

Biofuels

for students



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Biofuels

The aim of the lesson:

Let students recognize the basic differences between fossil fuels and biofuels and their impact on the environment.

ANNEX 2

Source:

<https://www.nationalgeographic.com/environment/global-warming/biofuel/>

Promising but sometimes controversial, alternative fuels offer a path away from their fossil-based counterparts.

BY [CHRISTINA NUNEZ](#)

Group 1

Biofuels, explained

Biofuels have been around longer than cars have, but cheap gasoline and diesel have long kept them on the fringe. Spikes in oil prices, and now global efforts to stave off the worst effects of [climate change](#), have lent new urgency to the search for clean, renewable fuels. Our road travel, flights, and shipping [account for nearly a quarter](#) of the world's [greenhouse gas](#) emissions, and transportation today remains heavily dependent on [fossil fuels](#). The idea behind biofuel is to replace traditional fuels with those made from plant material or other feedstocks that are renewable.

But the concept of using farmland to produce fuel instead of food comes with its own challenges, and solutions that rely on waste or other feedstocks haven't yet been able to compete on price and scale with conventional fuels. Global biofuel output needs to triple by 2030 in order to meet the [International Energy Agency's targets](#) for sustainable growth.

Biofuel types and uses

There are various ways of making biofuels, but they generally use chemical reactions,

fermentation, and heat to break down the starches, sugars, and other molecules in plants. The resulting products are then refined to produce a fuel that cars or other vehicles can use.

Much of the gasoline in the United States contains one of the most common biofuels: ethanol. Made by fermenting the sugars from plants such as corn or sugarcane, ethanol contains oxygen that helps a car's engine burn fuel more efficiently, reducing air pollution. In the U.S., where [most ethanol is derived from corn](#), fuel is typically 90 percent gasoline and 10 percent ethanol. In Brazil—the [second-largest ethanol producer](#) behind the U.S.—fuel contains [up to 27 percent](#) ethanol, with sugarcane as the main feedstock.

Alternatives to diesel fuel include biodiesel and renewable diesel. Biodiesel, derived from fats such as vegetable oil, animal fat, and recycled cooking grease, can be blended with petroleum-based diesel. Some buses, trucks, and military vehicles in the U.S. run on fuel blends with up to [20 percent biodiesel](#), but pure biodiesel can be compromised by cold weather and may cause problems in older vehicles. Renewable diesel, a chemically different product that can be derived from fats or plant-based waste, is considered a "drop-in" fuel that does not need to be blended with conventional diesel. Other types of plant-based fuel have been created for aviation and shipping. More than 150,000 flights have used biofuel, but the amount of aviation biofuel produced in 2018 [accounted for less than 0.1 percent](#) of total consumption. In shipping, too, adoption of biofuel is at levels far below the 2030 targets set by the International Energy Agency. Renewable natural gas, or [biomethane](#), is another fuel that potentially could be used not only for transportation but also heat and electricity generation. Gas can be captured from landfills, livestock operations, wastewater, or other sources. This captured biogas then must be refined further to remove water, carbon dioxide, and other elements so that it meets the standard needed to fuel natural-gas-powered vehicles.

Group 2

What is biofuel?

Biofuels are fuels produced from renewable organic materials. These fuels can be used for a range of reasons but in recent years they have played a growing role in transportation — including providing an alternative fuel for cars. There are two main types of biofuel used in cars: bioethanol and biodiesel. Bioethanol is an alcohol made from corn and sugarcane, whereas biodiesel is made using vegetable oils and animal fats. Both offer alternatives to non-renewable crude-oil derived fuels like petrol and diesel.

Is biofuel good for the environment?

Biofuels are seen as a good medium-term solution to traditional fuels as we move towards a world where electric vehicles are the norm. They are made from more sustainable energy

sources than either petrol or diesel.

Bioethanol is classed as carbon-neutral, as any carbon dioxide released during production is removed from the atmosphere by the crops themselves. Biodiesel recycles otherwise unusable waste products, such as animal fats and cooking oil.

When used, biofuels produce significantly fewer pollutant emissions and toxins than fossil fuels. Bioenergy Australia estimates that biodiesel could cut emissions by over 85% compared to diesel, while bioethanol could reduce emissions by around 50%.

However, it is important to note that the scale of these environmental benefits is dependent on how the specific biofuels are actually produced and used.

Group 3

A biofuel is a [fuel](#) that is produced through contemporary processes from [biomass](#), rather than a fuel produced by the very slow geological processes involved in the formation of [fossil fuels](#), such as oil. Since [biomass](#) technically can be used as a fuel directly (e.g. wood logs), some people use the terms biomass and biofuel interchangeably. More often than not however, the word biomass simply denotes the biological raw material the fuel is made of, or some form of thermally/chemically altered solid end product, like torrefied pellets or briquettes. The word biofuel is usually reserved for liquid or gaseous fuels, used for transportation.

The EIA (U.S. Energy Information Administration) follow this naming practice. [\[1\]](#)

If the [biomass](#) used in the production of biofuel can regrow quickly, the fuel is generally considered to be a form of [renewable energy](#).



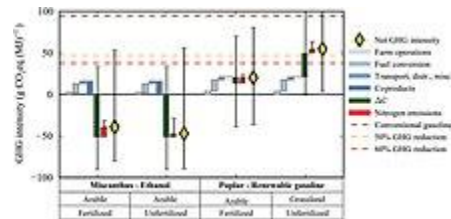
Biofuel logo

Biofuels can be produced from plants (i.e. [energy crops](#)), or from agricultural, commercial, domestic, and/or industrial wastes (if the waste has a biological origin).

[\[2\]](#) Renewable biofuels generally involve contemporary [carbon fixation](#), such as those that occur in [plants](#) or [microalgae](#) through the process of [photosynthesis](#).

Some argue that biofuel can be [carbon-neutral](#) because all biomass crops [sequester](#) carbon to a certain extent – basically all crops move CO₂ from above-ground circulation to below-ground storage in the roots and the surrounding soil. For instance, McCalmont et al. found below-ground carbon accumulation ranging from 0.42 to 3.8 tonnes per hectare

per year for soils below [Miscanthus x giganteus](#) energy crops,[3] with a mean accumulation rate of 1.84 tonne (0.74 tonnes per acre per year), [4] or 20% of total harvested carbon per year. [5]



GHG / CO₂ / carbon negativity for *Miscanthus x giganteus* production pathways. Relationship between above-ground yield (diagonal lines), soil organic carbon (X axis), and soil's potential for successful/unsuccessful carbon sequestration (Y axis). Basically, the higher the yield, the more land is usable as a GHG mitigation tool (including relatively carbon rich land.) However, the simple proposal that biofuel is [carbon-neutral](#) almost by definition has been superseded by the more nuanced proposal that for a particular biofuel project to be carbon neutral, the total carbon sequestered by the energy crop's root system must compensate for all the above-ground emissions (related to this particular biofuel project). This includes any emissions caused by direct or indirect [land use change](#). Many first generation biofuel projects are not carbon neutral given these demands. Some have even higher total GHG emissions than some fossil based alternatives.[6][7][8]

Some are carbon neutral or even negative, though, especially perennial crops. The amount of carbon sequestered and the amount of GHG (greenhouse gases) emitted will determine if the total GHG life cycle cost of a biofuel project is positive, neutral or negative. A carbon negative life cycle is possible if the total below-ground carbon accumulation more than compensates for the total life-cycle GHG emissions above ground. In other words, to achieve carbon neutrality yields should be high and emissions should be low.

High-yielding energy crops are thus prime candidates for carbon neutrality. The graphic on the right displays two CO₂ negative *Miscanthus x giganteus* production pathways, represented in gram CO₂-equivalents per megajoule. The yellow diamonds represent mean values. [9] Further, successful sequestration is dependent on planting sites, as the best soils for sequestration are those that are currently low in carbon. The varied results displayed in the graph highlights this fact. [10] For the UK, successful sequestration is expected for arable land over most of England and Wales, with unsuccessful sequestration expected in parts of Scotland, due to already carbon rich soils (existing woodland) plus lower yields. Soils already rich in carbon includes [peatland](#) and mature forest. [Grassland](#) can also be carbon rich, however Milner et al. argues that the most successful carbon sequestration in the UK takes place below improved grasslands. [11] The bottom graphic displays the estimated yield necessary to compensate for related lifecycle GHG-emissions. The higher the yield, the more likely CO₂ negativity becomes. The two most common types of biofuel are bioethanol and biodiesel.

NOTES:



The opinions presented in this document are the views of the STEP AHEAD II project partnership and do not have to express the opinions of the EU.