Energy at a Glance

Ethanol and Biodiesel

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Biofuels produce more harm than benefits after accounting for their negative impacts on fuel economy, air quality, land use, and food prices.

Ethanol and Biodiesel 101

Ethanol is a form of alcohol that has a variety of uses. When it is blended with gasoline it is called a biofuel. Ethanol is usually made from corn, sugarcane, wood, grass, or other plant parts.[1] In the United States, almost all ethanol used as biofuel is made from corn.[2] Biodiesel is made from vegetable oil, palm oil, or similar products, including leftover cooking grease. In the United States, the majority of biodiesel is made from soybean oil.[3]

The Energy Policy Act of 2005 imposed a Renewable Fuel Standard (RFS) mandate for the use of biofuels purportedly to reduce U.S. reliance on foreign sources of oil.[4]

Quick Bullets

- Ethanol has a lower energy density than gasoline, which means vehicles get fewer miles per gallon.
- Per unit of equivalent energy, ethanol produces more carbon dioxide (CO2) than normal gasoline.
- Ethanol fuels produce more nitrogen oxides (NOx) and other air pollutants, which contribute to worsening air pollution, especially in summer months.

Biofuels vs. Gasoline

Ethanol has a lower energy density than gasoline, at about 20 megajoules per liter compared to gasoline's 33.[5] As a result, when ethanol is added to fuel, vehicle fuel economy declines. It takes 1.5 times more fuel to travel the same distance on ethanol than with a purely gasoline-fueled vehicle. (See Figure 1 on page 2)

Ethanol also attracts water, which can separate and cause mechanical issues. Fuel blended with ethanol corrodes rubber components in older vehicles, older fuel storage tanks, and can damage small engines such as those used in lawnmowers and boats. The U.S. Coast Guard warns boaters not to use gasoline containing ethanol in their boats.

Typically, ethanol is not shipped via pipelines because it attracts water and is corrosive, resulting in shorter functional lives for pipelines.[6] This is why ethanol is usually shipped by truck, rail, and barge, which are less efficient modes of delivery which increase emissions and are more prone to accidental spills.

Biodiesel is also less energy dense than its petroleum counterpart, by about 9 percent. It has the same problem as ethanol in that it is corrosive to rubber parts in some vehicles.

Another drawback for biodiesel is the temperature at which it gels—or begins to form small ice crystals. Regular diesel begins to gel at 5°F to -2°F. Biodiesel can gel at temperatures as high as 60° F in extreme cases—and the best cold weather biodiesel (made from canola oil) gels at 14°F. This means heavy equipment and diesel big rig trucks must use expensive winter blends of biodiesel with special petroleum-based additives to function properly in regions with consistently cold winters.

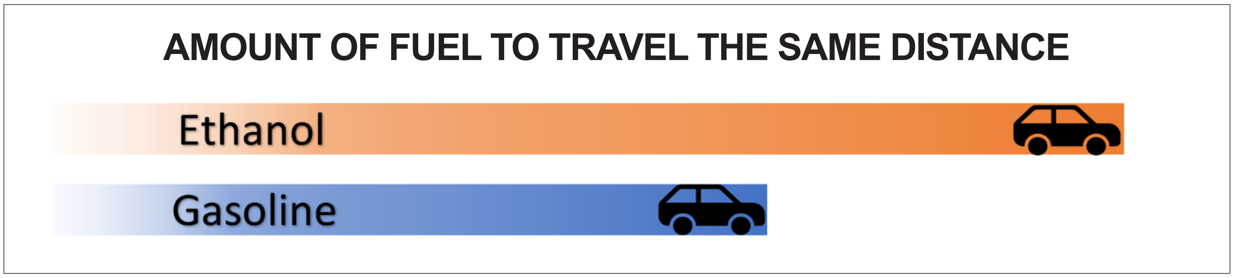


***Figure 1**: Difference in the amount of fuel it takes to travel the same distance with ethanol or gasoline fuel.*

Emissions

Despite carbon dioxide emissions from ethanol being less than gasoline on a per volume basis, because its energy density is significantly less than gasoline, ethanol use produces increased carbon dioxide emissions. In kilograms of CO_2 per energy output equivalent, ethanol comes in at 4.05 kg CO2 and gasoline at 3.30 kg CO_2. (See Figure 2)

A study from the Environmental Protection Agency (EPA) confirms the findings of a National Academy of Sciences report on biofuel policy, stating, "air quality modeling suggests that production and use of ethanol as fuel to displace gasoline is likely to increase such air pollutants as PM2.5, ozone, and SOx in some locations."[7]

The EPA also reports that ethanol produces greater NOx emissions than gasoline.

Another study concludes that using higher ethanol concentrations has led to the production of ozone at ground level, contributing to smog and causing greater "ozone-related mortality, hospitalization, and asthma by about 9% in Los Angeles and 4% in the United States as a whole relative to 100% gasoline."[8]

Food Prices and Land Impacts

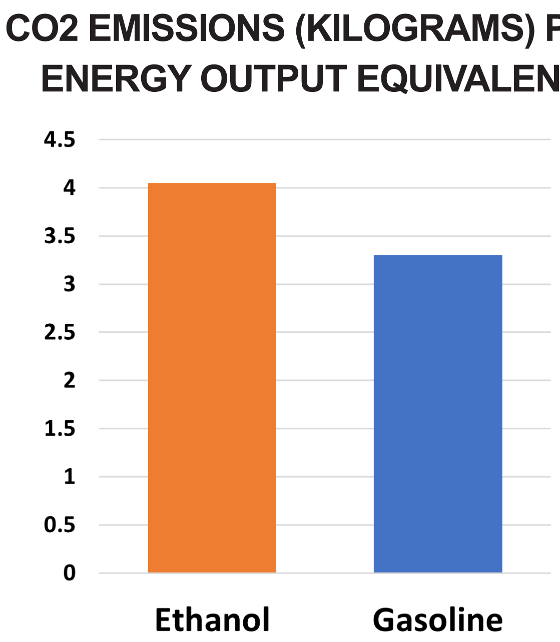
A study from the University of Wisconsin-Madison found the impact of RFS on food supplies, prices, and the environment was likely a net harm.[9]

According to the study:

> "… [T]he RFS increased corn prices by 30% and the prices of other crops by 20%, which, in turn, expanded US corn cultivation by 2.8 Mha (8.7%) and total cropland by 2.1 Mha (2.4%) in the years following policy enactment (2008 to 2016). These changes increased annual nationwide fertilizer use by 3 to 8%, increased water quality degradants by 3 to 5%, and caused enough domestic land use change emissions such that the carbon intensity of corn ethanol produced under the RFS is no less than gasoline and likely at least 24% higher."

Some countries, like Brazil, use much more ethanol than the United States. Brazil produces ethanol from sugarcane, not only because it grows well in Brazil's climate, but because producing ethanol from sugarcane is more energy efficient than other forms of ethanol.[10] Brazilian environmental scientists have linked expanded of sugarcane plantations for ethanol production to deforestation of the Amazon, which they estimate may counteract any carbon emissions savings from the biofuel use.[11]

Ethanol did not reduce U.S. dependence on foreign suppliers. Biofuels produce more harm than benefits after accounting for their negative impacts on fuel economy, air quality, land use, and food prices.



Endnotes

1 U.S. Department of Energy. “Ethanol Fuel Basics,” Alternative Fuels Data Center, Retrieved July 11, 2022 from https://afdc.energy.gov/fuels/ethanol_fuel_basics.html

2 U.S. Energy Information Administration (EIA), “Biofuels explained: Ethanol,” Retrieved July 11, 2022 from https://www.eia.gov/energyexplained/biofuels/ethanol.php

3 U.S. EIA, “Biofuels explained: biodiesel, renewable diesel, and other biofuels,” Retrieved July 11, 2022 from https://www.eia.gov/energyexplained/biofuels/biodiesel-rd-other-basics.php

4 Environmental Protection Agency, “Renewable Fuel Standard Program,” Retrieved July 11, 2022, from https://www.epa.gov/renewable-fuel-standardprogram

5 Biofuel.org.uk, “Bioalcohols,” Retrieved July 11, 2022, from http://biofuel.org.uk/bioalcohols.html

6 U.S. Department of Transportation, “Ethanol,” Pipeline and Hazardous Materials Safety Administration, Retrieved July 11, 2022 from https://primis.phmsa.dot.gov/comm/Ethanol.htm

7 Environmental Protection Agency, “Biofuels and the Environment: Second Triennial Report to Congress (Final report, 2018),” Retrieved July 11, 2022 from https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=IO&dirEntryId=341491

8 Mark Jacobson, “Effects of Ethanol (E85) versus Gasoline Vehicles on Cancer and Mortality in the United States,” Environmental Science & Technology, Vol. 41, No. 11, April 18, 2007, pp. 4150–4157.

9 Tyler Lark et al., “Environmental outcomes of the US Renewable Fuel Standard,” Proceedings of the National Academy of Sciences, Vol. 119, No. 9, February 14, 2022.

10 Filho, Murillo & Araujo, Carlos & Bonfá, Alfredo & Porto, Weber. “Chemistry Based on Renewable Raw Materials: Perspectives for a Sugar Cane-Based Biorefinery.” Enzyme research. 2011. 654596. 10.4061/2011/654596.

11 David Lapola et al., “Indirect land-use changes can overcome carbon savings from biofuels in Brazil,” Proceedings of the National Academy of Sciences, Vol. 107, No. 8, February 23, 2010, pp. 3388–3393.