

SIAM

Society of Indian Automobile Manufacturers

Building the Nation, Responsibly



BIO-INITIATIVE

by *SIAM*



ETHANOL ADOPTION: MULTIPLE BENEFITS PERSPECTIVE



About SIAM

SIAM works towards supporting the sustainable development of the Indian Automobile Industry with the vision that India emerges as the destination of choice in the world for design and manufacture of automobiles. It facilitates the enhancement of the competitiveness of the Indian Automobile Industry, reducing cost of vehicles, increasing productivity and achieving global standards of quality.

SIAM acts as a face of Automobile Industry in India and works closely with stakeholders in the formulation of the economic 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 the Indian Automobile Industry. It publishes Monthly Industry Statistics, Monthly Commodity Price Monitor and other periodic reports. It also organises international conferences, seminars and workshops on the topics of topical relevance and interest to the industry, and also on global best practices with a focus on sustainable mobility.

SIAM has a profound interface with the Indian Government and with International bodies like OICA (International Organization of Motor Vehicle Manufacturers), JAMA (Japan Automobile Manufacturers Association), ACEA (European Automobile Manufacturers' Association), UNICA (Brazilian Sugarcane Industry and Bioenergy Association), USGC (U.S. Grains Council), ANFAVEA (National Association of Automotive Vehicle Manufacturers, Brazil), ABRACICLO (Brazilian Association of Motorcycle, Moped, and Bicycle Manufacturers) etc. SIAM jointly with ACMA and CII organises Auto Expo-The Motor Show, a widely awaited biennial auto exhibition highlighting the trends in technological advancement adopted in the Auto Industry. SIAM also organises regional as well as segment specific shows across the country.

SIAM aims to promote sustainable mobility through environmental, social, and economical sustainability, to address climate change, air quality improvement, compliance with standards and promotes growth. In October 2022, SIAM hosted a global conference on 'Biofuels - A Pathway Towards A Sustainable Future' with participation from automotive industry experts, government officials, academia, and other stakeholder associations including the ambassador and experts from Brazil. In the same conference, SIAM reiterated its dedication for Ethanol adoption in India and established a 'CLEAR' strategy for ethanol adoption in India.

In December 2022, SIAM organized a flex fuel vehicle technology demonstration attended by automobile industry leaders. SIAM launched जैविक पहल (Bio-initiative) in the presence of Shri Nitin Gadkari for continued focus on information dissemination on Ethanol.





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Executive Summary



India is an automotive behemoth with approximate 29.5 crores vehicles running on roads. With an estimated 2 crore vehicles added every year and expanding middle class in this growing economy, the vehicle parc is bound to increase exponentially. Additionally, the automobile sector is the biggest contributor to the manufacturing GDP of India and aims to give employment to more than 4 crore families. India has embarked upon the development of sustainable practices in automotive sector, which ensure continuous improvement in production, usage, reuse and disposal practices related to vehicles.

India has adopted the 17 Sustainable Development Goals for 2030 developed by UN Department of Economic and Social Affairs. SIAM aims to promote SDGs related to automotive sector by bolstering dissemination and implementation of efficient, safe and affordable vehicles for sustainable mobility.

Every stakeholder in the energy and Indian mobility ecosystem is inspired towards long-term energy independence for the nation. SIAM believes that developing sources of automotive energy indigenously will also require adequate support system and dissemination of information about new technologies throughout the current and developing business stakeholders.

The Indian customer base, which is highly sensitive to price fluctuations, needs customers' confidence in Ethanol as an absolute necessity to ensure faster adoption and realization of benefits that come with a mature ethanol ecosystem. SIAM plans to take continuous learnings from our international partners to bring ethanol compatible technology to our customers. Moreover, the automotive players, OMCs and Sugar manufacturers will have to be supported through stable policies and fuel based incentives to ensure sustainable adoption. Under the able leadership of Ministry of Road Transport & Highways, Ministry of Petroleum & Natural Gas, Ministry of Heavy Industries, Ministry of Agriculture & Farmers welfare, Department of Food & Public Distribution and NITI Aayog, we believe that the robust incentive regime can effectively facilitate decarbonisation.

Ethanol production is planned to be used for multipronged benefits to the citizens of the nation. The current methods of ethanol production actively elevate farmer incomes by giving them an alternate source of income. Additionally, the farm based economy is supported through government schemes slated to bring in investment of approximately INR 40,000 crore and multiple employment opportunities in rural areas. Environmentally, ethanol indirectly helps reduce the pollution caused due to burning of farm stubble through the second-generation production method. In addition, ethanol directly affects air quality improvement by reducing mobility related emissions.

This paper focuses on the ethanol as a sustainable fuel and aims to support Indian Government's mandates towards a decarbonized, 'Aatmanirbhar Bharat'.



Introduction



In the context of the Indian automobile industry, a focus on ethanol ecosystem will benefit the industry and country. This will not only help conserve foreign exchange, but will also help generate employment through multiple developments in the alternate fuel adoption value chain. Bringing a low carbon fuel in Indian mobility will also help in reducing the emissions by removing older vehicles with newer, more fuel efficient vehicles. Bringing economic benefits to the farmer and other stakeholders dependent on farm economy.

With the alternate fuels (Like Ethanol, Hydrogen, Biofuels) development and electric mobility transition underway in the global environment, reduction of emission and fuel security from the perspective of cleaner mobility is required. During India's presidency of G-20, the government has indicated that the long-term low emission development strategy is for achieving climate goals and the need for sustainable productionⁱ.

Given the increasing importance of decarbonisation, this paper focuses on understanding and evaluating the importance, current state and future imperatives for building an ethanol ecosystem in India.

Widespread usage of ethanol is the need of the hour. Customers will get on board with the ethanol adoption plans of the government and the stakeholders only after getting an assurance from the perspective of performance and stability. The Indian customer needs to have a supportive ecosystem and plethora of options to ensure benefits to the society and the nation.

To get the ball rolling, government of India has already come out with multiple schemes and incentives to inspire and guide the stakeholders in the ethanol ecosystem. The related Indian industries namely automotive, oil & gas, sugar manufacturers and farmers, have been performing exceptionally to achieve the targets set by the government. The expert committees also have been guiding the stakeholders for every turn of the way so that the mandates and incentives of multiple industries are apparent to all.

This paper aims to delve on all these factors and shed light on the way ahead for a sustainable adoption of ethanol in Indian mobility.



Ethanol: An Organic Boon



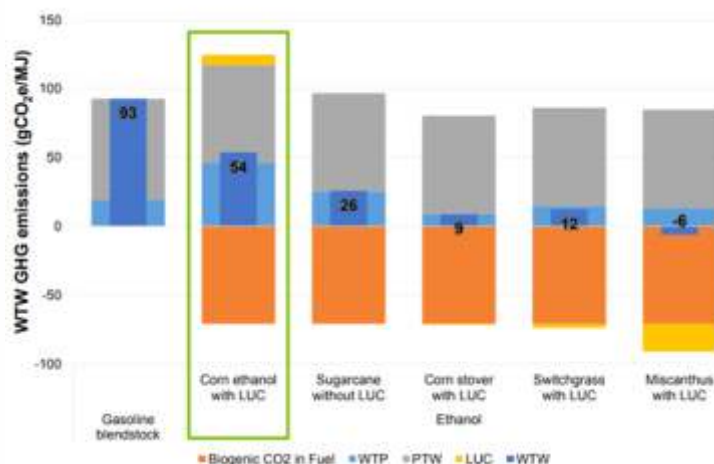
Environment friendly

Emission reduction

Ethanol consists of higher hydrogen to carbon ratio with respect to conventional petrol, leading to lower emissions. According to Alfred Szwarc, a Brazilian expert on sustainable transport "Intensive use of ethanol in flex-fuel vehicles in the last 15 years avoided emissions of over 450m tonnes of carbon dioxide (CO₂), the main contributor to global warming and climate change".

	Ethanol	Petrol
Chemical Formula	$\text{CH}_3\text{CH}_2\text{OH}$	$\text{C}_n\text{H}_{2n+2}$
Hydrogen to Carbon Ratio	3:1	1.6-1.8:1

Considering the CO₂ absorption during the growth of crops, ethanol blended fuel's life cycle GHG emissions are lower on average by 40% when compared to traditional fossil fuelsⁱ. According to expert committee, use of ethanol-blended petrol decreases emissions such as carbon monoxide (CO), hydrocarbons (HC) and oxides of nitrogen (NO_x). Higher reductions in CO emissions were observed with E20 fuel — 50 per cent lower in two-wheelers and 30 per cent lower in four-wheelersⁱⁱⁱ.



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Lifecycle (Well-to-Wheels) Greenhouse Gas Emissions for Gasoline (grams of CO₂-equivalent GHG per megajoule of energy)



Oil Extraction, Pre-Processing and Transportation to Refinery = 11 g/MJ

- Energy use for crude oil recovery
- Flaring
- Initial processing
- Energy use in pipelines, trains, barges

Oil Refining = 14 g/MJ

- Energy use for crude oil refining

Gasoline Distribution = 0.5 g/MJ

- Energy use in pipelines, trains, barges, trucks
- Energy use by fuel blenders and retailers

Gasoline Combustion = 73 g/MJ

- Tailpipe CO₂, CH₄, N₂O emissions

Land Use Change or Other Indirect Effects = ? g/MJ

- Not included in current lifecycle analyses for petroleum



Lifecycle (Well-to-Wheels) Greenhouse Gas Emissions for Ethanol (grams of CO₂-equivalent GHG per megajoule of energy)



Corn Production = 22 g/MJ

- Seed production
- Fertilizer production and use
- Chemical production and use
- Farm machinery energy use
- N₂O/CO₂ emissions from soils
- Animal feed co-product credit (-12)
- Hypothetical land use change (7)

Ethanol Production = 28 g/MJ

- Energy use (natgas, electricity) by ethanol biorefinery
- Denaturant addition

Ethanol Combustion = 0.3 g/MJ

- Tailpipe CO₂ emissions are biogenic
- Minor tailpipe CH₄ and N₂O emissions

Corn Transport = 1.5 g/MJ

- Energy use by trucks, trains, barges

Ethanol Distribution = 1.5 g/MJ

- Energy use by trucks, trains, barges
- Energy use by fuel blenders and retailers



Additionally, for the 2nd generation ethanol, the raw material used is the farm waste like corn cobs, rice husks, wheat straw and sugarcane bagasse that can all be transformed into cellulose and fermented into ethanol^{vi}. This process takes away farm waste that is burned in the farm lands to prepare the soil for next sowing season. Every year, the smoke produced from stubble burning by farmers in North India has been a major subject of concern due to the considerable health risks it poses^{vii}.

With the diversion of farm waste towards production of the biofuels like ethanol, emissions due to traditional practices like Parali burning will be curbed. The 2G ethanol plant at IOCL's Panipat refinery, which is the country's first such commercial project, which will directly manufacture 100 kilogrammes of ethanol per day from 425.5 metric tonnes of dry corn stover. According to its current capacity, this factory will consume around 4,250 quintals of paddy straw from approximately 212 acres each day and empty approximately 77,562 acres each year, thus saving emissions^{viii}.

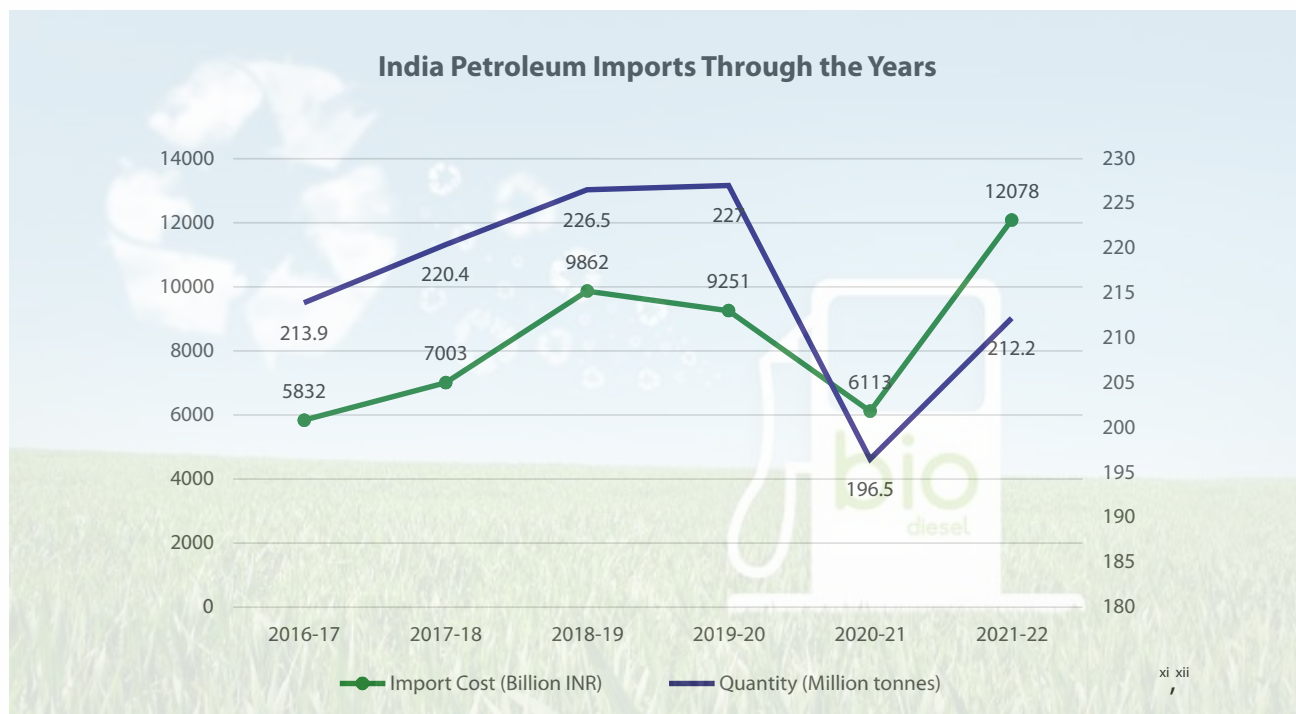


Renewable source of fuel

Unlike the mining of coal, production of petroleum and natural gas, renewables convert natural resources directly into fuel sources. Additionally, as sourcing fossil fuels is becoming harder and more expensive to procure for utilization at the cost of natural habitats and significant finances, renewable energy never runs out^{ix}.

Fuel Security for the Nation

India's crude oil import bill surged 76% to \$90.3 billion in the first half of 2022-23 even as the total import quantity increased by 15% to 116.6 million tonnes because of geopolitical scenario^x.



The current ethanol blending levels have saved approx. INR 41,000 crores worth of fuel imports for the nation^{xiii}. Mixing 20% ethanol in petrol will potentially reduce Indian fuel imports by INR 30,000 Crores per annum^{xiv}.

Diversification of Farm Economy

The major Ethanol Production methods are as follows:

Classification	Raw Material	Ethanol producing organic molecule
1st Generation	C & BH Molasses	Sugary (Glucose, Fructose, Sucrose)
	Sweet Sorghum Juice	
	Grains: Corn, Sorghum, Rice, Wheat, Millet	Starch
	Cassava (Tapioca)	



Classification	Raw Material	Ethanol producing organic molecule
2nd Generation	Lignocellulosic biomass: Bagasse, Sugar Cane Trash, Corn Cobs, Rice Straw etc.	Cellulose & Hemicellulose
	Pet coke & Municipal Solid Waste	Complex Mixed Organics

Sugar Manufacturers

In both 1st & 2nd generation production methods, sugar producers can provide raw materials required for ethanol production. Using already available raw materials, multiple sugar manufacturers have jumped on the ethanol production bandwagon.

Due to growth in exports of sugar and ethanol, Sugar industry in India is expected to grow by 6-7% in the years 2021-2022^{xv}. According to the Department of Economic Affairs, sugar mills/distilleries generated revenue of about 35,000 crore from the sale of ethanol to OMCs in the past four sugar seasons ending 2020-2021, which helped in clearing the sugar cane price arrears owed to farmers^{xvi}.

Farmers

Indian farmers, which form approx. 41 % of the total employment^{xvii}, earn INR 10,218 per household in a month. The net receipts from crop production increased by 22.6% as compared to the figures in 2014, net receipts from other sources increased by 92.6% with increase in overall net receipts at 59% with respect to the same figures in 2014^{xviii}.

The production of ethanol in the sugar distilleries and usage as a fuel will allow diversification and thus, safer economic avenues for the households dependent on farm incomes. Additionally, a conducive and sustainable ecosystem for 2G ethanol production method will allow usage of farm waste generated. This will once again boost income of farmers and prevent some traditional waste disposal practices that harm farm output and surrounding environment.



Ethanol as a Fuel – Progress & Initiatives in India



India started blending ethanol in petrol on a pilot basis in 2001 with a view to give a boost to the agriculture sector and to reduce environmental pollution. As a part of the pilot projects launched by the Government of India, 5% ethanol blended petrol was supplied to retail outlets. R&D studies were simultaneously conducted apart from the field trials. The success of these field trials paved a way for Ethanol Blending Petrol (EBP) in India.

In January 2003, Government of India launched an Ethanol Blending Petrol (EBP) Programme in 9 States & 4 UTs for sale of 5% Ethanol Blended Petrol. Based on the promising experiences Ministry of Petroleum & Natural Gas (MoPNG) extended this programme to 20 States and 4 UTs effectively from 20th September 2006. Public Sector Oil Marketing Companies (OMCs) were asked to sell 5% ethanol blended petrol subject to commercial viability as per Bureau of Indian Standards (BIS) specifications in the notified states and UTs^{xix}.

Even though the programme started early it faced the multiple challenges leading to adoption and growth, and the programme showed the mixed results with average blending ranging from 0.1% to 1.5% till 2013-14.

Challenges faced by the Ethanol Blending Programme in India are:

- Non-inclusion of conversion of grains to Ethanol, which resulted in restriction of grain-based distilleries to participate in the EBP Programme. Only Molasses based distilleries were part of the EBP Programme
- High Taxation on Ethanol. 18% tax rate was applicable
- Procurement Challenges due to poor infrastructure and multiple tenders' applications on a given Ethanol Supply Year (ESY)
- Dissatisfactory 'take home' price and irregular pricing for ethanol suppliers
- Limited availability of Feedstock (raw material)
- Constraints on the part of State Government Policies

These challenges made progress slow and reduction in investments in the sector. However, the underlying potential of the Programme was never disputed and the interventions from the Indian Government since 2014 has made drastic improvement and by March 2023, India achieved 10% blending & targeting 20% by 2025-26.



Interventions by the government since 2014 are tabulated below:

Timeline	Government Interventions
Dec 2014	Government Re-introduced administered price mechanism for ethanol to be procured under the EBP Programme;
Jan 2015	Opened an alternate route for Ethanol Production (2nd Generation including Petrochemical); Government also directed Oil Public Sectors Enterprises (PSEs) to set-up Bio-refineries;
ESY 2014-2015	Steps taken towards easing tender conditions – Multiple EOIs being floated, transportation slabs and rates;
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	Notified forward looking and updated National Policy on Biofuels – 2018 involving all stakeholders; The policy is aimed at taking forward the indicative target of achieving 20% blending of biofuels with fossil-based fuels by 2030, which is now revised to 20% by 2025-26;
Jul 2018	Interest Subvention Scheme for Enhancement and augmentation of ethanol production capacity in the country. Government to provide interest (interest subvention) for a period of 5 years. GST on ethanol lowered from 18% to 5%; The government is extending financial assistance in the form of interest subvention at 6 per cent per annum or 50 per cent of rate of interest charged by banks, whichever is lower, on the loans to be extended by banks for five years, including one-year moratorium;
ESY 2018-2019	Allowed conversion of B heavy molasses, sugarcane juice and damaged food grains to ethanol; Fixed differentiated ex-mil ethanol price and procurement priority based on raw material utilized for ethanol production. Marked beginning of an era of differentiated ethanol pricing, based on raw material utilized for ethanol production;
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;
Sep 2019	New sources sugar & sugar syrup introduced for ethanol production at fixed remunerative price;



Timeline	Government Interventions
Oct 2019	Published "Ethanol Procurement Policy on a long-term basis under EBP Programme"
Aug 2020	One time registration of ethanol suppliers for long term, including giving them visibility of ethanol demand for 5 years;
Sep 2020	OMCs started to provide off-take guarantee letter and consent to sign tripartite agreement with ethanol suppliers and bankers to support the ethanol capacity expansion projects; Opened a fresh window for inviting applications under interest subvention scheme for ethanol projects based on cane & Molasses;
Oct 2020	Further easing of tender conditions by OMCs like one time document submission, quarterly bank guarantees, multiple transportation rate slabs and transportation rates being linked to retail selling price (RSP) of diesel, reduction in security deposit and applicable penalty on non-supplied quantity etc.; Approval of National Biofuel Coordination Committee(NBCC) to utilize surplus stock of rice lying with Food Corporation of India(FCI) to be released to the distillers for ethanol production;
Nov 2020	Approval of NBCC to utilize Maize for ethanol production;
Jan 2021	Interest subvention scheme for enhancement and augmentation of ethanol production capacity extended to grain based distilleries & distilleries producing ethanol from other feedstock's like sorghum, sugar beet etc. apart from molasses based distilleries; DFPD extends financial assistance to project proponents for enhancement of their ethanol distillation capacity or to set up distilleries for producing 1st generation (1G) ethanol from feed stocks;
Jun 2021	Target of achieving 10% ethanol blending in petrol achieved; Target of achieving 20% ethanol blending in petrol preponed to 2025; roadmap for ethanol blending in India 2020-2025 released by the Prime Minister; Pilot project of E100 dispensing from 3 locations at Pune launched;
Oct 2021	Centre doubles incentives on sugar sacrificed for producing ethanol
Nov 2021	Cabinet committee on Economic Affairs gives approval for fixing higher ethanol prices derived from different sugarcane-based raw materials under EBF Programme for the forthcoming sugar season 2021-22; Oil PSEs given the freedom to decide the pricing for 2G ethanol;
Dec 2021	Government fixed higher ethanol price derived from different sugarcane based raw materials; Government lowers the GST to 5% from 18% on Ethanol meant for blending; Centre fixed 10% blending target for ESY 2021-22 & 20% by 2025-26 ^{xx} ;
Oct 2022	To encourage the blending of fuel, the Union Budget 2022-23 has announced an additional differential excise duty of Rupees Two per litre on unblended fuel from the 1st day of October 2022;





With all the initiatives taken by the Government, the Ethanol Blending Programme is on track to achieve the target of 20% blending by 2025-26.

To keep up with the '*Panchamrita*' announcement made by our prime minister in COP26 at Glasgow, the Government of India has been increasingly boosting the use of ethanol-blended fuel in the country. These efforts will pave the way for the 'Make in India' drive thereby leading to a reduction in the import of petroleum products. This will also promote the Aatmanirbhar Bharat initiative and give an impetus to the Prime Minister's vision of India becoming energy independent by 2047



Plans of Ethanol Production & Distribution



To achieve the target set by government through ethanol adoption roadmap, the ethanol ecosystem in India needs to develop. A widespread ethanol ecosystem will need continuous dedication from production and distribution stakeholders.

Ethanol Demand (in million litres)	Sugar Based	Grain based	Total
2019-20	2,570	1,660	4,230
2020-21E	4,000	1,920	5,920
2021-22E	4,400	2,670	7,070
2022-23E	5,350	2,930	8,280
2023-24E	6,000	3,880	9,880
2024-25E	6,600	6,280	12,880
2025-26E	6,840	6,660	13,500

Source: Government websites, Centrum Broking

Government Policies/Incentives:

- According to Final Ethanol Procurement Policy of MoPNG, OMCs are to procure ethanol derived from C heavy molasses, B heavy molasses, sugarcane Juice, sugar, sugar syrup, damaged food grains unfit for human consumption, surplus food grains as decided by NBCC under the ambit of NPB-2018, including fruit and vegetable wastes^{xxi}
- Government is administering ethanol price for EBP Programme. While ethanol procurement prices for sugarcane based raw materials viz. C heavy molasses, B heavy molasses, sugarcane Juice, sugar, sugar syrup has been fixed by the Government for an ESY, the price of ethanol derived from damaged and surplus food grains has to be fixed by OMCs^{xxii}
- **Interest subvention scheme** for enhancement and augmentation of ethanol production capacity extended to grain based distilleries & distilleries producing ethanol from other feedstock like sorghum,



sugar beet etc. apart from molasses based distilleries. About 114 sugar mills are likely to be benefitted as a result of this measure and ethanol production capacity of sugar mills in the country is likely to be enhanced by about 200 crore litres per annum in the coming 3 years^{xxiii}

- Government has launched “Pradhan Mantri JI-VAN (Jaiv Indhan- Vatavaran Anukool Fasal Awashesh Nivaran) Yojana” for providing viability gap funding to provide initial thrust to create 2G ethanol capacity in the country and attract investment in this sector. In this scheme, financial support to twelve Integrated Bio-ethanol Projects using lignocellulose biomass & other renewable feedstock with total financial outlay of INR 1969.50 crore for the period 2018-19 to 2023-24

- **Brazilian Example:**

- The Proálcool programme was initially introduced in 1975. Reductions in subsidies in the late 1980s coupled with low oil prices led to a drop in ethanol cars' sales to just 11%. However, policy decisions by subsequently elected governments has supported a boost in cars with ethanol fuel capability – which suggests that the political context at the launch of the programme was not the critical factor in its long-running success.
- Technological innovations from sugarcane industries were supported through government subsidies.
- The Brazilian government was able to maintain favourable prices for ethanol by inflating gasoline prices using its state-owned oil company, Petrobras. The pump price of ethanol was set at 64.5 percent of the price of gasoline and the government introduced higher gasoline taxes to pay for the true differences in price between the two fuels.

- **USA Example:**

- **Advanced Biofuel Feedstock Incentives:**
Provides financial assistance to landowners and operators for advanced biofuel production facilities
- **Advanced Biofuel Production Grants and Loan Guarantees:**
Provides loan guarantees for the development, construction, and retrofitting of commercial-scale bio-refineries
- **Advanced Biofuel Production Payments:**
Eligible producers of advanced biofuels, or fuels derived from renewable biomass other than corn kernel starch, may receive payments to support expanded production of advanced biofuels
- **Alternative Fuel Infrastructure Tax Credit:**
Refuelling equipment for E85 installed through December 31, 2022, is eligible for a tax credit of 30% of the cost, not to exceed \$30,000.
- **Biodiesel Education Grants:**
Competitive grants to educate entities that operate vehicle fleets, the public, and other interested entities about the benefits of biodiesel use.
- **Biodiesel and Ethanol Infrastructure Grants:**
Cost-share grants for the installation, retrofitting, or otherwise upgrading of refuelling equipment and infrastructure required to dispense high ethanol blends



- **Biomass Research and Development Initiative:**
Provides grant funding for projects addressing research, development, and demonstration of biofuels and bio-based products
- **Clean School Bus:**
Provides funding to eligible applicants for the replacement of existing school buses with clean, alternative fuel school buses or zero-emission school buses
- **CMAQ Improvement Program:**
For projects and programs that help meet the requirements of the Clean Air Act by reducing mobile source emissions and regional congestion
- **Environmental Justice Community Technical Assistance Program:**
Pilot facilitates sustained, community-wide economic and environmental benefits through DOE's clean energy deployment work
- **Ethanol Infrastructure Grants and Loan Guarantees:**
REAP program gives loan guarantees and grants to producers and small businesses to purchase RE systems or make efficiency improvements.
- **Integrated Bio-refineries Grant:**
Grants for bio-refinery development & feedstock improvement projects that reduce the cost of biofuel production & scale-up technologies
- **Public Transportation Research, Demonstration, and Deployment Funding:**
From FTA to give financial assistance to multiple players for research, demonstration, and deployment projects involving low or zero emission public transportation vehicles
- **State Energy Program Funding:**
To assist in design, development, and implementation of RE and energy efficiency programs, in the transportation sector by 2050 and accelerate alternative fuels usage
- **Value-Added Producer Grants:**
To help independent agricultural producers enter into or expand value-added activities such as biofuels production.

Sugar Manufacturers:

- In India, Over-production of sugar is a problem for the economy; we spend Rupees 15 lakh crores /year for import of petroleum products, hence we need to diversify the agriculture sector towards energy and power sectors. According to directions of Government and Ministry of Road Transport and Highways, sugar Industry needs to produce less sugar and more by-products, embracing the vision for futuristic technologies. The demand of Ethanol will have to be balanced with 'Sugar' supply
- Since a sustainable ethanol ecosystem requires a continuous supply of feedstock, a flexible plant is ideal, where in different feedstock can be used to produce ethanol. Hence, emphasise on more research is needed to make more genetically engineered biocatalysts that could use the same ethanol plant to ferment different sources to produce ethanol to reduce the cost of production of biofuel⁵



Oil Marketing Companies:

- OMCs have announced a relief scheme on ethanol supplies for the third and fourth quarter of SY 2021-22 based on feedstock. This move is to encourage vendors to maximise ethanol supplies and help in meeting blending targets^{xxiv}
- Bharat Petroleum Corporation Limited (BPCL) along with other oil marketing companies propose to set up ethanol plants of approximately 757 crore litre per annum capacity in ethanol deficit states. BPCL is setting up an integrated 2G & 1G bioethanol refinery at Bargarh, Odisha^{xxv}
- The Oil Marketing Companies, OMCs - Bharat Petroleum Corporation Limited, Indian Oil Corporation Limited and Hindustan Petroleum Corporation Limited have entered into a long-term purchase agreement for upcoming dedicated ethanol plants across the country^{xxvi}



Auto Industry Viewpoint



- First testing on ethanol was done in 2001 on E5 Blends. In 2003, the EBP programme launched with sales of 5% of ethanol blended petrol. Since, already testing of vehicles done before the launch, so cars are compatible with E5 blends^{xxvii}
- E5 was notified in 2015 by MoRTH. The rubber and plastic components used in gasoline vehicles produced since 2008 are compatible with E10 fuel. While, E10 was notified in 2019 by MoRTH^{xxviii}.
- Considering the supply of Ethanol Blended Fuel with minimum RON95, it is recommended that E20 material compliant and E10 engine tuned vehicles may be rolled out all across the country from April 2023. These vehicles can tolerate 10% to 20% of ethanol blended gasoline and also give optimal performance with E10 fuel.
- Vehicles with E20 tuned engines can be rolled out all across the country from April 2025. These vehicles would run on E20 only and will provide high performance.
- Since, India is planning to migrate towards E20 petrol fuel in India from 2025-26, all vehicles sold in India will need to be E20 Compliant. Varying degrees of engineering intervention would be required in the fuel, electrical, and exhaust systems, and most importantly the engine. Some components like piston, cylinder block, cylinder head, injectors, fuel rail will have to undergo change.
- There will not be a major structural change in the components in migrating from E10 to E20 for component manufacturer's view point. However, there will be changes in material of piston rings, piston heads, O-rings, seals, fuel pumps etc. all of which can be produced in the country^{xxix}.
- Currently produced two-wheeler and passenger vehicles in the country are designed optimally for E5, with rubber and plastic components compatible with E10 fuel; their engine can be calibrated for E10 for better performance. As the EBP rolls out in the country, vehicles need to be produced with rubberized parts, plastic components and elastomers compatible with E20 and engines optimally designed for use of E20 fuel^{xxx}.
- Retro-fitment on existing Vehicles: The existing vehicles on road are material compatible to E10 but their engine/vehicles are not tuned to E10 for optimum performance efficiency. Developing parts with upgraded material for a large number of vintage variants with a wide range of fuel system component designs and then getting the customers to get their vehicles upgraded is a mammoth task. Keeping this complexity in view, a recommendation to continue dispensing E10 with RON95 as a protection grade fuel all over the country has been made^{xxxi}.



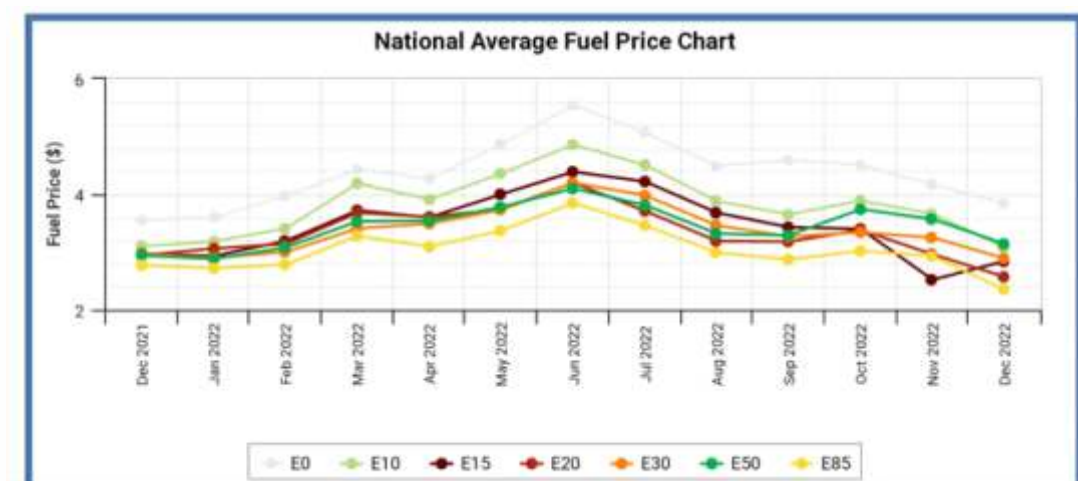
- Auto industry has highlighted certain potential challenges that may arise, as an effect of E20 on the E0 & E10 vehicles & that for the existing vehicles parc, the fuel hoses and all may get eroded. Auto industry is working on these with the help of Government^{xxxii}.
- Higher blends of Ethanol and their consideration: High-oxygen-containing fuels, can be used in FFVs. E85 (or flex fuel) is a term that refers to high-level ethanol-gasoline blends containing 20% to 85% ethanol. Fuels containing ethanol up to 85% (E85) are used in multiple countries like Brazil, USA and European countries. FFVs are gasoline cars with some modifications namely, all materials need to be compatible with ethanol. Additionally, volumetric fuel consumption is higher for E85 fuel than for gasoline^{xxxiii}.
- Globally, multiple countries are in difference phases of their approach to blending of ethanol in gasoline due to the inherent benefit of its usage. Not only from the pollution reduction point of view, but also from qualitative improvement in fuel. As the ethanol blends in gasoline increases, it also increases the complexities on the vehicle to handle higher blends. The table below indicates the impact of the higher blends of ethanol on vehicles:

Ethanol blend	Fueling system ^(a)	Ignition system	Catalytic converter	Basic engine	Lubrication oil	Intake manifold	Exhaust system	Cold start system
Up to E10	No necessary modifications							
E10-E25	Require modifications			No necessary modifications				
E25-E85	Require modifications							
E85-E100	Require modifications							

Ethanol Price Consideration

In its submission to the Apex committee of the government deciding on the usage of higher blends of ethanol, SIAM had recommended the usage of flex fuel from E20 to E85. SIAM has already provided the timelines to the government towards introduction of ethanol blended vehicles in the market.

As the ethanol content increases in the gasoline, the energy content in the gasoline/lit decreases. Globally, depending on the energy content of the ethanol (the impact on fuel economy lessens as the ethanol content decreases), the prices of the higher blends of ethanol are pegged lower to gasoline as indicated in the figure below:



In order to understand the concept of Ethanol fuel choices, it is important to understand the rationale and concept behind pricing of Ethanol fuels and consequentially, incentivising fuel choices for consumers at retail outlets. Price parity on an energy content basis means that drivers with FFVs in the country capable of running on fuels with higher ethanol content can achieve the same mileage per USD/INR with E85 as with E10, the main blend used in vehicles now.

As an illustration, the fall in the retail price of E85 fuel means that E85 is close to price parity with regular gasoline on an energy content basis. While ethanol has been cheaper than regular gasoline on a per-gallon/litre basis for several years, ethanol's lower energy content often meant that consumers paid more per kilometre when using higher ethanol blends such as E85.

As E85 is less energy dense than standard E10 gasoline, consumers using E85 will need to refuel more often. In addition, they may need to travel farther to reach a station that offers E85 if they are less widespread (In US, only 2% of all retail stations—offer E85 motor fuel with the overwhelming majority located in the Midwest). For these reasons, some consumers may be averse to switch from E10 to E85 until the latter is discounted below its energy parity price. It is important to ascertain the number of consumers who would avoid the switch without such a discount and the size of the discount that may be required.

Ethanol in US mobility

- In USA, E15, also known as Unleaded 88, has been around for about a decade. According to USEPA, all the vehicles from 2001 or newer can use E15 except for motorcycles, vehicles with heavy-duty engines like buses and delivery trucks, off-road vehicles like boats or snow mobiles, and lawn equipment^{xxxvi}.
- The E15 approved group of vehicles includes more than 80% of the cars, trucks and SUVs on the road today. As of 2018, there were more than 21 million FFVs in the United States. Multiple vehicles from international OEMs provide FFVs^{xxxvii}.



Mercedes-Benz

- Flexible fuel vehicles are designed to run on gasoline or gasoline-ethanol blends of up to 85% ethanol (E85). The FFVs are identical to gasoline-only models except for a few engine and fuel system modifications.
- FFVs experience no loss in performance when operating on E85. Few models generate more torque and horsepower than when operating on gasoline. However, less energy per volume contained in ethanol



w.r.t. gasoline, FFVs typically get about 15%–27% fewer miles per gallon when fuelled with E85^{xix}. However many FFVs have higher acceleration when operating on higher blends of ethanol.

- The FFVs in US give follow few specific features for customer awareness and ethanol adoption^{xi}:

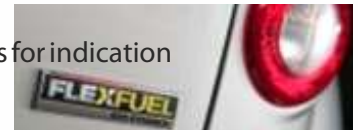
- Yellow Gas Cap or Fuel Filler Ring



- Some FFVs have labels on fuel door to indicate fuel type



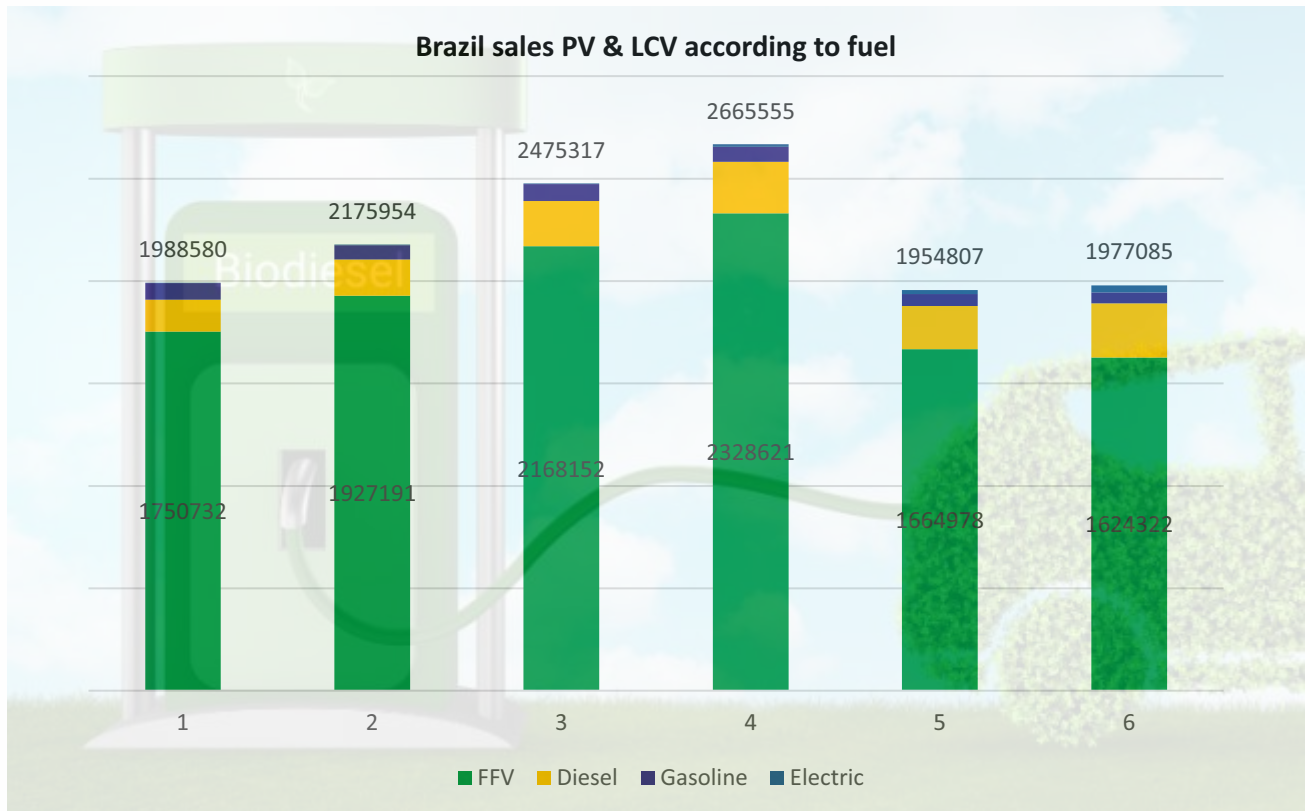
- Apart from the owner manual of the vehicle, some FFVs also give badges for indication



Ethanol in Brazilian mobility

- In 6 years of the Proálcool Programme from 1975 to 1981 the share of vehicles with ethanol fuel capacity rose to 90% of all new vehicles sold in Brazil.
- Ever since 2004, the promotion of FFVs that can run on both ethanol and gasoline provided consumers with the option to switch between the fuels gained traction. This innovation boosted the market once again, leading to increase in the share of FFVs to 90% within 5 years since FFVs were introduced^{xii}.
- Currently approx. 98% of all vehicles sold in Brazil are FFV vehicles, bringing the overall FFV share to 80% of vehicles (30 million units) and 34% of motorcycles (5 million units)^{xiii}.

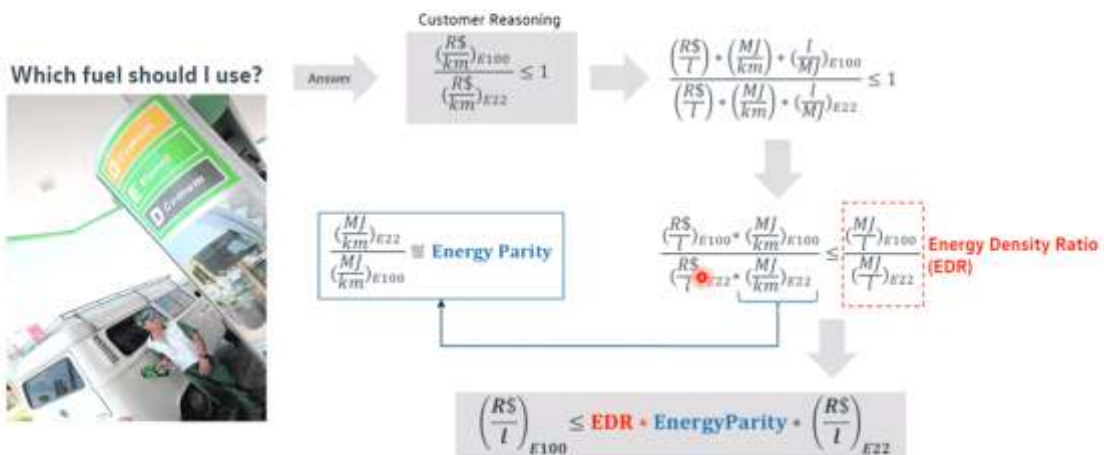




- Brazilian flex engines are being designed with higher compression ratios, taking advantage of the higher ethanol blends and maximizing the benefits of the higher oxygen content of ethanol, resulting in lower emissions and improving fuel efficiency.
- Brazil's auto industry began producing flexible-fuel cars in March 2003 powered by engines capable of running on any mix of ethanol or petrol. The first model was the Total Flex-badged version of the 1.6-litre Volkswagen Gol Power^{xliii}.
- Honda launched world's first flex-fuel motorcycle that was launched in Brazil. With adoption of newly developed fuel supply and fuel injection control systems, Honda's Mix Fuel Injection System enables flexible mixture of environmentally-responsible bio-ethanol and gasoline fuels. Adoption of this technology helps reduce CO₂ emissions, while reducing fuel costs for consumers as well^{xliiv}.
- In Brazil, the concept of Fuel choices with the reasoning is provided. The consumer chooses the fuel, which gives him/her the freedom of ethanol blend usage.

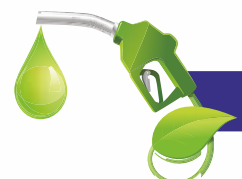


Fuel Choice: Reasoning



- Increasing Energy Parity (Higher Efficiency with Ethanol) and/or improving energy densith (MJ/l) ratio can incentivize ethanol choice at gas station.

30 Creation date: 14.02.20 | Responsible department for filing: B-TP | CSD-Class: Confidential - 01 year

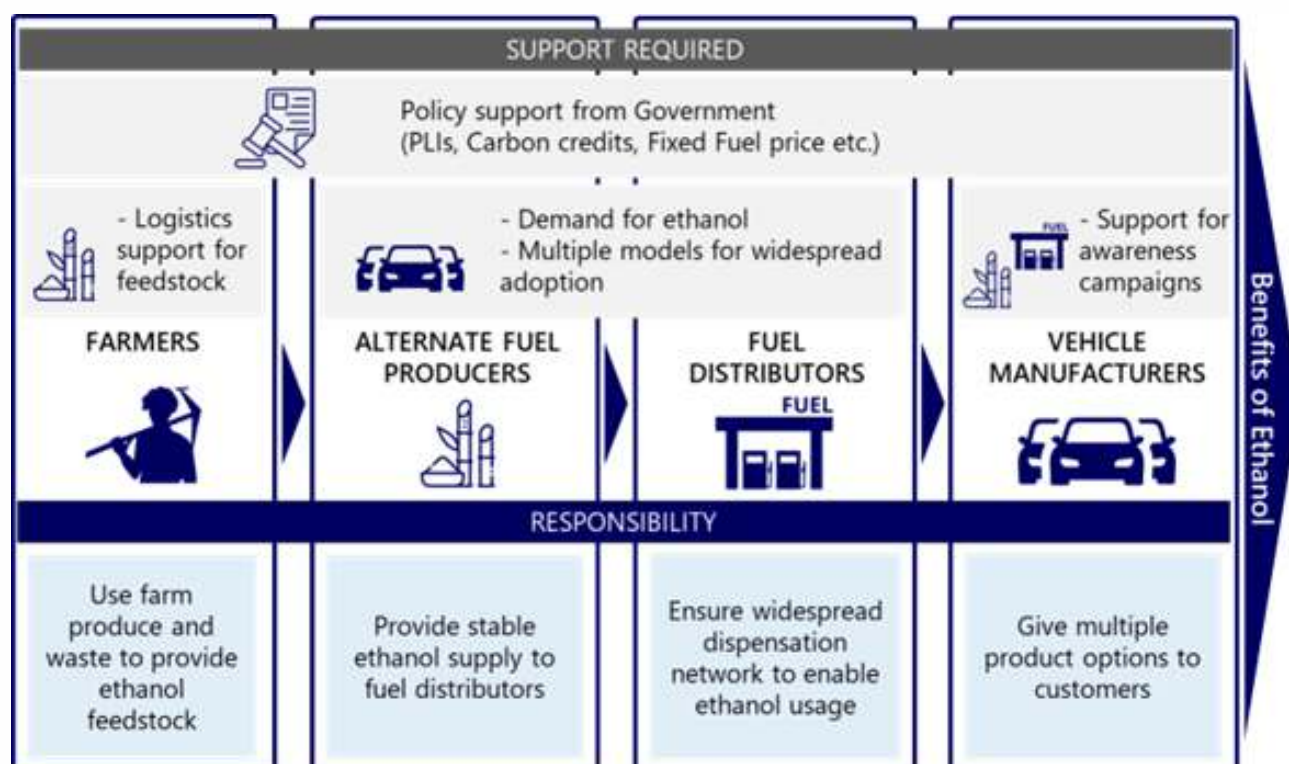


The Road Ahead



In the ethanol value chain, all the players require support from the ecosystem while also taking a few responsibilities to ensure that benefits of a sustainable ethanol ecosystem transpire to all citizens.

The farmers require policy support from the government in terms of MSP for relevant feedstock grains to incentivize and ensure feedstock supply from the farms. From the ethanol ecosystem's side, farmers need logistical support to ensure usage of farm produce and farm waste in ethanol production. Additionally, this support will prevent traditionally harmful practices like burning of Parali. On the flipside, farmers have a responsibility to use farm produce and waste so that they can avail the benefits espoused in the awareness campaigns by the government and industry players.



Alternate fuel producers i.e. sugar manufacturers and other refineries producing ethanol will need PLIs and assurance of competitive pricing of ethanol from the government. Fuel producers will also require a continuous feedstock to do their part in a sustainable ethanol ecosystem. In turn, fuel producers need to ensure a continuous flow of ethanol in the market irrespective of the raw material production cycle. Indian customers will need a stable fuel supply to materialize the benefits of ethanol adoption.

Fuel distributors in India need to ensure a widespread availability of the ethanol blended dispensation centres across the states. They need to spread awareness throughout the user base about the process and vigilance required for ethanol usage in different vehicle types. The OMCs of India will require support from government through fixed prices for ethanol blended fuel and incentivisation of 2G ethanol production, which addresses pollution from two sides. OMCs can also be championed by a provision of carbon credits, which would set up an international example in field of alternate fuels.

The vehicle manufacturers of India will also require policy support in the format of carbon credits or tax breaks in emission norms. As important stakeholders in responsible sustainable decarbonisation movement in India, OEMs need to ensure consumer awareness in terms of usage of flex fuel vehicles. This can be practiced during the purchase and service contact instances or in the product brand and design itself. Additionally, it is OEMs' onus to ensure that customers have options of multiple compatible models that can use ethanol blended fuels.

Customers, that need to adopt the ethanol blended fuel ecosystem, will need support of attractive fuel pricing, continuous fuel supply and strong vehicular support for higher blends. A strong policy mechanism, a dedicated industrial ecosystem as well as strong change management will, however, be needed to make this happen. Players that nimbly make the right moves can see significant benefits accrued to them.



Abbreviations

NBCC – National Biofuel Coordination Committee

DFPD – Department of Food and Public Distribution

ESY – Ethanol Supply Year

OMC – Oil Marketing Companies

MoPNG – Ministry of Petroleum and Natural Gas

EBP – Ethanol Blending Petrol

NPB – National Policy on Biofuel

REAP – Rural Energy for America Program

CMAQ – Congestion Mitigation and Air Quality

DOE – Department of Energy

RE – Renewable Energy

FTA – Federal Transit Administration

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- ^{iv} <https://afdc.energy.gov/files/u/publication/ethanol-ghg-reduction-with-greet.pdf>
- ^v <https://ethanolrfa.org/media-and-news/category/blog/article/2022/10/the-truth-about-ethanol-and-carbon-emissions>
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