SIAM
Society of Indian Automobile Manufacturers
Building the Nation, Responsibly

Ethanol's Role in INDIA'S DECARBONISATION JOURNEY

Context Paper 2025

जैविक पहल
BIO-INITIATIVE
by SIAM

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About SIAM

The Society of Indian Automobile Manufacturers (SIAM) is an apex national body representing all major vehicle and vehicular engine manufacturers in India. It is a society with charitable objectives registered under the Societies Registration Act, 1860. Its objectives include enhancing the contribution of automobile industry to the growth and development of Indian economy, assisting the automobile industry to meet its social obligations and encouraging the efficiency of industry in general and automobile industry particularly in India. SIAM focuses on activities related to improvement of environment and ensuring safety and protection of automobile vehicle users and public at large. Recognising these objectives, SIAM has been granted registration under the Income Tax Act, 1961 as an institution with charitable purpose.

To meet these objectives, SIAM works closely with stakeholders in the formulation of the economic, environment and commercial policies, regulations and standards relating to automobiles. It provides economic and statistical information as well as technical and public policy services to the stakeholders on behalf of Indian Automobile Industry. It publishes Monthly Industry Statistics, Monthly Commodity Price Monitor and other periodic reports. SIAM organises seminars and workshops on the subjects of topical relevance and interest to the industry. It also carries out various public policy activities, particularly in the field of Road Safety and Environment.

SIAM works closely with various Government departments, both at Central and State level and with international bodies like International Organisation of Motor Vehicle Manufacturers (OICA), International Motorcycle Manufacturers Association (IMMA) and coordinate with other counterpart international associations.

SIAM, jointly with ACMA and CII, organises the Auto Expo – The Motor Show, an exhibition showcasing the trends in the Automobile Industry.

SIAM aims to promote Sustainable Mobility through focused initiatives and campaigns on जैविक पहल (Bio Initiative), हरित हाइड्रोजन (Hydrogen Mobility), गैसगतिशीलता (Gas based mobility), विधुतीकरण (Electrification), चक्रीयता (Circularity) and सुरक्षितसफर (Safe Journey) in alignment with Sustainable Development Goals, 2030 and Net Zero by 2070.

Bridging the Carbon Gap: Biofuels as a Solution

On 12 December 2015, world leaders at the United Nations Climate Change Conference (COP21) in Paris set a target to reduce global greenhouse emission to hold global temperature rise to well below 2°C above pre-industrial levels and target limiting it to 1.5 °C above pre-industrial levels.[i] This has been a major topic of discussion for the countries signatory to the commitment under the UNFCCC over the years.

A climate study by Global carbon project warns that the remaining carbon budget to limit warming to 1.5°C is now just 130 billion tonnes of CO_2. The current pace of emissions is over 40 billion tonnes per year. At this pace of emissions, the limit of carbon budget could be exhausted in just three years. The carbon budget refers to the maximum amount of carbon dioxide that can be emitted into the atmosphere while still having a chance to meet global temperature goals. Currently, the global warming is already at around 1.24 °C above pre-industrial levels and we are not very far away from the target taken by the countries at Paris conference.[i]

Reduction in the carbon emissions is the need of the hour and decarbonisation is the way ahead to achieve the same. Governments across the globe are primarily aiming to systematically cut down emissions across all areas of the economy: from how we generate power to how we build, manufacture, and transport. As we go about achieving decarbonisation, we need to perform critical actions like transitioning to renewable energy sources, transforming heavy industries, decarbonising transport, cutting building emissions, regenerating land and nature, and focussing on building a circular economy.

GHG Emissions by Sector and End Use - Global, 2021

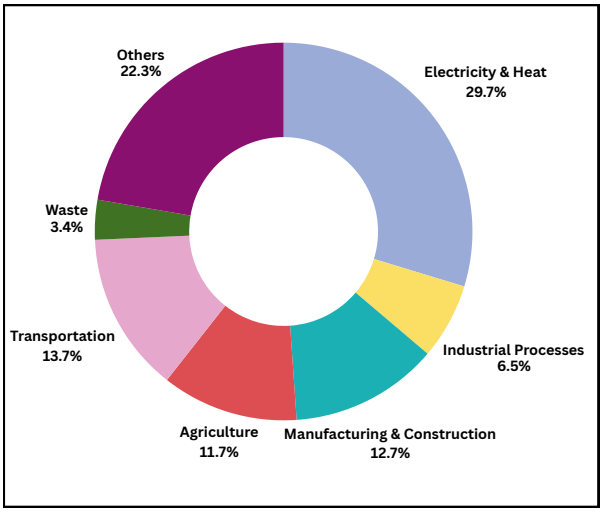


Figure 1: Sector wise GHG emissions 2021, Global (WRI).[xvi]

As of 2021, energy sector (75.7%) was the largest contributor to the Greenhouse gas emissions (GHG) emissions globally, followed by agriculture (11.7%) and industrial processes (6.5%). In the energy sector electricity and heat is the largest emissions contributor with 29.7% emissions followed by transportation at 13.7%. Over 94% of the fuel used for transportation is petroleum based, which includes gasoline and diesel, and results in direct emissions.

Analyzing the emissions from transportation sector, road transport has one of the largest carbon footprints among all the available modes due to high penetration of personal vehicles among people. Further, in road transportation, light duty vehicles are the largest contributors to carbon dioxide emissions followed by heavy trucks used for logistics and freight transport. Other sector contributing to emissions from transportation sector are shipping, pipeline and rail. To achieve the aim of limiting the global temperature levels, transportation is the key sector to curb CO_2 emissions.

Percentage Split of CO_2 Emissions by Sector - India, 2021

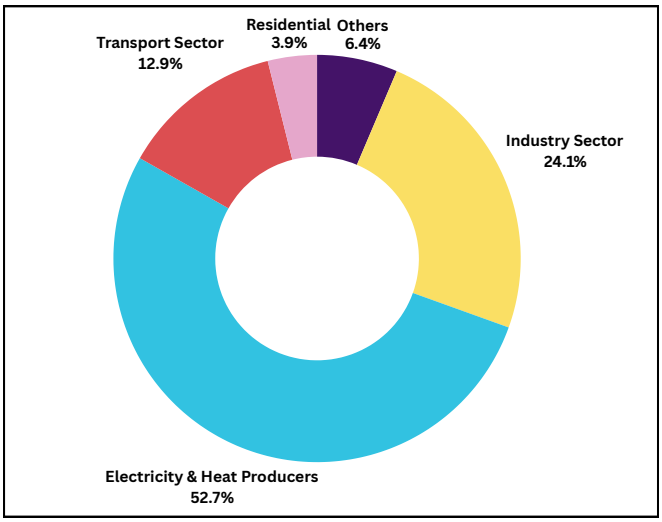


Figure 2: Sector wise GHG emissions 2021, Global (WRI) .[xvii]

Electricity generation is the largest contributor of carbon dioxide emissions followed by industry and transportation sector. With the growth of population and disposable income the size of the vehicle parc will increase and a shift away from the conventional fuel sources is needed to curb these emissions and meet the net zero emission goals.

If the aim of decarbonization is to be achieved one must focus on reducing the lifecycle emissions from vehicles

already on the road without requiring any modifications to existing engines. This also aligns well with the urgent need for scalable, low-emission solutions in the transportation sector. Unlike electric mobility, the adoption of biofuels blended with conventional gasoline and diesel does not require new infrastructure, making it a viable, nationwide solution. For a country like India, increasing the use of domestically produced biofuels helps reduce dependence on crude oil imports, thereby lowering vulnerability to global supply disruptions and price volatility.

The adoption of biofuels is closely aligned with several Sustainable Development Goals (SDGs) established by the United Nations as part of the 2030 Agenda for Sustainable Development. Specifically, it supports SDG 7 (Affordable and Clean Energy) by promoting cleaner energy alternatives; SDG 8 (Decent Work and Economic Growth) through the creation of green jobs and rural employment; SDG 12 (Responsible Consumption and Production) by encouraging the sustainable use of resources; and SDG 13 (Climate Action) by contributing to the reduction of greenhouse gas emissions and enhancing climate resilience.

In India, the adoption of biofuels supports Mission LiFE by promoting cleaner energy use and reducing carbon emissions. It encourages sustainable lifestyle choices in transportation, aligning with the mission's goal of fostering environmentally responsible daily habits.

Types of Biofuels

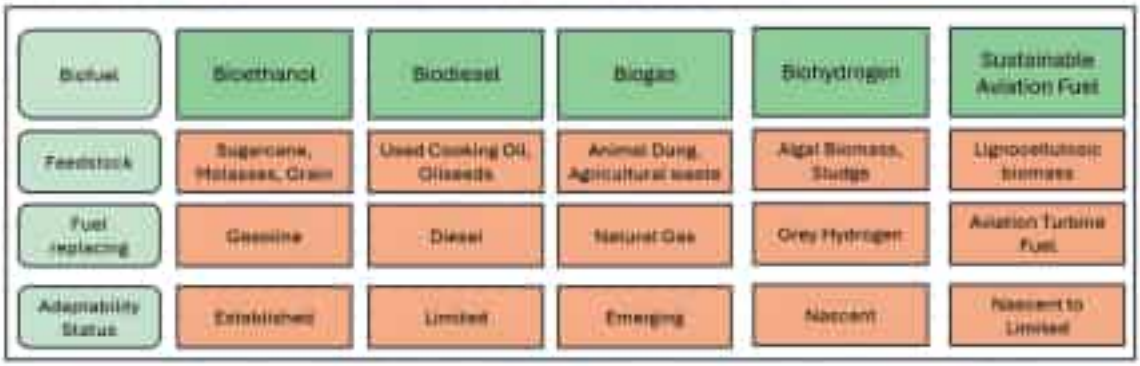


Figure 3: Types of Biofuels

Ethanol: Ethanol is a renewable fuel that is made from the fermentation of plant starches and sugar. It is an alcohol used as a blending agent with gasoline to increase octane and tone down carbon monoxide, particulate matter and other product emissions. This is also a byproduct of the chemical reaction with ethylene and other types of petroleum products. It can be produced in many ways like fermentation, distillation, and dehydration.

Biodiesel: This is made from vegetable oil, recycled cooking oil, soybean, palm oil, peanut oil, canola oil, animal fat, and fatty acids by a process of conversion known as transesterification.

Due to its versatile properties, it can be used as a replacement for petroleum and is biodegradable. The toxins produced are comparatively less as compared to petroleum. It is safer to handle. The energy content in Biodiesel is about 90% that of petroleum diesel.[iv]

Biogas: Biogas is a mixture of gases - primarily methane (CH_4), carbon dioxide (CO_2), and hydrogen sulphide (H_2S) - produced through the anaerobic digestion of organic biomass, such as manure, agricultural residues, food waste, and green waste. Due to its high methane content, biogas can be combusted similarly to natural gas, making it a viable renewable energy alternative. It is used as a cooking fuel in rural households and is supplied direct from biogas plant through pipe. It is used as an automotive Fuel (CBG) by replacing CNG in vehicles. It is also used as a fertilizer when digestate slurry from biogas plants is used as an organic fertilizer.

Bio-hydrogen: It is a renewable energy source, similar to biogas, produced through biological processes involving microorganisms such as bacteria, algae, and archaea. Common methods for biohydrogen production include photo fermentation, dark fermentation, direct photolysis, and indirect photolysis. India is scaling its National Green Hydrogen Mission. Biohydrogen can complement electrolysis by leveraging abundant agri-waste and biomass. Currently bio-hydrogen in India is at a nascent stage but it holds potential to replace grey hydrogen from Steam Methane Reforming (SMR) in decentralized applications.

Among all biofuels, ethanol is the most widely adopted in India, primarily due to the country's well-established Ethanol Blending Programme (EBP), supported by robust policy frameworks, a strong sugarcane and grain production infrastructure, and clearly defined blending mandates. India currently utilizes first-generation feedstocks (such as sugarcane and grains) and is progressively expanding into second-generation (2G) technologies, which use agricultural residues and other lignocellulosic biomass.
In contrast, biodiesel adoption remains limited, relying largely on Used Cooking Oil (UCO) and non-edible oilseeds. However, the fragmented nature of feedstock collection and weak enforcement of blending targets hinder its widespread implementation.

Types of Ethanol

Ethanol production can be classified into different types based on the feedstock used and the generation of production technology, with each generation employing distinct biomass sources and conversion methods.

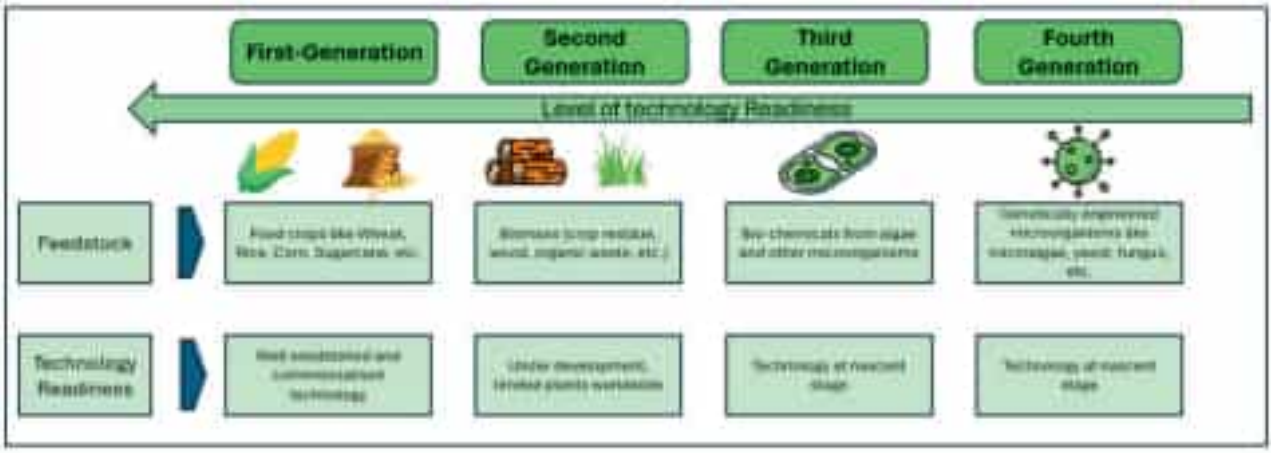


Figure 4: Different Types of Ethanol

First-Generation Ethanol: It is produced using conventional technologies from food-based feedstocks such as sugarcane, starch-rich grains, vegetable oils, and animal fats. While the production process is technologically straightforward and well-established, it raises concerns regarding food security, as it competes with food supply and can lead to rising food prices. In India, 1G ethanol production is at a fully commercialized and mature stage, with large-scale production facilities, Government support through blending mandates, and robust infrastructure driving widespread adoption.

Second-Generation Ethanol: Second-generation ethanol refers to advanced, sustainable biofuels produced through thermochemical or biochemical conversion processes using non-food biomass, such as agricultural residues e.g., straw, husks, stems, forest waste, wood chips, and fruit peels. These fuels mitigate the food-versus-fuel conflict and typically generate lower greenhouse gas emissions compared to 1G fuels. However, 2G ethanol production is technologically complex, cost-intensive and requires establishment of a waste collection supply chain adding to costs and limits its scale. In India, it is at an early commercial and developing stage, with a few operational plants supported by Government incentives, but broader adoption is still constrained by economic and technical challenges.

Third-Generation Ethanol: Third-generation ethanol is produced from microorganisms such as algae, which can be cultivated on non-arable land and with non-potable water, thus avoiding competition with food and reducing pressure on freshwater resources[v].

Fourth-Generation Ethanol: Fourth-generation ethanol involves the use of genetically engineered crops or microorganisms that are designed to absorb higher levels of carbon dioxide from the atmosphere.[vi] These crops are processed using 2G technologies, and some 4G biofuels are considered carbon-negative, meaning their production results in a net reduction of atmospheric carbon. In India, 4G ethanol remains at a conceptual and experimental stage.

Benefits of Ethanol

Emission Reduction Potential of Ethanol-Blended Fuel

The higher hydrogen-to-carbon ratio for ethanol as compared to conventional petrol leads to lower emissions.

Closed Carbon Loop

Linear Carbon Pathway for Gasoline

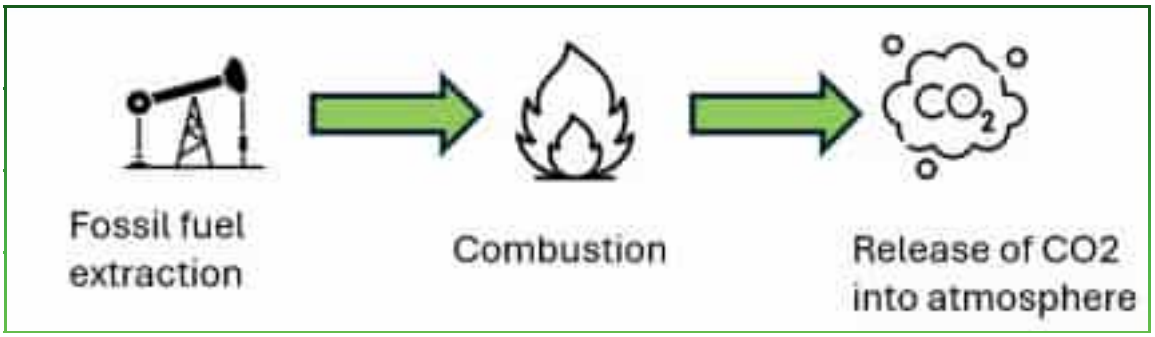


Figure 5: Carbon emission pathway for Gasoline as a fuel

Gasoline is a non-renewable source of energy derived from crude oil. Its lifecycle follows a linear carbon pathway starting from fossil fuel extraction, refining and combustion in internal combustion engines. This results in the direct release of CO_2 into the atmosphere. Since there is no natural mechanism to reabsorb this emitted CO_2, it contributes directly to the buildup of greenhouse gases and exacerbates climate change.

In contrast, ethanol represents a renewable source of energy. Its lifecycle begins with crops that absorb atmospheric CO_2 during photosynthesis. These crops are then used to produce ethanol, which is combusted in vehicles. Although this process emits CO_2, it is largely reabsorbed by the next crop cycle, thus forming a closed-loop or circular carbon cycle. This biogenic cycle significantly reduces net carbon emissions, making ethanol a more sustainable and environmentally responsible alternative to gasoline. A technical paper published in ARAI technical bulletin showcases the biogenic nature of CO_2 from Ethanol combustion. The research conducted

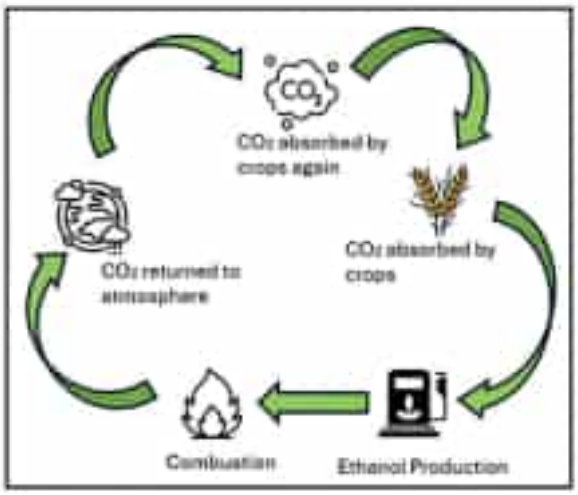


Figure 6: Carbon emission pathway for ethanol as a fuel

in India by a premier nuclear research agency established that E20 (20% Ethanol blended fuel has 14% biogenic CO_2 at vehicle tailpipe and this figure is 79% for E85 fuel. This establishes the fact, through scientific experimentation, that ethanol combustion causes less GHG effect.

Reduced Crude Oil Dependency

Furthermore, adopting biofuels can reduce crude oil import dependency, enhance energy security, and support rural economies in the country. Fuel ethanol blending by public sector OMCs under India's Ethanol Blending Program has saved approximately INR 1.13 lakh crore in foreign exchange from 2014 to 2024, reducing the need for crude imports by 19.3 million metric tonnes.[vii] Ethanol blending has also helped improve the financial health of farmers by accelerating sugar factory payments to cane farmers, totaling INR 92,400 crore over the past 10 years.[viii]

Global Perspective on Biofuel Blending

The United States is the world's largest producer of ethanol, having produced over 16 billion gallons in 2024.[ix] Together, the United States and Brazil produce 80% of the world's ethanol. The vast majority of U.S. ethanol is produced from corn, while Brazil primarily uses sugarcane.

Figure 7: World Fuel Ethanol Production (Mil. Gal.)

Source: RFA analysis of public and private data sources.[xi]

The United States being a net surplus nation in terms of fuel ethanol production is an exporter to more than 87 countries. Despite that US imports some quantity ethanol from Brazil.[x] As of 2022, the United States had 275 biofuel facilities of which four-fifths was for fuel ethanol and 72 plants for biodiesel.

Brazil is the world's second-largest producer of ethanol and third-largest producer of biodiesel. Brazil has 422 biofuel plants, including 291 ethanol plants, 38 biodiesel plants, and 4 biomethane plants. Brazil maintains a mandatory ethanol blending rate of 27% for gasoline, unchanged since 2015, with hydrous ethanol (E100) widely used as a standalone fuel. While there is no commercial-scale production of renewable diesel (HDRD) or sustainable aviation fuel (SAF) yet, Brazil's first HDRD plant is under development in Manaus, and select ethanol plants are certified to supply SAF feedstock to international producers.

The European Union is among the world's largest biofuel consumers, with 2023 bioethanol consumption reaching a record 6.58 billion liters. The EU has also emerged as a significant importer of bioethanol, bringing in approximately 1.24 billion liters in 2023, with the United States and Brazil as major suppliers.

The EU's advanced biofuels share remains modest but is projected to expand under the Renewable Energy Directive II (REDII), which mandates 5.5% advanced biofuels by 2030, alongside ambitious SAF blending targets rising to 70% by 2050.

China is the world's fifth-largest fuel ethanol producer, with a licensed production capacity of 7.7 billion liters across 22 grain-based ethanol plants, yet actual production remains low at 3.9 billion liters in 2023. Biodiesel production is also underutilized domestically, despite a total capacity of 3.7 billion liters from 48 plants. China's Sustainable Aviation Fuel (SAF) industry is emerging, with the operational Sinopec Zhenhai refinery (100 million liters/year) and over 3 billion liters of SAF capacity expected by 2026.

India's Ethanol Blending Journey

Ethanol blending programme was launched by the Government of India in the year 2003, with a 5% ethanol blending mandate in 9 states and 4 union territories. The aim was to reduce dependence on imported crude oil, promote the use of renewable fuels, and support the domestic sugar industry by creating an additional market for surplus sugarcane and molasses.

Initial Hiccups and the Inflection Point

The program faced several challenges like non-inclusion of conversion of grain to ethanol, high taxation of ethanol, limited availability of feedstock and infrastructure. This led to the actual blending levels staying as low as 1.4% in the initial years and a push was required by the Government. In 2006-07, the Ministry of Petroleum and Natural Gas extended 5% ethanol blending across 20 states and 4 UTs, laying the groundwork for nationwide coverage.

Despite this expansion, actual ethanol supply fell short of targets, with blending levels averaging only 1-1.5% nationally during this period. Till 2016-17 the blending levels of ethanol stayed as low as 2% and a formal push by the Government was needed to further this trend.

To address the challenges of EBP, the National Biofuels Policy was introduced in June 2018. The policy broadened the scope of raw materials beyond sugarcane to include damaged grains, surplus food stocks, and agricultural residues. The Government set a target of 20% ethanol blending by 2030, aiming to reduce crude oil imports, curb vehicular emissions, and boost rural incomes.

In December 2020, the Government of India released the Roadmap for Ethanol Blending in India 2020-25, advancing the E20 target from 2030 to 2025-26 to reduce crude oil import dependency which was over 85% that time and provide alternative income avenues for farmers. Key reforms such as differentiated ethanol pricing based on feedstocks, vehicle compatibility mandates, and production incentives were introduced. Building on this, India achieved 10% ethanol blending nationwide by June 2022, five months ahead of schedule supported by expanded distillation capacity and feedstock diversification.

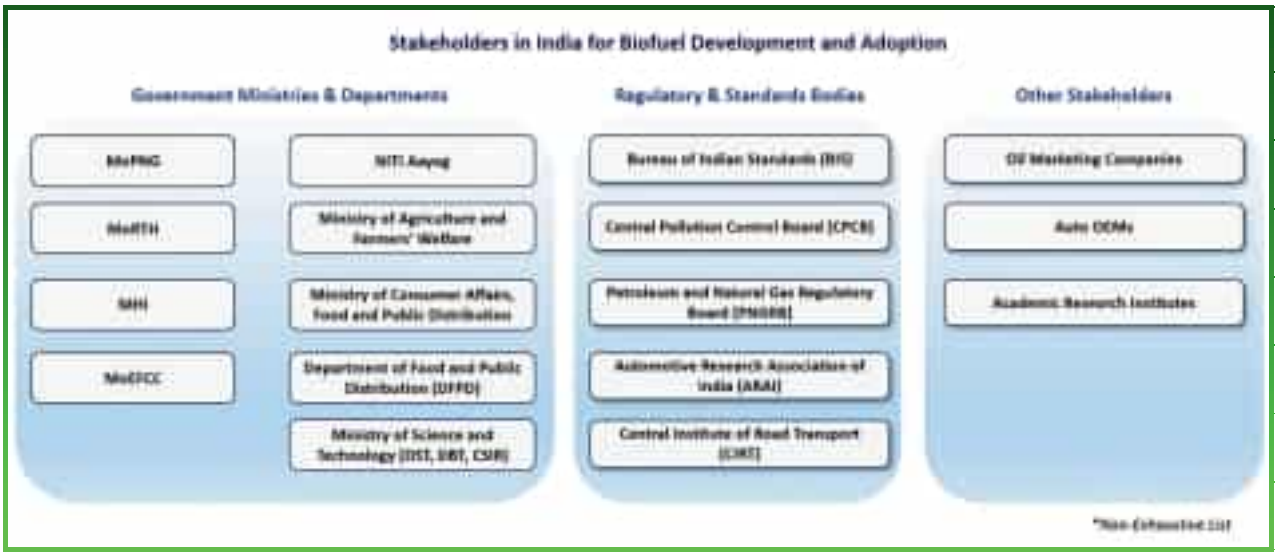


Figure 8: Stakeholder in India for Biofuel Development and Adoption

The National Policy on Biofuels was also amended in 2022, reaffirming the 2025-26 E20 target and introducing a 5% biodiesel blending target by 2030 to deepen the country's low-carbon fuel transition.

During the 2023-24 ethanol supply year, India recorded an average blending rate of 14.6%, marking a steady rise from previous years and reflecting improved ethanol availability.[xi] and production capacity.

To meet the advanced E20 target, oil marketing companies scaled up ethanol procurement, while the Government approved the use of surplus rice stocks, with 5.2 million tones allocated for ethanol production during this period.[xii]

The Journey From E10 to E20

The journey of the nation towards E10 was gradual & experimental. It began with pilot projects in 2001 supplying 5% ethanol-blended petrol at select retail outlets. Till 2013-14, blending rates hovered between 0.1% and 1.5% until there were multiple policy interventions, such as differential pricing and incentives for ethanol production from molasses and other feedstocks, that helped improve ethanol supply. By 2020-21, India achieved 8.5% blending and 20% blending in July 2025, 5 years ahead of target as envisaged by Hon'ble Prime Minister.

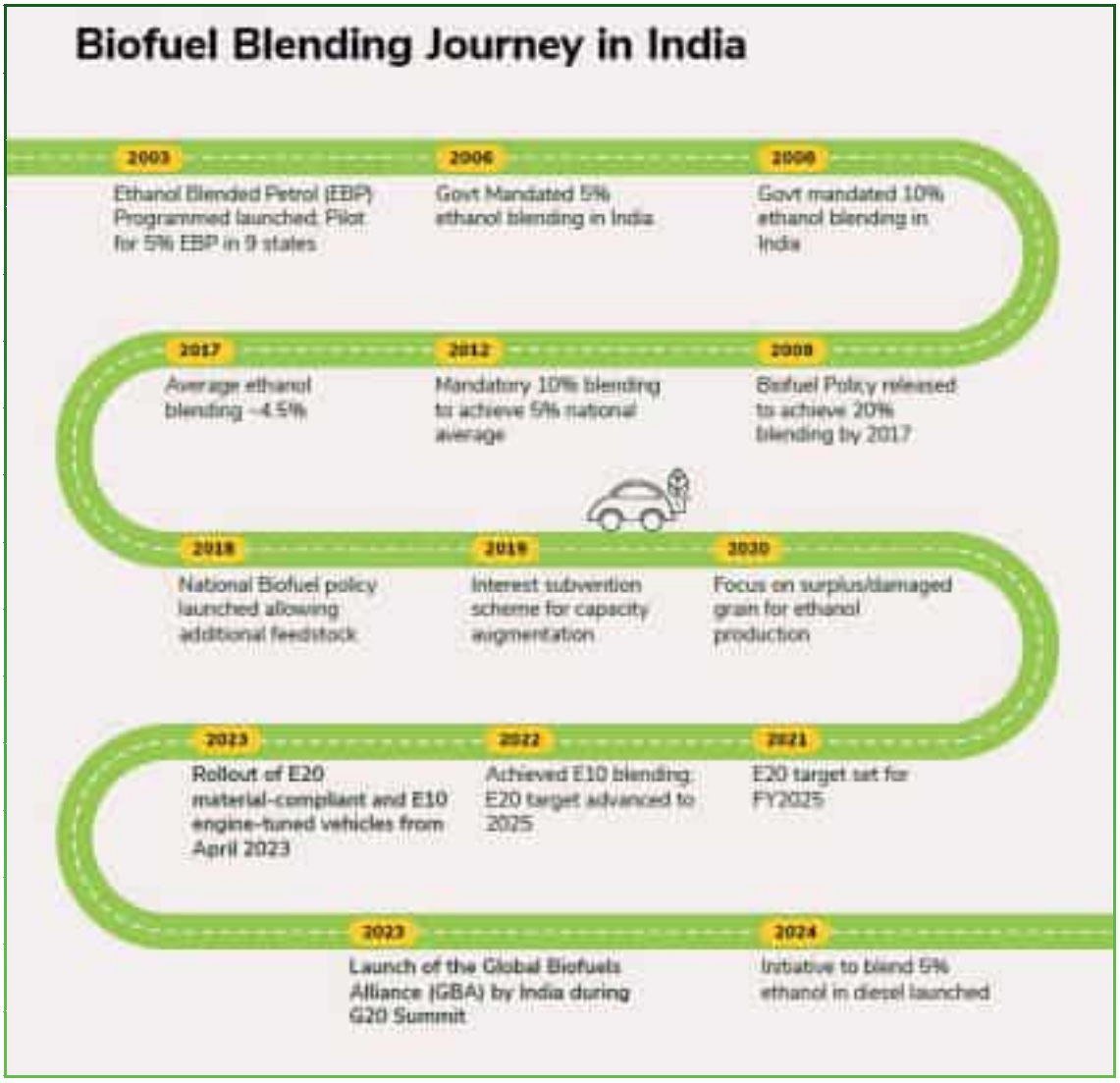


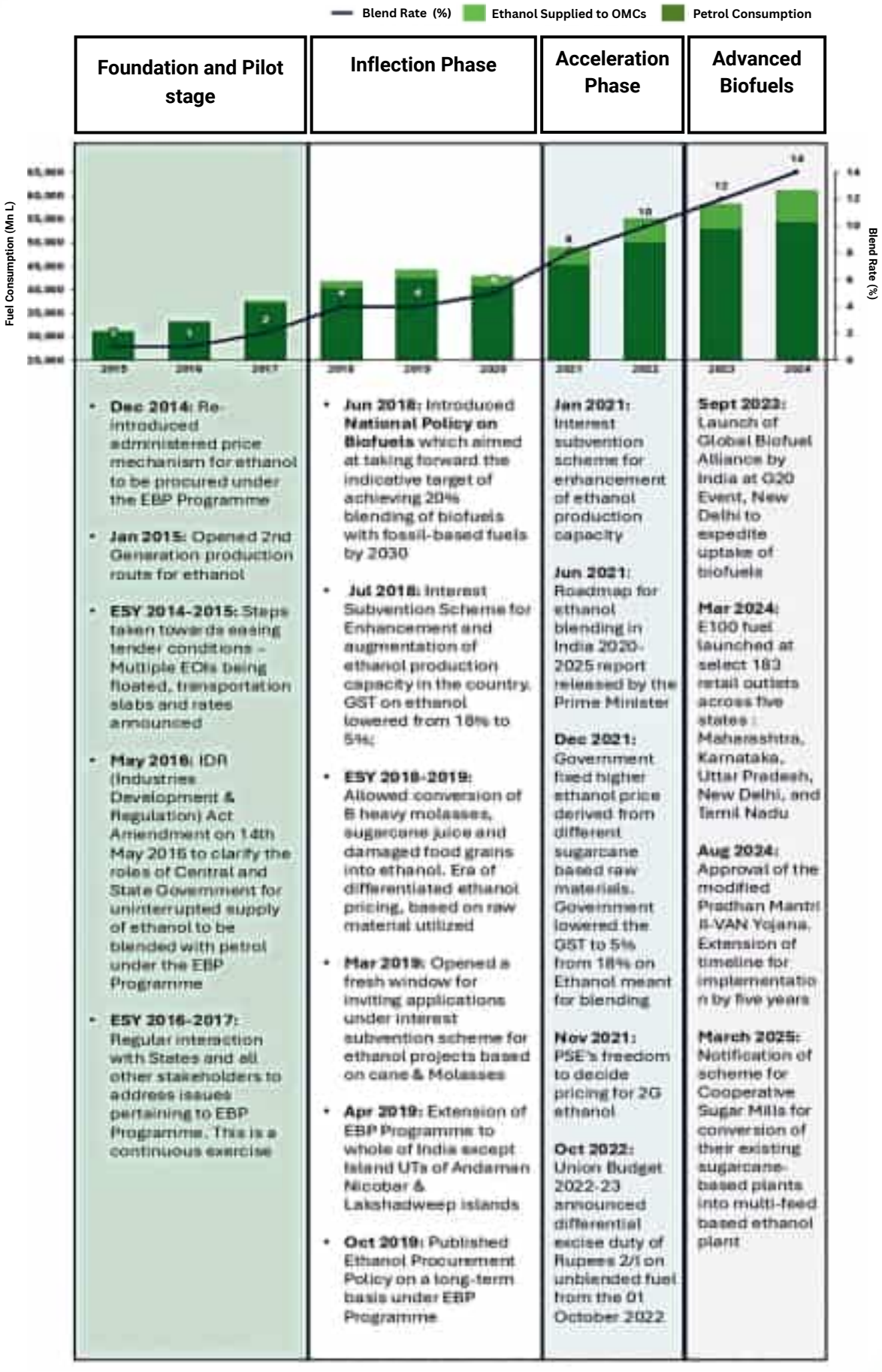
Figure 9: Biofuel Blending Journey in India

Unlike E10, India's transition to E20 was more aggressive. Originally targeted for 2030 under the National Policy on Biofuels 2018, the deadline for 20% blending was advanced to 2025 following Cabinet-level directives. From April 2023, E20 material-compliant, E10 engine tuned vehicles began rolling out nationwide. Most of the original equipment manufacturers in India have already updated their vehicles with E20 fuel-compliant engines. [xiii] For large scale adoption of E20 ethanol production capacity is being expanded significantly, with targeted capacities reaching 760 crore litres from molasses and 740 crore litres from grains by 2025-26.

Owing to the support by the Government and vehicle readiness by the OEMs the ethanol blending in gasoline target of 20% has been achieved 5 years ahead of its schedule. As a way forward, the Government is looking to achieve the higher percentage of blends and steps are being taken both on the supply side by the OMCs and vehicle readiness by the auto OEMs.

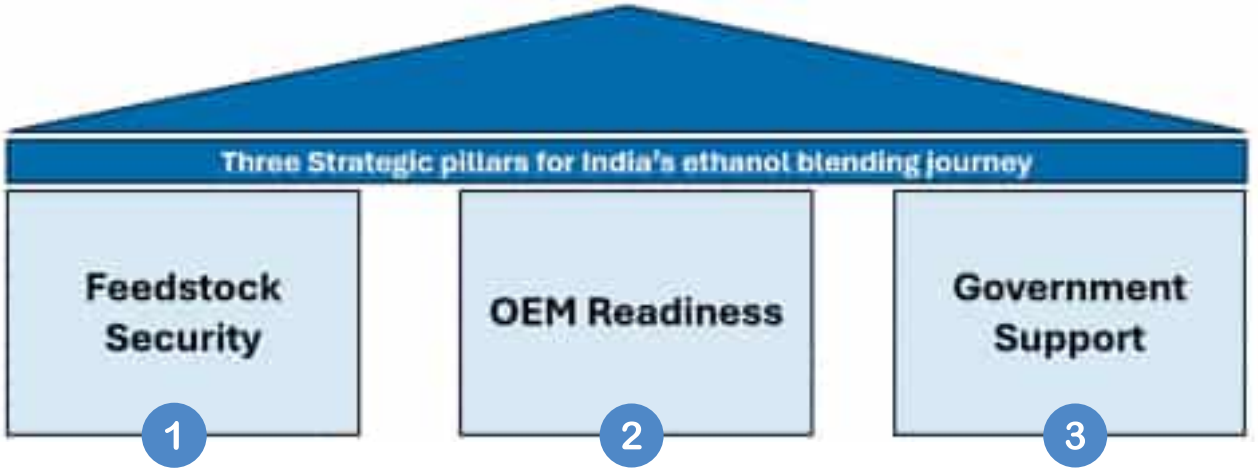
Support By The Government

The Government of India has played a central role in advancing the Ethanol Blending Programme through targeted policy measures and institutional support. Since 2014, reforms have focused on ensuring price viability for various feedstocks, providing financial support to distilleries, and simplifying regulatory processes. Measures included administered and differential ethanol pricing, interest subvention schemes, emission and safety standards for E20-compliant vehicles, and easier environmental clearances. Tripartite agreements between OMCs, banks, and mills further supported capacity expansion. These interventions laid the groundwork for scaling up production and infrastructure aligned with India's E20 roadmap.


Blend Rate (%)
Ethanol Supplied to OMCs
Petrol Consumption
Fuel Consumption (Mn L)
Blend Rate (%)
Foundation and Pilot stage
Inflection Phase
Acceleration Phase
Advanced Biofuels
• Dec 2014: Re-introduced administered price mechanism for ethanol to be procured under the EBP Programme
• Jan 2015: Opened 2nd Generation production route for ethanol
• ESY 2014-2015: Steps taken towards easing tender conditions – Multiple EOIs being floated, transportation slabs and rates announced
• May 2016: IDR (Industries Development & Regulation) Act Amendment on 14th May 2016 to clarify the roles of Central and State Government for uninterrupted supply of ethanol to be blended with petrol under the EBP Programme
• ESY 2016-2017: Regular interaction with States and all other stakeholders to address issues pertaining to EBP Programme. This is a continuous exercise
• Jun 2018: Introduced National Policy on Biofuels which aimed at taking forward the indicative target of achieving 20% blending of biofuels with fossil-based fuels by 2030
• Jul 2018: Interest Subvention Scheme for Enhancement and augmentation of ethanol production capacity in the country. GST on ethanol lowered from 18% to 5%;
• ESY 2018-2019: Allowed conversion of B heavy molasses, sugarcane juice and damaged food grains into ethanol. Era of differentiated ethanol pricing, based on raw material utilized
• Mar 2019: Opened a fresh window for inviting applications under interest subvention scheme for ethanol projects based on cane & Molasses
• Apr 2019: Extension of EBP Programme to whole of India except Island UTs of Andaman Nicobar & Lakshadweep islands
• Oct 2019: Published Ethanol Procurement Policy on a long-term basis under EBP Programme
Jan 2021: Interest subvention scheme for enhancement of ethanol production capacity
Jun 2021: Roadmap for ethanol blending in India 2020-2025 report released by the Prime Minister
Dec 2021: Government fixed higher ethanol price derived from different sugarcane based raw materials. Government lowered the GST to 5% from 18% on Ethanol meant for blending
Nov 2021: PSE's freedom to decide pricing for 2G ethanol
Oct 2022: Union Budget 2022-23 announced differential excise duty of Rupees 2/l on unblended fuel from the 01 October 2022
Sept 2023: Launch of Global Biofuel Alliance by India at G20 Event, New Delhi to expedite uptake of biofuels
Mar 2024: E100 fuel launched at select 183 retail outlets across five states : Maharashtra, Karnataka, Uttar Pradesh, New Delhi, and Tamil Nadu
Aug 2024: Approval of the modified Pradhan Mantri JI-VAN Yojana. Extension of timeline for implementation by five years
March 2025: Notification of scheme for Cooperative Sugar Mills for conversion of their existing sugarcane-based plants into multi-feed based ethanol plant

Way Forward

As India progresses towards higher blending rates like E27 or E30, the future roadmap must be built on three critical pillars: feedstock security, OEM readiness, and Government support.



First, ensuring a reliable and diversified feedstock supply is essential. With grain-based ethanol production rising rapidly and surpassing 50% production share in 2024 and second-generation technologies still in early stages, India must invest in expanding maize cultivation, optimizing surplus rice utilization, and fast-tracking 2G ethanol commercialization to meet future demand without compromising food security.

Second, OEMs must scale up production of higher blend ethanol-compatible vehicles, including Flex Fuel Vehicles. Indian OEMs introduced E20 material compliant vehicles from April 2023 and launched E20 engine compliant vehicles from April 2025. However, since a large portion of vehicle PARC in the country uses E10 engine compliant vehicles, backward compatibility testing for higher blends are vital for a seamless transition.

Third, robust Government support is required not only in the form of financial incentives for distilleries and farmers, but also through pricing policies, infrastructure development, regulatory framework and consumer education. For instance, pricing parity for fuels like E85 (up to 35% discount) against E10 fuel will be helpful in offsetting lower energy content to ensure customer acceptance by achieving same running cost (INR / km). Recognising Biogenic nature of Biofuels in CAFÉ Tailpipe emissions will also incentivize OEMs to consider these clean mobility options in their product plan.

1. Feedstock Security

Balancing Ethanol sources with growing demand

Ethanol split to OMCs based on feedstocks (Million Litres) (2019–2024)

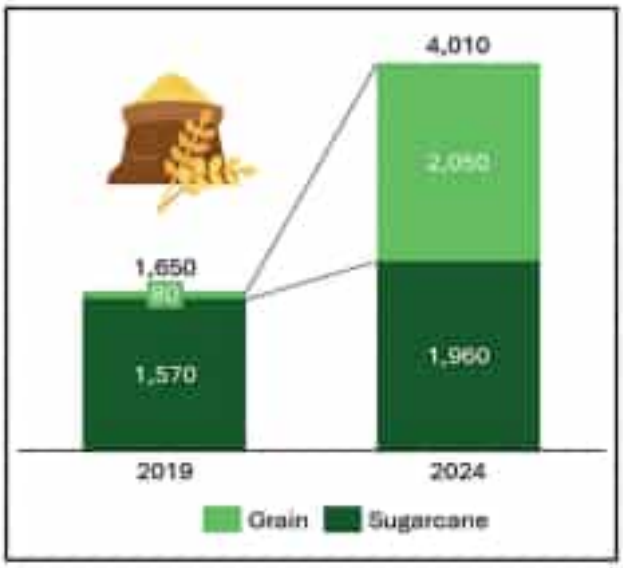


Figure 10: Shift feedstock landscape

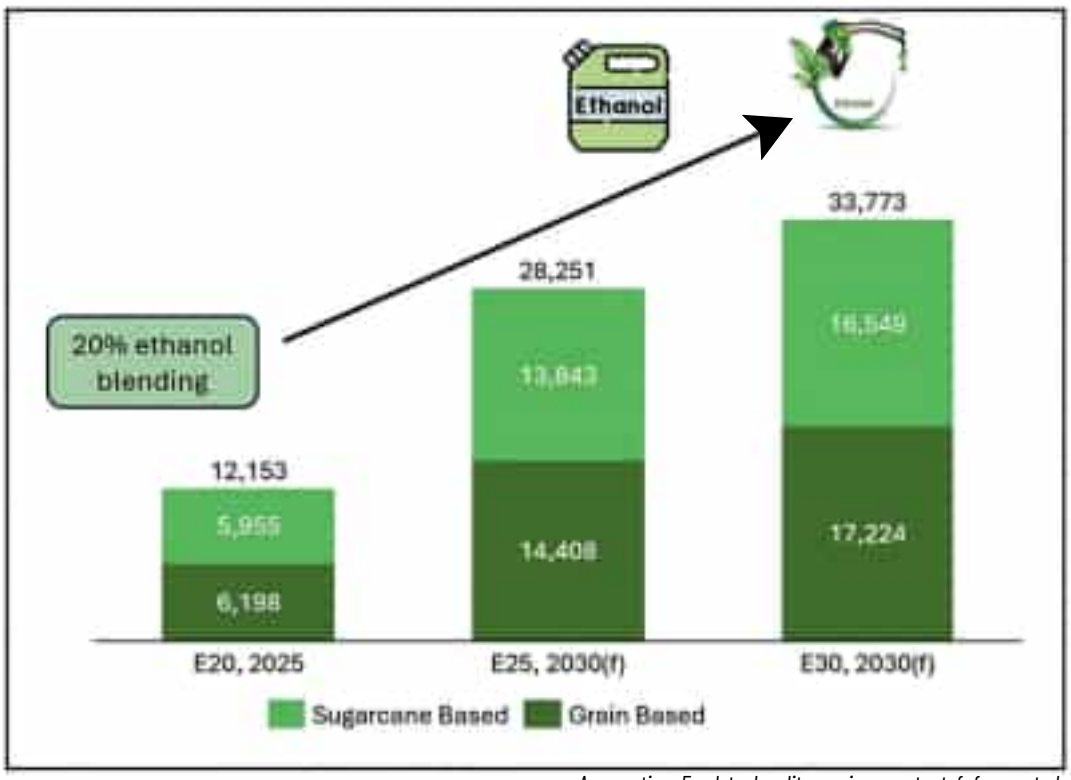
India's ethanol blending journey has seen a major shift in recent years. In 2019, nearly 95% of ethanol was produced using sugarcane-based feedstocks like C-heavy molasses. However, by 2024, this share dropped to 49%, with grain-based feedstocks now contributing more than half of India's ethanol output. This transition was driven by the need to reduce dependence on sugarcane, which is due to its water-intensive nature and dependence on monsoon rainfall. Government supported this shift by diversifying feedstocks for ethanol beyond sugarcane to include damaged food grains, surplus rice from FCI, and maize. In the ESY November 2023-October 2024, sugar mills and distilleries supplied 4010 million litres of ethanol to oil marketing companies out of which 2050 litres is grain based.

This transition helped in improving feedstock availability and gave India flexibility in achieving its E20 blending targets. However, it also introduced a new challenge of increasing reliance on food grains for fuel. This has triggered growing concerns about food security and price stability.

Food vs Fuel Conflict

With India aiming for E25 or E30 blending by 2030, the demand for ethanol will surge further. Achieving E30 blending by 2030 will require a combined 33.5 million tonnes of grains and 46 million tonnes of sugarcane annually which will put immense pressure on both food supply chains and agricultural resources like land, water, and fertilizer.

Projected Ethanol Demand for Mobility Under Different Blending Scenarios (Million Litres)



Assumption: Feedstock split remains constant, f=forecasted

Figure 11: Projected ethanol demand for mobility

To meet this demand, the country would need to add significant ethanol production capacity. Based on current estimates, an additional CAPEX of INR 5,157.71 crore will be required to expand grain and sugarcane-based ethanol capacity by 2030 for E30 blending. The cost is based on public investment board benchmarks of INR 180 crore per 100 kilolitre-per-day capacity for a 1G plant.

Table 1: Incremental Ethanol Production capacity and capex across different scenarios

Ethanol type	E25 by 2030	E30 by 2030
Sugarcane based (Mn litres)	8,974	9,965
Grain Based (Mn litres)	12,052	13,384
CAPEX Requirement (INR Crores)	3,840	5,158

But the problem is not just financial but is also structural in nature. Grains like maize, broken rice, and surplus stocks may appear as viable options to support this growth but these options are not only critical for food consumption and public distribution systems, and also for poultry and cattle feed. Ethanol production already consumes 18–20% of India's maize output, and this figure will grow sharply with higher blending targets.

As grain requirements rise, the risk of food vs fuel trade-offs increases. If grain is increasingly diverted to ethanol, there's a threat that distilleries will start offering better prices than the food sector, prompting farmers to prefer ethanol buyers. This becomes profitable for the farmers, but it risks triggering price inflation in food markets and can become a challenge for vulnerable and low-income households.

Moreover, whenever food grain stocks fall below safety levels, the Government pauses allocations to ethanol plants, prioritizing food security. This has happened in the past with maize and surplus rice. Such policy swings create uncertainty for investors and disrupt supply stability for ethanol production.

FCI cuts off rice supply, ethanol makers in a crisis

Dipak K Dash / TNN / Jul 25, 2023, 04:44 IST

NEW DELHI: Nearly 100 distilleries producing ethanol are staring at a serious crisis as the Food Corporation of India (FCI) has stopped supplying rice to them for more than a week. The government is reviewing its policy of supplying surplus rice from the FCI for manufacturing of ethanol and may put some restrictions, sources said.

Figure 9: Government controls grain supply to ethanol distilleries for food security purposes

Balancing energy security with food security is going to be one of the biggest challenges of India's ethanol roadmap. As the country pushes forward with aggressive blending targets, this food vs fuel debate will only grow louder unless structural solutions like promoting 2G ethanol are fast implemented.

Maize as a Bridge, 2G as the Goal

India's growing ethanol program has become reliant on food crops like maize, has disrupted the feed supply chain, turning a surplus grain into an import-dependent commodity. This diversion has inflated prices and triggered a cascading impact on livestock feed and soyabean markets. As long as food crops fuel biofuel ambitions, unintended economic and nutritional consequences will remain inevitable.

India's growing ethanol program has become reliant on food crops like maize. While maize has emerged as a practical option for ethanol in the short term, it has disrupted the feed supply chain and should not become the long-term solution. Although India is the 5th largest Maize producer in the world[xiv], India has become the net importer in 2024[xv]. The diversion of maize for ethanol has reduced its availability for livestock feed, raising feed costs across poultry and dairy sectors. To offset high maize prices, feed makers are increasingly using DDGS (a byproduct of ethanol), which has in turn driven down demand and prices for soyabean meal. This cascading shift has hurt soyabean farmers, with prices falling below the Government's minimum support price.

Reliance on grains like Maize can only be an option for transition and buy India some time to scale up second-generation ethanol production, which uses non-food biomass like crop stubble and forestry waste.

2G ethanol eliminates the food vs fuel conflict entirely. But this solution is currently expensive and underdeveloped. India has 6 commercial 2G ethanol plants, with 200 million litres per year in capacity. Out of this one is functional and other are around the corner to begin commercial stage production. There are other plants in the pipeline under the construction stage. Scaling this up with consistent investment, technology transfer, and R&D is critical.

In the meantime, it is important for India as a nation to balance its ambition for cleaner fuels with the need to keep food affordable and accessible. A smart ethanol roadmap will include grain-based ethanol as a temporary solution, but the focus must steadily shift toward 2G solutions to ensure a sustainable source to meet the advanced blending targets to reduce the emissions.

2. OEM Readiness

OEM Readiness for Ethanol Blending

OEMs have played a pivotal role in supporting the EBP. Over the past few years, they have aligned their product development and manufacturing strategies with national ethanol blending targets. From April 2023, all new gasoline-powered vehicles are being produced as E20 material compliant. They are designed to handle fuels containing 20% ethanol without compromising on safety or performance. Starting April 2025, all vehicles are made E20 engine-tuned, with upgrades in components such as gaskets, seals, and engine calibration systems to ensure optimal performance and emission compliance with E20 fuel. Agencies such as ARAI and IOC have validated these changes by performing tests especially in two-wheeler and four-wheeler segments.

Preparing for Higher Ethanol Blends

As India looks beyond E20 and sets sights on higher ethanol blends like E85, OEMs are already preparing for the next phase of readiness. For this transition there are substantial advancements in both materials and engine systems. Higher ethanol blends bring challenges such as increased fuel corrosion, changes in thermal properties, and cold-start issues. To address this, OEMs are upgrading fuel system components, engine tuning logic, and sensor technologies. The development pathway needs to ensure that engines can detect varying ethanol percentages and adapt fuel injection and combustion parameters accordingly. This gradual approach ensures that even as blending norms scale up, vehicles remain efficient, durable, and safe.

Flex Fuel Vehicles

Building on the progress with E20, several OEMs have initiated the development of Flex Fuel Vehicles, which can operate on a range of ethanol blends from E20 up to E85. Leading manufacturers across 2W, 3W, and 4W categories have already demonstrated FFV-ready models in various national and international automotive exhibitions. These FFVs meet BSVI Phase 2 emission norms and are calibrated to detect and adjust to different fuel blends automatically. With FFV-specific engines and materials in place, OEMs are ready to scale production further as enabling infrastructure and policy support becomes available. This is critical in India's roadmap towards significantly reducing fossil fuel dependence and emissions from transport.

3. Government Support: OEMs' Expectations from Government

To make the transition towards higher ethanol blends (E25, E30 or E85) feasible and consumer-friendly, certain policy and regulatory enablers are essential from the Government's side.

Differential Fuel Pricing to Reflect Energy Content

To drive customer acceptance for FFVs, it is essential that price of E85 fuel is at least 35% lower than E10, accounting for its lower energy content. This differential pricing is essential for users to switch to ethanol as fuel otherwise they may continue using lower ethanol blends in FFVs, defeating the purpose of the technology. Ensuring this price parity in running cost (INR/km) is key for mass-market acceptance.

Fiscal or Tax based Support for FFVs

For two-wheelers, GST reduction to 18% and for four-wheelers, any appropriate fiscal support can be offered by the government.

Incentives for Infrastructure Development

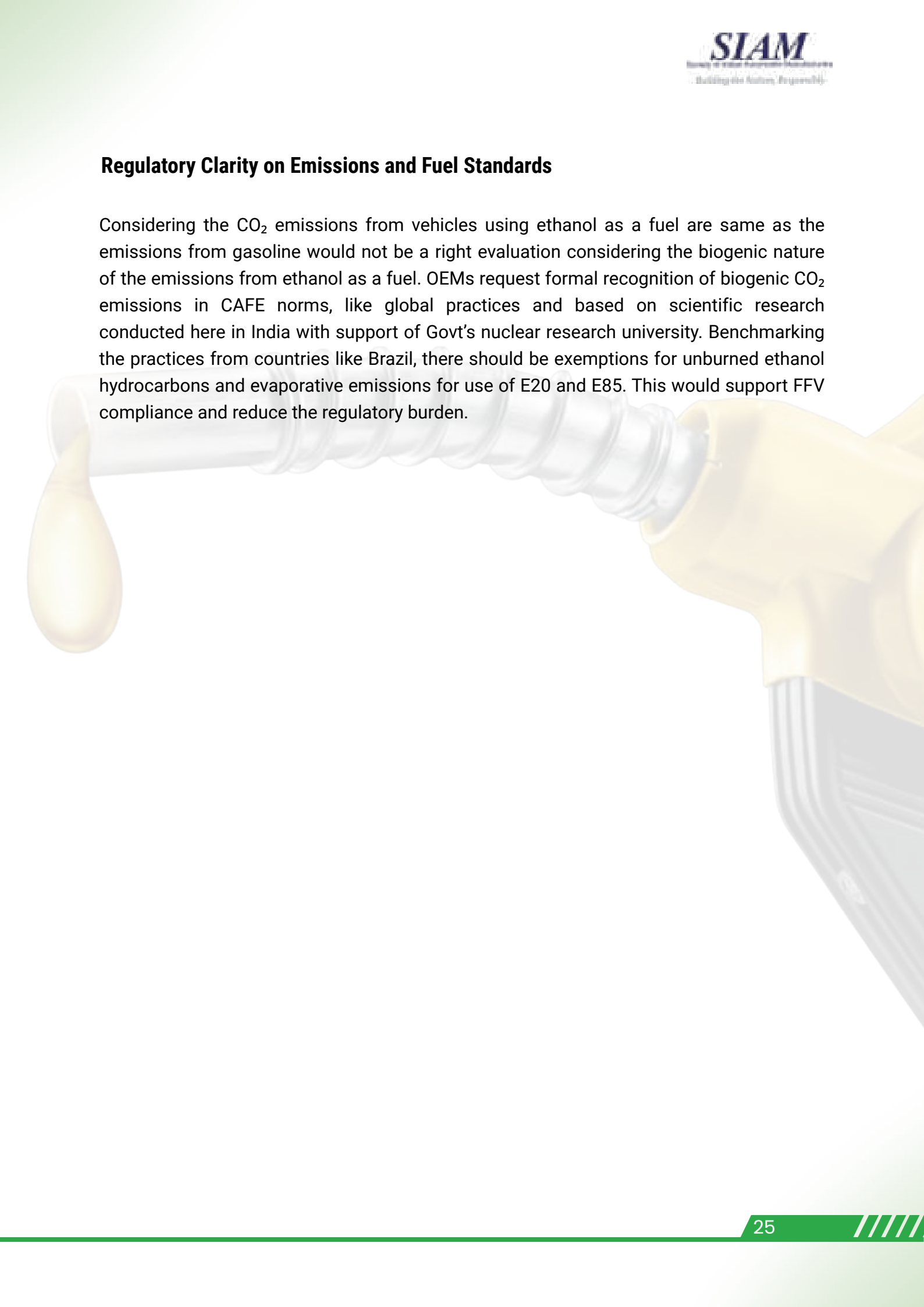
To execute the targets of higher ethanol usage in vehicles, OMCs also need financial support from the Government for development of ethanol storage and dispensing infrastructure. The Government can help the OMCs in the following ways:

- A published E85 retail rollout roadmap starting with surplus ethanol states and expanding to all Tier 1 & Tier 2 cities.

- Support for fuel labeling standards, ensuring customers can distinguish between E20 and E85 at retail outlets.

Regulatory Clarity on Emissions and Fuel Standards

Considering the CO_2 emissions from vehicles using ethanol as a fuel are same as the emissions from gasoline would not be a right evaluation considering the biogenic nature of the emissions from ethanol as a fuel. OEMs request formal recognition of biogenic CO_2 emissions in CAFE norms, like global practices and based on scientific research conducted here in India with support of Govt's nuclear research university. Benchmarking the practices from countries like Brazil, there should be exemptions for unburned ethanol hydrocarbons and evaporative emissions for use of E20 and E85. This would support FFV compliance and reduce the regulatory burden.



Conclusion

India's ethanol blending journey has evolved rapidly over the last decade, driven by a strong policy push, industry readiness, and national sustainability goals. Starting with E5 and E10 targets, India has now achieved E20 blending 5 years ahead of the target. The Government has played a pivotal role through key interventions such as interest subvention schemes, differentiated ethanol pricing at source, feedstock approvals, and procurement frameworks. These efforts have laid a strong foundation for a broader shift towards biofuels in the transport sector.

As blending levels have gone up, increasing focus is on grain based alternatives like maize and surplus food grains when compared to sugarcane-based ethanol. However, this transition brings challenges such as feedstock availability, food vs fuel debates, and land-use constraints. Maize is expected to play a crucial bridging role in meeting short-term capacity needs, while longer-term strategies involve scaling up second-generation ethanol from agri-residues and waste biomass under schemes like the modified Pradhan Mantri JI-VAN Yojana.

OEMs have also been active stakeholders in this transformation, developing E20-compliant and flex-fuel vehicles, aligning with BS-VI Phase 2 emission standards, and supporting policy dialogues through SIAM. The rollout of E20 material-compatible vehicles since 2023 and launch of E20-tuned vehicles in 2025 reflect industry alignment with Government targets. A forward looking, transparent roadmap with clarity and consistency will be extremely helpful for all stakeholders involved.

Looking ahead, India's ethanol roadmap must focus on three pillars: feedstock sustainability, OEM readiness, and Government support. Strategic investments in ethanol infrastructure, streamlined regulatory frameworks, and consumer pricing interventions will be essential to maintain the momentum. A coordinated effort between all stakeholders will help position biofuels as a scalable and inclusive solution for decarbonizing road transport while reducing crude oil dependency.

References

[i] https://www.sciencedaily.com/releases/2025/06/250627021853.htm?utm_source=chatgpt.com
[ii] https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions
[iii] https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions#t1fn2
[iv] https://advancebiofuel.in/types-biofuels-and-advantages/
[v] https://link.springer.com/article/10.1007/s43937-024-00032-w
[vi] https://www.sciencedirect.com/science/article/pii/S2352484722000014
[vii] https://energy.economictimes.indiatimes.com/news/oil-and-gas/ethanol-blending-saves-1-13-lakh-cr-in-forex-govt-revises-procurement-price/117716023
[viii] https://www.pib.gov.in/PressReleseDetailm.aspx?PRID=2083669&reg=3&lang=1
[ix] https://ethanolrfa.org/media-and-news/category/news-releases/article/2025/02/u-s-ethanol-production-and-exports-hit-records-in-2024-new-data-show#:~:text=Media%20&%20News,domestic%20consumption%20and%20record%20exports.
[x] https://ethanolrfa.org/markets-and-statistics/annual-ethanol-production
[xi] https://www.policycircle.org/policy/indias-ethanol-blending-strategy/
[xii] https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Biofuels%20Annual_New%20Delhi_India_IN2025-0031.pdf
[xiii] https://www.indiatoday.in/auto/latest-auto-news/story/indias-ethanol-drive-government-aims-at-30-blending-with-petrol-by-2030-2709892-2025-04-16
[xiv] https://apeda.gov.in/Maize
[xv] https://www.downtoearth.org.in/agriculture/lost-in-maize
[xvi] https://www.wri.org/insights/4-charts-explain-greenhouse-gas-emissions-countries-and-sectors
[xvii] https://www.iea.org/countries/india/emissions

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