Curriculum Links

Activity 1A – Biogas

The Department for Education is conducting a review of the primary and secondary National Curriculum. The links below relate to the statutory programmes of study for science in the National Curriculum, 2007 and specific sections of common science qualifications offered in UK schools.

Key stage 3

1.2 Applications and implications of science
a. exploring how the creative application of scientific ideas can bring about technological developments and consequent changes in the way people think and behave.
1.4 Collaboration
a. sharing developments and common understanding across disciplines and boundaries.
2.1 Practical and enquiry skills Pupils should be able to:

- use a range of scientific methods and techniques to develop and test ideas and explanations
- assess risk and work safely in the laboratory, field and workplace
- plan and carry out practical and investigative activities, both individually and in groups.

3.1 Energy, electricity and forces
a. energy can be transferred usefully, stored, or dissipated, but cannot be created or destroyed
3.2 Chemical and material behaviour
c. elements and compounds show characteristic chemical properties and patterns in their behaviour.
3.4 The environment, Earth and universe
c. human activity and natural processes can lead to changes in the environment.

Key stage 4

1 How science works
1.2 Practical and enquiry skills Pupils should be taught to:
a. plan to test a scientific idea, answer a scientific question, or solve a scientific problem
c. work accurately and safely, individually and with others, when collecting first-hand data
1.3 Communication skills Pupils should be taught to:
a. recall, analyse, interpret, apply and question scientific information or ideas
1.4 Applications and implications of science Pupils should be taught:
a. about the use of contemporary scientific and technological developments and their benefits, drawbacks and risks
b. to consider how and why decisions about science and technology are made, including those that raise ethical issues, and about the social, economic and environmental effects of such decisions
2.1 Organisms and health In their study of science, the following should be covered:
a. organisms are interdependent and adapted to their environments
2.2 Chemical and material behaviour In their study of science, the following should be covered:
a. chemical change takes place by the rearrangement of atoms in substances
c. new materials are made from natural resources by chemical reactions
d. the properties of a material determine its uses.
2.3 Energy, electricity and radiations In their study of science, the following should be covered:
a. energy transfers can be measured and their efficiency calculated, which is important in considering the economic costs and environmental effects of energy use
2.4 Environment, Earth and universe In their study of science, the following should be covered:
a. the effects of human activity on the environment can be assessed using living and non-living indicators
b. the surface and the atmosphere of the Earth have changed since the Earth's origin and are changing at present

Curriculum Links

AQA Biology GCSE

B3.4 Humans and their environment B3.4.3 Biofuels

- evaluate the use of biogas generators; Candidates should have considered a number of biogas generator designs ranging from third-world generators supplying a single family to commercial generators. They should understand how the output from a biogas generator might be affected by climatic conditions.

c) Biofuels can be made from natural products by fermentation. Biogas, mainly methane, can be produced by anaerobic fermentation of a wide range of plant products or waste material containing carbohydrates.

Suggested ideas for practical work:

■ build a simple biogas generator to collect methane and demonstrate how the methane can be burned as a fuel.

■ investigate and design a way of measuring the gas output of a biogas generator and compare the amount of gas produced by different materials.

AQA Physics and Science A GCSE

P1.4.1 Generating electricity

a) In some power stations an energy source is used to heat water. The steam produced drives a turbine that is coupled to an electrical generator.

Energy sources include:

■ biofuels that can be burned to heat water.

AQA Chemistry and Science GCSE

Unit C1.4 Crude oil and Fuels C1.4.3 Hydrocarbon fuels

e) Biofuels, including biodiesel and ethanol, are produced from plant material. There are economic, ethical and environmental issues surrounding their use.

AQA Science B GCSE

3.4.2.2 Fuels for cooking, heating and transport Candidates need to:

1. Name suitable fuels for cooking, heating our homes and for providing transport.
3. Explain some of the problems of burning fossil fuels (pollution, carbon dioxide production and global warming) and that resources of fossil fuels are finite.

3.4.2.3 Generation and distribution of electricity Candidates need to:

1. Define the terms renewable and non-renewable in the context of energy sources.
2. Know that fossil fuels (natural gas, oil and coal) release energy when they are burned, which can be used to generate electricity for our homes.
3. Explain how nuclear fuels and renewable energy sources (wind, solar, hydroelectric, wave, tidal, biomass and geothermal) may be used as alternatives to fossil fuels.

Within this context, candidates should be able to use scientific data and evidence to discuss, evaluate or suggest implications of the following:

■ the environmental impact over time of energy production by comparing the advantages and disadvantages of using alternative energy sources

■ the economic impact of using alternative energy sources

AQA Environmental Science GCSE

A2.4 What alternative energy technologies are available?

Scientists have developed alternative technologies to harness energy from sources other than fossil fuels. Environmental scientists use their knowledge to assess these alternatives for their efficiency and potential environmental impact.

Scientists have also developed methods of electricity generation from renewable resources that may be used instead of fossil fuels.

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Candidates should know and understand that:
• renewable energy resources are usually sustainable:
• not depleted by use including wind power
• capable of rapid replacement including biofuels
• most renewable energy resources:
• use kinetic energy to turn generators, which produce electricity (exceptions include solar water heating, photovoltaics, geothermal and biofuels)
• usually need larger areas than thermal power stations to yield the same amount of energy
• may be unreliable or cannot provide a constant supply of energy
• may detract from the appearance of a land/seascape (A1)
• may affect wildlife populations or habitat (B1)
Agricultural scientists have developed plant crops, together with the use of animal and plant waste to produce renewable biofuels.
Candidates should know and understand that:
• biofuels, eg biogas, bioethanol, biodiesel, are also renewable and can:
  • be burned to produce heat but release carbon dioxide
  • be used as vehicle fuel
  • be 'carbon neutral' or 'green' as carbon dioxide taken out of the air by photosynthesis when energy crops grow is returned when the fuel is burnt so that no extra is added to the atmosphere (B2)
  • be a waste product eg from sewage plants, poultry farms (A1)
  • be environmentally damaging when land is cleared, and biodiversity (B1)and food-producing farmland are lost (A1)
  • *have a lower energy density than fossil fuel*
Environmental scientists use their knowledge of chemistry, physics and biology to consider both the advantages and disadvantages of various energy resources. They consider a number of factors before making conclusions and recommendations.
Candidates should be able to:
• describe: biofuels
• in terms of:
  • efficiency
    —predictability
    —intermittency
    —*energy density*
  • potential environmental impact including:
    —emissions to air/water
    —mining/quarrying land take
    —disturbance to sediment patterns/water flow
    —hazardous waste
    —disruption of wildlife
    —noise/radio disturbance
    —loss of landscape value
Opportunities to investigate using scientific knowledge and skills:
• the amount of energy produced by different vegetable oils/alcohols
• the rise in temperature in a compost heap over time
• public attitudes towards different energy producing technologies

OCR Additional Science A and Biology A 21st Century GCSE
Module B4: The processes of life B4.3 How do living organisms obtain energy?
12. describe examples of the applications of the anaerobic respiration of microorganisms, including the production of biogas and fermentation in bread making and alcohol production.

OCR Biology A 21st Century GCSE
Module B7: Further Biology B7.5 New technologies
2. understand that bacteria and fungi can be grown on a large scale (fermentation) to include production of: d. enzymes for commercial products, such as washing powders and to make biofuels

Curriculum Links

OCR Physics and Science A 21st Century GCSE
Module P3: Sustainable energy P3.1 How much energy do we use?
1. understand that the demand for energy is continually increasing and that this raises issues about the availability of energy sources and the environmental effects of using these sources
2. recall the main primary energy sources that humans use: fossil fuels (oil, gas, coal), nuclear fuels, biofuels, wind, waves, and radiation from the Sun

OCR Biology and Science B Gateway GCSE
Module B6: Beyond The Microscope Item B6d: Biofuels
Summary: With problems of declining stocks of fossil fuels and long term problems of nuclear energy, many countries are developing cleaner fuels which need only simple technology. Many of these processes involve the use of microorganisms.
Assessable learning outcomes Foundation Tier only: low demand
Explain how plants produce biomass.
Recognise examples of fuels from biomass, to include:
• alcohol
• biogas
• wood.
Understand why biogas (mainly methane) is an important energy resource in certain remote parts of the world lacking a mains electricity supply or mains sewage system.
Recall that the rotting of organic material such as dead plants and animal waste:
• occurs in marshes, septic tanks and animal digestive systems
• produces a mixture of gases including methane
• is caused by the action of bacteria.
Recall that biogas can be produced on a large scale using a digester.
Explain why methane being released from landfill sites is dangerous: it can burn or explode preventing use of the site for many years.
Recall that biogas contains:
• mainly methane
• some carbon dioxide
• traces of hydrogen, nitrogen and hydrogen sulphide.
Describe how methane can be produced on a large scale using a continuous flow method of providing organic waste and removing the gas and remaining solids.
Describe the uses of biogas, to include:
• burning to generate electricity
• burning to produce hot water and steam for heating systems
• used as a fuel for vehicles.
Describe how biogas production is affected by temperature.
Higher Tier only: high demand
Recall that biogas containing more than 50% methane can be burnt in a controlled way but a lower percentage of about 10% is explosive.
Understand that biogas is a ‘cleaner’ fuel than diesel and petrol but does not contain as much energy as natural gas.
Explain why biogas production is affected by temperature.
Suggested practical and research activities
Research the use of biogas in Nepal.
Design a biogas digester and display the plans as a chart.
Research use of biogas in cities such as Newcastle and Leeds.

Curriculum Links

OCR Physics and Science B Gateway GCSE
Module P2: Living For The Future (Energy Resources)
Suggested practical and research activities
Build a model digester to generate methane from biomass.
Assessable learning outcomes
Foundation Tier only: low demand
Recall that fuels release energy as heat.
Recall the common fuels used in power stations:
• fossil fuels
• renewable biomass – wood, straw and manure

Edexcel Biology GCSE
Unit B3: Using Biology Topic 3 Biotechnology
3.2 Describe a fermenter as a vessel used to cultivate microorganisms for the production of biomolecules on a large scale
3.3 Explain the need to supply suitable conditions in fermenters, and the effect they have on growth rates, including:
a aseptic precautions
b nutrients
c optimum temperature
d pH
e oxygenation
f agitation
3.19 Demonstrate an understanding of the advantages and disadvantages of replacing fossil fuels with biofuels, including the facts that biofuels are renewable and that their production uses carbon dioxide but that growing the crops to make them requires land and may affect the availability of land for growing food.

SQA Standard Grade Science
Topic 3: Energy and its Uses Renewable Sources of Energy
1 Fossil fuels and nuclear fuels are non-renewable, but waves, wind, hydroelectricity and the sun are renewable sources of energy.
2 As the stocks of fossil fuels are depleted these alternative sources of energy will become more important.
Credit Level
3 Other renewable sources of energy include sugar alcohol and geothermal heat.
In sugar-growing countries, sugar can be fermented into alcohol which can be used as a fuel.
4 There are advantages and disadvantages in the use of each alternative or renewable energy source, to include: cost, the technology involved, visual pollution, and reliability of the energy source.

SQA Standard Grade Biology
Topic 7: Biotechnology Sub-Topic a – Living Factories b- problems and profit with waste

SQA Standard Grade Chemistry
Topic 15: Carbohydrates and Related Substances

Cambridge 21st Century science iGCSE
Module C2: Material choices C2.4 How should we manage the wastes that arise from our use of materials?

Curriculum Links

1. Recall the key features of a life cycle assessment (LCA) including:
• the environmental impact and sustainability of making the material from natural resources
4. in the context of a Life Cycle Assessment:
• can explain the idea of sustainable development, and apply it to specific situations

Cambridge Physics iGCSE (with significant similarity to Coordinated and Combined Science iGCSE)
1. General physics 1.6 Energy, work and power 1.6 (b) Energy resources
• Distinguish between renewable and non-renewable sources of energy
• Give advantages and disadvantages of each method in terms of cost, reliability, scale and environmental impact

Cambridge Environmental Management iGCSE
5. Action on the lithosphere
5.2 technologies and viability of alternative energy sources
solar, wind, wave, geothermal, hydro-electric, biomass
5.3 strategies for conservation and management of mineral and fossil fuel resources
increased efficiency in use, insulation, recycling, power from waste, new technology
5.5 industrial materials, technologies, and approaches which can contribute to solving environmental problems
monitoring, remedial action, recycling (processing wastes and industrial products at end of life), low waste technology (developing cleaner processes and products, conservation and efficiency)
15. Human activity and the atmosphere 15.5 the environmental, technological, economic and social factors which influence the distribution of different types and systems of farming
19 Managing agriculture 19.2 harvesting energy from living resources to provide power
biomass, biogas (methane), fuel from organic waste

Key stage 5

AQA Environmental Studies A-level
A2 Unit 3 – ENVS3 Energy Resources and Environmental Pollution 3.3.1 Energy
Renewable energy resources
Examples should be used to illustrate the factors affecting the ease of use of renewable energy resources and therefore their likely use in the future
Energy density: biofuels have medium energy densities
Ease of storage: Energy can be stored as potential energy of water in reservoirs and chemical energy in biofuels
Future energy supplies New technologies
New technologies may increase the amount of energy available for use by
• increasing the amount of energy available from existing energy resources
• allowing new resources to be exploited
Atmospheric pollution

- incomplete combustion of fossil fuels and biofuels

AQA Science in Society A-level
Unit 1 AS Exploring key scientific issues 3.1.3 Transport issues
Technical ways of reducing the impact of transport on local air quality and on greenhouse gases.
The advantages and disadvantages of different fuels, to include: fossil fuels, bio-fuels, fuel cells and hydrogen.

Curriculum Links

Fuels are valuable because they are concentrated sources of energy. There is a finite amount of fossil fuel (coal, oil, natural gas) on Earth. Other energy sources (wind, wave, biomass such as wood) are renewable. They can be replaced in the same sort of time scale as they are used.

Unit 3 A2 Exploring key scientific issues 3.3.5 Energy futures The context
The context for this topic is the challenge of reconciling the growing demand for energy resources worldwide, especially the demand for electricity, with the policy imperative to cut down the emission of carbon dioxide and other greenhouse gases. People want the benefits of a readily available supply of electricity but must balance this against the cost of each method of generation and its environmental impact. Renewable sources of energy are naturally and continually replenished; they include wind, solar power, geothermal, hydropower, and various forms of biomass.