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Report Highlights:

India's average ethanol blending rate with petroleum for calendar year 2022 is estimated at 9.3 percent. India's position as a structural surplus sugar producer and gradual utilization of alternative feedstocks will drive supply, while a 35 percent increase in offtakes by parastatal oil marketing companies for ethanol blending will drive demand. Continued industrial grade ethanol demand will result in approximately 635 million liters of imports, nearly all from the United States. By contrast, India's biodiesel market remains devastatingly limited owing to high feedstock prices and plant closures. India's National Biofuels Policy, amended in May 2022, reinforces initiatives to boost domestic production of ethanol and accelerate efforts toward attaining blending targets.

NOTE: Unless otherwise stated, calendar year (January to December) is the reference period used throughout the report. Indian Fiscal year (IFY) is April to March, and Ethanol Supply Year (ESY) are both from December to November.

SECTION I. EXECUTIVE SUMMARY

In 2022, India is estimated to achieve an average annual national ethanol blend rate of 9.3 percent, a new record, and a 15 percent increase over last year. India's average monthly blending rate reached 9.9 percent in May 2022 with recovering transportation fuel demand which remain well below pre-pandemic levels. Ethanol supplies for the Ethanol Blending Program (EBP) are forecast to undergo a downward correction from June through September when many distilleries pause operations. Additionally, FAS New Delhi (Post) has revised its 2021 ethanol blending rate with petroleum estimate upward to 8.1 percent due to increased diversion of Extra Neutral Alcohol (ENA) toward ethanol in the last three months of last year.

On May 18, 2022, the Union Cabinet officially approved amendments to the National Biofuels Policy (NBP). Originally envisaged in 2018, the NBP is India's focal policy directive administering its biofuels mandate. The recent amendments formalize last year's announcement to advance the Indian government's E20 target to 2025, permitting biofuel exports in specific cases, and measures to boost domestic biofuel production. India will likely achieve E10 in ESY 2022/23. India is well within reach to optimally develop its sugarcane/molasses-based distillation infrastructure to support reaching E20 by 2025.

Utilizing alternative feedstocks (such as rice, maize, and damaged food grains) toward the EBP mandate would be extremely challenging given limited availability, lower yields (especially for maize) and the colossal effort necessary to expand distillation infrastructure by approximately five billion liters within the next three years. Further, ancillary infrastructure requirements such as interstate transportation and nationwide rail networks remain a work in progress. Therefore, achieving E20 by 2025 seems unlikely, given these limitations and the continued prohibition on ethanol imports for fuel blending. Nevertheless, India's progress has been extraordinary, as even surpassing an 11 percent national blend rate would make it the world's third largest ethanol market after Brazil and the United States assuming only modest fuel pool growth.

Fuel and non-fuel ethanol consumption will outgrow domestic production for the eighth consecutive year. In 2022, ethanol imports will continue to fulfil supply to support the industrial, alcoholic beverage, and medical grade sectors. The Indian government's policies have attempted to augment domestic production, along with the continued prohibition of imported ethanol for fuel blending. Post estimates that 70 percent of India's domestically produced ethanol (undenatured and denatured) in 2022 will be utilized for the EBP mandate, indicating that significant space exists for imported ethanol (non-fuel blending) in the near term. In 2021, the United States remained the dominant ethanol supplier to India, with a market share of 91 percent. Ethanol imports are forecast to decline two percent to 635 million liters (almost all denatured) in 2022.

Biodiesel market penetration for on-road diesel remains marginal and is estimated at 0.07 percent. Contributing drivers include high feedstock prices observed globally due to various supply restraints, exacerbated by the Russian invasion of Ukraine, and high energy prices. India's biodiesel industry was already stressed over the last two years owing to plant closures due to the COVID-19 pandemic and high operational costs. Plans to develop a consistent used cooking oil (UCO) supply chain remain a work in

progress. Most biodiesel produced goes toward informal sectors with limited support from India's oil marketing companies (OMC), and demand remains insufficient. Additionally, a lack of larger feedstock supplies has prohibited market development. The government's import restrictions enacted in 2019 remain in place, while industry sources contemplate supplying steady volumes from special economic zones under the national blending program. India is reliant on fossil fuel imports and switching a portion of that to imported biodiesel is unappealing, as it does not solve the problem of energy import dependence. India's biodiesel exports capitalizing on European Union (EU) incentives that prioritize waste-based biofuel imports remain limited. Under the amended NBP.

India's biofuel policy remains focused on increasing self-sufficiency and rural development, given past investments to develop its fossil fuel resources (like coal) and expand oil refining capacity, ethanol imports for blending remain prohibited, and high biodiesel tariffs remain in place. Additionally, the policy supports local resource development and diverts surplus sugar created by India's sugar price support mechanisms and export subsidies (since rescinded), with gradual increased focus on efforts to address human health and environmental benefits.

For India to meet its long-term biofuel blending targets, for ethanol and biodiesel, Post has ascertained for over a decade that biofuels and biofuel feedstock imports are needed supplement domestic production. As India expands its production capacity and contemplates biofuel exports under the amended NBP, imported feedstocks will be needed to augment domestic supply, boost domestic production, and align with the government's "Make in India" campaign.

SECTION II. POLICY AND PROGRAMS

A) India's Biofuel Policy 2018

On May 18, 2022, the Union Cabinet, chaired by Prime Minister Modi, approved the Amendments to the 2018 National Biofuels Policy that incorporated various advancements in biofuels production and accelerated the E20 mandate to April 1, 2025. The revisions aimed for India to reach energy independence by 2047. Key amendments to the biofuels policy include:[1]

(i) Allowing the scope for more feedstocks toward biofuel production.
(ii) Advancing the target of E20 to ESY 2025/2026 from 2030 (originally announced on January 29, 2021).
(iii) Promoting domestic production of biofuels through Special Economic Zones and Export Oriented Units under the "Make in India" strategy. Developing indigenous technologies and generating more employment in the biofuels sector.
(iv) Expanding the member base of the National Biofuel Coordination Committee (NBCC)
(v) Allowing biofuel exports in specific cases.
(vi) Allows adjustments to biofuel targets stated in the NBP based on decisions taken during NBCC meetings.

The 2018 National Biofuels Policy prioritizes ethanol production from sugarcane, sugar juice derived from products including sugar beet, sweet sorghum, starch-containing crops (maize, cassava), and

[1] Data Sources: Government of India Ministry of Petroleum and Natural Gas and Indian government Press Information Bureau (PIB) announcement.

damaged food grains (broken rice). The policy also makes provision for the use of surplus food grains for ethanol production under the EBP mandate with the approval of the NBCC.[2]

Additionally, India's biofuels policy intends to achieve the following:

(A) Reduced oil import bill and increasing self-reliance: According to the MoPNG's view, a successful E20 program can result in potential savings of $4 billion[3] per year. Since 2021, India has imported close to 86 percent of its petroleum requirements, with approximately 98 percent of its fuel requirement in the transportation sector being met by fossil fuels.
(B) Protecting economic interests of farmers: India's OMCs have paid sugar mills approximately $5.4 billion for ethanol through the EBP. Additionally, the inclusion of damaged and surplus food grains as a feedstock means supplemental income for producers.
(C) Reduced emissions: According to MoPNG, from 2014-2021, the EBP would result in 19.2 million metric tons (MMT) less greenhouse gas (GHG) emissions.
(D) Improved ease of doing business through technology: Through the implementation of the Industries Development and Regulation Act, Indian state governments conduct business facilitating activities such as e-approvals and permits, and electronic and GPS tracking of the ethanol logistics fleet.

India has retained its target of achieving five percent blending of biodiesel with conventional diesel by 2030. The Indian government envisions that the targets will be met through the growth in domestic biofuel production (1-G, 2-G, and 3-G[4]), use of multiple feedstocks,[5] and encouraging biofuel blending to supplement gasoline and diesel use in vehicles and machinery, as well as in stationary and portable power applications.[6]

B) Selected Specifics on Ethanol, Biodiesel, and "Other" Biofuel Policy

Ethanol

Fuel Ethanol National Blend Rate - Ten Percent by 2022 and 20 Percent by 2025

The Indian government's continued emphasis on biofuel production has gradually found traction with investors with new funds augmenting sugarcane crushing and ethanol distillation capacities. The Ethanol Blending Program has never fully met its blending mandates during years of surplus sugar production, and it has typically fallen far short during cyclical downturns in the sugarcane harvest. However, India's transition as a structural surplus producer of sugarcane over the last five years has ensured ample supply of feedstock and the pricing/tendering system is being managed for the first time in India, in its two-decade old fuel ethanol program to effectively build fuel ethanol supply. Despite continuing logistical challenges, increased diversion toward ethanol will offset supply-demand gaps. For the first time, India is within reach to achieve its E10 blend target which will occur in ESY 2022.

[2] The NBCC includes representatives from the Ministry of Petroleum and Natural Gas (MoPNG); Department of Agriculture and Farmers Welfare, Department of Food and Public Distribution (DFPD), and Niti Aayog.
[3] Conversion factor: $1.00 equals Indian rupee (INR) 77.67.
[4] 1-G: First generation, 2-G: Second generation, etc.
[5] The Indian government has proposed a National Biomass Repository.
[6] Other applications include diesel generators or water pumps for irrigation.

On April 19, 2022, the governments of Brazil and India established a virtual "Center of Excellence on Ethanol," a technical exchange initiative with primary focus on improving the production efficiency of sugarcane/molasses ethanol and introducing higher ethanol blending in the fuel pool. An additional "Joint Working Group on Bioenergy Cooperation" envisages bilateral alliance on (A) implementation and scaling up ethanol blends (E20 and higher), flex-fuel vehicles, biodiesel, biogas/biomethane policies; and (B) technology development and advanced fuels including Sustainable Aviation Fuel (SAF), 2-G ethanol, etc. (Source: PIB).

On May 31, 2021, the Indian government amended the 1966 Sugarcane Control Order to allow the establishment of stand-alone ethanol units to boost production. Earlier, ethanol could only be produced from molasses or sugar juice (Source: Gazette of India). However, India's existing ethanol distillation capacity remains insufficient to accommodate surplus sugar as an ethanol feedstock (Table 1).

Table 1: India - Annual Ethanol Capacity in Billion Liters (as of April 2022)

Current and Required Distillation Capacities	Sugarcane/Molasses	Grains	Total
Current ethanol capacity	5.68	2.58	8.26
Capacity required by 2025	7.6	7.4	15.0
Additional Capacity needed	1.92	4.82	6.74

Data source: FAS New Delhi research and historical data series, Indian Sugar Mills Association (ISMA).

On April 6, 2022, the Department of Food and Public Distribution (DFPD), under the Ministry of Consumer Affairs, extended the loan disbursement timeline under the "Interest Subvention Scheme" from April to September 30, 2022. The extension encourages loan recipients to complete their projects while availing themselves of the grant benefits. Previously, DFPD had approved an interest subvention of $626 million (INR 45.7 billion) in December 2020.[7]

Further, in August 2021, India's parastatal OMCs invited state-wide bids to create an additional ethanol capacity of 6.48 billion liters and a guaranteed ethanol buyback through long-term purchase agreements for a ten-year period. The scheme drew 131 project proposals for an estimated four billion liters of annual capacity (Source: Ethanol for India). While the Indian government has encouraged ethanol capacity expansion since 2018 and has various timeline extensions on loans, the outcome to date has been tepid due to the complex regulatory environment despite recent government efforts to boost private sector attraction. The statement of purpose for accessing federal loans stipulates fulfilment of both the following conditions:

(i) In-principal approval by DFPD (some 983 projects have this), and
(ii) Long term agreement between OMCs and project proponents (some 131 projects have this).[8]

Unless projects meet both above conditions, banks are unwilling to sanction loans, resulting in only 67 projects meeting the eligibility criteria as of April 1, 2022.

[7] Interest subvention is the subsidy offered on interest rates and is a form of waiver of some percentage of interest. It is offered on several government lending schemes to promote a particular industry or public interest.
[8] Source: ISMA.

Expanded Eligible Feedstock and 2-G Purchasing Agreements

Since January 13, 2021, India allows the use of surplus rice (through the Food Corporation of India [FCI]) and maize for use as feedstocks to produce ethanol for fuel blending under the EBP program (Source: DFPD Announcement).

Ethanol Administered Price

The Indian government's Cabinet Committee on Economic Affairs on November 10, 2021, notified revised ethanol prices for ESY 2021-2022 (December 1, 2021, to November 30, 2022) (Table 2). These prices establish the base procurement price under the EBP mandate.

Table 2. Ethanol Procurement Prices (INR/Liter) by Indian Ethanol Supply Year

Feedstock	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
C-heavy molasses	42	39	40.85	43.46	43.75	45.69	46.66
B-heavy molasses	0	0	0	52.43	54.27	57.61	59.08
Sugarcane juice/sugar syrup/sugar	0	0	0	59.19	59.48	62.65	63.45
Damaged food grains	0	0	0	47.13	50.36	51.55	51.55
Surplus rice issued by FCI	0	0	0	0	0	56.87	56.87
Maize	0	0	0	0	0	51.55	51.55

Data source: MoPNG, Indian government.
Note: B-heavy molasses, sugarcane juice and damaged food grains were allowed only from ESY 2018-2019 onward. Surplus rice by FCI and maize were allowed beginning ESY 2020-2021.

Biodiesel

India retains an aspirational biodiesel blend goal (on-road use) of B5 by 2030. In 2022, the national average blend rate is estimated at 0.07 percent. Biodiesel is manufactured from imported palm stearin, palm acid oil, and small volumes of non-edible oils, UCO, and domestically sourced animal fats. Biodiesel use remains negligible due to limited feedstock availability, high feedstock prices, a lack of an integrated and dedicated supply chain, and import restrictions. Under the revamped NBP, there is a strong industry sentiment that the Indian government's biodiesel procurement prices would be revised.[9] Additionally, to meet its blending mandate, India would need to substantially invest in new plants to augment annual production volumes from its current effective capacity of 577 million liters, create a supply chain infrastructure for UCO and enforce necessary collection mechanisms. To date, since the 2018 Biofuel policy was established, the Indian government has not demonstrated the political will needed to induce/encourage substantially greater biodiesel production.

The biodiesel production environment in India is dominated by entrepreneurs operating micro, small, and medium enterprises (typically fuel traders) with relatively better access to the local fuel markets. However, since biodiesel is a low-cast, volume-driven industry, most traders opt for capital expenditure savings by establishing low-cost biodiesel manufacturing units that largely process low free fatty acid

[9] On its end, the OMCs have been working on a price formula since last year.

(FFA)[10] feedstocks (less than five percent) such as palm stearin, and palm oil, and other vegetable oils. Market price fluctuations impact the operational viability of these units, making biodiesel production commercially less attractive than conventional diesel. Since feedstock cost is upwards of 80% of total biodiesel production costs, manufacturing units must be modernized and have the required infrastructure to process all types of feedstocks, possibly even including UCO, so plants can switch between feedstock based on changes in relative prices.

The Indian biodiesel industry is limited by low access to feedstock at viable prices. In the region, primary palm oil producers like Malaysia and Indonesia mandate nationwide biodiesel blending ranging as high as B10 to B30. Due to limited feedstock alternatives, Indian domestic investments in production and technology are limited. On the demand side, rampant and widespread use of spurious, cheaper oil alternates are sold as biodiesel, posing regulatory and oversight challenges.

Import Policies

The Indian government requires import licenses to import biofuels. Import of biofuels for fuel blending remains prohibited. The import license applies to denatured ethyl alcohol (all strengths), undenatured ethyl alcohol (strength by volume of 80 percent or higher), pure biodiesel, biodiesel blends over 30 percent, and petroleum oils containing up to 30 percent biodiesel. In MY 2021/2022, the Indian government increased the sugarcane fair and remunerative price (FRP) to $3.73/100 kilograms (INR 290/quintal). Given the sugar surplus in the MY 2021/22 season, the FRP will remain less attractive for sugar mills, as stronger incentives exist to divert domestic ethanol for use in the EBP. [11] This increase may further encourage industrial-use ethanol users to seek additional imports to fill their consumption gap, creating demand for both domestically produced and imported ethanol.[12]

Table 3. India: Ethanol Import Duty (percent ad valorem on Customs Insurance, and Freight [CIF] Value)

ITC HS Tariff Number	Total Import duty
Ethyl alcohol and other spirits, denatured, of any strength; denatured ethanol; and denatured spirits [2207 2000]	Basic customs duty on denatured ethanol for manufacture of excisable goods is five percent. However, denatured spirits assessed five percent duty for all goods except above*
Undenatured Ethanol [2207 1000] of an alcoholic strength by volume of 80 percent or higher	150 percent (SWS of 10 percent on basic customs duty exempted; State excise/value added tax as applicable).

Source: www.cbic.gov.in (Updated as of May 2022)
Note: If the importer follows the procedure set out in the Customs (import of goods at concessional rate of duty) Rules, 2017, the central excise duty is a fixed amount and not a percentage on price. Since 2019, the five percent road and infrastructure cess (tax) on ethanol-blended petrol has been abolished (See: Excise on Biodiesel, Excise on ten percent blend gasoline, Excise on five percent blend gasoline).
*: Ethyl alcohol supplied to OMCs for blending with gasoline will be assessed a five percent Integrated Goods and Service Tax. Ethyl alcohol is subject to a combined Central and State Goods and Service Tax of 18 percent

[10] Free fatty acids are formed when vegetable oil is subjected to elevated temperatures during frying. One molecule of oil can yield three molecules of FFA. The levels of FFA in feedstock play a critical part in the biodiesel production.
[11] See FAS India Sugar Annual 2022, GAIN 0041.
[12] This assumes that international ethanol prices remain competitive and crude oil prices remain firm.

Table 4. India: Biodiesel Import Duty (percent ad valorem on CIF value)

ITC HS Tariff Number	Total Import duty
Biodiesel and mixtures thereof, not containing or containing less than 70 percent by weight of petroleum oils and oils obtained from Bituminous minerals (greater than B30 to B100) [3826 0000]	24.32 percent (ten percent basic plus ten percent Social Welfare Surcharge (SWS) on basic custom duty plus 12 percent Goods and Services Tax (GST)
Petroleum oil and oils obtained from Bituminous minerals (other than crude), containing by weight more than 70 percent or more of petroleum oils, contain biodiesel, other than waste oils (B1-B30), [2710 2000] *	30.98 (ten percent basic plus ten percent SWS on basic custom duty plus 18 percent IGST).

Data source: www.cbic.gov.in, (Updated as of May 2022)
*For the purposes of the sub-headings of 2710, the term "biodiesel" means mono-alkyl esters of fatty acids of a kind used as a fuel, derived from animal, vegetable or microbial fats and oils, whether or not used.

Other Biofuels: Drop-in-fuels, Bio-CNG, Bio-Hydrogen, Bio-methanol, Di-Methyl-Ether

The Ministry of Science and Technology's Department of Biotechnology (DBT) has supported biofuel feedstock development in the last decade through research initiatives, including international collaboration such as the Mission Innovation (IC4: Sustainable biofuels) program. Current research mostly focuses on cellulosic ethanol (2G) technology development, while exploring new technologies including lignin valorization, algal biofuels, waste biomass to energy, biobutanol and biohydrogen (Source: DBT).

Under the "Mission Innovation" umbrella, an "Integrated Biorefineries Mission" was launched on April 4, 2022, by the Ministry of Earth Sciences with the objective of advancing biofuels research, development, and commercialization. The ministry includes a "National Funding Opportunity on Sustainable Aviation Fuels" that supports research in advanced biofuels for aviation applications. Furthermore, the Sustainable Biofuels Innovation Challenge under the Mission Innovation also aims to accelerate biofuels research and cost reductions with the potential to substantially lower GHG emissions. The project has an outlay of $1.12 million to efficiently develop sustainable biofuels (Source: Mission-Innovation). India's Sardar Swara Singh National Institute of Bio-Energy, under MNRE, has also conducted advanced biofuels research, including activated carbon production from agriculture residue, bioethanol, and biogas, among others (Source: PIB).

C) Renewable Energy, Greenhouse Gas Emissions and Climate Change

Renewable Energy

India ranks fourth globally on installed renewable energy capacity with an ambitious target of achieving 175 gigawatts (GW) of installed capacity with renewable energy by 2022. This target includes 100 GW in solar, 60 GW in wind energy, ten GW from biomass and five GW from hydropower. Renewable installed capacity as of April 30, 2022, is estimated at some 111.4 GW (Table 5). The delays caused by the COVID-19 pandemic lockdowns and general logistical challenges have resulted in a 63.6 GW shortfall. However, India has met its near-term targets for biomass (10.63 GW) and hydropower (4.84 GW from small hydropower, 46.52 GW from large hydropower) production[13] (Source: PQARS). India's long-term target remains 500 GW by 2030.

[13] Note that biofuels are not included as part of this broader renewable energy outlook.

Table 5. India: Installed Capacity of Renewables (In Megawatts) by State

State/Union Territory	Small Hydro Power	Wind Power	Bio-Power					Solar Power	Total Capacity
			BM Power/Bagasse Cogeneration	BM Cogen. (Non-Bagasse)	Waste to Energy	Waste to Energy (Off-grid)	Total Bio-Power		
Andhra Pradesh	162.11	4096.65	378.10	105.57	53.16	29.21	566.04	4389.42	9214.22
Gujarat	89.39	9289.72	65.30	12.00	7.50	24.46	109.26	7619.40	17107.77
Karnataka	1280.73	5130.90	1867.10	20.20	1.00	13.85	1902.15	7597.92	15911.70
Maharashtra	381.08	5012.83	2568.00	16.40	12.59	35.16	2632.15	2667.83	10693.89
Rajasthan	23.85	4416.82	119.25	2.00	0.00	3.83	125.08	12946.99	17512.74
Tamil Nadu	123.05	9866.37	969.10	43.55	6.40	23.65	1042.70	5378.23	16410.35
Others	2790.69	2714.79	3466.71	572.33	142.49	123.45	4304.98	14737.87	24548.33
Total (in MW)	**4850.90**	**40528.08**	**9433.56**	**772.05**	**223.14**	**253.61**	**10682.36**	**55337.66**	**111399**
Total (in GW)	**4.85**	**40.53**	**9.43**	**0.77**	**0.22**	**0.25**	**10.68**	**55.34**	**111.40**

Note: All figures as on April 30, 2022.
Data source: MNRE, Indian government.

In November 2021, Prime Minister Modi announced India's net-zero emissions commitment by 2070 at the Conference of Parties (COP 26) (Source: Ministry Of External Affairs). India's other commitments intended to be achieved by 2030 include:

- Increasing non-fossil energy capacity to 500 GW,
- Fulfilling 50 percent of energy requirements from renewable sources,
- Reducing carbon intensity of the economy by 45 percent, and
- Reducing total projected carbon emissions by one billion tons.

In other renewables, the Indian government aims to expand its solar capacity by 30.8 GW through the PM-KUSUM program, valued at $4.37 billion. The primary objectives of PM-KUSUM are energy and water security, reducing diesel dependency for the farm sector, and generating income avenues for farmers via solar power (Source: PIB, PM-KUSUM).

For biomass power and cogeneration, as of March 2022, India has installed some 11 waste-to energy plants with a cumulative capacity of 132.1 MW, utilizing mostly municipal solid waste. Maharashtra, Uttar Pradesh, Tamil Nadu, and the Delhi/National Capital Region account for almost 44 percent of total waste generated nationwide (Source: MNRE). The Indian government maintains additional bio-energy programs under implementation:[14]

(i) Program on Energy from Urban, Industrial and Agricultural Wastes/ Residues,
(ii) Scheme to support Promotion of Biomass based cogeneration in sugar mills and other industries,
(iii) Biogas Power (off-grid) Generation and Thermal Application Program, and
(iv) New National Biogas and Organic Manure Program.

[14] Refer to MNRE for additional program details.

As of May 2022, MNRE estimates the government's investments at $2.5 billion (INR 19,500 crore[15]) and $3.27 billion (INR 25,425 crore) toward solar and the "green hydrogen economy," respectively. The Indian renewable energy sector is expected to attract $80 billion in investments by 2026. For 2022, some $15 billion are predicted to be invested in electric vehicles, green hydrogen, and solar equipment manufacturing. By some estimates, around 49 percent of total electricity would potentially come from renewable energy by 2040, and India is expected to add some 5000 compressed biogas plants by 2023 (Source: India Brand Equity Foundation).

India will continue to develop its regenerative economy as it increases electricity production from renewable sources like solar and wind, and the role of the bioenergy sector should be given more room to supplement grid stabilization and secure energy supply.

India is in its seventh year of the Nationally Determined Contributions under the 2015 Paris Climate Agreement. where it pledged to reach three major climate change goals by 2030. The goals to achieve by 2030 include a reduction in its Gross Domestic Product (GDP) emissions intensity from 33 to 35 percent, achieving a 40 percent electric power installed capacity from non-fossil fuels, and creating an additional carbon sink of 2.5-3.0 billion MT of carbon dioxide (CO_2) equivalent through additional forests and tree cover. However, large scale monoculture leaves newly planted forests vulnerable to drought and fire. Additionally, large tracks of land have been placed out of bounds to traditional grazers who need access to traditional grazing lands and is socially unsustainable (Source: UN Framework Convention on Climate Change [UNFCC]).

Greenhouse Gas Emissions

India's total GHG emissions are the third largest in the world, although per capita emissions remain well below the global average. However, India's power sector emissions are above the global average, largely due to increased coal consumption. In IFY 2021/2022, India's CO_2 emissions reached 2.88 gigatons (Gt). Emissions fell by seven percent in 2020 owing to the COVID-19 induced national lockdowns but increased 13 percent in 2022.[16]

India's efforts to attain net zero[17] include various mandates across government ministries, most notably the Ministry of Environment, Forests and Climate Change (MOEFCC), MNRE, and the Ministry of Heavy Industries, the latter of which oversees the "Faster Adoption and Manufacturing of Hybrid and Electric Vehicles" (FAME) program. In its 2022 Annual Budget, MOEFCC received $390 million (INR 3,030 crore) to use for programs promoting forest cover, afforestation, and pollution control. Concurrently, MNRE received $889 million (INR 6,901 crore) for programs to attain the government's renewable energy targets.[18]

Sectoral growth in transportation will continue to increase gasoline and diesel consumption, despite the temporary interval of reduced demand observed due to the national lockdowns in 2020 and 2021. The transportation sector has become the fastest growing energy end-use sector, with nearly half of India's cumulative oil demand attributed to transportation, the vast majority two-wheeled vehicles (Table 6).

[15] One *crore* equals 10 million.
[16] Source: Global Carbon Project.
[17] Defined as removing all equivalent CO_2 emissions as produced.
[18] Of this amount, solar energy received the highest allocation of funds ($433 million).

Energy demand in road transportation is projected to more than double over the next two decades, more than half of which is forecast to result from diesel-based freight transport.

Table 6. India. Projected Vehicular Fleet and Petroleum Demand Projections (Millions)

	Vehicle Type	2021	2022	2023	2024	2025	2026
Projected Addition of Petrol vehicles	Two-wheelers (in millions)	13.9	16.7	18.1	19.5	21.1	22.7
	Four-wheelers (in millions)	2	2.2	2.4	2.6	2.8	3
Motor Gasoline/Petroleum Demand Projections (MMTPA)		27.7	31	32	33	35	36

Data source: NITI Aayog.

The Indian government's policies attempt to address transport and mobility emissions across biofuels (EBP, and biodiesel), electric vehicles, and fuel efficiency standards. However, the Indian government's programs must be balanced with its economic, energy, sustainability, and self-reliance interests.

National Greenhouse Gas Inventory

In March 2022, MOEFCC announced that India is not obliged to completely stop carbon emissions under the UNFCC treaty, Kyoto Protocol, and Paris Agreement. India also stated that while accounting for 17 percent of the global population, it had contributed to only four percent of global GHG emissions. To date, India has not submitted its GHG emissions reduction targets.

In February 2021, India submitted its third biennial update report to the UNFCC and declared it met its voluntary goal in 2020 to reduce the emission intensity of GDP by 20-25 percent from its previous 2005-levels. In 2016, India's emission intensity per unit of GDP decreased by 24 percent. Greenhouse gas emissions included 2.8 million giga-grams (Gg) of CO_2 equivalent without Land Use, Land-Use Change and Forestry (LULUCF). India's LULUCF sector continues to remain a net sink. Considering emissions and removals from the LULUCF sector, net national emissions were 2.5 million Gg of CO_2 equivalent. India ranks third globally (behind China and the United States) in overall GHG emissions.

Table 7. India Green House Gas Emissions by Sector (Gigagrams)

GHG sources and removals	CO_2 emission	CO_2 removal	CH_4	N_2O	HFC 23	CF_4	C_2F_6	SF_6	CO_2 equivalent
Energy	2064840	NO	2072	68	NO	NO	NO	NO	2129428
IPPU	166227	NO	187	11	2	4	1	0.004	226407
Agriculture	0	NO	14423	339	NO	NO	NO	NO	407821
LULUCF	21289	330765	55	2	NO	NO	NO	NO	-307820
Waste	NO	NO	2820	52	NO	NO	NO	NO	75232
Memo Items	789305	NO	1	0.13	NO	NO	NO	NO	789359
Total without LULUCF	2231068	---	19502	469	2	4	1	0.004	2838889
Total with LULUCF	2252356	330765	19557	471	2	4	1	0.004	2531069

Abbreviation: NO – Not Occurring.

Note: Adopted from the Third Biennial Report. Submitted to UNFCC, February 2021 (Source: MOEFCC).

India's energy sector accounted for 75 percent of India's total emissions. The agriculture sector largely contributed to methane and nitrous oxide emissions, arising mostly from livestock rearing (enteric fermentation and manure management), paddy cultivation and fertilizer application. A summary of emissions and removals is presented in Table 7.[19]

Climate Change and India's Post-2020 Climate Goals

On May 24, 2022, the United States and India signed an "Investment Incentive Agreement" for expanded investments in India for private sector led projects in renewable energy and other areas. Since April 2021, through the "U.S.-India Climate and Clean Energy Agenda 2030 Partnership," the United States and India collaborate in a variety of renewable energy activities, including industrial decarbonization of fossil fuel-dependent sectors, new and emerging technologies, implementation of smart grids, and energy storage, among others. Additionally, biofuels are included within the "Responsible Oil and Gas" pillar within the U.S.-India Strategic Clean Energy Partnership.[20]

Indian government references, see: UNFCC: India's Intended Nationally Determined Contribution: Working toward Climate Justice and MOEFCC: National Action Plan on Climate Change.

[19] Refer to India's Third Biennial Report to UNFCC for additional information.
[20] Among the various goals of the pillar includes "[Exploring] cooperation to facilitate achieving climate goals by deploying in India carbon capture utilization and storage technology and advancing alternative fuels such as hydrogen and biofuels for transport and industry." See: U.S. Department of Energy Partnership Overview.

SECTION III. ETHANOL

PRODUCTION, SUPPLY AND DISTRIBUTION

Table 8. India: Ethanol Used as Fuel and Other Industrial Chemicals (Million Liters)

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022f
Beginning Stocks	60	60	75	61	128	150	300	112	309	452
Production	2,057	2,002	2,292	2,061	1,671	2,692	2,552	2,981	3,257	3,512
Imports	108	193	204	432	722	607	670	669	648	635
Exports	233	180	165	136	141	129	50	133	87	30
Consumption	1,932	2,000	2,345	2,290	2,230	3,020	3,360	3,320	3,675	4,460
Fuel Consumption	382	350	685	1,110	675	1,500	1,890	1,730	2,955	4,000
Ending Stocks	60	75	61	128	150	300	112	309	452	109
Balance check	0	0	0	0	0	0	0	0	0	0
Production Capacity										
Number of Refineries	115	115	160	161	161	166	170	220	231	252
Nameplate Capacity	2,000	2,000	2,100	2,210	2,215	2,300	3,000	3,500	4,300	5,700
Capacity Use (%)	103	100	109	93	75	117	85	85	76	62
Co-product Production (1,000 MT)										
Bagasse	102,360	105,642	108,699	97,485	79,176	118,784	99,942	126,976	139,264	135,168
Press Mud*	13,648	14,086	14,493	12,852	10,438	15,660	13,176	16,740	18,360	17,820
Feedstock Use for Fuel (1,000 MT)										
Molasses	1,592	1,458	2,854	4,625	2,813	6,250	7,000	6,407	10,944	13,333
Market Penetration (Million Liters)										
Fuel Ethanol	382	350	685	1,110	675	1,500	1,890	1,730	2,955	4,000
Gasoline	23,749	25,848	29,651	33,265	35,701	38,896	42,266	34,930	36,400	43,000
Blend Rate (%)	1.6	1.4	2.3	3.3	1.9	3.9	4.5	5.0	8.1	9.3

Data source: Post research and historical data series, Trade Data Monitor (TDM) and industry Sources.
f =Year 2022 is projected
Note: For ethanol imports originating from the United States, data used is from U.S. Census Bureau. HS codes include (a) denatured, fuel 2207.20.0010, (b) ethanol denatured, other 2207.20.0090, (c) ethanol undenatured, fuel 2207.10.6010 and (d) ethanol undenatured, other 2207.10.6090.
* Leftover sugarcane residue after juice extraction.

As of May 2022, Post estimates the total annual installed capacity of ethanol and alcohol (all grades) at 8.26 billion liters. Of this total, approximately 252 distilleries are sugarcane/molasses-based with a nameplate capacity[21] of 5.68 billion liters of ethanol (denatured and undenatured) for use in fuel, industrial, personal care, food, medical-grade alcohol (sanitizers, topical disinfectants, solvents, and preservatives in pharmaceutical preparation, etc.) and potable liquor applications. Final B- and C-heavy molasses, sugarcane juice, damaged food grains unfit for human consumption, surplus rice, maize, and any other potential raw materials available may be used for making ethanol.

CONSUMPTION

India's 2022 total ethanol consumption is forecast to rise by 21 percent to a record 4.46 billion liters, driven largely by ethanol for fuel blending, as India makes continued progress to meet its 2022 E10 and 2025 E20 mandates. Last year's consumption figures have been revised downward to 3.68 billion liters, reflecting lower than anticipated ethanol offtake by OMCs for fuel blending. While India achieved an

[21] Estimated ethanol manufacturing capacity estimated as of the 2022 sugar season, based on the number of operational days allowed by the Pollution Control Boards.

8.1 percent blend rate with gasoline in 2021, it was largely on account of a gasoline pool that had contracted sharply from 2019's pe-covid demand even though there was increased diversion of ENA toward ethanol.

Consumption will outgrow production for the eighth consecutive year, largely driven by burgeoning fuel ethanol demand used for gasoline blending. India's annual ethanol consumption growth of eight percent (five-year average, 2018-2022) remains strong compared to five percent production growth in the same period. Further, ethanol applications toward industrial, chemical, and medical use remain strong. These industries will likely find increasing challenges to secure supplies, especially post-July when sugar juice feedstock becomes unavailable due to closed mill operations. With the bull run currently witnessed in global sugar markets, Indian mills find various sales options for sugar exports,[22] ENA (potable liquor), or for fuel blending. Increased domestic fuel prices, coupled with relatively appealing ethanol purchase rates, are strengthening ethanol consumption, while consecutive above-average sugarcane harvests have lifted feedstock supply for production.

Post forecasts that continued sugarcane availability for the EBP mandate, coupled with government support in ethanol production, will increase OMC offtakes and result in a 2022 national blend average of 9.3 percent, higher than last year's 8.1 percent rate and a new record. This blend rate would likely increase if fuel-use ethanol imports were permitted, duty rates lowered, and procurement program inefficiencies rectified, such as storage capacities at oil depots, reduced interstate trade barriers and region-specific supply and demand mapping.

Approximately 4.16 billion liters of ethanol have been contracted against the 4.58-billion-liter requirement established by OMCs for ESY 2021. Of this volume, as of May 8, 2022, some 1.86 billion liters of ethanol have been supplied to OMCs under the EBP. Post estimates approximately 4 billion liters would be blended with gasoline under the EBP for 2022 (Table 8). High feedstock prices (sugar juice, B-heavy molasses) will likely result in increased diversion for ethanol production. India's industrial and potable liquor sectors will need to procure their feedstocks from grain-based distilleries, raw material imports, or imported finished products.

Ethanol demand for the EBP is much higher than last year due to surplus MY 2021/2022 sugarcane production, remunerative tender prices, and a gradual improvement of logistical performance that have ensured ethanol from surplus areas is moved to deficient regions in India. As of March 2022, OMCs maintain approximately 178 million liters of storage capacity that can annually store approximately 4.3 billion liters of ethanol.[23]

PRODUCTION

India's 2022 ethanol production is forecast at 3.51 billion liters, eight percent above last year owing to consecutive years of surplus sugarcane production (Table 8). Molasses supplies for ethanol are set to achieve record volume, due to various factors including increased price incentives that divert B-heavy molasses and sugarcane juice to produce fuel grade ethanol. As of May 8, 2022, MoPNG reports that approximately 4.16 billion liters have been contracted, of which an estimated 1.86 billion liters have been delivered, indicating a 43 percent procurement increase year-on-year. Supply is comprised of 989

[22] See: India's Government Restricts Sugar Exports, GAIN0050. Despite the recent export ban, exports will resume post October 31, 2022.
[23] Assumes an average 15-days of storage.

million liters from B-heavy molasses, 595 million liters from sugarcane juice, 56 million liters from C-heavy molasses, 113 million liters in damaged food grains, and 107 million liters from surplus rice.

In 2021, an estimated 3.53 billion liters of ethanol was contracted by OMCs, with 2.96 billion liters blended with gasoline to mark an 8.1 percent blend rate (revised upward from last year's 7.5 percent estimate). This revision accounts for higher than usual ENA diversion toward ethanol for the EBP mandate between the August-November period. The differential and remunerative prices, along with recent policy changes to attain E20 by 2025, will likely guarantee increased ethanol supplies for the EBP in 2022.

India has a total installed ethanol capacity of 8.26 billion liters, of which molasses-based distilleries constitute 5.68 billion liters, or 69 percent of overall production capacity. Grain-based distilleries account for 2.58 billion liters (31 percent). Ethanol production remains heavily dependent on sugarcane/molasses as its primary feedstock, as India gradually expands the use of alternative viable feedstocks. However, as 80 percent of India's sugar production is in the states of Uttar Pradesh (north), Maharashtra (west) and Karnataka (south), consistent ethanol supply nationwide continues to be a glaring challenge despite government investments (Table 9). An ethanol dedicated pipeline network which can move large volumes of fuel large distances at low cost like those found in the United States or Brazil is lacking.

Table 9. India: Estimated Ethanol Capacity of Molasses-based Distilleries by State

State	No. of Units	Kiloliter Daily Capacity	Kiloliters per Year
Andhra Pradesh	8	328	86,160
Bihar	8	565	162,750
Gujarat	12	585	153,485
Haryana	3	235	69,450
Karnataka	31	3,196	949,590
Madhya Pradesh	2	105	32,850
Maharashtra	114	7,305	2,165,570
Punjab	3	190	51,300
Tamil Nadu	12	575	173,595
Telangana	3	225	67,950
Uttar Pradesh	53	5,122	1,716,214
Uttarakhand	3	190	57,600
Total	**252**	**18,621**	**5,686,514**

Data source: ISMA.
Note: Annual capacity based on number of operational days as allowed by state pollution control boards. All India capacity as of March 31, 2022

The Indian states of Uttar Pradesh, Maharashtra, and Karnataka contribute 75-80 percent of total sugarcane production, while maize and rice are grown in most other states. A few states like Rajasthan, Kerala, Jammu and Kashmir, and the seven northeastern states have neither sufficient surplus grains nor adequate ground water for sugar or rice production. General investor reluctance toward ethanol projects

exists in certain states like Andhra Pradesh, Jammu and Kashmir, Tamil Nadu, Telangana, and the northeastern states, restricting the realization of a nationwide ethanol distillation network (Table 10).

Table 10: Ethanol Volume Supplied to OMCs by State by ESY (In Kiloliters)

State/Union Territory	2018-2019	2019-2020	2020-2021
Andhra Pradesh	101,600	53,400	135,100
Bihar	68,400	83,900	99,000
Chhattisgarh	32,600	47,000	76,200
Delhi	84,000	66,900	70,200
Goa	12,100	7,900	21,200
Gujarat	133,600	123,600	184,100
Haryana	123,800	130,700	144,400
Himachal Pradesh	700	16,200	27,500
Jammu and Kashmir	0	0	5,200
Jharkhand	700	24,100	41,700
Karnataka	194,000	187,700	247,100
Kerala	0	0	89,700
Madhya Pradesh	93,100	102,400	137,700
Maharashtra	297,800	219,200	394,800
Odisha	0	3,500	44,300
Punjab	104,000	115,300	142,000
Rajasthan	41,000	26,700	129,100
Tamil Nadu	74,800	35,200	232,700
Telangana	88,800	46,500	142,300
Uttar Pradesh	387,000	401,500	531,900
Uttarakhand	24,500	24,400	28,200
West Bengal	23,000	14,400	31,000
Total	**1,885,500**	**1,730,500**	**2,955,400**

Data source: Department of Food and Public Distribution, Indian government.

Since 2021, the Department of Food and Public Distribution, Ministry of Consumer Affairs, has agreed in principle to establish 196 grain-based ethanol plants. If fully utilized, the additional production capacity would result in an additional annual volume of 8.59 billion liters of ethanol for use in the EBP mandate. Still, Indian ethanol units remain subject to additional EBP requirements, despite easing environmental impact assessment requirements, government subsidies (interest subvention scheme), and the Indian government's efforts to fast-track construction (See: Gazette of India, Ministry of Environment, Forest and Climate Change Notification). Even with these uncertainties, the Indian government's endorsements demonstrate its intent to meet its blending goals.

According to the All-India Distillers Association (AIDA), India currently operates 113 grain-based distilleries with a cumulative annual capacity of 2.58 billion liters (Table 11). More than half of these units produce potable liquor (i.e., potable liquor, spirits), which is also among the top tax revenue streams for state governments across India.

Table 11. India: Installed Capacity of Grain- based Distilleries by State

State	Number of Distilleries	Annual Capacity (Million Liters)
Punjab	16	620
Maharashtra	28	430
Andhra Pradesh	15	390
Haryana	13	360
Madhya Pradesh	8	180
Bihar	4	130
Rajasthan	8	120
Rest of India	21	350
Total	**113**	**2,580**

Data source: AIDA.
Note: Annual capacity is based on 340 operational days.

Despite being at the threshold of achieving E10 by 2022, India would still require additional feedstock supplies to boost production to maintain E10 as the fuel pool grows, and even more feedstock as it reaches for E20 by 2025 on top of a growing fuel pool. The recent NBP mandate amendments allow for ethanol focused Special Economic Zones and Export Oriented Units that will further increase production. However, the additional capacities needed to augment grain-based ethanol distillation will remain a challenge.

Conflicting interests for sugar mills between exports (despite recent restrictions) and producing ENA pose a risk for India's immediate EBP aspirations. To achieve its ethanol blend ambition, India would need to strengthen measures that divert additional molasses to the EBP system, while permitting imports for fuel grade ethanol to efficiently utilize idle production capacities in the south, east and northeast regions. A two-tier procurement policy is needed that capitalizes on imports to supplement domestic production while enabling efficient utilization of existing capacities and improved economic performance. Opening the fuel blending market to imported ethanol would aid India in achieving its blending targets and support its larger "Make in India" campaign.

TRADE

Imports

According to the International Energy Agency, India is set to become the third largest ethanol market globally by 2026. Despite increased domestic production, India remains a net ethanol importer for all end uses except fuel blending. In 2021, ethanol imports declined three percent to 648 million liters, valued at $313 million. For the ninth consecutive year, the United States remained the largest ethanol supplier (denatured) to India, accounting for 91 percent of India's total ethanol imports (Table 12). Strong local demand for industrial and medical-grade ethanol continues to drive U.S. exports. Other suppliers which have (inconsistently) accounted for several percentage points are Brazil and Pakistan.

Post estimates India's 2022 imports will decline two percent to 635 million liters, (mostly denatured) due to higher prevailing global ethanol prices.[24]

[24] Ethanol prices in the United States have increased by almost 32 percent compared to last year.

Table 12. India Ethanol Imports by Primary Suppliers (Million Liters)

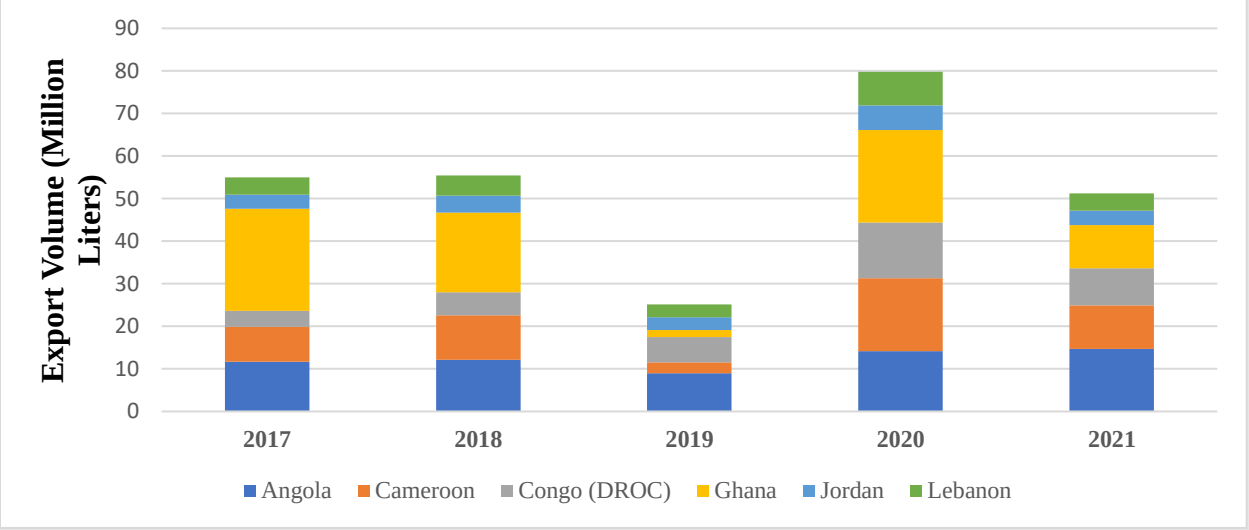
Country	2017	2018	2019	2020	2021
United States	695	569	623	664	592
United Kingdom	1	0.4	0.04	0.037	0.08
Brazil	0	0	0.038	0.25	56
Pakistan	3	2.2	1.6	0.4	0.08
All Others	4	34.4	42.56	2.72	0.02

Data source: U.S. Census Bureau, TDM, and Ministry of Commerce, Indian government.

Exports

In 2021, India's ethanol exports totaled 87 million liters (mostly undenatured), a 35 percent decline year-on-year. This is attributed to a higher domestic demand, leading to a lower exportable surplus. Top export destinations were Angola, Cameroon, and Ghana (Figure 1). Exports are expected to drop further to around 30 million liters in 2022 because of increased domestic demand. India's amended NBP mandate that stipulates establishing Special Economic Zones/Export Oriented Units for ethanol is unlikely to gain traction this year.[25]

Figure 1: India Ethanol Exports (Million Liters) by Top Buyers



Data source: U.S. Census Bureau, TDM and Ministry of Commerce, Indian government

[25] However, close to 25 percent of ethanol produced in these units could be sold domestically and still be considered exports.

SECTION IV. BIODIESEL

PRODUCTION, SUPPLY AND DISTRIBUTION

Table 13. India Biodiesel Production from Multiple Feedstocks (Million Liters)

Calendar Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022f
Beginning Stocks	14	15	11	13	13	18	25	23	16	26
Production	132	138	152	158	170	185	230	200	180	185
Imports	0.3	1.7	0.8	2.7	7.1	25.2	7.0	1	1	1
Exports	3.9	41.5	33.1	41.7	7.6	23.1	54.0	68	6	10
Consumption	128	102	118	119	165	180	185	140	165	180
Ending Stocks	15	11	13	13	18	25	23	16	26	22
Production Capacity (Million Liters)										
Number of Biorefineries*	6	6	6	6	6	6	6	6	6	7
Nameplate Capacity	465	480	500	550	600	650	670	580	520	577
Capacity Use (%)	28.4	28.8	30.4	28.7	28.3	28.5	34.3	34.5	34.6	32.1
Feedstock Use for Fuel (1,000 MT)										
Non-edible Industrial	70	75	85	90	100	110	140	145	90	110
Used Cooking Oil	49	50	55	55	55	60	65	50	55	70
Animal Fats & Tallow's	7	6	5	6	6	8	10	9	9	6
Total	126	131	145	151	161	178	215	204	154	186
Market Penetration (Million Liters)										
Biodiesel, on-road use	49	32	41	48	72	83	100	50	10	40
Diesel, on-road use	49,354	49,605	52,239	55,179	56,715	59,220	60,145	44,400	52,927	57,002
Blend Rate (%)	0.10	0.06	0.08	0.09	0.13	0.14	0.17	0.11	0.02	0.07
Diesel, total use	82,256	82,674	87,064	91,965	94,524	98,700	100,241	74,000	76,270	79,283

Data source: FAS New Delhi Research and historical data series, TDM and Industry Sources.
f =Year 2022 is projected.
*Indicates theoretical estimate.

The biodiesel market continues to remain informal, dispersed with minimal domestic production. As many countries operate at a minimum of B5, and several running below at B10 or higher (Brazil, Thailand, Argentina, Malaysia, Indonesia) due to high feedstock prices and anti-inflation measures, India's biodiesel market retains considerable growth potential with respect to engine compatibility of existing fleet. However, India must provide a viable strategy that builds a financially sustainable domestic industry with sufficient feedstock supply and adequate storage and delivery infrastructure. Access to imports would help jumpstart the process. Compared to the EBP mandate, a very limited number of domestic suppliers produce biodiesel, and most production capacities are under-utilized, with few viable feedstock sources and limited government support mechanisms to create the required demand-pull. The continued prioritization of ethanol hinders the growth of the biodiesel industry.

Most of India's biodiesel production is consumed by locally dispersed, informal groups to generate stationary power. Support received through OMC procurement is insufficient to build commercial sales. For years, field trials used *jatropha*,[26] some tree-borne oilseeds,[27] and other non-edible oilseeds grown on non-arable, rain-fed lands. Attempts failed to advance due to low yields. India does not produce drop-

[26] Jatropha is a genus of flowering plants in the spurge family, Euphorbiaceae.
[27] Treeborne oilseeds include Karanja, Mahua, Neem, Jojoba, Wild Apricot, Cheura, Kokum, Simarouba, etc.

in renewable diesel which, like biodiesel, is also based on animal fats and plant oils and has seen considerable commercial success in North America and Europe when incentivized.

CONSUMPTION

India's annual biodiesel consumption grew by three percent between 2013-2020. This sluggish growth was further impacted by COVID-19-induced transportation restrictions and lockdowns since 2020. Post estimates demand to recover nine percent to 180 million liters in 2022, indicating pre-pandemic consumption levels. This year, high energy prices, including biodiesel feedstocks (palm oil and derivatives), lower production in most feedstock growing regions (South America for soybean oil, Indonesia for palm oil), and/or higher feedstock prices have led several countries to temporarily lower blending mandates to reduce inflationary pressures. Decreased domestic transportation forced OMCs to procure reduced biodiesel volumes in the last two years. In 2021, due to high feedstock prices, OMC biodiesel procurement declined to a record low. However, with the government's revamped National Biofuels Policy, biodiesel procurement is forecast to increase from the current $0.89/liter (INR 65/liter) rate and may attract investments in production capacity and blending facilities.

With an estimated growth in the diesel pool in 2022 and high feedstock prices, Post estimates India's biodiesel blend ratio at approximately 0.07 percent. Estimated biodiesel volume procured for blending with on-road diesel has declined to less than 30 percent of total use. Blended diesel buyers are limited to certain OMC outlets, railways, certain State Road Transport Corporations, road transport fleets, and port authorities. Retail biodiesel prices are benchmarked with the India retail diesel price, with the current Integrated Goods and Services Tax rate at 12 percent. [28] Remaining biodiesel demand comes from various stationary applications. Smaller buyers will continue to procure biodiesel for small and medium scale enterprises. Biodiesel use applications include agriculture (irrigation pumps and tractors), brick kilns, mobile communication towers, and backup power generators.

PRODUCTION

In 2022, India will produce close to 185 million liters of biodiesel, three percent above last year. India has more than seven plants with a theoretical annual production capacity of one billion liters. However, total operating capacity remains at 577 million liters, as most plants remain closed from/since the pandemic. High feedstock prices, like imported palm oil, palm stearin, and domestically available animal tallows have reduced operating margins. Production capacity ranges from 11 million to 225 million liters for existing refineries. There are approximately seven plants under construction with a cumulative capacity of 350 million liters. Smaller production facilities operate with single kettle or basic processing, and most do not have glycine refining, methanol recovery, or post treatment.

Biodiesel producers use non-edible industrial oil (palm stearin), UCO, animal fat, tallow, and other oils (sludge, acidic oils, and tree-borne oils, etc.) as primary feedstocks to produce biodiesel, utilizing 32 percent of the total installed capacity. With the bull run in palm oil and limited animal tallow supplies, most functional producers utilized palm acid oil in 2021. A limited number of biodiesel plants function during the winter months due to the operational impacts posed during the high palm growth cycle.

[28] The Integrated Goods and Services Tax, or IGST, is levied when there is an interstate transfer of goods or services. It is one of the three components of the Goods and Sales Tax.

Production capacity has changed little over the years. Apart from UCO, there are no official regulations for supplying available feedstocks for biodiesel production.

India's biodiesel industry remains in its nascent stage as *jatropha* and other inedible oilseeds grown on non-arable lands have failed to reach necessary yields to make cultivation economically feasible, and there is no supply of virgin (first use) animal fat or vegetable oils available for biodiesel. As a result, most biodiesel manufacturers are susceptible to global vegetable oil price volatility. Supply chain and shipment issues will continue to pose challenges this year. Additionally, export controls adopted by Indonesia and Malaysia to fulfil their domestic biodiesel mandates will impact palm acid oil/palm stearin feedstock availability.

TRADE

India's 2022 biodiesel exports are expected to increase a few hundred liters to 10 million liters. Post revised its 2021 export estimates to six million liters, reflecting latest trade statistics. Nearly all biodiesel is exported to Spain and the Netherlands, taking advantage of EU incentives provided to waste-based biofuels. The Indian government only permits biodiesel exports from its Special Economic Zones and Export Oriented Units. India's biodiesel imports remain negligible due to established import restrictions.

SECTION V. ADVANCED BIOFUELS

The 2018 National Biofuels Policy indicates a 120-160 MMT annual surplus of available biomass, which, if converted, could produce 30 billion liters of cellulosic ethanol. The Indian government previously indicated that 5-10 billion liters of cellulosic ethanol could be in the fuel mix by 2030. India has four operational advanced biofuel plants, including a pilot and a demonstration plant, with a cumulative annual production capacity of 1.75 million liters of cellulosic ethanol.[29] Actual production is a mere fraction of this figure. There are several additional advanced biofuels plants in development, but far from reaching commercialization (Table 14).

Table 14. India: Existing and Proposed Advanced Biofuels Plants

Company	Status	Scale/Technology	Annual Production Capacity (Million Liters)
Assam Bio Refinery	Planned	Commercial/Cellulosic ethanol	3
Indian Glycols Kashipur	Operational	Demo/Cellulosic ethanol	0.75
Praj Biofuels	Operational	Demo/Cellulosic ethanol	1
Shell Bengaluru	Operational	Demo/Drop-in fuels	0.6
Numaligarh Refinery Limited	Planned	Commercial/Cellulosic ethanol	60
IOCL Panipat	Planned	Commercial/Cellulosic ethanol	30
BPCL Bargarh	Planned	Commercial/Cellulosic ethanol	30
HPCL Bhatinda	Planned	Commercial/Cellulosic ethanol	30
IOCL Panipat	Planned	Demo/Cellulosic ethanol	0.75
Indian Institute of Petroleum, Dehradun	Operational	Pilot/HEFA Biojet	0.01
IOCL Panipat	Planned	Commercial/3G ethanol	33

Source: Biofuture Platform, 2018.

Technologies are available that convert waste into biofuels and other biochemicals but are at a nascent stage and must be proven on a commercial scale (Table 15). For example, the National Institute for Transforming India (NITI Aayog) estimates that India annually generates 62 MMT of municipal solid waste (MSW), with significant potential for use in drop-in fuels[30] and energy production. As of February 2021, five projects with a cumulative capacity of 74.7 megawatts (MW) have been approved in principle by the government.

On November 20, 2020, MoPNG signed a memorandum of understanding with select oil and gas companies to establish 5,000 compressed biogas (CBG) plants in India with a cumulative capacity of 15 MMT by 2023/2024. A financial outlay of $27.4 billion under the Sustainable Alternative Toward Affordable Transportation program is in place to fund plant investments.[31]

[29] Cellulosic ethanol uses bagasse, wood waste, agricultural and forestry residues, among others as feedstock sources.

[30] A drop-in fuel is a synthetic and completely interchangeable substitute for conventional petroleum-derived hydrocarbons and does not require engine, fuel system or the fuel distribution network adaptation.

[31] According to MoPNG, around 1,500 CBG plants remain under development (Source: PIB).

Table 15. India: Biofuel Research and Development Classification

Fuel	Substitute	Technologies Deployed
Diesel	*Biodiesel, **HDRD (Green Diesel), Bio-based oxygenates (alcohols and ethers)	Esterification, Hydroprocessing, Fermentation, Syngas conversion
Aviation Turbine Fuel (ATF)	**Sustainable Aviation Fuel (or, Bio-ATF)	Hydroprocessing, Sugar conversion, alcohol-to-jet, Fischer–Tropsch process
Gasoline (Petrol/Motor Spirit)	*Ethanol (1G), **Ethanol (2G), **Methanol, Green (drop-in) gasoline	Fischer–Tropsch process, Gas Fermentation, Alcohol-to-gasoline, Hydroprocessing, Pyrolysis/Catalytic Cracking
Compressed natural gas (CNG)/piped natural gas (PNG)	*Bio-CNG/Bio-PNG, HCNG, Bio-H2	Waste Fermentation
Marine Fuel/Industrial Fuel Oil	**Green heavy distillate, biomass-derived oils	Hydroprocessing, Pyrolysis/Fluid catalytic cracking, Hydrothermal Liquefaction, MSW-thermochemical processing

*Indicates technologies are available | **Indicates emerging technologies (in development)
Source: DBT, Ministry of Science and Technology.

Presently, farmers are encouraged to practice intercropping with a variety of biomass crops including oilseeds. Suitable supply, distribution, collection, and fair price mechanisms are planned by the Indian government, including guaranteed buyback via ethanol purchase agreements with cellulosic ethanol suppliers to attract greater investment. Bio-compressed natural gas is a major potential by-product of cellulosic ethanol biorefineries and can be used as a transportation fuel. The product has also been given offtake assurances by public sector natural gas companies.

The Technology Information, Forecasting and Assessment Council's (TIFAC) 2018 report estimates India's total dry biomass generation at approximately 683 MMT across 11 crops suitable for biofuel production. However, only 178 MMT (26 percent) was found to include surplus crop residue. It is estimated that India could potentially produce 51.35 billion liters of cellulosic ethanol (2G), based on 178 MT of annual surplus crop residues (Source: TIFAC).

The aviation biofuels sector in India is currently limited to the Council of Scientific and Industrial Research–Indian Institute of Petroleum pilot program to produce Sustainable Aviation Fuel (SAF) using plant-derived, non-edible wastes and low-cost oils for drop-in biofuel for air and road transport purposes. The joint venture claims that the technology reduces SAF production costs when compared to the competing two-step technologies available in the United States or Europe (Source: Indian Institute of Petroleum). Since 2020, the pilot program has produced 4,000 liters of aviation biofuel and was used to operate a single flight.[32] However, limited availability of feedstocks (e.g., UCO, vegetable oils, etc.), along with high capital investment, operational expenditures, and competing technologies all impede viable commercial production for aviation biofuels in India.

SECTION VI: NOTES ON STATISTICAL DATA

For a comprehensive coverage of notes on statistical data, appendix and role of institutional stakeholders under India's Biofuel Policy, please refer to the USDA GAIN Biofuels Annual 2020 (IN0122).

[32] See: Economic Times; SpiceJet operates India's first biofuel-powered flight from Dehradun to Delhi. August 27, 2018.

Attachments:

No Attachments