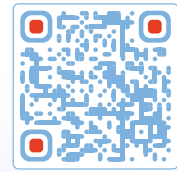


Follow the QR code for other factsheets, background information and references:

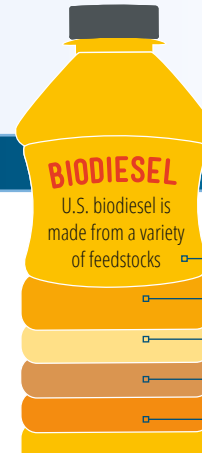
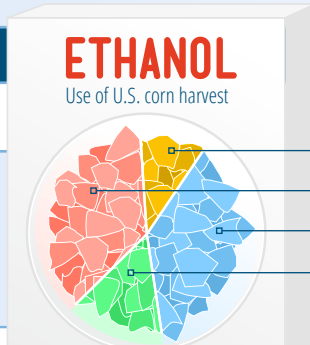


FIRST GENERATION BIOFUELS

Biofuels are liquid fuels akin to conventional gasoline and diesel, but made from plant and animal matter rather than petroleum. 'First generation biofuels' means ethanol and biodiesel produced using well-established, technologically mature processes.

FEEDSTOCKS

Ethanol is made almost entirely from corn – a significant fraction of U.S. corn is used to make ethanol.

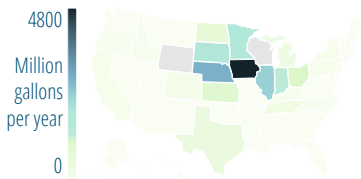


	ETHANOL	BIODIESEL
Production	Fermentation of sugars and starches (like making whiskey!).	Chemical reaction of vegetable oil or animal fat with methanol.
Blending	Blended into gasoline (10% by volume is standard).	Blended into diesel (5% by volume is standard).

PRODUCTION

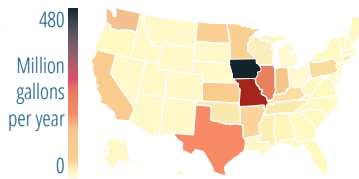
ETHANOL PRODUCTION

Average plant capacity 95 million gallons per year.



BIODIESEL PRODUCTION

Average plant capacity 35 million gallons per year.



Production and use of biofuels is incentivized under the federal 'Renewable Fuel Standard' (RFS).

GREENHOUSE GAS (GHG) EMISSIONS

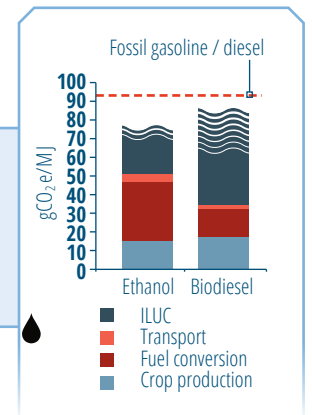
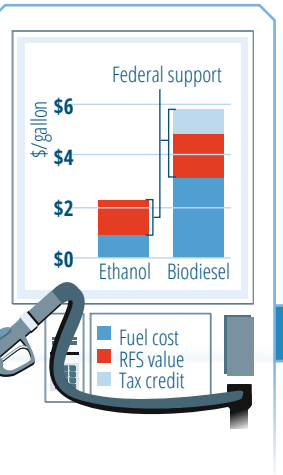
- ◆ Burning biofuels releases roughly the same amount of CO₂ per unit of energy as burning fossil fuels...
- ◆ ...but by convention this is counted as zero net emissions as this CO₂ was absorbed from the atmosphere during plant growth.
- ◆ There are still net 'lifecycle' emissions:
 - ◇ during crop cultivation, production and transport;
 - ◇ for crop-based biofuels, there may be significant emissions of nitrous oxide from fertilizers, loss of soil carbon, and land use change.

- ◆ The overall net GHG impact varies depending on feedstock and the details of feedstock and fuel production.

GHG emissions intensity can be expressed in grams of CO₂-equivalent emissions per megajoule of energy in the fuel (gCO₂e/MJ).

INDIRECT EFFECTS: INDIRECT LAND USE CHANGE (ILUC)

Increasing demand for crops stimulates farmland expansion around the world: this releases carbon from biomass and soils and may result in forest or peatland clearance. For example, consuming extra vegetable oil in the U.S. could indirectly lead to soybean expansion in Brazil and palm oil plantation expansion in Indonesia. ILUC is a complex phenomenon and is impossible to measure, so must be estimated using global economic models.



AIR POLLUTION...

...FROM VEHICLES

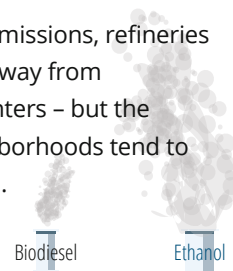
- ◆ Biofuels contribute to cleaner fuel combustion, reducing carbon monoxide, hydrocarbon, and particulate emissions; but use of biodiesel has been linked to elevated emissions of NO_x, and ethanol to elevated volatile organic compounds.
- ◆ Modern road vehicles are fitted with exhaust treatment devices to reduce pollutant emissions for all fuels.

...FROM FARMS

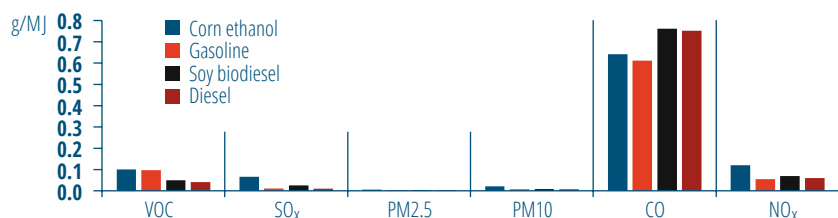
- ◆ Farming causes fertilizer-related emissions and soil disturbance leading to airborne dust.
- ◆ For example, corn production is associated with thousands of premature deaths in the U.S. through PM exposure.
- ◆ Farm emissions tend to primarily affect rural areas.

...FROM REFINERIES

- ◆ Ethanol production has been associated with higher SO_x, NO_x, and PM emissions than gasoline refining, and about the same level of VOC and CO.
- ◆ Biodiesel production on the other hand tends to emit less than diesel refining.
- ◆ As with farm emissions, refineries are normally away from population centers – but the affected neighborhoods tend to be low-income.



ETHANOL AND BIODIESEL DIESEL LIFE-CYCLE POLLUTANT EMISSIONS compared with gasoline and diesel



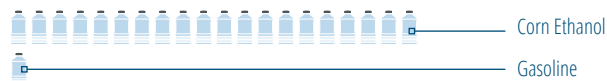
...OVERALL

Ethanol and biodiesel production and use are associated with increased air pollution.

WATER AND LAND IMPACTS

- ◆ Farming is associated with environmental issues due to water pollution from fertilizers, ecological impacts of pesticides, soil ecosystem disruption from tillage, and water abstraction.
- ◆ Up to 20% of total cropland expansion is associated with increased use of corn ethanol.

- ◆ 40% of irrigation water in the U.S. (15% of total water use) is for growing corn and soybean – the average water footprint for corn ethanol is 20 times that of an energy equivalent quantity of gasoline.

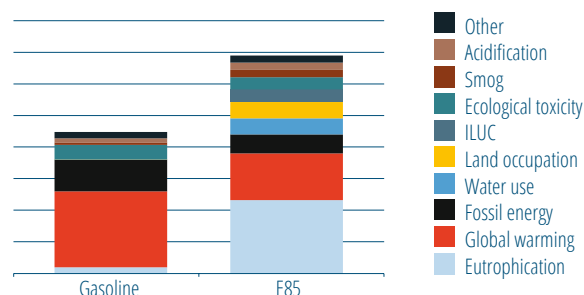


HAZARDS

- ◆ Spills of biofuels are less toxic to humans and wildlife than their fossil counterparts, and ethanol and biodiesel have relatively high biodegradability.

- ◆ Industrial handling of flammable and combustible material requires on-site safety precautions – for instance for biodiesel production where methanol undergoes reactions at high pressures and close to its boiling point – but these risks are comparable for biofuel plants and oil refineries.

INDICATIVE ENVIRONMENTAL IMPACT for gasoline versus an 'E85' blend of 85% ethanol and 15% gasoline



IMPACT INDICATORS

- ◆ Researchers have developed unified impact indicators to translate diverse environmental stresses onto a single scale.
- ◆ Even assuming lower greenhouse gas emissions, some research suggests that the overall environmental burden of first-generation biofuels is greater than for fossil fuel supply chains.