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Impact of Ethanol on Climate Change

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ABSTRACT

India is the third largest energy consumer in the world and fifth largest economy in the world. India stands at critical juncture in its quest for energy security and sustainable development. The country's growing energy demand concerns with environmental degradation and climate necessitates a transition towards cleaner and more sustainable energy sources. Indian ethanol programme in a considerable way that controls the climate change in terms of reduction of carbon foot print. In India, ethanol programme initiated in the year 2003 and a present condition it had developed blending of 20% blended with petrol. For achieving E20 programme successfully in the year 2025-26, National Biofuel Policy 2018 amended in the year 2022. Sugar industries have contributed more than 60% of ethanol made from sugarcane as feedstock and balance 40% from grain ethanol. Globally, US dominates in ethanol production and contributed at considerable level in reduction of carbon footprint through corn ethanol. Similarly, Brazil is the second nation in the world that contributed more than 30% ethanol produced from sugarcane as feedstock. India ranks third in the world have improved its ethanol blending rate 1.6 from 2013-14 to 12 % in 2024. OP28 was particularly momentous as it marked the conclusion of the first 'global stocktake' of the world's efforts to address climate change under the Paris agreement. This paper analyzes the real impact of ethanol on climate change and reduction in gas emission at global scenario.

Keywords: Ethanol, energy security, renewable energy,climate change, sustainable development, sugarcane feedstock, corn ethanol

INTRODUCTION

Globally environmental degradation is a serious threat to every nation due to surge in energy demand and industrial revolution. Greenhouse gas emission is a chief task of every nation that contributed environmental deterioration and have impact on climate change. To overcome this problem to every nation, biofuel is the sustainable energy source as transport fuel have contributed reduction in greenhouse gas emission.

Production and use of biofuels is considered to be the best source of transport fuel in every nation. Brazil is the first country in the world introduced ethanol as biofuel. At present scenario, US has advanced their renewable fuel like ethanol and contributed maximum extent in ethanol production and blending with ethanol. Fossil fuel derived sources have contributed largest level in greenhouse gas emission throughout the world. In spite of this fossil fuel, an alternative fuel source like ethanol and bio-diesel is the best fuel source currently utilized in every country. It has more potential national economic and security benefits that have reduced the import of petroleum fuels.

In this article, a detailed discussion on production of bio-fuels and its impact on climate change. COP28 was particularly momentous as it marked the conclusion of the first 'global stocktake' of the world's efforts to address climate change under the Paris Agreement. Having shown that progress was too slow across all areas of climate action – from reducing greenhouse gas emissions, to strengthening resilience to a changing

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climate, to getting the financial and technological support to vulnerable nations – countries responded with a decision on how to accelerate action across all areas by 2030. This includes a call on governments to speed up the transition away from fossil fuels to renewables such as wind and solar power in their next round of climate commitments..

MATERIALS AND METHOD

Ethanol (CH_3CH_2OH) is a renewable fuel that can be made from various plant materials, collectively known as "biomass." Ethanol is an alcohol used as a blending agent with gasoline to increase octane and cut down carbon monoxide and other smog-causing emissions. The most common blend of ethanol is E10 (10% ethanol, 90% gasoline) and is approved for use in most conventional gasoline-powered vehicles up to E15 (15% ethanol, 85% gasoline). Some vehicles, called flexible fuel vehicles, are designed to run on E85 (a gasoline-ethanol blend containing 15 % Gasoline %–85 % ethanol, depending on geography and season), an alternative fuel with much higher ethanol content than regular gasoline. Roughly 97% of gasoline in the United States contains some ethanol.

Most ethanol is made from plant starches and sugars—particularly corn starch in the United States, but scientists are continuing to develop technologies that would allow for the use of cellulose and hemi-cellulose, the non-edible fibrous material that constitutes the bulk of plant matter. The common method for converting biomass into ethanol is called fermentation. During fermentation, micro-organisms (e.g., bacteria and yeast) metabolize plant sugars and produce ethanol.

Pure ethanol and biodiesel are nontoxic and bio-degradable, and if spilled, they break down into harmless substances. However, fuel ethanol contains denaturants to make fuel ethanol undrinkable. Similar to petroleum fuels, biofuels are flammable (especially ethanol) and must be transported carefully. Ethanol and ethanol-gasoline mixtures burn cleaner and have higher octane levels than gasoline that does not contain ethanol, but they also have higher evaporative emissions from fuel tanks and dispensing equipment. These evaporative emissions contribute to the formation of harmful, ground-level ozone and smog. Gasoline requires extra processing to reduce evaporative emissions before blending with ethanol (Biofuel Basics, 2024).

Ethanol, the low carbon solution: The rise of global temperatures and cataclysmic natural disasters and weather events have hastened and intensified policy discussions around carbon's role in climate change (Figure 1). With renewable fuels like ethanol, we don't have to wait and hope for major technological or economic breakthroughs, the fuel is available now at a low cost to drive the decarbonization of liquid fuels.

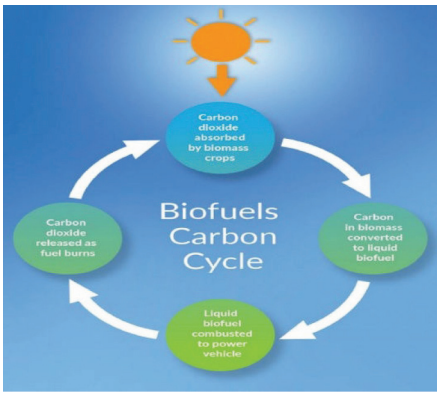

Figure 1 : Biofuels carbon cycle

Grain-based ethanol cuts greenhouse gas emissions significantly by 44 to 52% compared to gasoline, according to the Department of Energy's Argonne National Laboratory. Similarly, researchers from Harvard, MIT, and Tufts concluded that today's corn ethanol offers an average GHG reduction of 46% versus gasoline. Emerging technologies promise to boost that reduction to near 70% in the next few years, according to USDA. And ethanol made from corn kernel fiber and other cellulosic feedstocks is already delivering reductions of 80% or more (Biofuels and the Environment 2022).

Clearing the air with ethanol

In addition to reducing GHG emissions, ethanol is the best tool available to reduce tailpipe emissions of other harmful pollutants. Adding ethanol to gasoline reduces tail pipe emissions of the following pollutants, among others: Carbon monoxide, which can cause harmful health effects by reducing oxygen delivery to the body's organs. Exhaust hydrocarbons, which contribute to ozone, irritate the eyes, damage the lungs, and aggravate respiratory problems. Air toxics like benzene, which can cause cancer and reproductive effects or birth defects. Fine particulate matter, which can pass through the throat and nose and enter the lungs, causing serious health effects.

Global bio-fuel production

Worldwide fuel ethanol production reached over 29.5 billion gallons in 2023, which was an increase of nearly 1.4 billion gallons compared to the previous year and the highest figure on record (Figure 2). The United States, Brazil, and the European Union are among the leading countries in fuel ethanol production.

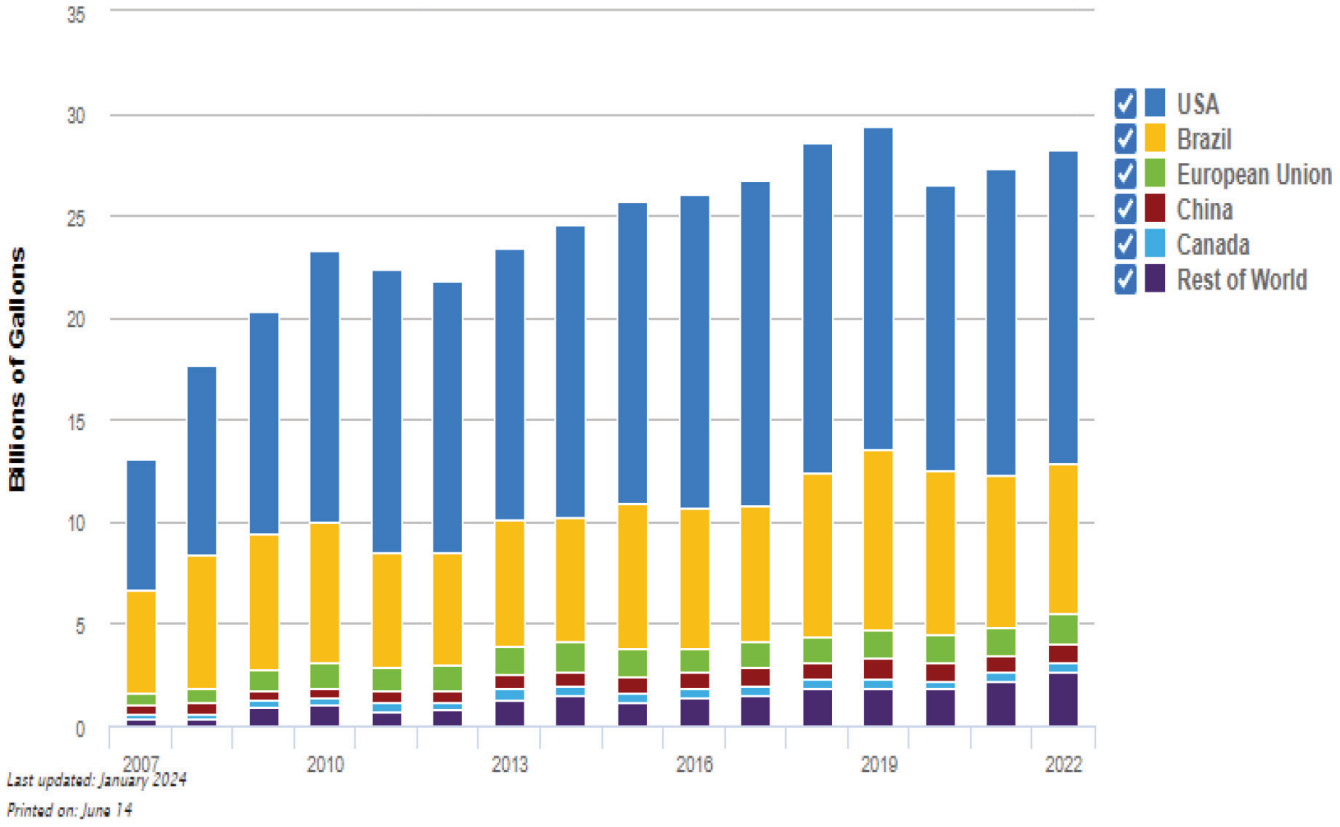

Figure 2 : Global ethanol production in 2023

India and ethanol production

The Government of India has been implementing Ethanol Blended with Petrol (EBP) Programme throughout the country wherein Oil Marketing Companies (OMCs) sell petrol blended with ethanol. Under EBP Programme, Government has fixed the target of 20% blending of ethanol with petrol by 2025.In order to achieve the target of 20% blending by 2025, about 1016 crore liters of ethanol is required and total requirement of ethanol including for other uses is 1350 crore litres (Figure 3). For this, about 1700 crore liters of ethanol producing capacity is required to be in place by 2025 considering plant operates at 80% efficiency. The Government has estimated the demand of ethanol required for 20% blending by 2025 keeping in view the growth of petrol-based vehicles in two-wheeler and passenger

vehicle segments and the projected sale of Motor Spirit (MS). Due to effective government policies, the supply of ethanol to Oil Marketing Companies (OMCs) has increased by more than 13 times to about 502 crore litres in ethanol supply year (ESY) 2022-23 from 38 crore litres in ESY 2013-14. The blending percentage has also increased from 1.53% in ESY 2013-14 to targeted 12% in ESY 2022-23.Ethanol Production capacity in the country is 1380 crore litres of which 875 crore liters is molasses based and 505 crore liters is grain based (COP28).

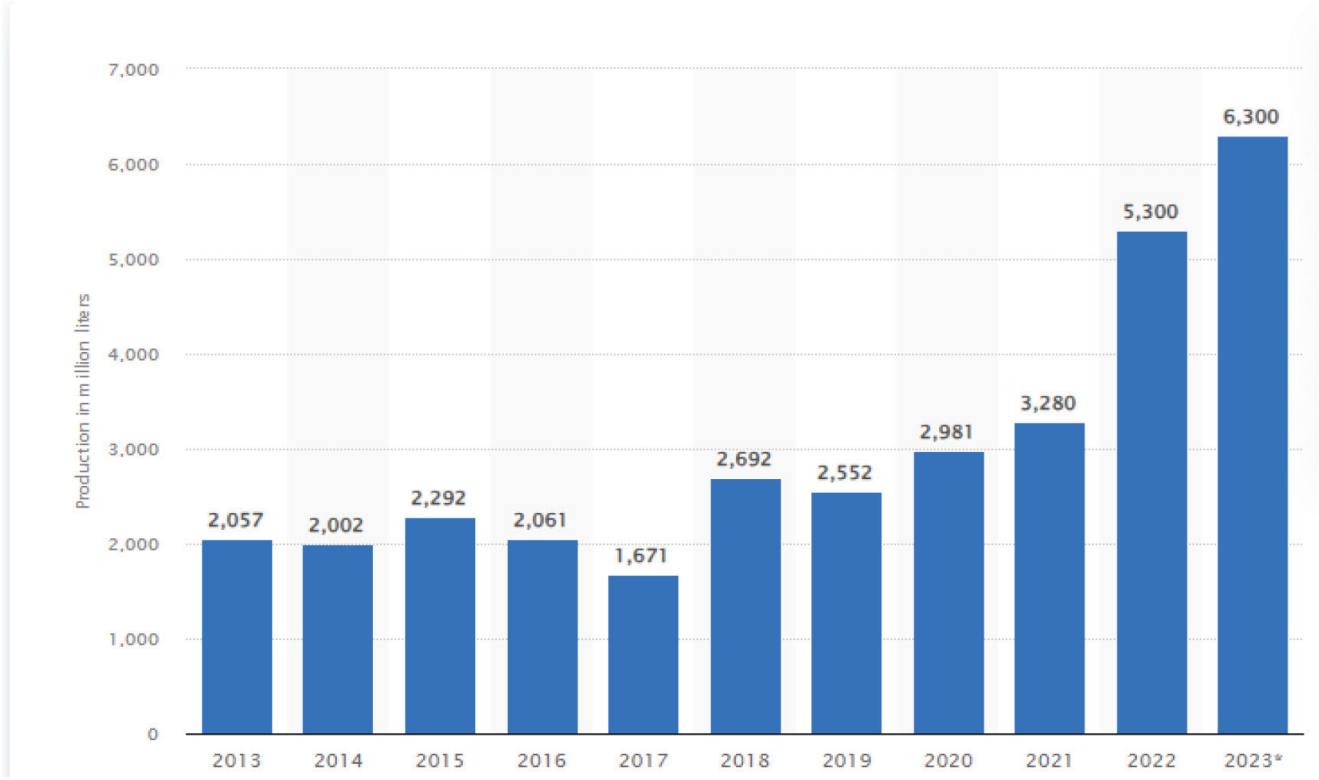

Figure 3 : Year wise ethanol production in India

Ethanol as transportation fuel

The most common use of fuel ethanol is in mixtures of finished motor gasoline. Most gasoline sold in the United States, Brazil, India, China, contains some ethanol. The exact amount may vary by region and season of the year. In general, the ethanol content of motor gasoline does not exceed 10% by volume. E10, E15, and E85 are the three primary gasoline-fuel ethanol blends in the United States, gasoline pumps that dispense motor gasoline containing fuel ethanol identify or label the gasoline according to the maximum level of the ethanol blend: E10, E15, and E85. A blend of 10% ethanol and 90% gasoline (by volume) is known as E10 gasoline. Motor gasoline with up to 15% ethanol content is called E15. E10 is the primary source of U.S. ethanol consumption. E85 is a gasoline-ethanol blend containing 51% to 83% ethanol, depending on geography and season. E85 is defined as an alternative fuel. In India, E20 ethanol blended petrol is available in most of the petrol outlets. In latest trend, E100 outlets have been started in the country and more than 100 outlets are functioning (COP28).

Ethanol and climate impact

Burning bio-fuels results in emissions of carbon dioxide (CO_2), a greenhouse gas. However, according to international convention, CO_2 emissions from bio-

fuel combustion are excluded from national greenhouse gas emissions inventories because growing the biomass feedstocks used for biofuel production may offset the CO_2 produced when biofuels are burned.

The effect that biofuel use has on net CO_2 emissions depends on how the biofuels are produced and whether or not emissions associated with crop land cultivation are included in the calculations. Growing plants for fuel is a controversial topic because some people believe the land, fertilizers, and energy used to grow biofuel crops should be used to grow food crops instead. In some parts of the world, large areas of natural vegetation and forests have been cleared or burned to grow soybeans and palm oil trees to make biodiesel. The processes for producing ethanol, renewable diesel, renewable heating oil and renewable aviation fuel require a heat source, and most producers of these bio-fuels currently use fossil fuels. Some U.S. ethanol producers burn corn stalks for heat and ethanol producers in Brazil use sugar cane stalks (called bagasse) to produce heat and electricity.

Corn ethanol @grain alcohol: Corn ethanol is ethanol produced from corn biomass and is the main source of ethanol fuel in the United States, mandated to be blended with gasoline in the Renewable Fuel Standard. Corn ethanol is produced by ethanol fermentation and distillation. It is debatable whether the production and use of corn ethanol results in lower greenhouse gas emissions than gasoline. Approximately 45% of U.S. corn croplands are used for ethanol production. Currently, corn ethanol is mainly used in blends with gasoline to create mixtures such as E 10, E 15, and E 85. Ethanol is mixed into more than 98% of United States gasoline to reduce air pollution. Corn ethanol is used as an oxygenate when mixed with gasoline. E 10 and E 15 can be used in all engines without modification. However, blends like E85, with a much greater ethanol content, require significant modifications to be made before an engine can run on the mixture without damaging the engine. Some vehicles that currently use E 85 fuel, also called flex fuel, include, the Ford Focus, Dodge Durango and Toyota Tundra, among others. USDA report, titled "A life-cycle analysis of the greenhouse gas emissions of corn-based ethanol," finds that greenhouse gas (GHG) emissions associated with producing corn-based ethanol in the United States are about 43 percent lower than gasoline when measured on an energy equivalent basis. Unlike other studies of GHG benefits, which relied on forecasts of future ethanol production systems and expected impacts on the farm sector, this study reviewed how the industry and farm sectors have performed over the past decade to assess the current GHG profile of corn-based ethanol. The report shows that the reductions in GHG emissions were driven by a variety of improvements in ethanol production, spanning from the corn field to the ethanol refinery. Farmers are producing corn more efficiently and using conservation practices that reduce GHG emissions, including reduced tillage, cover crops, and improved nitrogen management. Both corn yields and the efficiency of ethanol production technologies are also improving. Previous estimates of ethanol's GHG balance report lower efficiencies, largely due to anticipated conversion of grasslands and forests to commodity production as a result of increased demand for corn used in ethanol production.

Concerns surrounding the shift to maize

In the fiscal year 2022-23, India produced approximately 4.94 billion liters of ethanol (Saini and Hussain, 2023). This substantial output comprised 75% derived from sugarcane-based sources, while 15% originated from rice released by FCI, 4% from maize, and the residual 5% sourced from damaged food grains, including broken rice available in the open market (ibid.). Despite maize being globally recognized as a primary feedstock due to its lower water consumption and cost-effectiveness, its utilization for ethanol production remains at a nascent stage within India. Presently, ethanol production in grain-based distilleries primarily relies on Damaged Food Grains (DFG) like broken rice or FCI rice, with minimal emphasis on maize utilization. The incorporation of multiple feedstocks is envisioned to bolster feedstock security, mitigating reliance on any singular source and showcasing the economic and water efficient nature of maize based ethanol.

The government is contemplating increasing maize utilization for ethanol production, acknowledging its potential dominance in this domain. However, such a shift necessitates a significant surge in maize production to prevent disruption in its current applications in fodder, food manufacturing, starch, and various industrial processes. Meeting India's ethanol production

goals might necessitate an additional 30,000 square kilometers of maize cultivation by 2025-26, raising concerns about sustainable land usage expanding maize cultivation for ethanol poses a conundrum from a food security perspective, given its limited ethanol yield compared to sugarcane. This consideration, coupled with unreliable maize surpluses and the necessity to preserve its multifaceted use, underscores the complexity and challenges of shifting towards maize-based ethanol production in India.

Ethanol reduces harmful emissions:

Ethanol and other biofuels are often touted for their ability to reduce greenhouse gas emissions by replacing fossil fuels. Traditional biofuels like ethanol can reduce greenhouse gas emissions by 19-48 percent compared with gasoline, while advanced or cellulosic biofuels can reduce emissions by more than 100 percent. A less recognized benefit of biofuels is their ability to reduce other harmful emissions that are found in gasoline exhaust.

A new study out of the Swiss Federal Laboratories quantifies the emissions reductions that ethanol blends like E10 (10 percent ethanol) and E85 (85 percent ethanol) achieve compared with traditional gasoline, or E0. The study analyzed and compared emissions of nanoparticles, polycyclic aromatic hydrocarbons (PAHs), and alkyl- and nitro- PAHs. The study report reveals that using ethanol blends significantly decreased these harmful emissions. A flex-fuel vehicle was used for the experiments. Reduced emissions from ethanol.

The study authors compared emissions from a flex-fuel vehicle when fueled with E0, E10, and E85. E10 is already the most commonly used fuel in the United States as a result of the renewable fuel standard (RFS). Both E10 and E85 reduced particulate matter emissions by more than 95 percent when compared with E0, providing a substantial health benefit.

In addition, PAH emissions from E10 gasoline were 67-96 percent lower than E0, while PAH emissions from E85 were 82-96 percent lower than E0. The relative toxicity of these emissions also decreased—72 percent lower with E10 and 83 percent with E85. These results suggest that switching to higher ethanol blends in our gasoline can have positive effects for human health, as well as the positive effects on greenhouse gas emissions.

UNFCC COP 28 and net zero emission:

UN climate change conferences (or COPs) take place every year, and are the world's only multilateral decision-making forum on climate change with almost complete membership of every country in the world. To put it simply, the COP is where the world comes together to agree on ways to address the climate crisis, such as limiting global temperature rise to 1.5 ^{0}C, helping vulnerable communities adapt to the effects of climate change, and achieving net-zero emissions by 2050.

More than 70,000 delegates are expected to attend COP28, including the member states (or parties) of the UN framework convention on climate change (UNFCCC). Business leaders, young people, climate scientists, indigenous peoples, journalists and various other experts and stakeholders are also among the participants.

With the world's largest population and an economy that is expected to be worth $7 trillion by 2030, India's growth potential is substantial. This will inevitably lead to increases in the country's demand for resources and its environmental footprint. The International Energy Agency (IEA) forecasts in its latest world energy outlook that India's energy consumption will increase by 30 percent by 2030 and 90 percent by 2050, with carbon emissions from energy use rising by 32 percent and 72 percent in the same period. In response, India has announced and worked toward achieving ambitious climate targets, positioning itself as an emerging market that champions environmental protection. Realizing these ambitious targets will also be key to the world achieving a 1.5°C pathway, considering that India is the world's third-largest emitter of greenhouse gasses, accounting for 7 percent of the global total annually.

Subsequently, India's National Statement at COP26 in Glasgow signaled a stepping-up of the Paris commitments, with five targets labeled Panchamrit, the five "nectars for immortality." These targets included increasing non-fossil capacity to 500 GW, meeting half of the country's energy requirements from renewables, reducing carbon emissions relative to an

Table : 1 India's climate commitments (2015-2022)

Item	National Statement at UNSDS (2015)	2016 NDC	National Statement at COP26 (2021)	2022 NDC
Renewable energy generation capacity	175 GW by 2022		50% energy requirement by 2030	
Emissions intensity with respect to GDP relative to 2005		30–35% by 2030	45% by 2030	45% by 2030
Non-fossil-fuel-based electricity generation capacity		40% by 2030	500 GW by 2030	50% by 2030
Additional carbon sink through forestry		2.5–3 billion metric tons of CO^2 equivalent		2.5–3 billion metric tons of CO^2 equivalent
Reduce total projected carbon emissions			1 billion tons from 2022 till 2030	
Net-zero goal			Net zero by 2070	

unspecified baseline, a more aggressive reduction in emissions intensity with respect to GDP relative to the Paris commitment, and a target for net zero by 2070 (Table 1).

RESULTS AND DISCUSSION

Ethanol is the low carbon fuel, renewable, Agro based feedstocks utilized for its production. Ethanol (CH_3CH_2OH) is a renewable fuel that can be made from various plant materials, collectively known as biomass. Ethanol is an alcohol used as a blending agent with gasoline to increase octane and cut down carbon monoxide and other smog-causing emissions.

Ethanol as transportation fuel: The most common use of fuel ethanol is in mixtures of finished motor gasoline. Most gasoline sold in the United States, Brazil, India, China, contains some ethanol.

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