# Current Biofuels - Biogas

## Activity 1A - Biogas generator

**Learning outcomes:** By the end of the session students should be able to:

- Describe the features of a biogas generator.
- Evaluate the pros and cons of biogas feedstocks.
- Create a biogas generator.

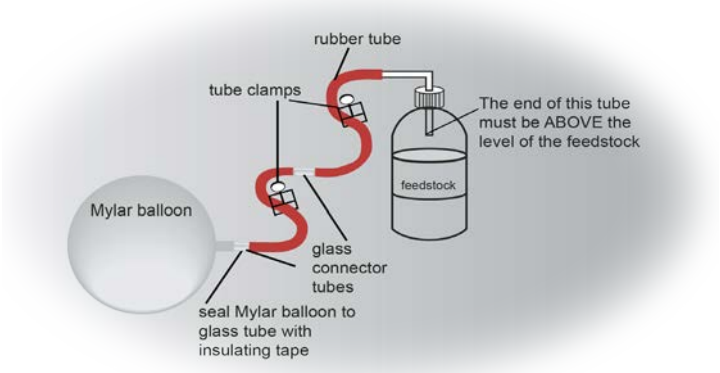
Food waste

In this activity students design and construct a biogas generator from household materials, collect the gas produced over a number of weeks and test it. Biogas generators can be constructed from household materials such as fizzy drinks bottles, and the gas burnt using a Bunsen burner. A list of possible materials is provided below. The wider the range of materials you can provide, the more creative students can be.

Designing and constructing a biogas generator makes an ideal project for students to express their creativity and problem-solving skills. The format of this exercise should be adjusted to suit the circumstances of the class and time available. It can be carried out in an hour-long session if sufficient materials are provided for the students to construct biogas generators and the gas from an already established generator is tested. If possible arrange time for students to design their own biogas generator and for the required materials to be collected. This activity works well as a long-term project that can be revisited periodically with a school or class. It can take up to six weeks to produce enough biogas to burn. This is also a good project for students to carry out towards British Science Association CREST awards or for a science fair.

First of all introduce the background to biogas production and explain the objective. Provide students with a schematic of an actual biogas generator and discuss the function of parts of the generator. You may want to show contrasting examples of biogas generators such as those used in developing countries for cooking and those used to generate electricity in power stations. Carry out a thought shower exercise in groups or with the whole class to decide on the materials required for the generator and to collect and burn the gas. Provide a list of organic material available for use in generating biogas and discuss the pros and cons before beginning construction of the generator. If students are designing their own biogas generator you will need to check their plans and ensure they have considered and can demonstrate how they will undertake the investigation safely.

An example of an effective set up is shown below:



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This activity is based on ones developed by the Department for Trade and Industry, It's Only Natural: Science programme 2005 and the Gatsby Science Enhancement Programme (SEP): Biofuels. 2009. www.sep.org.uk

**Age Range:** This activity is suitable for all secondary and post-16 students.

**Duration:** 20 minutes or longer depending on time and resources available.

**Suggested prior knowledge:** This activity does not require any specific prior knowledge but it is recommended that you elicit the existing student knowledge of fuels, microbes, properties of gases and health and safety.

## What you will need

- Water cooler bottle or fizzy drinks bottles
- Rubber tubing
- Clamps
- Bung or bottle top
- Measuring cylinder
- Tape
- Plastic tubes (a biro can be used so long as the hole in the tube is covered with tape)
- Mylar/foil balloon (rubber balloons are porous and allow the gas to escape)
- A variety of organic matter such as grass clippings, leaves, waste fruit and vegetables, tea bags
- Bunsen burner and heatproof mat
- Plasticine or blue-tack
- Disposable nitrile gloves

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## Health and Safety

Choose a suitable location to store and carry out the gas generation, bearing in mind the fire hazard.

CLEAPSS® Recipe book RB99 (Testing for gases).

Glass bottles should not be used to collect biogas due to the risk of explosion of a glass container.

The organic matter should be chosen bearing in mind microbial contamination, do not use any animal or human waste. Students should wear disposable gloves when handling organic matter and wash their hands at the end of the activity. Goggles and an apron are also recommended.

The following factors should be considered when planning to carry out any investigations involving microorganisms: nature of the organism used, source of the organism, temperature of incubation, culture medium used, type of investigation and the facilities available, chance of contamination, expertise of people involved. If necessary change the conditions or limit the involvement of students perhaps by carrying out the experiment as a demonstration. It is recommended that incubation is not carried out above 30°C to avoid the growth of potential human pathogens.

Further advice can also be sought from the Society for General Microbiology www.microbiologyonline.org.uk/teachers/safety-information and the Microbiology in Schools Advisory Committee.

## Extension activity

The amount of biogas produced by different feedstocks can be compared by the students. In order to do this, students will need to investigate and design a way of measuring the gas output of a biogas generator and compare the amount of gas produced by different feedstocks. Alternatively the same feedstock can be used and the effect of changing climatic conditions simulated by placing generators in different locations such as in front of a window, outside or in a dark room with relatively constant temperature.

The gas generated can be tested for the presence of saturated or unsaturated hydrocarbons by bubbling through bromine or iodine water.

## Suppliers

Standard laboratory equipment suitable for school use, including clamps, can be obtained through suppliers such as Rapid www.rapidonline.com Severalls Lane, Colchester, Essex, C04 5JS tel: 01206 751166 fax: 01206 751188, Philip Harris Education, Hyde Buildings, Hyde, Cheshire, SK14 4SH, tel: 0845120 4520 fax: 0800 138 8881 and Timstar Laboratory Suppliers Ltd, Timstar House, Marshfield Bank, Crewe, Cheshire, CW2 8UY, tel: 01270 250459, fax:01270 250601.

Mylar/foil balloons can be obtained from party shops as well as gift and card shops.

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## Further reading and links


Prochnow A, Heiermann M, Plochl M, Linke B, Idler C, Amon T, and Hobbs P J , 2009. “Bioenergy from permanent grassland--a review: 1. Biogas,” *Bioresource Technology* 100: 4931-4944

Prakashama R.S. , Sathisha T, Brahmaiaha P, Subba Raoa Ch, Sreenivas Rao Ch, Hobbs P J. Biohydrogen production from renewable agri-waste blend: Optimization using mixer design Int. *Journal of Hydrogen energy*, 34, 6143-6148.

Ravella SR, James SA, Bond CJ, Roberts IN, Cross K, Retter A, Hobbs PJ, 2010. *Cryptococcus shivajii* sp nov.: A Novel Basidiomycetous Yeast Isolated from Biogas Reactor. *Current Microbiology* 60:12-16 www.rothamsted.bbsrc.ac.uk/Research/Centres/ProjectDetails.php?Centre=NWR&ProjectID=5719

Burdass, D., Grainger, J.M. and Hurst, J.(editors) 2006, Basic Practical Microbiology – A Manual and Grainger, J. M. and Hurst, J. (editors) 2007, Practical Microbiology for Secondary Schools. available free from the Society for General Microbiology (SGM) www.microbiologyonline.org.uk/teachers/resources

Gatsby Science Enhancement Programme (SEP): Biofuels. 2009. www.sep.org.uk

Vicky Wong. Food Waste Recycling - Power from Potato Peelings, Catalyst: GCSE Science Review 2011, Volume 22, Issue 1 www.nationalstemcentre.org.uk/elibrary/file/14517/catalyst_22_1_491.pdf

Biogas learning activities are also available from The PACE Virtual Explorer for Secondary Science www.tusk.org/pace-biogas-project.asp

Video animation of a biogas plant in operation www.bioconstruct.com/technology/video-animation.html

The Royal Society (January 2008). *Sustainable biofuels: prospects and challenges*, ISBN 978 0 85403 662 2. http://royalsociety.org/Sustainable-biofuels-prospects-and-challenges/

Nuffield Council on Bioethics (April 2011), *Biofuels: ethical issues* www.nuffieldbioethics.org/biofuels-0


## Research groups

Dr Phil Hobbs, Principal Research Scientist and Dr Sreenivas Rao Ravella, Fermentation Scientist, Bioenergy Group, Rothamsted Research, North Wyke www.northwyke.bbsrc.ac.uk/pages/bioenergy.html