AQA GCSE (9–1)

Design & Technology

All Material Categories and Systems

Bryan Williams • Louise Attwood • Pauline Treuherz
Ian Fawcett • Dan Hughes • Dave Larby

SAMPLE CHAPTER
This title has been selected for an AQA approval process.

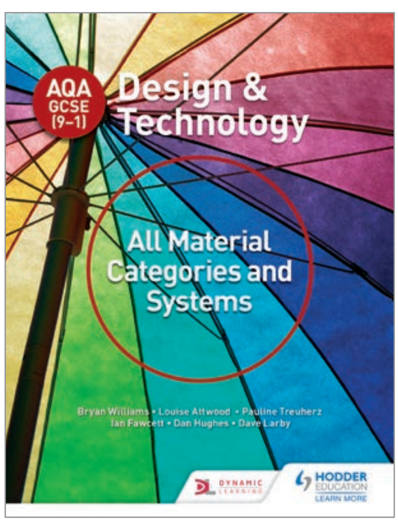
DYNAMIC LEARNING

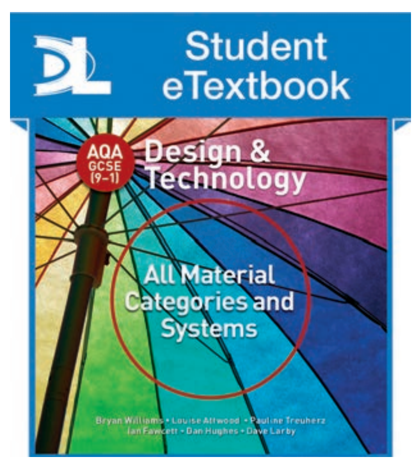
HODDER EDUCATION
LEARN MORE

Build in-depth understanding and inspire your students to tackle design challenges both practically and creatively, with a textbook that delivers the Core Technical plus Specialist Technical and Design & Making Principles needed for the 2017 AQA D&T GCSE.

The following print and digital resources have been selected for AQA approval processes.

AQA GCSE (9-1) Design and Technology: All Material Categories and Systems Student Book	9781510401082	May 2017
AQA GCSE (9-1) Design and Technology: All Material Categories and Systems Student eTextbook	9781510401167	June 2017
AQA GCSE (9-1) Design and Technology: Textile-Based Materials Student Book,	9781510401112	May 2017
AQA GCSE (9-1) Design and Technology: Textile-Based Materials Student eTextbook	9781510401228	June 2017
AQA GCSE (9-1) Design and Technology: Timber, Metal-Based Materials and Polymers Student Book	9781510401129	May 2017
AQA GCSE (9-1) Design and Technology: Timber, Metal-Based Materials and Polymers Student eTextbook	9781510401174	xJune 2017
AQA GCSE (9-1) Design and Technology: Electrical and Mechanical Systems and Components Student Book	9781510401105	June 2017
AQA GCSE (9–1) Design and Technology: Electrical and Mechanical Systems and Components Student eTextbook	9781510401242	July 2017
AQA GCSE (9-1) Design and Technology: Paper and Boards Student Book	9781510401099	June 2017
AQA GCSE (9-1) Design and Technology: Paper and Boards Student eTextbook	9781510401204	July 2017





To request Inspection Copies, eInspection Copies or free, no obligation 30-day Student eTextbook trials, visit:
www.hoddereducation.co.ukt/gcsedesignandtechnology

AQA GCSE (9–1)

Design & Technology

All Material Categories and Systems

Bryan Williams • Louise Attwood • Pauline Treuherz
Ian Fawcett • Dan Hughes • Dave Larby

HODDER EDUCATION
AN HACHETTE UK COMPANY

Photo credits: p.5 © Tomislav - Fotolia; **p.6** © martin33 - Fotolia; **p.8** © Anna Vaczi/123RF; **p.9** © Alonso Aguilar Als/123RF, © Nigel Hicks/Alamy Stock Photo, © Saskia Massink - Fotolia; **p.10** © Vladislav Gajic - Fotolia.com; **p.11** © Doug Houghton/Alamy Stock Photo; **p.13** © Stuart Aylmer/Alamy Stock Photo, © Donatas1205/123 RF; **p.14** © Bryan Fisher - Fotolia.com; © Scanrail/123 RF; © Ensuper/Shutterstock

Orders: please contact Bookpoint Ltd, 130 Milton Park, Abingdon, Oxon OX14 4SB. Telephone: (44) 01235 827720. Fax: (44) 01235 400454. Email education@bookpoint.co.uk Lines are open from 9 a.m. to 5 p.m., Monday to Saturday, with a 24-hour message answering service. You can also order through our website: www.hoddereducation.co.uk

ISBN: 9781510401082

First published in 2017 by

Hodder Education,

An Hachette UK Company

Carmelite House
50 Victoria Embankment
London EC4Y 0DZ

www.hoddereducation.co.uk

Impression number 10 9 8 7 6 5 4 3 2 1

Year 2021 2020 2019 2018 2017

Cover photo © Joerg Metzner/Restless Photography/Alamy Stock Photo

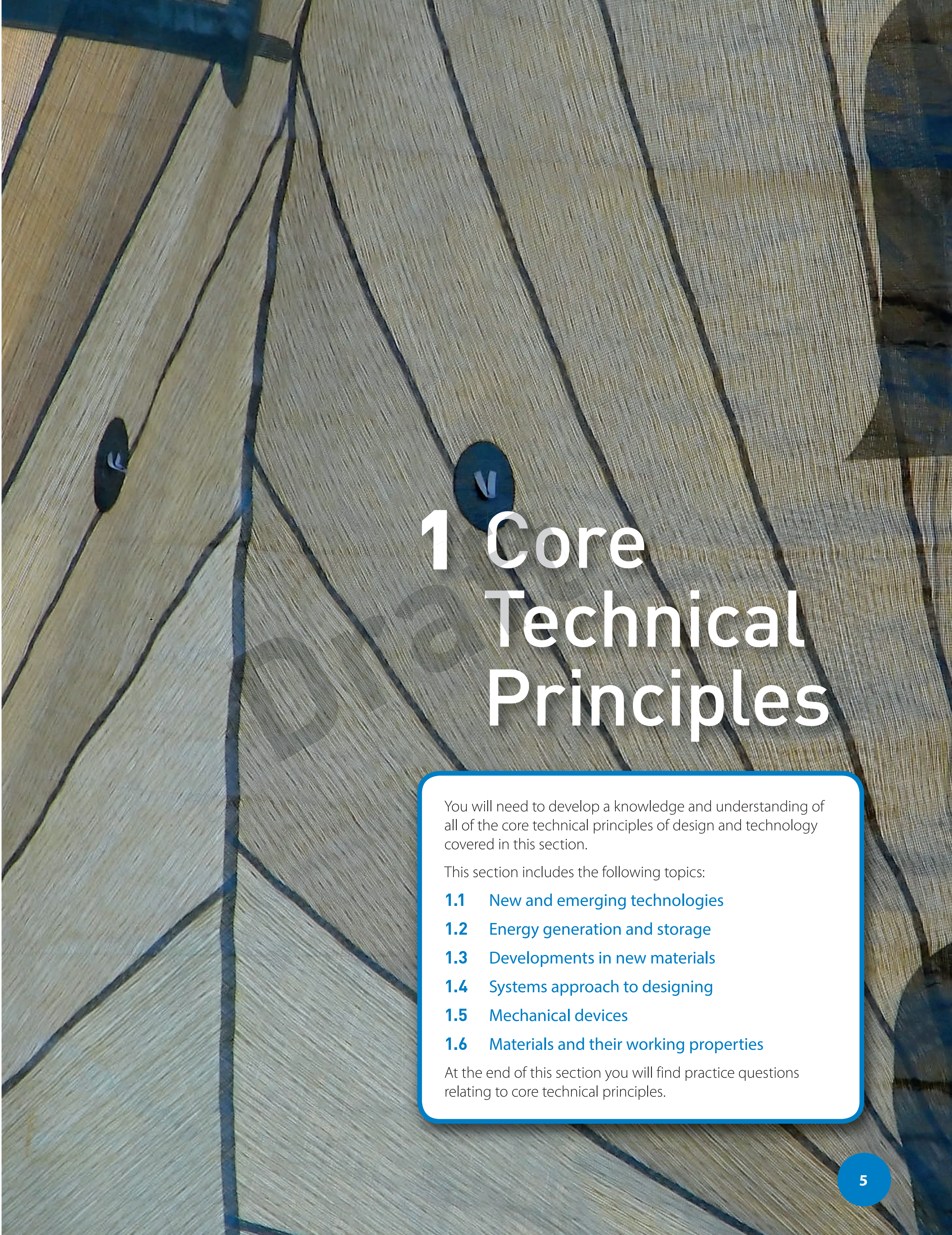
Illustrations by DC Graphic Design Ltd.

Typeset in 10/12 Myriad Pro Light by DC Graphic Design Ltd.

Printed in TBC

A catalogue record for this title is available from the British Library.

CONTENTS



1 Core Technical Principles

You will need to develop a knowledge and understanding of all of the core technical principles of design and technology covered in this section.

This section includes the following topics:

At the end of this section you will find practice questions relating to core technical principles.

1.2 Energy generation and storage

What will I learn?

Clear learning objectives for each topic explain what students need to know and understand.

In this topic you will learn about:

- ➜ using fossil fuels for energy generation
- ➜ alternative energy sources: their increasing use and different types
- ➜ how energy is stored
- ➜ batteries and their advantages and disadvantages.

Icons illustrate where science skills and knowledge can be applied to design and technology.

Without energy most of the things we do would be impossible. Over the last one hundred years we have become increasingly dependent on electricity and the energy sources that we rely on to provide it. Electricity can be produced in a number of ways. The majority of electricity in the United Kingdom is produced by burning fossil fuels, although an increasing amount is produced by using alternative technologies, which rely on the use of renewable sources of energy. Non-renewable sources, such as fossil fuels, are consumed and will eventually run out, whereas renewable sources are naturally replenished.

Fossil fuels

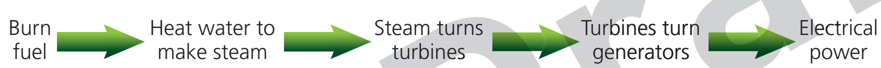


Figure 1.2.1 Energy conversion

Traditionally, Britain has relied on **fossil fuels** such as coal, gas and oil to provide its energy. Fossil fuels were formed over millions of years from dead organisms – coal from trees, and oil and gas from marine organisms.

All fuels have to be burnt to produce heat.

- In electricity generation the heat is used to convert water into steam at very high pressure and temperature, which is used to drive turbines connected to generators which produce electricity.

Burning any fossil fuel produces carbon dioxide, which adds to the 'greenhouse' effect and possible **global warming**.

Fossil fuel power stations can be built almost anywhere provided you can get the fuel to them, although there is a need for a water supply for cooling so they are normally found near rivers or the sea.

Coal

Although most deep coal mining in the UK has stopped, and the use of open pit mining has reduced, we still obtain 23 per cent of our electricity from coal-powered generating plants. This means we also have to import coal from abroad.

Mining and burning coal produces waste and atmospheric pollution, posing environmental problems. Waste tips, stock piles and open pits look unsightly and hazardous sulphur dioxide fumes from coal-powered stations add to atmospheric pollution causing acid rain, which damages trees and lakes.

An advantage of coal is that it doesn't require any processing before burning, although it is usually crushed. There are still sufficient reserves of coal to last hundreds of years.

ACTIVITY

Find out what percentage of energy production in the UK comes from each of the following sources:

- Coal
- Natural gas
- Oil

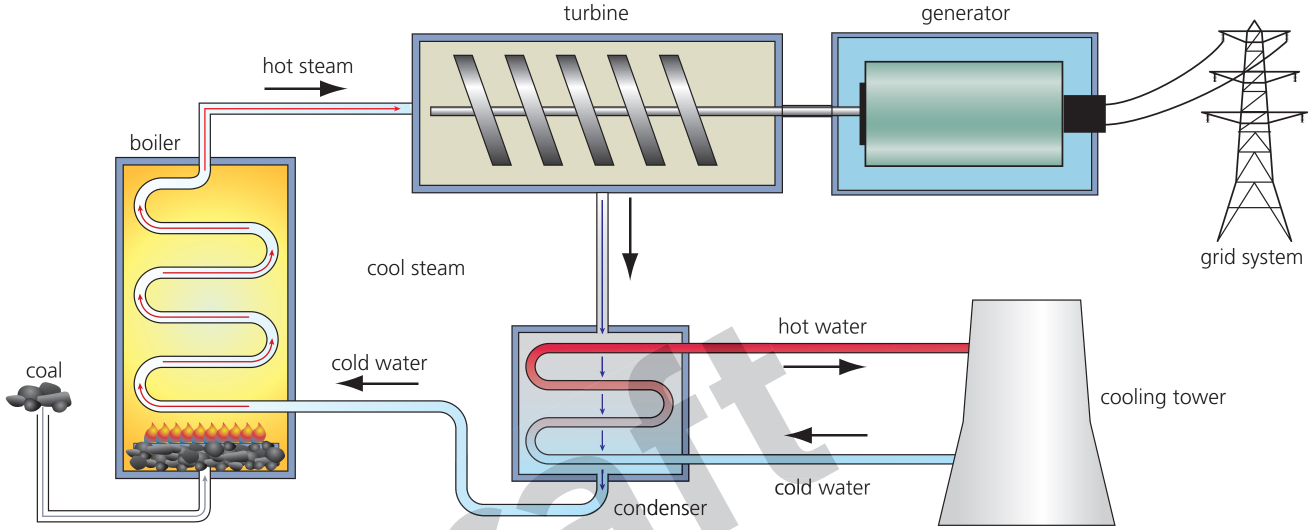


Figure 1.2.2 A coal-fired power station

Natural gas

Natural gas is currently the main source of power for electricity production in the UK. Natural gas is also used for heating and cooking, as well as for industrial uses. It can be burnt directly and does not require crushing like coal. It is easy to transport through pipelines. Mainly consisting of methane, gas is found deep underground with coal and oil deposits. It has to be processed before it can be used to remove water and other impurities.

As gas-powered electricity power stations can be brought into service quickly, they will remain important as a replacement for less reliable sources, such as wind power on days when there is insufficient wind available for the wind turbines.

Gas from the seas around Britain accounts for some of the gas we use, but the majority comes from pipelines connected to Europe and in liquefied form (LNG) shipped from around the world in tankers. There are deposits of shale gas under Britain, but there is considerable discussion about using these, as there might be pollution of water supplies and a risk of small earthquakes called seismic tremors.

Key terms throughout the text explain all important concepts and terminology.

KEY WORDS

Fossil fuels
A natural fuel such as coal, oil or gas, formed from the remains of living organisms

Global warming
An increase in the temperature of the Earth's atmosphere caused by the greenhouse effect and increased levels of greenhouse gases.

Oil

Oil is hardly used for electricity production in the UK. However, oil is used for some heating systems (typically in rural areas away from a mains gas supply) as well as being the main fuel used in road and sea transportation. It does need to be processed by refining from crude oil before it can be used. Stocks of oil will run out before coal. Although there is no immediate shortage, the amount of oil in the North Sea has reduced, which reflects a worldwide trend.

KEY WORD

Fission The process in which uranium atoms are split and produce heat

Nuclear power

Twenty-two per cent of the United Kingdom's electricity comes from nuclear reactors, in which uranium atoms are split to produce heat. This process is known as **fission**. A vast amount of energy can be produced by this process from a relatively small amount of uranium. The energy produced as heat is used to convert water to superheated steam, which in the same way as other power stations, drives turbines connected to generators to generate electricity.

Figure 1.2.3 Nuclear reactors use uranium to produce heat, which creates steam to drive turbines connected to generators that produce electricity

The current set of nuclear power stations are expected to close by 2025 because they are getting old and reaching the end of their serviceable life. Several replacement nuclear power stations are planned. The cost of safely disposing of unused nuclear power stations is high, and there have been several well-publicised incidents at nuclear plants in Japan, Ukraine and the United States which have resulted in nuclear material leaking. Nuclear waste is highly hazardous and can have long-lasting effects on the health of humans and animals for thousands of years if not dealt with carefully.

Source	% electricity production in UK
Coal	23%
Oil	<1%
Natural gas	30%
Nuclear	22%
Renewable	25%

Table 1.2.1 UK electricity production, 2015

Renewable energy

Recently, due to concerns over pollution and the possibility that some sources of fuel might eventually run out or become uneconomic to obtain, there has been much greater support for **renewable** sources of power, such as wind or solar energy.

Renewable energy sources provide 25 per cent of the electricity we use. Unlike fossil fuels they tend not produce any waste or significantly add to global warming by producing gases.

Wind

Wind energy has been used for thousands of years, and before the advent of steam power windmills were a very common sight scattered across the countryside and in the sea around our coasts. Today we use tall towers with propeller-like vanes driving a generator. Although sometimes found as single towers, more often they are grouped together to form a 'wind farm'. You may also see much smaller versions attached to caravans or boats to charge their batteries.

The best places to put wind turbines are on the coast, offshore on a hilltop, or between hills or mountains, so that the wind supply is reliable.

As the vanes are so long the tower needs to be very high, but the land underneath can still be used.

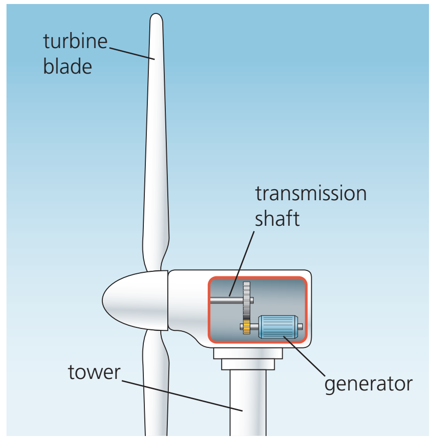


Figure 1.2.4 **The UK Government has set a target to generate 15 per cent of all energy from renewable sources by 2020. Building new wind turbines will help towards meeting this target.**

Solar

Solar technologies are either passive (for example, positioning a building to gain heat from the sun, by placing most windows to the south side of the building) or active (photovoltaic cells), depending on how they catch solar energy and convert it into power.

The amount of solar energy that reaches the Earth is vast, easily outstripping all of the combined fossil fuel and uranium deposits in a single year. The largest difficulty in gaining solar energy is position on Earth: being closest to the equator is the most efficient, and near a polar cap is the least. The difference between day and night is also an issue. The placement of photovoltaic panels is another issue as they take up valuable land. This has been solved to a degree by placing cells on roofs and the sides of tall buildings thereby lessening their environmental impact.

Figure 1.2.5 **Solar panels are often placed on roofs and the sides of tall buildings**

Tidal (marine)

Tidal energy relies on the gravitational pull of the Moon, which causes the change in water levels that we call tides. It has been estimated that Britain could provide around 20 per cent of its energy needs from tidal power.

The most common form of tidal power is the tidal barrage. A tidal barrage is a long dam that is built across the mouth of a river where it meets the sea. These are known as 'estuary barrages'. They can be constructed so that the incoming tide passes through turbines, generating electricity. The water can then be held in the high tide state upstream of the barrier, until it is needed. It is then released at low tide, flows out through the turbines, again turning them and generating electricity.

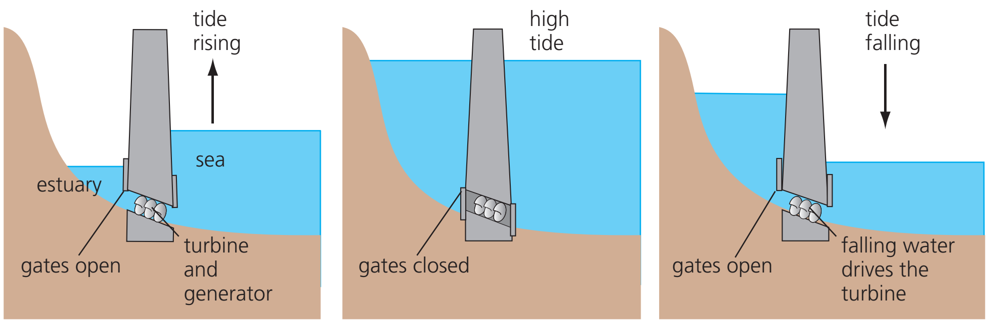


Figure 1.2.6 Tidal energy

Disadvantages are that the river would never be completely empty, flooding mudflats, which provide a habitat for thousands of birds. There may also be problems of waste disposal as many towns discharge sewage into rivers.

Water/hydro-electricity

Like wind power we have been harnessing the power of moving water for many years.

Hydro-electrical schemes use a dam to block a valley. Once sufficient water has built up behind the dam it is stored in a reservoir, it can be channelled through turbines that are used to turn generators for producing electricity. The main cost is the building of the dam, but it has the advantage that as the water is held, electricity can be produced very quickly by opening valves that control the flow to the turbines. The environmental effects are limited to the flooding of a valley, and sometimes reducing the water flow below the dam can affect the growing of crops.

Figure 1.2.7 Hydro-electricity channels water through turbines to turn generators producing electricity

Wave

Although the power contained in wave movements is very obvious, it has proved difficult to harness. Most ideas seem to rely on the up/down movement of the waves either being converted into mechanical energy and moving rams or pistons, or to compress air so that it is forced through a turbine. Like wind power the waves can vary a lot in size and power, so positioning is critical.

Figure 1.2.8 Pelamis offshore wave generator

Biomass

Biomass involves growing plants so that they can be burnt, or using decaying plant or animal materials to produce heat.

To reduce the amount of fossil fuel being used some vegetable oils are treated after being used for cooking. After processing they are suitable for diesel engines used to power large trucks used for deliveries and for small-scale electricity generation.

Plants such as oilseed rape or willow are grown as biomass crops, and are harvested so they can be burnt in furnaces. This burning to produce heat will cause some atmospheric pollution so measures need to be taken to reduce this, although it is not as severe as burning fossil fuels. The big advantage for biomass is that replacement crops can be grown very quickly to ensure a constant supply. However, the disadvantage is this land could also have been used for growing crops for food.

KEY WORDS

Renewable energy Energy from a source that is not depleted when used, such as wind or solar power

Hydro-electricity The process which uses a dam to block a valley and channels water through turbines that are used to turn generators for producing electricity

Biomass Growing plants so that they can be burnt, or using decaying plant or animal materials to produce heat

Energy storage systems, including batteries

Sometimes we do not want to use the energy we generate immediately, but instead want to capture it for use at a later date. Pumped storage systems, flywheels, clockwork, capacitors and rechargeable batteries are examples of devices used to store energy for use at a later time.

Kinetic pumped storage systems

A similar system to hydro-electric power generation is used in pumped storage systems. Here a hydro-electric dam system is used with two reservoirs, one at a low level, and one up a mountain.

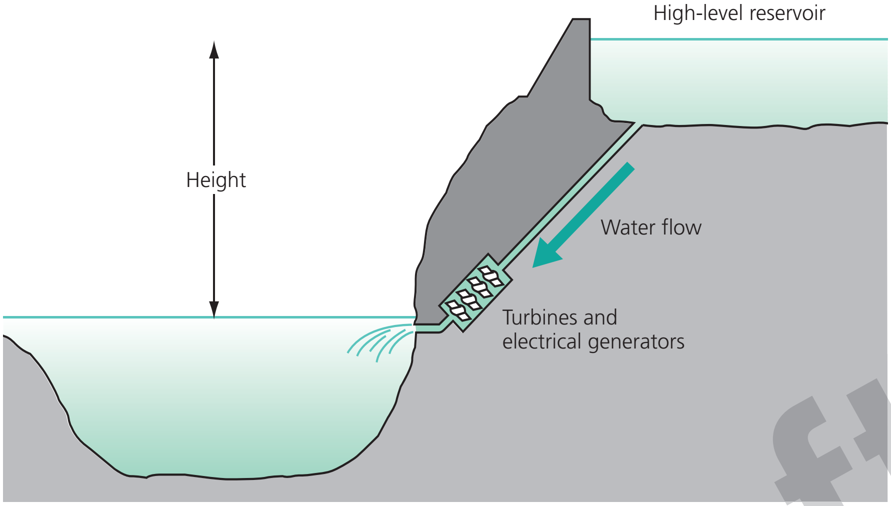


Figure 1.2.9 Kinetic energy conversion

They are a good way of dealing with sudden high demand for electricity. The classic example of this is a commercial break in the middle of a popular TV programme when everybody pops into the kitchen to put the kettle on for a hot drink. At moments like that the electrical power supply system might not be able to cope with demand, so an additional fast-acting top-up is needed. Nuclear and coal-powered stations are slow to respond so something else is needed. Gas-powered stations are often working at full capacity in winter months.

The pumped storage system instantly releases electricity into the system by turning on valves to allow water to flow from the high reservoir to the lower one through turbines. This cannot be sustained for long, but it is usually long enough for the other power stations to catch up with demand and avoid the need for power cuts. During the night, demand for electricity is usually low, but the nuclear and coal-powered stations cannot reduce their output significantly, so the excess electricity is available at low cost. This cheap excess electricity is used to pump the water back up to the top reservoir, ready for sudden peaks in demand the next day.

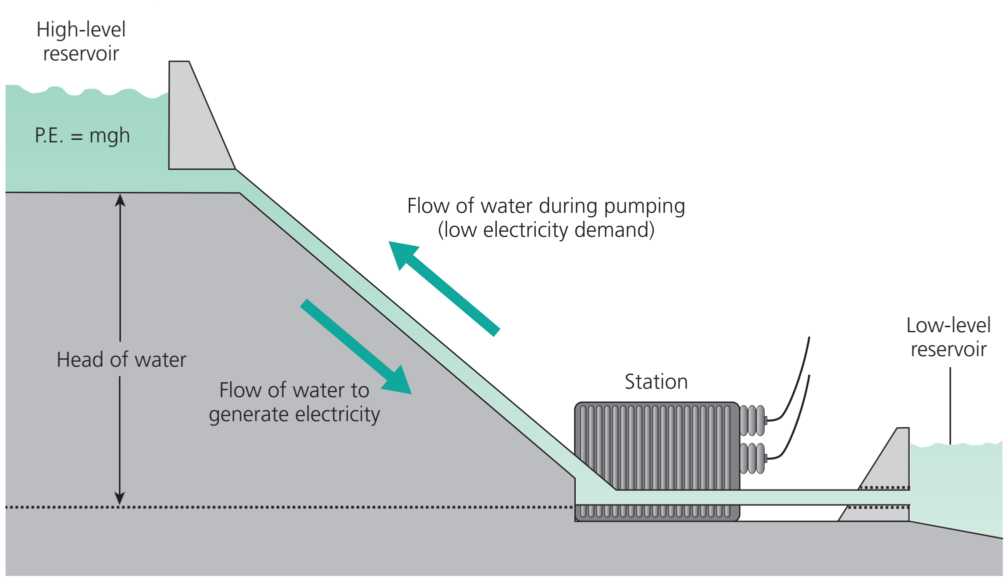


Figure 1.2.10 A pumped energy storage system

Mechanical energy storage

Energy can be stored in other forms. An example of this is the use of a flywheel. We have used flywheels in machines for centuries; they are a heavy spinning mass that continues to spin when the driving force stops.

A more recent development used in some buses in Belgium and Switzerland is a flywheel which is accelerated to a very high speed. When spinning at speed it stores the energy (rotational energy) and slows as it is released. Electricity is used to accelerate and slow the flywheel, so an energy conversion takes place. High-efficiency bearings are an important part of this technology and frequently magnetic bearings are used to reduce friction, which in turn increases the efficiency of the system. In this system, energy is also stored when the buses are braking.

Clockwork is still used for storing energy in toys and mechanical devices. Normally a key is used to wind up a spiral spring by forcing it into a smaller space, where it is stored as potential energy with a system of gears being used to release the energy slowly.

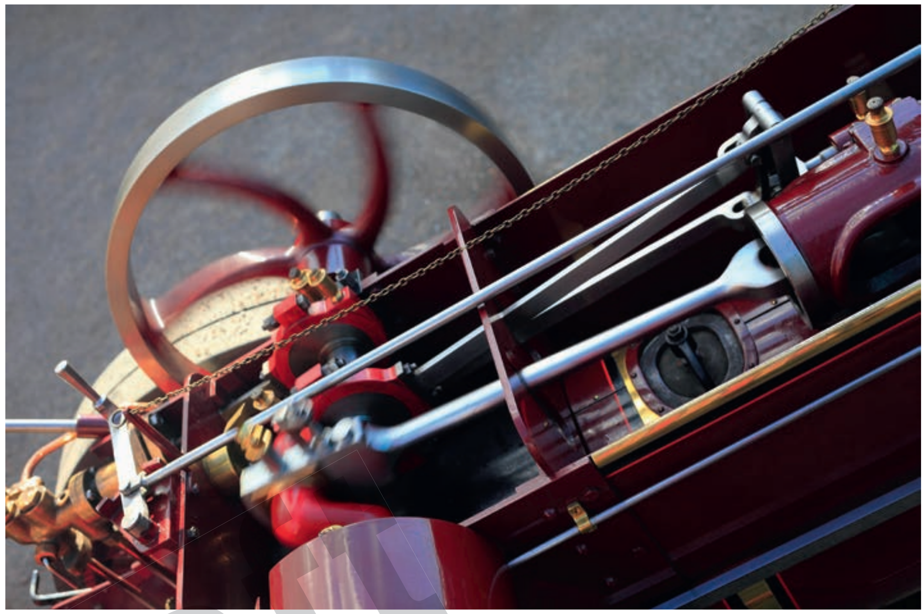


Figure 1.2.11 A traditional flywheel

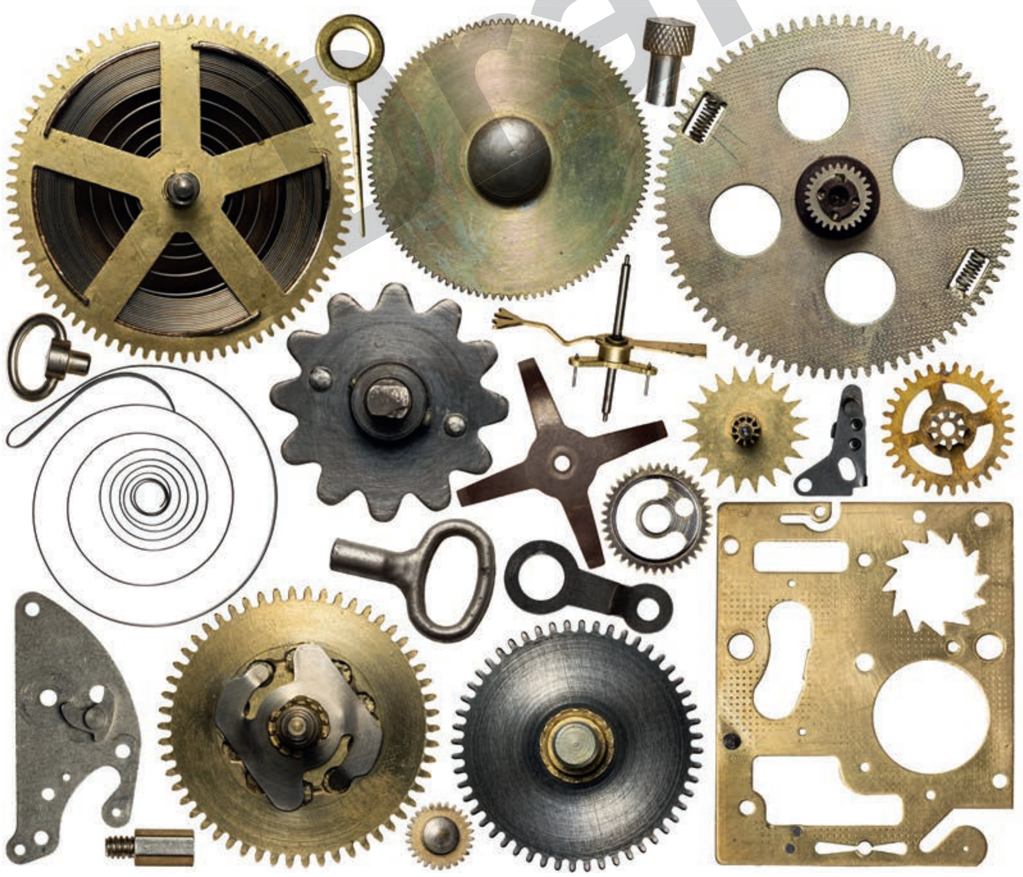


Figure 1.2.12 Clockwork is used for storing energy in toys and mechanical devices

Electrical energy storage

Capacitors

Capacitors are the most popular non-chemical method of storing electricity; their invention pre-dates the battery. They consist of two plates of opposite polarity; when the capacitor is charged, the positive charges migrate to one plate and the negative to the other.

Super-capacitors are used in electric vehicles because they can be recharged many more times than batteries – millions as opposed to thousands of times – which makes them very suitable for use in regenerative braking systems where the energy used to slow the vehicle is stored and used to drive the motor.

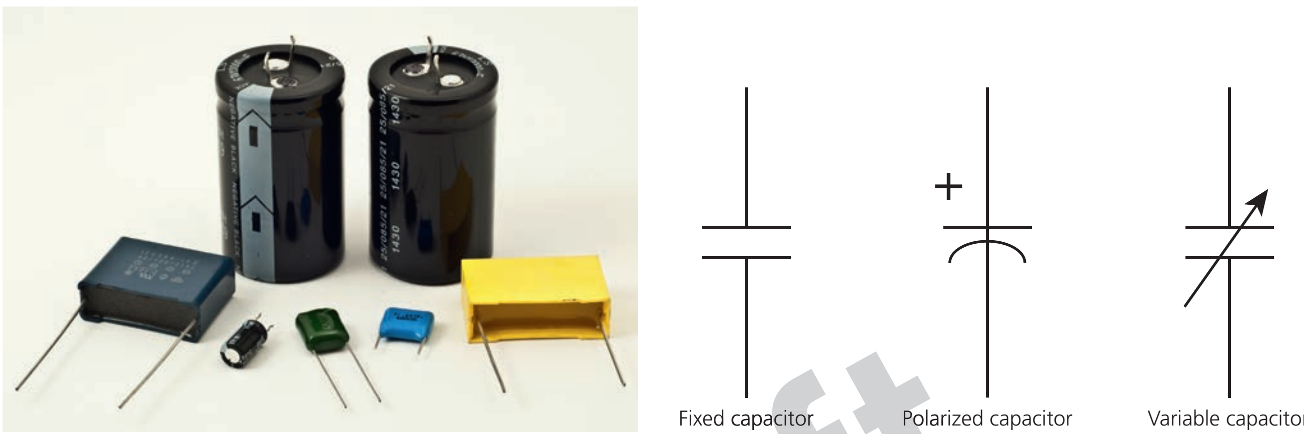


Figure 1.2.14 **Different types of capacitors**

Batteries

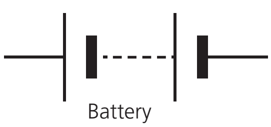


Figure 1.2.13 **Battery circuit symbol**

Although there are many types of devices consisting of one or more electrochemical cells we tend to refer to them all as batteries.

There are two main types of battery: primary or 'single-use', which we use and discard; or secondary 'rechargeable'. Both are extremely useful when we need electrical power in locations where mains electricity would be difficult or even impossible, such as moving cars.

Examples of primary types include alkaline batteries, such as we use in clocks, and zinc-carbon, which although cheaper than alkaline batteries do not last as long or store as much electrical energy in the same space. Typically, they produce about 1.5 volts per cell.

Rechargeable batteries are more expensive to purchase than alkaline batteries, but are cheaper to use as they can be recharged many times. There is, however, a limit to how many times they can be recharged. Nickel cadmium rechargeable batteries last longer if they are completely discharged before recharging. Lithium ion ones are more adaptable.

Rechargeable batteries typically have a cell voltage of 1.2 volts, so in a 12-volt device you would need 10 rechargeable batteries but only 8 single-use batteries.

Batteries come in a variety of shapes and sizes, with large lead–acid batteries for cars, trucks and even submarines at one end of the scale; and miniature batteries such as those used in hearing aids at the other. For all batteries there are issues related to safe disposal, as they contain harmful chemicals and metals that must not be allowed to contaminate groundwater supplies.

ACTIVITY

Most modern toys now use batteries rather than clockwork. Find out when batteries became the most popular energy storage method for toys. Explain the advantages of this development. What sorts of problems did the change cause?

Short activities throughout the text help to reinforce understanding.

Figure 1.2.15 Batteries are useful when we need electrical power where mains is unavailable

STRETCH AND CHALLENGE

Produce a short discussion document arguing whether Britain would be better off investing in a new nuclear energy power station or a tidal barrage across either the rivers Severn or Dee.

Stretch and challenge activities support progression and challenge more able learners.

KEY POINTS

- We rely on energy to power most aspects of our lives, such as light, heat, transport and communication.
- All fuels and biofuels cause pollution when burnt.
- Coal, gas and oil are all fossil fuels, and are finite resources.
- Most renewable sources reduce the risk of pollution.
- Many renewables cannot provide a constant supply, unlike fossil fuel or nuclear-powered power stations.
- Storage systems cannot generate power, but are useful for when extra supply is needed quickly, or if it is not possible to connect to a supply.

Reinforce learning and check knowledge and understanding with end of topic summaries and questions.

Check your knowledge and understanding

1 What is the best time of day to store energy in a pumped storage system?
2 What advantages do fossil fuel have that make them so popular?
3 Briefly explain why growing crops for biofuels might not solve the world's energy problems.
4 How can a flywheel store energy?
5 Give two disadvantages of secondary batteries.

PRACTICE QUESTIONS: Core Technical Principles

Multiple-choice questions

1. Which of the following is the name given to a method of funding a project by raising money from large numbers of people?

A Crowd sourcing
B Enterprise
C Fair trade
D Virtual retailing *[1 mark]*

2. A battery-operated motorised toy will need to work at a minimum of 5 volts. Which one of the following arrangements is suitable for powering the toy for as long a time as possible, before it needs to be replaced or recharged?

A. 4 x AA Alkaline batteries
B. 4 x AA Zinc oxide cells
C. 2 x Silver oxide coin cells
D. 4 x NiMH rechargeable *[1 mark]*

3. Which of the following is a smart material?

A Gore-Tex
B Kevlar
C MDF
D Shape memory alloy *[1 mark]*

4. You are designing a t shirt which should change colour when the wearer becomes hot. Which smart material would you use to make this happen?

A Photochromic pigments
B Quantum tunnelling composite
C Shape memory alloys
D Thermochromic pigments *[1 mark]*

5. A designer has created a security system for use in a home. The system is intended to alert the home owner to an intruder. What is the output in this system?

A Flashing light
B Light sensor
C Motion sensor
D Rocker switch *[1 mark]*

6. What is the correct order?

A Fabric → Fibre → Yarn
B Fibre → Yarn → Fabric
C Fabric → Yarn → Fibre
D Yarn → Fibre → Fabric *[1 mark]*

7. What is the selvedge of a fabric?

A The bias grain
B The finished edge
C The raw edge
D The straight grain *[1 mark]*

8. Which of the following is a thermosetting polymer?

A Acrylic (PMMA)
B Low-Density Polythene (LDPE)
C Melamine Formaldehyde (MF)
D Polypropylene (PP) *[1 mark]*

Short-answer questions

1. What is the definition of a smart material? *[1 mark]*
2. Name a modern material. *[1 mark]*
3. State two properties of the modern material you have named in the question above. *[2 marks]*
4. Name two sensors that could be used in a system to alert home owners of an intruder. *[2 marks]*
5. Explain the advantages of using a cotton weft knit jersey fabric for a t-shirt. *[6 marks]*
6. What are the benefits of using a manufactured board over a solid timber in the manufacture of an office desk? *[4 marks]*
7. Explain what is meant by 'planned obsolescence'. *[2 marks]*
8. State two ways in which you can prolong the life of a product. *[2 marks]*
9. Which class of lever is a wheelbarrow? *[1 mark]*
10. There are two other classes of levers. Name items that are examples of each type. *[2 marks]*

This page is intentionally blank

This page is intentionally blank

This page is intentionally blank

For the 2017 specification

AQA GCSE (9-1) Design & Technology

All Material Categories and Systems

This sample chapter is taken from AQA GCSE (9-1) Design and Technology: All Material Categories and Systems Student's Book which has been selected for an AQA approval process.

Build in-depth understanding and inspire your students to tackle design challenges both practically and creatively, with a textbook that delivers the Core Technical plus Specialist Technical and Design & Making Principles needed for the 2017 AQA D&T GCSE.

The insight of our author team will build topic knowledge, including the technical principles of materials with which you are less familiar, to help ensure you can navigate the specification with confidence whilst your students' ideas flourish.

- Build topic knowledge with learning objectives directly linked to the specification and short activities to reinforce understanding
- Develop mathematical and scientific knowledge and understanding with activities that link topics to maths and science
- Inspire your students as they undertake the iterative design process, with examples of imaginative design-and-make tasks, and a look at how to approach the Non-Exam Assessment
- Check knowledge and understanding with end of topic summaries and practice questions

Dynamic Learning

This book is supported by Dynamic Learning – the online subscription platform that helps make teaching and learning easier. Dynamic Learning provides unique tools and content for:

- front-of-class teaching
- streamlining planning and sharing lessons
- focused and flexible assessment preparation
- independent, flexible student study

Sign up for a free trial – visit: **www.hoddereducation.co.uk/dynamiclearning**

To request Inspection Copies or eInspection Copies and pre-order your class sets visit

www.hoddereducation.co.uk/ gcsedesignandtechology

ISBN 978-1-5104-0108-2

9 781510 401082