

Kibworth Mead Design Technology

Sustainability

Sustainability is about how the product can continue into the future with as little impact as possible on the environment.

In the exam you might read the term 'ecological issues'. This sounds similar to 'economical', however they mean two different things:

Ecological is to do with the environment and the impact on nature.

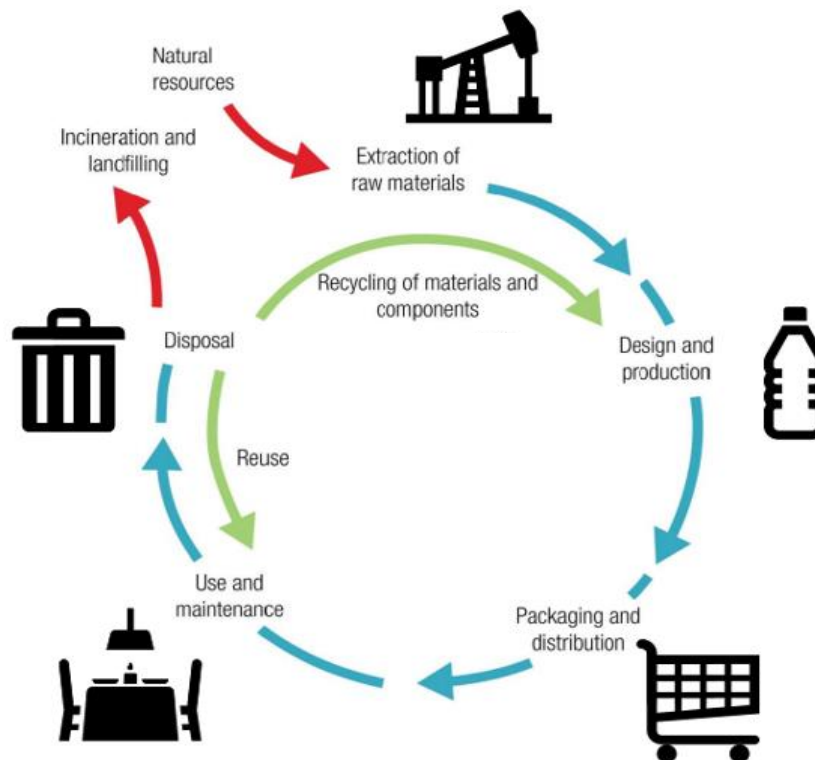
Economical is to do with money.

In this guide it will cover:

- Life cycle assessment (LCA)
- Sourcing and extraction
- Power and energy
- Product miles
- Carbon footprint
- End of life
- 6Rs

At the back the Do Nows from lessons (with answers) will be included as well as example exam questions. Your teachers will be happy to mark these exam questions for you or you can use the mark schemes on the AQA website to help you.

Life Cycle Assessment (LCA)



A designer uses a life cycle assessment (LCA) to analyse the impact on the environment at each stage of a product's life. They can then look to see how they can make changes to improve the product and make it more environmentally friendly.

A designer might consider the following questions:

- **Extraction** – where does the material come from? Is it mined, drilled, cause deforestation etc.
- **Manufacturing** – how is the material made into a product? Does that require a lot of energy and power?
- **Distribution** – how is the product transported and to where?
- **Use** – how is the product used and will it impact the environment?
- **End of Life** – what happens to it at the end?

Sourcing & Extraction

For the first part of an LCA, the designer looks into the source of the material:

- Timber – trees
- Polymers – crude oil
- Metals – ore
- Paper & board - trees

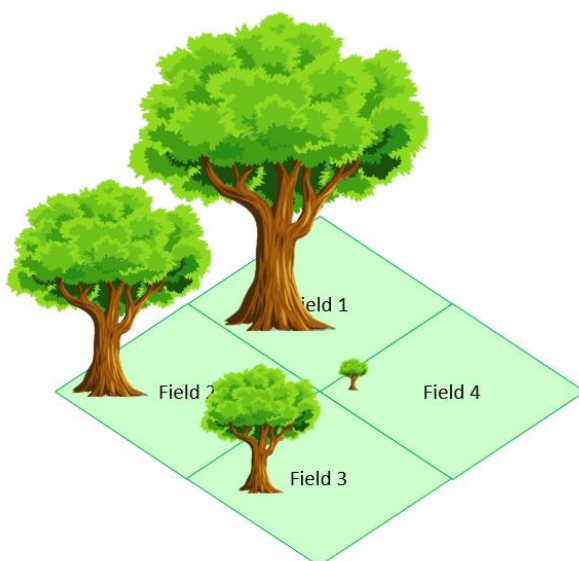
Some of these sources are FINITE resources (they will eventually run out because they are non-renewable).

Each of these sources requires a different method of extraction:

Trees

Trees need to be felled (cut down). The branches are cut off and the trunk of the tree cut into manageable lengths for processing (see Timber revision guide).

Trees need to come from managed forests. These forests ensure that the felling of trees is managed, and new trees are given time to grow to replace those trees cut down. Remember this diagram from our lessons:



The cutting of trees has to be managed. Once all the fully grown trees in Field 1 are cut down, the trees in Field 2 need to all be fully grown to continue the supply.

Fresh trees can then be planted in Field 1 to start the cycle again!

When this doesn't happen, there can be two key issues with tree farming:

- Deforestation
- Slash and burn farming

Some desirable timber such as Brazilian Mahogany comes from the rainforest. This timber is in high demand (lots of people want it) so companies cut down a lot of these trees without planting new ones or waiting for new ones to grow. This is DEFORESTATION.



It has seen large parts of the rainforest destroyed with animal homes and habitats lost. Due to the climate of the rainforest, once a large area like this has been destroyed, it can often become baron land that won't regrow the trees needed.

In some countries, the growing population and need for more food requires more farmland area. When burnt, the ash from trees contains minerals and nutrients for the soil so farmers will cut down a large area of forest – burn it – then use the soil to grow crops. However, once the nutrients from the ash have been used, the land becomes useless, and crops/trees won't grown on it anymore. This is called SLASH AND BURN farming.



The solution to these problems are for companies to buy sustainably sourced timber from the tree farms mentioned above. To show timber is sustainably sourced, it will have a mark:

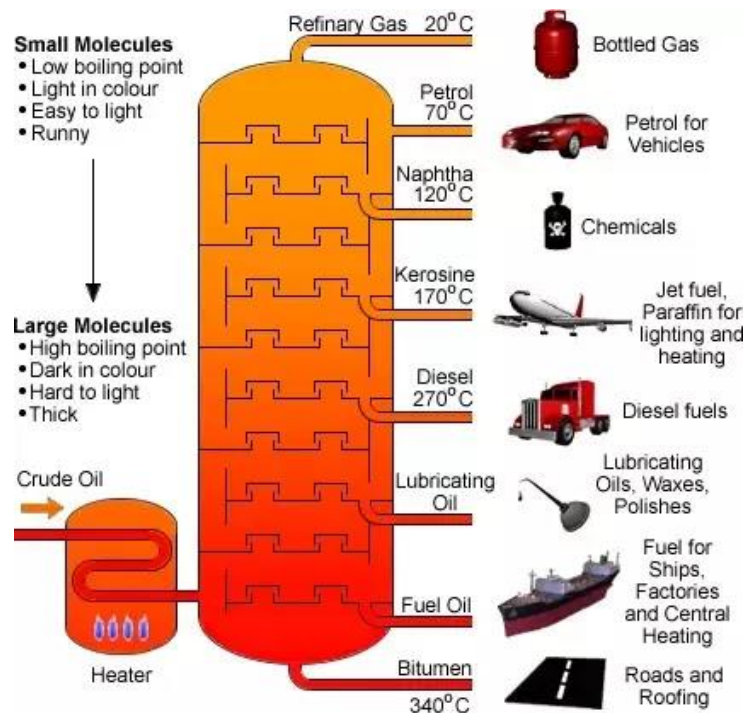
- FSC – Forest Stewardship Council
- PEFC – Programme for Endorsement of Forest Certification



Crude Oil

This is a finite resource so will run out. Oil is found in pockets underground and needs to be drilled to reach before being pumped out. All this requires a lot of power and machinery (releasing a lot of CO₂ into the air (see Power and Energy Section)).

Once the oil has been pumped out of the ground, we still can't use it. Instead, it needs to be refined. This process is called Fractional Distillation:



NOTE: You won't need to learn all the text on this diagram, however you might need to draw a basic diagram of the process, showing the different layers being separated.

Fractional distillation is covered more in the Polymer Revision Guide, however as you can see, from a sustainability perspective, heat is required, and this will release a lot of CO₂ (see Power and Energy Section).

Oil is a finite resource as mentioned so we are taking from the Earth without being able to give back. Oil also has another issue – spills! With some oil pockets under the sea, offshore drilling is needed. When these platforms break or if a ship transporting oil sinks, the oil is spilled out into the sea, harming the sea life and the oil is lost and can't be used.

Metal Ores

Just like Crude Oil, these are a finite resource. These are also located in the Earth (not as deep as oil), however they aren't a liquid so can't be drilled and pumped out. Instead, they need to be mined.

Mining is done now by excavating (digging out) a large area of land.



Just like metal ores, coal is also mined this way. Digging out this large area of land requires a lot of power and energy so a lot of CO₂ is released but also destroys a large amount of habitat.

The impact extraction of materials has on plant and animal life is called the **Ecological Footprint**.

Power and Energy

FACT: As of 30th September 2024, the UK no longer uses coal to generate electricity.

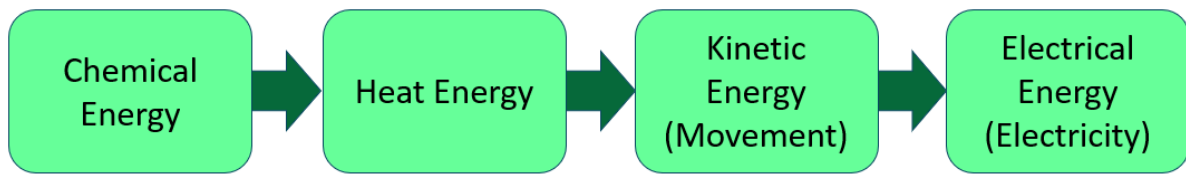
Electricity comes from many different sources. Traditionally this came from burning coal, however this is being replaced. Natural gas is also used but again this is being replaced. Coal and natural gas were used because they burn at high temperatures and burn for longer than timber for example.

Electricity is made through the transfer of energy. Kinetic energy (movement) is converted by a generator into electrical energy that we can use. However, there are different ways of making the kinetic energy.

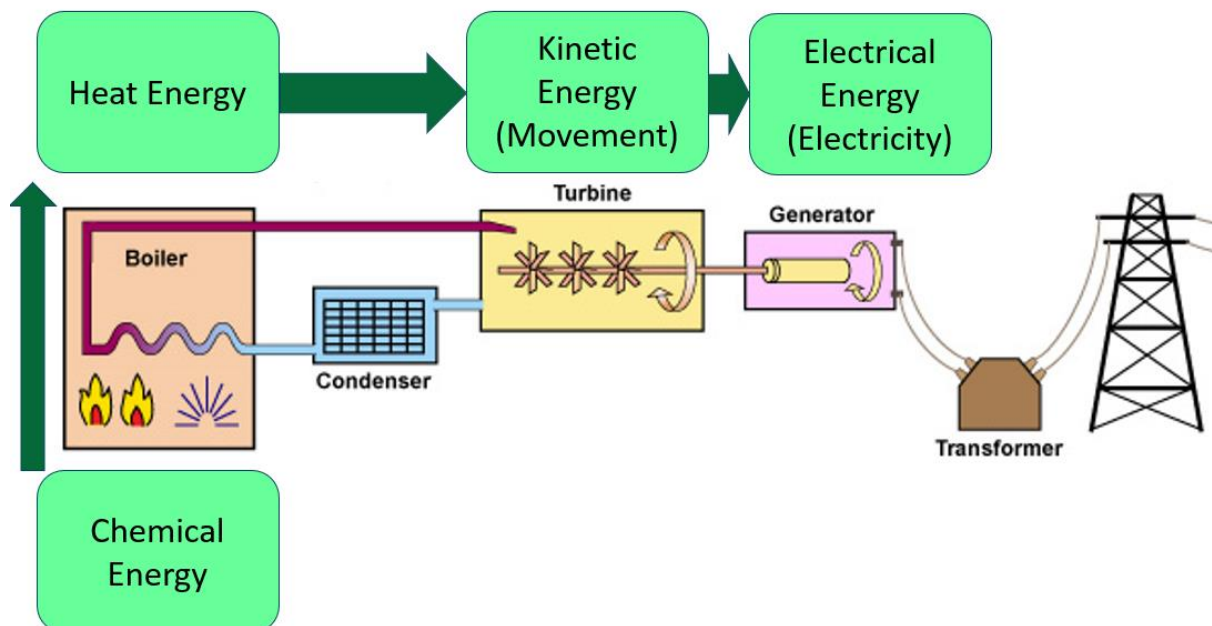
When coal and natural gas are used, they are burned. This turns the chemical energy into heat energy.

The heat energy is then used to boil water and when the water becomes steam it changes the heat energy into kinetic energy as the steam rises.

This kinetic energy then turns turbines to make more kinetic energy that can be used by the generator.



NOTE: You might have to draw a diagram similar to the one below:



Burning any substance creates a lot of CO₂ so the production of electricity that we use to power our factories and machines produces a lot of CO₂ that is pumped into the atmosphere. Too much CO₂ leads to global warming.

There are solutions however and instead we can get electricity from renewable sources that don't create CO₂:

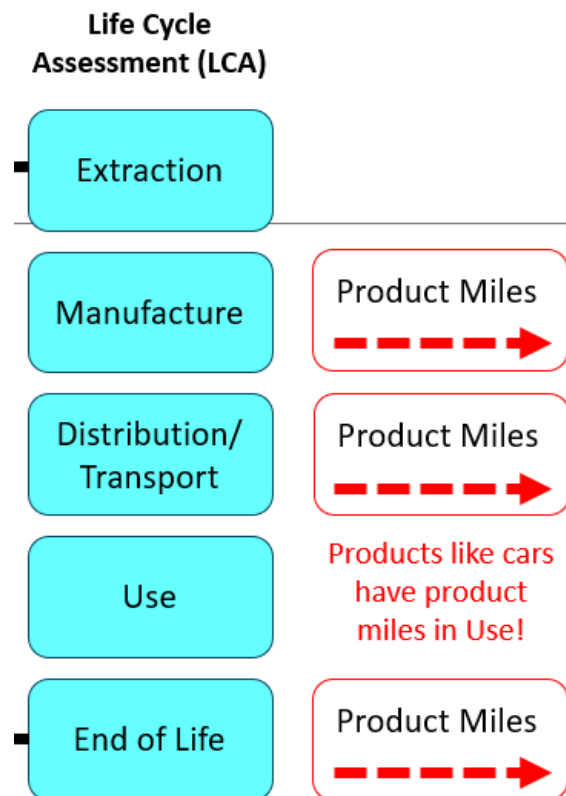
- Solar
- Tidal
- Wind
- Hydroelectric (dams)
- Biofuel
- Nuclear (very dangerous however)

Nuclear works in a similar way to coal power, however the nuclear reaction creates the heat and this heat doesn't release CO₂. A nuclear power plant breaking can cause catastrophic problems – Chernobyl is an example of this.

	Positives	Negatives
Solar	Cheap to set up Can be used for individual houses	Doesn't produce power when it is dark Less power in winter when it is needed most
Tidal	Constant supply of electricity as the sea is always moving	Rough water is needed meaning installation and repair is dangerous
Wind	Cheap to set up Produces more power in winter when demand is higher	Doesn't produce power unless there is wind Harmful to birds
Hydroelectric	Lakes made as a result can be positive for wildlife Constant supply of electricity Flow of water can be controlled to suit power needs	Vast land needs to be flooded Very expensive to set up
Biofuel	Uses current farming technology The crops absorb the CO ₂ produced through burning the fuel when used	Lots of land needed Crops need a large amount of water
Nuclear	Generates a lot of energy	Very expensive to set up Waste produced is radioactive

Product Miles

Product miles are how far a product has travelled. This doesn't just mean once the product has been made, instead it looks at the miles it covers across the LCA:



Examples would be:

- If a product is assembled in the UK, but some parts such as screws come from other countries or different parts of the country, this adds to the product miles.
- If the product is made in China or India, then it is shipped to the UK for sale, this adds to the product miles.
- When customers drive to the shops to buy the product or then when the bin lorry or recycling lorry collects the product at the end of its life, this adds to the product miles.

This is important to consider because transportation requires power and electricity. This all creates extra CO₂ that is harmful to the Earth (global warming)

Carbon Footprint

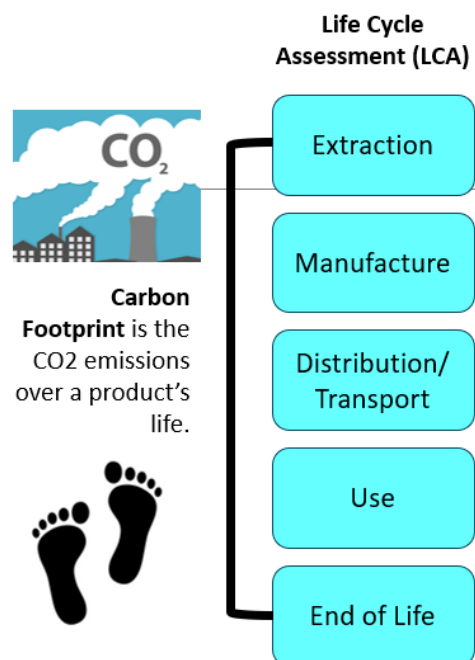
The Earth's atmosphere is a delicate balance between different gasses. Life on Earth is balanced with animals breathing in Oxygen and breathing out CO₂ and plants absorbing CO₂ and releasing Oxygen.

With the development of technology and our production of power, we now release more CO₂ into the atmosphere, upsetting the balance and leading to impacts such as global warming.

Carbon footprint is the amount of CO₂ released by a product/person during their lifetime.

For a person this isn't just their breathing, it is the CO₂ emissions from using their car, how much electricity they use etc.

For a product it is the CO₂ emissions across the LCA:



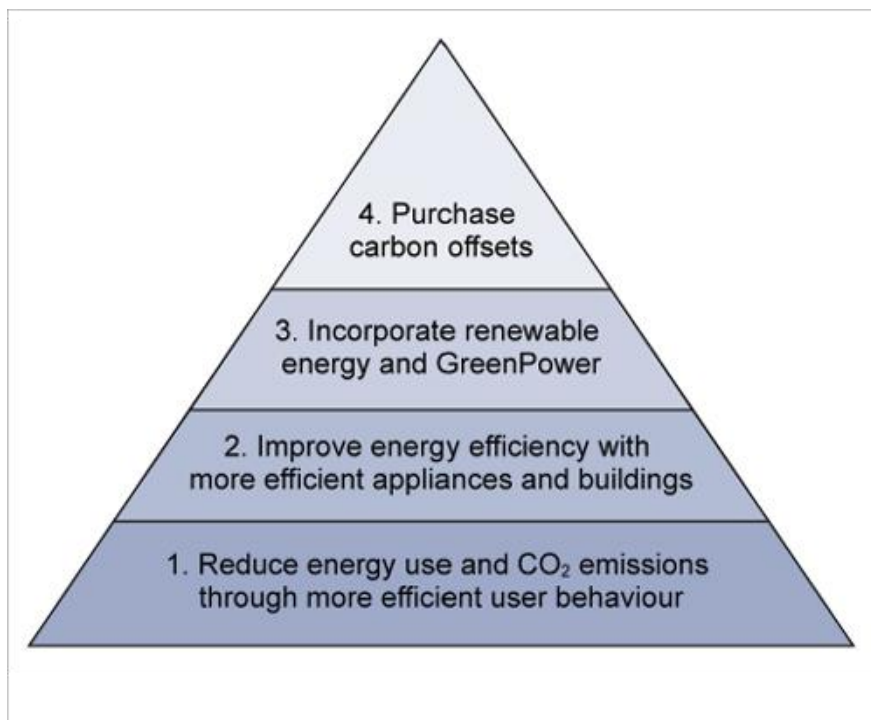
This isn't just the CO₂ released through Product Miles. It is the CO₂ released at all stages of the LCA:

- **Extraction** – the CO₂ released through felling, mining, drilling etc.
- **Manufacture** – the CO₂ released by the factory making the product and the Product Miles of the components of the product (see Product Miles section)

- **Distribution** – the CO₂ released through the Product Miles of how far the product travels to be sold
- **Use** – the CO₂ the product releases when being used. For an electronic product like a mobile phone, when being used it needs electricity. If that electricity comes from coal (see Power and Energy section) then that releases CO₂
- **End of Life** – the CO₂ released from recycling, or the machines used to put the product into landfill (see End of Life and 6Rs sections)

Carbon Offsetting

Companies look to try and reduce the Carbon Footprint of their products by analysing the LCA and seeing how they can reduce CO₂ emissions:



The best is number 1 – use techniques like Lean Manufacturing or Kaizen to make manufacture as efficient as possible to use less energy and reduce CO₂ emissions.

For number 2, this is about making sure energy isn't wasted. LED lightbulbs use less energy so make sure all lighting is through LEDs.

Number 3 is then if you can't improve efficiency, look to use renewable power such as solar or wind.

Finally, number 4 is carbon offsetting. This is when a company can't improve their efficiency or use renewable power so instead invests in businesses that help reduce CO₂ such as the FCS (Forest Stewardship Council) or other rainforest protection companies.

The idea with this is that if they can't reduce their own CO₂, invest in another company that is looking to reduce the overall CO₂ in the atmosphere!

End of Life

Once a product has served its purpose or has broken, it gets thrown away.

When products are thrown away they end up in a landfill site:



This is a managed hole in the ground where rubbish is simply dumped. Some of it will rot away and decay, but other parts such as metal, plastic etc will just sit in the hole.

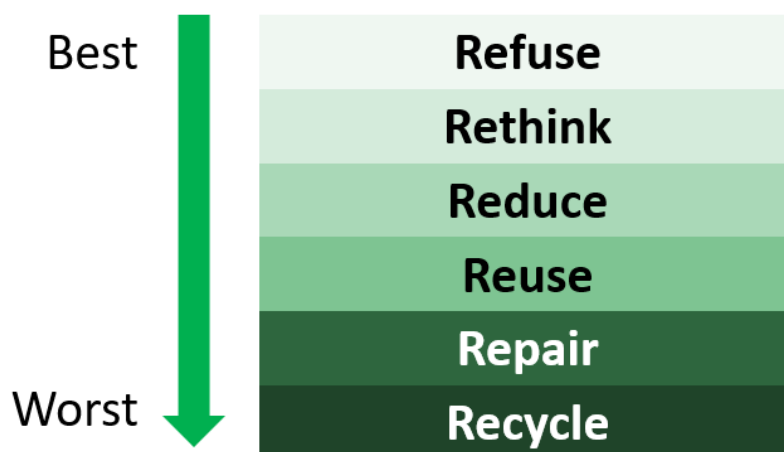
Landfill again requires digging up a large amount of land (**ecological footprint**) and requires power to manage to filter the smell and waste water so they don't harm the surrounding environment.

6Rs

There is a solution to landfill. Designers use a tool called the 6Rs analysis to see how their product can be improved so it doesn't end up in landfill:

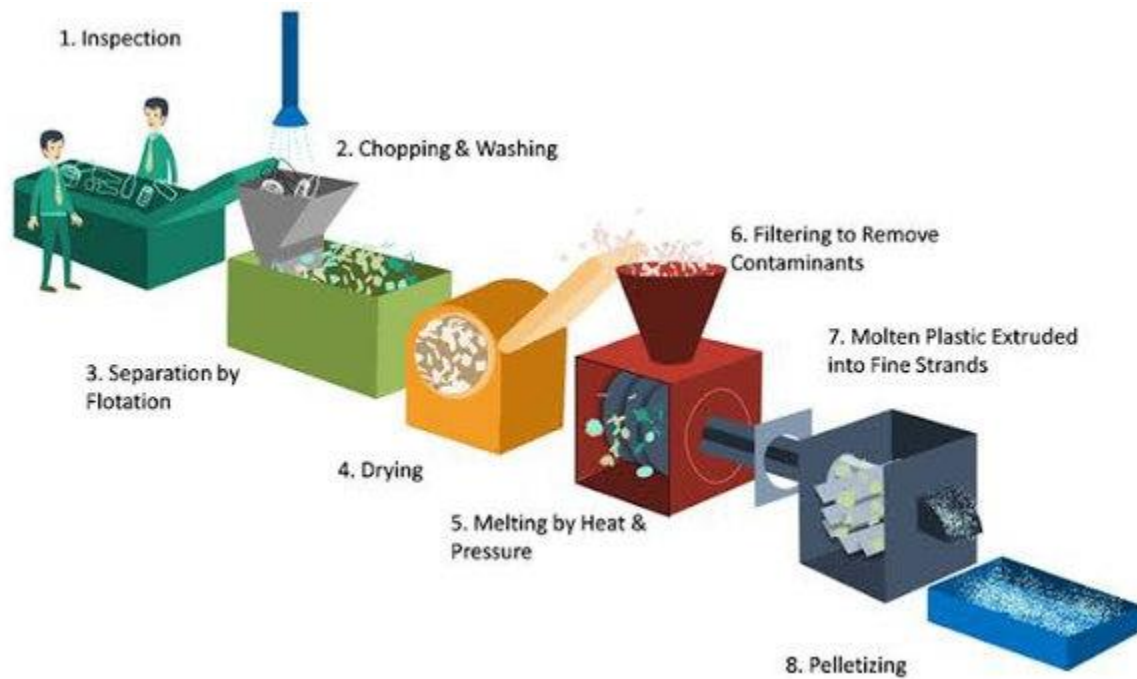
- **RETHINK** – can we change the design to make it more environmentally friendly? For example, cars are being changed to electric rather than petrol/diesel
- **REFUSE** – as a designer saying deciding not to use a material. Refusing to use Thermoset Polymers for example
- **REDUCE** – can we use less, think packaging. Does the plastic container need to be that big or can it be smaller?
- **REPAIR** – as a designer have you designed your product to be repaired? Are spare parts available to extend the product life?
- **REUSE** – can the product be made into a different one? We would still need to buy a new product, but we have prevented the old product from being thrown away
- **RECYCLE** – have we used materials that can be easily separated (not chemically bonded together) and that can be recycled

Designers need to think about which 6R is best:



Trying to refuse a material such as plastic or metal because they are more harmful to the environment is better than making the product out of only recycled plastic.

The recycling process is the worst 6R because of the power it requires:



Not only does it need a lot of electricity, but the heat required to melt the material would either come from coal or natural gas or require an even bigger amount of electricity – all of which releases CO₂.

What recycling does save from the LCA is the Extraction part. No new materials are needed so no more mining or drilling and the ecological footprint is reduced. It also reduces the amount of material that ends up in landfill.

Do Now Questions

Why are polymers considered unsustainable when analysing their source?

They come from crude oil, and this is a finite resource. A lot of heat is also needed to turn crude oil into usable polymers and this heat will come from coal (a fossil fuel).

Which polymer type can't be recycled?

Thermoset

What happens to a product when it is recycled?

The product is broken down into its different materials. If those materials can be recycled, then they are heated up and melted so they can be made into more products.

What are the five stages of a life cycle assessment?

Extraction, Manufacture, Distribution, Use, End of Life

What is a landfill site?

A managed hole in the ground where rubbish is disposed into.

Why is recycling unsustainable?

It requires heat which comes from using fossil fuels like coal or natural gas.

Why does deforestation occur?

The timber is needed to meet high demands or the land is needed for housing/farming.

What is 'slash and burn'?

Trees are cut down and burnt. The ash from the burnt trees temporarily provides nutrients for farming crops/animals.

Name a mark to look for on timber that shows it was sustainably grown.

FSC or PEFC

Which polymer type can't be recycled?

Thermoset

What are the 6Rs?

Reduce, Refuse, Repair, Reuse, Rethink, Recycle

Which 6R is the best for the environment and why?

Refuse – this is because you stop using the material completely so save on the pollution from extraction and manufacture.

Why 6R is the worst for the environment and why?

Recycle – the heat needed for recycling comes from fossil fuels.

Why are oil and coal finite resources?

They can't be replenished/remade. Once they are used, they are gone.

What gas does burning fossil fuels create?

Carbon Dioxide.

Explain the changes in energy to produce electricity.

1. Chemical energy in the coal/gas becomes heat energy that is used to boil water.
2. As the water boils, the heat energy becomes kinetic energy that is used to turn turbines.
3. A generator then turns the kinetic energy into electrical energy.

What does sustainability mean?

The avoidance of the depletion of natural resources in order to maintain an ecological balance (*being able to use a resource again and again without causing long term harm to the environment*).

What type of resource is oil?

Finite resource/fossil fuel

What are the 5 stages in a life cycle assessment?

Extraction, Manufacture, Distribution, Use, End of Life (Recycling)

What is carbon offsetting?

Investing in companies/projects that help reduce carbon such as forest projects. The company doesn't reduce their carbon emissions but instead support projects that help balance out carbon emissions.

Why is lean manufacturing the best way to reduce carbon emissions?

Lean manufacturing is only producing what is needed. This means no extra products are made so no extra carbon emissions are produced.

Why is renewable energy not the best way to reduce carbon emissions?

Fossil fuels are needed to make the sources such as wind turbines. They also don't produce enough energy, so some non-renewable energy is needed still.

What is carbon footprint?

The amount of CO₂ emitted at each stage of the product life cycle.

What are product miles?

How far a product travels and as a result, how much CO₂ is released.

What is an ecological footprint?

The impact on the environment a product has. This could be the extraction of fossil fuels, deforestation or the disposal of the product.

What is a social footprint?

The impact a product has on people. Are they given a fair wage? Is child labour used? Does the product have a positive impact on people?

GCSE Exam Questions

June 2023 Paper (Mark scheme - [Mark scheme: Paper 1 - June 2023 \(sanity.io\)](#))

0 2 Which **one** of the following statements is true?

- A** Coal is used to generate hydro-electric power.
- B** Fossil fuels produce argon when they burn.
- C** Gas is a renewable resource extracted from the ground.
- D** Oil is extracted from the ground to produce petroleum.

[1 mark]

0 6 When manufacturers focus on the reduction of waste during production, it is called

- A** batch manufacture.
- B** flexible manufacture.
- C** lean manufacture.
- D** mass manufacture.

[1 mark]

2 8 Explain how **each** of the following issues may be considered before designing and manufacturing new products.

[4 marks]

Fair trade _____

Global warming _____

0 8 Which **one** of the following is a renewable resource?

A Metal ore

B Natural gas

C Oil

D Water

[1 mark]

1 0 Which **one** of the following statements is **true**?

A Continuous improvement is the concept of storing waste.

B Lean working reduces efficiency.

C Global warming is due to decreasing levels of carbon dioxide.

D Pollution is created by the burning of fossil fuels.

[1 mark]

1 8

Carbon dioxide is released as a result of making, transporting and using a product during its lifetime. This is called a 'carbon footprint'.

Analyse and evaluate what factors contribute to carbon release or 'carbon footprint' from raw material source to final disposal.

Give examples in your answer.

[8 marks]

1 9 . 2

Analyse and evaluate how the design and manufacture of garden furniture may cause deforestation and what steps can be taken to address this.

[6 marks]

November 2021 Paper (Mark scheme - [Mark scheme: Paper 1 - November 2021 \(sanity.io\)](#))

0 3 Which **one** of the following has a positive impact on the environment?

A Global warming

B Inefficient working

C Pollution

D Reducing waste

[1 mark]

1 2 Explain the disadvantages of extracting fossil fuels as a source of energy.

[3 marks]

1 9 Before a consumer makes a product purchase they should consider the six Rs shown in **Table 6**.

Table 6

Reduce	Refuse	Re-use	Repair	Recycle	Rethink
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Analyse and evaluate how the six Rs may help a consumer make an informed decision whether to purchase or not.

[8 marks]
