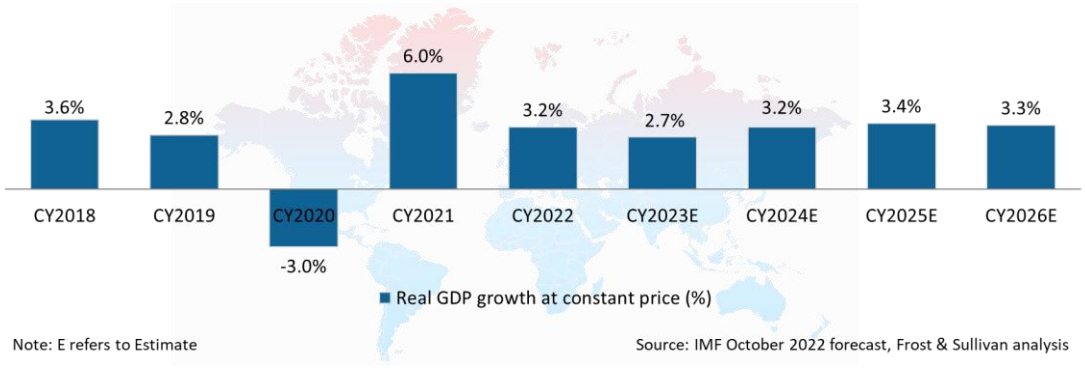
CHAPTER 1: GLOBAL MACRO-ECONOMIC REVIEW

World Macro-economic Overview:

Real GDP Review and Outlook:

The global real gross domestic product (GDP) Outlook for CY2023 is positive with International Monetary Fund (IMF) increasing its growth outlook for CY2023 to 2.9% in February 2023 from the earlier 2.7% in October 2022, backed by the resilient demand from the United States of America (USA) and Europe. Easing energy costs and increasing economic participation from China because of relaxation in COVID related restrictions also are expected to contribute to the growth in CY2023.

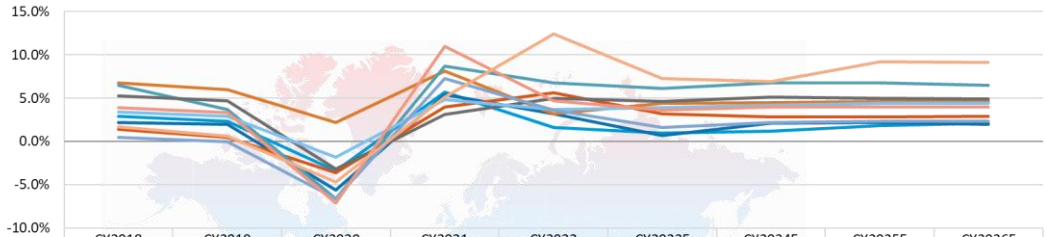
Exhibit 1.1: Real GDP Growth – Historic and Forecast, World, CY2018 – CY2026E



Note: E refers to Estimate

Source: IMF October 2022 forecast, Frost & Sullivan analysis

Exhibit 1.2: Real GDP Growth by Select Regions & Countries – Historic and Forecast, World, CY2018 – CY2026E



	CY2018	CY2019	CY2020	CY2021	CY2022	CY2023E	CY2024E	CY2025E	CY2026E
USA (%)	2.9%	2.3%	-3.4%	5.7%	1.6%	1.0%	1.2%	1.8%	2.1%
Europe (%)	2.2%	2.0%	-5.6%	5.4%	3.2%	0.7%	2.1%	2.2%	2.0%
Middle East (%)	1.4%	0.5%	-3.6%	4.0%	5.6%	3.2%	2.8%	2.8%	2.9%
China (%)	6.8%	6.0%	2.2%	8.1%	3.2%	4.4%	4.5%	4.6%	4.6%
India (%)	6.5%	3.7%	-6.6%	8.7%	6.8%	6.1%	6.8%	6.8%	6.5%
SEA (%)	5.3%	4.7%	-3.2%	3.1%	5.0%	4.6%	5.1%	5.0%	4.9%
Africa (%)	3.4%	2.9%	-1.8%	4.8%	3.7%	3.9%	4.2%	4.4%	4.4%
South America (%)	0.5%	0.0%	-6.6%	7.3%	3.6%	1.6%	2.2%	2.3%	2.3%
Central America (%)	3.9%	3.3%	-7.1%	11.0%	4.7%	3.6%	4.0%	4.0%	4.0%
Carribbean (%)	1.7%	0.6%	-4.7%	5.1%	12.4%	7.3%	6.9%	9.2%	9.1%

Note: E refers to Estimate

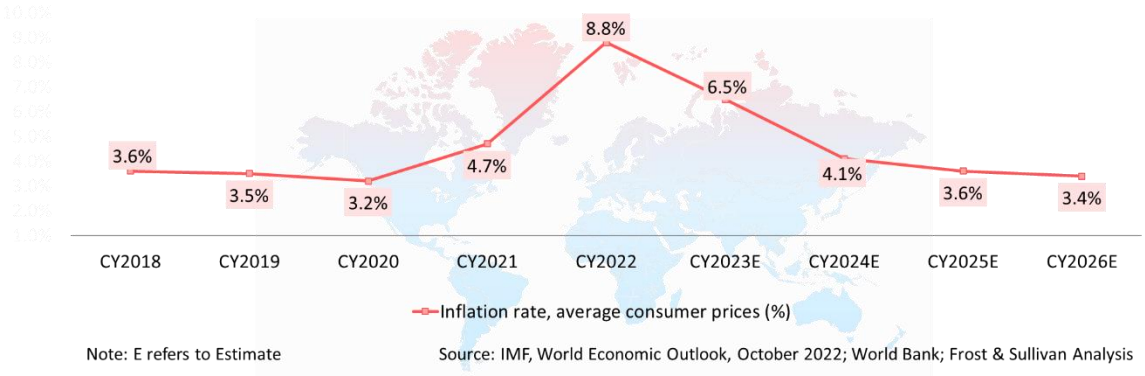
Source: IMF, World Economic Outlook, October 2022; World Bank; Frost & Sullivan Analysis

India is among the fastest growing economies, expected to grow at 6.1% in CY2023, after recording a growth of 6.8% in CY2022. India is expected to boost its capital spending in FY24 by 33% to about USD 122.3 billion, which is expected to create jobs and economic growth in the long-term. The USA's GDP is expected to grow by 1.0% in CY2023 backed by stronger-than-expected consumption and investments in the third quarter of CY2022, a strong labour market and consumer balance sheets. Europe is expected to grow at 0.7% in CY2023 as the region is adopting to higher energy costs quicker than expected. China's outlook too remains positive and forecast to grow at 4.4% in CY2023, driven by removal of COVID restrictions.

Inflation:

Increase in central bank rates to control inflation and Russia's war in Ukraine continued to weigh on economic activity across the world. Global inflation rate is expected to drop to 6.6% in CY2023 from 8.8% in CY2022, still above the pre-pandemic levels of 3.5%.

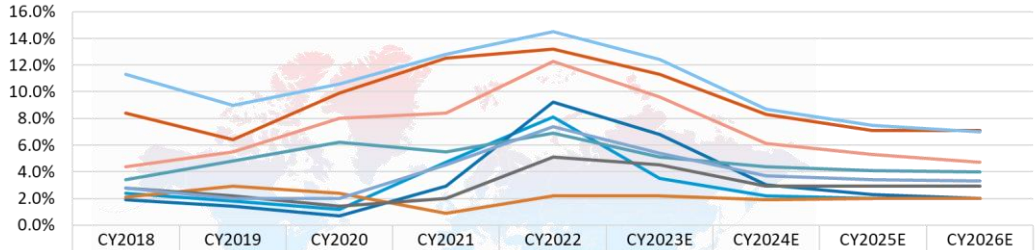
Exhibit 1.3: Inflation Rate – Historic and Forecast, World, CY2018 – CY2026E



Note: E refers to Estimate

Source: IMF, World Economic Outlook, October 2022; World Bank; Frost & Sullivan Analysis

Exhibit 1.4: Inflation Rate by Select Regions & Countries – Historic and Forecast, World, CY2018 – CY2026E



	CY2018	CY2019	CY2020	CY2021	CY2022	CY2023E	CY2024E	CY2025E	CY2026E
USA (%)	2.4%	1.8%	1.2%	4.7%	8.1%	3.5%	2.2%	2.0%	2.0%
Europe (%)	1.9%	1.4%	0.7%	2.9%	9.2%	6.8%	3.0%	2.3%	2.0%
Middle East (%)	8.4%	6.4%	9.9%	12.5%	13.2%	11.3%	8.3%	7.1%	7.1%
China (%)	2.1%	2.9%	2.4%	0.9%	2.2%	2.2%	1.9%	2.0%	2.0%
India (%)	3.4%	4.8%	6.2%	5.5%	6.9%	5.1%	4.4%	4.1%	4.0%
South East Asia (%)	2.8%	2.2%	1.4%	2.0%	5.1%	4.5%	2.9%	2.9%	2.9%
Africa (%)	11.3%	9.0%	10.6%	12.8%	14.5%	12.4%	8.7%	7.5%	7.0%
Central America (%)	2.8%	2.0%	2.0%	4.5%	7.4%	5.4%	3.7%	3.4%	3.3%
Carribbean (%)	4.4%	5.5%	8.0%	8.4%	12.3%	9.6%	6.1%	5.3%	4.7%

Note: E refers to Estimate

Source: IMF, World Economic Outlook, October 2022; World Bank; Frost & Sullivan Analysis

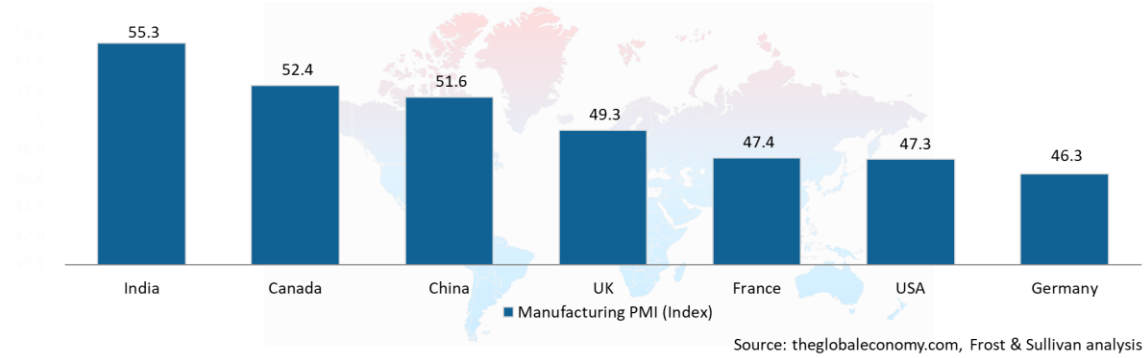
In most economies, amid the cost-of-living crisis, the priority remains achieving sustained disinflation. With tighter monetary conditions and lower growth potentially affecting financial and debt stability, it is necessary to deploy macroprudential tools and strengthen debt restructuring frameworks. Accelerating COVID-19 vaccinations in China would safeguard the recovery, with positive cross-border spill overs. Fiscal support should be better targeted at those most affected by elevated food and energy prices, and broad-based fiscal relief measures should be withdrawn. Stronger multilateral cooperation is essential to preserve the gains from the rules-based multilateral system and to mitigate climate change by limiting emissions and raising green investment.

Manufacturing Purchasing Managers Index:

The manufacturing Purchasing Managers Index (PMI) is an indicator of economic health for the manufacturing sector. Manufacturing activity across the USA, Europe and Asia reduced in January 2023, underscoring the uncertainty of the global economic recovery. However, Europe's Purchasing Managers' Index (PMI) for manufacturing reached a five-month high of 48.8 – although a number

below 50 indicates contraction. China's economic activity got back to growth mode in January 2023, after a wave of COVID-19 infections restricted manufacturing activities. China's official PMI rose to 50.1 in January 2023 and 51.6 in February 2023 from 47.0 in December 2022, as domestic orders and consumption drove manufacturing output higher. (Source: theglobaleconomy.com[1])

Exhibit 1.5: Manufacturing PMI, Select Countries, February 2023



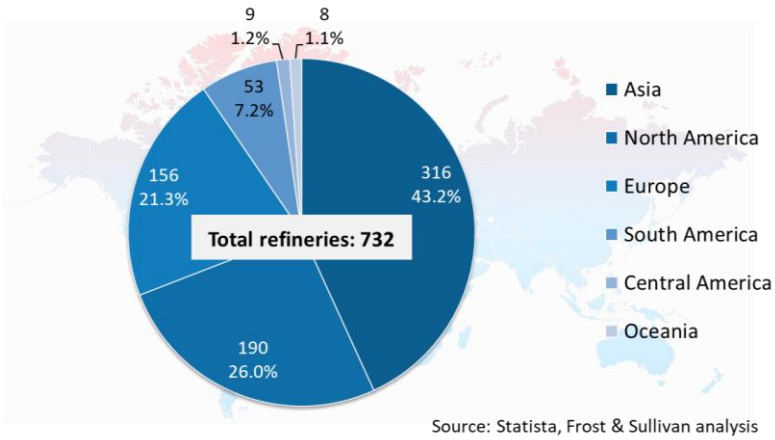
Source: theglobaleconomy.com, Frost & Sullivan analysis

Global end-user segment analysis

Sectoral Analysis – Refinery:

The global demand for oil refining is driven by increasing investment in refinery capex and construction sector. The demand for petroleum products is driven by positive outlook towards aviation and road transportation segments. Further, rapid industrialization and urbanization, along with increase in population among developing countries, such as China and India, ae expected to create demand for automobiles, which would in turn drive the demand for refined petroleum products.

Exhibit 1.6: Count of operational refineries, World, CY2021



Source: Statista, Frost & Sullivan analysis

There are about 732 refineries in the world at the end of CY2021 and about 43% of them are in Asia, followed by 26% in North America and 21% in Europe. The total refinery capacity in CY2021 was 101.9 million barrels per day. Installed capacity grew by a Compounded Annual Growth Rate (CAGR) of 0.7% from CY2011 to CY2021. The USA, China, Russia, India, and South Korea are the top five countries in terms of refining capacities and account for 50.4 million barrels per day cumulatively in CY2021. In terms of market share, these five countries account for 49.4% of the total installed capacity in CY2021.

[1] *https://www.theglobaleconomy.com/rankings/pmi_manufacturing/*

Exhibit 1.7: Crude Oil Refinery Installed Capacity, World, CY2011 – CY2021

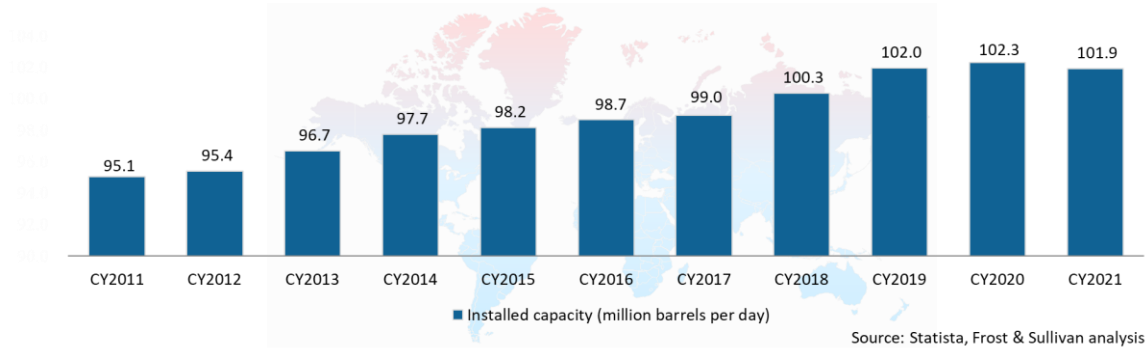
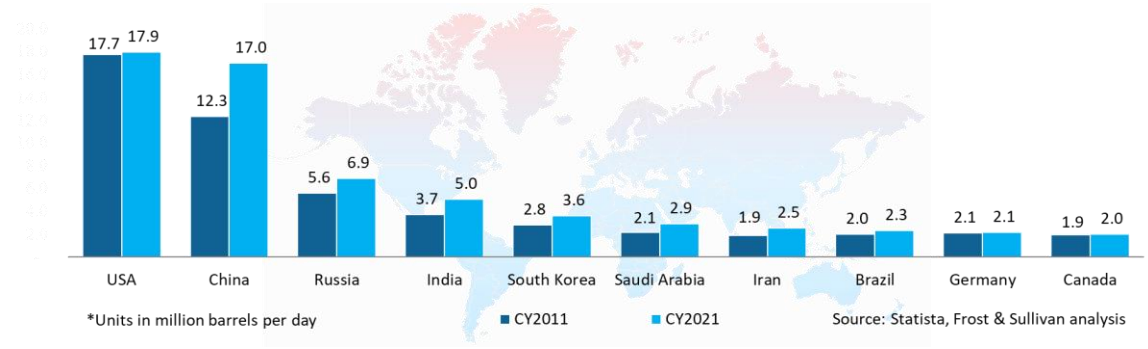


Exhibit 1.8: Crude Oil Refinery Installed Capacity – Top 10 Countries, World, CY2011 & CY2021

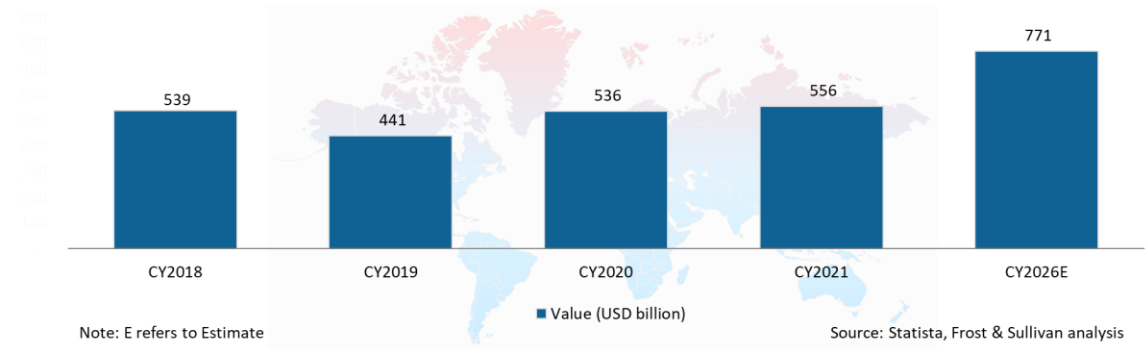


To meet the growing demand for refined petroleum products, governments of developing countries are planning to expand the country's refining capacity. Indian government is aiming to double the country's refining capacity to around 450-500 million metric tons (MMT) by CY2030. Other key driver for capacity addition is the government initiative to reduce import dependency, for example, the KSA, Iraq, and Iran.

Sectoral Analysis – Petrochemicals:

The petrochemical sector is a major global industry with substantial economic and environmental impacts. This industry evolved from oil & gas processing by adding value to by-products that have limited applications in the fuels segment. The output from the petrochemical plants is used as raw materials for manufacturing a wide range of industrial and consumer products such as plastics, fertilizers, synthetic fibers, solvents, additives, adhesives, and pharmaceuticals.

Exhibit 1.9: Petrochemical industry market size, World, CY2018 – CY2026E

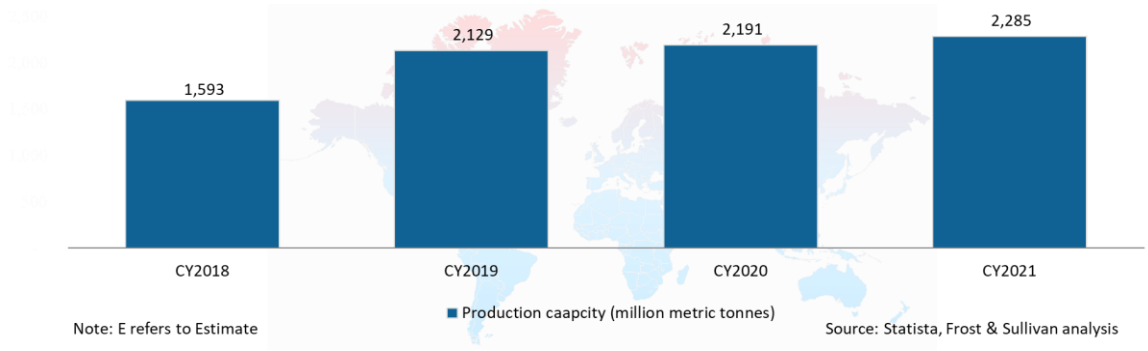


The global petrochemical industry is valued at USD 556 billion in CY2021, registering a CAGR of 1.0% between CY2018 and CY2021. Continued growth in key end user segments such as packaging and

construction, driven by economic development in China, India and Southeast Asian countries would drive the demand for petrochemicals in the long-term. The global market is expected to reach USD 771 billion by CY2026, recording a CAGR of 6.8% between CY2021 and CY2026.

Until the twentieth century, production of petrochemicals was concentrated primarily in Western Europe, USA, and Japan. However, Middle East and Asia has seen significant capacity additions in the last few decades. The current petrochemical production capacity is 2,285 million metric tons (MMT) and has recorded a CAGR of 12.8% from CY2018 – CY2021.

Exhibit 1.10: Petrochemical production capacity, World, CY2018 – CY2021



Asia Pacific is the largest region in terms of consumption. Increased government spending and manufacturing capacity are expected to impact demand in this region. The USA is another key market, backed by shale gas exploration. Driven by this growth, the total production capacity is expected to reach a little over 3,100[2] MMT by CY2030. China, India, and Iran would be the key countries contributing to these capacity additions.

Exhibit 1.11: Petrochemical capacity additions – planned and announced, World, CY2019 - CY2030

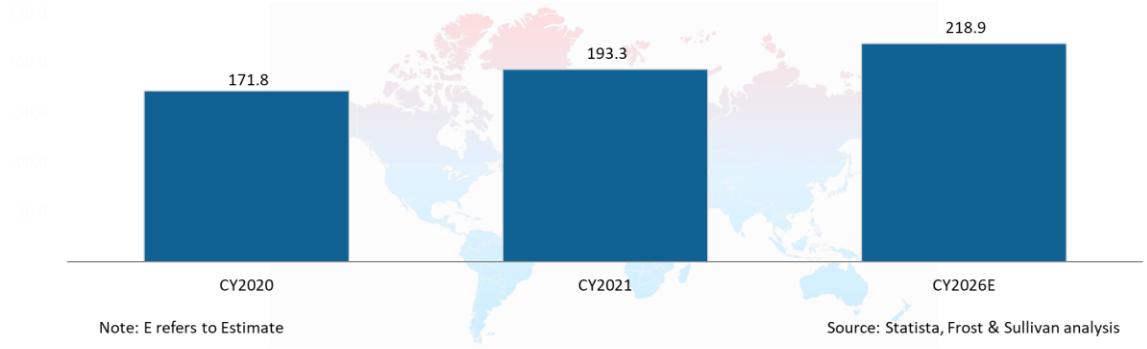
Sectoral Analysis – Fertilizers:

Growing population and changing dietary habits are contributing to the growth of the fertilizer industry globally. As per the United Nations report, the world population is expected to cross nine billion people by CY2050 and this would put significant pressure on agriculture industry, which is already suffering from production loss due to manpower shortage and loss of agricultural plots to urbanization. Food and Agriculture Organization cites that more than 70% of the world's population

[2]*https://www.petro-online.com/news/fuel-for-thought/13/global-data/china-to-lead-global-petrochemical-capacity-additions-by-2030/57234*

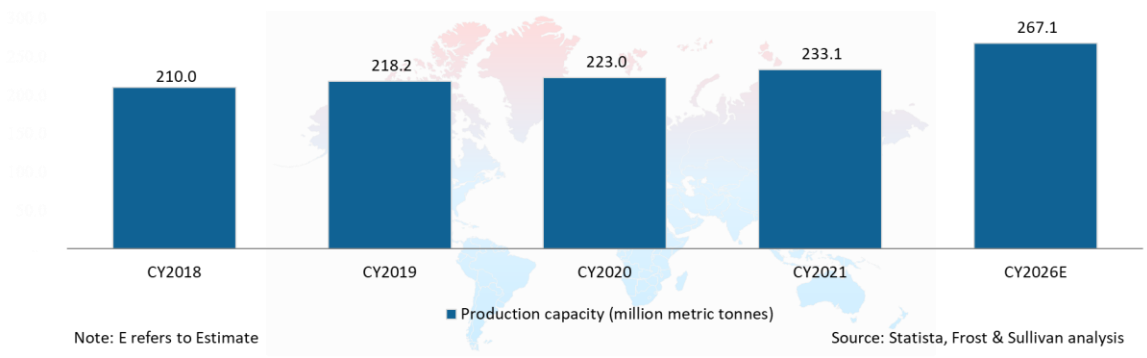
would live in urban places by CY2050 and this would create demand for food, which would in turn drive the fertilizers market.

Exhibit 1.12: Fertilizer industry market size (USD billion), World, CY2020 – CY2026E



Asia-Pacific is the largest fertilizer market and is expected to remain the dominant region during the forecast period. The growing agricultural practices and demand for high-quality agricultural produce are expected to drive the growth of the fertilizers market in Asia-Pacific. Rice, sugarcane, fruits, vegetables, cereals, and grains are among the major crops grown in Asia. China is the largest producer and exporter of fertilizers in the world and accounts for around 25% of the production in CY2021 as per United States Department of Agriculture (USDA). Urea, one of the major fertilizer types has a global capacity of 233.1 MMT in CY2021 and is expected to reach 267.1 MT by CY2026, recording a CAGR of 2.8%.

Exhibit 1.13: Urea production capacity, World, CY2018 – CY2026E



India is the third largest producer and second largest consumer of fertilizers in the world. India is still import-dependent for their fertilizer demand and therefore has significant potential for capacity additions in the coming years.

CHAPTER 2: INDIAN MACRO-ECONOMIC REVIEW

India Macro-economic Overview:

Indian economic growth ended on a positive note in FY22, outperforming many other major economies, as the pandemic faded. The government has been promoting structural reforms (as part of the FY22 budget), such as a focus on disinvestment and higher FDI limits, while also working on a national logistics policy. These reforms are critical for accelerating the post-pandemic economic recovery. The FY24 budget has proposed a total capex outlay of INR 10 trillion, which is a 33% increase y-o-y and 3.3% of the total GDP. In addition, the government has announced seven priorities for the

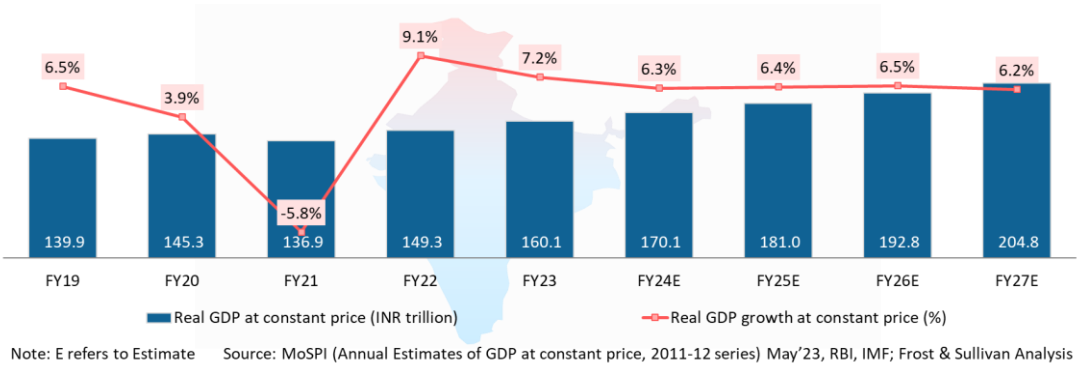
budget, 'Saptarishi' which include inclusive development, reaching the last mile, infrastructure, and investment, unleashing the potential, green growth, youth power, and the financial sector.

In CY2019, the Indian government set a target of becoming a USD 5 trillion economy and a global powerhouse by FY25. As a result of the COVID pandemic, the government revised the original timeline by 18–24 months. In a realistic scenario, the target is achievable with a GDP of 8 - 8.5%.

Review and outlook of real GDP growth in India:

The Indian economy is the fifth largest in the world, with a GDP of USD 3.75 trillion in FY23 (MoSPI estimates). The last decade was a mixed bag for the Indian economy with a see-saw movement in the GDP growth between FY11 and FY21. The economy, which was already slowing down since FY18, received a massive jolt in FY21 due to Covid 19 pandemic and shrunk by 5.8% in FY21. However, the Indian economy showed tremendous resilience and bounced back from Q3 FY21 on the back of corrective measures taken by the government along with huge pent-up demand and the festive season. FY22 and FY23 were strong, and the Indian economy registered 9.1% and 7.2% growth respectively, outperforming many other major economies.

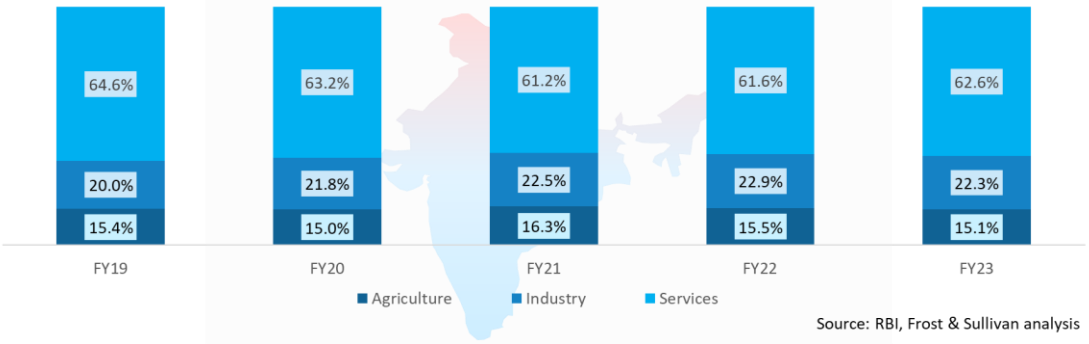
Exhibit 2.1: Real GDP and real GDP growth (annual percentage change), India, FY19 - FY27E



Note: E refers to Estimate Source: MoSPI (Annual Estimates of GDP at constant price, 2011-12 series) May'23, RBI, IMF; Frost & Sullivan Analysis

The outlook for FY24 looks positive, with a 6.3% growth in real GDP. The government has implemented a slew of measures to get the economy back on track. Through various policy initiatives such as Atmanirbhar Bharat, PLI schemes and so on, there is a strong emphasis on the growth of the domestic manufacturing sector. These initiatives will assist the economy in achieving medium-term stable growth of 6.3% between FY23 and FY27.

Exhibit 2.2: Percentage Contribution of Gross Value Add by Sectors, India, FY19 - FY23



Source: RBI, Frost & Sullivan analysis

The privatisation of a few public sector undertakings is expected to boost private sector participation in the industry. Favourable business environment, liberal FDI norms, constantly improving 'Ease of

Doing Business' rankings, enormous consumer base and rapidly improving digital infrastructure are some of the key factors that will drive investment in India in the coming years.

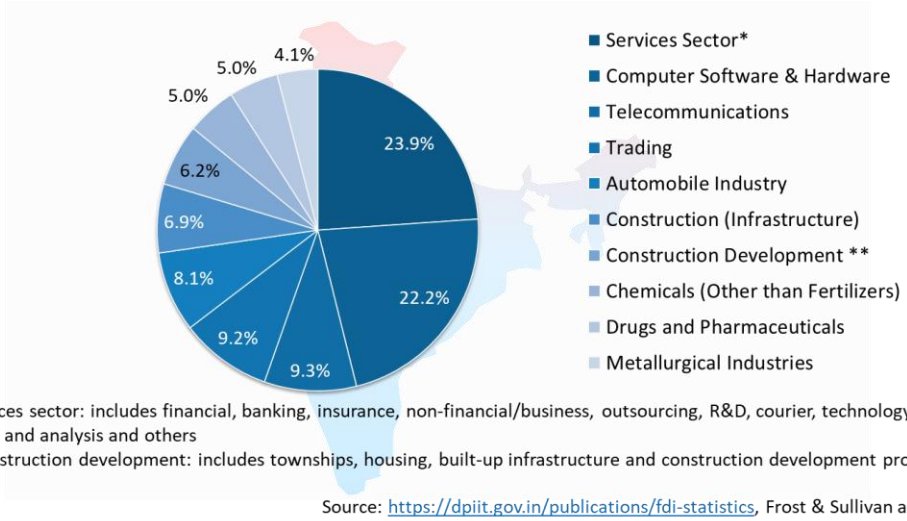
Services sector is the major driver of the Indian economy with a share of 61.6% in FY22 followed by Industrial segment with a share of 22.9%. The Manufacturing segments GVA contribution stood at 18.2% of the total GVA in FY22.

Growth Drivers of the Indian Economy:

Services Sector: The Services sector is the major contributor to the growth of the Indian economy. The services industry not only accounts for the majority of India's GDP, but it also attracts significant foreign investment, contributes significantly to export, and employs many people. The key segments contributing to the growth of the Services sector are IT and E-commerce.

Manufacturing Sector: The manufacturing scenario in India has changed a lot in the last few years. From CY2014, the government policies changed and started favouring local manufacturing. According to the World Bank, India ranked 63rd out of 190 countries in 'Ease of Doing Business' in CY2021, an improvement of 79 positions between CY2014 and CY2021. The government's focus on manufacturing being one of the key pillars of the future Indian economy, through Make-in-India policies attracted the interest of both global and domestic companies. The following factors will contribute to India becoming the next manufacturing hub of the world.

Exhibit 2.3: Total FDI Equity Inflows, India, FY01 – FY22



* Services sector: includes financial, banking, insurance, non-financial/business, outsourcing, R&D, courier, technology, testing and analysis and others
** Construction development: includes townships, housing, built-up infrastructure and construction development projects

Source: https://dpiit.gov.in/publications/fdi-statistics, Frost & Sullivan analysis

India slashed the corporate tax rates to 22% from 30% for existing companies and to 15% from earlier rate of 25% for new manufacturing companies in CY2019. This concessional corporate tax rate of 15% would remain available for one more year, till March 2024, for newly incorporated manufacturing companies and this is set to give India the much-needed competitive edge over other countries.

- Stable political government that assures global investors on consistency in policies.
- Rising cost of labour in China while India is still at a lower end of this cost.
- Creation of National Manufacturing Zones (NMZ) in close coordination between centre and states for investment promotion.
- High domestic demand for products and services
- Duties and tariffs to discourage imports and encourage domestic value addition.

- Digitalization that accentuates demand for select products.

Key government policies and schemes driving manufacturing in India: The Government of India is encouraging domestic manufacturing through supporting policies and initiatives that are likely to lead to overall development in the ecosystem and will open up gates of opportunities for companies, vendors, and distributors in the market. Incentives for local manufacturing, demand side support through Government procurement, import barriers via duties and favourable steps like GST that reduced complexity of operations, are pull factors for both MNCs as well as domestic manufacturers to invest in India. Some of the key initiatives/ schemes/ programs introduced by the government in boosting the electronics industry in India include:

Atmanirbhar Bharat (Make in India initiative): In CY2014, the government of India announced this initiative to make India a global manufacturing hub, by facilitating both domestic as well as international companies to set-up manufacturing bases in India. India has the potential to be one of the most attractive manufacturing destinations and support the objective of 'Make in India for the World'. As per the scheme, the government released special funds to boost the local manufacturing. The scheme has also introduced multiple new initiatives, including promoting foreign direct investment, implementing intellectual property rights, and developing the manufacturing sector.

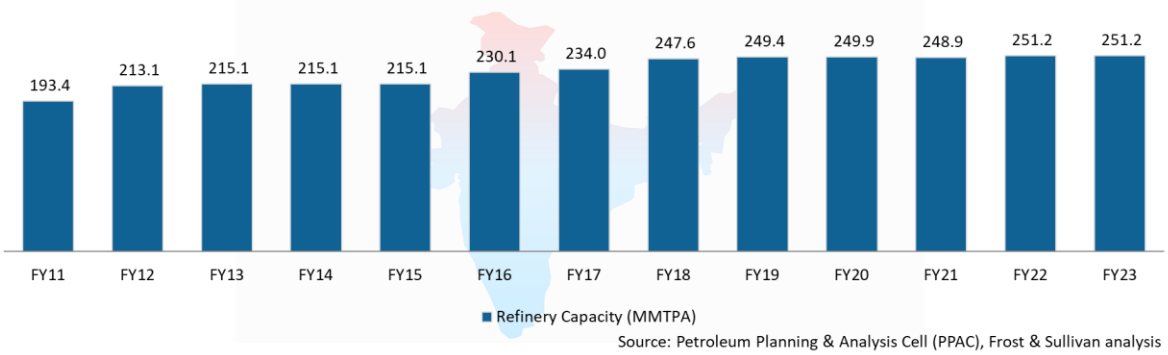
Atmanirbhar Bharat Abhiyaan, or Self-reliant India campaign, launched in May 2020, is the government's vision of New India following the announcement of a special economic and comprehensive package worth INR 20 trillion, or 10% of India's GDP, to combat the COVID-19 pandemic in India. This scheme entails a variety of measures across sectors, with larger focus on the CAPEX and R&D. The Make in India initiative, a part of the 'Atmanirbhar Bharat Abhiyan', would provide an additional boost to country's business operations by encouraging substitution of imports of low-technology products from other countries and generating demand for local manufacturing. Atmanirbhar Bharat Abhiyan is planned to get carried out in two phases:

- Phase 1: The emphasis will be on segments like medical, textiles, electronics, plastics and toys.
- Phase 2: For products like gems and jewellery, pharmaceutical and steel, etc.

Sectoral Analysis – Refinery:

India has witnessed solid growth in the refining industry in the past decade. The country has achieved self-sufficiency in refining demand and today is a key exported of quality refined petroleum products. The current installed capacity is at 251 million metric tons per annum (MMTPA) and is the fourth largest in the world after the USA, China, and Russia. The installed capacity grew by a CAGR of 2.4% between FY11 and FY23.

Exhibit 2.4: Installed Refinery Capacity, India, FY11 - FY23



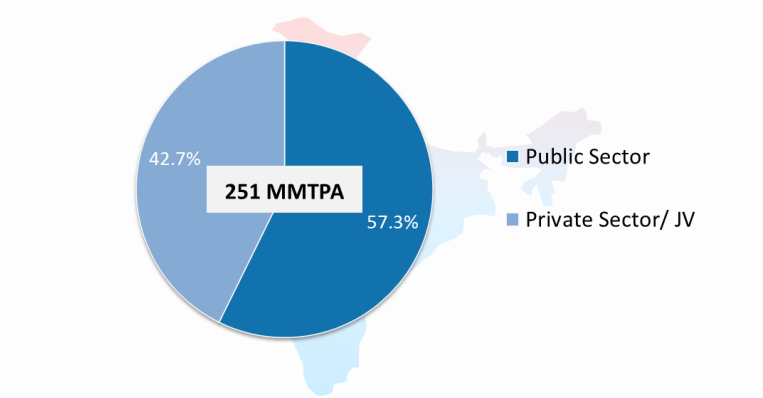
Source: Petroleum Planning & Analysis Cell (PPAC), Frost & Sullivan analysis

The capacity utilization stood at about 96% of the installed capacity in FY23. Crude oil processing in Indian refineries increased by 6% from 241.7 MMT in FY22 to 255.2 MMT in FY23. There are a total 23 refineries in the country, 18 in the public sector, 2 in the joint venture and 3 in the private sector.

Oil demand in India is expected to grow 2X to reach 11 million barrels per day by CY2045. Diesel demand in India is projected to reach 163 MT by FY30; diesel and gasoline are expected to account for 58% of India's oil demand by CY2045.

To launch Make in India campaign in oil & gas sector, the government approved a policy to provide "Purchase Preference linked with Local Content (PP-LC)" in all public sector plants under Ministry of Petroleum & Natural Gas in CY2017. The objective of the policy is to incentivize the growth in local content in by implementing oil and gas projects in India and providing purchase preference to the manufacturers/ consumers who meet the local content targets in oil and gas business activities.

Exhibit 2.5: Installed Refinery Capacity by Sector, India, FY23



Source: Petroleum Planning & Analysis Cell (PPAC), Frost & Sullivan analysis

The Government has adopted several policies to fulfil the increasing oil and refining demand. It has allowed 100% foreign direct investment (FDI) in many segments of the sector, including natural gas, petroleum products and refineries, among others. The FDI limit for public sector refining projects has been raised to 49% without any disinvestment or dilution of domestic equity in existing PSUs. Today, it attracts both domestic and foreign investment, as attested by the presence of companies such as Reliance Industries Ltd (RIL) and Cairn India.

Rapid economic growth is leading to greater demand for oil production, refining, and transportation. Crude oil processing reached a peak – 5.39 million barrels per day in January 2023 since CY2009 due to the increased exports to western countries, that were previously sourcing from Russia. In terms of barrels, India's oil consumption is forecasted to rise to 7.2 MBPD (360 MMTPA) by CY2030 and 9.2 MBPD in (460 MMTPA) by CY2050. Based on the growing demand, India is planning to double its oil refining capacity to 450-500 MMTPA by CY2030.

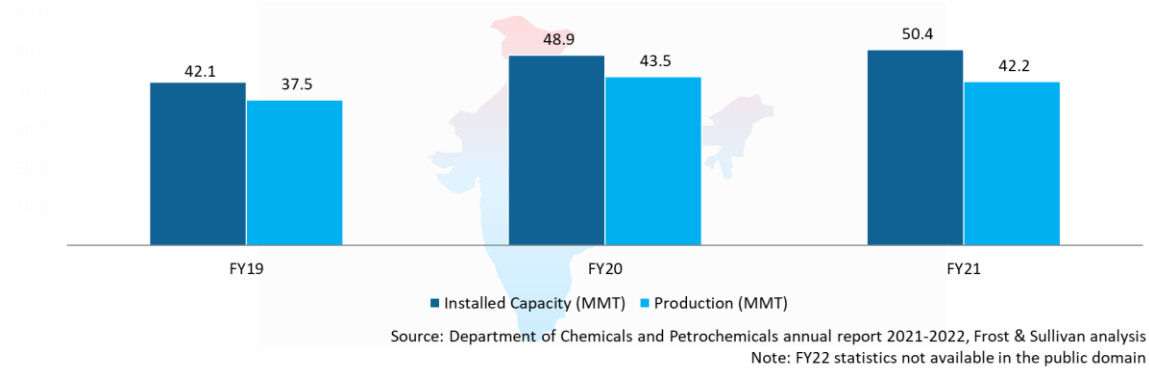
Sectoral Analysis - Petrochemicals:

Petrochemical market in India is currently valued at USD 190 billion[3], and has a high growth potential backed by the lower per capita consumption when compared to the developed economies. The production in FY21 was 42.2 MMTPA and is expected to reach 53.8 MMPTA, registering a growth of

[3]*https://www.livemint.com/news/india/india-will-contribute-10-of-incremental-global-petchem-demand-growth-puri-11671353138931.html*

around 4% CAGR from FY21-FY27, backed by a large population base and increasing penetration of petrochemical products in India. India is expected to add about 158 MMTPA of petrochemical capacity by CY2030, which would be about 20% of the expected global capacity additions.

Exhibit 2.6: Installed capacity and production of petrochemical products, India, FY19 - FY21

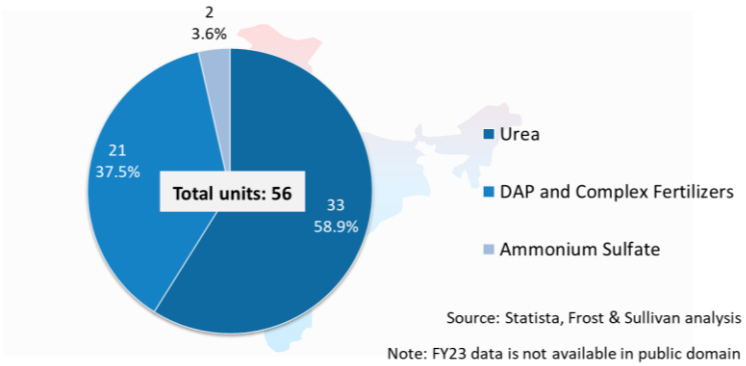


Source: Department of Chemicals and Petrochemicals annual report 2021-2022, Frost & Sullivan analysis
Note: FY22 statistics not available in the public domain

Sectoral Analysis - Fertilizers:

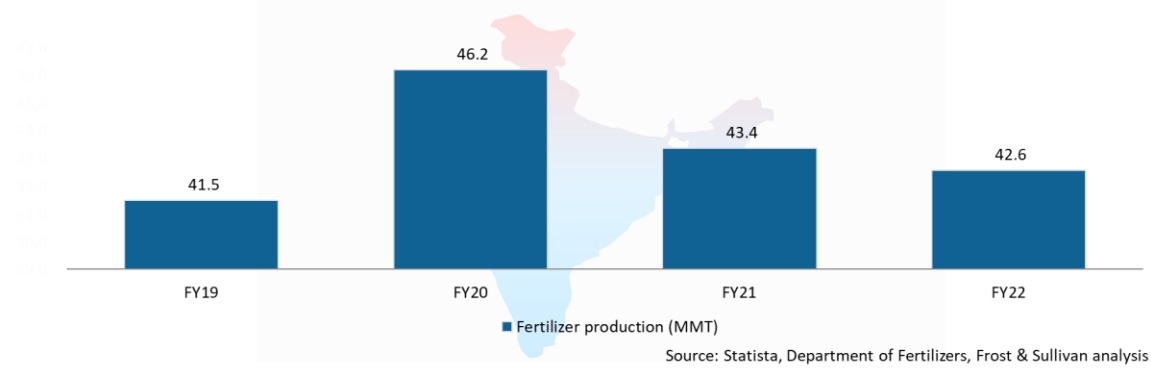
Fertilizers have played a key role in India's green revolution and subsequent self-reliance in food-grain production. This led to a significant growth in the fertilizers industry in India. Despite the growth, India remains one among the lower consumers of fertilizers when compared with other emerging and developed countries. Driven by the growing population, urbanization levels and decreasing arable land, the demand for fertilizers is expected to increase in the long-term in India. There are about 56 fertilizer manufacturing units in India and 33 of them produce urea.

Exhibit 2.7: Fertilizer Manufacturing Units by Types, India, FY22



Source: Statista, Frost & Sullivan analysis
Note: FY23 data is not available in public domain

Exhibit 2.8: Fertilizer production, India, FY19 - FY22

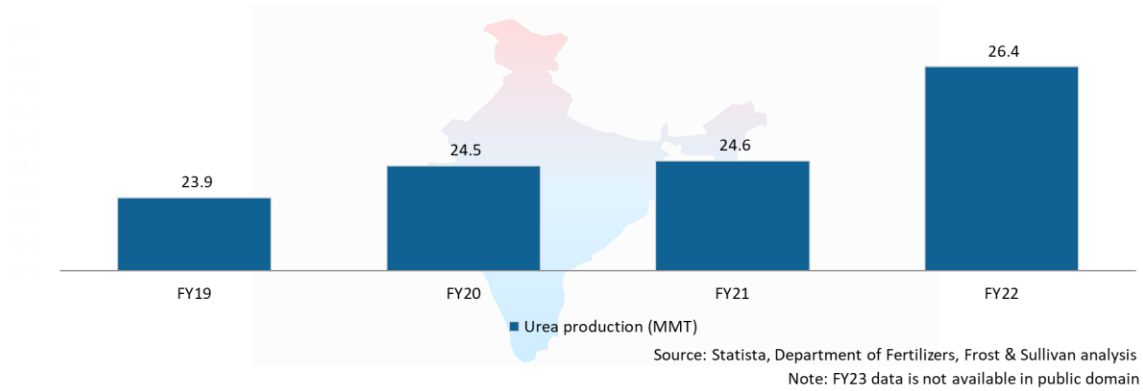


Source: Statista, Department of Fertilizers, Frost & Sullivan analysis
Note: FY23 data is not available in public domain

Total fertilizer production stood at 42.6 MMT in FY22, growing at a CAGR of 0.7% from FY18 – FY22. Marketing and promotional activities are key for the penetration of fertilizers; several governmental and non-governmental awareness campaigns are being conducted to educate farmers on the benefits of fertilizers. Multi modal approach through television, radio and customized rural workshops are expected to increase the consumption of fertilizers in the coming years. Increasing rural incomes and easy availability of loans are also expected to have a positive impact on fertilizer demand in the long-term.

One of the key fertilizer type, urea, recorded a manufacturing of 26.4 MMT in FY22, growing at a CAGR of 2.4% from FY18 – FY22.

Exhibit 2.9: Urea production, India, FY19 - FY22



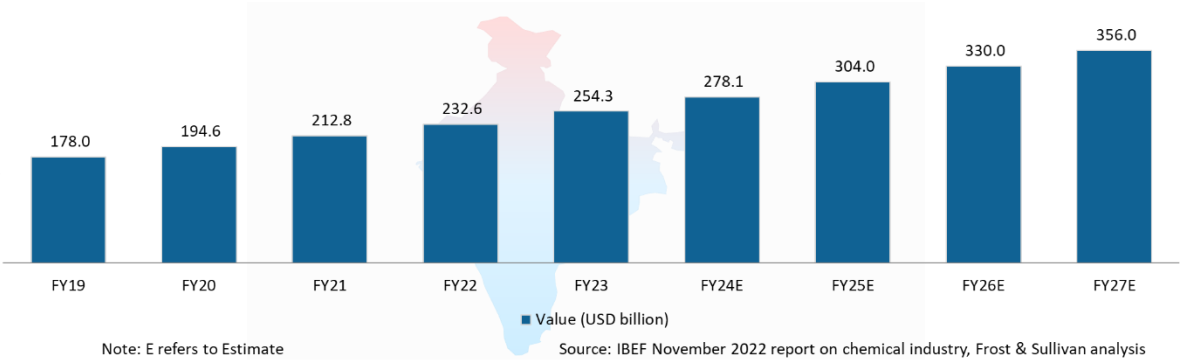
Source: Statista, Department of Fertilizers, Frost & Sullivan analysis
Note: FY23 data is not available in public domain

Several government initiatives such as the Urea Subsidy Scheme, Nutrient Based Subsidy Scheme (NBS) and Direct Benefit Transfer (DBT) projects for fertilizer subsidy payments implemented on a PAN India basis are expected to drive the industry demand in India and create further capacity additions in the long-term.

Sectoral Analysis – Chemicals:

India's attractiveness as a manufacturing hub has been rising because of competitive labour costs, ability to build manufacturing plants at lower costs than in the developed world, and recent changes to corporate tax rates. India has significant presence in production of basic organic chemicals, pesticides, paints, dyestuffs and intermediates and fine and specialty chemicals.

Exhibit 2.10: Chemical industry market size, India, FY19 - FY27E

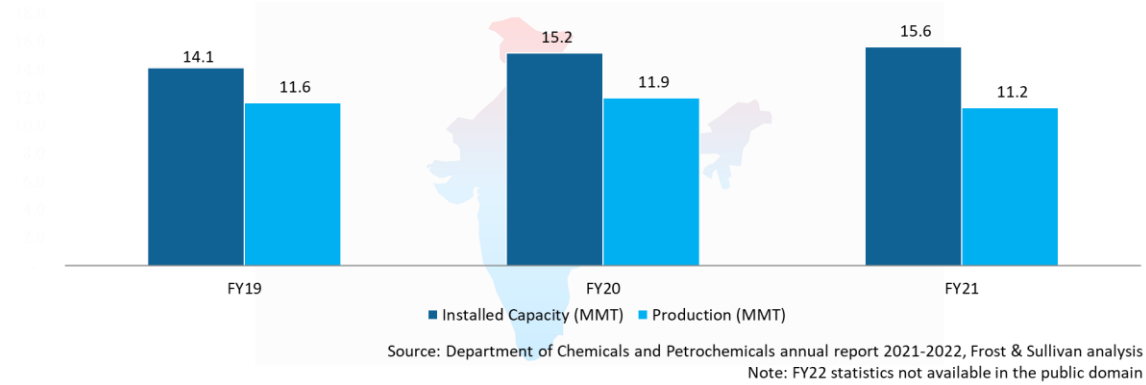


Note: E refers to Estimate
Source: IBEF November 2022 report on chemical industry, Frost & Sullivan analysis

The Indian chemical industry is one of the most important sectors of the economy and contributes to about 7.0% of the GDP in FY23. Chemicals industry in India is highly diversified and consists of more than 80,000 commercial products. The industry can be segmented into bulk, specialty, agrochemicals,

polymers, and others. Despite COVID-19, the chemical industry has been one of the few sectors to have survived the slowdown and grown by leaps and bounds.

Exhibit 2.11: Installed capacity and production of chemical products, India, FY19 - FY21



Source: Department of Chemicals and Petrochemicals annual report 2021-2022, Frost & Sullivan analysis
Note: FY22 statistics not available in the public domain

Rising demand for chemicals from end user segments such as agriculture, consumer durables, retail, infrastructure, automotive, electronics and healthcare are expected to drive the demand for chemicals, which would create the need for further capacity additions in the long-term. Key chemical clusters in India are Gujarat, Maharashtra, Odisha, Tamil Nadu, Andhra Pradesh, and Uttar Pradesh.

CHAPTER 3: USAGE AND APPLICATIONS OF PRODUCTS OF INTEREST

Products / Services under assessment:

This report includes the following product / services groups for opportunity assessment. These are as follows:

1. Heating equipment
    a. Process fired heaters
    b. Steam/ hydrogen reformers
    c. Cracking furnaces
2. Waste gas handling systems
    a. Flare systems
    b. Incinerators
3. Renewable energy systems
    a. EPC of Hydrogen Fuelling Stations
    b. EPC of Solar PV plants

A brief description of the above products / services and their applications are provided below.

Heating equipment:

Product overview:

a. Process fired heaters:

- A process fired heater [(also called direct heaters)] is a type of industrial heater used to heat fluids or gases directly by burning a fuel source such as natural gas or propane. In a direct fired heater, the fuel is burned in a combustion chamber, and the heat is transferred to the fluid or gas being heated through direct contact. The heated fluid or gas is then

circulated through a system to provide heat to a process or space. Direct fired heaters come in a variety of designs, including vertical and horizontal configurations, and can be customized to meet specific heating requirements. They are generally more efficient than indirect fired heaters, which require a heat transfer medium such as thermal oil or steam to heat the fluid or gas. Direct fired heaters are an effective and efficient heating solution for a wide range of industrial applications, but proper design, installation, and operation are critical to ensure safe and reliable performance.

b. Steam/ hydrogen reformers:

- In industrial processes, Reformers are devices used to convert hydrocarbons, such as natural gas or naphtha, into synthesis gas or syngas, which is a mixture of hydrogen and carbon monoxide. Syngas is a key building block to produce a wide range of chemicals, including methanol, ammonia, and synthetic fuels. Reformers typically operate at high temperatures and use a catalyst to promote the conversion of hydrocarbons into syngas. There are two main types of reformers:
  - **Steam reformers:** These use steam and a catalyst to react with hydrocarbons to produce syngas. Steam reforming is the most common method for producing syngas, as it is highly efficient and can handle a wide range of feedstocks.
  - **Autothermal reformers:** These use a combination of steam and oxygen to promote the reaction between hydrocarbons and water. Autothermal reforming can produce syngas at a higher temperature and pressure than steam reforming and can be more efficient for certain feedstocks.

c. Cracking furnaces:

- Cracking furnaces are used to break down large hydrocarbon molecules into smaller ones, which can then be used to produce a variety of products, including fuels, chemicals, and plastics. The process of breaking down hydrocarbons is known as cracking, and it typically involves heating the hydrocarbon feedstock in the presence of a catalyst. Cracking furnaces operate at high temperatures and pressures and are typically fuelled by natural gas or fuel oil. They can be either fired or electrically heated and can be configured in a variety of ways, including vertical and horizontal designs. The most common type of cracking furnace is the steam cracking furnace, which uses steam as a diluent to prevent thermal cracking and promote the formation of smaller hydrocarbons.

Product applications:

These products are being used [primarily / inter alia] in refineries, petrochemicals, and fertilizer plants. The product versus application mapping is presented below.

Exhibit 3.1: Usage of heating equipment in the segments of interest

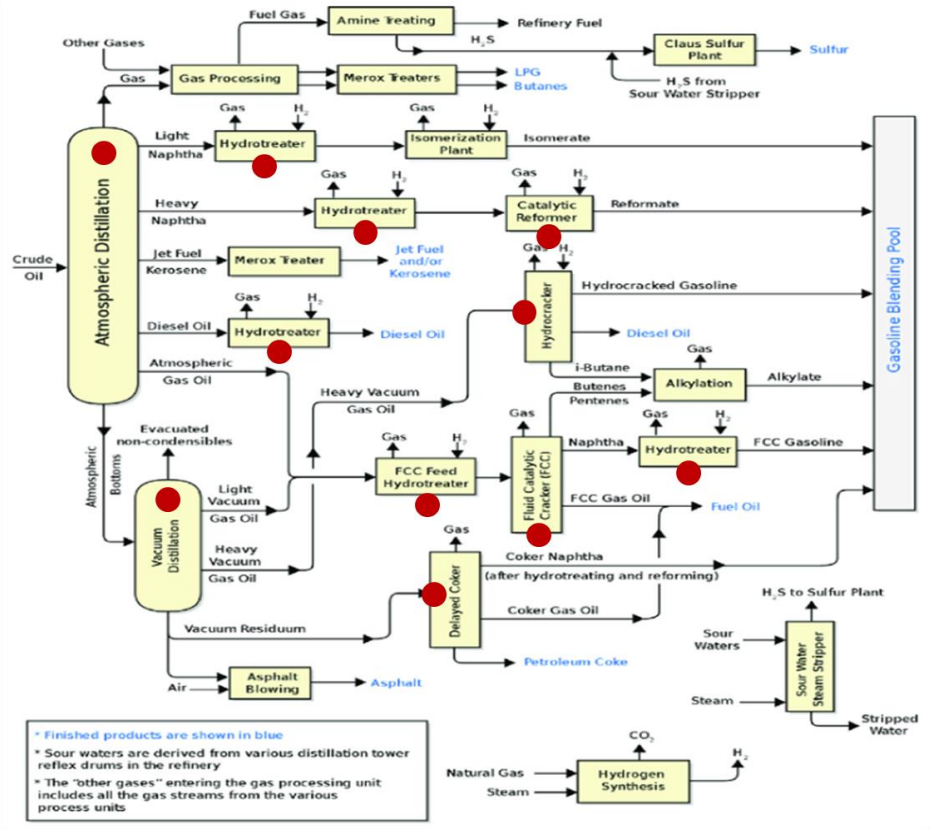
Segments	Process Fired Heaters	Reformers	Cracking Furnaces
Refinery	✓	✓	
Petrochemicals	✓	✓	✓
Fertilizers	✓	✓	

Source: Frost & Sullivan research

A. Applications of heating equipment in a refinery:

Process fired heaters and reformers are used in a typical refinery. Process fired heaters are the critical equipment in a refinery. Around 10 – 20 process fired heaters are used in any typical refinery. Of all the process fired heaters, four applications such as the crude distillation unit (CDU), vacuum distillation unit (VDU), delayed coker unit and catalytic reforming units are the most critical and the capex for these heaters is also high when compared with the other heater application areas in the refinery. Other applications for process fired heaters are hydrotreaters, hydrocrackers, fluid catalytic cracker (FCC), etc.

Exhibit 3.2: Process flow diagram of a typical refinery



This indicates the various units in a refinery where heating equipment are used

Source: https://www.researchgate.net/figure/Process-flow-diagram-of-a-typical-refinery_fig3_355678568, Frost & Sullivan

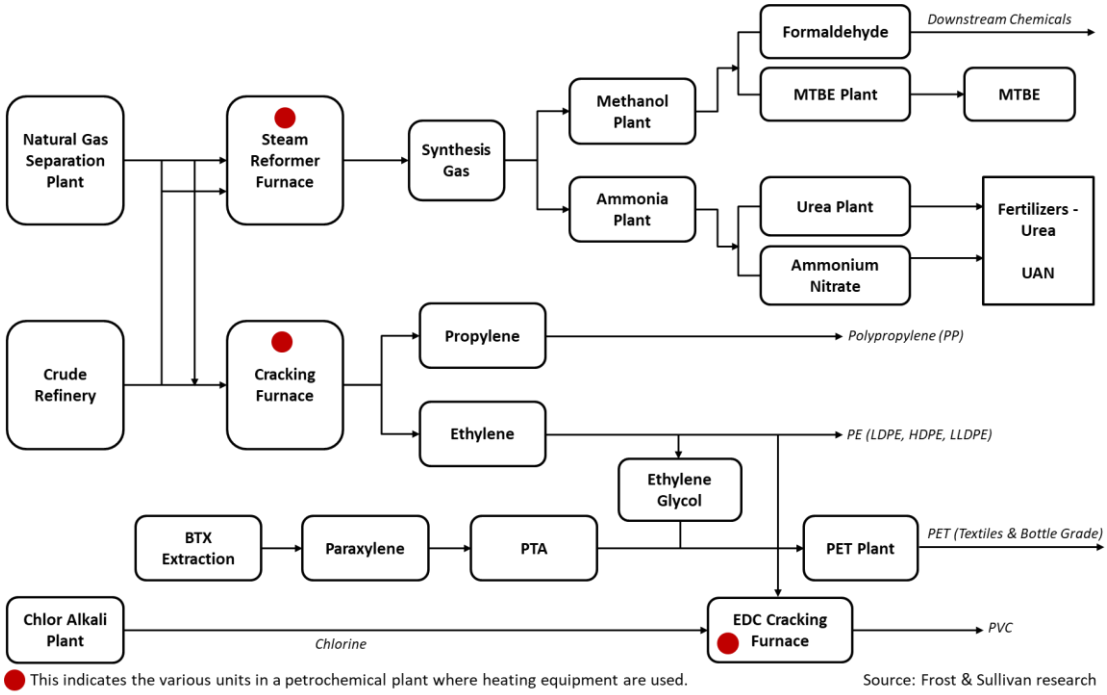
Key processes where process fired heaters are used in a refinery are:

1. Crude Distillation Unit (CDU)
2. Vacuum Distillation Unit (VDU)
3. Fluid Catalytic Cracker Unit (FCCU)
4. Hydrocracker Unit
5. Visbreaker Unit
6. Delayed Coker Unit
7. Catalytic Reforming Unit
8. Hydrotreating Unit
9. Bitumen Blowing Unit

B. Applications of heating equipment in a petrochemical plant:

Various heating equipment such as process fired heaters, reformers and cracking furnaces are used in a petrochemical plant. Reformers and cracking furnaces are the most critical equipment in a petrochemical plant. The feedstock (primarily naptha and natural gas) is fed into the cracking furnace where it is cracked under high-severity conditions, producing ethylene, propylene, and other by-products. This process is called pyrolysis or steam cracking.

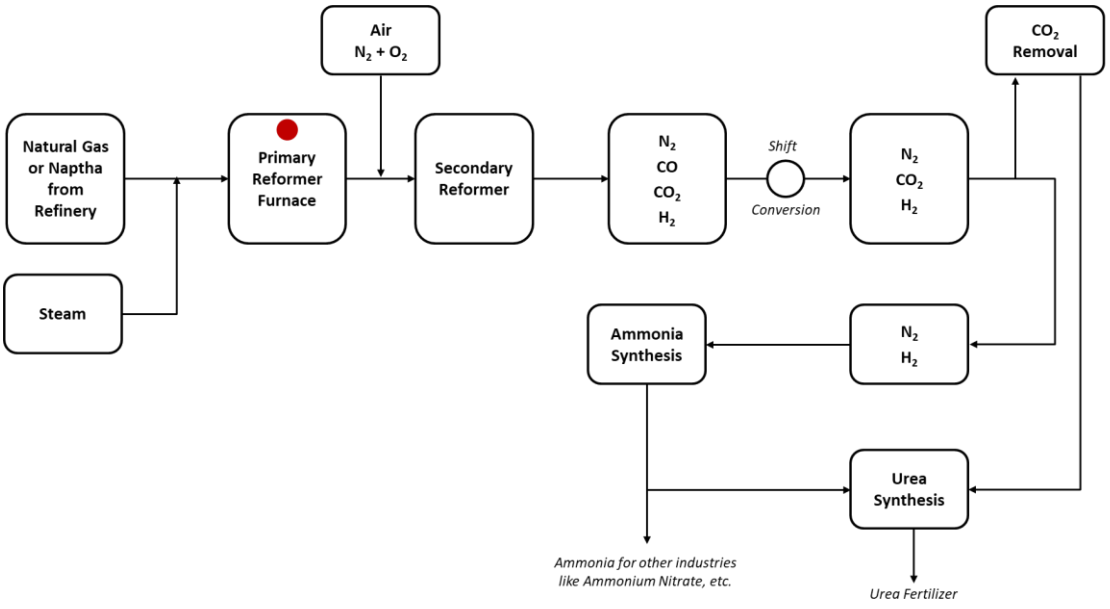
Exhibit 3.3: Process flow diagram of a typical petrochemical plant



C. Applications of heating equipment in a fertilizer (Urea) plant

Process fired heaters and reformers are used primarily in the ammonia plant of an integrated urea plant. Reformers are the most critical equipment in an ammonia plant. Reformers are used in ammonia production, which is later converted into urea. The process begins with a primary reformer to create hydrogen from a natural gas feedstock at temperatures over 1800°F. The hydrogen is then fed by a hydrogen transfer line into a secondary reforming vessel. In the secondary reformer, hydrogen in the presence of nitrogen reacts with a catalyst to form ammonia.

Exhibit 3.4: Process flow diagram of a typical ammonia plant



This indicates the various units in an Ammonia and Urea plant where heating equipment are used.

Source: Frost & Sullivan research

Capex:

Refinery: Refinery capacities vary from 3 MMTPA to 30 MMTPA. For capex etimation purpose, a mid sized refinergy of 15 MMTPA capacity has been considered. In a 15 MMTPA refinery, at an overall level, approx. 16 process fired heaters and one reformer are used with a combined capex of approximately INR 19,000 million.

Petrochemical: Capacity of a petrochemical plants vary from as low as 0.3 MMTPA to as high as 7.5 MMTPA. However, since most of the plants are in 1-1.5 MMTPA range, the same capacity range has been considered for estimating the capex. In a 1-1.5 MMTPA petrochemical plant, approx. 4 process fired heaters, 1 reformer and 6 cracking furnaces are used with a combined capex of approximately INR 26,500 million.

Fertilizer (Urea): Capacity of a fertilizer (Urea) plant vary from 0.5 MMTPA – 1.3 MMTPA. For capex estimation purpose, a mid sized Urea plant of 1 MMTPA capacity has been considered. In a 1 MMTPA Urea plant, 2 low capex process fired heaters and a reformer are used with a combined capex of approximately INR 3,000 million.

Exhibit 3.5: Summary of heating equipment usage in the segments of interest and corresponding capex

Segments	Process Fired Heaters				Reformers		Cracking Furnaces	
	High Capex Heaters*		Low Capex Heaters					
	Nos.	Price per unit (INR million)	Nos.	Price per unit (INR million)	Nos.	Price per unit (INR million)	Nos.	Price per unit (INR million)
Refinery (15 MMTPA)	4	2,000	12	750	1	2,000	0	0
Petrochemicals (1 – 1.5 MMTPA)	0	0	4	500	1	3,500	6	3,500
Fertilizers (1 MMTPA)	0	0	2	500	1	2,000	0	0

*CDU, VDU, Delayed coker unit, Catalytic reforming

Source: Frost & Sullivan research

Waste gas handling systems:

Product overview:

a. Flare systems:

- Flare system is a gas combustion device used in industrial plants such as petroleum refineries, chemical plants, natural gas processing plants, at oil or gas production sites with oil wells, gas wells, offshore oil and gas rigs, and landfills. Flare systems provide for the safe disposal of gaseous wastes. Flaring of gasses is intermittent in nature and is required whenever there is excess pressure in the system. For example, a failure in the water-cooling system of the furnaces may result in the shutdown of the furnaces. This in turn may result in increase in pressure of the system, hence, flaring is done. Thus, the flaring system is not used continuously. There are two types of flaring systems:
  - **Vertical flare systems:** The vertical flaring system is preferred to flare high pressure gas. Vertical flare has a safety diameter of 90 meters to prevent harm to other equipment. Thus, the vertical flare has large area requirement.
  - **Ground flare systems:** In ground flaring, the combustion of gas is done very close to the ground and the flaring region is surrounded by high walls to prevent access of wildlife and nearby inhabitants. Due to the surrounding wall, the lightning from the flare is not visible and the safety perimeter is reduced. The ground flaring system, thus, requires less area and does not cause harm to nearby farms. The ground flaring system can be used to flare both high pressure and low-pressure gas.

b. Incinerator systems:

- All sulphur recovery units (SRUs) in have thermal incinerators to treat the tail gas effluent from the SRUs prior to emitting the waste gas to the atmosphere. The purpose of the thermal incinerator is to facilitate the oxidation of all the common reduced sulphur compounds (H_2S, COS, CS_2 and sulphur vapour) to SO_2 prior to release to the atmosphere. The thermal incinerator also provides significant thermal energy to the SRU tail gas to raise the waste gas temperature sufficiently to ensure that the stack plume rises in the atmosphere. This facilitates the effective dispersion of the plume and ensures that the ground level concentration of the SO_2 from the plume does not exceed the standards for this pollutant.

Product applications:

Exhibit 3.6: Usage of waste gas handling systems in the segments of interest

Segments	Flaring Systems	Incinerators
Refinery	✓	✓
Petrochemicals	✓	
Fertilizers	✓	

Source: Frost & Sullivan research

While flaring systems are used across the segments of interest i.e., refinery, petrochemical and fertilizer plants, incinerators are primarily used in the refinery in the Sulphur Recovery Unit (SRU) for tail gas incineration.

Exhibit 3.7: Summary of waste gas handling systems usage in the segments of interest and corresponding Capex

Segments	Flaring Systems		Incinerators	
	Nos.	Price per unit (INR million)	Nos.	Price per unit (INR million)
Refinery (15 MMTPA)	1	2,000	1	500
Petrochemicals (1 – 15 MMTPA)	1	1,000	0	0
Fertilizers (1 MMTPA)	1	500	0	0

Source: Frost & Sullivan research

Renewable energy systems:

Product overview and application:

EPC of Hydrogen Fuelling Stations

- Setting up of Hydrogen Refuelling Stations consists of design, procurement, and construction work. A regular Hydrogen Refuelling Stations consists of hydrogen storage tanks, hydrogen gas compressors, a pre-cooling system and a hydrogen dispenser, which dispenses hydrogen to pressures of 350 bar, 700 bar or dual pressure dispensing, depending on the type of vehicle being refuelled.
- Based on data published by Department of Energy, U.S.A, across all the 111 planned new hydrogen fuelling stations, an average hydrogen station has capacity of 1,240 kg/day (median capacity of 1,500 kg/day) and requires approximately USD 1.9 million in capital (median capital cost of USD 1.9 million).
- As per Ministry of Renewable Energy, India, so far, two Hydrogen refuelling stations have been established in India. One at Indian Oil R&D Centre, Faridabad and the other one at National Institute of Solar Energy, Gurugram.

EPC of Solar PV Plants

- The solar Engineering, Procurement and Construction (EPC) refers to design, procurement, and construction of solar power plants. EPC companies are responsible for the end- to-end execution of solar projects, including feasibility studies, site assessment, engineering and design, equipment procurement, construction, and commissioning.
- Projects for EPC providers range from
  - Full turn-key EPC projects, where the EPC provider fully manages plant construction and typically provides operations and maintenance (“O&M”) services for the plant for two to five years, making a margin on the procurement of components and on the services provided.
  - Partial EPC projects, where the EPC provider is hired only for the engineering and construction of the plant.

- In-house EPC projects, where the EPC provider only takes on specific sub-contracted tasks from an in-house EPC team.
- Some EPC solution providers have also found opportunities in project development. The project is often sold immediately before construction, and an EPC contract is signed.

- Utility-scale solar projects, typically grid-connected solar power plants, have been the dominant segment in the Indian solar EPC market. These projects are usually developed by independent power producers (IPPs) or state-owned utilities. They contribute significantly to India's renewable energy capacity. Technological advancements in solar PV modules, inverters, energy storage, and monitoring systems have contributed to the growth of the solar EPC market. Improvements in solar panel efficiency, reduction in costs, and advancements in storage technologies have made solar power more viable and attractive for both large-scale and distributed solar projects.

CHAPTER 4: DEMAND FOR PRODUCTS OF INTEREST IN INDIA

End user sector outlook:

Refinery sector: Growth drivers and outlook

India is the 3rd largest oil consumer in the world and the oil demand is expected to reach 11 million barrels per day by CY2045, recording 2X growth between CY2022 and CY2045. Growing demand for transportation fuels and petrochemical feedstock are the primary growth enablers of the Indian refinery industry. India is expected to be one of the largest contributors to non-OECD petroleum consumption globally. As per Ministry of Petroleum and Natural Gas (MoPNG), the country's consumption of petroleum products during FY23 increased by 10% compared to FY22, reaching a volume of nearly 223 million metric tonnes. There are 18 refinery projects expected to be commissioned by FY31 with a cumulative capacity of 124.0 MMTPA.

Exhibit 4.1: List of upcoming refinery projects, India, FY24 - FY31

S. No.	Project Owner	Location	Project	Target Completion Year	Installed Capacity (MMTPA)	Capex (INR million)
1	Nayara Energy	Vadinar	Expansion phase 3 project	FY24	26.0	1,500,000
2	HPCL	Visakhapatnam	Expansion project	FY24	6.7	262,640
3	HPCL	Rajathan	Greenfield project	FY25	9.0	720,000
4	IOCL	Barauni	Expansion project	FY25	3.0	148,100
5	IOCL*	Guwahati	Expansion project	FY25	0.2	7,700
6	IOCL	Mathura	Expansion project	FY25	3.0	86,680
7	IOCL	Koyali	Expansion project	FY26	4.3	240,000
8	IOCL	Digboi	Expansion project	FY26	0.4	7,680
9	NRL	Numaligarh	Expansion project	FY26	6.0	280,260
10	RIL*	DTA Jamnagar	Expansion project	FY26	7.5	288,900
11	CPCL	Nagapattinam	Expansion project	FY27	9.0	315,800
12	IOCL*	Bongaigain	Expansion project	FY27	2.3	88,600
13	IOCL	Panipat	Expansion II project	FY27	10.0	329,460
14	BPCL*	Bina	Phase 3 expansion project	FY29	6.0	231,120
15	MRPL	Kuthethur	Phase 4 expansion project	FY29	6.3	241,550
16	HPL*	Kakinada	Greenfield project	FY31	1.7	65,480
17	IOCL	Paradip	Expansion project	FY31	10.0	520,000
18	Al-Quebla Al-Watya	Thoothukkudi	Greenfield project	FY31	12.7	490,000
				Total	**124.0**	**5,823,980**

Source: Petroleum Planning & Analysis Cell, CMIE Capex database, Frost & Sullivan analysis

*For projects where the capex information were not available, an average capex cost of INR 38,520 million per MMTPA is considered. Average capex has been derived from the capex of a long list of past, ongoing and future projects and the norm has been validated through discussions with the industry experts.

Petrochemicals sector: Growth drivers and outlook

Petrochemicals are key elements in the Indian industrial segment and a major driver for economic growth. In CY2020, the per capita consumption of polymers in India was around 12 kilograms, while the global average was 37 kilograms. With the progressive GDP growth, demand for the petrochemical products is expected to grow significantly over medium to long term. Driven by increased domestic consumption and global demand, the Indian petrochemical sector is seeing investments to benefit from the market opportunities.

Exhibit 4.2: List of upcoming petrochemical projects, India, FY24 - FY31

S. No.	Project Owner	Location	Project	Target Completion Year	Installed Capacity (MMTPA)	Capex (INR million)
1	Reliance	Dahej	Debottlenecking cum expansion 2 project	FY24	1.2	132,500
2	Reliance	Jamnagar	Crude-to-Chemical unit project	FY24	6.6	700,000
3	Reliance	Dahej	Petrochemical complex project – new unit	FY24	1.3	142,000
4	HMEL	Bhatinda	Bhatinda petrochemical complex (Guru Gobind Singh polymer additions complex) unit project	FY24	1.3	229,000
5	RIICO*	Barmer	Ramnagar PCPIR Project	FY24	2.4	258,190
6	Kinfra	Kochi	Ambalamugal petrochemical park project	FY25	0.1	12,000
7	Reliance	Vadodara	Debottlenecking of petrochemical plant & expansion plant project	FY26	0.7	22,700
8	BCPL	Lepetkata	Petrochemical complex plant expansion project	FY27	0.1	3,870
9	HPL*	Cuddalore	Cuddalore petrochemical complex project	FY27	1.8	191,810
10	HPL*	Balasore	Balasore petrochemical complex project	FY28	4.0	426,230
11	Reliance	Hazira	Petrochemical complex debottlenecking and expansion plant project	FY28	0.5	100,000
12	IOCL	Panipat	Naptha cracker unit (Phase II) and HDPE manufacturing plant project	FY29	0.6	55,950
13	GAIL + HPCL	Kakinada	Kakinada SEZ cracker unit (greenfield petrochemical complex) project	FY31	1.5	320,000
14	Groupe Veritas (GV)	Dighi Port	Nanavali petrochemical complex project	FY31	0.6	22,740
15	IOCL	Paradip	Paradip petrochemical PCPIR project	FY31	0.3	35,110
				Total	**23.0**	**2,652,090**

Source: CMIE Capex Database, Company Websites/ News Articles, www.offshore-technology.com, Frost & Sullivan analysis

*For projects where the capex information were not available, an average capex cost of INR 110,000 million per MMTPA is considered. Average capex has been derived from the capex of a long list of past, ongoing and future projects and the norm has been validated through discussions with the industry experts.

The government's ongoing efforts to promote economic development in India is one of the main factors influencing the growth of the petrochemical industry. The Department of Chemicals and Petrochemicals (DCPC) of the Government of India (GoI) has implemented several initiatives to improve the industry's overall competitiveness, quality, and output. Initiatives such as Make in India, Aatmanirbhar Bharat Abhiyan, and the Production-Linked Incentive (PLI) Scheme are implemented to attract domestic manufacturing and facilitate exports. The acceptance of petrochemicals in diverse industries such as healthcare, construction, agriculture, textiles, automotive, etc. is expected to accelerate the demand for petrochemical production in India.

A few of the notable measures for promoting the growth of the petrochemical industry are the mandatory standards set by the Bureau of Indian Standards (BIS), public procurement policies for chemicals and petrochemicals, schemes for setting up plastic parks, and adequate support for research and innovation by setting up canters of excellence. Policy incentives, low cost of manufacturing and manpower, and overall demand scenario are boosting business confidence to plan

larger petrochemical complexes in India. To promote investment in the petrochemicals sector, active steps are being taken in amending the PCPIR (Petroleum, Chemicals and Petrochemicals Investment Region) policy. The proposed new PCPIR policy will be implemented between CY2020–CY2035 and is expected to attract an approximate combined investment of over INR 34,000 billion (USD 420 billion) for the sector. There are 15 petrochemical projects expected to be commissioned by FY31 with a cumulative capacity of 23.0 MMTPA.

Fertilizer sector: Growth drivers and outlook

India is an agricultural economy and about 80% of the people depend on agriculture. India surpassed China to become the most populous country in CY2023. With the growing population, there is a need to increase agricultural production and diversify agricultural base. The government is focussing on irrigation, adoption of new agricultural technologies, credit facilities to farmers and the use of various agriculture input like better quality seeds, efficient and balanced use of fertilizers and insecticides to improve the yield. Fertiliser is one of the main agriculture inputs for increasing food grain production. It strengthens the soil and enhances its fertility.

Chemical fertilizers are the most used types in India, and they are classified into Urea, Diammonium Phosphate (DAP), Single Super Phosphate (SSP), Muriate of Potash (MOP) and other Complex fertilizers like Calcium Ammonium Nitrate (CAN) and various grades of NPK Fertilizers (Fertilizers having different grades of Nitrogen (N), Phosphorus (P), and Potassium (K)). Urea is the major fertilizer used in India and accounts for about 60% of the total fertilizer consumption in India. Local production of urea is not able to meet the domestic demand and about 30% of the demand is met through imports. India is planning capacity additions in this segment to reduce its import dependency and has a target to become self-reliant by CY2025. There are about four urea projects expected to be commissioned by FY26.

Exhibit 4.3: List of upcoming fertilizer (Urea) projects, India, FY24 - FY31

S. No.	Project Owner	Location	Project	Target Completion Year#	Installed Capacity (MMTPA)	Capex (INR million)
1	IFFCO	Kalol	Fertilizer plant modernization/expansion project	FY24	0.07	1,670
2	Talcher Fertilizer	Talcher	Odisha Ammonia Urea manufacturing plant project	FY25	1.04	50,000
3	BVFCL	Namrup	New brownfield Ammonia-Urea complex project	FY26	0.86	49,330
4	FACT	Udyogamandal	New Urea project*	FY26	0.50	24,020
				Total	**2.48**	**125,020**

Source: CMIE Capex Database, Frost & Sullivan analysis

*For projects where the capex information were not available, an average capex cost of INR 4,805 per MMTPA is considered. Average capex has been derived from the capex of a long list of past, ongoing and future projects and the norm has been validated through discussions with the industry experts.

#All the announced/ongoing urea projects will be commissioned by FY26 - no visibility of projects that will be commissioned post FY26.

Heating equipment:

Demand potential for heating equipment in India:

The demand potential for the heating equipment i.e., process fired heaters, reformers, and cracking furnaces have been estimated for Oil & Gas downstream segments only. The methodology used to estimate the demand potential is as below:

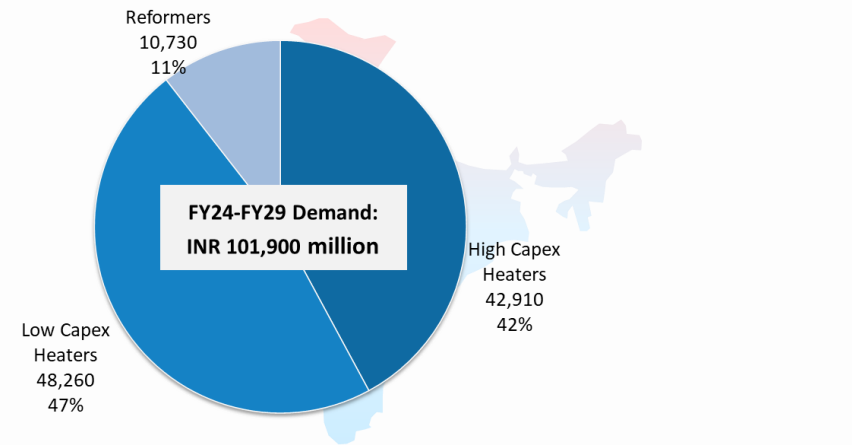
- **Step 1:** Derivation of capex norm for the segments of interest. A long list of projects (historical, ongoing, and upcoming) and their capex have been considered to derive the norm.

- **Step 2:** Derivation of capex norm for the products of interest in the segments of interest. This has been derived through discussions with the industry stakeholders and mapping the usage of products (in Nos.) across the segments of interest and average capex for each product.
- **Step 3:** Estimation of the total capacity additions in the segments of interest till FY31 – project that are ongoing / in the initial stage / announced and likely to come on stream by FY31.
- **Step 4:** Estimation of the total capex for the projects that will come online till FY31. **Considering a 2-year lag between equipment ordering and project commissioning, projects that would be commissioned between FY26 and FY31, have been considered for demand estimation.**
- **Step 5:** Application of the equipment capex norm on the project capex in the segments of interest to derive the demand for equipment –by type of equipment and by segments of interest.

A. Demand potential from Indian refinery segment:

- Based on exhibit 4.1, **12 refinery projects are likely to be commissioned between FY26 and FY31. Total installed capacity of these projects are 76.2 MMTPA with total capex of INR 3,098,850 million.**
- Considering a 2-year lag between equipment ordering and project commissioning, **these projects will generate demand for heating equipment between FY24 and FY29.**
- Heating equipment account for **3.3% of the total capex** of a refinery project.
- Hence, **demand for heating equipment from Indian refineries between FY24 and FY29 would be INR 101,900 million i.e., approx. INR 17,000 million on annualized basis.**
- This potential is based on the projects announced till date and may go up if more projects are commissioned during the forecast period.

Exhibit 4.4: Demand for heating equipment from refineries, India, FY24 - FY29



All values are in INR million

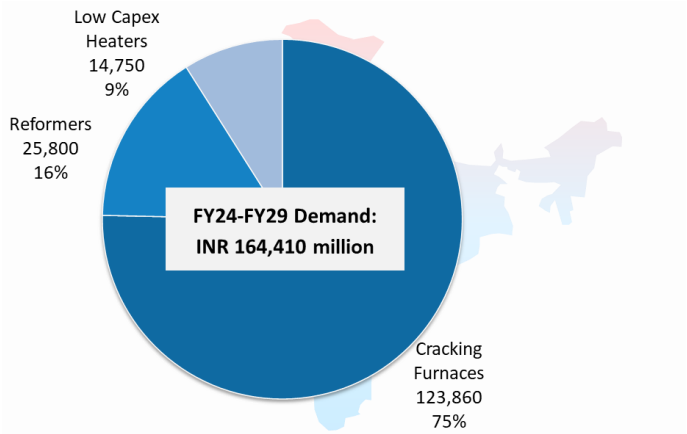
Source: Frost & Sullivan research and analysis

B. Demand potential from Indian petrochemical segment:

- Based on exhibit 4.2, **9 petrochemical projects are likely to be commissioned between FY26 and FY31. Total installed capacity of these projects are 10.1 MMTPA with total capex of INR 1,178,400 million.**

- Considering a 2-year lag between equipment ordering and project commissioning, **these projects will generate demand for heating equipment between FY24 and FY29.**
- Heating equipment account for 16.6% of the total capex of a petrochemical project. However, since cracking furnaces are used in approx. 80% of the petrochemical plants, the above norm has been adjusted to **14.0% of the total capex** for estimating the demand potential.
- Hence, **demand for heating equipment from Indian petrochemical segments between FY24 and FY29 would be INR 164,410 million i.e., approx. INR 27,500 million on annualized basis.**
- This potential is based on the projects announced till date and may go up if more projects are commissioned during the forecast period.

Exhibit 4.5: Demand for heating equipment from petrochemical segments, India, FY24 - FY29

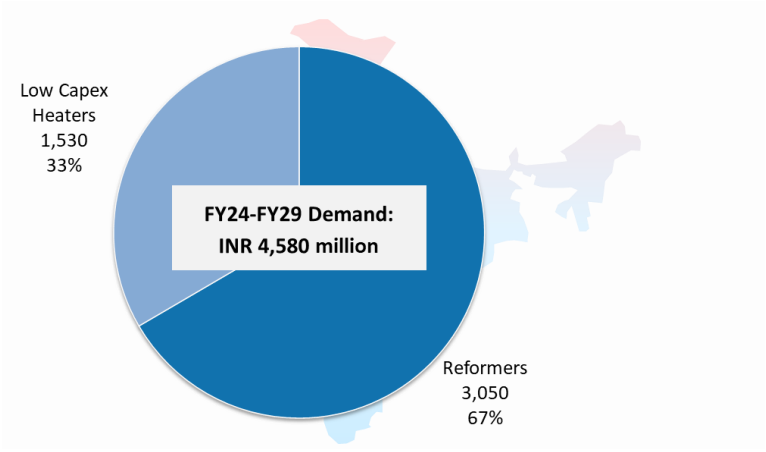


All values are in INR million

Source: Frost & Sullivan research and analysis

C. Demand potential from fertilizer (Urea) segment:

Exhibit 4.6: Demand for heating equipment from fertilizer (Urea) segments, India, FY24 - FY29



All values are in INR million

Source: Frost & Sullivan research and analysis

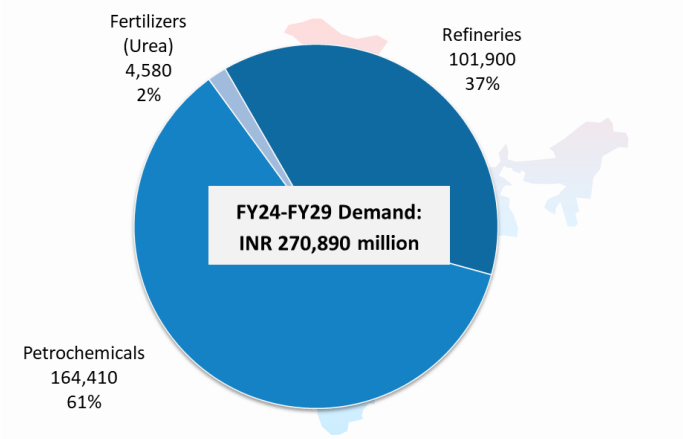
- Based on exhibit 4.3, **2 fertilizer (Urea) projects are likely to be commissioned between FY26 and FY31. Total installed capacity of thse projects are 1.4 MMTPA with total capex of INR 73,350 million.**
- Considering a 2-year lag between equipment ordering and project commissioning, **these projects will generate demand for heating equipment between FY24 and FY29.**

- Heating equipment account for **6.2% of the total capex** of a fertilizer (Urea) project.
- Hence, **demand for heating equipment from Indian fertilizer (Urea) segments between FY24 and FY29 would be INR 4,580 million i.e., approx. INR 750 million on annualized basis.** This potential is based on the projects announced till date and may go up if more projects are commissioned during the forecast period.

D. Overall demand potential by segment and by type of heating equipment

- Overall demand for heating equipment from Indian refineries, petrochemicals and fertilizer (Urea) segments between FY24 and FY29 is estimated at **INR 270,890 million i.e., approx. INR 45,000 million on annualized basis.**
- 61% of this demand would come from petrochemicals followed by 37% from refineries and 2% from fetilizers (Urea).
- 46% of this demand would come from cracking furnces followed by 24% from low capex heaters, 16% from high capex heaters, and 14% from reformers.

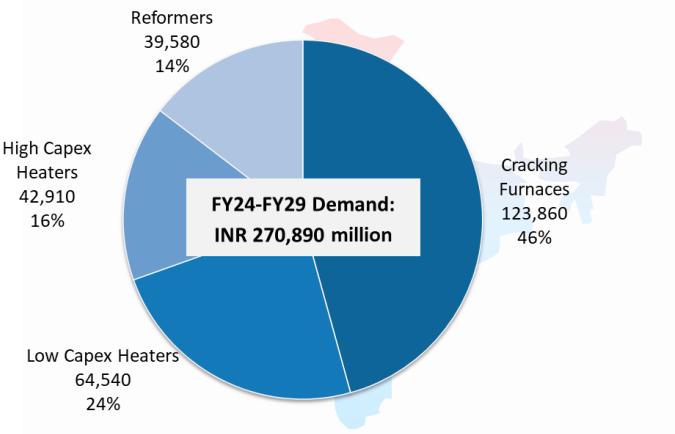
Exhibit 4.7: Overall demand of heating equipment by segments, India, FY24 - FY29



All values are in INR million

Source: Frost & Sullivan research and analysis

Exhibit 4.8: Overall demand by type of heating equipment, India, FY24 - FY29



All values are in INR million

Source: Frost & Sullivan research and analysis

- Potential estimated is based on the projects announced till date and may go up if more projects commissioned during the forecast period.

- Heating equipment suppliers indicated that order booking has grown by 25% in the last 2 years and the market is showing an upward trend – **cumulative order booking for heating equipment in the last 6 years was approximately INR 150,000 milion i.e., INR 25,000 million on annualized basis.**
- Considering the same, **cumulative order booking in the next 6 years (FY24-FY29) may see an approximate 80% jump from the cumulative order booking in the last 6 years**.

Brief competitive landscape:

The process fired heaters market has high barriers to entry and there are only a handful of suppliers, despite surge in demand. The market has high entry barriers as the engineering of industrial process fired heaters requires a complex understanding of various oil products. If the operation of a process fired heater is interrupted for even one day, users could incur significant losses, which is why suppliers undergo a thorough selection process. Since energy efficiency is one of the key performance indicators of any refinery, petrochemicals and, fertilizer plants and is determined by the efficiency of the process fired heaters, the process fired heaters become a critical aspect for customers and hence selection of suppliers for process fired heater requires strong credentials and references. Besides, there are certain regulatory standards to be mandatorily adhered to in the industry. Therefore, there are limited suppliers who can supply these critical equipment. Further, 7 out of the 12 oil refining companies in India are customers of JNK India, and the company has supplied or are in the process of supplying heating equipment to 11 of the 24 operating oil refineries across India.

The Indian heating equipment market is closely competed among seven companies with JNK India and Thermax being the most prominent and comparable players. Bharat Heavy Electricals Limited is also a participant however, its revenue from heating equipment is comparatively lower compared to its other flagship businesses. Other participants in the Indian heating equipment market are Esteem Projects, Heurtey Petrochem Solutions, TR Engineering, and ITT Engineering India.

Exhibit 4.9: Competition mapping, India, FY23

S. No.	Company Name	Origin	Process Fired Heaters	Reformers	Cracking Furnace
1	JNK India	India	✓	✓	✓
2	Thermax	India	✓		
3	Bharat Heavy Electricals Ltd	India	✓		
4	Esteem Projects	India	✓		
5	Heurtey Petrochem Solutions	France	✓	✓	✓
6	TR Engineering	Spain	✓		
7	ITT Engineering India	Italy	✓	✓	✓

Source: Frost & Sullivan Analysis

Since its inception, JNK India has been working closely with JNK Heaters Co., Ltd, ("JNK Heaters") a KOSDAQ listed company. JNK Heaters was established in 1998 and has been engaged in the design, manufacturing, installation, and maintenance of industrial furnaces. JNK India is the youngest and one of the leading heating equipment companies in India in terms of new order booking between FY21 to FY23, having a market share of approximately 27% in terms of new order booking in FY23. In terms of revenue from heating equipment, JNK India is the largest company in India with a revenue of more

than INR 4,000 million in FY23. In terms of volume, the company is currently installing 25 units, which is higher than any of its competitors currently executing in the Indian market.

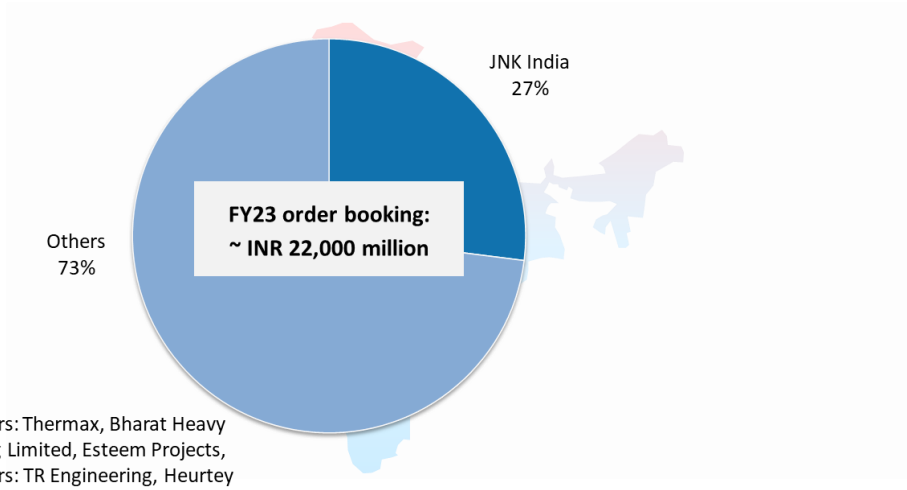
JNK India is a well-recognized process fired heater company among the Oil & Gas downstream companies, and has capabilities in thermal designing, engineering, manufacturing, supplying, installing, and commissioning process fired heaters, reformers, and cracking furnaces to companies forming part of some highly regulated industries, acts as a significant entry barrier to new entrants.

JNK India has one of the largest workforces among its competitors in India. The company has 190 design, execution, and R&D engineers for process fired heaters in India with capabilities of detailed engineering in process, mechanical, structural, electrical, instrumentation, piping, and civil engineering.

Market size and market share analysis

Based on discussion held with the leading heating equipment suppliers, approximately INR 22,000 million of heating equipment have been ordered in FY23. There is a boost in the order booking in the last few years with most of the suppliers reported their order booking has significantly increased in the last 2-3 years. Majority of these orders have come from PSU refineries. With strong pipeline of Oil & Gas downstream projects till CY2030, the order booking is likely to increase in the coming years.

Exhibit 4.10: Market share (new orders) of heating equipment suppliers, India, FY23



Others:
Large players: Thermax, Bharat Heavy Engineering Limited, Esteem Projects,
Small players: TR Engineering, Heurtey Petrochem, ITT Engineering India, etc.

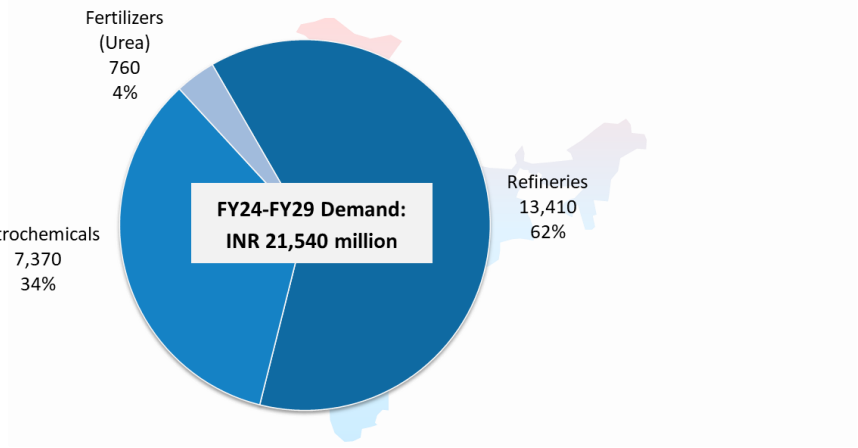
Source: Frost & Sullivan research and analysis

JNK India is one of the market leaders in the Indian heating equipment market with approximately 27% market share in terms of new order booking in FY23. JNK India's long-standing experience with its customers and its capability to provide customized solutions with a proven track record in product development and execution catering to the diverse needs of its customer base, gives JNK India a competitive advantage, since there are very few competitors with similar capabilities.

Waste gas handling systems:

Overall demand potential by segment and by type of waste gas handling systems

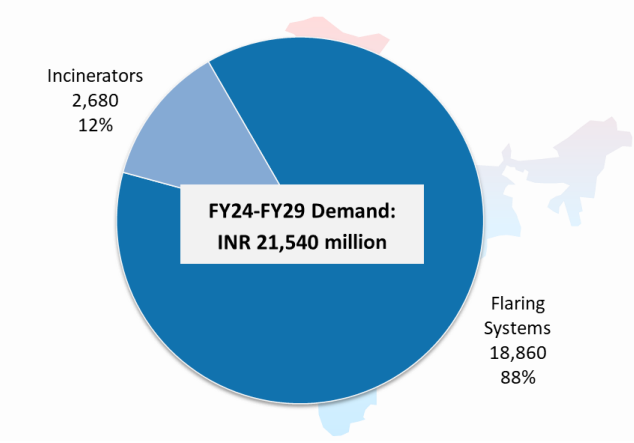
Exhibit 4.11: Overall demand of waste gas handling systems by segments, India, FY24 - FY29



All values are in INR million Source: Frost & Sullivan research and analysis

- Overall demand for waste gas handling systems from Indian refineries, petrochemicals and fertilizer (Urea) segments between FY24 and FY29 is estimated at **INR 21,540 million i.e., approx. INR 3,600 million on annualized basis.**
- 62% of this demand would come from refineries followed by 34% from petrochemicals and 4% from fetilizers (Urea).
- 88% of this demand would come from flaring systems and the remaining from incinerators. Demand for incinerators would come from refineries only.

Exhibit 4.12: Overall demand by type of waste gas handling systems, India, FY24 - FY29



All values are in INR million Source: Frost & Sullivan research and analysis

- Waste gas handling system suppliers indicated that order booking has been stable in the last 2 years and is expected to remain the same in the coming few years – **cumulative order booking for waste gas handling systems in the last 6 years was approximately INR 16,000 million i.e., approx. INR 2,650 million on annulaized basis.**
- Considering the same, **cumulative order booking in the next 6 years (FY24-FY29) may see approx. 35% jump from the cumulative order booking in the last 6 years**.

Brief competitive landscape:

The market for waste gas handling systems is closely competed in India, with about 5-8 companies in total. JNK India, Zeeco and Airoil Flaregas are some of the prominent companies in this space.

Exhibit 4.13: Competition mapping, India, FY23

S. No.	Company Name	Origin	Flare Systems	Incinerators
1	JNK India	India	✓	✓
2	Zeeco	USA	✓	✓
3	John Zink Hamworthy	USA	✓	✓
4	Airoil Flaregas	India	✓	
5	Ador Welding	India	✓	

Source: Frost & Sullivan research

Renewable energy systems:

EPC of Hydrogen Fuelling Stations

Green Hydrogen – introduction from Indian perspective

Addressing the nation on the 75th Independence Day, the Indian Prime Minister announced the National Hydrogen Mission with an aim of making India a hub for the production and export of green hydrogen. India is at a crucial juncture in terms of its energy landscape and green hydrogen has a critical role to play to make the nation self-reliant and energy-independent. On January 4, 2022, the National Green Hydrogen Mission was approved by the Union Cabinet.

Currently, India spends over $160 billion of foreign exchange every year for energy imports. These imports are likely to double in the next 15 years without remedial action. With this approval, the stage is set for India to become a global champion in green hydrogen.

The initial outlay for the Mission will be INR 197,440 million, including an outlay of INR 174,900 million for the Strategic Interventions for Green Hydrogen Transition (SIGHT) programme, INR 14,660 million for Pilot Projects, INR 4,000 million for Research & Development, and INR 3,880 million towards other Mission components. Ministry of New and Renewable Energy (MNRE) will formulate the scheme guidelines for implementation of the respective components.

Mission Sub-Components

1. SIGHT Programme: Under the Strategic Interventions for Green Hydrogen Transition Programme (SIGHT), two distinct financial incentive mechanisms – targeting domestic manufacturing of electrolysers and production of Green Hydrogen – will be provided under the Mission.

2. Pilot projects: The Mission will also support pilot projects in emerging end-use sectors and production pathways. Regions capable of supporting large scale production and/or utilization of Hydrogen will be identified and developed as Green Hydrogen Hubs.

3. R&D Projects: Public-Private Partnership framework for R&D (Strategic Hydrogen Innovation Partnership – SHIP) will be facilitated under the Mission. R&D projects will be goal-oriented, time bound, and suitably scaled up to develop globally competitive technologies.

4. Skill Development: A coordinated skill development programme will also be undertaken under the Mission.

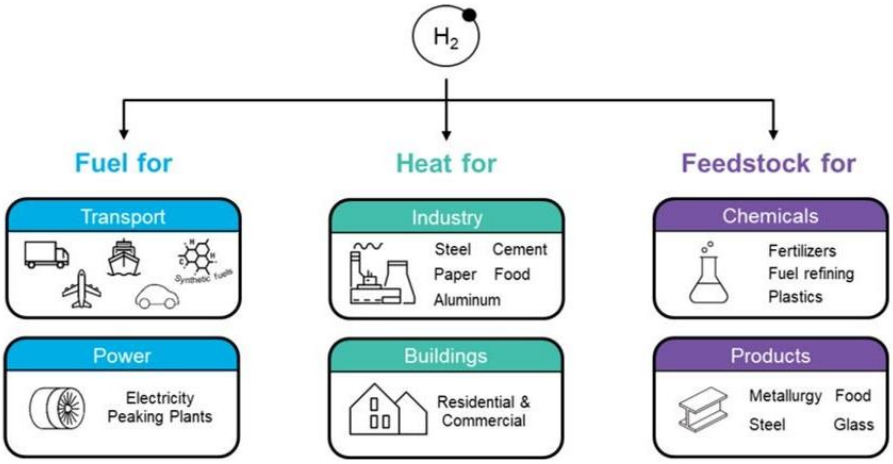
Mission Outcomes

The Mission will result in the following likely outcomes by CY2030:

- Development of green hydrogen production capacity of at least 5 MMT (Million Metric Tonne) per annum with an associated renewable energy capacity addition of about 125 GW in the country
- Over INR 8 trillion in total investments
- Creation of over Six lakh jobs
- Cumulative reduction in fossil fuel imports over INR 1 trillion
- Abatement of nearly 50 MMT of annual greenhouse gas emissions

The Mission will support pilot projects in other hard-to-abate sectors like steel, long-range heavy-duty mobility, shipping, energy storage etc. for replacing fossil fuels and fossil fuel-based feedstocks with Green Hydrogen and its derivatives.

Exhibit 4.14: Application of Green Hydrogen



Source: Bloomberg NEF, Frost & Sullivan analysis

Grey, Blue and Green Hydrogen

Hydrogen is the lightest and most abundant element in the universe. It is rarely found in nature in its elemental form and must always be extracted from other hydrogen-containing compounds. Depending on the nature of the method of its extraction, hydrogen is categorised into three categories, namely, Grey, Blue and Green.

1. Grey Hydrogen: It is produced via coal or lignite gasification (black or brown), or via a process called steam methane reformation (SMR) of natural gas or methane (grey). These tend to be mostly carbon-intensive processes.

2. Blue Hydrogen: It is produced via natural gas or coal gasification combined with carbon capture storage (CCS) or carbon capture use (CCU) technologies to reduce carbon emissions.

3. Green Hydrogen: It is produced using electrolysis of water with electricity generated by renewable energy. The carbon intensity ultimately depends on the carbon neutrality of the source of electricity (i.e., the more renewable energy there is in the electricity fuel mix, the "greener" the hydrogen produced).

Applications of Green Hydrogen

Hydrogen and Ammonia are envisaged to be the future fuels to replace fossil fuels6. Production of these fuels by using power from renewable energy, termed as green hydrogen and green ammonia, is one of the major requirements towards environmentally sustainable energy security of the nation. Government of India is taking various measures to facilitate the transition from fossil fuel / fossil fuel-based feed stocks to green hydrogen / green ammonia.

Hydrogen in Indian Context: Increasing renewable energy use across all economic spheres is central to India's Energy Transition. Green Hydrogen is considered a promising alternative for enabling this transition. Hydrogen can be utilized for long-duration storage of renewable energy, replacement of fossil fuels in industry, clean transportation, and potentially also for decentralized power generation, aviation, and marine transport.

Hydrogen for integrating renewable energy: Hydrogen provides a means for storage of variable renewable energy for stabilizing its output. For long duration storage, running into several hours, converting excess available energy into hydrogen and utilizing it for grid support and other applications is seen to be a suitable alternative.

Hydrogen in Industry: In industry, hydrogen can potentially replace the coal and coke in iron and steel production. Steel manufacturing is one of the largest carbon emitters in the world, decarbonising this sector using hydrogen is expected to have significant impact on our climate goals.

Hydrogen has the potential to reduce fossil fuel imports: At present, hydrogen produced from natural gas is widely utilized for production of nitrogenous fertilizers, and petrochemicals. Substituting this with green hydrogen could allow use of renewable energy in these important sectors and reduce import dependence.

- India's annual Ammonia consumption for fertilizer production is about 15 million tonnes, roughly 15 per cent of this demand (over 2 million tonnes per annum) is currently met from imports. Mandating even 1 per cent green ammonia share is likely to save about 0.4 million standard cubic feet per day of natural gas import.
- Use of hydrogen in steel industry could substitute imported coking coal. During FY19, the total demand of coking coal for the steel industry was 58.37 million tonne (MT). Out of this, 51.83 MT was met through imports.

Hydrogen based transport: Fuel cell electric vehicles (FCEVs) run on hydrogen fuel and have no harmful emissions. Battery Electric Vehicles (BEVs) may be suitable for light passenger vehicle segment for shorter driving range. For heavy duty vehicles with longer trip range, such as buses, trucks and other commercial vehicles, FCEVs are likely to become cost competitive in the coming years.

- While Battery Electric Vehicles (BEVs) are dependent on imported raw materials like lithium and cobalt for lithium-ion batteries, the hydrogen fuel cell supply chain can be wholly indigenized, making India Aatmanirbhar in the clean transportation segment.

India's progress towards Green Hydrogen

- Indian Government aims to transform India into an energy independent nation by CY2047 where green hydrogen will play an active role as an alternate fuel to petroleum/ fossil-based products.

- In CY2020, India's hydrogen demand stood at 6 million tonnes (MT) per year. It is estimated that by CY2030, the hydrogen costs will be down by 50 per cent.
- The demand for hydrogen is expected to see a five-fold jump to 28 MT by CY2050 where 80 per cent of the demand is expected to be green in nature.
- Some of the prominent industrial mammoths such as Reliance Industries Limited (RIL), Gas Authority of India Limited (GAIL), National Thermal Power Corporation (NTPC), Indian Oil Corporation (IOC) and Larsen and Toubro (L&T) plan to foray into the green hydrogen space. RIL plans to become a net-carbon zero firm by CY2035 and invest nearly INR 750 billion over the next three years in RE.
- The government-led public sector undertaking (PSU), Indian Oil, is at the forefront of the green hydrogen revolution. It is planning to setup India's first green hydrogen unit for the Mathura refinery, which will be used to process crude oil.
- National Thermal Power Corporation (NTPC) has recently set up a tender to establish a **first-of-its-kind hydrogen refuelling station to be powered entirely by renewables in Leh** through a stand-alone 1.25 MW solar system.
- **Two hydrogen refuelling stations have been established** (one each at Indian Oil R&D Centre, Faridabad, and National Institute of Solar Energy, Gurugram). The refuelling station at Indian Oil R&D Centre has been set up by JNK India.
- Based on inputs received from the industry experts, hydrogen will work for trucks and buses for intra-city and inter-city applications when their daily run is above 200 kms. To start with, **hydrogen with fuel dispensing stations ready for refuelling in every 200 km range are required every 200 kms on main highways.**
- India has declared its ambition to become an exporter of hydrogen to Japan, South Korea, and Europe.
- Various hydrogen powered vehicles have been developed and demonstrated under projects supported by Government of India. These include 6 Cell buses by Tata Motors Ltd., 50 hydrogen enriched CNG (H-CNG) buses in Delhi by Indian Oil Corporation Ltd. in collaboration with Govt. of NCT of Delhi, 2 hydrogen fueled Internal Combustion Engine buses (by IIT Delhi in collaboration with Mahindra & Mahindra).

India's distinct advantage in terms of low-cost renewable electricity, complemented by rapidly falling electrolyser prices, can enable green hydrogen to be not just economical compared to fossil-fuel based hydrogen but also compared to the green hydrogen being produced around the globe.

With proactive collaboration among innovators, entrepreneurs and government, green hydrogen has the potential to drastically reduce CO2 emissions, fight climate change, and put India on a path towards net-zero energy imports. It will also help India export high-value green products making it one of the first major economies to industrialise without the need to 'carbonise'.

EPC of Solar PV Plants

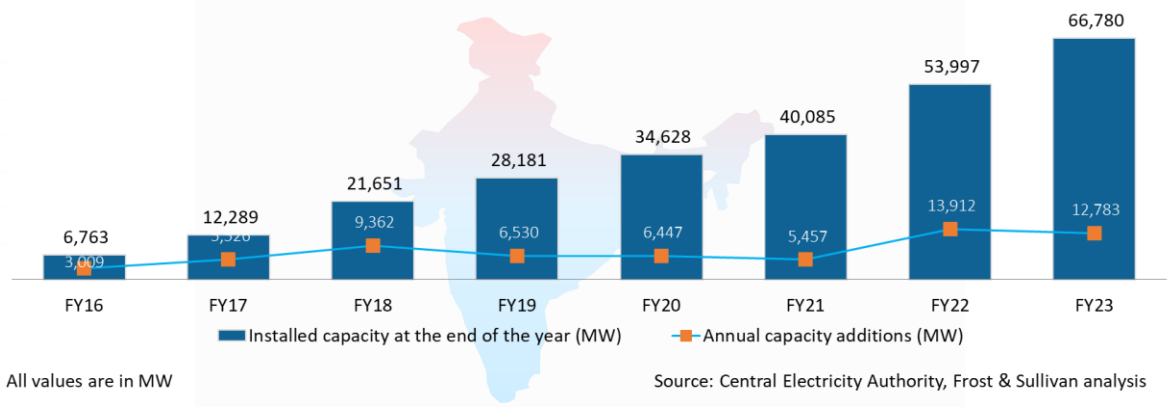
Overview of the Indian Solar Market

Indian renewable energy sector is the third most attractive renewable energy market in the world, which is a key part of the energy transition[4]. Markets are ranked on attractiveness on the basis of their renewable energy investment and deployment opportunity. With the Indian government's increased support and improved economics, the Indian solar power sector has become attractive from an investor's perspective.

The use of solar power in India is growing at a rapid rate. The country's solar installed capacity has gained pace over the past few years. India's installed cumulative solar energy capacity stood at 66,780 MW at the end of FY23, representing 53% of the overall installed renewable energy capacity of 125,160 MW in the country at the end of FY23. Solar power installed capacity has increased by more than 25 times, from 2.63 GW in March 2014 to almost 67 GW at the end of FY23. India has added nearly 13 GW of solar power in FY23.

India is targeting an ambitious 500 GW of installed renewable energy capacity by CY2030 of which about 300 GW (over 60%) is expected from solar. As announced in the COP26 conference held in November 2021, India has committed to generating 500 GW of power from non-fossil (e.g., solar, wind, hybrid power sources, hydrogen, biofuels, etc.) fuel sources by CY2030, and reducing carbon emissions by one billion tons by the end of the decade.

Exhibit 4.15: Installed solar capacity, in MW, India, FY16 - FY23



Measures taken by the Indian Government to promote Solar Energy

As India is moving swiftly towards achieving its target of emerging global leader on the solar front, positive steps are to be taken to resolve the imports of important components like solar cells, modules, and solar inverters that the Indian solar industry is considerably dependent upon.

Certain measures taken by the Indian government include the following: -

Import Duty: The Indian government has been taking several measures to promote local manufacturing under its 'Make in India' mission. As part of its moves to reduce imports, India imposed a 40% duty on the import of solar modules and a 25% duty on the import of solar cells in April 2022. This is expected to boost and promote domestic manufacturing substantially.

[4] *Source: https://www.ey.com/en_in/recai*

PLI Schemes: The Production Linked Incentive (PLI) Scheme was introduced by the Indian government, as an attempt to boost India's manufacturing capabilities and exports. Under the provisions of this scheme, manufacturers receive support from the government for establishing integrated manufacturing units of high-efficiency solar photo voltaic modules.

Bureau of Indian Standards Certification: The Indian government mandated the requirement of BIS certifications on all solar products, which will help set higher quality parameters for domestic manufacturers, ultimately benefiting end customers.

Approved List of Models and Manufacturers: To protect the interest of customers and to also ensure the manufacturing of reliable PV modules, the Ministry of New and Renewable Energy had also introduced an Approved List of Models and Manufacturers (ALMM) of solar PV cells and modules. The above actions are expected to help India emerge as a leading global supplier of solar products, along with meeting its domestic requirements.

Key drivers to PV deployment in India

1. The country plans to tap the vast potential for solar PV in the region to achieve its different climate goals, notably: (1) installing 500 GW of non-fossil fuel electricity generation capacity by CY2030, from which 280 GW should come from solar PV, (2) sourcing 50% of energy demand from non-fossil fuel sources by CY2030, and (3) reduce the emission intensity of GDP by 45% by CY2030, from CY2005 levels.

2. The Central Electricity Regulation Commission published a draft regulation for General Network Access to Interstate Network which will improve access to the electricity network. The draft document is also reaffirming the Renewable Energy Certificates, which certificates that the electricity produced comes from a renewable energy source.

3. The National Action Plan on Climate Change sets out Renewable Power Obligations, which mandate electricity distributors to generate a defined percentage of their electricity from renewable energy sources. The last set target was that by CY2022, 21% of the electricity consumed by each state must come from renewables, half of which must come from solar.

4. As a support for solar PV technology, large tenders are launched by the Indian Renewable Energy Development Agency.

5. India is supporting local PV manufacturing through Production Linked Incentives (PLI). The second round of the PLI scheme, approved in September 2022, plans to add 65 GW of fully and partially integrated PV module production capacity, significantly expanding the funding from the first round issued in February 2021. This is expected to boost domestic manufacturing to meet domestic demand as well as exports.

Key barriers to PV deployment:

1. The rooftop segment in India is still struggling to take off compared to the utility-scale segment. Most of the installations comes from commercial and industrial clients, while residential installation levels are very low. The country had aim to install 40% of its total fleet on roofs by CY2022, the lack of development in the segment comes as a big gap in the country's solar deployment and a missed opportunity. However, several positive steps are being taken in the right direction, such as the creation of the Central Financial Assistance, an institution dedicated to help households to finance their solar installations. Several states have also implemented various forms of Virtual Net Metering.

2. A new notification issued by the Ministry of finance increased the Goods and Services Taxes (GST), which applies on renewable goods. The increase went from 5% to 12%.

3. The purchasing of modules is currently limited to specific manufacturers that are included in the Approved List of Modules and Manufacturers (ALMM). While the objective of the policy is to foster the domestic manufacturing capacities, this comes at a price for developers, who can only buy from domestic suppliers, whose equipment prices can be costlier than foreign manufacturers. At the same time, India does not have enough domestic manufacturing capacities to supply its whole internal market. Therefore, imports are still being purchased, but face a basic custom duty of 40% for module and 25% for cells.

4. The largest renewable power purchaser in India are power distribution companies (DISCOMs). They are involved in long-term Power Purchase Agreements (PPA) with solar and wind power generation companies. However, in several instances DISCOMs tried to renegotiate or to cancel a PPA contract invoking financial difficulties. This context of unreliable buyers is so far not favourable for the development of a PPAs market in India.

Segmentation of Indian Solar EPC market

The solar EPC market in India can be segmented based on various factors:

Project Type:

a. **Utility-Scale Solar EPC:** India's utility-scale solar installations have witnessed significant growth in the past years. As per a research report published by Mercom India Research, India's utility-scale solar pipeline project pipeline stood at 58 GW at the end of FY23 with another 51 GW projects tendered and pending auction.
b. **Rooftop Solar EPC:** India's rooftop solar segment has also seen remarkable growth. At the end of FY23, India's installed rooftop solar capacity stands at 8,877 MW (source: MNRE).

End-User Segment:

a. **Commercial and Industrial (C&I):** The commercial and industrial segment is a significant market for solar EPC. The C&I sector accounted for a significant portion of the installed rooftop solar capacity in India, with installations ranging from small businesses to large industrial complexes.
b. **Residential:** The residential segment is an emerging market for solar EPC in India. While the installed residential rooftop solar capacity is smaller than the C&I segment, it has been growing steadily as more homeowners adopt solar power. Exact numbers for residential installations are not readily available.

Geography:

a. **Grid-Connected Solar EPC:** Grid-connected solar installations are spread across various states and regions in India. States like Rajasthan, Gujarat, Andhra Pradesh, Tamil Nadu, and Karnataka have witnessed significant grid-connected solar capacity additions.
b. **Off-Grid Solar EPC:** Off-grid solar installations cater to remote and rural areas where grid access is limited. These installations include solar home systems, mini-grids, and other off-grid solutions. The exact number of off-grid installations in India is not readily available.

Technology:

a. **Photovoltaic (PV) Solar EPC:** PV technology dominates the solar EPC market in India. The majority of solar installations, both utility-scale and rooftop, utilize PV technology.
b. **Concentrated Solar Power (CSP) EPC:** CSP technology has limited adoption in India compared to PV. At the end of CY2021, India's CSP capacity was relatively small, and most solar EPC projects are PV-based.

Ownership and Business Models:

a. **Third-Party EPC:** Many solar EPC projects in India are executed by third-party EPC companies. These companies provide end-to-end EPC services for solar projects developed by IPPs, government agencies, and other project owners. The exact market share of third-party EPC companies is not readily available.
b. **Developer EPC:** Some solar projects in India are developed and executed by project developers themselves. These developers have in-house EPC capabilities or partner with EPC companies for specific project requirements.

These are not mutually exclusive and there can be overlap among them. The market segmentation allows solar EPC companies to tailor their offerings, expertise, and marketing strategies to specific customer segments and project requirements.

Competitive landscape

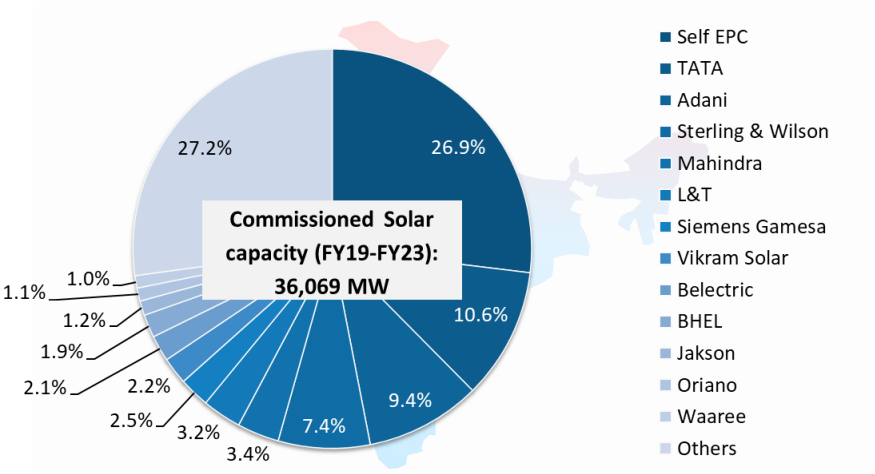
The Indian solar EPC market is primarily dominated by a few major players, while there are also developers who opt for self-EPC and there are a few smaller firms offering this service. However, due to the significant decline in solar tariffs in India, an increasing number of developers have chosen to carry out their own EPC to optimize costs. Prominent EPC companies in the solar space are:

1. **Tata Power Solar Systems:** Tata Power Solar has been at the forefront of driving solar adoption in India. Other than EPC Services, it offers Solar Modules, Rooftop Solutions, (O&M). Tata Power Solar has a state-of-the-art manufacturing facility in Bengaluru, India, where it produces high-quality solar modules. The company has executed several landmark solar projects in India and has expanded its operations internationally, catering to global markets.
2. **Adani Solar:** Adani Solar specializes in the manufacturing of high-quality solar modules and offers comprehensive solutions for solar power projects. Adani Solar has expanded its operations globally and serves customers across various geographies.
3. **Sterling and Wilson Solar:** Sterling and Wilson Solar offer end-to-end solutions for solar power projects. In addition to its EPC services, Sterling and Wilson Solar has also ventured into other segments of the solar value chain, such as energy storage solutions and solar rooftop installations. The company has successfully delivered projects across various geographies.
4. **Mahindra Susten:** Mahindra Susten offers comprehensive EPC services for solar power projects. The company has expertise in utility-scale solar projects, rooftop installations, and solar parks. They also offer Integrated, Energy solutions, green Building and O&M Services.
5. **L&T Solar:** L&T Solar is engaged in various aspects of the solar value chain, including manufacturing solar modules, offering EPC (Engineering, Procurement, and Construction) services for solar power projects, and providing O&M (Operations and Maintenance) services.

Indian Solar EPC market size

According to the Central Electricity Regulatory Commission, the EPC cost of a utility-scale solar project accounts for approximately 79% of the total project cost. As solar tariffs continue to fall, developers are implementing cost-cutting measures to enhance their margins, leading to a decline in EPC costs. The growing number of players in the market, all offering competitive pricing, has also contributed to the decrease in EPC prices. With rising competition, only EPC players capable of undertaking large projects can benefit from economies of scale, making it challenging for smaller EPC firms to sustain themselves as profit margins shrink. Consequently, smaller EPC firms without sufficient financial resources for project development tend to focus on rooftop solar and captive projects to maintain their operations. Additionally, larger developers are establishing their internal EPC capabilities to improve project viability, resulting in a reduction in the customer base of standalone EPC firms. In response, standalone EPC firms have had to diversify their operations to remain viable.

Exhibit 4.16: Market share of leading Solar EPC companies in India, FY19 – FY23



Source: India RE Navigator, Bridge to India, Frost & Sullivan analysis

The drive for cost optimization by developers has expanded the scope of EPC contracts, transforming them into turnkey solution providers. Nowadays, contractors are not only responsible for basic EPC services but also for obtaining approvals and providing operations and maintenance (O&M) services. Over the past few years, the number of projects in the Indian solar EPC market has significantly increased while tariffs have rapidly decreased. This transformation has largely led to EPC contractors evolving into turnkey solution providers. Furthermore, executing the complete project, rather than solely the EPC component, is expected to improve profit margins.

Outlook of the Indian Solar EPC market

Considering India's ambition of installing 300 GW of solar capacity by CY2030, there is potential of 170 – 175 GW of Solar EPC business over the next 6-7 years – approximately 25 GW of Solar EPC business opportunity every year. Considering the FY23 annual capacity addition of approximately 13 GW, this is almost double the current market size. In value terms, annual business potential is approx. INR 100 billion. However, a significant portion of this opportunity may not be realized considering the historical capacity addition trends and increasingly, developers are establishing their internal EPC capabilities to improve project viability.

This trend is likely to result in a higher proportion of companies with in-house EPC capabilities, potentially leading to consolidation within the Indian Solar EPC market. Consequently, stand-alone EPC firms are anticipated to either merge with larger players or integrate themselves into complete project developers and power producers. Additionally, the advent of automation technologies has facilitated more streamlined operations, albeit with higher initial capital costs. However, these technologies offer significant cost savings over the lifetime of projects. Automation has become a crucial component in the solar energy industry due to the increasing penetration of information technology. EPC companies are progressively adopting automation to enhance service quality, improve operational margins, and reduce project lifetime costs. Nonetheless, achieving higher returns will not solely depend on improving service quality but also on securing a greater number of contracts to leverage economies of scale.

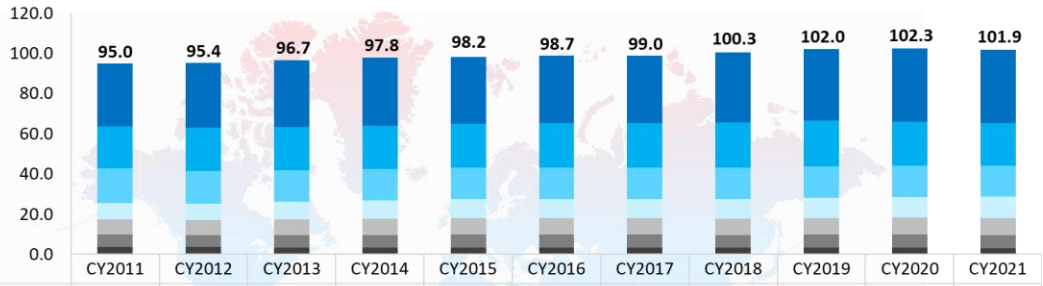
CHAPTER 5: DEMAND FOR PRODUCTS OF INTEREST IN GLOBAL MARKETS

End user sector outlook:

Refinery sector: Installed capacity, growth drivers and outlook

Global refining capacity in the last one decade has grown at a paltry CAGR of 0.8% - from 95.0 million barrels per day (mbpd) in CY2011 to 101.9 mbpd in CY2021. The capacity is largely stagnant in the last 3 years and has gone down slightly in CY2021. Asia Pacific, North America, and Europe are the top three regions in terms of installed refining capacity with share of 36%, 21% and 15% respectively. The Middle East region that houses most of the large Oil & Gas producers in the world, accounts for 11% share. Africa has the least share among all the regions at 3%.

Exhibit 5.1: Installed refining capacity, Global, CY2011 – CY2021



	CY2011	CY2012	CY2013	CY2014	CY2015	CY2016	CY2017	CY2018	CY2019	CY2020	CY2021
Asia Pacific	31.3	32.4	33.2	33.9	33.3	33.5	33.8	34.7	35.5	36.5	36.5
North America	21.0	21.4	21.5	21.4	21.8	22.1	22.1	22.3	22.6	21.8	21.5
Europe	17.2	16.3	15.9	15.7	15.7	15.5	15.5	15.7	15.7	15.6	15.1
Middle East	8.2	8.3	8.7	9.0	9.4	9.6	9.6	9.8	10.2	10.2	10.8
CIS	7.3	7.4	7.9	8.0	8.2	8.2	8.2	8.1	8.3	8.3	8.5
South & Central America	6.5	6.0	6.2	6.4	6.5	6.5	6.5	6.4	6.4	6.6	6.4
Africa	3.6	3.6	3.4	3.4	3.4	3.4	3.3	3.3	3.3	3.3	3.2

Units in Million Barrels Per Day

Source: BP Statistical Review 2022, Frost & Sullivan analysis

There has been a rise in the global oil and gas refinery and petrochemical capacities thereby by driving the growth in the global process fired heaters market. Further, the global demand for oil refining is driven by increasing investment in refinery capex and construction sector. The demand for petroleum products is driven by positive outlook towards aviation and road transportation segments. Further, rapid industrialization and urbanization, along with increase in population among developing countries, such as China and India, is expected to create demand for automobiles, which would in turn drive the demand for refined petroleum products. Major factors driving the demand for refineries globally are:

- Demand for oil and other petroleum products
- Country level initiatives to improve self-sufficiency in refining capacity
- Increasing investments in construction

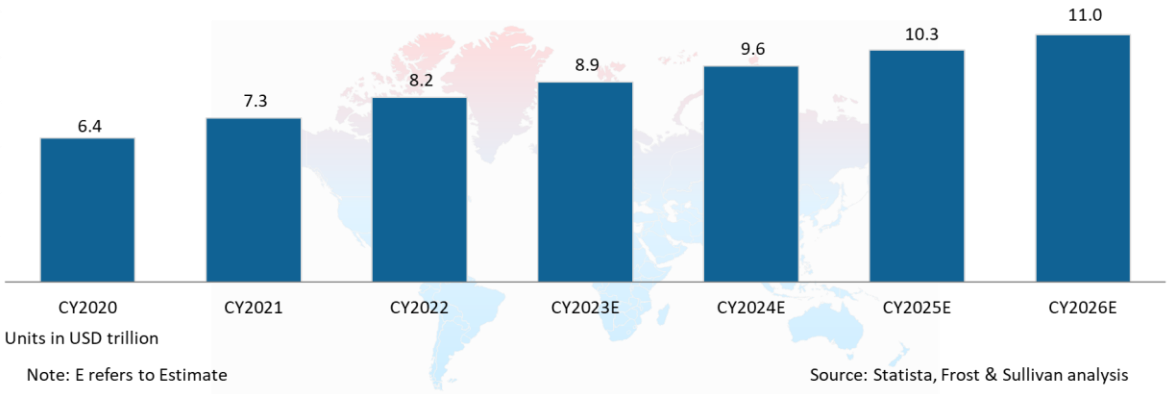
Demand for oil and petroleum products: Population growth, transportation, industrial investments, and electricity generation are the key factors driving the energy demand in the world.

- **Growth in passenger and commercial vehicles drive demand for petroleum and diesel:** The global automobile sales in volume terms is expected to grow at a CAGR of 3.5 – 4.0% from CY2020 to CY2030. Developing economies are expected to drive the demand for automobiles in the long-term. Strong economic growth and increasing per capita incomes are the major factors that would positively impact the demand for passenger cars in the developing countries. The growth in automobile sales would in turn create demand for fuels such as petrol and diesel, and thereby the demand for refining capacities.
- **Aviation industry's growth creating demand for aviation fuel:** The aviation industry is a vital engine of global socio-economic growth creating direct and indirect employment, supporting tourism and local businesses, and stimulating foreign investment and international trade. Major factors driving the demand for aviation services are rising disposable income, rapidly growing middle class, and increased travel demand. With the e-commerce operations increasing rapidly since COVID-19, the air cargo market has increased, and thus the demand for freighter aircraft is expected to grow in the long-term. The growth in the aviation sector would create demand for jet fuel, which would positively impact the demand for refining capacity.

Country level initiatives to improve self-sufficiency in refining capacity: Energy is a key factor that determines the economic growth of any country and therefore several countries in the world have rolled-out initiatives and capex allocations to improve their oil refining industry output by adding new capacities. This would result in reduced dependency on imported petroleum products and improve their self-sufficiency in the long-term. These new capex injections would create demand for products of interest such as direct fired heaters, flare systems and incinerators.

Increasing investments in construction: The future of the global construction industry looks good with opportunities in residential, non-residential, and infrastructure segments. The global construction industry is expected to grow at a CAGR of 8.4% between CY2020 to CY2030 to become USD 14.4 trillion industry by CY2030.

Exhibit 5.2: Construction industry market size, Global, CY2020 – CY2026E



Note: E refers to Estimate

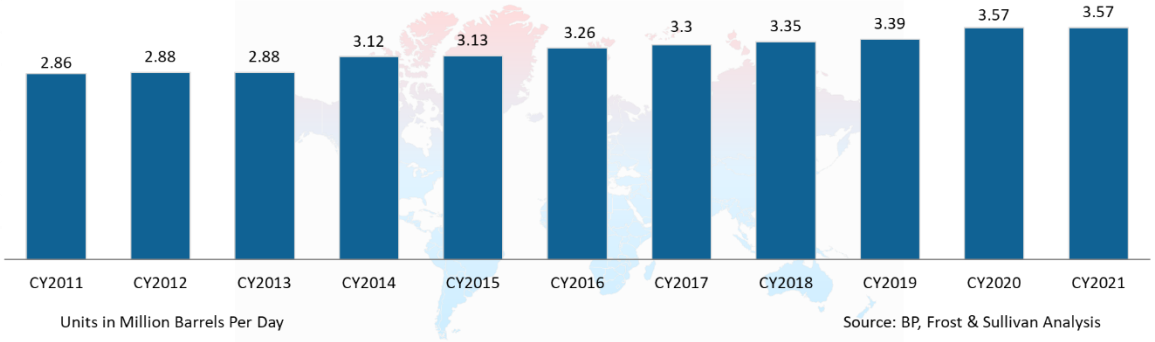
Source: Statista, Frost & Sullivan analysis

Construction sector is a major consumer of natural resources and energy. According to the International Energy Agency (IEA), the buildings and construction sector accounts for a whopping 36% of worldwide energy use. With the expected growth in the construction sector, the demand for materials used in road construction and roofing would increase, thereby creating demand for asphalt, tar, and shingles, which are by-products of crude oil.

Overview of Refinery sector in the countries of interest and outlook

South Korea (Asia): There are five existing refineries in South Korea and the country has one of the world's largest oil refining capacities. SK Innovation has two refineries, one in Ulsan (840 kilo barrels per day or kbpd) and another in Incheon (375 kbpd). The other refineries are held by GS Caltex in Yeosu (800 kbpd), by S-Oil in Onsan (669 kbpd) and by Hyundai Oilbank in Daesan (520 kbpd). In addition to these five large refineries, Korean refiners operate processing units that convert ultra-light grade crude oil (condensate) into products such as naphtha for petrochemical use.

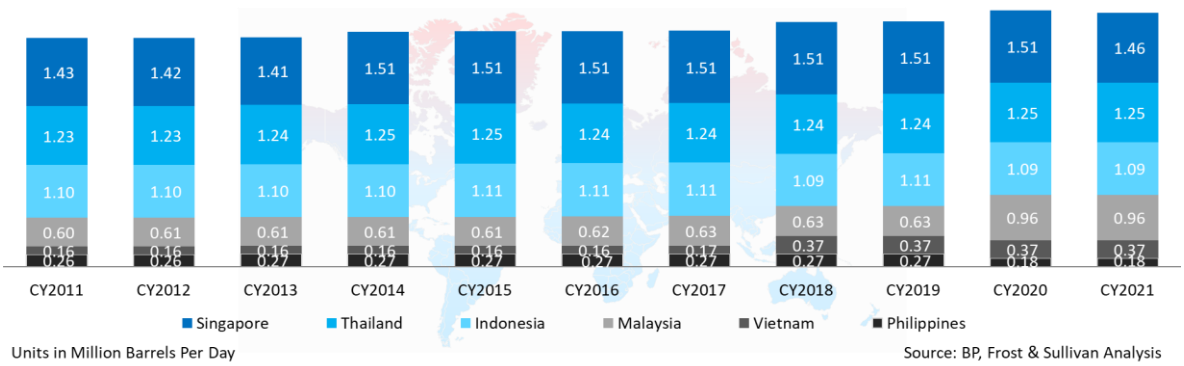
Exhibit 5.3: Refinery installed capacity, South Korea, CY2011 - CY2021



The consumption of petroleum and other liquids stood at 5.259 quadrillion Btu. South Korea was the eighth-largest consumer of petroleum and other liquids in the world in CY2021. Consumption grew in CY2021, mainly driven by higher use for transportation, new petrochemical facilities that required more liquefied petroleum gas (LPG) and naphtha, and higher use by domestic industry.

Southeast Asian Countries (Asia): Southeast Asian countries, for the purpose of this report, has been referred to six countries namely, Singapore, Thailand, Indonesia, Vietnam, Malaysia, and Philippines. The total installed refining capacity in these six countries was 5.3 mbpd in CY2021. Singapore has 28% share of this refining capacity followed by Thailand (24% share), Indonesia (21% share), and Malaysia (18% share).

Exhibit 5.4: Refinery Installed Capacity, Southeast Asia, CY2011 - CY2021

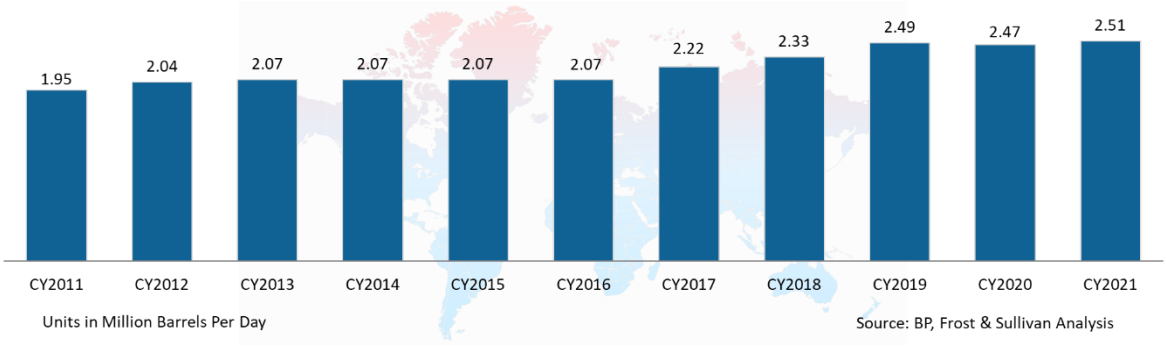


The region has a total of 29 refineries with Singapore has the region's largest refinery – ExxonMobil Jurong Island Refinery (605 kbpd). Other large refineries in the region are Shell Pulau Bukom Refinery (500 kbpd) and SRC Jurong Island Refinery (290 kbpd) in Singapore, Cilacap Refinery (348 kbpd) in Indonesia, PTT Global Chemical Refinery (280 kbpd) and Thai Oil Refinery (275 kbpd) in Thailand, and Pengerang RAPID Refinery (300 kbpd) in Malaysia.

Around 35.2 MMTPA of refinery capacity is expected to be added in Southeast Asian countries by CY2030. Of this, around 57% of the refining capacity is expected to come up in Philippines.

Iran (Middle East): Iran was the fifth-largest crude oil producer in OPEC in CY2021 and the third-largest natural gas producer in the world in CY2020. It holds some of the world's largest deposits of proved oil and natural gas reserves, ranking as the world's third-largest oil and second-largest natural gas reserve holder in CY2021. At the end of CY2021, Iran accounted for 24% of oil reserves in the Middle East and 12% in the world. Despite its abundant reserves, Iran's crude oil production has fallen since CY2017 as the oil sector has been subject to underinvestment and international sanctions for several years.

Exhibit 5.5: Refinery Installed Capacity, Iran, CY2011 – CY2021

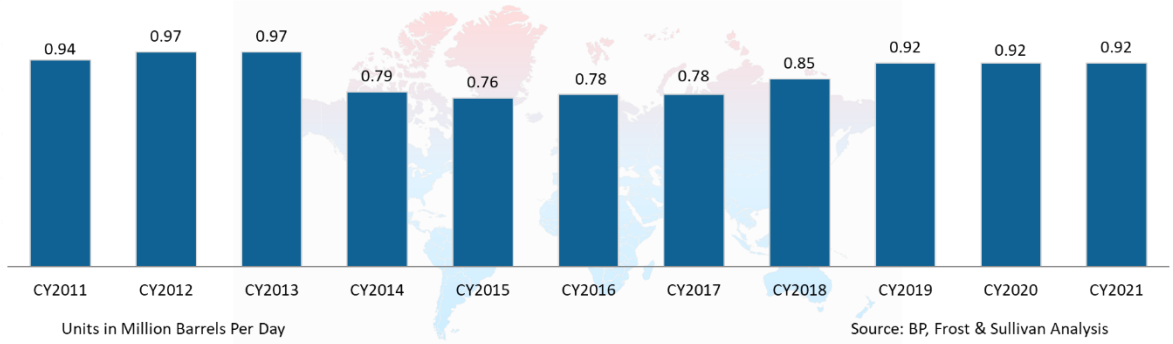


Under the 7th National Economic Development Plan, Iran is expected to reduce crude oil and natural gas sales by developing the value chain and bring its oil refining capacity to 3 mb/d. The country is facing imbalance in petroleum products consumption and therefore the petroleum ministry is expected to take measures to ensure completion of the incomplete refining projects.

Iran's refining and distribution industry has refined 2.2 mb/d of crude oil and gas condensate, supplied 112 ml/d of gasoil and 100 ml/d of gasoline, increased fuel supply by 23% last year. In line with building a value chain in the refining industry, the 13th administration of Iran has approved construction of eight integrated refining/petrochemical complexes to run on crude oil and condensate.

Iraq (Middle East): Iraq is the second-largest crude oil producer in OPEC after Saudi Arabia. It holds the world's 5th largest proven crude oil reserves, at 145 billion barrels, representing 17% of proved reserves in the Middle East and 8% of global reserves. Iraq consumed about 850,000 barrels per day of petroleum and other liquids in CY2021. The installed refinery capacity was 0.92 mbpd in CY2021. Domestic refineries meet most of Iraq's petroleum product needs but the country imports gasoline and diesel.

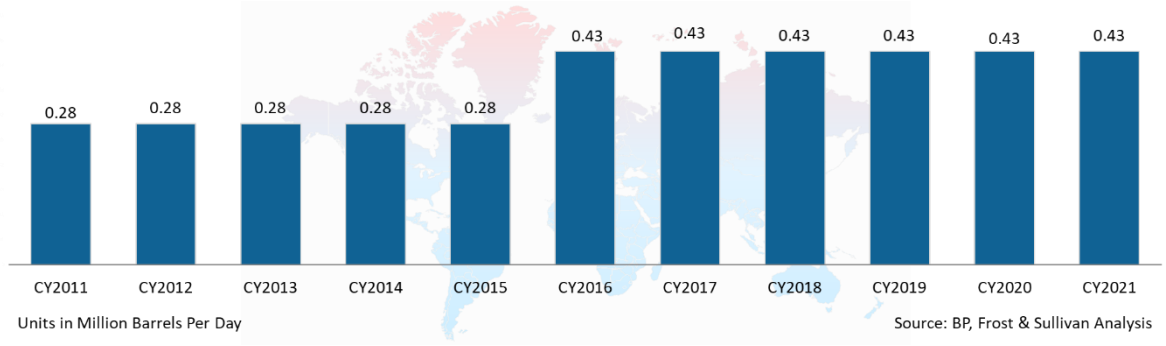
Exhibit 5.6: Refinery Installed Capacity, Iraq, CY2011 – CY2021



Several new refineries are planned, along with capacity expansion and upgrades at several existing refineries, to alleviate domestic gasoline and diesel shortages, reduce government import costs for oil products, and eventually increase exports of refined products. The country is expected to add 72.0 MMTPA of refining capacity by CY2030.

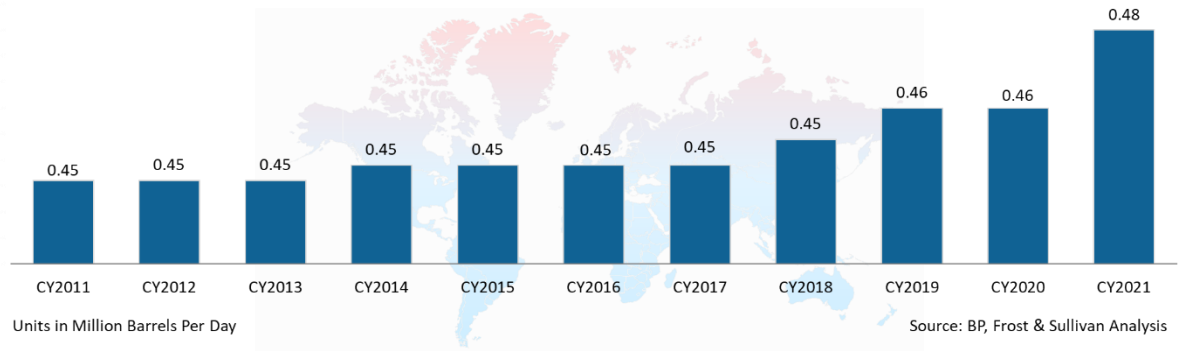
Qatar (Middle East): Qatar was the world's 6th largest dry natural gas producer, the 2nd largest LNG exporter, and the 3rd largest holder of natural gas reserves in CY2021. The current installed capacity is at 0.43 million barrels per day across three refineries. There are no new capacity additions expected in Qatar by CY2030.

Exhibit 5.7 Refinery Installed Capacity, Qatar, CY2011 – CY2021



Nigeria (Africa): Nigeria has an estimated 37.1 billion barrels of proved crude oil reserves in CY2023. Nigeria is a major hydrocarbons producer in Africa and its production is the mainstay of the country's economy. a strong refinery capacity to meet its domestic demand, Nigeria is fully reliant on imported petroleum products as its four state-owned refineries have been shut in for long-term maintenance or rehabilitation since CY2020.

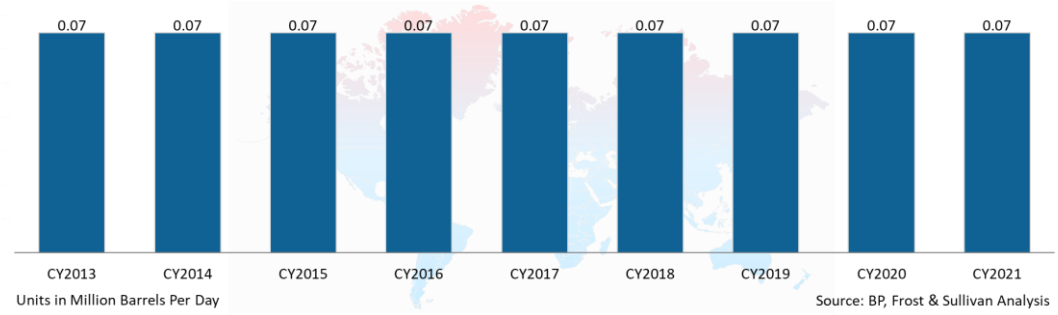
Exhibit 5.8: Refinery Installed Capacity, Nigeria, CY2011 – CY2021



The Nigerian government's plan construct smaller modular refineries have faced financial hurdles. There are four refinery projects in the pipeline with a combined capacity of 65.5 MMTPA by CY2030. Upon commissioning of these refineries, Nigeria would become a net petroleum product exporter.

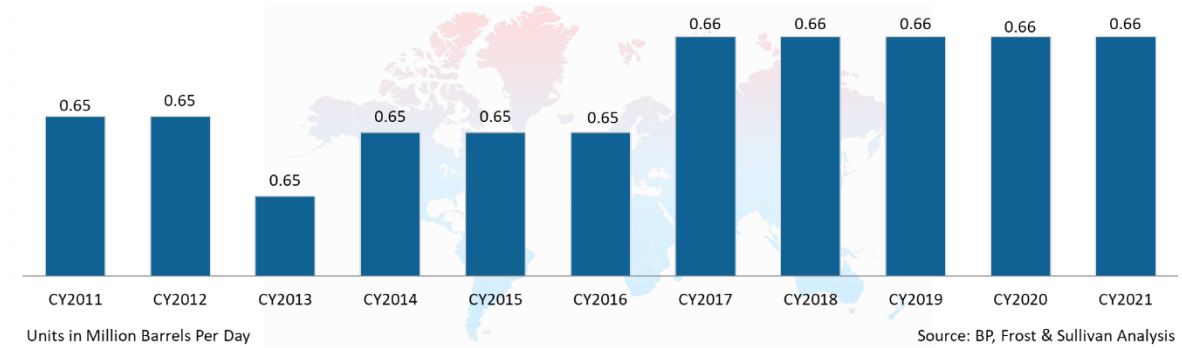
Angola (Africa): Angola had an estimated 7.2 billion barrels of proved crude oil reserves in CY2022. There is only operational refinery in Luanda with a capacity of 0.07 mbpd in CY2021. There are about three upcoming refinery projects in Angola with a cumulative capacity of 18.1 MMTPA by CY2030.

Exhibit 5.9: Refinery Installed Capacity, Angola, CY2013 – CY2021



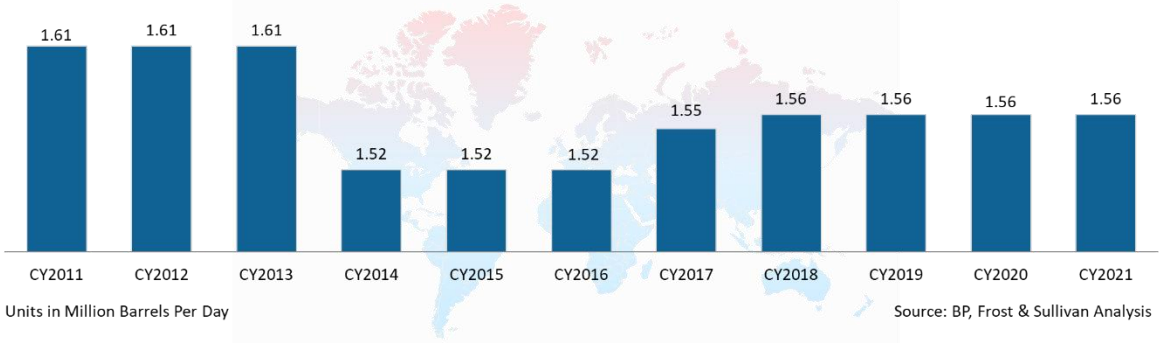
Algeria (Africa): Algeria is a major crude oil and natural gas producer in Africa and has been a member of the Organization of the Petroleum Exporting Countries. There are about five operation refineries in the country with a cumulative installed capacity of 0.66 million barrels per day. There are about two upcoming refinery projects in Algeria with a cumulative capacity of 10.7 MMTPA by CY2030.

Exhibit 5.10: Refinery Installed Capacity, Algeria, CY2011 – CY2021



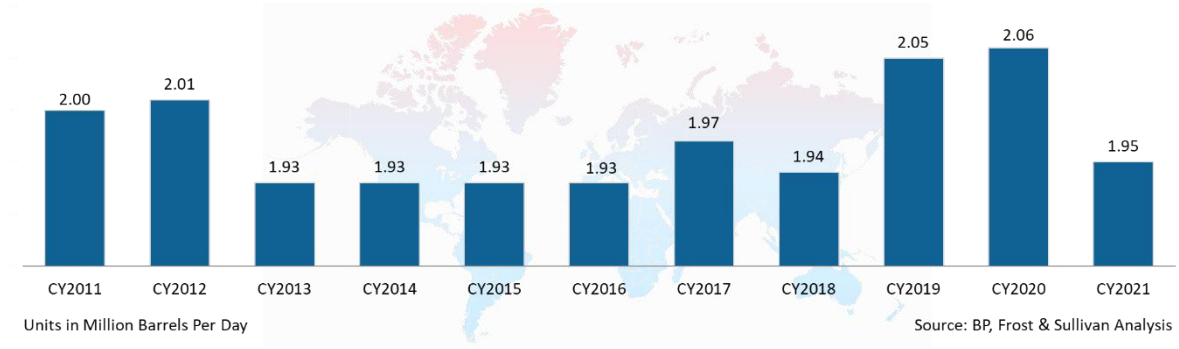
Mexico (Americas): Mexico's proven oil reserves were 6.0 billion barrels, including crude oil, lease condensate, natural gas liquids, and oil sands in early CY2023. There are six existing refineries in Mexico with a combined capacity of 1.56 million barrels per day. There are about two upcoming refinery projects in Mexico with a cumulative capacity of 20.1 MMTPA by CY2030.

Exhibit 5.11: Refinery Installed Capacity, Mexico, CY2011 – CY2021



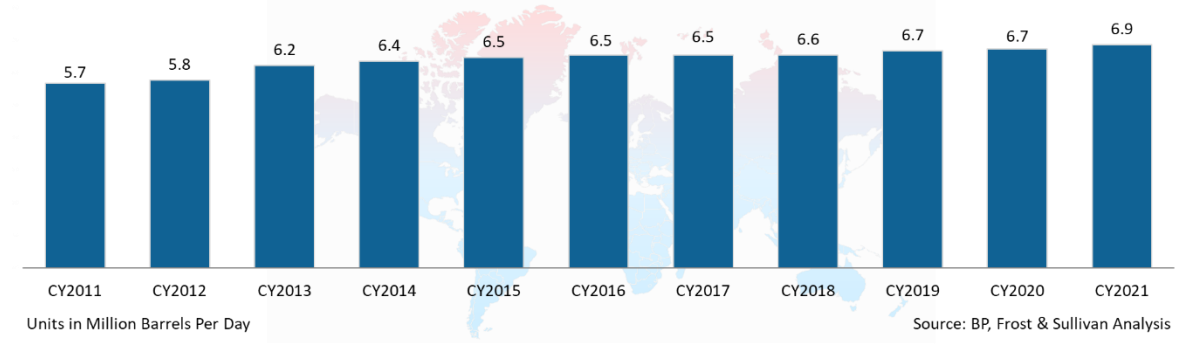
Canada (Americas): Canada ranked fourth in CY2021 among energy producers of petroleum and total liquids in the world. Canada is a net exporter of most energy commodities and is a significant producer of natural gas, hydroelectricity, and crude oil and other liquids. The current installed refining capacity in Canada is at 1.95 million barrels per day in CY2021. There are about four upcoming refinery projects in Canada with a cumulative capacity of 34.3 MMTPA by CY2030.

Exhibit 5.12: Refinery Installed Capacity, Canada, CY2011 – CY2021



Russia (CIS): Russia has the third largest refinery capacity worldwide, after the United States and China. As per Rystad Energy, at present, Russia has 44 active refineries with a capacity of 6.9 million barrels per day. As per BP statistical review, between CY2011 and CY2021, the daily refinery capacity across the country grew by nearly 1.2 million barrels. Rosneft, Lukoil and Gazprom are the top three refiners in the country. Most of the Russian refineries are mid-sized to small refineries with capacity less than 200,000 barrels per day. The largest refineries in the country are Omsk Refinery (Gazprom, 362,000 bpd), Kirishi Refinery (Surgutneftegas, 346,000 bpd), Ryazan Refinery (Rosneft, 295,000 bpd), Norsi-Oil (Lukoil, 293,000 bpd), Yaroslavl Refinery (Slavneft, 271,000 bpd), and Volgograd Refinery (Lukoil, 250,000 bpd).

Exhibit 5.13: Refinery Installed Capacity, Russia, CY2011 – CY2021



Russian refineries are operating under capacity and are unlikely to recover in the short term, as approximately 0.9 million barrels per day of refining capacity is currently not being used. This is due to a range of factors including demand impacts from the Russia-Ukraine conflict, transportation bottlenecks, planned maintenance and/or scheduled turnarounds.

There are a total of 53 refineries expected to be commissioned in the 21 countries of interest by CY2030. Cumulative capacity of these 53 refineries is 9.15 million barrels per day or 460.7 MMTPA. Countries of interest are South Korea, Malaysia, Thailand, Indonesia, Philippines, Singapore, Vietnam, Iran, Iraq, Qatar, Nigeria, Algeria, Angola, Mexico, Canada, Uzbekistan, Kazakhstan, Saudi Arabia, Oman, Egypt, and Gabon.

Exhibit 5.14: List of upcoming refineries, Global, CY2023-CY2030

Name of the Refinery	Country	Installed Capacity BPD	Installed Capacity MMTPA	Commissioning Year
Shaheen project in Ulsan (Integrated Refinery)	South Korea	63,530	3.2	CY2026
South Korea Total		**63,530**	**3.2**	
Thailoil refinery in Sriracha	Thailand	125,000	6.3	CY2023
Thailand Total		**125,000**	**6.3**	
Balikpapan refinery upgradation	Indonesia	100,000	5.0	CY2024
Cilacap Refinery Upgradation	Indonesia	52,000	2.6	CY2026
Indonesia Total		**152,000**	**7.7**	
Manila Refinery	Philippines	400,000	20.1	CY2027
Philippines Total		**400,000**	**20.1**	
Dung Quat refinery (upgrade)	Vietnam	22,000	1.1	CY2025
Vietnam Total		**22,000**	**1.1**	
Kermanshah refinery unit	Iran	50,000	2.5	CY2025
Persian Gulf's Qeshm island	Iran	70,000	3.5	CY2025
Lavan in the Persian Gulf	Iran	150,000	7.6	CY2026
Bandar Abbas (Shahid Qassem Soleimani petrorefinery)	Iran	300,000	15.1	CY2027
Morvarid Makran Refinery	Iran	300,000	15.1	CY2027
Star refinery	Iran	300,000	15.1	CY2027
Anahita Refinery	Iran	150,000	7.6	CY2030
Iran Total		**1,410,000**	**71.0**	
Kerbala Refinery	Iraq	140,000	7.1	CY2023
Upgradation of Haditha refinery	Iraq	20,000	1.0	CY2024
Baiji complex, Rehab	Iraq	210,000	10.6	CY2025
Upgrade Qayyarah refinery	Iraq	70,000	3.5	CY2025
Zubair oil field (new plant)	Iraq	300,000	15.1	CY2025
Refinery in the Dhi Qar province	Iraq	100,000	5.0	CY2026
Southern Iraqi town of Nassiriya	Iraq	150,000	7.6	CY2027
Southeastern Maysan Governorate	Iraq	50,000	2.5	CY2028
Nineveh Governorate	Iraq	70,000	3.5	CY2028
Southern Basra city	Iraq	30,000	1.5	CY2028
Southern Dhi Qar Governorate	Iraq	50,000	2.5	CY2028
Unit in Wasit in East Iraq	Iraq	100,000	5.0	CY2028
Unit in Muthanna in South Iraq	Iraq	70,000	3.5	CY2028
Western Alanbar Governorate	Iraq	70,000	3.5	CY2028
Iraq Total		**1,430,000**	**72.0**	
Fergana Refinery Modernisation	Uzbekistan	109,000	5.5	CY2023
Karaoul Bazar - BOR's condensate refinery	Uzbekistan	50,000	2.5	CY2025
Uzbekistan Total		**159,000**	**8.0**	
Atyrau refinery	Kazakhstan	119,000	6.0	CY2023
Shymkent oil refinery	Kazakhstan	238,000	12.0	CY2029
Kazakhstan Total		**357,000**	**18.0**	
Saudi Aramco and SABIC Yanbu	Saudi Arabia	400,000	20.1	CY2025
Jubail Refinery Project	Saudi Arabia	400,000	20.1	CY2027
Saudi Arabia Total		**800,000**	**40.3**	
Duqm CBH	Oman	300,000	15.1	CY2023
Oman Total		**300,000**	**15.1**	
Dangote Refinery	Nigeria	650,000	32.7	CY2023
Waltersmith Refinery	Nigeria	50,000	2.5	CY2025
BUA Refinery	Nigeria	200,000	10.1	CY2026
Tongeji Island Refinery	Nigeria	400,000	20.1	CY2028
Nigeria Total		**1,300,000**	**65.5**	

Cabinda Refinery	Angola	60,000	3.0	CY2024
Soyo	Angola	100,000	5.0	CY2024
Lobito Refinery	Angola	200,000	10.1	CY2025
Angola Total		**360,000**	**18.1**	
Hassi Messaoud III refinery	Algeria	112,000	5.6	CY2024
Tiaret Refinery	Algeria	100,000	5.0	CY2030
Algeria Total		**212,000**	**10.7**	
Petroleum Hub	Ghana	900,000	45.3	CY2030
Ghana Total		**900,000**	**45.3**	
Assuit oil refinery upgrade	Egypt	56,000	2.8	CY2023
Egypt Total		**56,000**	**2.8**	
Sogara Upgrade	Gabon	19,000	1.0	CY2025
Gabon Total		**19,000**	**1.0**	
Olmeca Refinery	Mexico	340,000	17.1	CY2023
Soto La Marina	Mexico	60,000	3.0	CY2027
Mexico Total		**400,000**	**20.1**	
Heartland Refinery	Canada	188,000	9.5	CY2025
Edmonton Refinery II	Canada	167,000	8.4	CY2025
Dubose Refinery	Canada	200,000	10.1	CY2028
Kitimat Refinery	Canada	125,000	6.3	CY2030
Canada Total		**680,000**	**34.3**	
Ilsky Refinery Expansion	Russia	170,000	1.5	CY2023
Novoshakhtinsky Refinery Expansion	Russia	240,000	1.8	CY2024
Yanos Refinery Upgrade	Russia	99,000	3.4	CY2024
Moscow Refinery Expansion	Russia	90,000	4.4	CY2025
Afipsky Refinery Upgrade	Russia	87,000	1.6	CY2026
Komsomolsk Refinery Exapnsion	Russia	32,000	3.7	CY2026
Perm Refinery Exapnsion	Russia	44,000	1.8	CY2026
Khabarovsk Refinery Phase 2	Russia	72,000	5.0	CY2027
Ryazan refinery Expansion	Russia	36,000	2.2	CY2027
Sakhalin Refinery	Russia	36,000	4.5	CY2028
Omsk Refinery Expansion	Russia	30,000	8.4	CY2028
Refinery as part of VNHK Complex	Russia	67,500	12.0	CY2029
Russia Total		**1,003,500**	**50.3**	
Countries of Interest - Total		**10,149,030**	**510.9**	

Source: Country ministry websites, ministry presentations, EIA, www.offshore-technology.com, www.spglobal.com, Reuters, Frost & Sullivan analysis

Heating equipment:

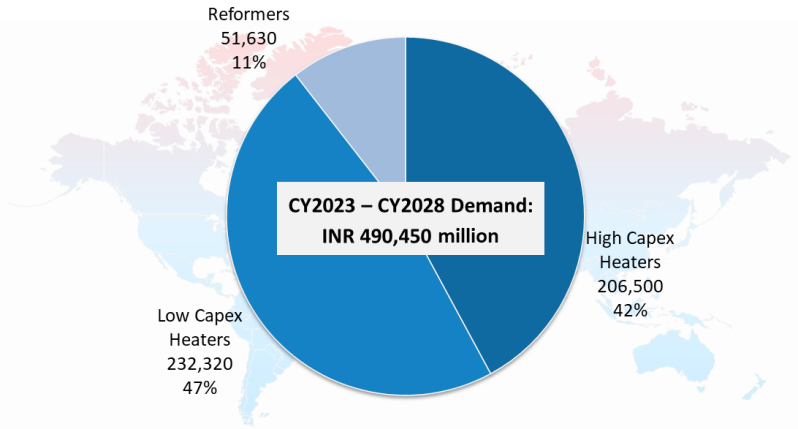
Demand potential for heating equipment:

Only the refinery segment has been considered for estimating demand for heating equipment from the 22 countries of interest namely, South Korea, Malaysia, Thailand, Indonesia, Philippines, Singapore, Vietnam, Iran, Iraq, Qatar, Saudi Arabia, Oman, Egypt, Nigeria, Algeria, Angola, Gabon, Kazakhstan, Uzbekistan, Mexico, Canada, Russia. Methodology for estimating the demand potential has already been explained in the heating equipment section of the chapter 4 of this report.

- Based on exhibit 5.14, **52 refinery projects are likely to be commissioned between CY2025 and CY2030. Total installed capacity of these projects are 510.9 with an estimated capex of USD 186 Bn / INR 14,900,000 million (1 USD = INR 80)**
- Considering a 2-year lag between equipment ordering and project commissioning, **these projects will generate demand for heating equipment between CY2023 and CY2028.**
- Heating equipment account for **3.3% of the total capex** of a refinery project.

- Hence, **demand for heating equipment from the refineries in the countries of interest between CY2023 and CY2028 would be INR 490,450 million i.e., approx. INR 81,750 million on annualized basis.**
- This potential is based on the projects announced till date and may go up if more projects are announced in the coming years.

Exhibit 5.15: Demand for heating equipment from refineries, Global, CY2023 – CY2028



Source: Source: Frost & Sullivan research and analysis

Brief competitive landscape:

Globally, heating equipment is a closely competed market. There are approx. 12-13 companies which manufacture process fired heaters, reformers, and cracking furnaces. The major global companies are Furnace Engineering Inc., Furnace Improvement Services (FIS), JNK Korea, Heurtey Petrochem Solutions, ITT S.p.A, Tecnicas Reunidas (TR), Unit Birwelco, Boustead International Heaters, and Born Inc. Other than that, there are a few Indian companies (already mentioned in the previous chapter) which also caters to some global demand.

JNK Korea, is the only industrial-use process fired heater producer in Korea and is ranked amongst the top three industrial use process fired heater producer globally.

Exhibit 5.16: Competition mapping, Global, CY2023

S. No.	Company Name	Origin	Process Fired Heaters	Reformers	Cracking Furnace
1	JNK Korea	South Korea	✓	✓	✓
2	Furnace Engineering Inc.	Japan	✓	✓	✓
3	Furnace Improvement Services (FIS)	USA	✓	✓	✓
4	Heurtey Petrochem Solutions	France	✓	✓	✓
5	ITT S.p.A	Italy	✓	✓	✓
6	Tecnicas Reunidas (TR)	Spain	✓	✓	
7	Unit Birwelco	UK	✓		
8	Boustead International Heaters	UK	✓		
9	Born Heaters Inc.	USA	✓		

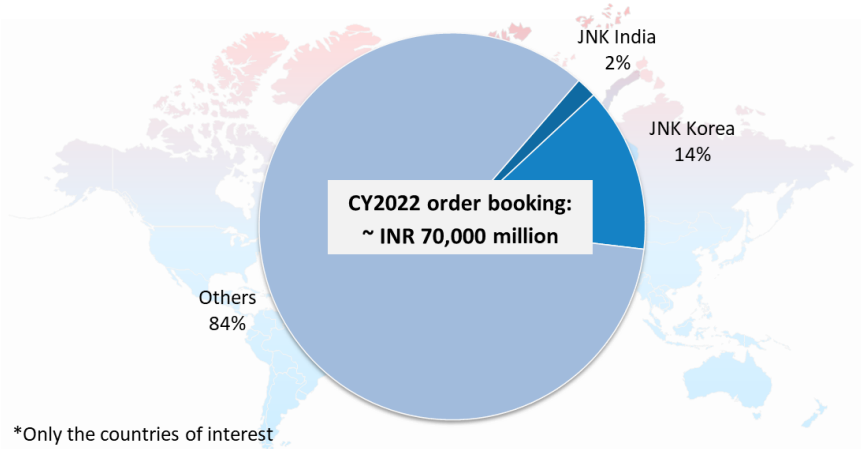
Source: Frost & Sullivan research

Market size and market share analysis:

Based on discussion held with few of the leading global suppliers, approximately INR 70,000 million of heating equipment have been ordered by the refineries from the countries of interest in CY2022. There is a boost in the order booking as the oil prices softened in the last two years post pandemic. Some of the large refineries that issued orders during this period are Dangote Refinery (Nigeria) – 32.7 MMTPA, Olmeca Refinery (Mexico) – 17.1 MMTPA. JNK Korea has installed its process fired heaters for its customer in Lagos, Nigeria, where one of the biggest refineries in the world (Dangote Refinery) is operated, having a capacity of 32.7 MMTPA.

JNK Korea is engaged in the design, manufacturing, installation, and maintenance of Fired Heaters and ranks amongst top three industrial use fired heater producer globally. The Company distributes its products within domestic market and to overseas markets. Based on the order booking in CY2022, JNK India and JNK Korea has 2% and 14% market share globally.

Exhibit 5.16: Market share (new orders) of heating equipment suppliers, Global*, CY2022



*Only the countries of interest
Others: Companies mentioned in exhibit 5.16

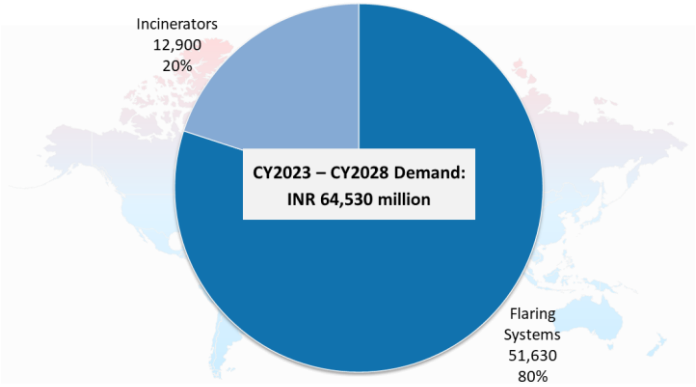
Source: Frost & Sullivan research & analysis

Waste Gas Handling Systems:

Demand potential for waste gas handling systems:

- As mentioned above, Based on exhibit 5.14, **52 refinery projects are likely to be commissioned between CY2025 and CY2030. Total installed capacity of these projects are 510.9 with an estimated capex of USD 186 Bn / INR 14,900,000 million (1 USD = INR 80)**
- Considering a 2-year lag between equipment ordering and project commissioning, **these projects will generate demand for heating equipment between CY2023 and CY2028.**
- Waste gas handling systems account for 0.4% **of the total capex** of a refinery project.
- Hence, **demand for waste gas handling systems from the refineries in the countries of interest between CY2023 and CY2028 would be INR 64,530 million i.e., approx. INR 10,750 million on annualized basis.**
- This potential is based on the projects announced till date and may go up if more projects are announced in the coming years.

Exhibit 5.17: Demand for waste gas handling systems from refineries, Global, CY2023 – CY2028



Source: Source: Frost & Sullivan research and analysis

CHAPTER 6: PROFILES OF KEY PLAYERS

Overview of Company profiles

1. Thermax Limited (India)

- Thermax Ltd is an Indian multinational engineering conglomerate, involved in clean air, clean energy and clean water, headquartered in Pune.
- Product and service offerings include boilers, chillers, water treatment solutions, air pollution control systems, waste management solutions, solar thermal systems.
- Chemicals & fertilizers, Distillery, Power generation, Refineries and Petrochemicals are the key industries served.

2. Bharat Heavy Electricals Limited (BHEL) (India)

- BHEL is the largest government-owned power generation equipment manufacturer in India.
- BHEL is engaged in the design, engineering, manufacturing, construction, testing, commissioning and servicing of a wide range of products, systems and services including turbines, boilers, transformers, heat exchangers, motors, switchgears, control systems and solar panels.
- Key industries served by the company includes - power & energy, oil & gas.

3. Esteem Projects Private Limited (India)

- Esteem projects is a leading Engineering, Procurement and Construction company headquartered in Mumbai.
- Key product offerings include Fired heaters, Steam Naphtha Reformers, Gas Cracking Furnaces, Steam reformer furnaces and other Furnaces and EDC crackers.
- Oil & Gas, Petrochemicals and fertilizers are the industries served by the company.

4. JNK Heaters Co. Limited (South Korea)

- JNK Heater is a globally renowned fired heater company with widespread domestic and global experience, engaged in the design, manufacturing, installation and maintenance of Fired Heaters and Hydrogen production facilities.
- Refinery, Petrochemicals, Natural gas and hydrogen are the key industries served.

5. Furnace Engineering Inc. (Japan)

- Furnace Engineering Co. is a specialised manufacturer of heating furnaces, supplying to domestic and overseas plant sites.
- Fired heaters, reformers, incinerators and waste heat recovery units are the key products offered by the company.
- Refinery, petrochemicals, fertilizer are the key industries served.

6. Furnace Improvement Services Inc. (USA)

- FIS has been actively providing value-added solutions for Fired Heaters, Boilers, and Waste Heat Recovery Units to end-users around the world for over 24 years.
- Petrochemicals and refineries are the key industries served.

7. Heurtey Petrochem Solutions (France)

- Heurtey Petrochem Solutions is a world leader in process furnaces for refining, petrochemicals, syngas and hydrogen markets.
- The company provides a comprehensive offer including the design and manufacturing of Process Furnaces, Waste heat recovery units as well as process feasibility studies and other services.

8. ITT S.P.A. (Italy)

- ITT is a leading international engineering group specialized in thermal design, detail engineering and supply of fired heaters, reformers and ancillary equipment as well as associated services
- Refineries and petrochemicals are the key industries served.

9. Tecnicas Reunidas, S.A. (TRSA) (Spain)

- TRSA is a Spanish-based general contractor which provides engineering, procurement and construction of industrial and power generation plants, particularly in the oil and gas sector.
- Heaters, Reformers and Cracking Furnaces are the key product offerings.
- The business divisions of TRSA are oil and gas, power generation and infrastructures.

Profile 1: Thermax Limited, India

Company Overview	• Established in 1966, Thermax is an engineering company headquartered in Pune. • It provides sustainable solutions in energy and environment. The company's systems, products and services assist customers in achieving better resource productivity and improving cost efficiency, besides maintaining a cleaner environment. • It offers a portfolio of products for heating, cooling, water and waste management, and specialty chemicals.			
Product Offerings	• Boilers - including waste heat recovery boilers, fired boilers, and heat recovery steam generators. • Absorption chillers • Water treatment solutions - including reverse osmosis systems, demineralization plants, and ion exchange resins, for various applications. • Air pollution control systems - including bag filters, electrostatic precipitators, and wet scrubbers, for controlling emissions from industries. • Waste management solutions - including waste incineration systems and waste-to-energy plants, for the safe disposal of hazardous and non-hazardous waste. • Solar thermal systems - Thermax offers solar thermal systems for various applications, including industrial heating, cooling, and drying. • Chemicals - Thermax produces and supplies a range of chemicals, including boiler water treatment chemicals, cooling water treatment chemicals, and process chemicals.			
Industries Served	• Chemical and Fertilisers • Distillery		• Power Generation • Refineries and Petrochemicals	
Global Presence	• Bangladesh • Brazil • Brazil • Canada • Denmark • Egypt • Germany • India	• Egypt • Indonesia • italy • kenya • Malasiya • Mauritius • Myanmar • Netherlands	• Nigeria • Phillippines • Poland • Saudi Arabia • Senegal • Singapore • Srilanka • Tanzania	• Thailand • Turkey • UK • USA • UAE • Vietnam • Zambia
Major Project Wins	• Babcock & Wilcox Enterprises, Inc. manufacture and sell select industrial boilers and supercritical utility boilers up to 800 MW in thermal power plants • Balcke Durr To offer dry electrostatic precipitators, regenerative air gas heaters and pulse jet bagfliters • Lambion Energy Solutions, Germany To offer grate technologies • Marsulex Environment Technologies, USA To offer wet & semi dry flue gas desulphurisation technologies			
Key Clients	• Tata Steel • Hindalco Industries • Indian Oil		• Adani Power • Bharat Petroleum • Essar Oil	

Source: Company website

Profile 2: Bharat Heavy Electricals Limited (BHEL), India

Company Overview	• Established in 1964, Bharat Heavy Electricals Limited (BHEL) is a government-owned engineering and manufacturing company headquartered in New Delhi, India. • In addition to manufacturing, BHEL also provides a range of services, including project management, engineering, procurement, and construction. • With a focus on providing equipment and services for the power sector, as well as other industries.		
Product Offerings	• Power generators -including steam turbines, gas turbines, and hydro turbines. • Boilers -including sub-critical boilers, super-critical boilers, and ultra-super-critical boilers for thermal power plants. • Turbines - including steam turbines, gas turbines, and hydro turbines. • Transformers - BHEL manufactures power transformers, distribution transformers, and special transformers for various applications. • Motors - including AC motors and DC motors, for various applications. • Switchgear - BHEL manufactures switchgear, including high-voltage switchgear, medium-voltage switchgear, and low-voltage switchgear, for power transmission and distribution. • Control systems -including distributed control systems and programmable logic controllers, for various applications. • Transportation equipment - BHEL manufactures and supplies locomotives, railway coaches, and electrical multiple units (EMUs) for the railway sector. • Solar panels - BHEL offers solar panels and solar systems for both on-grid and off-grid applications.		
Industries Served	• Power and Energy • Oil and Gas		
Global Presence	• Egypt • Libya • Sudan • Tanzania • Indonesia • Iraq	• Germany • Mexico • Malaysia • Thailand • Vietnam • Oman	• Qatar • UAE • Venezuela • Vietnam • Greece • Cyprus
Major Project Wins	• BHEL has received a order for setting up the 2 x 660 MW Talcher Thermal Power Project Stage-III on EPC basis from NTPC Ltd. • Aimed at gainfully utilising the country's vast reserves of coal & lignite, BHEL has entered into strategic MoUs with Coal India Limited (CIL) and NLC India Limited (NLCIL) for setting up Coal Gasification based plants. • IOCL, Odisha: BHEL supplied and installed a crude oil preheat exchanger.		
Key Clients	• NTPC • NHPC • Power Grid Corp. • ONGC	• Indian Oil Corp. • Reliance Industries • HPCL	

Source: Company website

Profile 3: Esteem Projects Private Limited, India

Company Overview	• Established in 1993, Esteem projects is a leading Engineering, Procurement and Construction company headquartered in Mumbai. • Esteem Projects has a diversified portfolio of services, which includes project management, design, engineering, procurement, construction, commissioning, and maintenance.	
Product Offerings	• Fired Heaters • Steam Naphtha Reformers • Gas Cracking Furnaces, Steam reformer furnaces and other Furnaces • EDC crackers	
Industries Served	• Oil and Gas • Petrochemicals • Fertiliser	
Global Presence	• Uganda • Tanzania • United Arab Emirates • Oman	• Sri Lanka • Nepal • Germany • Poland
Major Project Wins	• DHDT Heaters Package for BS-VI Project supplied by Esteem to Gujarat Refinery of Indian Oil Corporation Ltd and Panipat Refinery of Indian Oil Corporation Ltd. • Commissioning of PrimeG heater supplied by Esteem to Haldia Refinery of Indian Oil Corporation Ltd. This heater is part of the prestigious BS-VI Fuel up-gradation project of IOCL. • Esteem has been selected for the Augmentation of existing Fired Heater package of VGO Unit at IOCL Gujarat Refinery at Indian Oil Corporation Ltd., Gujarat Refinery.	
Key Clients	• ABB • Bharat Petroleum • Bharat Oman Refineries • CPCL • Indian Oil	• ONGC • Jacobs • Numaligarh Refineries • HMEL

Source: Company website

Profile 4: JNK Heaters Co. Limited, South Korea

Company Overview	• JNK heaters started in 1986 and spun off as an independent company in 1998. • Headquartered in Seoul, South Korea. • The company engaged in the design, manufacturing, installation and maintenance of Fired Heaters and Hydrogen production facilities. • The company ranks amongst top three industrial use fired heater producer globally. The Company distributes its products within domestic market and to overseas markets. • JNK Korea is listed on the Korea Exchange KOSDAQ.
Product Offerings	• Fired Heaters • Hydrogen fuel value chain • Bio-gas refining technology
Industries Served	• Refinery • Petrochemicals • Natural Gas • Hydrogen
Global Presence	• South Korea • USA • Iran • Saudi Arabia • Vietnam • Nigeria • Algeria
Major Project Wins	• GS E & C, South Korea (CY2016) • Dangote Oil Refinery Company, Nigeria (CY2021) • Xebec Adsorption Inc, China (CY2021)
Key Clients	• Samsung Total BTX (South Korea) • JG Summit Naphtha Cracker (USA) • Skikda Refinery (Algeria) • Dena Methanol (Iran) • Saudi Jubail Sarada (Saudi Arabia)

Source: Company website

Profile 5: Furnace Engineering Inc., Japan

Company Overview	• Established in 1990 • Headquartered at Yokohama, Japan • ISO 9001:2015 and ISO 14001:2015 certified company. • The company provides technology driven solutions for combustion equipment to reduce cost, improve efficiency and on-stream factors to maximize return on investment. • The company has executed more than 500 + projects. • They have two subsidiary companies – FEIS Co. Ltd. and Furnace Engineering Projects Pvt. Ltd. • They have about 50 people in the company and undertake projects under LSTK contracts.	
Product Offerings	• Furnaces/ Fired Heaters • Reformers • Incinerators • Waste Heat Recovery Units • They provide full range of services from design, fabrication, erection, and consulting for heater project execution.	
Industries Served	• Refinery – CDU, VDU, CCR, Reactor Charge, Fractionator Feed, Feed Preheater, Regeneration, Stabilizer Reboiler, Stripper Splitter Reboiler, Column Reboiler, Visbreaker • Petrochemicals - Ethylene Cracking Furnace, EDC Cracking, Hot Oil Heater, Rich Oil Heater, Steam Superheater, Tar Heater • Fertilizer – Primary Reformer, Start-up Heater • Other Industries - Conventional Feed Preheater, CO Reformer, Waste Heat Recovery Unit (WHRU), Process Module & Cold Box	
Global Presence	• South Korea • Thailand	
Major Project Wins	• Hot oil heater, PTA Plant, Thailand • Naptha Cracking Furnace, Ethylene Plant, Japan • H2 reformer, Korea • Vacuum Gasoil Hydrotreater (VGO-HDT) Unit at IOCL Panipat Refinery Expansion Project (P-25), India	
Key Clients	• JGC • Chiyoda Corporation • Toyo Engineering • Kawasaki • Mitsubishi Heavy Industries	• Samsung • SK E&C • Hyundai Engineering and Construction • Cosmo

Source: Company website, https://www.linkedin.com/company/furnace-engineering-projects-pvt-ltd/posts/?feedView=all

Profile 6: Furnace Improvement Services Inc., USA

Company Overview	• Established in 1996
	• Headquarter: Sugar Land, TX, USA
	• The company initially entered the heaters business by conducting engineering studies for fired heaters and provided solutions to customers to overcome operational problems. Later developed into a full-fledged engineering and consulting company.
	• They started supplying new heaters on turnkey basis in CY2002.
	• Completed over 400 engineering studies and projects.
	• The company has patented the below technologies
	  ○ *Inclined firing system*
	  ○ *Split flow technology*
	  ○ *Flue gas injection*
	  ○ *Smart stack damper*	

Product Offerings	• Design, build, and commission fired heaters.
	  ○ *Crude heater*
	  ○ *Reformer charge heater*
	  ○ *Vacuum heater*
	  ○ *Hydrotreater heater*
	  ○ *Coker heater*
	  ○ *CO Boilers*
	  ○ *Waste heat boilers*
	• Revamping of heaters
	• CFD modelling, 3D modelling.
	• Detailed engineering, fabrication, erection, and start-up assistance	

Industries Served	• Refineries	
Global Presence	• United States of America (USA) • India (Delhi and Pune)	
Major Project Wins	• HPCL, Mumbai, Extract / Raffinate Recovery Heaters • Valero, Texas City, Reformer and NHT • Alon, Big Spring, Hydr ogen Heater • Phillips 66, WRR-Reformer Heaters	
Key Clients	• ConocoPhillips • Valero • Lyondell • Devon • Reliance Industries Limited	• Chevron • Koch Industries • Shell • HP • Indian Oil

Source: Company website

Profile 7: Heurtey Petrochem Solutions, France

Company Overview	• Established in 1974 and has more than 60 years of experience. • Global headquarters: Rueil-Malmaison – France • In CY2018, Axens acquired 100% of the shares of Heurtey Petrochem. • The company has sold more than 3,500 furnaces with more than 2,000 references	
Product Offerings	• Furnaces - Crude distillation, Vacuum distillation, Catalytic reforming (CCR, semi-regenerative reformer), Isomerization, Catalytic Cracking, Hydrodesulfurization, Hydrotreating, Hydrocracking, Delayed coking, Visbreaking, Bitumen, Hot oil heaters, Steam superheaters, Gas regeneration heaters, Reboilers, Charge heaters, Start-up heaters, CO Boilers • Waste heat recovery units • Emission reductions • They also provide feasibility studies, mechanical studies, process studies, field survey & assessment, detailed engineering, prefabrication & modularization, on-site installation, commissioning and start-up, revamping & modernization, spare parts sourcing, technical support and training	
Industries Served	• Refining • Petrochemicals • Gas - syngas and hydrogen	
Global Presence	• South Korea • China • India (Mumbai, Vadodara) • USA • Brazil	• Romania • Russia • UAE • France
Major Project Wins	• Not available	
Key Clients	• Total • Exxon Mobil • Chevron • Shell • Reliance Industries Limited • Cheniere	• Valero • Indian Oil • BP • ConocoPhillips • Essar

Source: Company website

Profile 8: ITT S.P.A, Italy

Company Overview	• ITT is part of ITT Holdings and was established in 1954, headquartered at Milan, Italy; has 65 plus years of experience. • ITT offers in-depth experience in thermal and mechanical design enhanced by its state-of- the-art propriety software. • It is an approved vendor to most EPC contractors as well as big oil and national oil companies worldwide. • The company has supplied more than 1,000 process fired heaters and 80+ reformers for hydrogen, ammonia, or methanol production. • ITT is approved with process licensor such as HTAS, Davy Process, KBR, Uhde, Casale, Lurghi, Energiron	
Product Offerings	• Fired heaters - Crude Oil, Vacuum, Hydrocracker, Hydrotreater, Start-up, Hot Oil, CCR, Visbreaking, Delayed Coker, Ethane Cracker (Ethylene Propylene) • Reformers – Hydrogen, Ammonia, Methanol • Waste heat management - Waste Heat Recovery Section (WHRS), Waste Heat Boiler, Heat Recovery Steam Generation System (HRSG), Air Preheating System (APH) • Services include engineering services, project execution, revamping and retrofit consulting services, construction supervision services, start-up and training services.	
Industries Served	• Refining • Petrochemicals	
Global Presence	• India (Mumbai) • Switzerland • South Korea	• Brazil • China • Others
Major Project Wins	• Charge Heater, SABIC, Saudi Arabia • PEMEX, Steam Reformer, Mexico • IOCL, Reactor Feed Heater, India • RAFFINERIA DI GELA, Reactor Feed Heater, Italy • Saudi Aramco, Hot oil heater, Saudi Arabia • Steam reformer, Haifa Negev Technologies, Israel • Steam cracker heaters, Orlen, Poland	
Key Clients	• ENI Angola Exploration B.V. • Salzgitterag • Petrobras • Haifa Negev Technologies Ltd • SRC Basrah	• SOPC, Egypt • Nasr Petroleum Company • PDH Polska • Anadarko

Source: Company website

Profile 9: Tecnicas Reunidas, S.A., Spain

Company Overview	• Established in 1960
	• Headquartered in Madrid, Spain and has presence in 60 countries
	• The company has two business lines that support sustainable growth and decarbonization.
	  ○ *Services to produce clean fuels*
	  ○ *Services to produce petrochemical products*		

Product Offerings	• Heaters • Reformers • Cracking Furnaces		
Industries Served	• Clean Fuels • Circular Economy • Hydrogen • Natural Gas • Petrochemicals • CCS		
Global Presence	• India • Malaysia • Russia • China • Italy • Saudi Arabia • Algeria	• Oman • UAE • Kuwait • Turkey • Sharjah • Bahrain	• Qatar • Mexico • Canada • Chile • Peru • Argentina
Major Project Wins	• Gonzalez Ortega CCGT Power Plant • San Luis Rio Colorado CCGT Power Plant • Olefins Expansion Project • Sasa purified terephthalic acid project • Ostroleka CCGT Power Plant,		
Key Clients	• Bapco • Saudi Aramco • Duqm Refinery • KNPC • Petroperu • MGT Teesside • ADOC	• Ashuganj Power Station Company • Nova Chemicals • YPFB • Suncor Energy Oil Sands • EnerSur (GDF Suez) • ENAP Refinery Bio Bio (ERBB)	

Source: Company website

Financial Ratios

Exhibit 6.1: Revenue from operations and Total profit, India, FY19 – FY22

	Revenue from operations[1] (INR million)					Total Profit[2] (INR million)				
Name of the Company	FY19	FY20	FY21	FY22	CAGR*	FY19	FY20	FY21	FY22	CAGR*
BHEL Ltd.	304,414.0	214,900.0	173,087.0	212,111.0	-11.3%	10,024.2	-14,683.5	-26,997.0	4,447.0	-23.7%
Thermax Ltd.	59,732.0	57,313.0	47,913.0	61,283.0	0.9%	3,254.0	2,125.0	2,066.0	3,123.0	-1.4%
Esteem Projects Pvt. Ltd.	561.0	713.0	308.0	NA	NA	32.0	38.0	19.0	NA	NA

NA - Data not available
* CAGR represent FY20 to FY22

Source: Annual Reports of Companies published in RoC, MCA; Frost & Sullivan Analysis

[1] Revenue from operations = As stated in profit and loss statement (excluding other income)
[2] Total Profit = Total profit after tax

Exhibit 6.2: Gross margin, EBITDA margin and PAT margin, India, FY19 – FY22

	Gross margin[3] (%)				EBITDA margin[4] (%)				PAT margin[5] (%)			
Name of the Company	FY19	FY20	FY21	FY22	FY19	FY20	FY21	FY22	FY19	FY20	FY21	FY22
Bharat Heavy Electricals Ltd.	13.0%	0.1%	3.3%	6.7%	9.2%	1.5%	-16.1%	5.1%	3.3%	-6.8%	-15.6%	2.1%
Thermax Ltd.	32.9%	33.8%	32.7%	29.5%	10.2%	8.8%	9.7%	8.9%	5.4%	3.7%	4.3%	5.1%
Esteem Projects Pvt. Ltd.	35.0%	35.1%	49.9%	NA	9.4%	9.8%	13.0%	NA	5.7%	5.4%	6.4%	NA

NA - Data not available

Source: Annual Reports of Companies published in RoC, MCA; Frost & Sullivan Analysis

[3] Gross margin = Gross Profit / Operating Revenue
[4] EBITDA margin = EBITDA / Total Revenue
[5] PAT margin = PAT / Total Revenue

Exhibit 6.3: RoE and RoCE, India, FY19 – FY22

	RoE[6] (%)				RoCE[7] (%)			
Name of the Company	FY19	FY20	FY21	FY22	FY19	FY20	FY21	FY22
BHEL Ltd.	3.2%	-4.9%	-9.9%	1.7%	82.8%	68.3%	58.8%	65.8%
Thermax Ltd.	10.8%	7.0%	6.6%	9.3%	149.5%	139.3%	118.8%	136.7%
Esteem Projects Pvt. Ltd.	12.5%	14.1%	6.5%	NA	177.6%	278.6%	57.2%	NA

NA - Data not available

Source: Annual Reports of Companies published in RoC, MCA; Frost & Sullivan Analysis

[6] RoE = PAT / Average of Networth (shareholders fund) of current FY and previous FY
[7] RoCE = EBIT (Operating expense + dep and amort) / Average of Capital employed of current FY & previous FY
(Capital Employed = Networth + Debt – Cash & Cash Equivalent)

Exhibit 6.4: Gross fixed asset turnover ratio, Net working capital, Net working capital days, India, FY19 – FY22

	Gross Fixed Asset Turnover Ratio[8]				Net Working Capital[9]				Net Working Capital Days[10]			
Name of the Company	FY19	FY20	FY21	FY22	FY19	FY20	FY21	FY22	FY19	FY20	FY21	FY22
BHEL Ltd.	1.19	0.77	0.64	0.75	153,257.0	100,343.0	79,862.0	64,908.0	184	170	168	112
Thermax Ltd.	2.90	2.90	2.35	2.25	10,833.0	11,904.0	13,958.0	9,797.0	66	76	106	58
Esteem Projects Pvt. Ltd.	5.55	7.15	3.04	NA	18.0	215.0	233.0	NA	11	110	276	NA

NA - Data not available

Source: Annual Reports of Companies published in RoC, MCA; Frost & Sullivan Analysis

[8] Gross Fixed Asset Turnover Ratio = Turnover (Operating Revenue) / Total Gross Fixed Asset (total fixed assets)
[9] Net Working Capital = Current Asset – Current Liabilities
[10] Net Working Capital Days = (Net Working Capital *365) / Total Operating Revenue