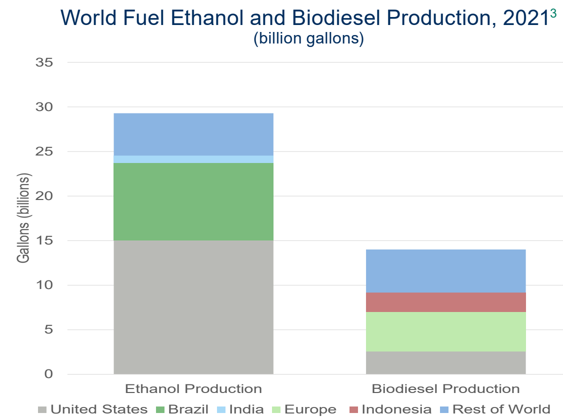
Biofuels

Biofuels have the potential to reduce the energy and greenhouse gas emission intensities associated with transportation, but can have other significant effects on society and the environment. Depending on demand, crop growing conditions, and technology, they may require significant increases in cropland and irrigation water use. Also, biofuels may have already affected world food prices.

Patterns of Use

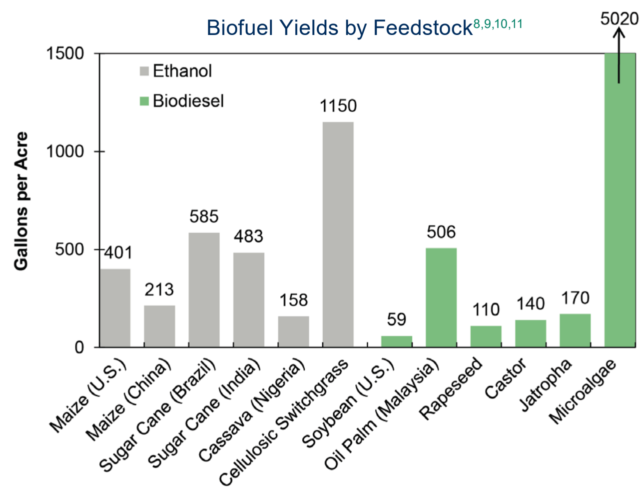
Production

- In the U.S., ethanol is primarily derived by processing and fermenting the starch in corn kernels into a high-purity alcohol. 94% of U.S. ethanol is derived from corn, while Brazil uses sugar cane as the primary feedstock.[1,2]
- The U.S. and Brazil produced about 81% of the world's ethanol in 2021.[3]
- In the 2020/21 season, 5 billion bushels of corn, 34% of the U.S. supply, became ethanol feedstock.[4]
- Cellulosic ethanol feedstocks are abundant and include corn stalks, plant residue, waste wood chips, and switchgrass. Making ethanol from these sources is more difficult because cellulose does not break down into sugars as easily.[5]
- Biodiesel can be made from animal fats, grease, vegetable oils, and algae. In the U.S., soybean oil, corn oil, and recycled cooking oils are common feedstocks.[6]
- Biodiesel from algae is an area of ongoing research. Algae could potentially produce 10 to 100 times more fuel per acre than other crops.[7]



Consumption and Demand

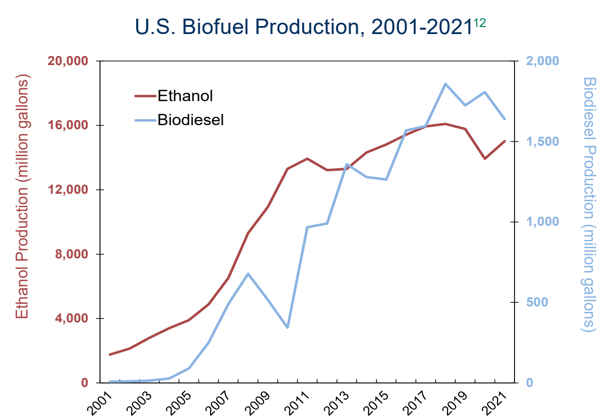
- In 2021, for the second time since tracking began, the U.S. exported more oil than was imported. The average U.S. petroleum consumption was 19.8 million barrels per day.[12]
- In 2021, there were 197 ethanol refineries and 75 biodiesel production plants in the U.S.[13,14]
- U.S. biodiesel production facilities operated at 68% capacity in 2021.[12,14]
- Many biodiesel producers are reliant on federal tax credits and remain sensitive to volatile feedstock (soybean oil) and energy (petroleum) prices. The biodiesel tax incentive was recently retroactively reinstated from January 1, 2018 and will remain in place until the end of 2022.[15]
- In 2021, 10% of U.S. vehicle fuel consumption (by volume) was ethanol and over 98% of U.S. gasoline contains ethanol.[2,12]
- E85 sells for less than regular gasoline, but contains less energy per gallon. Flex-fuel vehicles using E85 see a 15-27% reduction in fuel economy.[16]



Life Cycle Impacts

Energy

- The Fossil Energy Ratio (FER) is the ratio of energy output to nonrenewable energy inputs.[17] Gasoline has a value of 0.8 (1.2 BTU of fossil fuel needed to supply 1 BTU of gas at the pump).[19] Recent estimates have produced a FER of about 1.5 for ethanol, though areas with highly efficient corn agriculture, such as Iowa and Minnesota, have FERs close to 4, and scientists believe with increased efficiency in biomass handling, the energy balance could eventually rise to 60.[20]
- From 1990-2006, the FER for soybean biodiesel improved from around 3.2 to 5.5.[21] During the same period, ethanol transitioned from an energy sink to a net energy gain. Much of the improvement came from the reduction of fertilizer inputs to grow corn.[20]
- In comparison, petroleum-based diesel has a FER of 0.83.[22]

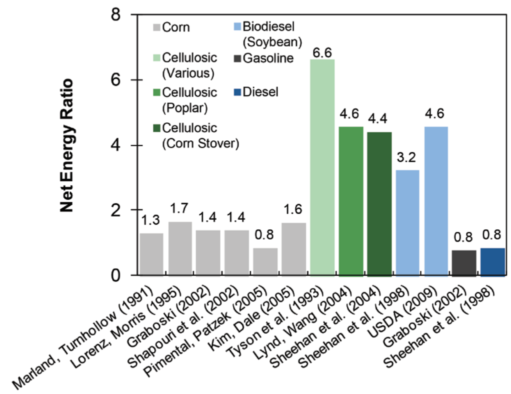


Greenhouse Gases (GHGs)

- On average, GHG emissions from corn ethanol are 34% lower than gasoline when including Land Use Change (LUC) emissions and 44% lower when excluding them.[23]
- GHG emissions for cellulosic ethanol average around 97% lower than gasoline when including LUC emissions and 93% lower when excluding LUC emissions.[23]

- The use of B20 (20% biodiesel, 80% petroleum diesel), a common biodiesel blend in the U.S., can reduce CO_2 emissions by 15% compared to petroleum diesel. The use of B100 (100% biodiesel) can reduce CO_2 emissions by 74%.[24,25]
- Biodiesel CO_2 emissions are assumed to be taken up again by growth of new feedstock, thus, tailpipe CO_2 emissions from biofuels are excluded from emissions calculations.[26,27]
- Studies have suggested that increased biofuel production in the U.S. will increase global GHG emissions, due to higher crop prices motivating farmers in other countries to convert non-cropland to cropland. Clearing new cropland releases carbon stored in vegetation, preventing the future storage of carbon in those plants.[28]

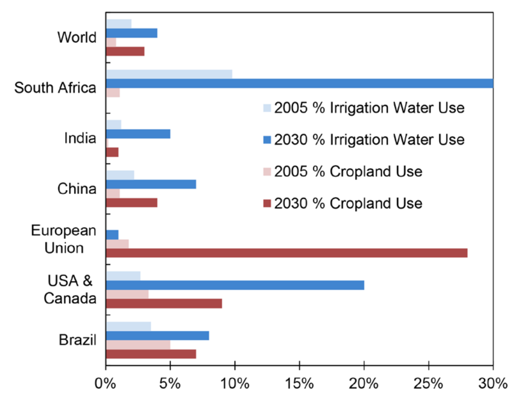
Fuel Return on Fossil Energy Investment[17,18]



Other Impacts

- A large hypoxic zone (with a five-year average area of 5,380 square miles) occurs in the Gulf of Mexico each summer.[29] Excess nitrogen, primarily from fertilizer runoff from Midwest farms, causes algae blooms that decompose and deplete dissolved oxygen, injuring or killing aquatic life. Increasing corn ethanol acreage without changing cultivation techniques will make reducing the hypoxic zone more difficult.[30]
- Globally, average arable land used for biofuels is predicted to rise from 2.5% today to 6% in 2050. However, the impacts of growing biofuel crops vary widely due to regional differences in climate and farmland availability.[31]
- The irrigation of feedstocks requires considerably more water than the manufacturing of biofuels. Although a typical biorefinery consumes 1 to 4 gallons of water per gallon of biofuel, corn grown in 2003 in Nebraska's dry climate required 780 gallons of irrigation water per gallon of ethanol.[33] The majority of corn production for ethanol occurs in highly irrigated areas, with substantial amounts from groundwater.[34]
- A review of studies focused on the food price crisis of 2006-2008 found that the growth of biofuel feedstock contributes between 20-50% to the price increase of maize. Land use change resulting from the expected increase in biofuel demand is expected to increase global maize and wheat prices 1-2% and vegetable oil prices by around 10%.[35]

Percentage of Cropland and Irrigation Water Required for Biofuels, 2005 vs 2030[32]



Solutions and Sustainable Actions

- Under the Energy Independence and Security Act of 2007, the Renewable Fuel Standard (RFS2) requires that 36 billion gallons per year (bg/y) of biofuels be produced by 2022: 16 bg/y from cellulosic sources, 5 bg/y from other advanced sources, and no more than 15 bg/y of corn ethanol. Life cycle GHG standards are also in place to ensure the biofuels produce fewer emissions than their petroleum counterparts.[36]
- U.S. ethanol producers, blenders, and resellers have been supported by a series of tax incentives, some of which were extended in 2020.[37]
- Fuel content standards are one policy option to encourage biofuel use. Regular gasoline sold in Brazil is required to contain 27% ethanol.[38] Overall, ethanol makes up 54% of transportation fuel in Brazil, compared to 10% in the U.S.[39,40]
- In 2012, new auto manufacturing standards for model years 2017-2025 were set, raising corporate average fuel economy (CAFE) standards to 54.5 miles per gallon for new light-duty vehicles in 2025. In 2020, the Safer Affordable Fuel-Efficient (SAFE) Vehicle Rule revised the CAFE standards down to an annual fuel efficiency improvement of 1.5% until 2030, equal to an average fleet-wide target of 40.5 mpg.[41,42] In 2021, NHTSA assessed the Safe Rule and has proposed repealing the rule in favor of establishing regulations that align with the Energy Policy and Conservation Act (EPCA).[43]
- Public transportation, carpooling, biking, and telecommuting are excellent ways to reduce transportation energy use and related impacts. See the CSS Personal Transportation Factsheet for more information.

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