Liquid biofuels - keeping our wheels turning into the future
Investigating fuels produced from biomass

Biofuels are fuels that are produced from biomass, rather than by the very slow geological processes involved in the formation of fossil fuels, such as coal and oil. Biomass is plant material or animal waste which can be replenished and so biofuels are sources of renewable or sustainable energy. There are many different kinds of solid, liquid and gaseous biofuels.

Unlike other renewable energy sources, biomass can be converted directly into liquid fuels (biofuels) to help meet transportation fuel needs. The two most common types of biofuels in use today are ethanol and biodiesel, both of which represent the first generation of biofuel technology. First generation biofuels are made from edible crops, provoking a 'food versus fuel' controversy.

Miscanthus Biofuel Crop near Alkborough, North Lincolnshire

First generation biofuels

Ethanol is a renewable fuel that can be made from various plant materials. The sugar component of the biomass, such as glucose, is extracted. This is then fermented in a second stage to yield ethanol with some methanol. Ethanol is an alcohol used as a blending agent with petrol (gasoline) to increase the octane rating and reduce carbon monoxide and other noxious emissions. Almost all petrol now contains some ethanol. The most common blend of ethanol is E10 (10% ethanol, 90% petrol). Some vehicles, called flexible fuel vehicles, are designed to run on E85, an alternative petrol-ethanol blend with a much higher ethanol content containing 51% - 83% ethanol, depending on geography and season.

Biodiesel is a liquid fuel produced from renewable sources, by combining ethanol with new or used vegetable oils and animal fats such as recycled cooking grease. Like petroleum-derived diesel, biodiesel is used to fuel diesel engines. It is a replacement for petroleum-based diesel fuel, having a slightly higher octane rating and being cleaner-burning and of low toxicity. It can be blended with petroleum diesel in any percentage, including B100 (pure biodiesel) but the most common blend is B20, containing 20% biodiesel and 80% petroleum diesel.

Second-generation biofuels

The Bioenergy Technologies Office (BETO) in the UK is collaborating with industry to develop synthetic biofuels. These are made from biomass waste that does not compete with food crops. Such fuels are rich in cellulose and are made from the cell walls of plants, which can include stalks, leaves, husks, branches, forestry waste (felled trees) and fruit stones.

Technological advances in hydrocarbon biofuels are expected to lead to petroleum substitutes made in existing oil refineries for use in vehicles and smaller engines. By a process called pyrolysis, plant waste can be converted to a bio-oil. This oil is a 'chemical soup' containing a wealth of molecules. Some have fuel uses, others are for the pharmaceutical industry and for food or fragrances.

Biofuel-powered bus, Bristol

Your local area

Go with your group to a local area where you have a good view of the surrounding region or just look out of the window, or study a view on a screen.

Ask the pupils:

1. Could biofuels be produced here, in this area?
2. If they could, what impact might they have?
3. If they could be produced here, should they be produced here?
4. If they cannot or should not be produced here, but will have to be produced somewhere else, what will the impacts be on that community and region?

Back up:
Title: Liquid biofuels - keeping our wheels turning into the future

Subtitle: Investigating fuels produced from biomass

Topic: This activity describes the use of biomass to produce biofuels as an alternative to petrol (gasoline)

Age range of pupils: 14 years upwards

Time needed to complete activity: 30 minutes

Pupil learning outcomes: Pupils can:
- explain what is meant by biofuels;
- describe first generation biofuels, ethanol and bio-diesel;
- explain that producing ethanol and bio-diesel competes with food crops for land;
- describe second generation biofuels which do not compete with food crops for land.

Context:
The activity describes both first and second generation biofuels. The latter are currently undergoing extensive research and it is hoped that in the future they will replace petrol (gasoline) entirely.

Following up the activity:
Evaluate the possibilities for energy sources alternative to fossil fuels using the Earthlearningidea, 'What is/are the least bad option(s) for plugging the future global energy gap?' at https://www.earthlearningidea.com/PDF/343_Plugging_energy_gap.pdf
for other ideas of what could be developed in your area.

Search 'net-zero' on the Earthlearningidea website to find Earthlearningideas relating to climate change mitigation or adaptation. Use a search engine like Google to explore the internet for more information about likely global impacts of 'net-zero'.

Underlying principles:
- Petrol and diesel made from non-renewable mineral oil can be wholly or partially replaced with biofuels made from renewable vegetable matter.
- There is a conflict between using land to grow crops for food or for making biofuels.
- Plant waste, converted to bio-oil has many uses, including as a fuel.

Thinking skill development:
A pattern develops from first to second generation biofuels. Discussion about whether they should be produced in the local area involves metacognition and growing crops for biofuels instead of food causes cognitive conflict.

Resource list:
- normal school resources

Useful links:
Government Office of Energy Efficiency and Renewable Energy
https://www.energy.gov/eere/bioenergy/biofuel-basics

Source: Martin and Elizabeth Devon with thanks to Dr. Martin Taylor, University of Hull for technical advice.
This information was as accurate as possible in spring 2021. The full list of net zero emissions activities can be seen on the next page.

The ‘How will the ‘net-zero’ target affect your local area?’ series of Earthlearningideas

Topic			Earthlearningidea title
Introduction			How will the ‘net-zero’ target affect your local area?
Possible mitigation measures	Use alternative energy sources	Solar	Harnessing the power of the Sun
		Wave	Harnessing the power of waves
		Wind	Farming the wind: through onshore and offshore windfarms
		Tidal	Tidal energy
		Nuclear	Nuclear power - harnessing the energy of the atom
		Nuclear waste	Nuclear waste disposal
		Biofuel	Liquid biofuels: keeping our wheels turning into the future
		‘Blue’ hydrogen	Blue hydrogen: the fuel of the future? *Also:* Hydrogen of many colours
		Geothermal – hot rocks	Deep geothermal power from ‘hot dry rocks’: an option in your area?
		Geothermal – flooded mines	A new use for old coal mines
		Hydro – small scale	Small-scale hydroelectric power schemes
		Heat pumps	Heat from the Earth
		Waste – incineration	Energy from burning waste
		Waste – methane	Energy from buried waste
	Stop fuels releasing greenhouse gases	Carbon capture	Capturing carbon?
	Store energy from sources that give irregular energy supplies	Batteries	Nuclear batteries: the future?
		‘Green’ hydrogen	Green hydrogen used to even out renewable energy supplies? *Also* Hydrogen of many colours
		Hydro – storage	Matching supply and demand using stored water
		Compressed gas	Storing gas underground: What can we store? How can we do it? How will it help?
	Provide raw materials for new technologies	Electric vehicles	Electric vehicles: the way to go?
		Insulation	How do I choose the best insulation?
	Remove carbon form the atmosphere	Enhanced weathering	Speeding up nature to trap carbon dioxide
		Tree planting	Let’s plant some trees
Possible adaptation measures		Coastal flooding	How will rising sea level affect our coastlines?
		Inland flooding	Inland flooding: a Sheffield case study
		Landslides	Landslide danger
		Agriculture	The future for global agriculture