INDUSTRY REPORT ON INDIAN ETHANOL MARKET

SUBMITTED TO

Regreen Excel EPC India Ltd.

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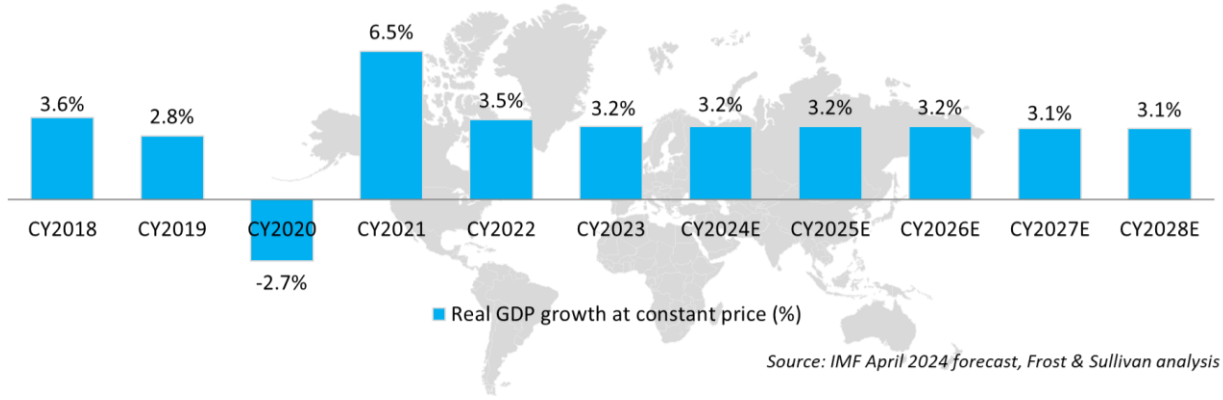
1. MACROECONOMIC OVERVIEW OF GLOBAL AND INDIAN ECONOMY

1.1 Global Real GDP review and outlook

The Global economy (real GDP), which is now well on the path of recovery, has undergone stress in the last few years due to extended trade conflicts, slowdown in investments across the world and then a novel virus. Global economy was showing signs of slowdown since CY2018 and then entered a recession in CY2020 owing to the unprecedented crisis caused by COVID-19 pandemic. The pandemic brought economic activity to a near standstill in CY2020 and to an extent in CY2021, as many countries had to impose strict restrictions to curb the spread of the virus.

The global economy showed tremendous resilience and recorded a sharp growth in CY2021. However, the global economy once again was affected with multiple hurdles in CY2022 – These were Russia-Ukraine war, inflation, slowdowns in US and Europe, supply chain issues and other difficulties. The impact of these factors got moderated in CY2023 with global real GDP stabilized at 3.2% growth. The global economy is expected to grow at the same pace over the next three years before moderating to 3.1% in CY2027 and CY2028. However, this outlook faces headwinds in the form of higher interest rates implemented by central banks to combat inflation and reduced government spending due to accumulated debt.

Exhibit 1.1: Real GDP growth, World, CY2018 – CY2028E



Source: IMF April 2024 forecast, Frost & Sullivan analysis

Exhibit 1.2: Real GDP Growth by select regions and countries, World, CY2018 – CY2028E

Country / Region	CY2018	CY2019	CY2020	CY2021	CY2022	CY2023	CY2024E	CY2025E	CY2026E	CY2027E	CY2028E
World	**3.6%**	**2.8%**	**-2.7%**	**6.5%**	**3.5%**	**3.2%**	**3.2%**	**3.2%**	**3.2%**	**3.1%**	**3.1%**
United States	3.0%	2.5%	-2.2%	5.8%	1.9%	2.5%	2.7%	1.9%	2.0%	2.1%	2.1%
China	6.8%	6.0%	2.2%	8.4%	3.0%	5.2%	4.6%	4.1%	3.8%	3.6%	3.4%
India	**6.5%**	**3.9%**	**-5.8%**	**9.7%**	**7.0%**	**7.8%**	**6.8%**	**6.5%**	**6.5%**	**6.5%**	**6.5%**
North America	2.8%	2.1%	-3.0%	5.7%	2.3%	2.5%	2.6%	1.9%	2.0%	2.1%	2.1%
Europe	2.3%	2.0%	-5.4%	6.3%	2.5%	0.4%	0.8%	1.5%	1.7%	1.6%	1.6%
Asia and Pacific	5.3%	4.1%	-0.8%	7.1%	4.0%	4.8%	4.4%	4.2%	4.1%	4.1%	4.0%
Middle East and Central Asia	2.8%	1.7%	-2.4%	4.5%	5.3%	2.0%	2.8%	4.2%	3.8%	3.9%	3.6%
Africa	3.4%	2.9%	-1.7%	4.9%	4.0%	3.2%	3.5%	4.0%	4.0%	4.2%	4.3%
Latin America	0.5%	0.0%	-6.4%	7.5%	4.0%	1.5%	1.4%	2.7%	2.6%	2.5%	2.4%

Source: IMF April 2024 forecast, Frost & Sullivan analysis

India continues to remain the fastest-growing large economy in the world since CY2021 and registered a real GDP growth of 7.8% in CY2023, after recording a growth of 7.0% in CY2022. The USA's GDP has grown

by 2.5% in CY2023 backed by increases in consumer spending, non-residential fixed investment, state and local government spending, exports, and federal government spending. China's economy has grown by 5.2% in CY2023, primarily driven by removal of COVID restrictions during end CY2022/beginning CY2023. On the other hand, Europe's GDP growth was muted in CY2023 – the region is grappling with multiple issues including a war and higher energy prices and registered a mere 0.4% growth in CY2023.

1.2 Indian Macro-economic overview

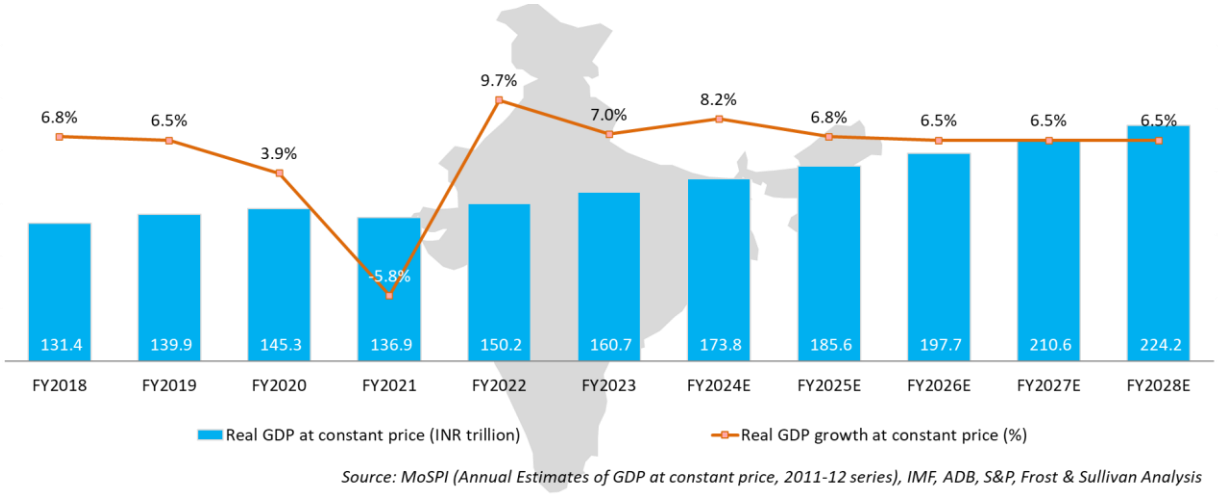
Indian economy has shown robust performance in the last three financial years and achieved 7.2% real GDP growth in FY2023 followed by 8.2% growth in FY2024, outperforming many other major economies and least impacted by the inflationary pressure globally. Structural reforms including disinvestment, higher FDI limits, and a national logistics policy were aimed at bolstering India's manufacturing sector post-pandemic. In addition, the Indian government in the recent FY2025 budget has set out nine priorities in pursuit of 'Viksit Bharat'. These priorities are a) prductivity and resilience in agriculture, b) employment & skilling, c) inclusive human resource development and social justice, d) manufacturing & services, e) urban development, f) energy security, g) infrastructure, h) innovation, research & development, and i) next generation reforms.

In CY2019, the Indian government had set a target of becoming a USD 5 trillion economy by FY2025. As a result of the COVID pandemic, the original timeline has been revised by 18–24 months. India's GDP is likely to surpass USD 4 trillion in FY2025 and expected to reach USD 5 trillion in another 3-4 years to become the third largest economy by surpassing Germany and Japan.

1.3 Review and outlook of Real GDP growth of India

The economy has achieved a record growth of 8.2% in FY2024, exceeding all the expectations. This surge showcases the resilience and strength of the Indian economy amidst evolving global dynamics. The manufacturing sector has emerged as a key driver of this growth, witnessing a surge of 9.9% in FY2024, a stark contrast to -2.2% growth registered in the previous year.

Exhibit 1.3: Annual Real GDP and growth, INR trillion, India, FY2018 – FY2028E



Source: MoSPI (Annual Estimates of GDP at constant price, 2011-12 series), IMF, ADB, S&P, Frost & Sullivan Analysis

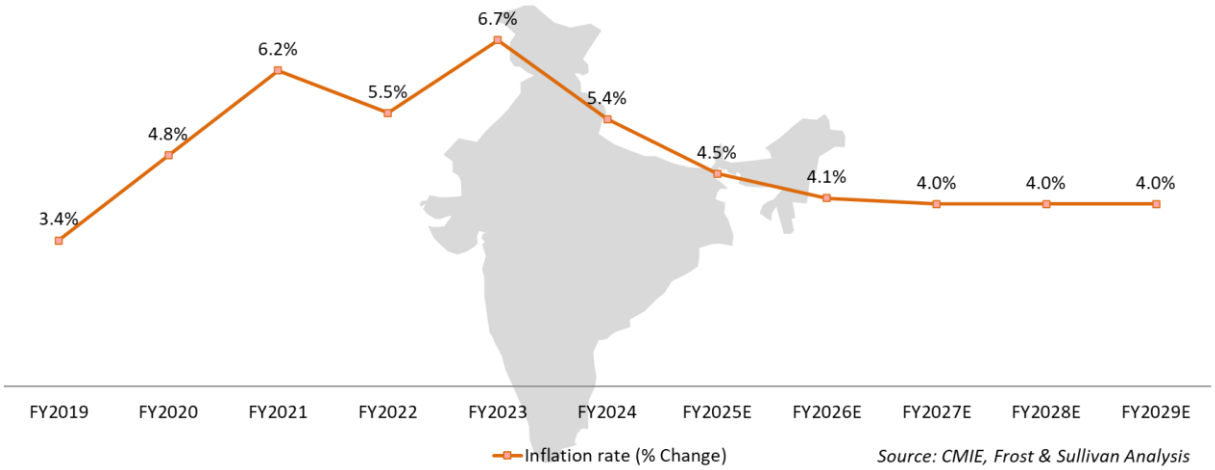
The Indian government has implemented a slew of measures to get the economy back on track post the Covid-19 pandemic. There has been a strong focus from the government to make the country a global manufacturing hub through various policy initiatives such as Atmanirbhar Bharat, PLI schemes, etc. These

initiatives along with stable domestic demand and private investments will help the economy to grow at 6.9% CAGR between FY2025 and FY2028.

1.4 Inflation in India – Historical and Outlook

Inflation started showing an upward trend since FY2019 and increased to 6.7% in FY2023. Rising inflation emerged as a key macroeconomic concern in FY2023 with prices of almost every commodity touching new heights. However, in line with the global trend, the inflation in India moderated to 5.4% in FY2024 due to a drop in commodity prices and actions taken by Reserve Bank of India (RBI). The RBI has left its inflation forecast for FY2025 unchanged at 4.5% even though there is spike in crude oil prices and persisting worries about supply chain due to the Red Sea crisis. In the medium term, RBI expects the inflation to be stabilized at around 4% by FY2029.

Exhibit 1.4: Annual Inflation rate, India, FY2018 – FY2028E



Source: CMIE, Frost & Sullivan Analysis

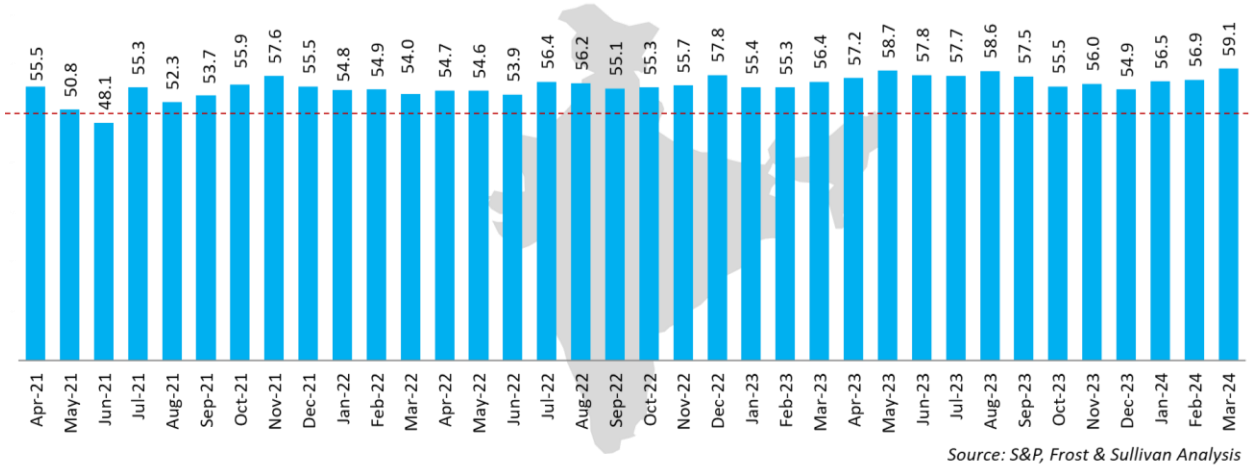
1.5 Index of Industrial Production (IIP)

Post pandemic, since June 2021, industrial activity in the country started picking up and continued its momentum through FY2022 – FY2024 with industrial output recording a sharp growth across all the four constituent sectors in the last three consecutive years. FY2024 IIP provisional data indicates 5.5% growth for the manufacturing sector. The other three segments i.e., Mining, Electricity, and General have grown by 7.5%, 7.1%, and 5.9% respectively in FY2024.

1.6 India manufacturing PMI (Purchase Managers Index)

A reading above 50 indicates an expansion of the manufacturing sector compared to the previous month; below 50 represents a contraction, while 50 indicates no change. The Manufacturing PMI reached a record high of 58.7 in May 2023, the strongest improvement in factory activity since October 2020, boosted by strength of demand. Output growth was at a 28-month high, new orders expanded for the 23rd month running, with the rate of increase steepest since January 2021, and both overseas orders and employment increased the most in six months. However, the manufacturing PMI started falling from August 2023 to an 18-month low of 54.9 in December 2023 before recovering to 59.1 in March 2024 – the highest reading in the last three financial years reflecting stronger growth of new orders and renewed job creation. Growth of new orders accelerated to the quickest in nearly three-and-a-half years during March 2024.

Exhibit 1.5: Manufacturing PMI, India, April 2021 – March 2024



Source: S&P, Frost & Sullivan Analysis

1.7 Sectorial share of Gross Value Added (GVA)

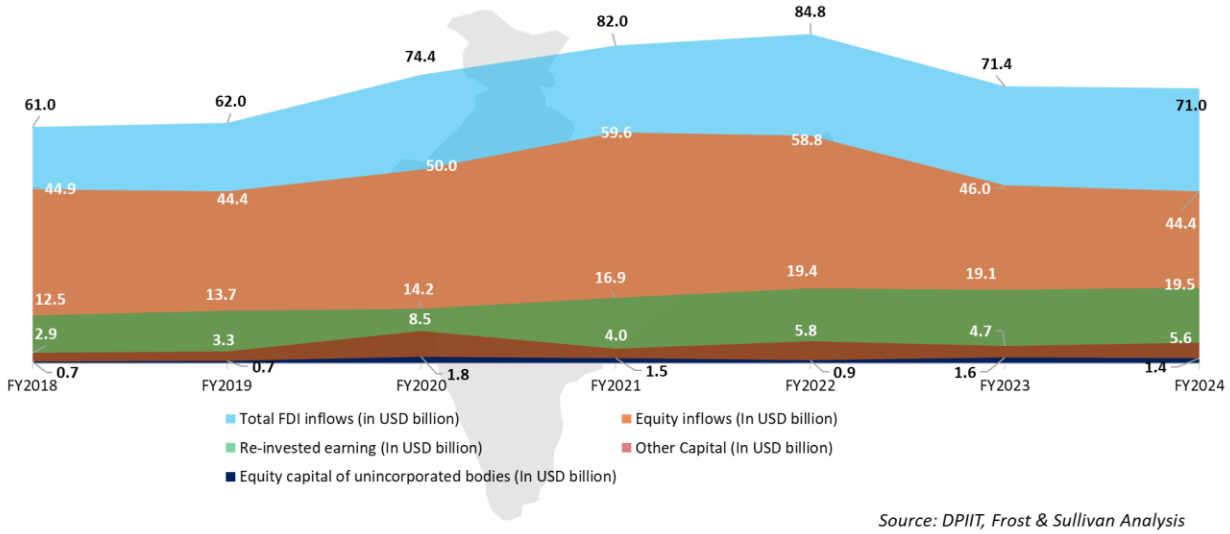
The Gross Value Added (GVA) of India increased steadily since suffering a decline of 4.5% in FY2021. The country's GVA has grown by 9.6% and 6.8% respectively in FY2022 and FY2023 and as per the provisional estimates released by MOSPI, the country's GVA is poised to grow at 7.1% in FY2024. Among the sectors, Construction sector GVA has achieved the highest growth in FY2024 at 10.8% followed by Manufacturing sector at 10.0% and Financial, Real Estate & Professional Services sector at 8.2%.

The manufacturing GVA of the country was growing at a steady pace between FY2016 and FY2022 and even registered growth in the covid year - the growth was highest in FY2022 at 10.8%. The manufacturing GVA however suffered a decline of 2.7% in FY2023 before bouncing back and registering a 10.0% growth in FY2024, as per provisional estimates released by MOSPI. The manufacturing GVA has grown to INR 27.5 trillion at the end of FY2024. One of the key reasons for this healthy growth in FY2024 is the government's vision of making India a global manufacturing hub. Indian manufacturing sector's contribution has increased from 16% to 17% buoyed by initiatives like Make in India, Production Linked Incentive (PLI) schemes and sector specific initiatives that aim to make India a global manufacturing destination.

1.8 Foreign Direct Investment (FDI)

Foreign Direct Investment (FDI) in India has significantly increased in the last few years on the backdrop of improved 'Ease of Doing Business' ranking and proactive manufacturing policies from the Indian Government. The country received a record USD 434.9 billion FDI between FY2018 and FY2023. FDI reached a record USD 84.8 billion in FY2022 – the highest FDI in any fiscal year till date. Even though the FDI declined to USD 71.4 billion in FY2023, it is still at par with the last 6 year's average FDI in the country – India has achieved this feat despite the Indian government's restrictions on FDI from China. In FY2024, India has registered a gross FDI inflow of USD 71.0 billion. Despite high interest rates across the globe, India's FDI inflows remained steady as compared to its peer developing economies, because of the 'demand strength' of the economy.

Exhibit 1.6: FDI inflow, USD billion, India, FY2018 – FY2024



Source: DPIIT, Frost & Sullivan Analysis

1.9 India emerging as a global manufacturing hub

At present, China is the world's second-largest economy and accounts for approximately 29% of the global manufacturing output. China has been the manufacturing hub of the world for decades, but the country has been gradually losing its position due to several factors. Ageing manufacturing hubs that rely on cheap labour are no longer working for China. A shrinking and ageing workforce in China implies that the country's labour-driven manufacturing expertise is fading and is facing stiff competition from other South Asian and Southeast Asian nations including India. China's statistics bureau indicated that the country has lost 41 million workers in the last three years. China's rapidly ageing population is estimated to cross 400 million by CY2035 and is expected to pose a major threat to the country's labour-intensive economy.

Another factor that is hampering China's position as a global manufacturing hub is rising labour costs. The real average daily wage in CY2023 was USD 36.0 in China compared to USD 6.03 in India – this is forcing the major companies to explore cheaper manufacturing destinations such as India, Thailand, Vietnam, Bangladesh, etc. Besides the above factors, escalating trade tensions between China and the United States have forced many global companies to diversify their supply chain and opt for the China+1 strategy. For instance, companies like Apple have aggressively expanded their operations in India – a path that many large manufacturing companies are expected to follow in the coming years.

Economic development in India is gaining pace on the back of a strong domestic consumption base and increasing private investments. While India has the advantage of cheap labour and a young workforce, the Government in the last few years has taken multiple initiatives to make the country an attractive manufacturing destination for the world. An institutional mechanism to fast-track investments is also in place, in the form of Project Development Cells (PDCs) in all concerned Ministries/Departments of the Government of India.

India recorded USD 451 billion and USD 437 billion of merchandise export in FY2023 and FY2024 respectively and is well on its course to become a global manufacturing hub with the potential to export goods worth USD 1 trillion by CY2030 (source: IBEF). Indian manufacturing sector accounts for 17% of GDP in FY2023 and employs over 27.3 million workers. The Indian government plans to increase the share of manufacturing in the economy to 25% by CY2025 through the implementation of various programs and

policies. The Indian government announced an outlay of INR 1,970 billion for implementing PLI schemes for 14 key manufacturing sectors. With the announcement of PLI Schemes, significant creation of production, skills, employment, economic growth, and exports is expected over the next five years and more.

1.10 Government policies and schemes driving manufacturing in India

The manufacturing sector of India is going through a major transformation in the last 6-7 years. The Government of India has launched several schemes and initiatives to promote India as a global manufacturing hub. Some of the notable initiatives are:

A. Make in India initiative

'Make in India' is an initiative that was launched on 25th September 2014 to facilitate investment, foster innovation, build best-in-class infrastructure and make India a hub for manufacturing, design, and innovation. Vocal for local was a unique initiative that promoted India's manufacturing prowess to the world. 'Make in India' initiative is not a state/district/city/area-specific initiative, rather it is being implemented all over the country.

B. Production Linked Incentive (PLI) scheme

Keeping in view India's vision of becoming 'Atmanirbhar', Production Linked Incentive (PLI) Schemes for 12 key sectors were announced with an outlay of INR 1,955 billion to enhance India's manufacturing capabilities and exports. The scheme has been designed to promote local manufacturing and facilitate employment. As per the scheme, a total production of INR 11,500 billion is expected including INR 7,000 billion of exports in the first five years from launching the scheme.

C. Goods and Services Tax (GST) and Corporate Tax rebate

GST is a landmark indirect tax reform in India's history. GST is a single domestic indirect tax law for the entire country. The objective of GST was to replace the prevailing complex and fragmented tax structure with a unified system that would simplify compliance, reduce tax cascading, and promote economic integration. GST regime was implemented from 1st July 2017, and India has adopted the dual GST model in which both the Centre and States levy taxes. Under the Indian GST, goods and services are categorized into four different tax slabs - 5%, 12%, 18%, and 28%. There are a few food items and essential services that are exempt from GST.

While GST has helped to improve India's 'Ease of Doing Business' ranking, the government has also modified the direct taxation to help Indian companies grow profitably. To promote growth and investment in the country, the government introduced a provision in FY2020 that allows any domestic company an option to pay 22% income tax instead of 30% with certain conditions. The government also allowed any new domestic company incorporated on or after 1st October 2019 making fresh investment in manufacturing, an option to pay income-tax at the rate of 15%. This concessional rate is in effect till the end of FY2024.

D. Credit support to Micro, Small and Medium Enterprises (MSMEs)

MSMEs are the backbone of the Indian economy, contributing approximately 30% of the country's GDP, 45% of manufacturing output and providing employment to 110 million people. The Government of India has been proactive to ensure that the credit facilities are always available to MSMEs. Towards this, the

Indian government initiated a mission named 'Atmanirbhar Bharat Abhiyan' to make India a Self-Reliant nation. The main purpose of launching this program was to support the country during the pandemic, one of which was to provide emergency credit lines to businesses. For MSME, there was no guarantee fee and no fresh collateral. A subordinated debt of INR 200 billion was issued for stressed MSMEs. Besides, the government announced INR 500 billion equity infusion for the MSMEs who had an available business but could not accomplish it due to lack of funds.

E. Export promotion schemes

Exports play a major role in the economic development of a country. More the exports more will be the inward foreign remittance, more jobs & employment, lower current account deficit, and hence greater overall economic growth. The Indian government in the past years have introduced multiple schemes to promote exports to boost domestic manufacturing and to make India a global manufacturing hub. Some of the notable export promotion schemes are:

- Merchandise Exports from India Scheme (MEIS Scheme)
- Rebate of Duties & Taxes on Export Products (RoDTEP)
- Export Oriented Units Scheme (EOU)

F. National Industrial Corridor Program (NICP)

The National Industrial Corridor Program (NICP) is an infrastructure program of the Government of India aiming to develop industrial cities in the country. The government of India envisages to develop new industrial cities as "Smart Cities" and to converge the next-generation technologies in the infrastructure sector.

The overall objective of NICP is to "enhance India's competitiveness in manufacturing through the creation of world-class infrastructure and reduced logistics costs". The broad objective of the program is to provide plug-and-play infrastructural facilities for setting up large-scale manufacturing units and to create futuristic Indian cities that can become global manufacturing and investment destinations. This will create employment opportunities and lead to the overall socio-economic development of the country.

Starting with five, currently, there are eleven industrial corridors that the program is developing. These 11 corridors are spread across India and the program will see the development of 'smart cities' along these corridors. These cities will house the workforce required for the industrial corridors. Planned urbanization is envisaged in these planned cities with state-of-the-art infrastructure which is expected to give a tremendous boost to industrialization.

2. OVERVIEW OF ETHANOL INDUSTRY AND TECHNOLOGY EVOLUTION

2.1 Introduction of Ethanol and its applications

Ethanol, known as ethyl alcohol, is a volatile, and flammable liquid that occurs naturally and can also be synthesized. Its natural occurrence is a result of the fermentation process, where yeasts act on sugars to produce Ethanol. Fermentation utilizes readily available feedstocks like rice, maize or sugar syrup, molasses fostering a sustainable approach. The same process is followed in producing alcoholic beverages. On the other hand, its synthetic production involves the hydration of ethylene, a process that takes place in the presence of a phosphoric acid catalyst. Ethanol production methods are becoming more and more diverse and this shift, from relying on crops to potentially using synthetic processes, could free up agricultural resources. Regardless of the risks, Ethanol's properties make it useful in many fields, including:

- **Fuel:** Ethanol is used as a biofuel additive for gasoline. It helps reduce harmful emissions, improves engine performance, and is considered a renewable energy source.
- **Personal care products:** Ethanol acts as a disinfectant in hand sanitizers and cleaners, while also helping various ingredients blend smoothly in lotions and fragrances.
- **Food Ingredients (excluding beverages):** Used as a solvent to distribute flavourings and colourings evenly throughout food products, enhancing their taste and visual appeal.
- **Chemical Intermediates & Solvent:** Ethanol's ability to dissolve many substances makes it valuable in creating various chemicals and acting as a cleaning agent in industrial processes.
- **Pharmaceutical:** Ethanol is used as a disinfectant and antiseptic. It's capable of eliminating many types of bacteria and viruses on contact, making it a key ingredient in sanitisers and disinfectants.
- **Food Industry:** Ethanol is used as a flavouring agent and preservative. It helps distribute food colouring evenly throughout a product and can also help preserve the product.
- **Industrial Solvent:** Ethanol is a common solvent used in the manufacturing of a variety of products including paints, and plastics.

2.2 Factors driving demand for Ethanol in India

India is at a crossroads in its transportation sector. With growing concerns about air pollution, dependence on imported oil, and the desire for a more sustainable future, Ethanol is emerging as a promising solution. The government's blending targets, coupled with a multi-pronged approach encompassing policy incentives, technological advancements, and market development, are expected to significantly increase demand for Ethanol in the coming years.

A. Government Policies and Incentives

- **Increased Blending Mandates:** The Indian government's target of achieving 20% Ethanol blending (E20) by ESY 2025-26 is a game-changer. This aggressive mandate translates into a legal requirement for higher Ethanol content in gasoline, directly boosting demand. This has successfully translated to India achieving 11.6% blending by February 2024.

- **Financial Support for Producers:** The government recognizes the need to incentivize Ethanol production to meet the rising demand. Financial support through subsidies and tax breaks for Ethanol producers acts as a catalyst for capacity expansion. This ensures a steady supply of Ethanol and encourages investment in the sector.
- **Focus on Diversification:** Initially, sugarcane / molasses was the primary feedstock for Ethanol production in India. However, concerns about competition with food security and land-use change led the government to promote alternative feedstocks. The government actively encourages the use of rice, corn/maize, and cellulosic biomass for Ethanol production. This approach not only addresses sustainability concerns but also creates new markets for farmers and agricultural residues.

B. Environmental Concerns and Energy Security

- **Air Quality Improvement:** India's major cities struggle with severe air pollution. Ethanol, a cleaner-burning fuel compared to gasoline, offers a compelling solution. By reducing tailpipe emissions, widespread adoption of Ethanol blends can significantly contribute to cleaner air and improved public health.
- **Reduced Dependence on Oil Imports:** India is heavily reliant on imported oil, making its energy security vulnerable to global price fluctuations. Ethanol production from domestic feedstocks presents a strategic advantage. Increased Ethanol blending reduces dependence on imported oil, enhances energy security, and insulates India from the volatility of international oil markets.

C. Technological Advancements

The Ethanol industry is leveraging a variety of advanced technologies to enhance production efficiency and sustainability. One such technology is the Cellulosic technology that is being developed to produce Ethanol from non-food biomass materials, such as agricultural residues and energy crops. This technology includes enzymatic hydrolysis and thermochemical conversion processes. Furthermore, the industry is exploring the use of nanotechnology for enzyme immobilization and the development of more efficient catalysts. These advancements are not only improving the economic viability of Ethanol production but also contributing to the reduction of greenhouse gas emissions.

D. Market Developments

The growing adoption of flex-fuel vehicles capable of running on a wider range of Ethanol-gasoline blends is a significant market development. These vehicles create a larger consumer base for EBP (Ethanol-blended petrol), driving demand for Ethanol. Recent announcements by car manufacturers regarding the launch of flex-fuel vehicles indicate a positive trend, signaling a shift towards a more Ethanol-compatible vehicle fleet.

2.3 Overview of Ethanol Blending Programme (EBP) in India

Ethanol is a popular biofuel that can be produced through natural fermentation of carbohydrates (found in sugarcane juice or molasses). The Indian Government has been actively pursuing ways to lessen the country’s carbon footprint. One of the major initiatives in this direction is the promotion of the ethanol industry. The reason behind promoting ethanol is twofold - ethanol is a greener alternative to fossil fuels, also known as biofuels and its production can provide a significant boost to the country's agricultural sector. There have been concerted efforts and policy initiatives by the Government towards biofuels in

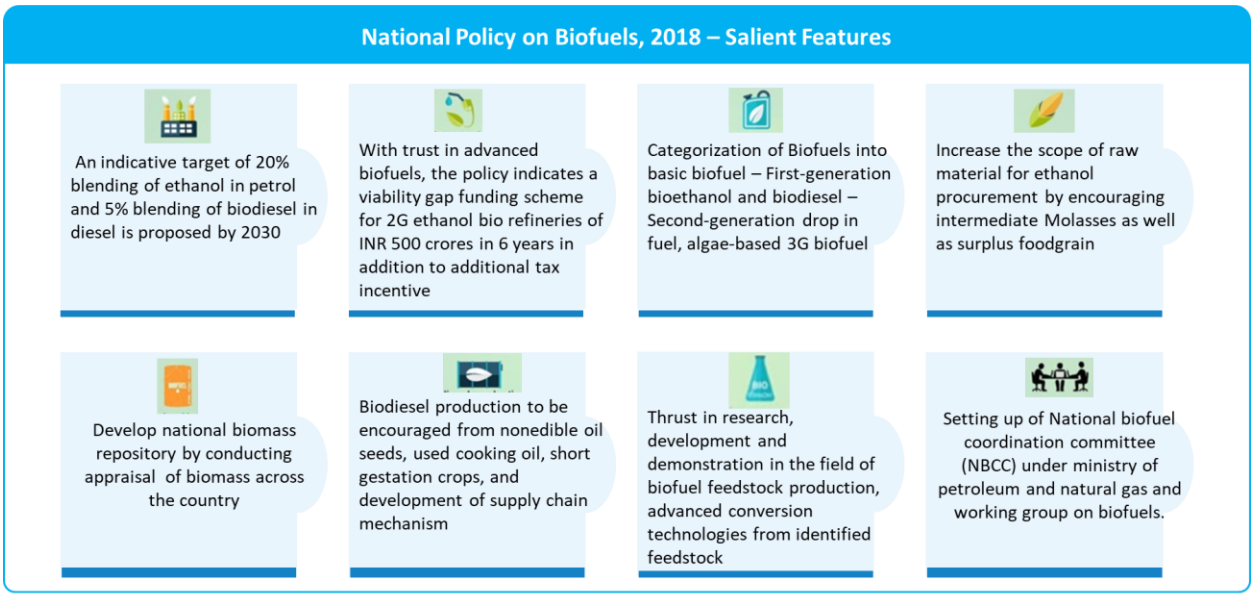
the past few years. Other than sugarcane / molasses, the Government has allowed use of damaged and surplus food grains for ethanol production, and has introduced several initiatives and incentives such as Ethanol Blending Program (EBP), Interest Subvention Scheme, E100, and Global Biofuel Alliance (GBA) in the Ethanol sectors making the industry favourable for growth domestically. Companies like Regreen Excel is well-positioned to capture industry tailwinds and growth prospects, both globally as well as in the domestic market, and are well placed to benefit from the emerging opportunities.

The EBP is an initiative by the Government of India to reduce the import of fuels from other countries, conserve foreign exchange, and increase value addition in the sugar and grain industry through promoting the usage of Ethanol. The blending of ethanol into petrol aims to achieve the following objectives:

- **Energy Security:** Increased use of ethanol can help reduce the import dependency. The E20 or 20% blending initiative can achieve savings of about USD 4 billion in country's annual oil import bill.
- **Benefits of the farmers:** Oil companies purchase ethanol from farmers, thus providing a stable source of income to sugarcane growers. The government also plans to promote the production of ethanol from non-food feedstock and crops that consume less water such as maize.
- **Environmental Impact:** The use of ethanol-blended petrol leads to a reduction in the emissions of harmful gases such as Carbon Monoxide (CO), Hydrocarbons (HC), and Nitrogen Oxides (NOx).

The Government of India started pilot projects, field trials, R&D studies etc. way back in 2001, success of which paved the way for EBP in India. The EBP was launched in January 2003 and the programme received a boost post Government's introduction of National Policy on Biofuels in 2018. The policy targets 20% blending of Ethanol in petrol by ESY2025-26. This translates to a near three-fold increase in demand for fuel Ethanol from an estimated 4.5 billion litres per annum (BLPA) in FY2023 to an anticipated 13.0 BLPA by FY2029. The Ethanol Supply Year (ESY) in India runs from December of a year to November of the following year. In May 2024, India's average ethanol blending in petrol surpassed 15% for the first time, reaching a ratio of 15.4%.

Exhibit 2.1: Salient features of the National Policy on Biofuels, 2018



Source: MoPNG, Frost & Sullivan analysis

A. Implementation timelines

The Indian government has implemented a series of initiatives to promote Ethanol blending in petrol (EBP) and achieve its blending targets. Here's a factual timeline of these key developments:

2003:

- Introduction of the Ethanol Blending Petrol (EBP) Programme, mandating Oil Marketing Companies (OMCs) to blend 10% Ethanol in petrol.

2009:

- Launch of the National Biofuel Policy 2009, setting an indicative target of 20% blending of bio-Ethanol in petrol and biodiesel by 2017.
- Focus on promoting the plantation of non-edible oilseed plants for biodiesel production.

2014:

- Reintroduction of Administered Price Mechanism (APM) for Ethanol procurement under the EBP program.
- Introduction of an alternative route for Ethanol production using second-generation (2G) technologies, including petrochemicals. Oil PSUs were directed to set up bio-refineries.
- Streamlining of the tendering process for Ethanol procurement with multiple Expressions of Interest (EOIs), transportation slabs, and rates.

2016:

- Amendment to the Industrial Disputes Act (IDA) on May 14th, 2016, to clarify roles of central and state governments in ensuring a continuous supply of Ethanol for the EBP program.

2018:

- Announcement of the National Biofuel Policy 2018 after consultations with stakeholders. This policy addressed concerns related to the EBP program and involved all stakeholders.
- Revision of target timelines due to feasibility concerns:
  - 20% blending of bio-Ethanol in petrol by CY2030.
  - 5% blending of biodiesel in diesel by CY2030.
- Shift in focus towards advanced biofuels, including:
  - Second-generation (2G) Ethanol.
  - Biodiesel from used cooking oil.
  - Other "waste to fuel" technologies.
- Reduction in Goods and Services Tax (GST) on Ethanol for the EBP program from 18% to 5%.
- Introduction of allowing alternate raw materials for Ethanol production for the first time.
- Permission for production of Ethanol from B-heavy molasses, sugarcane juice, and damaged food grains.
- Implementation of a differential ex-mill price mechanism for Ethanol based on the raw material used for production, prioritizing fixed differential prices.

July 2018:

- Introduction of the Interest Subvention Scheme to improve and enhance Ethanol production capacity in the country. The government provided interest subvention for a period of five years for interest rates above 6%.

2019

January 2019:

- Relaxation of environmental clearance (EC) conditions for dedicated Ethanol projects, exempting them from EIA and Public Hearing under Category B2.

April 2019:

- Expansion of the EBP program to encompass all of India except the island Union Territories (UTs) of Andaman & Nicobar and Lakshadweep.

September 2019:

- Introduction of new sources of sugar and sugar syrup for Ethanol production at fixed remunerative prices.

October 2019:

- Publication of the "Ethanol Procurement Policy on a Long-Term Basis under EBP Program."

2020:

- Significant improvement in blending from 0.38 billion liters in ESY 2014-2015 to 1.88 billion liters in ESY 2018- 2019, achieving 5% blending.
- Further increase to 7% blending in ESY 2019-2020.
- Target for blending set at 10% for ESY 2021-2022.

August 2020:

- Implementation of a one-time registration system for Ethanol suppliers for long-term contracts, providing them with visibility of Ethanol demand for five years.

October 2020:

- Further simplification of tender conditions by Oil Marketing Companies (OMCs), including:
  - One-time document submission
  - Quarterly bank guarantees
  - Multiple transportation rate slabs with rates linked to Retail Selling Price of Diesel (RSP)
  - Reduction in security deposit and applicable penalty on supplied quantities
- Approval by the National Biofuels Coordination Committee (NBCC) to utilize surplus rice stocks held by the Food Corporation of India (FCI) for Ethanol production.
- Establishment of a separate price for Ethanol derived from FCI rice.
- Approval by NBCC to utilize maize for Ethanol production.
- Issuance of tenders by OMCs with EOI for registration of all Ethanol producers for ESY 2020-21

November 2020

- Approval of NBCC to utilize maize for ethanol production.
- OMCs issue Tendor with EOI for registration of all producers of Ethanol for ESY 2020-21 for 1.95 billion Litres and for the period 2020-25.

30 December 2020

- Interest subvention Scheme approved for expansion of Distilleries for Ethanol.

2021:

January 2021

- Grain Distilleries included in the interest subvention scheme for capacity expansion.

February 2021

- Included multimodal transportation of Ethanol and Ethanol Blended Petrol (EBMS) to ethanol deficit states.

June 2021

- Road map for Ethanol Blending in India 2020-25.
- MOEFCC issued notification S. No. 2339(E) dated 16th June 2021: "Grain based distilleries with Zero Liquid Discharge producing ethanol; solely to be used for Ethanol Blended Petrol Programme of the Government of India shall be considered under B2 Category" with condition that the project proponent shall file a notarized affidavit that ethanol produced from proposed project shall be used completely for EBP Programme. Besides other conditions, EIA and Public Hearing Stand waived.

August 2021

- EOI Tendor issued by OMCs for grain distilleries specifying State wise quantities other than UP and Maharashtra for 4.78 billion Litres.
- Applications received and approved by November 2021.

2022

January 2022

- Long Term Off Take Agreement (LTOA) signed with 131 project proponents to set up dedicated ethanol plants.

June 2022

- Amendment on policy of Biofuels with advancement of 20% blending target from 2030 to 2025, 5 years ahead of the original target plan.

October 2022

- Price for Ethanol manufactured from maize introduced.

November 2022

- OMCs increased their storage capacities for Ethanol from 53.9 million Litres in 2017 to 344 million Litres till November 2022.
- This would cover 20 days storage at the depots at a cost of INR 7.5 billion.

2023

15 May 2023

- Tendor for EOI by OMCs for grain distilleries for select States on the same pattern as August 2021 Tendor for 3.01 billion Litres of Ethanol.

07 July 2023

- Order for usage of Rice from Food Corporation of India withdrawn.

23 July 2023

- Price of Ethanol from Maize revised.

October 2023

- OMCs released tendor for ESY 2023-24 for supply of 8.25 billion litres.

07 December 2023

- Order issues by Ministry of Food & Public Distribution stopping the use of Sugar Cane Juice and B Heavy Molasses by Sugar Mills for Ethanol.

28 December 2023

- Price of Ethanol from C Heavy Molasses revised.
- Price of Maize Ethanol revised.

2024

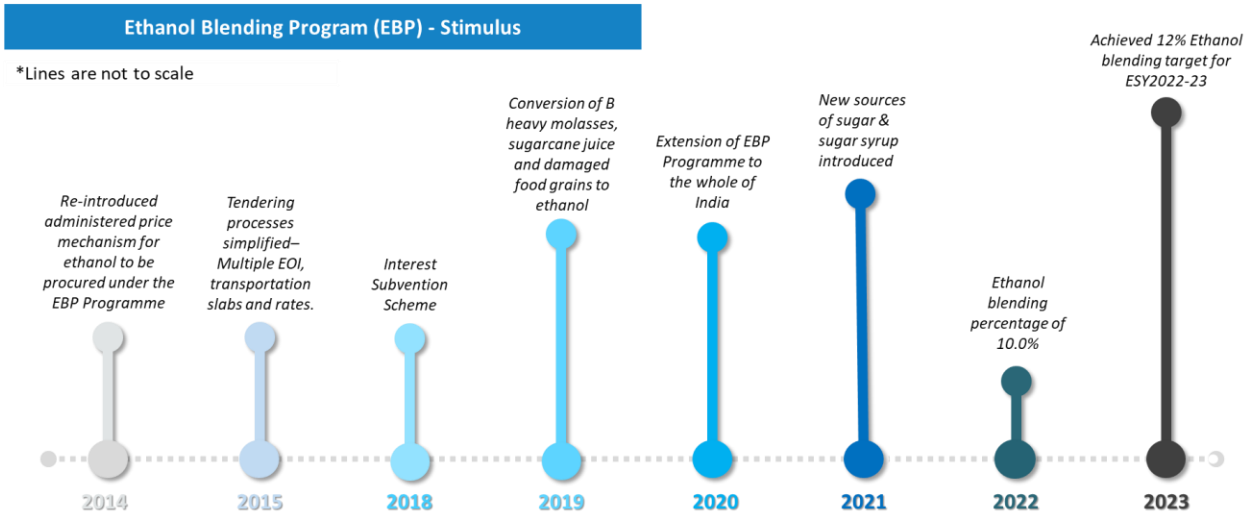
January 2024

- Time for completion of projects extended to 30 September 2024 by DFPD.
- Maize MSP raised by Government of India to promote Maize cultivation.

March 2024

- OMC release allocation of Ethanol to all applicants for grain Distilleries who applied against EOI Tendor issued in 2023 for 1.78 billion litres.
- On March 18 2024, Hon Minister for Petroleum & Natural Gas Mr Hardeep Singh Puri launches Ethanol 100 Fuel at 183 Stations in five states.

Exhibit 2.2: Evolution of Ethanol Blending Program (EBP) in India, CY2014 – CY2023



Source: Frost & Sullivan research and analysis

B. Significance of Ethanol blending

- **Reducing Fossil Fuel Dependence:** India imports most of its oil, which makes it vulnerable to fluctuations in global markets and geopolitical risks. By using Ethanol, India can reduce its oil imports and increase its energy self-reliance.
- **Protecting the Environment**: Ethanol burns cleaner than gasoline, which means it produces less harmful emissions that cause air pollution and climate change. By using Ethanol, India can improve its air quality and meet its climate goals. According to a study by the Indian Institute of Science,

Bangalore, blending Ethanol with petrol can reduce the carbon monoxide emissions by 30-50% and hydrocarbon emissions by 20%.

- **Supporting Farmers**: Ethanol production requires agricultural inputs, such as sugarcane or corn. By using Ethanol, India can create a new demand for these crops, which can boost the income and livelihood of farmers and rural communities.
- **Generating Economic Benefits:** Ethanol blending can stimulate the growth of the Ethanol industry, which can create new jobs, investments, and innovations. It can also help India develop a more sustainable and modern energy system. Ethanol blending is expected to save the country USD 4 billion per annum, i.e., INR. 300 billion.
- **Enhanced Vehicular Performance:** Ethanol has a higher-octane rating than gasoline, which means that it can improve the engine performance and reduce the knocking tendency.

C. Steps taken by the government to boost Ethanol blending

The Indian government has implemented several policies to support the Ethanol Blended Petrol (EBP) program:

- **Differential Ethanol pricing**: The government sets different prices for Ethanol based on its feedstock (sugarcane juice/ sugar/sugar syrup, B- heavy molasses, C-heavy molasses, damaged rice, maize). This system is reviewed annually to reflect production costs, availability, and demand. The government has introduced a differential pricing policy wherein higher rates were offered to sugar mills for production of Ethanol from B-heavy molasses and sugarcane juice. Further In ESY 2019-20, even higher prices were offered for conversion of sugar/sugarcane juice to Ethanol. The ex-mill prices of Ethanol produced from various variants of sugarcane and food grains being paid to Ethanol suppliers for ESY2024 is given in the exhibit below. The Indian government sets the ex-mill price of Ethanol based on different feedstocks. For sugarcane-based Ethanol (sugar, juice, or syrup), the price considers the Fair and Remunerative Price (FRP) of sugarcane, plus conversion costs, depreciation, and the cost of capital. B Heavy Molasses pricing is linked to the normative cost of sugar with an additional cost of capital. C Heavy Molasses pricing is based on both molasses prices and ex-mill sugar prices.

Exhibit 2.3: Administered price of Ethanol by raw material source, ESY2024

RAW MATERIAL SOURCE	EX-MILL ETHANOL PRICE (INR/LITRE)
Sugarcane juice/ Sugar/ Sugar Syrup	65.61
B-Heavy Molasses	60.73
C-Heavy Molasses	56.28
Damaged Food Grains	64.00
Maize	71.86

Source: Announcements from PSU OMCs

- **Tax Relief:** E10 and E20 blends receive lower taxes compared to regular petrol, making them more attractive to consumers. Additionally, Ethanol itself enjoys lower excise duty and GST rates compared to petrol.

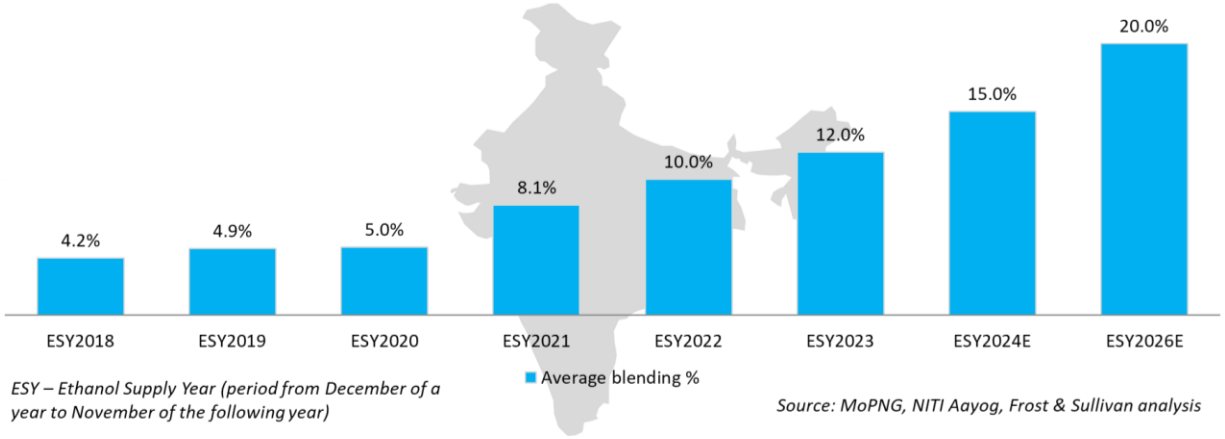
- **Future Incentives:** The government is considering offering tax benefits and other incentives to manufacturers and buyers of vehicles compatible with higher Ethanol blends (E20 and above). These policies have demonstrably contributed to the success of the EBP program, including achieving the 20% Ethanol blending target in petrol by 2025.

D. Ethanol blending targets in India

The Indian government has achieved significant milestones in its Ethanol Blending Programme. The supply of Ethanol to Oil Marketing Companies (OMCs) increased from 0.38 billion litres in ESY 2013-14 to about 5.02 billion litres in ESY 2022-23, a 13 times increase in Ethanol supply to OMCs in the last 9 years. During the same time, the blending percentage also increased from 1.5% in ESY 2013-14 to an ambitious 12% at the end of ESY 2022-23. This accomplishment demonstrates India's commitment to cleaner energy and reduced dependence on imported oil.

Building on this success, the government has set an even more ambitious target of 15% Ethanol blending for ESY 2023-24. Till May 2024, India's average ethanolpopul blending in petrol surpassed 15% for the first time, reaching a ratio of 15.4%. Looking ahead, the long-term vision is even more impressive. India is expected to achieve the accelerated Ethanol blending target of 20% by ESY 2025-26, which is 5 years ahead of the original target plan. This aggressive target showcases the country's dedication to promoting sustainable energy solutions and fostering a greener future.

Exhibit 2.4: Average Ethanol blending with petrol, target in percentage, India, ESY2018 – ESY2026E



ESY – Ethanol Supply Year (period from December of a year to November of the following year)

Source: MoPNG, NITI Aayog, Frost & Sullivan analysis

Besides, the government is evaluating a plan to blend 5% ethanol in diesel (ED-5) as it nears its goal of achieving 20% ethanol blending in petrol within the next two years and the program is currently at an experimental stage.

E. Current status of Ethanol blending programme in India

Since 2003, India has been actively promoting the use of biofuels by blending Ethanol, a cleaner-burning alternative, with conventional petrol. Initially, the program aimed for a 5% Ethanol mix, but the government has set a more ambitious target of 20% by ESY 2025-26 Currently, the average Ethanol content in petrol hovers around 12%, with some regions exceeding this target. To incentivize further adoption, the government provides financial assistance to companies that increase their Ethanol blending ratio.

The Indian Ethanol industry has evolved from using primarily Molasses as the feedstock to use grains and multiple feedstocks within the same plant. The government is exploring alternative feedstocks like rice,

corn/maize and other grain based feedstocks. This approach promotes sustainability and reduces dependence on a single crop. To ensure a steady supply, OMCs have planned to set up 12 new Ethanol production facilities that utilize agricultural waste as feedstock, also known as 2G Ethanol. This multi-pronged approach aims to significantly reduce air pollution and contribute to a cleaner environment.

While the Indian automotive industry has embraced Ethanol blending, with car manufacturers introducing flex-fuel vehicles compatible with higher Ethanol blends, implementing the program on a large scale presents some challenges. These include potential disruptions in the supply chain, ensuring competitive pricing for Ethanol blends, and mitigating any concerns regarding food security. Through continued collaboration between the government, industry, and research institutions, India is well-positioned to overcome these challenges and achieve its Ethanol blending goals, paving the way for a more sustainable transportation sector.

F. Way forward

The Ethanol Blending Programme (EBP) holds significant promise for promoting cleaner and renewable fuels in transportation. To fully unlock its potential, several key strategies can be implemented.

Firstly, the government has raised the current 12% Ethanol blending target to 20% or even higher. This increased focus on biofuels would encourage their wider adoption. Secondly, incentivizing Ethanol production through subsidies or tax breaks for producers is crucial. This would ensure a readily available supply of Ethanol for blending with petrol.

Developing the necessary infrastructure for EBP is another critical step. Investments in production facilities, storage solutions, and distribution networks tailored to EBP are essential to smooth implementation. Public awareness campaigns promoting the environmental benefits and potential cost savings of EBP would further drive its acceptance.

Encouraging the use of flex-fuel vehicles through tax incentives or subsidies for buyers would provide consumers with a wider range of fueling options and accelerate the transition to EBP. Finally, modifying fuel quality standards to accommodate higher Ethanol blends would establish a clear regulatory framework for EBP, paving the way for its widespread use. By implementing these strategies, the Ethanol Blending Programme can become a cornerstone of a cleaner and more sustainable transportation sector.

2.4 Overview of other key Government policies driving demand for Ethanol in India

A. Interest Subvention Scheme

To enhance the Ethanol production capacity in the country to achieve the blending targets set under the EBP Programme, the Government has notified various Ethanol interest subvention schemes. Under these schemes, the Government is facilitating entrepreneurs to set up new distilleries (molasses-based, grain-based and dual-feed-based) or to expand the existing distilleries (molasses-based, grain-based and dual-feed-based) throughout the country. Interest subvention of 6% per annum or 50% of the rate of interest charged by banks/financial institutions on the loans, whichever is lower, would be borne by the Central Government for five years including a one-year moratorium.

B. India's Ethanol 100 (E100) initiative

E100 is a revolutionary automotive fuel that consists of 100% Ethanol. The adoption of E100 aligns with India's commitment to decarbonization and reducing greenhouse gas emissions. With wider adoption,

E100 is expected to be cheaper than petrol or diesel because of ethanol's lower cost and hence, E100 is expected to receive continued focus, support, and investment.

In a recent development, India commenced the sales of E100 across 183 IOCL outlets in Maharashtra, Karnataka, Uttar Pradesh, New Delhi, and Tamil Nadu. This launch is expected to have a positive ripple effect, boosting the agriculture sector, creating rural employment opportunities, and generating foreign exchange savings. Furthermore, E100 boasts a high octane rating, making it ideal for high-performance engines while minimizing environmental impact. Additionally, E100 can be used in a wide range of vehicles, including flex-fuel vehicles designed for gasoline, Ethanol, or a blend of both. This adaptability positions E100 as a potential mainstream fuel option with the development of appropriate infrastructure. Overall, the introduction of E100 signifies India's commitment to sustainable technologies, clean mobility solutions, decarbonization efforts, and fostering a robust domestic Ethanol industry.

C. Global Biofuel Alliance (GBA)

Global Biofuels Alliance (GBA) is a multi-stake holder alliance of Governments, International Organizations, and Industries, an initiative by India as the G20 Chair, bringing together the biggest consumers and producers of biofuels to drive development and deployment of biofuels. Announced during G20 Summit on 9th September 2023, the initiative aims to position biofuels as a key to energy transition and contribute to jobs and economic growth. Established with the goal of promoting sustainable and renewable energy sources to combat climate change and reduce dependency on fossil fuels, the GBA has seen a significant increase in both membership and influence since its inception.

The Alliance intends to expedite the global uptake of biofuels through facilitating capacity-building exercises across the value chain, technical support for national programs and promoting policy lessons-sharing, technology advancements, and intensifying utilization of sustainable biofuels through the participation of a wide spectrum of stakeholders. The alliance will bring together the biggest consumers and producers of biofuels globally to drive development and deployment of biofuels. GBA will facilitate development, adoption, and implementation of internationally recognized standards, codes, sustainability principles and regulations to incentivize biofuels adoption and trade. The alliance will also act as a central repository of knowledge and an expert hub. GBA aims to serve as a catalytic platform, fostering global collaboration for the advancement and widespread adoption of biofuels. The Global Biofuels Alliance aims to position biofuels as a key to energy transition and contribute to jobs and economic growth in the developing countries.

The initiative will be beneficial for India at multiple fronts and will help strengthen India's position globally. Further, the alliance will focus on collaboration and will provide additional opportunities to Indian industries in the form of exporting technology and equipment. It will also help accelerate India's existing biofuels programs such as PM-JIVAN Yojna, SATAT, and GOBARdhan scheme, thereby contributing to increased farmers' income, creating jobs and overall development of the Indian ecosystem.

The alliance currently has 24 member countries and 12 international organizations. Notable members include Brazil, a leader in sugarcane ethanol production; the United States, which has substantial investments in both corn ethanol and biodiesel; Germany, with its advanced bioenergy technologies; and India, which has been expanding its biofuel production from non-food biomass. Each member country brings unique contributions to the alliance, ranging from technological innovations to policy frameworks that facilitate the broader adoption of biofuels. This diversity not only enhances the ability of the GBA to

tackle a wide range of challenges associated with biofuel production and use but also helps in tailoring sustainable energy solutions that respect local environmental, social, and economic contexts.

In CY2023, the GBA launched an ambitious project to develop next-generation biofuels, such as algae-based fuels and advanced cellulosic ethanol, which promise higher yields and lower environmental impacts. Furthermore, educational campaigns and training programs have been conducted worldwide to increase awareness and build capacity in the sustainable production and utilization of biofuels.

During the recent G20 deliberations in Brazil, the alliance as immediate goals has adopted a work plan focused on assessing country landscapes, drafting policy frameworks, and conducting biofuel workshops. India has also suggested three potential workstreams to support biofuel trade, increase awareness in biofuels, and identify support mechanisms for enhanced adoption of biofuels during the deliberations. According to the International Energy Agency (IEA), biofuels have a potential to grow by 3.5-5-times by CY2050 due to Net-Zero targets, creating a huge opportunity for India. A record 171.2 billion litres of biofuels were procured globally in CY2022, with India contributing just 2.7 per cent or 4.6 billion litres. Despite this, India remains the third-largest producer of Ethanol, after the United States (US) and Brazil.

2.5 Description of Ethanol production process through Molasses and Grains

Ethanol production utilizes fermentation to convert readily available carbohydrates into a biofuel alternative. Two prominent feedstocks within this industry are molasses and grains, each requiring slightly different pretreatment steps before the core fermentation process.

Molasses-based production utilizes molasses, a byproduct from sugarcane processing rich in fermentable sugars. The molasses is diluted with water to achieve optimal sugar concentration for efficient yeast activity. Subsequently, yeast is introduced to the mixture, initiating the fermentation process where sugars are converted into Ethanol and carbon dioxide. After fermentation, the Ethanol is separated and purified through distillation to reach the desired concentration.

On the other hand, Grain-based production, commonly using rice and recently maize (corn) requires additional processing steps before fermentation. The starches present in the grains are first broken down into simple sugars through a process called saccharification. Enzymes or mild acid hydrolysis achieve this conversion, making the starches accessible to the yeast during the subsequent fermentation stage. Similar to the molasses process, yeast is then introduced to convert the simple sugars into Ethanol and carbon dioxide. Finally, distillation separates and purifies the Ethanol to the required specifications.

Exhibit 2.5: Comparison between various feedstocks used for Ethanol production

FEEDSTOCK	YIELD (MT/ACRE)	BRIX MOISTURE (%)	SUGAR / STARCH CONTENT (%)	EXPECTED RECOVERY (LTRS./MT)
Rice / Paddy	2.61	10 – 12	65 – 68	425 – 475
Maize / Corn	2.35	10 – 14	58 – 62	380 – 405
Millet / Bajra	1.40	10 – 12	55 – 60	365 – 390
Sorghum / Jowar (Grain)	1.52	10 – 12	62 – 65	410 – 425
Sorghum Stalk (Juice)	12 - 18	14 – 20	12 – 18	60 – 70
Sugar Cane	15 – 40	14 – 20	12 – 20	70 – 84

B-Molasses	6 – 6.5	80 – 85	50 – 55	300 – 320
C-Molasses	4 – 5	85 - 90	40 - 45	220 – 240
Cassava / Sabudana	15	80 - 85	28 - 38	200 – 210

Besides rice and maize, sweet sorghum is also emerging as an alternate feedstock for ethanol production. Sweet sorghum is a highly efficient and versatile feedstock for ethanol production due to its high sugar content, rapid growth cycle, and adaptability to various climatic conditions. Sweet sorghum stalks boast a sugar concentration comprising predominantly sucrose, with smaller amounts of fructose and glucose. This soluble sugar content makes the crop an ideal and readily fermentable feedstock for ethanol production. Beyond its impressive sugar profile, sweet sorghum's agronomic advantages make it a standout choice for biofuel production in India. Its short 4-month life cycle, resilience to adverse environmental conditions, and low input requirements translate to cost-effective cultivation. Ethanol produced from sweet sorghum is inherently cleaner, with lower sulfur content and reduced biological and chemical impacts, positioning it as a sustainable alternative to conventional fossil fuels.

The below table depicts various processes involved and their applicability in production of Ethanol from Grain and Molasses.

Exhibit 2.6: Molasses based vs. Grain based Ethanol production processes

STEPS	DESCRIPTION	MOLASSES BASED	GRAIN BASED
Feedstock handling	Processing the raw material (cane handling & milling for grains, molasses for molasses-based)	Applicable	Applicable
Feedstock preparation	Preparing the feedstock for fermentation (dilution for molasses, milling for grains)	Applicable (Dilution)	Applicable (Milling)
Saccharification	Converting complex carbohydrates (starches) into simple sugars (required for grains)	Not Applicable	Applicable (Enzymatic or Acid Hydrolysis)
Fermentation	Yeast converting sugars into Ethanol and carbon dioxide	Applicable	Applicable
Distillation (Evap/Condensation)	Separating and purifying Ethanol from the fermented broth	Applicable	Applicable
Dehydration	Removing additional water from Ethanol for higher concentration (industrial use)	Applicable	Not Applicable
Co-Product Processing	Processing leftover material after distillation (DDGS drying for grains)	Not Applicable	Applicable (DDGS Drying)
Waste Management	Utilizing leftover materials for composting, bio-methanation, or evaporation for concentration	Applicable	Applicable
Energy Recovery	Utilizing waste heat for electricity generation (slop boiler & turbine)	Applicable	Applicable
Storage	Storing the final purified Ethanol	Applicable	Applicable

Source: Frost & Sullivan analysis

A. Molasses-based Ethanol production

Molasses is the major raw material in a distillery. Around 80 % of the total molasses is used for alcohol production whereas rest is used for animal feeds and other products. Molasses is a syrup containing mixture of crystallizable sugars, non-sugar solids originating from cane or beet, chemicals from the sugar manufacturing process and some water. Followings are the steps involved in production of Ethanol from Molasses:

- **Feedstock Preparation (Dilution):** The journey begins with molasses, a thick syrup byproduct from sugarcane processing. While rich in fermentable sugars like sucrose and glucose, molasses is often too concentrated for optimal yeast activity. Therefore, it's diluted with water to achieve the desired sugar concentration for efficient fermentation.
- **Fermentation:** The diluted molasses is transferred to large fermentation tanks. Here, the magic of yeast comes into play. Yeast (typically Saccharomyces cerevisiae) is introduced, initiating the fermentation process. These tiny powerhouses consume the simple sugars in the molasses and convert them into Ethanol and carbon dioxide through a biological process. Fermentation Process is exothermic in nature and heat generated during fermentation is removed by circulating contents of fermenter through external heat exchanger that is cooled by cooling water. The fermentation typically occurs at controlled temperatures (around 30°C-35°C) and it takes about 24-36 hours. for the reaction to complete. The CO_2, which is liberated, is scrubbed in water, with the help of CO_2 Scrubber, to recover alcohol. The water from the scrubber is returned to the fermenter.
- **Multi-Pressure Distillation:** Following fermentation, the resulting broth, a mixture of Ethanol, residual sugars, yeast cells, and other components, needs separation. This is where distillation takes center stage. The system is designed to produce rectified spirit. The fermented wash is heated in a series of multi pressure distillation columns where separation of alcohol takes place. It involves two distinct steps combined to achieve separation of alcohol from fermented wash or beer which contains 10% to 12% alcohol to concentration upto 95% to 96%. The Multi-pressure system saves energy by recovery and re-use of secondary energy without impacting the overall plant performance. Distillation is carried out in stages and are operated in different pressures to optimize energy consumption. The maximum concentration of Ethanol that can be obtained by distillation is 96% (rectified spirit) due to a formation of an Ethanol-water azeotrope of this concentration. The rectified spirit is directly taken into a feed tank from where it is fed to the recovery column of dehydration plant for its further dehydration to produce fuel grade Ethanol of minimum 99.8% Ethanol.
- **Dehydration:** Rectified Spirit with a minimum alcohol content of 95% v/v undergoes dehydration for fuel blending purposes. Industrial dehydration systems encompass various methods such as adsorption with molecular sieves, entrainer dehydration, and membrane processes. Among these, the molecular sieve system stands out, facilitating Ethanol dehydration beyond 95% purity. This system effectively eliminates water from the Ethanol/water vapor mixture exiting the rectification column, yielding a dehydrated product. Pressure swing adsorption using molecular sieve is a commonly employed technique for this purpose. The final product attains a strength of 99.8% v/v, meeting the requisite standards for fuel blending applications.
- **Multi-Effect Evaporation (MEE):** The spent wash from Analyser bottom is concentrated in a Multiple Effect Evaporator (MEE) to a brix of 60° for its incineration in an incinerator type boiler. The

concentrated spent wash or slop generated from the evaporator is incinerated in specially designed slop incineration boilers with bagasse as support fuel which at the one hand leads to final disposal of spent wash to achieve zero liquid discharge and at the other hand generates steam and power required for the process. By integrating the slop boiler and turbine into a co-generation system, Ethanol production facilities can maximize the efficiency of their operations and minimize waste.

- **Ethanol Storage:** The dehydrated Ethanol coming out of dehydration unit is transferred to product day tanks. After quality testing and approval, it is suitably denatured before transfer to the depot for blending. A suitable denaturant is petrol itself. A prescribed quantity as per excise regulations is blended into the Ethanol. Subsequently, after gauging, the Ethanol is transferred to respective bulk storage tanks.
- **Waste Management:** The leftover material after distillation (spent wash) can be utilized for various purposes. Bio-composting can convert these residuals into organic compost, while bio-methanation can transform them into biogas through a biological process. Evaporation can also be used in this stage to concentrate the residuals before further processing.

B. Grain-based (Rice and Maize) Ethanol production

The main raw materials for a Grain distillery are rice and maize. These grains contain about 60% to 70% of fermentable starch and the balance composition consists of proteins, fats, fiber, ash and other solids. The starch is first converted into sugars by milling, liquefaction, and saccharification to obtain a fermentable sugar namely glucose. Followings are the steps involved in production of Ethanol from Grains:

- **Grain receiving and storage:** Grains are received by trucks either loose or in bags and emptied into a pit below the statted floor. From the pits, the grains are transferred by a bucket conveyor into the designated silo. In case the silos are full, the grain would be stored in the warehouse by using a forklift for unloading and subsequently transferred to the silos by emptying them on the slatted pit.
- **Grain cleaning, handling, & milling:** The grains from the silos are transferred to grain hopper where the grains pass through a vibrating screen for removing dust and fines, a magnetic separator for removal of iron particles, and a de-stoner for removal of stones. A dust collector system is provided for collection of dust to avoid pollution. The cleaned gains then flow into a hammer mill to get the desired flour fineness. Flour is then emptied into intermediate flour bins which control flour and water addition to get a uniform slurry for liquefaction. The slurry preparation is carried out in the pre-mash tank.
- **Liquefaction:** This process initiates the conversion of starch into simple molecules of dextrin. This involves partial hydrolysis / liquefaction of starch, in presence of enzyme α-amylase, at a specified temperature. Enzymatic activities breakdown the starch molecules to soluble dextrins and oligosaccharides. The pH is maintained between 3-3.5 and temperature as 55°C-60°C. Around 25% of the required dose of the enzyme α-amylase is added here.
- **Saccharification:** Unlike molasses, grains primarily contain starches, which are not directly fermentable by yeast. To overcome this hurdle, a crucial step called saccharification is employed. Simultaneous saccharification is the formation of fermentable glucose for fermentation by yeast in the next step of the process. This can be achieved through two main methods:

  - **Enzymatic saccharification:** Enzymes specifically break down the starches into simple sugars. This method is more efficient and allows for lower processing temperatures. The breakdown of dextrins formed during liquefaction takes place with the help of a second enzyme, glucoamylase or amylo-glucosidase. The pH is adjusted in the range of 4.0 to 5.0 and the optimum temperature for the amyloglucosidase enzyme reaction is between 30°C-35°C.
  - **Mild acid hydrolysis:** A dilute acid solution, like sulfuric acid, is used to break down the starches. This method is less expensive but requires careful control of temperature and acid concentration to avoid degrading the liberated sugars.

- **Fermentation:** Fermentation is carried out in batch fermenters. Final liquefied slurry from final liquefaction tank after saccharification is pumped into fermenter and is diluted to appropriate sugar concentration with process water. Previously hydrated and actively growing yeast as well as enzymes, nutrients and additives are added to the fermenter during filling. The purpose of fermentation is to convert the fermentable sugars into alcohol. During fermentation, sugars are broken down into alcohol and carbon-dioxide. Significant heat release takes place during Fermentation. The fermenter temperature is maintained between 30°C-32°C by forced recirculation flow through plate heat exchangers by fermenter pumps. The carbon dioxide generated during fermentation is scrubbed in water, in CO_2 scrubber. This CO_2 contains alcohol, which is recovered by collecting CO_2 scrubber water into mash holding tank.
- **Multi-pressure distillation:** The Multi-pressure system saves energy by recovery and re-use of secondary energy without impacting the overall plant performance. By operating at different pressure levels vapors of one column from the overhead can be used to heat the re-boiler of another column operating at a lower pressure. The clarified wash contains about 12% Ethanol in water along with various impurities including dissolved gases, inorganic impurities and organic impurities like aldehydes formed during fermentation. The maximum concentration of Ethanol that can be obtained by distillation is 96% (rectified spirit) due to a formation of an Ethanol-water azeotrope of this concentration.
- **Dehydration:** Dehydration is used to eliminate water from Ethanol for fuel Ethanol for blending in petrol. Systems in industrial use include adsorption with molecular sieves, entrainer dehydration, and membranes. The molecular sieve system allows the dehydration of Ethanol past 95% purity. Continuous production is realized by utilizing a pressure swing adsorption system with two molecular sieve beds. The two molecular sieve beds operate sequentially and are cycled so that one is under regeneration while the other is under operation, adsorbing water from the vapour stream.
- **Decantation:** Grain stillage contains proteins, minerals, fat and fibers which make a valuable animal feed. Insoluble substances in grain stillage are separated in a decanter and mixed with concentrated stillage from the evaporation section before it is sent to the drying section. Wet cake has 30-32% w/w solids as removed from bottom of Decanter which can be sold directly in wet form as cattle feed (DWG). Thin slops coming out of Decanter are sent for Evaporation for concentration up to 30-35% w/w solids. The concentrated thin slops called as Syrup is mixed with wet cake and sold in wet form as cattle feed (DWGS) or the entire mixture can be dried in a DDGS Dryer and then sold in dry form as Cattle feed which is called Distillers Dried Grain with Solubles (DDGS).

- **Multi-Effect Evaporation (MEE):** Multi–effect Evaporation is used for the separation of thin slops or low concentrated waste water streams into a concentrated fraction and a condensate stream, which are reused in the process. The product at the desired concentration of 30-35% is obtained through this process. The condensate from surface condensers is collected in a common condensate pot. The condensate is transferred for further treatment and recycle.
- **DDGS (Distiller's dried grains with solubles) Dryer:** The leftover liquid (stillage) after distillation in grain-based production is not discarded. It's a valuable resource! This residual liquid contains residual sugars, yeast cells, and other components. It's concentrated and dried to produce Distillers Dried Grains.
- **Ethanol Storage:** The dehydrated Ethanol coming out of dehydration unit is transferred to product day tanks. After quality testing and approval, it is suitably denatured before transfer to the depot for blending. A suitable denaturant is petrol itself. A prescribed quantity as per excise regulations is blended into the Ethanol. Subsequently, after gauging, the Ethanol is transferred to respective bulk storage tanks.

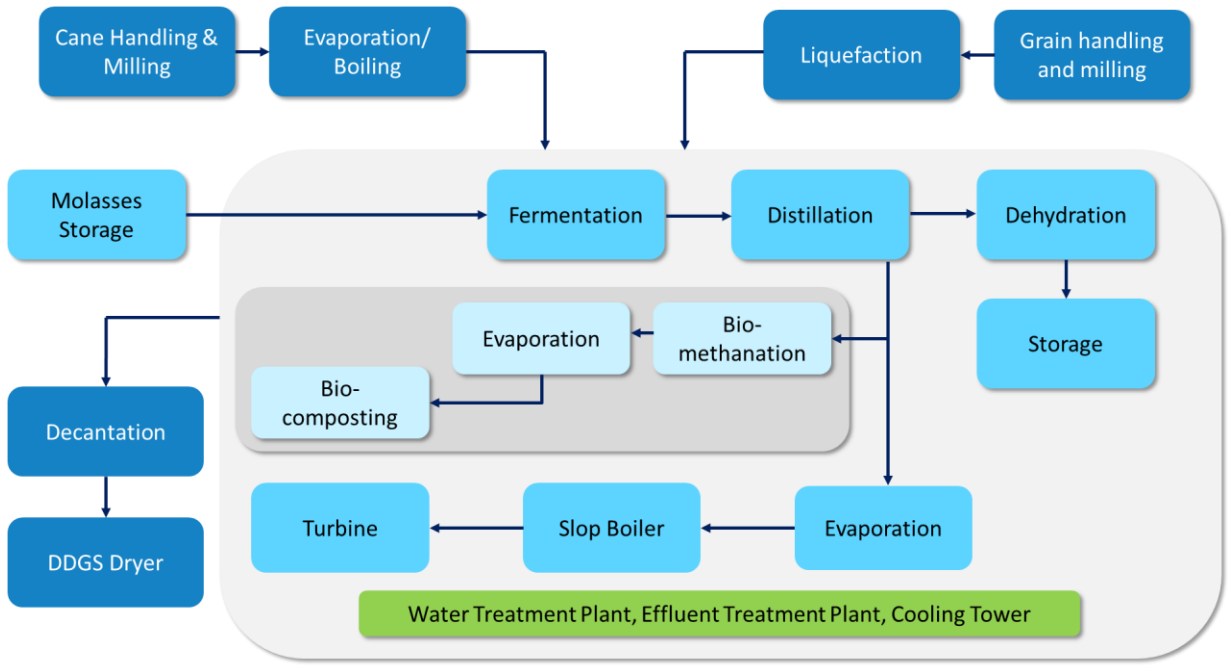
C. Sweet Sorghum-based Ethanol production

Below is a detailed process description for converting sweet sorghum to ethanol:

- **Juice Extraction**
  - **Initial Cleaning:** Upon arrival, the stalks are cleaned using mechanical separators to remove soil, leaves, and other debris.
  - **Crushing and Milling:** The cleaned stalks are fed into mills where they are crushed to extract juice. Roller mills apply pressure to break down the stalks and maximize juice extraction. The juice is collected in large tanks.
  - **Screening and Filtration:** The juice passes through coarse screens to remove large particulates, followed by fine filtration using rotary drum filters or pressure filters to eliminate smaller particles and impurities. Clarification might be done using settling tanks or centrifuges to separate any remaining solids.
- **Juice Treatment**
  - **pH Adjustment:** The juice is treated to adjust its pH level to the optimal range for fermentation using food-grade acids or alkalis.
  - **Heating:** The juice is heated to deactivate enzymes that could degrade sugars during fermentation.
- **Fermentation:** The treated juice is transferred to fermentation tanks where yeast is added. The yeast ferments the sugars (mainly sucrose, glucose, and fructose) in the juice, producing alcohol and carbon dioxide. The fermentation process is closely monitored to maintain optimal conditions and maximize ethanol yield.
- **Distillation:** Similar to molasses and grain based production, distillation is used to separate and purify the ethanol from the fermented broth. The process utilizes evaporation and condensation to achieve this separation.

- **Dehydration:** The rectified ethanol is passed through molecular sieves or a pressure swing adsorption system to remove remaining water, producing anhydrous ethanol (99.5% purity).
- **By-product Utilization**
  - **Bagasse:** The fibrous residue, known as bagasse, can be used as a biofuel for generating steam and electricity, or as a raw material for producing paper, electricity, and bio-composting. Bagasse is also rich in micronutrients and minerals, making it a nutritious source of animal feed, especially for dairy cattle.
  - **Vinasse:** The liquid residue, called vinasse or stillage, is used as fertilizer in agricultural fields, for anaerobic digestion to produce methane gas, or for other industrial applications.

Exhibit 2.7: Process diagram of a multi-feedstock Ethanol production plant



Source: Stakeholder interaction, Frost & Sullivan Analysis

2.6 Introduction and Evolution of '*E-max*' technology for Ethanol production

Regreen-Excel's ***'E-max'*** technology is a set of solutions designed to improve efficiency and sustainability in Ethanol production facilities. Launched in 2018, the technology has seen several upgrades to address industry needs. These advancements focus on:

- **Larger plants**: Can handle bigger facilities to meet increased production demands.
- **Diverse feedstocks:** Can handle a wider variety of raw materials, offering flexibility in feedstock selection.
- **Multiple products:** Enables facilities to produce not just Ethanol, but also additional products from the production process.
- **Reduced operating costs:** Aims to minimize expenses associated with running the plant.
- **Stricter safety regulations:** Meets the latest safety standards for Ethanol production facilities.

- **Oil Marketing Company (OMC) requirements:** Complies with the specific requirements set by Oil Marketing Companies.

'E-max' also incorporates increased automation, reducing the need for manual labor. This focus on automation can lead to lower operating costs. Environmentally, the technology supports plants with Zero Liquid Discharge (ZLD), minimizing wastewater generation and promoting sustainability. Later versions, like ***'E-max75'*** (released in 2022), achieve significant reductions in energy and water usage compared to earlier versions. This translates to a more environmentally friendly production process. Importantly, these reductions don't compromise on Ethanol yield or ZLD compliance, ensuring both efficiency and environmental benefits.

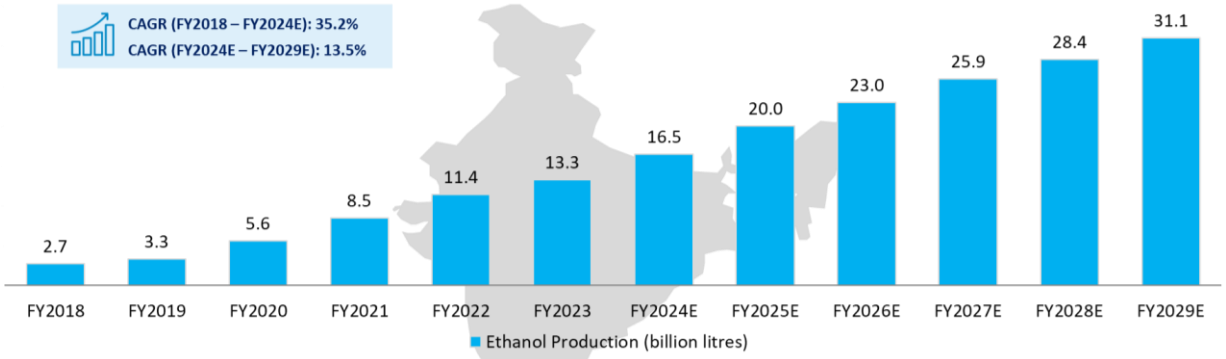
3. OPPORTUNITY LANDSCAPE OF THE INDIA'S ETHANOL MARKET

3.1 Growth in Ethanol production capacity in India

The Ethanol industry is witnessing a surge in global demand on account of various factors such as the biofuel boom due to environmental concerns and stricter emission regulations pushing the transportation sector towards cleaner alternatives and expanded use of ethanol in production of alcoholic beverages, hand sanitizers, and industrial solvents. Diversification of feedstock which ensures a more reliable supply chain for ethanol production, and continuous advancements in fermentation and distillation technologies are also leading to more efficient and cost-effective ethanol production. Driven by government initiatives promoting biofuels and a focus on energy security, the Indian market is ripe with opportunity. Traditionally reliant on sugarcane molasses, the industry is embracing diversification with new feedstock options like grains and exploring 2G Ethanol production from agricultural residues. This shift towards sustainability is further supported by technological advancements offering efficient and environmentally friendly production solutions. While challenges like feedstock availability and stricter environmental regulations exist, the Indian Ethanol industry is well-positioned for a dynamic future, playing a key role in the nation's energy independence and environmental goals.

India's Ethanol production landscape is undergoing a remarkable transformation as it is rapidly emerging as a key player. India's ethanol production capacity witnessed significant growth in recent years, driven by a confluence of factors such as Government of India initiatives promoting biofuels, a growing focus on energy security, and a vast agricultural base offering diverse and abundant feedstock. India is one of the fastest growing markets for Ethanol at present. The number of molasses based distilleries in the country increased by more than 2 times in the the last 9 years while, total capacities of these distilleries increased by more than 4 times during the same period. Besides, since the launch of National Biofuel Policy in 2018, 85 new grain distilleries have been commissioned and 70 more distilleries are at various stages of execution. At an overall level, India's Ethanol production capacity grew by more than six times in the last 6 years – from a modest 2.7 billion litres in FY2018 to 16.5 billion litres (provisional estimate) at the end of FY2024, at a CAGR of 35.2%.

Exhibit 3.1: Ethanol production capacity in India, in billion litres, FY2018 – FY2029E



Note: FY based installed capacities have been derived from published ESY based installed capacities. It is assumed that approx. 60% of the overall commissioned capacity during an ESY is commissioned between December and March. FY2024 is a provisional estimate based on ESY2022-23 actual installed capacity and incremental capacities required to meet ESY2023-24 blending target.

Source: Statista, PIB, and Frost & Sullivan analysis

India aims to reduce its dependence on imported oil and enhance energy security. Ethanol, a domestically produced biofuel, plays a crucial role in achieving this goal. Fortunately, India's vast agricultural base

provides a diverse range of potential feedstocks for Ethanol production, unlocking immense potential for continued growth within the sector. This includes sugarcane molasses, grains like corn and broken rice.

3.2 Overview of Ethanol capacity and production in India

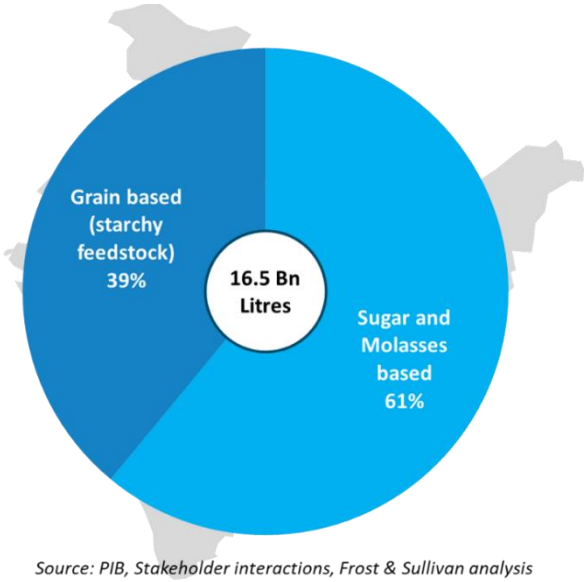
A. Ethanol production capacity in India split by feedstock

India's Ethanol production is currently leaning towards sugar and molasses, accounting for approximately 61% of the total output. This can be attributed to several factors such as India's well-established sugarcane industry, providing a readily available and geographically concentrated source of feedstock. Additionally, the technology for ethanol production from sugar and molasses is mature and cost-effective. However, while it leverages existing infrastructure and offers a readily available feedstock, it raises concerns about long-term sustainability.

Grain-based Ethanol, utilizing starchy feedstocks including corn (maize), and broken rice, makes up the remaining 39% of production capacity. The government's push for grain-based Ethanol production is driven by its desire to diversify feedstocks and reduce dependence on sugarcane.

Second-generation Ethanol produced from lignocellulosic biomass and algal biomass currently does not hold any share in India's Ethanol production. These advanced feedstocks offer significant advantages in terms of sustainability and reduced competition with food production. However, the technology for their conversion into Ethanol is still under development in India, and commercially viable production processes are yet to be established.

Exhibit 3.2: Ethanol production capacity split by feedstock, in %, India, FY2024

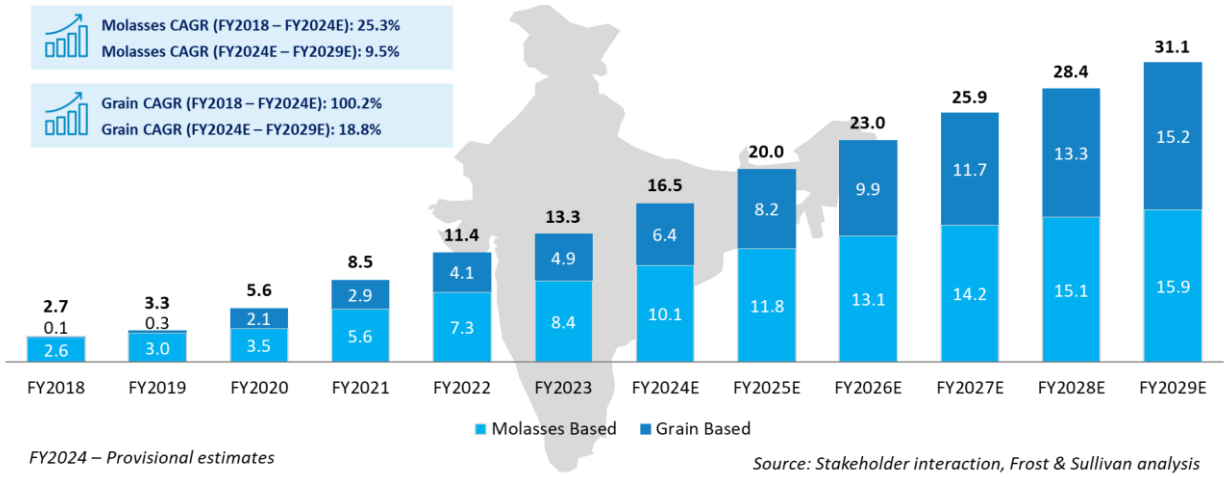


Source: PIB, Stakeholder interactions, Frost & Sullivan analysis

India's Ethanol production capacity for blending and other uses increased from 2.7 billion litres at the end of FY2018 to approximately 16.5 billion litres at the end of FY2024, at a CAGR of 35.2%. The launch of major new Ethanol projects in line with a new interest subvention scheme, approved by the Food Ministry in January 2023, has fuelled the growth of Ethanol production in the country. The current dominance of sugar and molasses in India's ethanol production presents both opportunities and challenges and notably, the upcoming projects include molasses-based, grain-based and dual feedstock-based facilities. Within grain, earlier rice and now maize / corn has become a prominent feedstock. Besides, grains such as sweet

sorghum is emerging as a potential feedstock for future due to its high sugar content, rapid growth cycle, and adaptability to various climatic conditions.

Exhibit 3.3: Ethanol production capacity split by feedstock, in billion litres, India, FY2018 – FY2029E



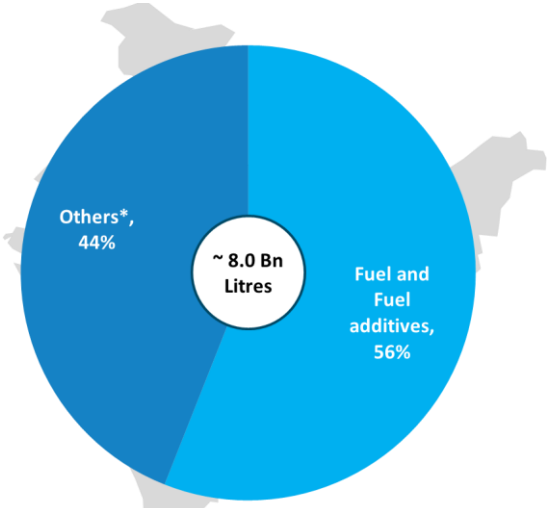
FY2024 – Provisional estimates

Source: Stakeholder interaction, Frost & Sullivan analysis

B. Ethanol production in India split by applications

Ethanol production in India is experiencing a significant upswing, driven by a confluence of government initiatives and environmental concerns. To reduce harmful emissions and improve fuel efficiency, the government has set an ambitious target of achieving 20% Ethanol blending in gasoline by ESY 2025-2026. This vision is further supported by the launch of "ETHANOL 100" at select retail outlets across several states. This initiative promotes Ethanol as a viable alternative fuel, aiming to reduce dependence on fossil fuels, improve sustainability, and contribute to a cleaner environment by lowering greenhouse gas emissions. The fuel ethanol production accounted for approximately 56% share of total Ethanol produced in India in FY2023.

Exhibit 3.4: Ethanol production split by applications, share in %, India, FY2023



**Others include beverages, industrial solvents, disinfectants, & personal care*

Source: PIB, Stakeholder interactions, Frost & Sullivan analysis

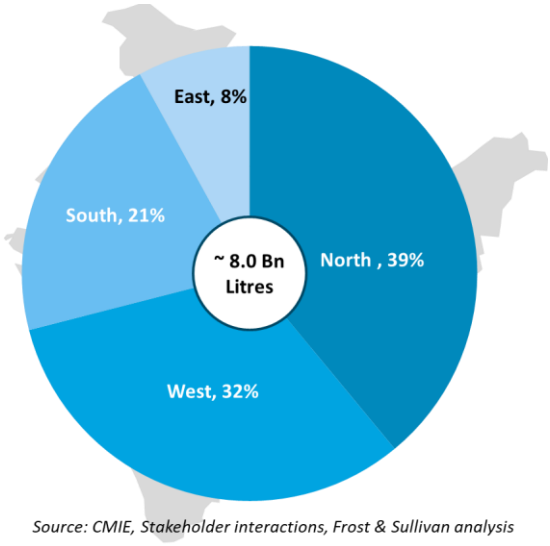
The remaining 44% ethanol finds application in diverse segments consisting of beverages, industrial solvents, disinfectants, and personal care products, and has witnessed steady growth. Rising demand from the pharmaceutical and paints & coatings industries fuels the market for industrial solvents.

Similarly, the growing emphasis on hygiene has propelled the use of Ethanol-based disinfectants. However, the future trajectory of this segment hinges heavily on broader economic factors. Government policies and credit availability significantly impact industrial activity, which in turn affects the demand for Ethanol in these applications.

C. Ethanol production in India split by region

Examining India's Ethanol production reveals a clear regional distribution. The Northern region reigns supreme with a 39% share, followed by the West (32%), South (21%), and East (8%) in FY2023. This dominance can be attributed to the North's massive ethanol production capacity, robust agricultural sector, particularly in states like Uttar Pradesh, Punjab, and Haryana. These states are major producers of sugarcane and maize, both critical feedstocks for Ethanol production. Additionally, the North boasts a well-developed infrastructure for Ethanol production and distribution, further solidifying its leadership position.

Exhibit 3.5: Ethanol production in India split by region, share in %, FY2023



Source: CMIE, Stakeholder interactions, Frost & Sullivan analysis

Government policies promoting biofuels have also played a significant role. Notably, the allowance of damaged and surplus food grains for Ethanol production has provided a substantial boost. This, coupled with the changing lifestyles and rising consumption of alcoholic beverages (partly influenced by Western cultural trends), has further fueled the demand for Ethanol in North India. Here, Ethanol primarily serves two purposes: as a biofuel and in the production of alcoholic beverages.

While the Western region, a powerhouse in sugarcane production due to states like Maharashtra, holds a significant 32% share, factors like water scarcity for irrigation and competition from more lucrative cash crops could pose challenges to its full Ethanol production potential. The Southern region, despite having states like Karnataka and Tamil Nadu that are significant sugarcane and rice producers, holds a 21% share. This is due to factors such as less focus on Ethanol as a biofuel, competition from other industries, or logistical challenges in distribution. In the Southern region, Ethanol is used in a variety of applications, including potable alcohol and in the chemical and pharmaceutical industries.

The Eastern region, with the smallest share of 8%, faces challenges such as less agricultural activity suitable for Ethanol production, non-availability of feedstocks, lack of infrastructure for Ethanol production and distribution, or less favourable government policies. In the Eastern region, the major

application of Ethanol is in fuel and fuel additives. With the start of the National Policy on Biofuel 2018, which has put forth an Ethanol blending target of 10% in ESY2022 and 20% by ESY2025, the demand for Ethanol is set to grow significantly in this region as well.

D. Leading Ethanol producers in the country and their capacities

Traditionally, sugar mills dominated production, utilizing molasses, a byproduct of sugar processing, as their primary feedstock. Companies like Bajaj Hindusthan Sugar, Shree Renuka Sugars, and Balrampur Chini Mills Limited were at the forefront, leveraging their existing sugar infrastructure for Ethanol production.

However, a recent push towards biofuels and energy security has led to a focus on diversification. Grain-based Ethanol, seen as a more sustainable option, is gaining ground. This shift has opened doors for new players alongside established sugar companies. Additionally, grain traders and processors are entering the Ethanol space, capitalizing on their expertise in handling grain feedstocks. The landscape is becoming more dynamic.

While sugar mills maintain a significant presence, the future of India's Ethanol industry lies in its ability to adapt and expand. Companies that can efficiently utilize both traditional and new feedstocks, while embracing technological advancements, are likely to emerge as the leaders in this evolving market.

Exhibit 3.6: Some large Ethanol producers and their capacities, Molasses-based, India, FY2024

COMPANY	DISTILLATION CAPACITY (BILLION LITRES PER ANNUM)
Shree Renuka Sugars Limited	0.46
Balrampur Chini Mills Limited	0.38
Dalmia Bharat Sugar Limited	0.31
Bajaj Hindusthan Sugar Ltd (BHSL)	0.29
Triveni Group	0.24
E.I.D Parry	0.15

Source: Frost & Sullivan research

Some of the Regreen Excel's prominent Molasses-based customers are Godavari Biorefineries, DSCL Sugar, Dalmia Bharat Sugar, Hermes Distillery, Ugar Sugar Works, Balrampur Chini Mills, to name a few. Among the Grain distilleries and Ethanol producers, Globus Spirits, Gulshan Polyols, Mash Biofuels, India Glycol are the prominent customers.

Exhibit 3.7: Some large Ethanol producers in the country and their capacities, Grain-based, India, FY2024

COMPANY	DISTILLATION CAPACITY (BILLION LITRES PER ANNUM)
Jurala Organic Farms & Agro Inds	0.21
Mash Bio-Fuels Pvt. Ltd.	0.20
Gulshan Polyols Ltd.	0.18
India Glycols Ltd.	0.10
B C L Industries Ltd.	0.07

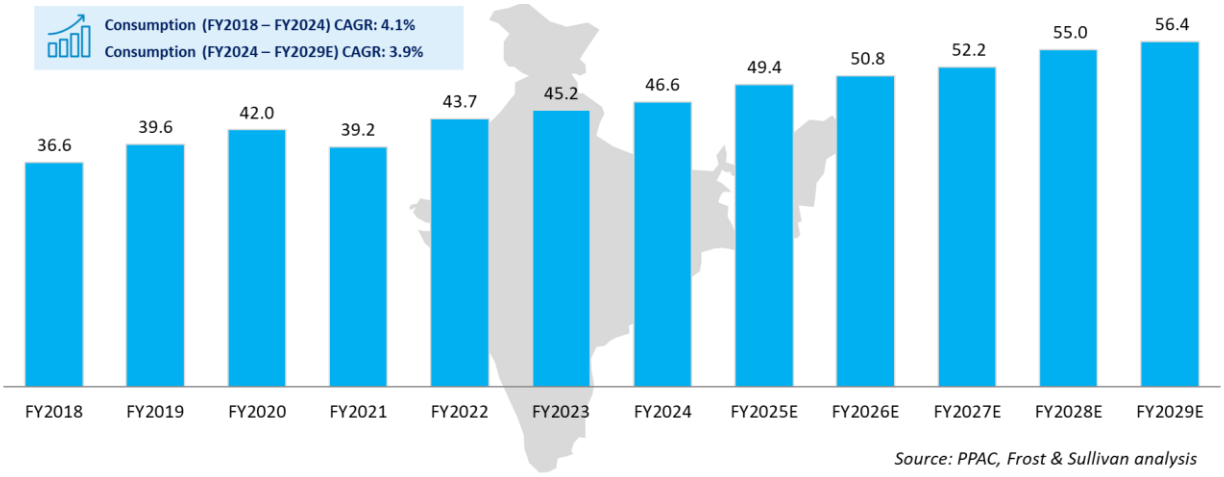
Source: Frost & Sullivan research

3.3 Fuel Ethanol supply scenario in India

A. Petrol consumption in India

Domestic petrol consumption in India followed a distinct three-part trend. Initially, between FY2018 and FY2020, consumption rose steadily due to several factors. India's robust economic growth during this period led to increased disposable incomes, potentially resulting in higher vehicle ownership and usage. Additionally, investments in road construction and improved connectivity facilitated greater mobility, further boosting petrol demand. Finally, the growing trend of urbanization, with people migrating towards cities, fueled a rise in two-wheeler ownership, a major consumer of petrol.

Exhibit 3.8: Petrol consumption in India, billion litres, FY2018 – FY2029E



Source: PPAC, Frost & Sullivan analysis

FY2021 witnessed a significant dip in petrol consumption compared to the pre-pandemic years. This can be primarily attributed to the nationwide lockdowns and travel restrictions imposed to curb the spread of COVID-19. Reduced economic activity and a shift towards work-from-home arrangements further dampened demand.

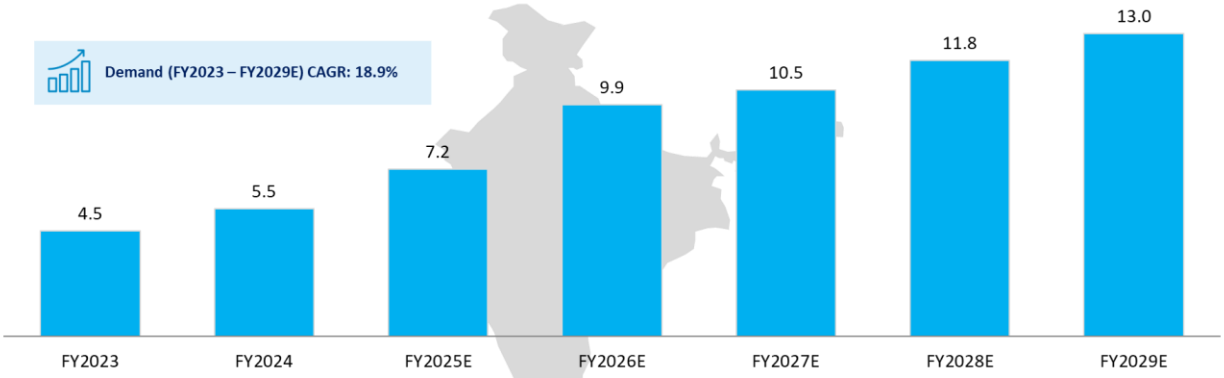
From FY2022 onwards, domestic petrol consumption resumed its upward trajectory. However, the long-term outlook presented in the data (FY2029) suggests a potential slowdown in the sales of motor spirits. The Indian government's ambitious plans to promote electric vehicles (EVs) could lead to a gradual shift away from petrol-powered vehicles in the long run. The increasing emphasis on biofuels like Ethanol blending in petrol could also contribute to a plateauing of petrol consumption.

B. Demand for Fuel Ethanol in India

The Indian government serves as the architect of this transformation. With a roadmap featuring an escalating Ethanol blending mandate from the current 12% (February 2024) to approx. 20% by ESY2025-26, the projected demand for Ethanol is poised for a dramatic ascent.

This translates to a near three-fold increase, catapulting from an estimated 4.5 billion litres per annum (BLPA) in FY2023 to an anticipated 13.0 BLPA by FY2029. The sheer magnitude of this growth underscores the government’s commitment to reducing dependence on imported oil and embracing cleaner energy alternatives.

Exhibit 3.9: Demand for Fuel Ethanol, billion litres, India FY2023 – FY2029E



Demand for Fuel Ethanol is available on ESY basis – this requirement has been converted to FY basis through discussions with industry stakeholders.

Source: Industry interactions, Frost & Sullivan analysis

Besides, the government is evaluating a plan to blend 5% ethanol in diesel (ED-5) and the plan is currently at an experimental stage. If technically feasible, the programme can further boost the demand for Fuel Ethanol in the country in the coming years.

C. Challenges in meeting Fuel Ethanol demand

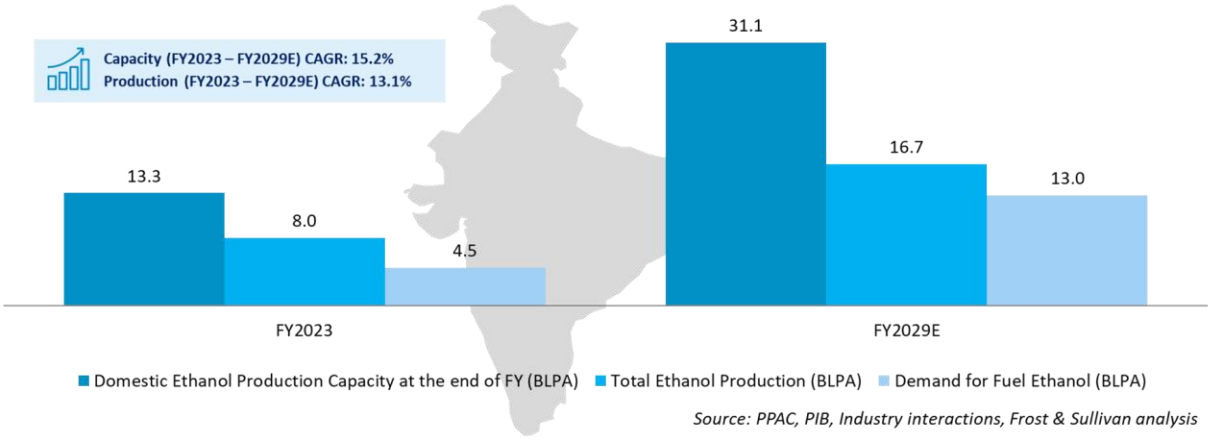
- **Compatibility Concerns:** While Ethanol offers environmental benefits, concerns exist about its compatibility with existing fuel infrastructure. Traditional gasoline storage and delivery systems, including vehicle fuel tanks and pumps, might not be optimized for Ethanol blends. This can lead to potential corrosion or degradation of these components, necessitating upgrades or replacements.
- **Feedstock Availability and Price Fluctuations:** A major challenge lies in securing a sustainable supply of Ethanol feedstock. Currently, corn and sugarcane are the primary sources, but their availability can be impacted by factors like weather patterns and competition from food production. This variability can lead to fluctuations in Ethanol prices, impacting its economic viability as a fuel alternative.
- **Reduced Energy Density:** Compared to gasoline, Ethanol has a lower energy density. This translates to vehicles needing more frequent refueling when running on higher Ethanol blends. Additionally, some older vehicles might experience performance issues with higher Ethanol content, potentially requiring adjustments or leading to increased maintenance costs.
- **Sustainability of Ethanol Production:** The environmental impact of Ethanol production itself needs careful consideration. Large-scale production of Ethanol using traditional feedstocks can be water-intensive and require significant land use. Sustainable practices are crucial to ensure that the environmental benefits of replacing gasoline with Ethanol aren't outweighed by these concerns.
- **Finding the Right Balance:** The key lies in finding a balanced approach that maximizes the environmental benefits of Ethanol blending while mitigating the potential drawbacks. Research into advanced biofuels derived from non-food feedstocks offers promising solutions. Additionally, infrastructure upgrades and promoting flex-fuel vehicles better suited for Ethanol blends can address compatibility concerns. By carefully managing these challenges, Ethanol can be a valuable tool in the transition towards a cleaner transportation sector.

D. Production vs demand for Fuel Ethanol in India

The domestic ethanol production capacity is projected to increase from 13.3 billion litres per annum (BLPA) in FY2023 to 31.1 BLPA by FY2029. This phenomenal growth is a testament to the government's commitment to biofuel blending and India's aspiration for energy security. Stakeholers are adopting a two-pronged approach to bridge the demand-supply gap.

- **Enhancing Efficiency:** Continuous improvement in conversion processes (efficiency), adoption of advanced technologies like cellulosic Ethanol production, and optimizing feedstock utilization are crucial to maximizing output from existing and upcoming facilities.
- **Expanding the Player Base:** Encouraging new players to enter the Ethanol production landscape is essential. Government incentives, streamlined licensing procedures, and promoting research and development in this sector can act as catalysts for attracting new investments.

Exhibit 3.10: Production vs Demand for Fuel Ethanol in India, in billion litres, FY2023 – FY2029E



Source: PPAC, PIB, Industry interactions, Frost & Sullivan analysis

E. Fuel Ethanol pricing by source

From the inception of the EBP Program, various pricing models have been adopted by the government which were based on the prevailing macro-economic situation of the sugar industry and the oil sector. The Ethanol procurement gained momentum after the introduction of Administered Pricing Mechanism for Ethanol from ESY 2014-15. Prices of Ethanol produced from sugarcane sources is approved by the Cabinet Committee on Economic Affairs (CCEA), while that from foodgrains is decided by OMCs. Since ESY 2018-19, the Government has introduced a differential pricing policy wherein higher rates were offered to sugar mills for production of Ethanol from B-heavy molasses and sugarcane juice.

- The prices are revised annually by the Cabinet Committee on Economic Affairs (CCEA) based on various factors such as cost of production, availability, and demand.
- The differential pricing policy has resulted in an increased supply of Ethanol for the Ethanol Blended Petrol (EBP) programme and is likely to help achieve the 20% Ethanol blending in petrol by 2025.

Exhibit 3.11: Ex-mill price of Fuel Ethanol by raw materials, in INR per litre, ESY2019-20 – ESY2029-30E

RAW MATERIAL	ESY 2019-20	ESY 2020-21	ESY 2021-22	ESY 2022-23	DEC 2023	ESY 2029-30E
C-Heavy Molasses	43.75	45.69	46.66	49.41	56.28	~65 – 66
B-Heavy Molasses	54.27	57.61	59.08	60.73	60.73	~78 – 79

Sugarcane Juice/ Syrup	59.48	62.65	64.45	65.61	65.61	~81 - 82
Damaged foodgrains	50.36	51.55	52.92	64.00	64.00	~69 - 70
Surplus rice issued by FCI	-	56.87	56.87	58.50	58.50	~64 – 65
Maize	-	51.55	53.45	66.07	71.86	~88 - 90

Source: PIB, Frost & Sullivan Analysis

India's Ethanol production is undergoing a transformation, fueled by a growing appetite for clean energy and a strategic shift in feedstock choices. Fueled by rising production costs, inflation, and surging demand for Ethanol itself, the prices of traditional feedstocks like C-heavy molasses, B-Heavy Molasses, and Sugarcane juice/syrup have been on a steady climb over the years. This price pressure has spurred a search for more sustainable and cost-effective alternatives.

Introduced in FY2021, surplus rice issued by the Food Corporation of India (FCI) emerged as a game-changer. This move not only offered a cost-effective option for Ethanol producers but also provided a much-needed solution for managing overflowing FCI stockpiles. The stable pricing of surplus rice over the years further strengthens its appeal. This development marks a subtle shift towards grain-based Ethanol production in India. Rising molasses prices, potential limitations on molasses availability due to competing demands, and government policies promoting the use of surplus food grains for Ethanol production are all contributing factors. The pricing model is based on the Fair and Remunerative Price (FRP) of Sugar Cane on which the cost of conversion, depreciation and cost of capital is added to compute the ex-mill price of Ethanol (INR 65.61/litre). The pricing model followed for B Heavy is linked to the normative cost of sugar on which cost of capital is added to compute the ex-mill price of Ethanol (INR 60.73 per litre).

3.4 Availability of Ethanol feedstock in India

India's ambitious Ethanol Blending Petrol (EBP) program hinges on a critical factor: feedstock availability. While the program holds immense potential for energy security and environmental benefits, ensuring a consistent supply of suitable raw materials remains a key challenge. This section delves into current state of various feedstock options in India.

A. Current feedstock landscape and challenges:

- **Sugarcane:** Traditionally, sugarcane has been the dominant feedstock for Ethanol production in India. However, several factors are impacting its availability:
    - **Diversion for Sugar Production:** Sugarcane prices often incentivize diversion towards sugar production, creating competition with Ethanol feedstock.
    - **Seasonality:** Sugarcane crushing season is limited, leading to seasonal fluctuations in Ethanol production.
    - **Land and Water Concerns:** Expanding sugarcane cultivation raises concerns about land use sustainability and water resource depletion.
- **Molasses**: Molasses, a byproduct of sugar production, presents a potential feedstock option. However, its availability is directly tied to sugarcane production and faces similar seasonality issues. Additionally, different grades of molasses (B-Heavy and C-Heavy) have varying suitability for Ethanol production, impacting overall feedstock potential.

- **Damaged Food Grains:** The inclusion of damaged food grains like rice offered a promising alternative. However, concerns regarding competition with food security and logistical challenges led to a recent withdrawal of this option.

B. Growing emphasis on Corn (Maize) based Ethanol in India

Maize has become a strategically important crop in India due to its usability in Ethanol production, which is then blended with petrol. The government aims to decrease reliance on sugarcane-based Ethanol over time and make better use of maize.

The Indian government is set on increasing its domestic Ethanol production by diverting more maize (corn) towards this purpose. This plan aims to achieve a nearly ten-fold rise in Ethanol output within the next five years. To achieve this, several initiatives are being rolled out:

- **MSP procurement scheme:** The government's Minimum Support Price (MSP) procurement scheme provides a crucial safety net for maize farmers in India. By guaranteeing a pre-determined minimum price for their crop, the scheme incentivizes farmers to cultivate maize and reduces the risk associated with fluctuating market prices. This encourages them to invest in essential inputs like fertilizers and improved seeds, potentially leading to higher yields and improved overall income stability.
- **Increased maize production:** The Indian Institute of Maize Research (IIMR) plays a vital role in developing climate-resilient maize hybrids suitable for diverse Indian conditions. These hybrids offer several advantages, including increased yield potential, improved resistance to diseases and pests, and better adaptation to various growing conditions. This translates to a reduced risk of crop failure and a more sustainable agricultural system. Additionally, promoting best agricultural practices through extension services and farmer training programs equips farmers with the knowledge necessary to maximize their yields. Investments in irrigation infrastructure can further enhance maize production by mitigating the impact of droughts and ensuring a reliable water supply for cultivation.
- **Focus on high-yielding seeds:** Scientists are developing new, high-yielding maize varieties to significantly increase productivity.

India's current maize usage for Ethanol production stands at approximately 0.8 million tonnes (MT) in FY2024. However, ambitious projections anticipate exponential growth, reaching 3.4 MT by FY2025 and a staggering 10 MT by FY2028. To achieve this remarkable increase, India, with its current network of around 20 operational maize-based Ethanol plants, needs a comprehensive strategy that addresses both the quantity and quality of maize production. By combining the MSP procurement scheme with a robust research and development framework, the government aims to create a favorable environment for maize farmers. This approach, complemented by investments in irrigation infrastructure and improved agricultural practices, is critical for achieving India's ambitious biofuel targets and ensuring a sustainable future for its Ethanol program.

4. ETHANOL PLANT EPC MARKET IN INDIA

4.1 Scope of Work for an EPC company

An Engineering, Procurement, and Construction (EPC) company specializing in the setup of ethanol plants holds a pivotal role in advancing the biofuel industry both in India and globally. Such a company leverages its expertise to deliver turnkey solutions, ensuring that ethanol plants are built to the highest standards of efficiency, sustainability, and technological innovation. The company not only contributes to the local economy but also addresses global energy needs and environmental challenges.

Setting up an ethanol plant involves a multitude of activities that ensure the successful installation and operation of various systems and sub-systems. Here's an in-depth look at the work and impact of an EPC company setting up ethanol plants across India and overseas.

A. Comprehensive project capabilities:

An EPC company dedicated to ethanol plant setups offers a wide range of services that cover the entire project lifecycle:

1. **Project Planning and Design:**
    - **Feasibility Studies and Detailed Project Report:** Conducting thorough feasibility studies to assess the technical and economic viability of proposed project.
    - **Engineering Design:** Creating detailed engineering designs that comply with industry standards and client requirements.
    - **Project Management:** Developing comprehensive project plans, schedules, and budgets to ensure timely and cost-effective execution.
2. **Procurement:**
    - **Vendor Management:** Sourcing high-quality equipment and materials from trusted suppliers.
    - **Contract Management:** Negotiating and managing contracts with vendors and subcontractors.
3. **Construction:**
    - **Site Preparation:** Performing site surveys and preparing the ground for construction.
    - **Civil and Structural Works:** Constructing the foundational structures, including buildings, tanks, and supporting infrastructure.
    - **Installation/Erection:** Installing process equipment, piping systems, and electrical systems.
    - **Commissioning:** Testing and commissioning the plant to ensure all systems operate correctly and efficiently.

B. Key project components:

Setting up an ethanol plant involves several critical components and systems:

1. **Fermentation:** Installing fermenters, cultures vessels/pre-fermenters and related equipment to convert feedstock into ethanol.
2. **Distillation Columns:** Setting up multi-pressure distillation systems for producing Extra Neutral Alcohol (ENA) and Rectified Spirit (RS).

3. **Dehydration System:** Implementing molecular sieve dehydration technology to produce fuel-grade ethanol.
4. **Evaporation and Waste Management:** Integrating multi-effect evaporation systems for spent wash treatment and waste-to-energy solutions
5. **Supporting Infrastructure:** Constructing utilities like cooling towers, water treatment plants, cogeneration power plants including boilers, and turbines etc.
6. **Civil:** Developing civil infrastructure such as plant foundations, internal roads, control rooms, laboratories, and storage facilities etc.

C. Innovative and Sustainable solutions:

- **Advance Technologies:** An EPC company employ cutting-edge technologies in projects, such as automated control systems, energy-efficient processes, and innovative waste management solutions. These technologies enhance the operational efficiency and environmental sustainability of ethanol plants.
- **Environmental Stewardship:** By focusing on sustainable practices, EPC companies try to minimize the environmental impact of ethanol production. This includes the efficient water and energy usage, and the integration of waste-to-energy systems.

Each project is tailored to meet the specific needs of the region. These projects contribute significantly to local economies by creating jobs, supporting agriculture, and promoting sustainable development. The global projects provide local energy solutions and contribute to global efforts to combat climate change. An EPC company specializing in the setup of ethanol plants also plays a critical role in the global transition to renewable energy. By delivering comprehensive, high-quality projects across India and internationally, the company supports sustainable energy production, economic development, and environmental conservation. Through innovative technologies and efficient project execution, the company continues to drive progress in the biofuel industry, making a lasting impact on the world's energy landscape.

4.2 Cost of setting up of an Ethanol plant

The cost of setting up an ethanol plant is influenced by various factors, including the type of feedstock, the intended output, plant capacity, configurations, and the materials used. Here's a more detailed breakdown of these considerations:

Feedstock type: The type of feedstock used in ethanol production plays a significant role in determining the overall cost of setting up the plant. Common feedstocks include:

- **Molasses:** A by-product of sugar production, often used in molasses-based distilleries.
- **Grain:** Such as corn, or broken rice, used in grain-based distilleries.
- **Multi feed:** A combination of different feedstocks to provide flexibility and cost-efficiency

Each feedstock requires specific processing equipment and handling systems, impacting the capital expenditure (CAPEX).

Intended output: Ethanol plants can be designed to produce:

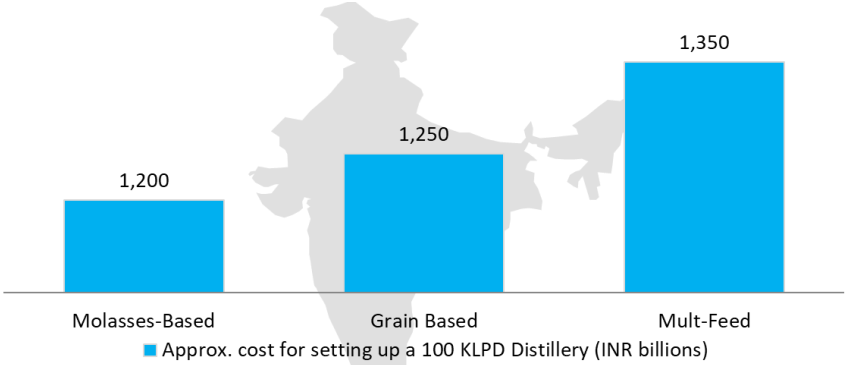
- **Fuel Ethanol:** Used as a renewable fuel additive to gasoline, requiring dehydration units to produce high-purity ethanol (e.g., 99.8% v/v).
- **Extra Neutral Alcohol:** Used in beverages, pharmaceuticals, and personal care products, necessitating high-purity distillation systems.

Execution Model:

- **Full EPC -** In this model, a single EPC company is responsible for the entire project from start to finish. This includes all phases such as engineering, procurement, construction, and commissioning of the entire plant, ensuring the delivery of a fully operational facility.
- **Process Plant EPC** - In this model, the project is divided into specific packages, each managed by a different EPC contractor or company specializing in that area. For instance, one company may setup the process plant, another the power plant, and yet another the water and wastewater treatment facilities

Establishing a 100 KLPD molasses-based distillery requires an investment of approximately INR 1,200 million (INR 12 million per KLPD). In comparison, setting up a grain-based distillery of the same capacity could cost around INR 1,250 million (INR 12.5 million per KLPD) and a multi-feed distillery of the same capacity mat cost around 1,350 million (INR 13.5 million per KLPD). The cost difference arises due to the distinct processing requirements for each feedstock. Grain-based distilleries typically need more extensive pre-treatment and processing equipment compared to molasses-based plants.

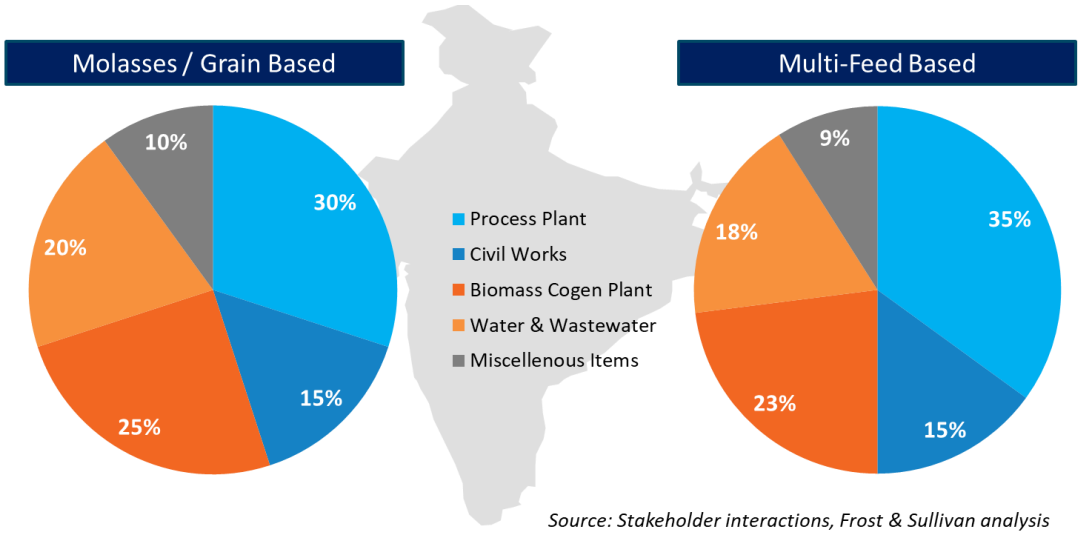
Exhibit 4.1: Approximate cost for setting up a 100 KLPD Distillery, INR billions, FY2024



Source: Stakeholder interactions, Frost & Sullivan analysis

The above cost can further be split into five packages: Process Plant, Civil Works, Power Plant, Water and Wastewater and Miscelleous Items. Cost contributions of these packages for a Molasses / Grain based vs. Multi feed distillery have been shown below:

Exhibit 4.2: Distillery set up cost splits by packages – Molasses / Grain based Vs Mult-Feed based



Source: Stakeholder interactions, Frost & Sullivan analysis

Among the large Ethanol Plant EPC providers (FY2024 revenue of more than INR 10 billion) in India, Regreen Excel is the fastest growing company and offers all of the above mentioned packages. The company has 34% market share in terms of total revenue from EPC of ethanol projects in India in FY2024. The company till the end of FY2024 has executed 108 ethanol projects and 49 more projects are at various stages of execution. Over the years, the company has built end-to-end capabilities in setting-up ethanol plants, across feedstocks such as molasses / sugarcane syrup, grains, or a combination thereof (multi feedstock), which enabled the company to provide concept to commissioning solutions to its customers.

- **Total projects undertaken (executed + under execution) till the end of FY2024: 157 projects**
  - 93 Grain Distilleries
  - 59 Molasses Distilleries
  - 5 Grain and Molasses Distilleries
  - 39 ENA Plant
  - 112 DDGS Dryers
  - 30 Biomass Cogen Plant
  - 59 Water and Wastewater ZLD Plant

4.3 India's Ethanol plant EPC market – Historical and Projections

Ethanol plant EPC market has been defined as the total cost of Ethanol projects commissioned in a financial year. Methodology adopted and industry norms considered to derive the India's Ethanol EPC market:

1. Ethanol Capacity Addition (till FY2023)

- Historical ethanol capacity addition statistics are available only on Ethanol Supply Year (ESY) basis. ESY basis capacity addition statistics till ESY 2022-23 has been collated from Government portals.
- ESY or Ethanol Supply Year is a term used in the Ethanol Supply parlance and is defined as ethanol supply period from 1st December of a year to 30th November of the following year. Based on interactions with the industry experts, it has been established that approx. 60% of the overall commissioned capacity during an ESY is commissioned between December and March and the rest 40% is commissioned in the last 8 months of an ESY.
- Basis this, FY basis Ethanol installed capacity till FY23 has been derived.

2. Ethanol Capacity Addition projections (FY2024 – FY2029)

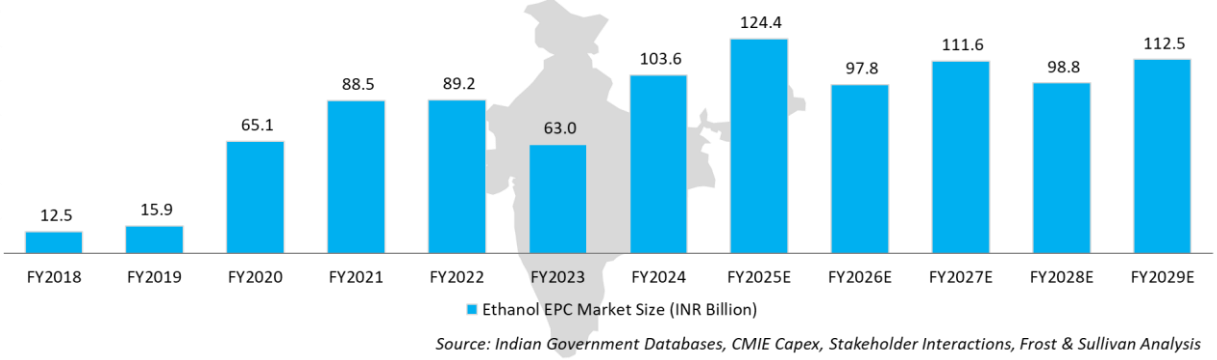
- Since ethanol capacity added till March 2024 of ESY 2023-24 is not publicly available, FY2024 likely capacity has been derived through demand of ethanol for blending and other purposes. From the Government sources, amount of Fuel Ethanol required during ESY 2024-25 for meeting the blending target has been established. That including usage of ethanol for other purposes have been used to derive the demand for Ethanol in India during ESY 2024-25.
- Considering an average 70% capacity utilization (based on inputs received from the Ethanol suppliers), capacity required to meet the above demand has been established. This capacity has been considered as the year-end capacity for ESY 2023-24. Post that, using the same methodology as mentioned in the point 1., approximate Ethanol production capacity at the end of FY2024 has been established.

- FY2025 – FY2029 installed capacity addition has been derived through two routes:
  - **Route A – Ethanol demand of the country:** Towards this, demand for petrol in the country has been established through desk research. Considering 20.2% blending by FY2027 (Government's target is to achieve 20% blending by ESY 2025-26) and 23.0% blending by FY2029 (due to introduction of E100), requirement for Fuel Ethanol has been established. That including the requirement of Ethanol for other purposes and considering 70% capacity utilization, likely installed capacity additions between FY2025 – FY2029 have been derived.
  - **Route B – Based on visibility of projects on ground:** The projects where EPC contract has already been awarded, for those projects, likely commissioning year has been established based on current status of each project and inputs received from the EPC companies. For the projects where EPC contract is yet to be awarded, 60% completion ratio has been considered to derive realistic capacity additions from those projects. The completion ratio has been derived through analysis of the previously announced projects and expert inputs. Capacity additions have been aggregated to derive the likely capacity additions between FY2025 – 2029
- Mean of the capacity addition projections derived through the above mentioned two routes have been considered as the realictic installed capacity additions between FY2025 – FY2029.

3. Derivation of Indian Ethanol EPC market size

- Average cost of setting up a distillery (Rs. million / KLPD) – historical costs and likely escalations have been established through discussions with the EPC companies. Average project cost in FY2018 was INR 10 million / KLPD. The same increased by 25% to INR 12.5 million in FY2024 and expected to increase further to INR 15 million / KLPD by FY2029.
- These thumb rules have been applied on the historical and projected capacity additions to derive the EPC market size. The Indian Ethanol EPC market has grown from INR 12.5 billion in FY2018 to INR 103.6 billion in FY2024, at a CAGR of 42%. The market is expected to peak to INR 124.4 billion in FY2025 as the country to expected to build necessary capacity to meet 20% blending target by then.
- Post that, the annual Ethanol EPC market till FY2029 would be range bound between approximately INR 100 billion to INR 115 billion – EPC opportunities during that period will arise from additional demand for Ethanol due to higher usage of E100 fuel, increased usage of Ethanol in various other applications and exports.

Exhibit 4.3: Ethanol EPC Market Size, India, INR billion, FY2018 – FY2029E



Source: Indian Government Databases, CMIE Capex, Stakeholder Interactions, Frost & Sullivan Analysis

4.4 Competitive landscape and market share analysis

India's Ethanol EPC business is fairly organized with top four EPC companies account for 90-92% of the revenue. These companies are Regreen Excel, Praj Industries, Mojj Engineering, and KBK Chem-Engineering. Among these companies, Regreen Excel and Praj Industries being the most prominent and comparable player. The Ethanol EPC also poses significant entry barriers such as long customer validation process, high degree of product and technical precision, complexity and stringent specifications.

- **Regreen Excel:** Regreen Excel EPC India Ltd. is a technocrat driven organization having a cumulative Team experience of more than 3 decades. It is the youngest manufacturer and supplier of Ethanol plants (Distillery, Sugar & Cogeneration, Bio Fuels, Zero Liquid Discharge Systems, and Renewable Energy) amongst the leading players in India as of March 31, 2024. It is a 'concept to commissioning' company offering end-to-end solutions for its projects. Regreen Excel is a recognised brand in the industry, 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 it a competitive advantage, since there are very few companies with similar capabilities.

  Besides, the company has collaborated with a global company to develop solar power generation units for all its distillery projects where 10% power from Solar is mandated. This entity will handle the comprehensive engineering design, supply, and installation of these solar units. They will be mounted on the rooftops of the projects, generating electricity to power the distilleries, and thereby reducing energy costs.

- **Praj Industries:** Praj Industries is a globally leading company with a bouquet of sustainable solutions for Bio-energy, High Purity Water, Critical Process Equipment, Breweries and Industrial Wastewater Treatment. The company has presence across the globe with 1,000+ References in 100+ countries across all 5 continents. (source: company website)

- **Mojj Engineering:** The company offer various services such as raw material handling to waste treatment, from single-process units to complete, integrated turnkey plants. The company is a manufacturer of Bio Ethanol Plants (Distilleries), Evaporators, and Dryers in India and aboroad. (source: company website)

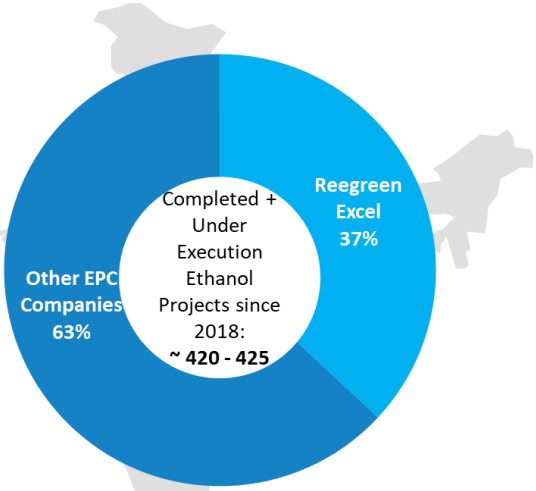
- **KBK Chem-Engineering:** KBK Chem-Engineering is an EPC Solution and Technology provider for Distilleries, Bio-ethanol, Brewery, Sugar, Chemical processing, Co-generation plants, and Water and Waste Water Solutions. KBK has executed over 60 projects globally. (source: company website)

A. Market share by no. of projects undertaken since the launch of National Biofuel Policy in 2018

- Based on discussions with the industry stakeholders, since the launch of National Biofuel policy in 2018 till the end of FY2024, the above mentioned companies and the other small EPC providers have undertaken (executed + under execution) approximately 420 - 425 Ethanol projects. Regreen Excel, among them, has undertaken 157 ethanol projects – 108 projects have been executed and 49 propjects are at various stages of execution at the end of FY2024. These projects comprise of grain distilleries, molasses distilleries, grain and molasses distilleries, ENA plants, DDGS dryers, biomass co-generation plants, water and wastewater treatment ZLD plants. Regreen Excel is India's leading technology driven EPC company in terms of total number of EPC projects undertaken since the launch

of National Biofuel Policy in 2018 and has approximately 37% share among the executed + under execution projects since 2018 till the end of FY2024.

Exhibit 4.4: Market share by Ethanol projects completed and under execution since 2018, in percentage



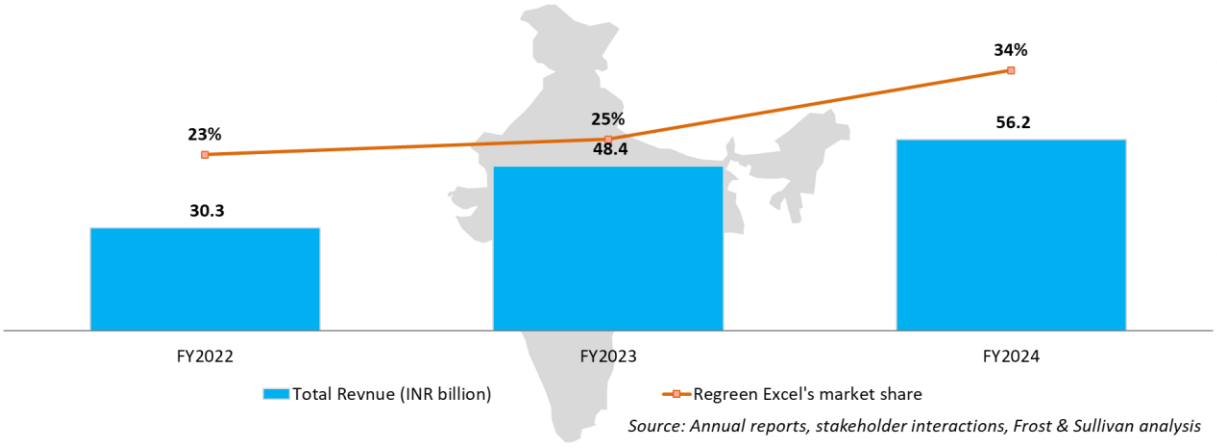
Other EPC Companies: Praj Industries, Mozz Engineering, KBK Chem-Engineering, Other small EPC contractors

Source: Stakeholder interactions, Frost & Sullivan analysis

B. Market share by revenue from EPC of Ethanol Projects

In this methodology, total revenue has been defined as the cumulative revenue of the above-mentioend four companies from Ethanol based EPC projects and their cumulative market share of 92% among the similar types of EPC companies. Based on discussions with these companies and the industry stakeholders, total revenue from Ethanol EPC projects has grown by almost 1.9 times between FY2022 to FY2024 – approximately INR 30 billion in FY2022 to INR 56 billion in FY2024.

Exhibit 4.5: Market share by revenue from EPC of Ethanol projects



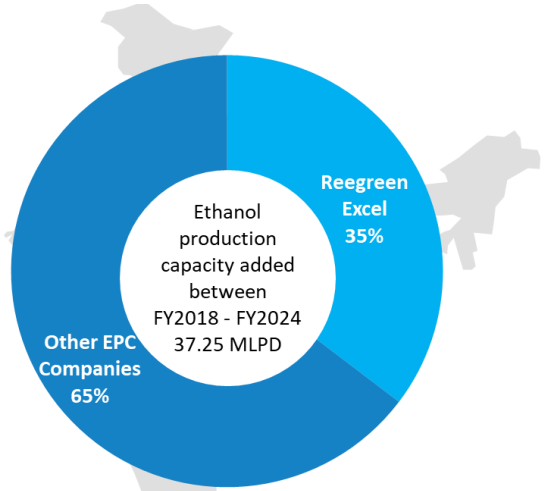
Source: Annual reports, stakeholder interactions, Frost & Sullivan analysis

In terms of revenue generated by the leading Ethanol EPC companies in India during this period, Regreen Excel's revenue has increased by approximately 2.7 times – from INR 7,019 million in FY2022 to INR 19,299 million in FY2024. In terms of market share, Regreen Excel's market has improved from approximately 23% in FY2022 to 34% in FY2024.

C. Market share by total capacity of Ethanol projects executed between FY2018 – FY2024

Approximately, 37.25 MLPD (million litres per day) of ethanol production capacity has been added in the country between FY2018 and FY2024. During this period (FY2018 – FY2024), Regreen Excel executed 13.16 MLPD capacity of ethanol projects. Based on this, Regreen Excel's share in the executed projects between FY2018 and FY2024 stands at 35%.

Exhibit 4.6: Market share by capacity of projects executed, FY2018 - FY2024



Other EPC Companies: Praj Industries, Mozz Engineering, KBK Chem-Engineering, Other small EPC contractors

Source: Stakeholder interactions, Frost & Sullivan analysis

4.5 Threats and challenges to the business and its products and services

A. Threats and challenges related to end-user industry i.e., Ethanol production plants

1. **Availability of Feedstock:** Sugarcane and rice were in surplus when the biofuels policy was announced. However, erratic temperatures and rains affected yield and availability of these crops in 2022 and 2023. Therefore, the availability of feedstock for ethanol blending is also under threat. Besides, Feedstock crops have multiple usage within the industries. Sugar mills are aiming for higher exports due to attractive prices, whereas Maize has varied applications across diverse set of industries. In the case of rice, the trade-off is between meeting its food, export, and ethanol needs.

   Climate change has an impact on the crop yields. The uncertainty around yields makes projecting future supplies tricky. This poses a greater risk on the investments committed by the OMCs and Distilleries in greenfield and brownfield Ethanol capacities.

2. **Alternate technologies are not economically viable:** Cellulosic and lignocellulosic materials used in 2G Ethanol production require complex pre-treatment processes to break down their tough structure. This pre-treatment adds significant cost and complexity to the production process. At present, capex required to set up a 2G Ethanol plant is almost 3.5 times costlier than setting up a 1G Ethanol plant. Research efforts are needed to develop cost-effective and efficient pre-treatment technologies suitable for India's diverse feedstock options. Current 2G conversion technologies often have lower efficiency compared to traditional 1G Ethanol production.

Optimizing these conversion processes to achieve higher yields of Ethanol from the available feedstock is crucial for economic viability.

3. **Growing competitions from alternate biofuels and energy options:** Bio-ethanol is one of the solutions for reducing fossil fuel imports and achieving energy security. Indian Govt. is promoting other biofuels such as Compressed Biogas (CBG), Methanol, Biodiesel, etc. to reduce dependency on fossil fuel imports. Besides, falling prices of Batteries and Hydrogen would make a more compelling case for switching to Electric Vehicle. These alternate fuels and energies pose a great risk on future and sustained demand for Ethanol in the coming years.

4. **Annual growth in Fuel Ethanol demand may slow down post achievement of 20% blending target:** 20% blending target set by the Govt. is a technical limitation and can be stretched to maximum 25 – 27% in future. This may retard the annual growth in Fuel Ethanol demand once the country achives the 20% blending target. However, increased penetration of E100, potential 5% blending of Ethanol with Diesel, increasing usage of Ethanol across varied industrial applications, and exports would continue to drive the demand for Bio Ethanol in the coming years.

B. Threats and challenges related to Ethanol EPC industry

5. **Increased competition:** Due to growing business opportunities, the Ethanol EPC business in the past years has seen entry of many small time companies who currently accont for only 5% share in the overall Ethanol EPC market, however poses risks to the bigger companies as there companies work at lower prices and thin prices and deliver sub-optimal outputs.

C. Threats and challenges related to the Company

6. **Diversification risk:** Indian government, along with 1G Ethanol, also promoting various other bio-fuels such as Compressed Biogas (CBG), 2G Ethanol, Sustainable Aviation Fuel (SAF), Methanol, Bio-diesel, etc. The company has plans to invest and diversify to some of the above mentioned technologies. While diversification is often considered as a risk mitigation strategy, diversification also comes with certain risks such as higher capital investments, complexity, new markets and business models and uncertainties.

5. OPPORTUNITY LANDSCAPE OF THE GLOBAL ETHANOL MARKET

5.1 Importance of ethanol for the global economy

In the ongoing quest for cleaner and more sustainable energy sources, ethanol is emerging as a significant player on the global stage. Derived from various renewable feedstocks like sugarcane, corn, or cellulosic biomass, ethanol offers a versatile alternative to traditional fossil fuels. The Asia-Pacific region, particularly China and India, is witnessing a significant rise in ethanol demand due to their burgeoning populations, growing economies, and expanding automotive industries. Understanding its diverse applications and its potential contribution to decarbonization efforts necessitates a closer look at this biofuel:

A. Ethanol's Widespread Uses

Transportation Fuel: Ethanol is blended with gasoline, directly powering vehicles and reducing dependence on petroleum. This blended fuel offers improved octane rating and cleaner burning characteristics compared to gasoline alone.

Beverage Industry: In the beverage industry, ethanol plays a central role in the production of alcoholic beverages through a process called fermentation. Yeast consumes sugars that are present in various feedstocks like fruits, grains, or sugarcane juice. During this process, yeast converts those sugars into ethanol and carbon dioxide. The resulting ethanol content determines the alcoholic strength of the final beverage.

Industrial Applications: Ethanol serves as a solvent in various industrial processes, including the production of paints, coatings, and pharmaceuticals. It is also used in the manufacturing of plastics, plasticizers, and certain cleaning solutions.

B. Ethanol's Role in Decarbonization

Greenhouse Gas Reduction: While the lifecycle emissions of ethanol production vary depending on feedstock and production methods, it generally offers lower greenhouse gas emissions compared to gasoline. This translates to a potential reduction in net carbon emissions when used as a transportation fuel.

Renewable Feedstocks: The utilization of plant-based materials for ethanol production allows for the creation of a renewable fuel source. This helps to reduce reliance on finite fossil fuel reserves and contributes to a more sustainable energy mix.

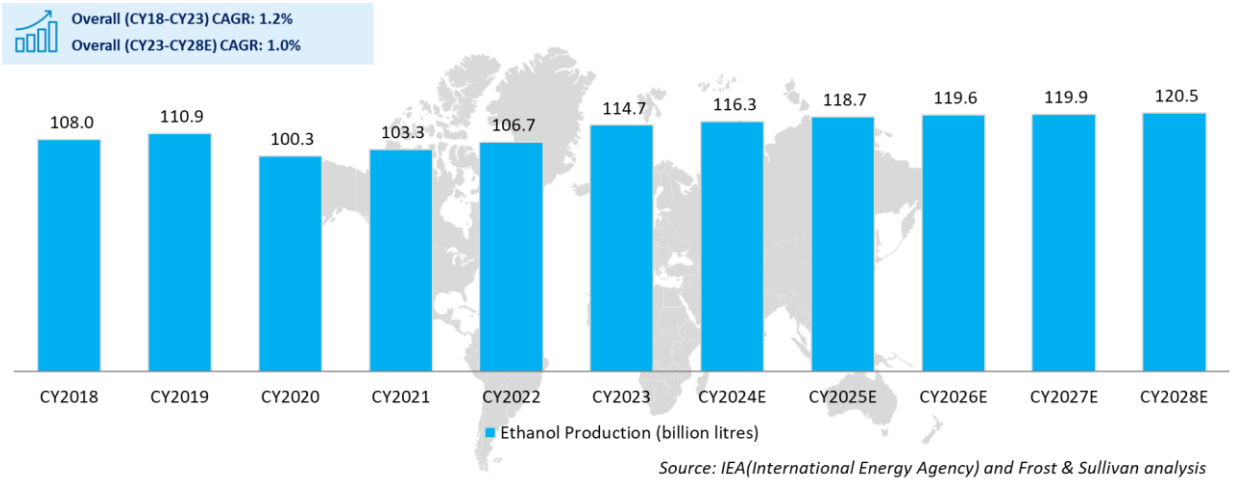
Waste-to-Energy Potential: Second-generation ethanol production technologies utilizing cellulosic biomass from agricultural waste offer an opportunity to convert waste materials into valuable biofuel, promoting resource efficiency and reducing reliance on virgin feedstocks.

5.2 Global ethanol industry: Introduction

Global ethanol production has exhibited a clear upward trend, reflecting its growing importance as a biofuel. In CY2018, production stood at 108.0 billion litres, rising to 110.9 billion liters in CY2019. A temporary dip occurred in CY2020, with production dropping to 100.3 billion liters, likely due to a factors including global pandemic's impact. However, despite these challenges, a steady and significant increase has been observed since CY2021. Production climbed to 103.3 billion litres in CY2021, followed by 106.7 billion liters in CY2022, and a substantial jump to 114.7 billion litres in CY2023.

Looking ahead, the projections for the coming years suggest a steady increase in global ethanol production. The production is expected to reach 116.3 billion litres in CY2024, 118.7 billion litres in CY2025, 119.6 billion litres in CY2026, 119.9 billion litres in CY2027, and finally 120.5 billion litres by CY2028.

Exhibit 5.1: Global Ethanol Production – Historic and Forecast, World, in billion litres, CY2018 – CY2028E



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

The global ethanol market is driven by research and development efforts from key players. Several leading companies are vying for a competitive edge in this space. These companies include

- Archer Daniels Midland
- Cargill
- Braskem
- Flint Hills Resources
- British Petroleum
- Andersons Ethanol Group
- Aventine Renewable Energy
- HPCL Biofuels
- Butamax Advanced Biofuels and
- Advanced Bioenergy

This mix of established industry giants and emerging players highlights the dynamic nature of the global ethanol market.

5.3 Demand outlook for Ethanol in Southeast Asian countries

A. Indonesia

- **Ethanol Mandate and Targets:** Indonesia currently has a 5% ethanol blending mandate, with a 20% target by 2025.This means that a certain percentage of gasoline sold in Indonesia must contain ethanol as a biofuel component.
- **Industrial Ethanol Consumption:** In 2018, industrial ethanol consumption in Indonesia was estimated at 137 million litres. However, domestically produced ethanol faces challenges. It is uncompetitive with the price of gasoline and other oxygenates, and its cost is double that of U.S. FOB Gulf ethanol.

- **Future Projections:** According to Presidential Regulation 40/2023, Indonesia aims to produce 1.2 billion litres of sugarcane ethanol by 2030. If Indonesia eventually implements an E10 blending mandate nationwide, it would require an estimated 890 million litres of ethanol per year, equivalent to 17% of total U.S. ethanol exports in 2022.
- **Government Policies:** Indonesia plans to mandate bioethanol content in gasoline at 15% and use it nationwide by 2031.

B. Philippines

- **Ethanol Production:** In 2022, the Philippines produced approximately 375 million litres of ethanol used as fuel, reflecting an increase from the previous year. However, ethanol production growth has been almost flat, with only one percent growth to 360 million litres. Limited feedstock remains a challenge for local producers. They can only supply half of the requirements for gasoline blending.
- **Ethanol Imports:** To fill the gap, the Philippines imports ethanol. In 2022, imported ethanol is expected to grow by 33 percent to 300 million litres.
- **Fuel Ethanol Demand:** Fuel ethanol demand in the Philippines is expected to increase by 13 percent in 2022. The total demand for ethanol reached 570 million litres in 2021.
- **Government Policies:** The Department of Energy (DOE) is preparing standards for a targeted escalation of ethanol blend to gasoline products, aiming for 20% (E20) by volume from the current 10%.

C. Vietnam

- **Gasoline Consumption and Ethanol Imports:** Vietnam's gasoline consumption has grown steadily at approximately 4-5% per annum. In the first three months of 2020, Vietnam spent approximately $2.5 billion on imports of crude oil and petroleum products, including ethanol.
- **Market Growth and Advantages:** As a developing country with a growing population and economy, Vietnam has a significant demand for energy. The ethanol market in Vietnam has been expanding in recent years. The demand for ethanol is driven by the government's efforts to:
  - Reduce reliance on imported petroleum.
  - Promote renewable energy sources.
- **Demand for Fuel Ethanol:** Vietnam has over 3.5 million cars and nearly 60 million motorbikes in operation, making it the fourth-largest motorbike market globally. The number of cars in operation increased by 44% from 2016 to 2019, while motorbike growth was 23% during the same period. Ethanol is blended with gasoline to produce gasohol (such as E5 and E10). Gasohol is used as a fuel for road motor vehicles.

D. Cambodia

- **Market Overview:** The Cambodia Ethanol Market has experienced growth due to several factors:
  - **Manufacturing Sector Growth**: In 2022, the manufacturing sector contributed significantly to Cambodia's GDP, driving industrial output. This growth increased the demand for ethanol in industrial solvents (e.g., plastics, rubber, textiles).

- **Rapidly Growing Food and Beverage Sector**: Urbanization and rising GDP per capita led to substantial investments in the food and beverage industry. Notably, companies like Vattanac Brewery Ltd. and Hanuman Beverages invested millions in the alcoholic beverage sector.

- **Projected Growth:** According to 6Wresearch, the Cambodia Ethanol Market size is expected to grow at a CAGR of 4.5% during 2023-2029. Government programs, such as the Roadmap for Clean Energy Transition towards Carbon Neutrality, will drive the adoption of renewable energy. Ethanol is anticipated to be used more frequently as a cooking fuel and a source of electricity in the coming years.

- **Government Policies:** There are no specific laws in Cambodia supporting biofuel development.

E. Myanmar

- **Market Overview:** The Myanmar Ethanol Market has witnessed growth due to several factors:
  - **Increasing Demand for Premium Alcoholic Beverages:** There is a rising demand for high-quality alcoholic drinks in Myanmar, driven by higher disposable income and changing consumer preferences.
  - **Environmental Concerns:** Growing awareness about environmental issues has led to interest in cleaner fuels like ethanol.
  - **Blended Ethanol at Gas Stations:** Efforts to provide blended ethanol at fuel stations contribute to market growth.

- **Market Size and Trends:** According to 6wresearch, the Myanmar Ethanol Market size is expected to grow during the period from 2020 to 2026. The installation and manufacturing of medium-scale ethanol processing plants in sugar mills are expected to fuel this growth. However, the market faced challenges in 2020 due to the coronavirus outbreak, impacting demand for organic chemical compounds. Nevertheless, recovery is anticipated in the near future.

F. Thailand

- **Ethanol Production:** In 2022, Thailand produced approximately 3,123 million litres of ethanol. Primary sources: sugarcane and tapioca fermentation.

- **Domestic Ethanol Consumption:** Thailand's Ethanol consumption is 1,583 million litres. 1,504 million litres for Fuel energy (e.g., gasohol), 54 million litres is exported, 15 million litres is used in liquor production, and 10 million litres is imported.

- **End Use & Government Policies:** Ethanol is blended with gasoline to create various fuel types, including gasohol 91, gasohol 95, E20, and E85. Thai government is now supporting electric vehicle adoption as part of its "30@30" policy, where 30% of new vehicles will be zero emissions by 2030. This puts the Thai ethanol industry in a difficult position.

5.4 Demand outlook for Ethanol in East African countries

A. Ethiopia

- **Ethanol Production**: Ethiopia has been producing bioethanol from molasses (a sugar by-product) for over 30 years. The government's strategy focuses on the production of bioethanol and biodiesel from various crops, including sugar cane, jatropha, castor, and palm. Ethanol

production is currently linked with government sugar estates, while biodiesel production aims to involve private investment. Approximately 30 million liters of ethanol are produced annually in Ethiopia, with plans to increase production through new sugar mills and distilleries.

- **Ethanol Demand**: The current ethanol production in Ethiopia is about 21 million liters, but there is potential for growth. The country's ambitious plans include constructing or operating thirteen sugar factories, which are expected to produce 3.6 million metric tons of sugar, 339 million liters of ethanol, and contribute 250 MW of excess power to the grid. Despite this, the current sugar demand in Ethiopia stands at 720,000 tons.
- **Opportunities and Challenges**: Ethanol has great potential to meet household energy demand in the developing world, including Ethiopia. However, challenges such as a lack of alcohol fuel for the household sector need to be addressed to fully utilize this potential. Overall, Ethiopia's biofuel sector faces both strengths and weaknesses, and policies play a crucial role in shaping its development.
- **Government Policies:** The Ethiopian government has taken several steps to promote ethanol use within the country.
  - **Clean Cooking With Ethanol:** The government issued regulations in 2007 to promote ethanol as a gasoline blend (E5) and for domestic cooking purposes.
  - **Bioethanol Road Map:** Starting in 2015, a target of 15% ethanol share was set to address foreign currency loss, energy insecurity, and climate change.

B. Kenya

- **Ethanol Production:** Ethanol production is primarily from molasses, which is a byproduct of sugar production. The country produced approximately 690,000 Metric Tons (MT) of ethanol from molasses in the 2021-2022 period. The ethanol industry in Kenya is privately owned and operated, with significant potential for growth. Sugarcane farmers in the Nyanza province (Western Kenya) contribute to the ethanol supply.
- **Ethanol Demand:** As a cleaner alternative to traditional fuels, ethanol is gaining popularity for cooking purposes. The Ethanol Cooking Fuel Masterplan highlights the trend towards cleaner fuels, projecting a drastic increase in ethanol demand over the next decade. Affordability, availability, health benefits, and environmental awareness contribute to this demand. Under the E10 policy, Kenya requires approximately 200 million liters of bioethanol annually for blending with gasoline. This policy aims to reduce dependence on petroleum fuel imports. Nairobi, the capital city of Kenya, requires about 120 million liters of bioethanol per year for cooking. However, the current production capacity stands at 1.8 million liters per year.
- **Government Policies:** Here are some key aspects of the government's policy on ethanol.
  - **Ethanol Cooking Fuel Masterplan:** The Masterplan emphasizes the potential of ethanol as a clean cooking fuel, especially for the urban poor.
  - **Regulation of Ethanol Use:** New rules ensure that all ethanol produced or imported into Kenya is denatured to prevent misuse.
  - **Blending with Petrol:** Kenya has initiated policies related to ethanol blending with petrol. Rules are being developed to compel oil marketers and the Kenya Petroleum Refinery Limited (KPRL) to blend ethanol with petrol.

C. Uganda

- **Ethanol Consumption in Uganda:** Uganda's ethanol consumption has been significant. In 2019, the country consumed approximately 12.2 liters of ethanol per person annually, which is higher than the African region average. The price of ethanol in Uganda is around 2832.05 Uganda Shillings per liter.
- **Market Trends:** The Ugandan ethanol market declined in 2022 compared to the previous year. however, overall consumption has expanded.
- **Environmental Considerations:** Ethanol use can contribute to ecological sustainability by reducing dependence on firewood and charcoal, which cause environmental degradation and climate change.
- **Government Policies:** Uganda has plans to enact a policy that will allow the blending of ethanol with petrol using the E10 blend.

D. Tanzania

- **Production:** Tanzania is developing its sugar industry to ensure self-sufficiency, which will create secondary production of 52 million liters of molasses-based ethanol annually.
- **Fuel Ethanol Blending:** Fuel ethanol blending is expected to average 930,000 barrels per day in both 2023 and 2024. This contributes to the overall ethanol production.
- **Domestic Consumption:** Industrially produced alcoholic drinks contribute to per capita consumption, equivalent to about 5 liters of pure alcohol in Tanzania. Additionally, there is an estimated annual per capita amount of unrecorded consumption from locally brewed alcohol, which adds about 2 liters of pure alcohol.
- **Clean Cooking Fuel Potential:** Tanzania is becoming a proving ground for clean cooking fuels. While sugarcane mills historically prioritized sugar production, the growth in ethanol consumption for cooking may trigger increased local ethanol production.
- **Government Policies:** Fuel ethanol blending is expected to average 48,500 million litres per year in both 2023 and 2024. Other policy initiatives are
  - **UNIDO's Clean Cooking Initiative:** The United Nations Industrial Development Organization (UNIDO) is actively involved in promoting clean cooking solutions in Tanzania with an aim of supplying ethanol to 500,000 households. Additionally, a market for 90 million liters/year of ethanol fuel supply will be established.

5.5 Demand Outlook for Ethanol in West African countries

A. Nigeria

- **Production:** Nigeria has limited ethanol production capabilities. There are only two major ethanol-producing companies, namely Allied-Atlantic Distilleries and Unichem, both located in Ogun State and both using cassava as their main feedstock. The country produced approximately nine million liters of ethanol per year, which is only three to four percent of the country's requirement.

- **Demand:** Despite the abundance of cassava roots as essential raw materials for ethanol production, Nigeria produces about six percent of the national need and imports between 300 million and 350 million liters of ethanol yearly. The demand for ethanol in Nigeria is primarily driven by the portable alcohol industry and chemical industries. Nigeria currently spends N 160 billion annually to import ethanol for industrial use while local production only accounts for 3% of ethanol consumption in the country. The ethanol market in Nigeria is expected to witness growth during the forecast period owing to the increasing adoption of ethanol in various applications coupled with changing lifestyle and changes in taste and preferences of the people. The market is anticipated to regain the economy with healthy growth in the near future.
- **Government Policy:** The biofuel policy in Nigeria projects a 90% gasoline – 10% fuel ethanol mix, with the Nigerian National Petroleum Corporation (NNPC) enforcing the blending requirements.

B. Ghana

- **Production:** Ethanol production in Ghana is primarily based on sugar and molasses, with an increasing interest in grain-based and second-generation sources. The production capacity of ethanol in Ghana has been developing, with the country's only ethanol producer—Caltech—having produced 150,000 liters of ethanol from cassava since starting up the 3 million liters per year facility. However, it's important to note that the ethanol market in Ghana is anticipated to witness growth in the coming years due to the rising requirement of ethanol as a biofuel and for other uses.
- **Demand:** The demand for ethanol in Ghana includes its use as an industrial solvent, fuel and fuel additives, beverages, disinfectant, personal care, among others. The demand for ethanol as a biofuel and for other uses has been rising, contributing to the market's expansion.
- **Import:** Over 60 million litres of ethanol is imported every year into Ghana, indicating a substantial demand for both food and non-food industries.
- **Government Policy:** The country is exploring the use of E10, a blend of 10% ethanol with gasoline, as a transition fuel to help reduce carbon emissions and save on fuel costs.

C. Benin

- **Production:** Benin has limited ethanol production capabilities, with two main plants contributing to the country's ethanol output. The Benin Sugar Plant (YUEKEN) and the Benin International Plant produce 4,200 m^3 and 3,000 m^3 of ethanol a year from sugar and cassava, respectively.
- **Demand:** The demand for ethanol in Benin is influenced by the country's energy needs and the potential for biofuels as a substitute for traditional biomass and fossil fuels. With its large import of $ 370 Million and virtually no internal production of petroleum products and Ethanol there is scope for the production of Ethanol.
- **Biofuel Strategy:** The government of Benin, recognizing the heavy energy crisis characterized by power shortages and rising fossil fuel prices, has been exploring a strategy for the production and use of modern biofuels. This includes assessing the technical and economic production potential from available and new possible feedstocks based on existing agricultural, environmental, and social conditions. Major source of raw material is Cassava available in large

quantities across the country. While the whole program shall depend on Government initiatives and policies there is scope for the setting up of Ethanol plants in Benin.

D. South Africa

- **Production:** South Africa produces just over 400 million liters of ethanol a year, with a significant portion used for potable purposes within Africa1. The country can produce about 1.5 billion liters of ethanol from fermenting waste gases in the steel and ferro-alloys industries alone, thanks to carbon recycling through microbial engineering2. Additionally, assuming that 50% of the cane produced can be diverted from the export market to domestic ethanol production, South Africa can produce approximately 700 million liters of ethanol from sugar cane.
- **Demand:** High-level estimates suggest that the local South African demand for fuel ethanol could be approximately 2.4 billion liters annually, with 75% (1.8 billion liters) from aviation, and 25% (600 million liters) from the national fuel blending mandate3. The market is expected to reach a size of more than USD 1.40 Billion by 2029. The market's expansion is further supported by governmental initiatives, including regulatory policies promoting biofuel blending mandates and incentives for ethanol production. The increasing awareness of the environmental benefits of ethanol as a renewable fuel source also fosters consumer demand and stimulates market expansion.
- **Government policies:** The current blending mandate stands at 2% ethanol, with plans to increase it to 5% in the near future. Additionally, the South African National Standard for petrol (SANS 1598) allows for the blending of fuel ethanol up to 5% for standard grade petrol and up to 10% for E10 petrol.

5.6 Demand outlook for Ethanol in Latin American countries

A. Brazil

- **Production:** Brazil is the world's second-largest producer of ethanol fuel. In 2017, Brazil produced 26.72 billion liters of ethanol, which was 26.1% of the world's total ethanol used as fuel. The production of fuel ethanol in Brazil reached 8.26 billion gallons in 2023, representing 28% of the global output. Total Brazilian ethanol production for 2022 was estimated at 31.66 billion liters, an increase from the previous year due to the rise in sugarcane production and steady growth in corn ethanol production.
- **Demand:** Ethanol is a significant part of Brazil's National Energy policies, with the country's ethanol production growing by 45 times since 1975. The Brazilian Energy Research Company projected that the demand for ethanol fuel in Brazil could reach 50 billion liters by 2030. In 2008, ethanol was already economically viable as a fuel in 17 out of 26 Brazilian states, with 87% of new car sales being flex-fuel engines capable of running on ethanol. The market for ethanol in Brazil is well-established, and there is a steady demand for it, particularly as the country moves towards decarbonization and renewable energy sources. The growth in both production and demand for ethanol in Brazil reflects the country's commitment to renewable energy and its role in the global biofuels market.
- **2G Ethanol:** Brazil is producing second-generation (2G) ethanol. This advanced biofuel, also known as cellulosic ethanol, is made from inedible parts of plants, such as sugarcane bagasse

and straw. As of recent data, there are three 2G ethanol production plants in Brazil. Two of these plants produce ethanol at an industrial scale, and one operates at a pilot scale. The development of 2G ethanol is significant because it allows for the use of non-food biomass, which can increase agricultural efficiency and reduce the carbon footprint of ethanol production. However, it's important to note that while there is potential for expansion, the production of 2G ethanol faces challenges such as high production costs and the need for advanced technology. Brazil's involvement in 2G ethanol production underscores its commitment to advancing renewable energy technologies and reducing greenhouse gas emissions.

- **Government Policies:** Brazil's government policy on ethanol is quite comprehensive and has been a key part of the country's energy strategy for decades. Here are some key points:
  - **Ethanol Blending Mandate:** The government mandates a minimum share of ethanol in gasoline, which is currently set at a 27% blend. This percentage has changed over time, with historical rates being 22% in 1993, 25% in 2007, 20% in 2011, 25% again in 2013, and 27% in 2015.
  - **RenovaBio Program:** Launched in 2019, this program aims to increase the ethanol supply by 45% until 2030, reaching an output of 50 billion liters. It's part of Brazil's larger effort to decarbonize its transport matrix.
  - **Flex-Fuel Vehicles:** Since 2003, Brazil has promoted the use of flex-fuel vehicles that can run on 100% ethanol, gasoline, or any mix of the two. Today, 93% of cars in Brazil come with a flex-fuel engine.
- **Economic and Environmental Benefits:** Brazil's ethanol program has led to significant foreign exchange savings and reduced CO2 emissions, contributing to a 50% reduction in air pollution and improved public health in major cities like São Paulo.

B. Argentina

- **Ethanol Production:** Argentina is the second largest producer of Ethanol in South America after Brazil and the sixth largest producer in the world ahead of India. In 2023, Argentina's ethanol fuel production was approximately 1160 million Litres with a slight decrease compared to the previous year. The production has remained relatively stable above one thousand million litres in recent years with a record production in 2022.
- **Demand:** The demand for ethanol in Argentina has been influenced by government policies and blending mandates. In 2018, fuel ethanol consumption reached 1.2 billion liters, supported by strong government incentives. For 2022, the forecast was a record consumption of 1.1 billion liters, attributed to increased gasoline demand and a higher blend rate. According to the research report "Argentina ethanol Market Research Report, 2029," published by Actual Market Research, the Argentina ethanol market is expected to reach market size of more than USD 3.90 Billion by 2029.
- **Government Policies:** The ethanol policy in Argentina, established in 2006, has encouraged the development of a domestic industry using corn and sugarcane as feedstocks. The current blend mandate is E12, which means that the gasoline sold in Argentina contains 12% ethanol. However, consumption is mostly met by internal production, with little room for trade. The ethanol market in Argentina is primarily driven by government support through policies such as blending

mandates, price controls, and tax breaks, which foster a stable environment and incentivize domestic production. Additionally, the country's renewable energy push, aligned with Argentina's renewable energy goals, attracts investment and promotes ethanol usage. Argentina's government plans to raise its requirement for ethanol blend in gasoline from the current 12% to up to 26% from next year, an industry body executive told Reuters last week. Argentina, which has been experiencing energy shortfall for some years, in February lifted the ethanol blend from 10%, providing a boost to its sugar industry amid low global prices. The country produces its ethanol from corn and sugarcane.

- **New Biofuels Law:** In August 2021, Congress passed a new Biofuels Law that reduces the mandated biodiesel blend rate from 10% to 5%. Discussions are underway to reduce the blending rate in gasoline from 12% to 10% and balancing economic and environmental considerations.

C. Colombia

- **Ethanol Production:** In Colombia, the ethanol market has shown some fluctuations in recent years. In 2022, ethanol production in Colombia was reported at 350 million liters. For 2023, the production was forecasted to increase to 380 million liters, thanks to better weather conditions improving sugarcane harvests.
- **Demand:** The demand for ethanol in Colombia saw a decrease in 2022, with consumption amounting to 390 million liters. However, the demand was expected to rise in 2023, reaching an estimated 460 million liters. These figures reflect the dynamics of the ethanol market in Colombia, which is influenced by factors such as weather conditions affecting sugarcane production, government mandates on ethanol blending, and economic growth that impacts fuel consumption. The country’s ethanol production is derived entirely from sugarcane, and it plays a crucial role in meeting the domestic demand for ethanol, which is primarily driven by the fuel sector due to blending mandates.
- **Government Policies:** The Colombian government proposed increasing the mandatory blend to E10 in 2024.

5.7 Demand outlook for Ethanol in North American countries

A. USA

- **Demand:** In 2022, the fuel ethanol consumption in the United States was around 52,850 Million Litres. The consumption has seen a nearly tenfold increase since 2000, reaching its peak in 2019. The demand for ethanol in motor gasoline and E85 is expected to increase between 740 million litres (1.4 percent) and 5,285 million litres (10.4 percent) above 2021 levels, depending on U.S. economic growth over the decade.
- **Production:** The total annual fuel ethanol production in 2022 was about 15.4 billion gallons (approximately 0.4 billion barrels). The production capacity of the United States increased from 13.6 billion gallons per year in 2011 to about 17.7 billion gallons per year by the end of 20223. Most of the U.S. fuel ethanol production capacity (93%) is located in the Midwest region, with Iowa, Nebraska, and Illinois being the top producers.

- **Government Policies:** The U.S. government has implemented several policies to support ethanol production and use:
  - **Renewable Fuel Standard (RFS):** The RFS requires renewable fuel to replace or reduce the quantity of petroleum-based transportation fuel, heating oil, or jet fuel.
  - **Incentives and Support Programs:** The Biomass Crop Assistance Program (BCAP) provides financial assistance to landowners and operators for establishing, producing, and delivering biomass feedstock crops for advanced biofuel production facilities.

B. Canada

- **Production:** In 2020, the monthly production of fuel ethanol (denatured) ranged from approximately 85,451 cubic metres in April to 158,166 cubic metres in January. The annual production of ethanol for all markets was 238 million litres.By 2021, fuel ethanol production reached 30.14 thousand barrels per day, showing a significant increase from 20023. The total ethanol production in Canada was expected to reach 2 billion liters in 2023, including 1.66 billion liters of fuel ethanol.

- **Demand:** Ethanol consumption generally exceeds production in Canada, making it a net importer. In 2022, the estimated ethanol consumption stood at 4.1 billion liters, compared to two billion liters in production. Fuel ethanol consumption reached 3.4 billion liters in 2022, up 20 percent from the previous year, and is expected to increase to 3.88 billion liters in 2023. These figures indicate a growing ethanol industry in Canada, with increasing production capacities and consumption rates, reflecting the country's efforts towards cleaner energy sources and reduced greenhouse gas emissions.

- **Government Policies:** The Government of Canada has implemented policies to support the development and adoption of clean fuels, including ethanol:
  - **Clean Fuel Regulations:** The regulations require liquid fossil fuel suppliers to gradually reduce the carbon intensity from the fuels they produce and sell for use in Canada.
  - **Carbon Intensity Reduction:** The goal is to decrease the carbon intensity of gasoline and diesel by approximately 15% below 2016 levels by 2030.
  - **Support for Clean Fuels Sector:** This includes a $1.5 billion investment towards a Clean Fuels Fund to support the production and adoption of low-carbon fuels like hydrogen and biofuels.
  - **Lifecycle Emissions Focus:** Ffocusing on emissions throughout the lifecycle of fuels – similar similar to approaches in British Columbia, California, Oregon, and other jurisdictions.

C. Mexico

- **Ethanol Production:** In Mexico, ethanol production is primarily derived from the sugar industry, with sugarcane being a significant crop. As of the 2016/2017 harvest season, Mexico produced 13.8 million liters of ethanol. However, the country faces several challenges in increasing production, including the need for improved distillation technology, better fermentation processes, and supportive legislative frameworks.

- **Ethanol Demand:** Regarding demand, Mexico's ethanol consumption was reported at 175 Million litres in 2021, showing a slight increase from the previous year's consumption of 168 Million Litres. The production of Ethanol in Mexico in 2022 was 48 Million Litres only.

- **Imports:** The country imports ethanol, mainly from the U.S. and Guatemala, with annual volumes ranging between 130-180 million liters. Despite being a significant producer of sugar and corn, Mexico has not fully utilized these resources for ethanol production due to regulatory and cultural obstacles.

- **Government Policies:** The government policy regarding ethanol in Mexico has been shaped by a combination of regulatory and cultural factors. Here are some key points:
  - **Ethanol Blending:** The current regulation allows an ethanol content in fuel of only 5.8%.
  - **Bioenergy Law:** The "Law for the Promotion and Development of Bioenergy" supports rural development, ensuring food security, and reducing greenhouse gas emissions.
  - **Ethanol Use:** Federal regulation to allow E10 discretionary blending outside the three major cities of Mexico City, Guadalajara, and Monterrey.

5.8 Demand outlook for Ethanol in EU countries

A. European Union (EU)

- **Ethanol Production:** The EU is a significant producer of ethanol with a capacity of approximately 8 billion liters across 65 plants and 20 countries. The feedstocks used differ between regions. In 2022, the European Union's fuel ethanol production was estimated to be roughly 5.6 billion liters1. The EU has a capacity of approximately 8 billion liters across 65 plants and 20 countries.

- **Demand:** Germany, France, and the UK are the largest consumers of ethanol in the bloc, responsible for 62% of total demand2. The demand for ethanol is strong both from the ethanol-blend biofuel sector and the food industry. Germany is the largest consumer of fuel ethanol in the EU, followed by other countries like France and the UK, which together account for a significant portion of the total demand. The consumption patterns indicate the importance of ethanol in the transportation sector, as well as its role in other industries within the European Union.

- **Government Policies:** European Union (EU) has established policies regarding the production and use of ethanol as part of its renewable energy strategy:
  - **Renewable Energy Directive:** The directive aims at least 14% share of renewable energy in the final consumption of energy in transport by 2030. This includes a minimum share of 3.5% of advanced biofuels.
  - **Union Database for Biofuels:** The database traces renewable and recycled carbon fuels from the point of origin to the market.
  - **Biofuels and Biogas in Co-Processed Fuels:** Establishes the share of biofuels and biogas in mixed fuels to achieve the Renewable Energy Directive target for renewables in transport.

B. Turkey

- **Production:** In 2021, Turkey's fuel ethanol production was 1.79 thousand barrels per day. The production has been increasing at an average annual rate of 52.60% since 20021. However, the production value contracted in 2022.

- **Demand:** The demand for ethanol and ethanol-based products in Turkey is on the rise, which has led to an increase in ethanol production capacity by companies within the country. This is also

reflected in the rising export practices of ethanol, with increased demand from international markets.

- **Market Dynamics:** The Turkey Ethanol Market is expected to grow due to the shift towards bio-based materials for ethanol production, such as corn, wheat, and barley, over sugarcane, due to their lower carbon emission rate. This shift is one of the leading factors accelerating the growth of the ethanol market in Turkey.
- **Government Policies:** The Turkish Energy Regulatory Agency (EMRA) issued a regulation that made biofuel blending mandatory for bioethanol (3%) and biodiesel (1%). This mandate promotes the use of renewable energy sources and reduce greenhouse gas emissions. This continues at 3% till now.

6. OPPORTUNITY LANDSCAPE IN THREE ADJACENT BUSINESSES

6.1 Compressed Biogas (CBG)

A. Role of Biogas in India's CNG/PNG ecosystem

India's energy landscape is undergoing a transformation, with a growing focus on clean and sustainable alternatives namely CBG, SAF, and 2G Ethanol. In this evolving scenario, biogas is emerging as a game-changer, playing a crucial role in bolstering the nation's CNG (Compressed Natural Gas) and PNG (Piped Natural Gas) ecosystem. Traditionally viewed as a waste product, biogas, primarily composed of methane, is now recognized as a valuable renewable resource. Government of India initiatives and incentives indicate a strong commitment towards promoting the CBG market and making it a key player in the renewable energy sector. By harnessing the power of organic matter decomposition, biogas offers a domestic source of clean fuel that can be injected into the existing CNG and PNG infrastructure. This not only reduces dependence on imported fossil fuels but also contributes to a cleaner and more sustainable energy future for India. The CBG market in India has been witnessing a significant upward trend since 2018 after launching of SATAT scheme.

The following factors indicate importance of Biogas in India's sustainability journey:

- **Biogas as a biofuel in India's decarbonization journey:** The escalating levels of atmospheric carbon dioxide, driven by the insatiable energy demands of rapid economic development, have disrupted Earth's natural carbon utilization capacity. To mitigate this imbalance, a transition toward renewable energy sources is imperative. By targeting a substantial 6% reduction in fossil fuel consumption by 2030, India can significantly curb carbon emissions. Biogas boasts robust potential for demand growth with its greenhouse gas (GHG) abatement properties.
- **Biogas will help to reduce India's natural gas import:** The future of India's natural gas sector is poised for a significant shift, with biogas projected to play an increasingly prominent role in replacing imported Liquefied Natural Gas (LNG). India can reduce its LNG import expenses substantially through shifting to biogas and biomethane, aiming for a 20% replacement. The SATAT scheme targets production of 15 MMTPA /17,460 MMSCM of CBG, highlighting the transformative potential of biogas within India's CNG and PNG ecosystem.
- **Reduce pollution stemming from burning of biomass:** Biomass combustion contributes significantly to air pollution. Incomplete combustion of biomass produces black carbon, a potent short-lived climate pollutant that absorbs solar radiation and warms the atmosphere. Biomass fire releases a cocktail of greenhouse gases (GHGs) such as CO_2, N_2O, and CH_4 into the atmosphere, including particulate matter (PM2.5 and PM10) that can travel long distances, causing respiratory problems even hundreds of miles away. Crop residue burning causes 44,000–98,000 premature deaths annually due to particulate matter exposure-related health issues. States like Punjab, Haryana, and Uttar Pradesh account for 67–90% of these deaths. Converting the crop residues / stubbles into Biogas can solve a much debated air pollution related issues in the North India in the beginning of winter season.

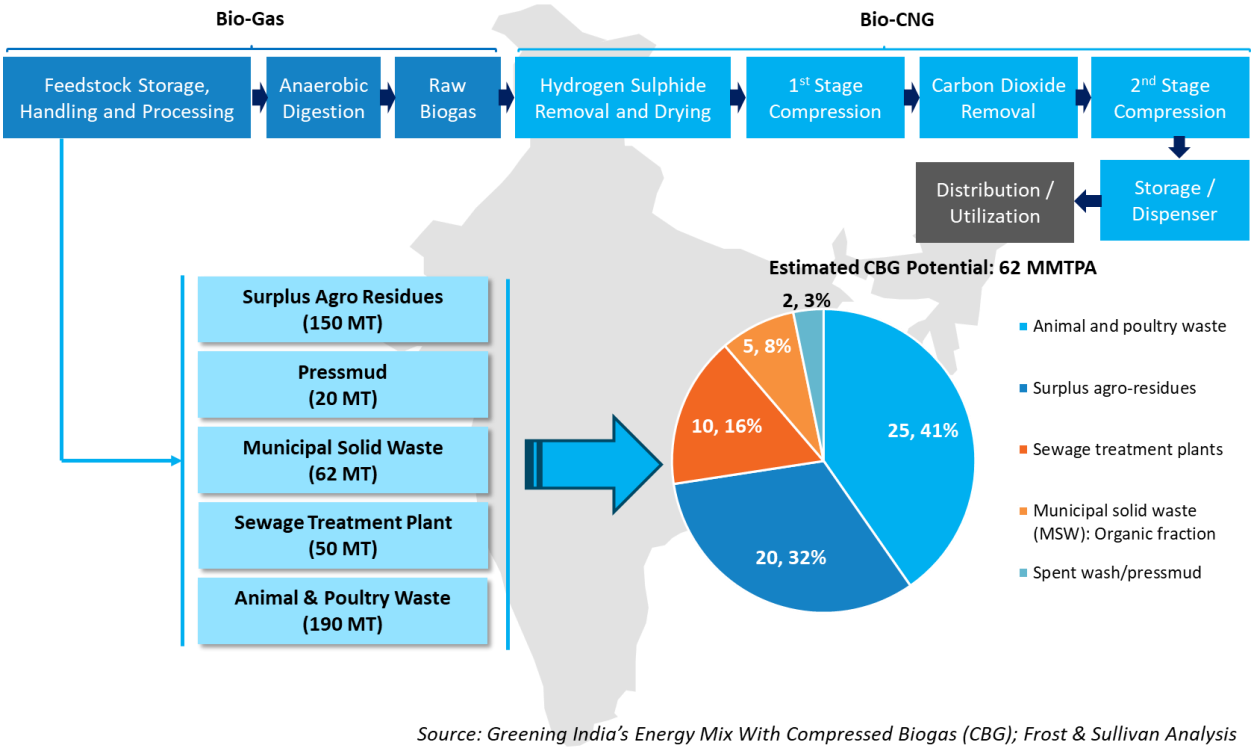
B. Potential for CBG generation in India

India has a diverse range of feedstocks for biogas generation and the most common of them are animal waste, agricultural residue, organic fraction of municipal solid waste (MSW) and sewage sludge. Total

Compressed Biogas generation potential from these feedstocks has been estimated at 62 million metric tonnes per annum (MMTPA). Animal waste and agricultural residue are the primary sources of CBG production in India. Cattle dung and chicken litter have a potential to produce 25 MMTPA of CBG, while agricultural residue has a potential to produce 20 MMTPA of CBG. Other sources such as sewage from sewage treatment plants, municipal solid waste, and pressmud have potentials to produce 10, 5, and 2 MMTPA of CBG respectively.

Bio-CNG production in India reveals a strong reliance on aimal and poultry waste, contributing a significant 190 million tonnes at 40% of total contribution. This is followed closely by surplus agro residues waste at 150 million tonnes at 32%, highlighting the potential for utilizing more agricultural waste streams. Municipal Solid Waste (MSW) and Sewage Treatment Plants offer additional opportunities for feedstock diversification, currently contributing to 62 million tonnes at 13% and 50 million tonnes at 11% respectively. Press-mud feedstock contributes to 20 million tonnes at 4%. Focusing on optimizing waste collection and processing infrastructure for these sources can significantly enhance Bio-CNG production in the country and promote a more sustainable waste management strategy.

Exhibit 6.1: Bio-CNG generation potential from various feedstocks



Source: Greening India's Energy Mix With Compressed Biogas (CBG); Frost & Sullivan Analysis

C. Government policies driving the growth of Indian CBG sector

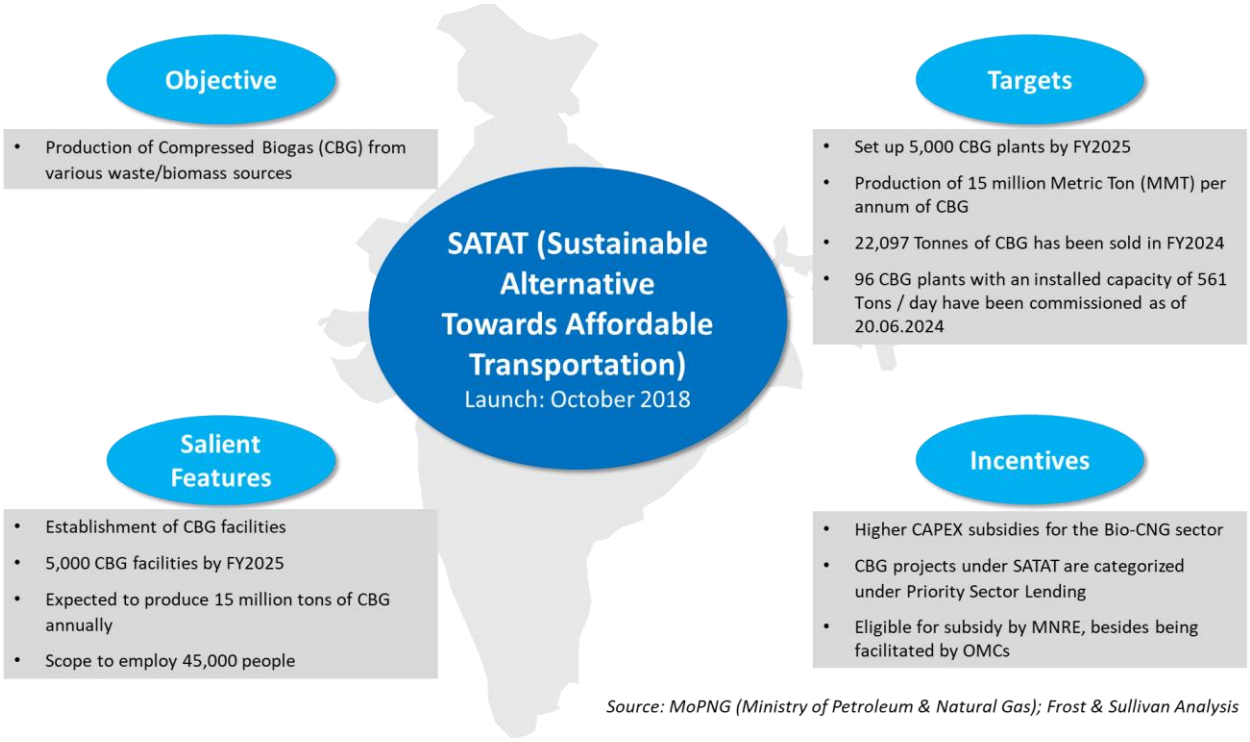
Following are various government initiatives to promote consumption of CBG in the country:

- **National Bio Energy Programme**: The Ministry of New and Renewable Energy (MNRE) has notified the National Bioenergy Programme on 2nd November, 2022. The programme has been recommended for implementation in two phases with a total budget outlay of INR 17 billion and a budget outlay of INR 8.6 billion has been allocated for the Phase-1. This programme has a provision of Central Financial Assistance (CFA) for various components related to Power generation, Biogas / BioCNG generation, and Briquette / Pellet manufacturing, wherein Biomass is one of the major feedstock material, which

primarily shall be sourced from rural areas. The National Bioenergy Programme shall not only promote the utilization of surplus biomass but also provide an additional source of income for rural households.

- **Sustainable Alternative Towards Affordable Transportation (SATAT):** The SATAT scheme is a revolutionary initiative launched by the Government of India. The primary objective of this scheme is to provide a sustainable solution to produce alternative fuels like Compressed Biogas (CBG) from various waste/biomass sources in India. This initiative is a significant step towards reducing dependence on fossil fuels, managing waste in an eco-friendly way, reducing pollution, and providing additional income to farmers. Under SATAT scheme, the CBG plants will use paddy stubble — the burning of which increases air pollution in north India during winters. On the other hand, CBG can be used to replace CNG. As per Government estimates, these CBG plants will produce 15 million tonnes of gas, enough to reduce the country's CNG bill by 40%.

Exhibit 6.2: SATAT Scheme, targets, salient features and incentives



Source: MoPNG (Ministry of Petroleum & Natural Gas); Frost & Sullivan Analysis

- **PM-PRANAM Scheme:** PM PRANAM (Promotion of Alternate Nutrients for Agriculture Management Yojana) is a proposed scheme by the Indian government. It aims to reduce the use of chemical fertilizers and promote the balanced use of biofertilizers and organic fertilizers. The scheme is designed to lessen the subsidy burden on chemical fertilizers and encourage states to adopt alternative fertilizers.
- **Financial Assistance for Biomass Aggregation Machinery:** The Financial Assistance for Biomass Aggregation Machinery is a scheme introduced by the Indian government. It provides support to Compressed Bio Gas (CBG) producers for the procurement of machinery required for biomass aggregation. This initiative aims to facilitate CBG production and address the funding challenges faced by entrepreneurs looking to establish CBG operations.

- **CBG Blending Obligation (CBO):** In a major step towards enhancing use and adoption of CBG, the National Biofuels Coordination Committee (NBCC), in November 2023 announced the introduction of phase-wise mandatory blending of CBG in CNG (Transport) & PNG (Domestic) segments of CGD sector. The key objectives of the CBO are to stimulate demand for CBG in CGD sector, import substitution for Liquefied Natural Gas (LNG), saving in Forex, promoting circular economy and to assist in achieving the target of net zero emission etc. The CBO will encourage investment of around INR 375 billion and facilitate establishment of 750 CBG projects by FY2029. It was, inter-alia, decided that:

  a. CBO will be voluntary till FY2025 and mandatory blending obligation would start from FY2026.

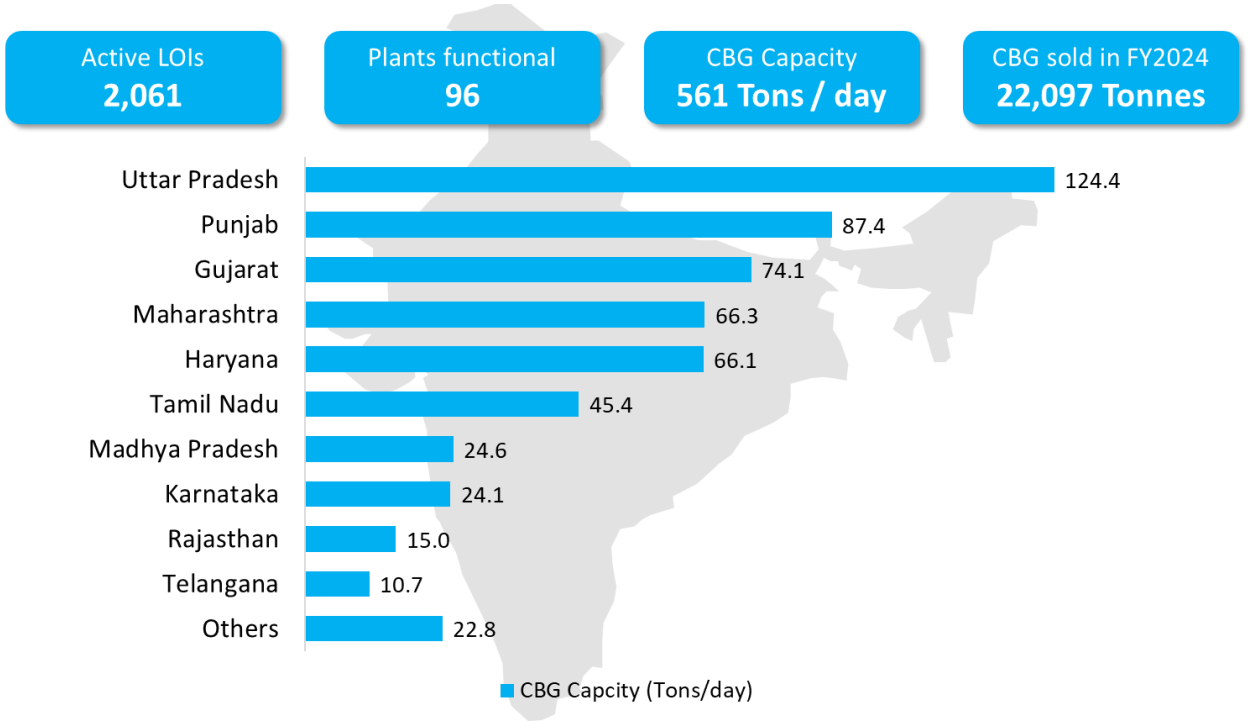
  b. CBO shall be kept as 1%, 3% and 4% of total CNG/PNG consumption for FY2026, FY2027, and FY2028 respectively. From FY2029 onwards, CBO will be 5%.

  c. A Central Repository Body (CRB) shall monitor and implement the blending mandate based on the operational guidelines approved by the Indian Government.

D. Current state of CBG production in India

According to the information available on SATAT and GOBARdhan portal of Government of India, there are 96 functional CBG plants in India as on 20.06.2024 with a cumulate CBG production capacity of 561 Tons / day. Besides, there are 2,061 active Letter of Intent (LOI) for setting up similar plants and in FY2024, 22,097 tonnes of CBG has been sold in the country. This indicates approximately 2.5 times increase from 38 CBG plants, 225 Tons / day capacity at the end of October 2022. Advancements in technology have made the production of CBG more efficient and cost-effective, further boosting the market growth.

Exhibit 6.3: Status of CBG production, India, as of 20.06.2024



Some of the renowned producers of CBG at present are Verbio India (33 TPD), Lakhimpur Kheri RNG (21.2 TPD), Jakraya Sugar (20 TPD), Reliance Bio Energy (20 TPD), Reliance Industries (20 TPD), Inodore Clean

Energy (17 TPD), Sangrur RNG (14.8 TPD), Patiala RNG (14.8 TPD), Circle CBG India (14.6 TPD), HPCL (14.3 TPD), Bharat Biogas Energy (14.0 TPD) etc.

E. The way forward for Compressed Biogas (CBG) market

- **Government Initiatives**: Indian government has been instrumental in shaping the opportunity landscape for various sectors, including the Compressed Biogas (CBG) market. Through a series of initiatives as mentioned in the previous section, the government has demonstrated its commitment to promoting sustainable energy solutions. These initiatives not only provide financial incentives but also create a conducive environment for the growth and development of the CBG market. The government's sustained focus on bioenergy is a testament to its vision of a sustainable and energy-efficient future. This proactive approach presents a promising opportunity landscape for stakeholders looking to invest in India's CBG market. The government's support is expected to drive innovation, encourage investment, and foster growth in this sector.
- **Corporate Investments**: Leading corporate houses like Reliance Industries and Adani New Industries Limited (ANIL) have planned to invest INR 5-6 billion each in the sector. ANIL reportedly plans to use its existing city-based gas network to use CBG in cooking fuel, while Reliance Industries is expected to use its fuel outlets in India, for automobiles Such investments will provide a major boost to the sector.
- **Emphasis on indegenious CBG production**: There is growing interest in CBG as one of the key sources of clean energy that is indigenously available. This could play a key role in bringing down the reliance on imports for energy. The demand for CBG is expected to rise as industries and consumers become more aware of the environmental benefits of using cleaner and more sustainable energy sources.
- **Potential for Import Substitution**: CBG has the potential to replace imported Liquefied Natural Gas (LNG), leading to savings in foreign exchange. This could significantly contribute to the country's economic stability and energy security.
- **Impetus on building more CBG plants**: The establishment of CBG plants across the country will create a robust infrastructure for CBG production and distribution. For instance, earlier this year inauguration of India's biggest CBG (bio-CNG) plants at Indore in Madhya Pradesh, named Gobar-Dhan, which has the capacity to process 550 tonnes of waste and produce 17,000 kilograms of bio-CNG each day. The Indore Municipal Corporation (IMC) has also tied up with Gobar-Dhan and has assured the purchase of 50 percent of the fuel to run its CNG buses. IMC has also promised to provide sufficient segregated waste to the plant to ensure adequate feedstock for its biogas production.
- **Employment Opportunities**: The CBG sector is expected to create numerous job opportunities, contributing to economic growth. This will not only help in reducing unemployment but also stimulate economic development in the regions where the CBG plants are established.
- **Environmental Benefits**: CBG production helps in managing waste and reducing greenhouse gas emissions. This aligns with India's commitment to environmental sustainability. The use of CBG as a cleaner and more sustainable energy source will significantly contribute to the country's efforts to combat climate change.

These opportunities make the CBG market a promising sector for investment and growth in the coming years. The government's commitment to promoting the use of CBG, coupled with increasing corporate investments and rising consumer demand, is expected to drive the growth of the CBG market in India.

Even with a very conservative estimate, India's CBG market is poised to grow at more than 70 – 75% CAGR over the next 7-8 years if the country's CBG production is to reach anywhere near to 15 MMTPA from the current production of 22,097 TPA in FY2024. Regreen Excel is well positioned to capture this growth on account of its existing presence in such areas of emerging opportunities.

6.2 Sustainable Aviation Fuel (SAF)

A. Present landscape of the Sustainable Aviation Fuel (SAF) market in India

Sustainable Aviation Fuel (SAF) could be another high growth business in the coming years. SAF is a critical alternative to traditional jet fuel, offering a pathway to reduce the aviation industry's carbon footprint. SAF is produced from sustainable feedstocks and is chemically similar to fossil jet fuel. The use of SAF can result in a significant reduction in carbon emissions over the lifecycle of the fuel. Typical feedstocks include cooking oil, animal or plant waste oils, solid waste from homes and businesses, forestry waste, and energy crops. The aviation industry is heavily dependent on fuel, and with the expected doubling of passengers to over 8 billion by 2050, it is essential to act to reduce aviation's carbon emissions. The use of SAF is not just about reducing emissions; it's also about ensuring the sustainability of the aviation industry. With the growing awareness of climate change and the need for sustainable practices, SAF provides a viable solution that aligns with global sustainability goals.

The aviation sector in India is experiencing rapid growth, making it the third-largest aviation market in the world. This growth is driven by several factors, including the rise of low-cost carriers, infrastructure development, increasing disposable income, and the expansion of the tourism industry. However, this growth has also led to increased environmental concerns, putting pressure on the aviation industry to reduce its carbon footprint. In response to these environmental concerns, the Ministry of Civil Aviation (MoCA) in India has been actively promoting sustainable development in the aviation sector. One of the key strategies has been the promotion of Sustainable Aviation Fuel (SAF), a green alternative to conventional jet fuel. SAF is produced from various sources such as animal fats (biomass), wastes (used cooking oil), and agri-residues (palm fatty acid distillate). It can be safely blended with traditional jet fuel. The usage of SAF against conventional jet fuels would result in a lifecycle carbon reduction of up to 80 percent.

Furthermore, the Indian government is also investing in research and development to explore more efficient and sustainable ways of producing SAF. This includes exploring new feedstock options, improving production processes, and developing new technologies for SAF production. The government is also providing incentives and subsidies to encourage the production and use of SAF. In addition to these efforts, the Indian government is also working on regulatory frameworks to support the use of SAF. This includes setting standards for SAF production and use, providing guidelines for SAF blending with conventional jet fuel, and establishing certification processes for SAF producers.

B. Government policies and targets related to Sustainable Aviation Fuel (SAF) market

The Indian government has set ambitious targets for the use of SAF. By 2030, the government aims to achieve a 5% blending of SAF with conventional jet fuel. This target is a significant step towards self-reliance and decarbonization of the aviation sector. To achieve this, the government is working closely with industry players to develop the SAF supply chain in India. Indian Oil Corporation, the country's largest fuel retailer, has signed an MoU with LanzaJet, a sustainable aviation fuel producer, to build a commercial-

scale SAF plant in India. This collaboration is a significant milestone in India's journey towards sustainable aviation.

Praj Industries recently collaborated with IOCL and AirAsia India to successfully fly India's first commercial passenger flight with 1% SAF produced at the company's bench scale setup that was blended with aviation turbine fuel (ATF). The company has developed a proprietary technology to process agricultural feedstocks for the production of SAF using the alcohol-to-jet (ATJ) pathway that can be blended with ATF.

The Ministry of Petroleum and Natural Gas has set indicative targets for airlines. By 2027, the fuel used on flights should be 99% conventional fuel and 1% SAF. This target is expected to increase to 2% by 2028 and 5% by 2030. These targets are indicative of the government's commitment to reducing the carbon footprint of the aviation industry. Indian government's vision, policies, and targets related to Sustainable Aviation Fuel are a testament to its commitment to sustainable development and environmental conservation. Through strategic partnerships and ambitious targets, India is paving the way for a greener and more sustainable aviation industry.

C. Present day challenges in the production of Sustainable Aviation Fuel (SAF) in India

The following are some of the present day challenges in the production and usage of Sustainable Aviation Fuel (SAF) in India:

Exhibit 6.4: Challenges in production and usage of SAF

CHALLENGES	DESCRIPTION
Limited Infrastructure	There is limited infrastructure for the production, storage, and distribution of SAF, making it difficult to scale up the production and supply of SAF.
Feedstock Availability	The limited availability of feedstock for SAF production, and there is competition for resources from other industries, such as the food and agriculture sectors.
High Production Cost	The cost of producing sustainable aviation fuel remains a concern, and widespread adoption may be hindered until production processes become more economically viable.
Policy Framework	The Indian SAF market is currently characterized by nascent policy frameworks.
Technology-Neutral Policies	For India to be a leader in sustainable aviation, the country needs stable, technology-neutral policies that incentivize innovation, assure long-term offtake and advocate GHG intensity-based price support for aviation fuels.

Source: Frost & Sullivan research and analysis

D. The way forward for Sustainable Aviation Fuel (SAF) sector in India

Indian government's approach to promoting SAF is comprehensive, involving a mix of policy measures, research and development efforts, industry collaborations, and regulatory frameworks. This approach not only addresses the environmental concerns associated with the aviation industry but also supports the growth and development of the SAF industry in India. This is a significant step towards achieving India's climate goals and contributing to global efforts to combat climate change

Looking ahead, the future of SAF in India is promising. The country is well-positioned to become a leader in the rapidly growing global SAF industry, given its access to feedstock and low-cost solar energy. Early

adoption of SAF can provide environmental and economic benefits at 10 times higher than initial costs as India's aviation sector grows, while progressing on global climate goals.

Moreover, the development of the SAF supply chain could create new employment opportunities in areas such as biomass production, waste management, and fuel transportation. The availability of rapid-scaling, low-cost renewable energy in India, coupled with ample amounts of SAF feedstocks (such as agricultural waste, used cooking oils and municipal solid waste), provides the country with a significant opportunity to develop its domestic SAF production industry. Thus, investing in sustainable aviation could help to create new jobs and support economic development in India.

6.3 Second Generation (2G) Ethanol

India's biofuel policy is undergoing a significant shift with the growing focus on 2G Ethanol production. This move is driven by a two-pronged strategy: addressing the limitations of 1G Ethanol and ensuring a sustainable future for the biofuel sector.

A. Challenges with sustainable production of First Generation (IG) Ethanol

- **Feedstock competition:** Traditional 1G Ethanol, produced from molasses derived from sugarcane, faces competition from the sugar industry for this feedstock. This competition can limit the availability of molasses for Ethanol production, hindering efforts to meet ambitious blending targets.
- **Seasonality:** Sugarcane harvesting is seasonal, leading to fluctuations in molasses production and consequently, Ethanol output. This inconsistency can disrupt blending programs and create challenges in meeting year-round demand for Ethanol.
- **Land use concerns:** Expanding sugarcane cultivation for 1G Ethanol production raises concerns about land-use changes. This can lead to potential competition with food production and raise environmental concerns.

Second Generation (2G) Ethanol has the potential to solve many of the above mentioned issues:

- **Diverse feedstocks:** 2G Ethanol utilizes cellulosic and lignocellulosic materials like agricultural residue (straw, stalks), waste biomass, and even non-food sources. This diversification reduces dependence on seasonal crops and promotes utilization of waste materials.
- **Sustainable approach:** Unlike 1G Ethanol, 2G production doesn't compete with food crops for land. It utilizes waste materials that would otherwise decompose and release greenhouse gases, contributing to a more sustainable biofuel cycle.
- **Year-Round production:** The availability of cellulosic and lignocellulosic materials is not limited by seasonality. This allows for more consistent 2G Ethanol production, ensuring a reliable supply for blending purposes.

B. Government policy regarding production of 2G Ethanol in India

Indian government is taking a multi-pronged approach to promote 2G Ethanol production through a new scheme known as **Pradhan Mantri JI-VAN (Jaiv Indhan – Vatavaran Anukool fasal awashesh Nivaran) Yojana**. This initiative aims to establish 12 commercial-scale and 10 demonstration-scale 2G bio-Ethanol projects across the country. The primary focus is on utilizing non-food biomass feedstocks and other renewable sources. This ambitious program strives to achieve several key objectives:

- **Commercial viability**: Establishing commercially viable 2G Ethanol projects is crucial for long-term success. This program aims to create a conducive environment for 2G technology adoption by fostering profitable ventures.
- **Empowering farmers:** The scheme seeks to provide farmers with a remunerative income source for their agricultural residues, which are often considered waste products. This incentivizes sustainable waste management practices and creates a new income stream for the rural population.
- **Combating environmental pollution:** Open burning of agricultural residues is a significant contributor to air pollution. By providing an alternative use for these materials, the program aims to reduce environmental pollution and promote cleaner air.
- **Achieving biofuel blending targets:** India's Ethanol Blended Petrol (EBP) program promotes biofuel use. This scheme supports the production of 2G Ethanol, a crucial factor in meeting EBP targets and reducing dependence on imported fossil fuels. Additionally, it aligns with India's vision of achieving a 10% reduction in import dependence.
- **Employment generation:** Establishing and operating 2G bio-Ethanol facilities has the potential to create significant employment opportunities, both in rural and urban areas. This contributes to economic development and fosters new job markets.
- **Swachh Bharat Mission synergy:** The initiative aligns with the Swachh Bharat Mission (Clean India Mission) by promoting the aggregation of non-food biofuel feedstocks, including waste biomass and even urban waste. This facilitates waste management solutions and contributes to a cleaner environment.
- **Technological self-reliance:** A long-term objective is to achieve the indigenization of 2G biomass-to-Ethanol technologies. By fostering domestic research and development, India aims to become self-sufficient in this critical technology, reducing reliance on foreign expertise.

Through this comprehensive scheme, India is taking a significant step towards a more sustainable and secure energy future. The focus on 2G Ethanol holds immense potential to address environmental concerns, empower farmers, and contribute to India's clean energy goals.

Outlay for Pradhan Mantri JI-Van Yojana

The Pradhan Mantri JI-VAN Yojana receives a total financial outlay of INR. 19.7 billion for the period from FY2019 to FY2024. This funding is strategically allocated to support the development of a robust 2G Ethanol sector in India.

- **Commercial projects:** The lion's share, INR. 1,800 crore, is dedicated to supporting 12 commercial-scale 2G bio-Ethanol projects. This significant investment aims to establish financially viable ventures that can drive long-term growth in the sector.
- **Demonstration projects:** To bridge the gap between research and development, and commercialization, Rs. 150 crore is allocated for 10 demonstration-scale projects. These projects provide valuable data and insights to refine the technology before widespread commercial adoption.
- **Administrative support:** The remaining INR. 9.50 crore is allocated to the Centre for High Technology (CHT) to cover administrative expenses associated with managing the JI-VAN Yojana.

The Pradhan Mantri JI-VAN Yojana supports Viability Gap Funding (VGF) to encourage the development of 2G Ethanol projects in India. This support is distributed across two phases:

- **Phase I (2018-19 to 2022-23):** This initial phase prioritizes establishing a strong foundation for the 2G Ethanol sector. Six commercial-scale and five demonstration-scale projects will be chosen for VGF support.
- **Phase II (2020-21 to 2023-24):** Following the initial success of Phase I, the program has expanded its reach. The remaining six commercial-scale and five demonstration-scale projects will receive VGF support.

Project Selection Process:

- **Proposal submission:** Project developers interested in participating submit proposals for evaluation by the Scientific Advisory Committee (SAC) of the Ministry of Petroleum and Natural Gas (MoP&NG).
- **Rigorous review:** The SAC meticulously examines each proposal, ensuring adherence to program guidelines and technical feasibility.
- **Steering committee Approval:** Projects recommended by the SAC are then considered by the MoP&NG Steering Committee, chaired by the Secretary of MoP&NG. This final approval process ensures project alignment with national energy goals.

This two-phased approach allows the JI-VAN Yojana to strategically invest in the 2G Ethanol sector. Phase I establishes a strong foundation, while Phase II builds upon the initial successes. Additionally, the thorough project selection process ensures that only well-designed and technically sound projects receive VGF support. This contributes to the program's overall effectiveness in promoting the development of a robust 2G Ethanol industry in India.

In a recent development, the Union Cabinet has approved modifications to the Pradhan Mantri JI-VAN Yojana, extending its timeline until FY2029. The modified scheme will now cover advanced biofuels produced from lignocellulosic feedstocks such as agricultural and forestry residues, industrial waste, synthesis gas, and algae. The inclusion of 'Bolt on' plants and 'Brownfield projects' aims to utilize existing infrastructures to improve their viability and leverage their operational experience.

C. Current status of 2G Ethanol production in India

Indian Oil has set up 2G Ethanol bio-refinery project with capacity of producing 100 KL of Ethanol per day using rice straw as feedstock at Panipat, Haryana at a cost of INR 9,090 million. The Ethanol produced at Panipat plant will be used for blending in petrol, lowering fuel emissions, and helping reduce environment pollution. A one of kind and the first in Asia (soure: IOCL Ethanol Brochure 2023), the plant is designed to utilize agri-crop residue as feed to produce Ethanol from rice straw, which is currently largely being burnt causing severe environmental problems. The collection of rice straw from farmers will help increase their income directly. In addition, the project will create agricultural jobs through sourcing of rice straw.

D. Key challenges in 2G Ethanol production

While India holds immense potential for 2G Ethanol production, several key challenges need to be addressed to achieve widespread adoption. Below is a detailed breakdown of these hurdles:

- **Technology hurdles:** Cellulosic and lignocellulosic materials used in 2G Ethanol production require complex pre-treatment processes to break down their tough structure. This pre-treatment adds significant cost and complexity to the production process. Research efforts are needed to develop cost-effective and efficient pre-treatment technologies suitable for India's diverse feedstock options. Current 2G conversion technologies often have lower efficiency compared to traditional 1G Ethanol production. Optimizing these conversion processes to achieve higher yields of Ethanol from the available feedstock is crucial for economic viability.
- **Feedstock availability and sustainability:** Ensuring a reliable and sustainable supply of feedstock is critical. Developing efficient collection mechanisms for agricultural residues and managing these resources to avoid competition with soil nutrient replenishment requires careful planning and stakeholder engagement. The current logistics infrastructure for collecting, transporting, and storing bulky feedstock materials like agricultural residues is often inadequate. Upgrading this infrastructure will optimize feedstock utilization and minimize transportation costs.
- **Economic viability**: Currently, the cost of producing 2G Ethanol is higher compared to traditional 1G Ethanol. Technological advancements, efficient feedstock management practices, and government support mechanisms are crucial to bring down production costs and make 2G Ethanol commercially viable. Without a stable and fair pricing mechanism for 2G Ethanol, producers may face economic uncertainty. Exploring market-driven pricing systems with minimum support prices and carbon credit incentives can encourage investment in 2G production.

These hurdles can be overcome through multi-pronged approach that addresses technological hurdles, policy frameworks, and economic considerations.

- **Technological innovation and knowledge Sharing**: Foster public-private partnerships to accelerate research and development (R&D) efforts. Establish dedicated research centres focused on improving 2G conversion technologies, optimizing feedstock utilization, and exploring innovative feedstock sources like algae and municipal waste. It is also important to bridge the gap between academia and industry by establishing training programs and workshops. Equip engineers and technicians with the necessary expertise to operate and maintain 2G bio-refineries effectively. Encourage domestic research institutions and private companies to develop and adapt existing 2G technologies to suit India's specific feedstock availability and climatic conditions. This reduces reliance on foreign technologies and promotes domestic innovation.
- **Robust policy framework and financial incentive:** Establish a clear and stable long-term policy roadmap for 2G Ethanol development. This provides clarity and predictability for investors and project developers, fostering long-term investments in the sector. Expand the Pradhan Mantri JI-VAN Yojana or introduce new schemes to offer attractive financial incentives for setting up 2G bio-refineries. Explore innovative solutions like loan guarantees, tax breaks on feedstock and equipment imports, and carbon credits for sustainable production practices. Simplify and expedite the approval process for setting up 2G bio-refineries. Address concerns around land acquisition, environmental clearances, and grid connectivity to reduce project development timelines and costs.
- **Feedstock Availability and Sustainability:** Develop a comprehensive strategy for sustainable feedstock management. This includes promoting crop residue collection practices that minimize soil erosion and depletion of essential nutrients. Explore the potential of dedicated energy crops grown

on marginal lands, ensuring they don't compete with food production. Encourage the utilization of non-food waste biomass sources like municipal solid waste, agricultural waste (bagasse, straw), and forestry residues. This not only promotes waste management but also creates a reliable source of feedstock for 2G production. Invest in building robust logistical infrastructure to efficiently collect, transport, and pre-treat feedstock materials. This ensures a steady supply of feedstock to bio-refineries, optimizing production efficiency.

E. The road ahead for 2G Ethanol in India

The road ahead for 2G Ethanol in India promises a clean and secure energy future, but requires a collaborative effort from various stakeholders. Technological advancements are crucial, with research focused on optimizing pre-treatment processes to break down feedstock efficiently and improve conversion rates for higher Ethanol yields. Simultaneously, ensuring a sustainable and reliable supply of feedstock is paramount. This involves developing efficient collection mechanisms for agricultural residues while maintaining soil health, and exploring alternative feedstocks like waste biomass.

To bridge the economic gap, bringing down production costs through technological innovation and creating a stable pricing mechanism with minimum support prices or carbon credit incentives are essential. Additionally, fostering public awareness about the environmental and economic benefits of 2G Ethanol will stimulate market demand for 2G-blended fuels. Building capacity among farmers through training programs on sustainable residue collection methods empowers them to actively participate in the 2G value chain and benefit from new income opportunities. Finally, continued government support through schemes like the JI-VAN Yojana, alongside streamlined regulatory processes, will incentivize private sector investment and accelerate the growth of the 2G Ethanol industry. By addressing these key areas collaboratively, India can pave the way for a future powered by clean and sustainable 2G Ethanol.

7. COMPETITIVE BENCHMARKING

The following tables capture the operational details of leading ethanol producers in India.

7.1. Operational Benchmarking

A. Regreen Excel EPC India Ltd.

Company Overview (Origin and Incorporation year must be included)	• Established in 2009 and headquartered in Pune, India, the company specializes for EPC projects in the field of the distillery, biofuel, CBG, Biomass, co-generation, water, wastewater, ZLD systems, and renewable energy industries.	
Product / Services Offerings	• Grain Milling System • Liquefication Plants • Fermentation Plants, Ethanol Plants • Distillation Plants • Dehydration Plants • Evaporation Plants • Dryer & DDGS Plants • Zero Liquid Discharge • Zero Liquid Effluent Discharge • Sugar Industry and Cogeneration • Waste Heat Recovery & Recycle • CBG and Biomass Cogeneration	
Financial indicators (FY2024)	• Revenue • EBITDA Margin • PAT Margin • ROE % • ROCE% • Debt/ Equity	• INR 19,299.08 million • 4.64% • 3.10% • 63.73% • 86.89% • 0.16
Key Clients	• Balrampur Chini Mills • HPCL Biofuels • DCM Shriram Group • Dalmia Group • Baramati Agro • Ugar Sugar Works • Gulshan Polyols • Hermes Distillery • KRIBHCO	• Zuari Envian Biofuels • India Glycol • LH Sugars • Satish Sugars • Shamnur Sugars • Dhampur Bio organics • Uttam Sugars • Globus Spirits • Jubilant Life Sciences • Olam Group

B. Praj Industries

Company Overview (Origin and Incorporation year must be included)	• Established in 1983 and headquartered in Pune, India, the company specialises in Biofuels, Bioenergy, Renewable energy, Bioeconomy, circular economy, green fuels, brewery, beer, alcohol, ethanol, water, wastewater treatment, process equipment, distillation, oil & gas, environment, bio CNG, bio methanation, Bio mobility, and Renewable Chemicals and Materials.

Product / Services Offerings	• Bio Energy- 1G Ethanol, Bio Ethanol and Compressed Biogas • Praj Hipurity Systems • Critical Process Equipment & Skids • Wastewater Treatment- Treatment and disposal, 3Rs-Reduce, Recycle & Reuse, ZLD & resource recovery, Solvent recovery system, Total Water Management, VAS (value-added services) • Brewery & Beverages- Industrial brewery, craft brewery, beverages, partners	
Financial indicators (FY2024)	• Revenue • EBITDA Margin • PAT Margin • ROE % • ROCE% • Debt/ Equity	• INR 34,662.78 million • 12.44% • 8.18% • 22.23% • 26.82% • 0.00
Key Clients	• Incauca • Addax Petroleum • Bajaj Hindustan Ltd • Globus Spirits	• British Sugars • Seagrams • Vivergo Fuels • ThaiBev

C. Mojj Engineering Systems Ltd.

Company Overview (Origin and Incorporation year must be included)	• Established in 1986 and headquartered in Pune, India, the company specialises in the design and manufacture of turnkey projects for Dryers, Distillation and Evaporation Systems (Bioethanol), Detergents, Coffee, and DDGS.	
Product / Services Offerings	• Biotechnology- Ethanol Plants for Industrial & Potable alcohol, Malt Whisky Plant, Vinasse Zero Discharge Plant & DDGS Dryers • Evaporators- Complete range of Evaporators - Rising & Falling Film, Forced Circulation & Scrapped Surface along with Zero Liquid Discharge Plants • Dryers- Complete range of Spray Dryer, Flash Dryer, Fluid Bed Dryers, Rotary Dryer, Granulators & many more	
Financial indicators (FY2023)	• Revenue • EBITDA Margin • PAT Margin • ROE % • ROCE% • Debt/ Equity	• INR 5,814.27 million • 9.38% • 6.39% • 31.61% • 39.75% • 0.23
Key Clients	• Jamkhandi Sugars Ltd • DCM Shriram • Vijayanagar Sugar Pvt. Ltd • Utopian Sugars	• Sadashivarao Mandlik Kagal Tal. SSKL • Zanzibar Sugar Factory Limited (ZSFL) • Samarth SSKL • Ajinkyatara SSKL

D. KBK Chem-Engineering Pvt. Ltd.

Company Overview (Origin and	• Established in 1997 and headquartered in Pune, India, the company specializes in EPC Solutions and Technology providers for Distilleries, Bioethanol, Brewery, Sugar,

Incorporation year must be included)	Chemical processing, Edible Oil, Fish Meal processing and Co-generation plants with Efficient Management along with Water and Waste Water solutions.	
Product / Services Offerings	• Fermentation • Distillation • Ethanol (Dehydration) • Evaporation • Biogas • Compositing • Water Management System	
Financial indicators (FY2023)	• Revenue • EBITDA Margin • PAT Margin • ROE % • ROCE% • Debt/ Equity	• INR 4,599.39 million • 4.60% • 2.14% • 93.98% • 32.40% • 6.26
Key Clients	• Shree Renuka Sugars Ltd • HPCL • GMR Group • BHL	• GNFC • Kranti Sugar • Adani Wilmar Ltd • Baramati Agro

7.2. Financial benchmarking

Exhibit 7.1: Revenue from the operation of key competitors, value in INR Million, FY2022 – FY2024

Company Name	FY2022	FY2023	FY2024
Regreen Excel	7,019.04	11,928.43	19,299.08
Praj Industries	23,333.17	35,280.38	34,662.78
Mojj Engineering	3,951.81	5,814.27	NA
KBK Engineering	1,912.91	4,599.39	NA

Source: Annual Reports of Companies published in RoC, MCA; Frost & Sullivan Analysis
NA: FY2024 financial numbers are not available in public domain

Exhibit 7.2: Y-o-Y growth in Revenue from operations of key competitors, India, in percentage, FY2022 – FY2024

Company Name	FY2022	FY2023	FY2024
Regreen Excel	NA	70%	62%
Praj Industries	79%	51%	-2%
Mojj Engineering	106%	47%	NA
KBK Engineering	280%	140%	NA

Source: Annual Reports of Companies published in RoC, MCA; Frost & Sullivan Analysis
NA: FY2024 financial numbers are not available in public domain

Revenue growth = (Current year revenue – previous year revenue)/ previous year revenue

Exhibit 7.3: EBITDA of key competitors, India, value in INR Million, FY2022 – FY2024

Company Name	FY2022	FY2023	FY2024
Regreen Excel	74.45	438.19	895.26
Praj Industries	2,299.74	3,536.01	4,313.05
Mojj Engineering	290.69	548.79	NA
KBK Engineering	176.89	213.42	NA

Source: Annual Reports of Companies published in RoC, MCA; Frost & Sullivan Analysis
NA: FY2024 financial numbers are not available in public domain

EBITDA is calculated as the sum of profit after tax, income tax, finance cost and depreciation.

Exhibit 7.4: EBITDA margin of key competitors, India, in percentage, FY2022 – FY2024

Company Name	FY2022	FY2023	FY2024
Regreen Excel	1.06%	3.67%	4.64%
Praj Industries	9.86%	10.02%	12.44%
Mojj Engineering	7.34%	9.38%	NA
KBK Engineering	9.11%	4.60%	NA

Source: Annual Reports of Companies published in RoC, MCA; Frost & Sullivan Analysis
NA: FY2024 financial numbers are not available in public domain

EBITDA margin is calculated as EBITDA divided by total revenue. Total revenue is calculated as revenue from operations and other income.

Exhibit 7.5: PAT of key competitors, India, Value in INR Million, FY2022 – FY2024

Company Name	FY2022	FY2023	FY2024
Regreen Excel	41.54	286.66	598.30
Praj Industries	1,502.40	2,398.18	2,833.91
Mojj Engineering	177.19	373.81	NA
KBK Engineering	400.47	99.36	NA

Source: Annual Reports of Companies published in RoC, MCA; Frost & Sullivan Analysis
NA: FY2024 financial numbers are not available in public domain

Exhibit 7.6: PAT Margin of key competitors, India, in percentage, FY2022 – FY2024

Company Name	FY2022	FY2023	FY2024
Regreen Excel	0.59%	2.40%	3.10%
Praj Industries	6.44%	6.80%	8.18%
Mojj Engineering	4.48%	6.39%	NA
KBK Engineering	20.63%	2.14%	NA

Source: Annual Reports of Companies published in RoC, MCA; Frost & Sullivan Analysis
NA: FY2024 financial numbers are not available in public domain

PAT Margin has been calculated as restated profit for the year during the given period as a percentage of total income during that period.

Exhibit 7.7: RoE and RoCE of key competitors, India, in percentage, FY2022 – FY2024

	ROE			RoCE		
Company Name	FY2022	FY2023	FY2024	FY2022	FY2023	FY2024
Regreen Excel	101.31%	86.91%	63.73%	97.71%	128.83%	86.89%
Praj Industries	16.39%	22.24%	22.23%	22.12%	28.87%	26.82%
Mojj Engineering	22.11%	31.61%	NA	28.93%	39.75%	NA
KBK Engineering	NA	93.98%	NA	27.65%	32.40%	NA

Source: Annual Reports of Companies published in RoC, MCA; Frost & Sullivan Analysis
NA: FY2024 financial numbers are not available in public domain
Note: For ROE, only parent's share has been considered. For Mojj Engineering and KBK Chem-Engineering, we have considered Total PAT and Total Shareholder's Equity as there is no bifurcation.

Return on Equity has been calculated as restated profit for the period/ shareholder's equity; Return on capital employed has been calculated as restated profit before tax / by capital employed where capital employed is sum of tangible net worth (less intangible assets including goodwill), total debt, and deferred tax liabilities.

Exhibit 7.8: Debt to equity ratio comparison of key competitors, India, FY2022 – FY2024

Company Name	FY2022	FY2023	FY2024
Regreen Excel	0.92	0.07	0.16
Praj Industries	0.00	0.00	0.00
Mojj Engineering	0.23	0.23	NA
KBK Engineering	-1.97	6.26	NA

Source: Annual Reports of Companies published in RoC, MCA; Frost & Sullivan Analysis
NA: FY2024 financial numbers are not available in public domain

Debt to equity ratio has been calculated as total debt divided by shareholder's equity; Total Debt = Long-Term borrowings + Short-Term borrowings + Current portion of long term debt.

Exhibit 7.9: Inventory days, trade receivable days, and trade payable days of key competitors, India, FY2022 – FY2024

	Inventory days			Trade receivable days			Trade payable days		
Company Name	FY2022	FY2023	FY2024	FY2022	FY2023	FY2024	FY2022	FY2023	FY2024
Regreen Excel	29	55	37	27	49	59	35	67	60
Praj Industries	59	56	52	75	67	85	59	48	52
Mojj Engineering	66	85	NA	69	73	NA	44	48	NA
KBK Engineering	90	34	NA	74	59	NA	24	16	NA

Inventory days has been calculated as average inventory/cost of goods sold or revenue multiplied by 365; Trade receivable days has been calculated as average trade receivables/cost of goods sold or revenue multiplied by 365; Trade payable days has been calculated as average trade payables/cost of goods sold or revenue multiplied by 365.