Core Theory

New & Emerging Technologies

Name:

Every 2 weeks you will be set a new theory section to read, write revision cards for, respond to questions and mark / give feedback on a previous section.

This work booklet will be a brilliant revision tool for you and should be kept up to date and in good condition.

Topic	Due Date	Completed	Marked	Score
Production Techniques & Systems	28th January			
Informed Design Decisions	11th February			
Energy Generation	25th February			

If the section tasks are not completed for the due date you will stay after school on the due date to complete some of the task and then be asked to complete the full task for the following day or you will be given another after school detention with the Head of Design & Technology, Mrs Douglass.

Task 1: Read the information provided for each topic. Highlight key information. Use the information for each topic to create a set of your own revision cards. You will have covered how to create revision cards which suit your learning style in your PHSE lessons. You can use the space provided in the booklet which can later be cut out or create you own set of cards.

Remember:

- Add all vital information, cut out only unnecessary words e.g. full paragraphs into concise sentences.
- Use key and technical vocabulary
- Highlight or underline key words
- Add sketches and diagrams where necessary
- Use lists, bullet points, tables to make the notes easy to read

Task 2: Use the information, your own additional research and your completed revision cards to answer the exam style questions for each section.

Remember:

- Write in full sentences in order to practise your exam technique.
- Use your revision cards or information as a second option, try to answer the question from memory at first and then add once you have checked your notes.

Task 3: Collect the mark scheme from Mrs McVay on the due date for each section. As part of your next set of homework you need to mark your responses or ask someone at home to mark if for you and give feedback.

Remember:

- Look for the key words from the marks scheme and tick where you see these.
- In the feedback box add any missing information, additional responses or corrections.

Production Techniques & Systems

Chapter 4 - Production techniques and systems

Objectives

- Understand contemporary and potential future use of automation, Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM)
- Be able to recognise and characterise the use of Flexible Manufacturing Systems (FMS)
- Understand how Just In Time (JIT) and lean manufacturing contribute to manufacturing efficiencies

Production techniques and systems

The use of computers in industry has grown enormously over the last 30 years and as a result, the way products are designed and manufactured has become increasingly automated. Computers are now used in all areas of design and manufacture; this chapter looks at how computers and digital integration have changed production lines and working practices.

Automation

One consequence of the use of computers is that production lines flow more easily and have far less need for human interaction. Manual production lines of the past were slower and more expensive to operate than today's automated production lines.

Some traditional manufacturers still rely on skilled manual labour. These products tend to be bespoke, low volume and high cost items such as sports cars and high-end furniture. Their loyal customer base prefers hand-built products and is happy to pay a premium for them.

Most manufacturing, however, is becoming increasingly automated. Automation involves computers using complex software systems that have an overview of many, if not all, aspects of production. **Product data management** (PDM) is the term used for these software systems, in which all information is stored centrally, updated live and is accessible by all employees that need the most up-to-date information. PDM reduces mistakes, ensures all teams within the company work together and allows for accurate costing and forecasting of production progress.

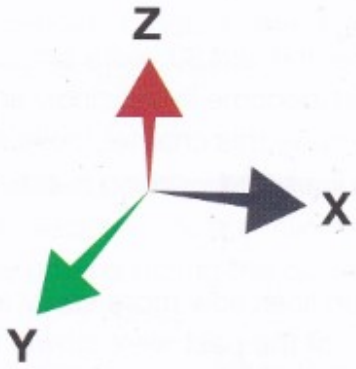
Computer aided design and manufacturing

Within an automated production system, **computer aided design** (CAD) and **computer aided manufacturing** (CAM) are essential to ensure a smooth transition between the designing and manufacturing of products.

Computer aided design is the design of new products using specialist software. Computer aided manufacture uses CAD files to realise these designs into prototypes or finished products. CAD software has a number of benefits over designs being produced entirely by hand, although many designers prefer to start sketching an original idea using pen and paper as ideas can sometimes be expressed more freely. Once the design is formulated it can be sketched accurately in CAD software, where it can be manipulated and thoroughly tested until the design is finalised.

As touch sensitive screens and styluses improve, more designers are moving to a totally digital design process. Nevertheless, there is no real substitute for getting pen to paper and this is the recommended route to take when beginning your GCSE designs. Once you have an initial design, there is a lot of very high quality free CAD software available to experiment with. Most schools will have a preferred option for you to use.

CAD and CAM work through the use of **computer numerical control** (CNC). The CAD software generates a series of machine codes which are then interpreted by the CNC machine into movements of the machine bed, machine tool paths and other actions such as motor speeds to control tooling such as needles or cutters.



The most common file types used to output CAD are .DXF, .STL and .OBJ files. Most CAM machines come with software that allows you to convert the CAD file into the language that the machine understands. This stage is called **post processing** and it will normally allow you to run a virtual simulation of the production of the component to see if there are any potential errors.

Advantages of CAD	Disadvantages of CAD
Designs can be altered easily	CAD software is complex to learn
It can be faster to draw designs and complex shapes, saving labour costs and development time	Software can be very expensive
Designs are easily saved and historic versions kept or archived	Compatibility issues with software
Designs or parts of designs can be easily copied or repeated	Security issues - risk of data being corrupted or hacked
Designs can be sent by email for approval and manufacture	Software often subject to regular updates
Designs can be worked on by whole teams simultaneously	Ever increasing demand on computer memory, RAM and graphics capabilities
Designs can be rendered to look photo-realistic to gather public opinion in a range of finishes	Data can be lost in power cuts / outage
Designs can be simulated to judge ease of manufacture	
CAD software can process complex stress testing and associated calculations to predict the behaviour of a product before production	

The most frequently used CAM equipment used in schools are laser cutters, vinyl cutters, computerised sewing and embroidery machines, CNC milling and engraving machines, CNC routers and CNC lathes.

Advantages of CAM	Disadvantages of CAM
Faster than traditional machines and tools	Expensive set up costs for equipment
More accurate than traditional methods	Training costs and time
High repetitive accuracy	CAM machines need specialist engineers when they need maintaining or repairing
Machines can run 24/7	CAM machines can do work that is traditionally done by skilled workers and has led to unemployment in many manufacturing sectors
Can produce work directly from CAD files	

Flexible manufacturing systems

A **flexible manufacturing system** (FMS) is a collection of automated machines that are adaptable and are used in production lines where the products that are being made may change on a regular basis. This allows manufacturers to respond quickly to fluctuations in the market and consumer demands, which may be influenced by trends and fashion.

If a manufacturer was making only one product, like an aluminium can, machines could be dedicated to that task and therefore not have to be recalibrated or retooled. FMS machines are flexible and adaptable and therefore better equipped for batch production, although the need for flexibility may incur additional setup costs.

CNC machines are frequently used in FMS as they are easily reprogrammable, making changes quick, simple and cost effective.

Robot arms are also used because they can be programmed to perform many tasks. They can even perform multiple tasks while on one production line, making the FMS capable of real-time changes and even greater manufacturing flexibility.

Just In Time and lean manufacturing

Lean manufacturing is based on an ethos of eliminating waste in manufacture, overburden and bottlenecks. A growing number of responsible manufacturers now adopt this principle to save money and resources. It was first witnessed in Japan during the 1990s and has grown in popularity as manufacturers across the world are cutting down on the waste that they produce. To do this, they have had to change the way they operate.

By using **Just In Time** (JIT) production methods, manufacturers are able to respond to customer demands more effectively. JIT manufacturing ensures that customers get the right product at the right time at the right price. A customer's order triggers the production process and the manufacturer makes the product specifically to meet the order.

Many companies now seek to make constant improvements to their systems and they reward employees if they find ways to cut waste even further.

Advantages of just in time:

- Products are made to order, so no products need storing whilst waiting to be sold, thus saving on storage costs
- Money is not tied up in unsold stock
- Orders are often secured on a deposit or full payment, so money is in the bank before outlay is needed on materials and production costs
- Materials and components are supplied just when needed, saving financial outlay on unused materials and additional storage (very low stock levels are maintained)
- Improved competitiveness results from minimal waste of materials and time
- Stock does not become old, out of date or obsolete
- High reliance on making sure products are 'right first time' means less time is spent correcting mistakes, or money wasted on faulty products
- Almost all waste is reused or recycled, meaning there is little or no landfill waste produced

Disadvantages of just in time:

- Relies on high quality, fast and reliable supply chain for raw materials and components
- All production could stop if the supply chain breaks down
- Stock is not ready to be purchased off the shelf; some consumers prefer not to wait at all and some sales could be lost
- Usually a deposit or the whole cost of the product needs to be paid upfront which could be offputting for some consumers
- Discounts from suppliers for bulk purchasing of materials may be not available

Industry and Enterprise:

Questions

Q1. Why is it a good ideas for companies to invest in product data management systems? (1 mark)

Feedback:

Q2. Why do some people prefer to buy hand built products rather than mass produced products? (3 marks)

Feedback:

Q3. What movements do x, y and z coordinates represent in a CNC machine? (3 marks)

Feedback:

Q4. How do CNC machines cut a curve when their 2 or 3 axis used are straight lines? (1 mark)

Feedback:

Q5. What are the steps which need to be taken to send a completed CAD file to a CNC machine? (2 marks)

Feedback:

Q6. How does an FMS allow companies to react to changing markets and trends? (1 mark)

Feedback:

Q7. What types of products do you think are best suited to be produced by the JIT method and why? (2 mark)

Feedback:

Q8. Why do you think each customers order is given a personal reference number in the form of a barcode or QR code when using JIT? (1 mark)

Feedback:

Q9. Find out what is meant by the term Kaizen and how it would suit lean manufacturing... (2 marks)

Feedback:

Total marks : / 16

WWW?

EBI?

Informed Design Decisions

Chapter 5 - Informing design decisions

Objectives

- Be able to evaluate the advantages and disadvantages of planned obsolescence from different perspectives
- Understand how products can be designed to be repaired and recycled
- Be aware of ethical and environmental concerns when designing with new technologies

Evaluating the use of new technologies

When designers first come up with ideas for a new project or product they will carry out a great deal of market research. They need to fully understand the task and have a thorough knowledge of the current marketplace.

During this process designers will find out about the latest technologies and materials available and evaluate their use against a number of criteria such as:

- cost
- reliability
- longevity
- sustainability
- recyclability

Only after detailed analysis, testing and evaluation will a new material be used in a product. Any potential long term issues may still remain unknown, and this is one of the risks with new and emerging technologies.

Planned obsolescence

As consumers we expect some products to last a long time and others we throw away after only one use. A sofa would be expected to last for many years, if not decades; a pair of headphones perhaps a year or two at best; many ball-point pens will be disposed of once they run out of ink, as they are not designed to be refilled. Ensuring a product only performs its task for a certain length of time is known as **planned or built-in obsolescence** and is something designers and manufacturers need to consider for a number of reasons.

Appropriately engineered quality – If a product only needs to last for a short period of time then it would be a waste of materials and energy to ensure that it is robust enough to last a long time. A disposable razor has a plastic handle instead of a metal one because the non-replaceable blade will be blunt after a few uses. Therefore, an appropriate polymer, e.g. polystyrene, is the best material as it is much cheaper to produce.

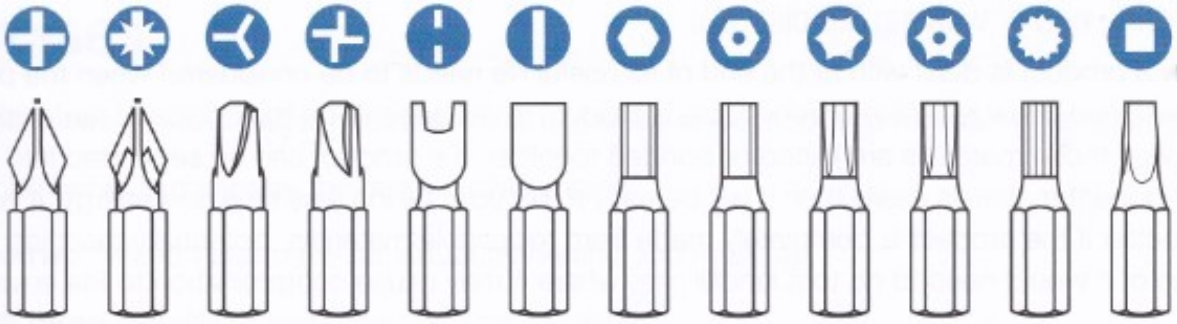
Upgrading and function – Some products are designed to receive updates, be facelifted or upgraded whereas others are not. Manufacturers need to decide how upgradable a product should be. If it is continuously upgraded then the chance of new sales reduces as customers wait for a significant upgrade before purchasing a new model. If it does not have enough potential for upgrade, it may not appear to be value for money and again sales may be lost.

The smart phone is a good example as it can normally be upgraded a few times. After a while, however, it will stop being able to receive updates, certain features will no longer work and it will become inefficient or obsolete.

New technologies (technology push) – It is impossible for designers and manufacturers to see too far into the future, but changes in materials, manufacturing techniques, technologies and customer desires are inevitable. This is why most manufacturers avoid producing goods that will last for a long time. As the technology moves on, customers will demand newer versions.

Fashion and trends – Many goods are sold as novelty items and these are often governed by trends in the market, seasons and fashion. The quality of goods will vary depending on how long they are meant to last and the price point that they are manufactured to. Most Hallowe'en or Christmas items are not designed to last, and if you get a few years' use out of them then it is considered a bonus.

To keep market share – Many large companies now produce new product ranges on a regular basis. Unfortunately, this is not always driven by new technologies, but by the need to keep ahead of their competitors by creating the latest 'must have' item. Regular customers will feel the need to have the latest version and this type of obsolescence is about companies trying to keep their share of the market.



Design for maintenance

An ever-decreasing number of products are designed to be repaired. Those that are repairable often require specialist tools (see diagram above) and home repair is becoming increasingly discouraged and harder to achieve. One reason is that many products, especially consumer electronics and mechanical devices, have become very complex and beyond the ability of most people to repair without specialist training.

Another reason is that companies want customers to buy a new product as soon as possible, and if a product breaks after the guarantee has expired they may offer a discount on a new version to keep their customers' business.

Some companies have service contracts with repair firms and make a profit from organising the repairs for their customers. This is another reason why specialist tools are needed to repair certain products; they do not want just anybody to be able to offer this service.

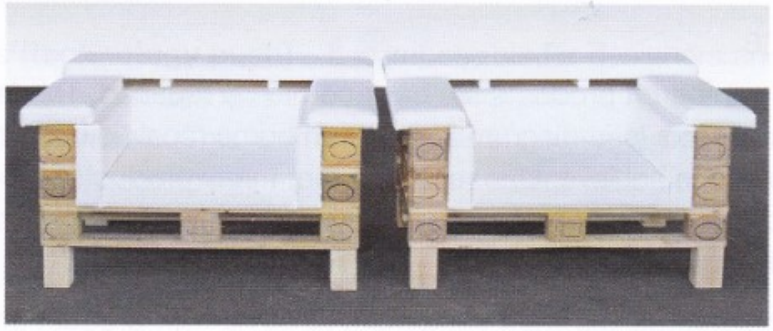
Ethics and the environment

Chapter 2 contains a discussion of the need for designers to consider the impact that new products may have on the environment. Finding out whether a new technology will have an adverse effect on the environment is normally discovered through thorough research and by conducting a **life cycle assessment** (LCA).

It is becoming increasingly important for companies to show that they are environmentally and socially responsible as consumers become more aware, through increased access to social media and global news, of the issues surrounding global pollution of land, air and sea. This has made consumers more demanding and companies need to closely monitor their social and ecological footprints.

Considering end of working life disposal

How a product is dealt with at the end of its useful life needs to be considered when the product is designed. How reusable or recyclable a product is will depend on the choice of materials and the way those materials are joined or bonded together. If a product can be separated into its Component materials easily then it will be easy to recycle, taking less time and energy. It will also be better if the product is completely made from recyclable materials, potentially meaning that none of it would need to go to a landfill site, where it may cause contamination to the environment.



Some products, like glass milk bottles, are designed to be reused, whereas some are given a new life by some very inventive people. Old car tyres are used to build houses or used for swings in children's playgrounds; they are even being used to produce a high quality oil. Shipping pallets are turned into all sorts of products including chic furniture, floorboards and sheds. Newspaper can become insulation for cavity walls in houses and can even be compressed to form the walls of houses themselves.

When a product is reused instead of recycled, it generally uses less energy and does not degrade in quality due to the recycling process (see more on reusing and recycling in Chapter 22).

If a product is designed in such a way that the materials are difficult to separate or it contains non-recyclable material, then it is much more likely to find its way to a landfill site. This is because it is not cost effective to reclaim the material if too much time and energy is required to do so.

Responsible end of life design should include:

- as few materials as possible
- recycled and recyclable materials where possible
- easy-to-separate materials avoiding permanent bonding methods
- built-in reusability where possible

Sustainability and The Environment:

Questions

Q1. What affect does planned obsolescence have on material use? (1mark)	Feedback:
Q2. How do you think a customer feels when a newer version of a product is released? (2 marks)	Feedback:
Q3. Why do you think electronic and computer based products are prone to planned obsolescence? (2 marks)	Feedback:

Q4. Why is it usually cheaper to buy a new product than paying for an existing product to be repaired? (1 mark)

Feedback:

Q5. A customer can set up a service contract when purchasing a product. This is have an ongoing or additional cost for the customer but will ensure the product can be serviced and kept working as long as the contract is in place.

Explain one advantage and one disadvantage of a service contract for:

A) The customer

B) The Manufacturer (4 marks)

Feedback:

Q6. What are the potential benefits to the environment of a service contract and a repair before replace approach? (2 marks)

Feedback:

Total marks : / 12

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Energy Generation

Chapter 6 – Energy generation

Objectives

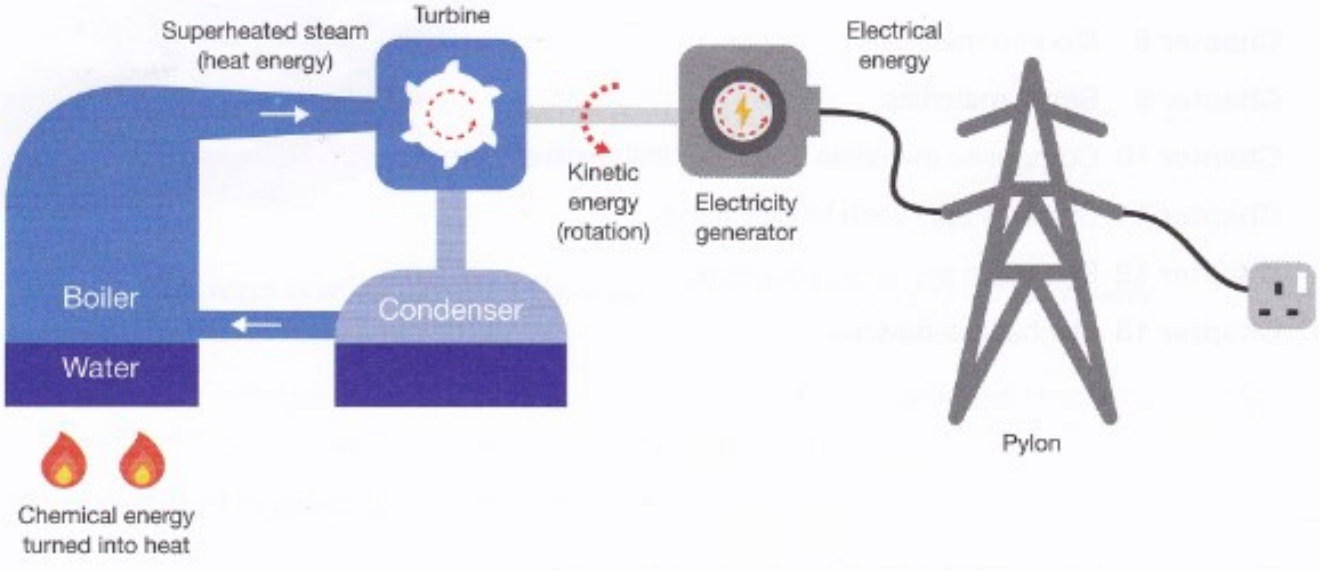
- Understand how power is generated from fossil fuels and nuclear power
- Understand how power is generated from renewable energy sources such as:
  - wind, solar, tidal, hydroelectric and biomass
- Be aware of the arguments for and against the selection of fossil fuels, renewable energy and nuclear power

Energy generation

There are many ways to convert energy, and these can be separated into two main categories; fossil fuels and renewables. Countries across the world are attempting to steer their economies to adopt as many renewable sources of energy production as possible, in order to help reduce the build-up of greenhouse gases, which are thought to be one of the main contributing factors of **global warming**.

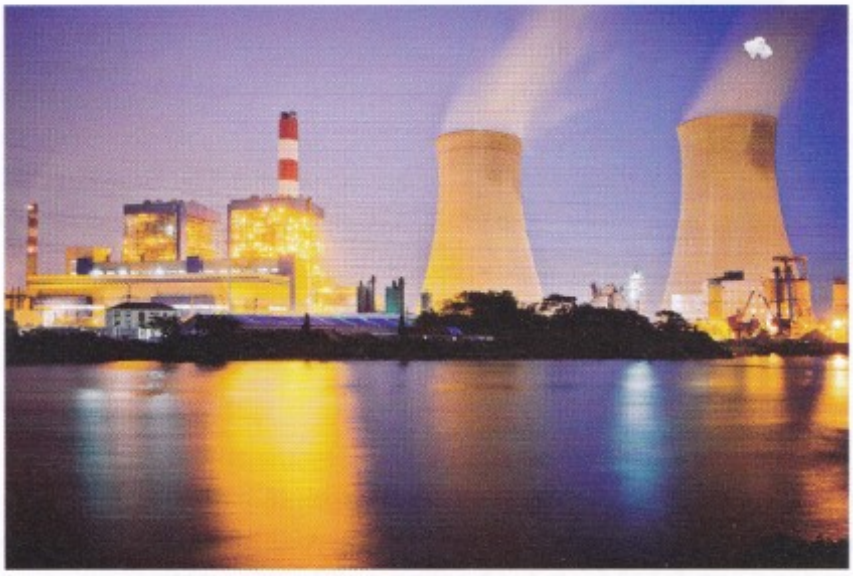
Turbines and generators

Most forms of electricity production involve rotating a turbine which turns a generator. Fossil fuels are burned to create heat which in turn superheats water. The resulting steam is used to rotate **turbines** which are linked to a generator to provide us with a supply of electricity. Biofuels, which are renewable energy sources, use a similar process. In the case of wind, wave and hydroelectric energy production, the energy harnessed from the wind, waves or falling water is converted into mechanical energy which directly rotates the turbine. A generator then converts the mechanical energy from the turbine into electrical energy.



Fossil fuels

Most of the heat that we use to generate electricity in the UK comes from burning fossil fuels such as coal, gas and oil. These are considered **finite** resources as they were formed over many millions of years and cannot be replaced as they run out. In 2016, coal- and gas-fired power stations accounted for around 55% of the UK's energy production. Oil however, is mainly used for transportation and heating; only around 1% of our electricity is generated from oil.

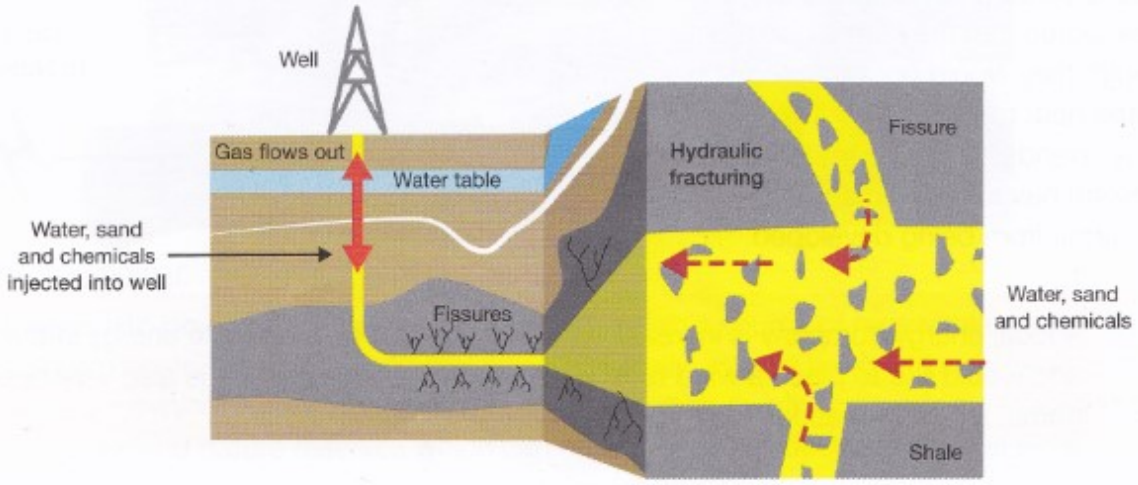


When **fossil fuels** are burned, they produce CO_2 (carbon dioxide). Although some modern power stations can scrub the exhaust gas emissions by trapping the CO_2, it is still generally not considered to be an environmentally friendly or sustainable way of creating energy.

Shale gas

Shale gas is a natural gas that is trapped within areas of shale in the earth's crust. Shale is a sedimentary rock that can be a rich source of petroleum and natural gas. **Fracking** is the controversial process of extracting gas from the shale. It involves drilling a well down into the earth's crust and then sending a high-pressure water, sand and chemical mixture into the rock to release the trapped gas. The gas then travels back up the drilled shaft and is collected at the well head. Although this technique is only in its infancy in the UK, it is widely used in many parts of the world.

Environmental campaigners believe fracking can damage the environment by releasing gases and other toxic particles into the water table. There are also concerns that the fracking process can cause earth tremors.



Renewable energy sources

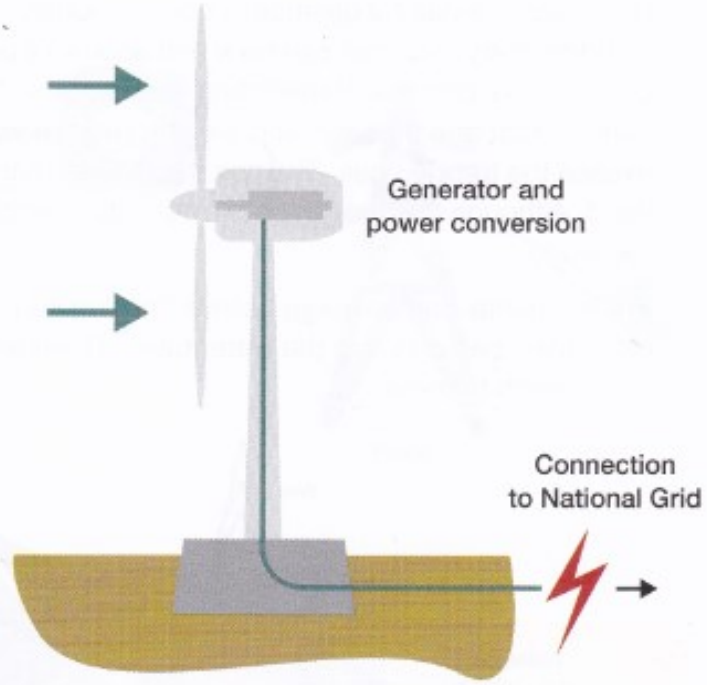
Energy that comes from the planet's non-finite resources is considered to be **renewable**. This includes wind, wave and tidal, hydroelectric, geothermal, biomass and solar energy. Although a continuing matter of debate, nuclear energy is also sometimes included in this category as the amount of uranium it uses is unlikely to run out in under 1000 years and may well last many times longer. It also produces very low levels of CO_2.

A major argument against including nuclear energy in a list of renewables is the harmful nuclear waste produced by nuclear power reactors. This nuclear waste is considered a radioactive pollutant and that goes against the idea of a renewable resource producing minimal pollution.

Nuclear energy accounts for about 22% of the UK's electricity. Other forms of renewable energy produced just over 23% in 2015, according to government statistics; up from 17.6% in 2014. Greener ways of producing electricity are on the rise, although it is proving more difficult to reduce our dependency on fossil fuels for heating and transportation.

Wind turbines

Wind farms are becoming a common sight around the country. An increasing amount of our energy is being produced this way and it is a relatively cheap option. Wind turbines produce more power in the winter months when the demand is higher, but they have some drawbacks. They do not produce power when it is not windy or when it is too windy, they can harm wildlife, especially birds, and they are considered an eyesore by many. Most people agree that they are a good idea, although they would not like to have one situated near to where they live. The term 'nimby' stands for 'not in my back yard'. Nimbyism has stopped many proposed wind farms from being developed.



Solar energy

The photovoltaic effect involving the conversion of solar energy into electrical energy was discovered in 1839 by French physicist Alexandre-Edmond Becquerel, but it is only since the turn of this century that the price of producing photovoltaic cells has dropped enough for it to be a viable method for large scale energy production. **Solar farms** are now commonplace in the countryside and many private houses also have solar panels fitted.

The solar cell technology captures the sun's rays and converts them into electrical energy. The cells only produce energy during the daytime and production is less in the winter months, owing to the shorter daytime length and the reduced angle of the sun's rays.

Tidal energy

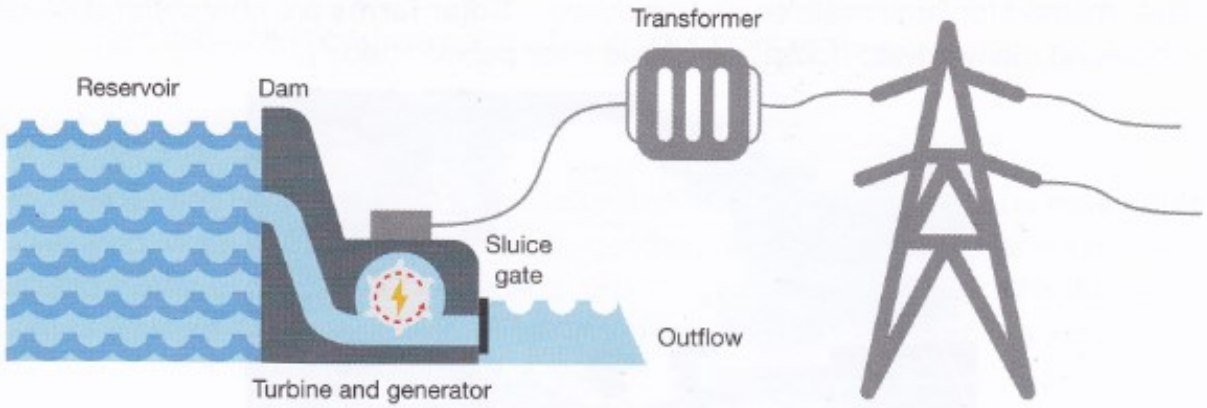
There are a few different varieties of **tidal** energy devices but they all use the same principle to generate electricity. They rely on the movement of water to turn turbines which drive the generators that produce electricity.

The benefit of tidal energy production over wind and solar is that it is more predictable and generally more consistent. The main difficulty is the environment in which the machinery needs to be located. Usually the conditions are harsh and some distance from land, making repair and maintenance more difficult. Investment in wave and tidal energy is nevertheless increasing and large scale projects are beginning to be developed.

Hydroelectric power

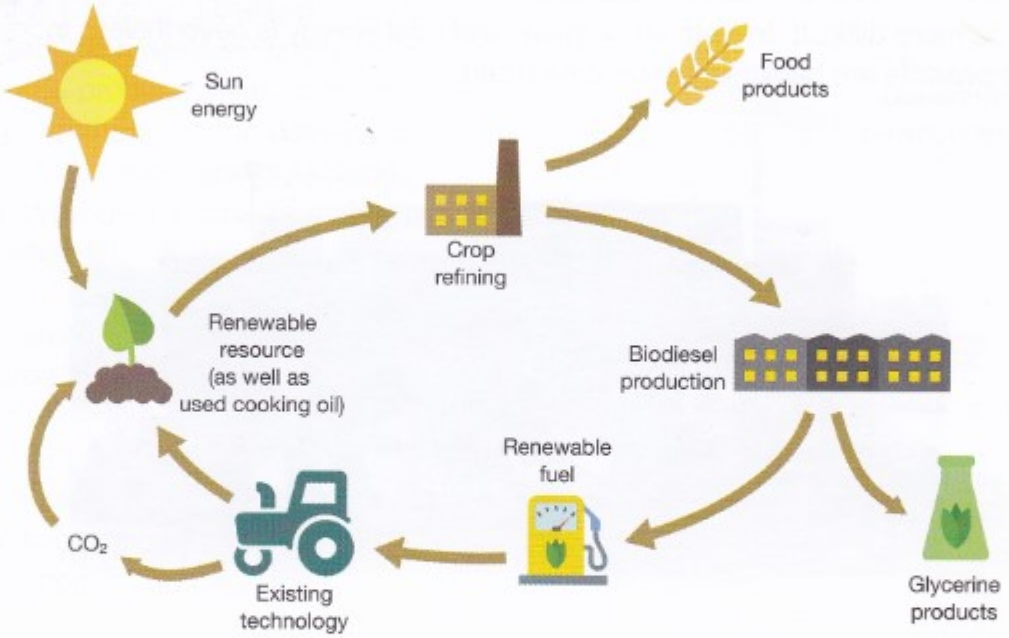
Hydroelectric power (HEP) generation is a very reliable source of renewable energy. It has high initial set-up costs, both financially and environmentally, as vast areas of land need to be flooded to create a reservoir. However, the reservoirs usually mature into thriving leisure facilities such as boating lakes and nature reserves which can have a positive effect on the local area.

Power generation is more efficient during periods of heavy rainfall. At other times, water is pumped back up to the top of the reservoir when the demand for electricity is low. The flow of water through the turbine is easily controlled, making it simple to alter the power being produced depending on the demand at different times of the day.



Biofuel

The production of **biofuel** is becoming a viable way of producing energy for our transportation and heating needs. Oil- and starch-producing crops are grown, harvested and refined into a number of products, including biodiesel. The process is commonly known as **biomass** energy production. The term biomass can include other solid biofuels such as wood chips and farm waste.

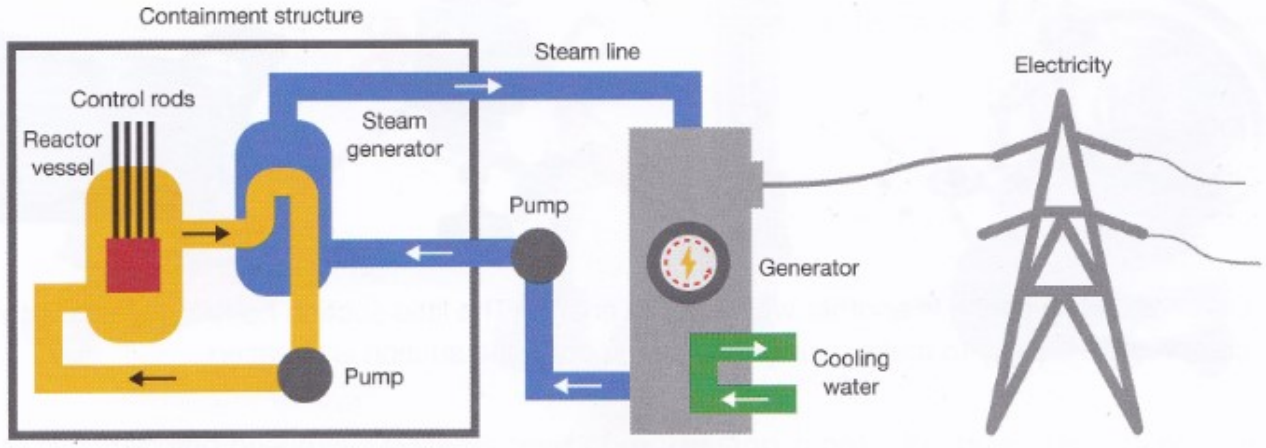


In 2016, only about 3% of fuel for the UK's transportation system came from biodiesel, according to the Department of Transport. A growing number of companies and private users are recycling spent cooking oil, (a waste product from the catering industry) and converting it into biodiesel by refining it independently.

Products produced from biomass are considered to be carbon neutral as they absorb CO_2 whilst growing and produce similar levels of CO_2 when they are burned for energy. However, they do require additional energy to convert them into usable fuels. There are a growing number of campaigners across the planet that believe the vast amount of land needed to produce the crops for biomass is contributing to food shortages in developing countries. The crops also use up large volumes of water which can be a scarce commodity in some communities.

Nuclear power

The most controversial method of energy production is **nuclear** power. Considered a clean and efficient energy source, it provides over 11% of the world's electricity. The process harnesses a nuclear reaction that takes place inside the reactor vessel. Control rods are moved in or out of the reactor's core to regulate the amount of power that is generated. The reaction generates vast amounts of heat which, like other methods, superheats water and generates power by driving turbines and generators.



The downside of nuclear power is that it is very expensive to build a reactor and the waste product from the reaction is **radioactive** and very dangerous to all forms of life. It must be contained correctly and carefully stored so that the radiation does not leak. Nuclear waste is usually stored underground as it stays radioactive for a very long time; some materials will stay radioactive for millions of years.

There have been a few very high profile disasters involving radiation leaks at nuclear power plants, including Fukushima Daiichi, Japan 2011 where a tsunami hit and Chernobyl, Ukraine in 1986. Both caused devastation to the surrounding natural environment.

People, Culture and Society:

Questions

Q1. Explain 2 main differences between fossil fuels and renewable fuels … (2 marks)	Feedback:
Q2. When fossil fuels are burned, explain what role water plays in the generation of energy by a generator… (1 mark)	Feedback:
Q3. In 5 stages, explain the process of extracting shale gas through fracking... (5 marks)	Feedback:

Q4. Give 2 points for and 2 points against fracking to provide a fuel source (4 marks)

Feedback:

Q5. For the following renewable energy sources, briefly explain how the energy is created from the renewable source... (9 marks)

Wind

Wave

Tidal

Hydroelectric

Geothermal

Biomass

Geothermal

Solar

Nuclear

Feedback:

Q6. An energy company have proposed placing wind turbines on your school site and near to your home. Give 2 positives and 2 negatives for this proposal… (4 marks)

Feedback:

Q7. What might be the effect of placing a dam at the end of a valley and flooding the valley to create a reservoir for a hydroelectric power station? (2 marks)

Feedback:

Q8. List 4 positive factors for the use of hydroelectric power (4 marks)

Feedback:

Q9. If biofuel is so environmentally friendly, why do you think it is not more commonly used at present? (1 mark)

Feedback:

Q10. What are the social and environmental issues surrounding the disposal of waste from nuclear energy production? (2 marks)

Feedback:

Total marks : / 26

WWW?

EBI?