AQA Geography A-level

3.2.5: Resource Security

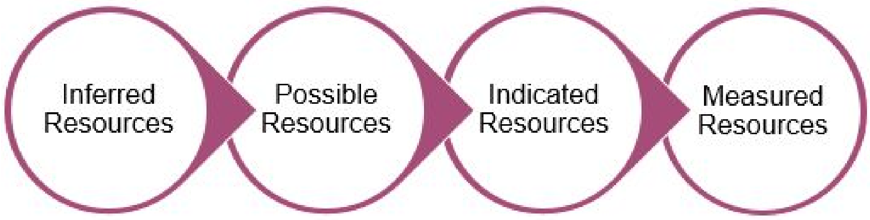
Detailed Notes

Resource Types

A **resource** is any type of **asset, commodity or item** which has value to **enhance the quality of human life** or help it **function more effectively**. You will study **water, energy and mineral** resources. They can be categorised into different types:

Stock Resources: **Finite** and will run out eventually e.g. fossil fuels.
Flow Resources: **Infinite** and can be replenished and renewed e.g. biofuel.

Natural resources are those that exist without human intervention and can include **stock and flow** resources. To use resources they must be exploited and this follows a process of exploration:

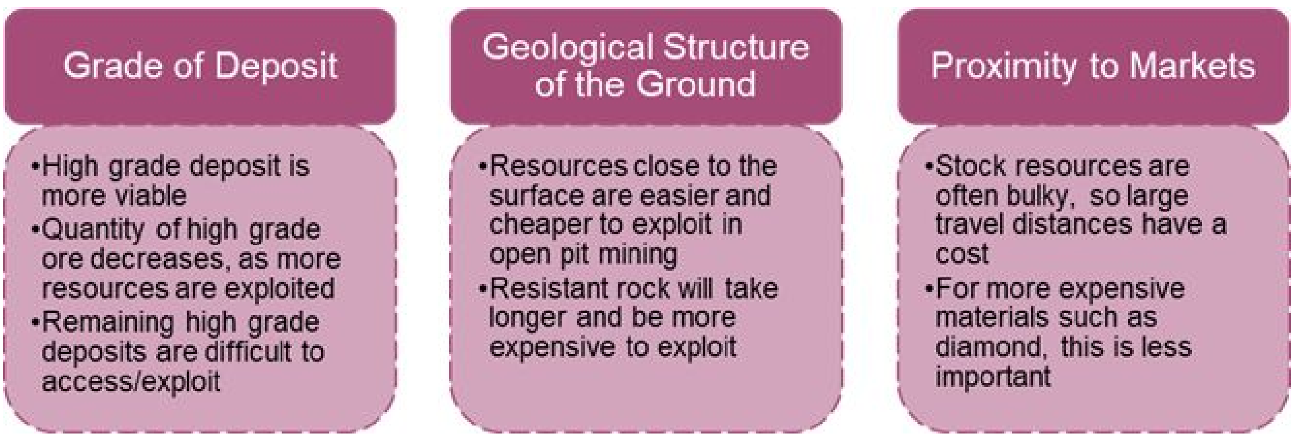


Inferred: Economic viability of resource is uncertain
Possible: Expected that inferred resource could become indicated with further exploration
Indicated: Conditions and location of resource can be predicted to allow initial planning
Measured: Detailed mine planning possible

Resource exploration for **stock resources** may include assessing the **grade of deposit** (percentage quantity of desired resource in all the material that is being exploited).

Resource Exploration and Exploitation

Exploration is the process of searching for available resources and then upgrading the resource from **inferred to measured** if appropriate. Resources are difficult to find due to their **uneven global distribution**, but new technologies such as **remote sensing**, allow **more efficient exploration**. **Exploitation** is the process of extracting the material from the ground and its use is dependent on the **economic viability** of a resource. This varies due to:

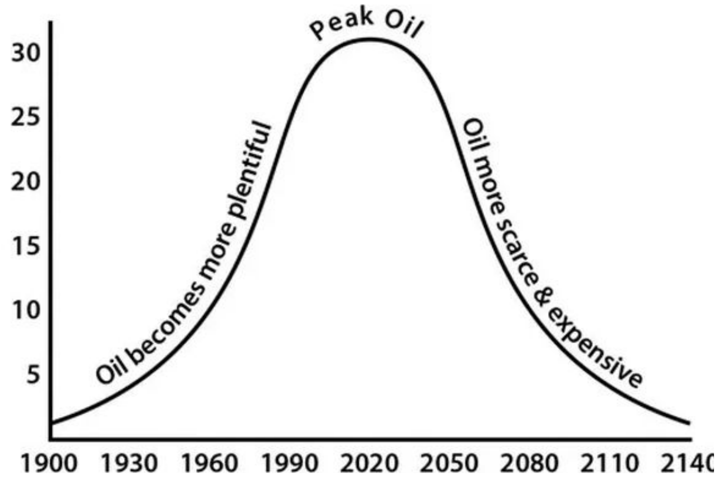


Resource Frontier

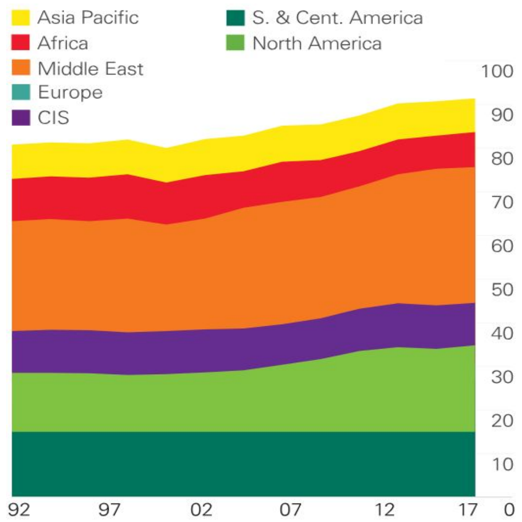
A **resource frontier** is the **boundary** between exploited areas and areas considered too difficult to exploit under **current political and technological conditions**. Resource frontiers are changing as **technology advances** to allow new areas to be exploited. **Changing/warmer climates** may allow areas such as Antarctica to be exploited.

Resource Peak

The amount of the resource being extracted will **vary over time** but usually follows a long-term trend known as **'Hubbert's Curve'**. Production **increases exponentially** until it **peaks around halfway through available resources** and is followed by **decreasing production**.

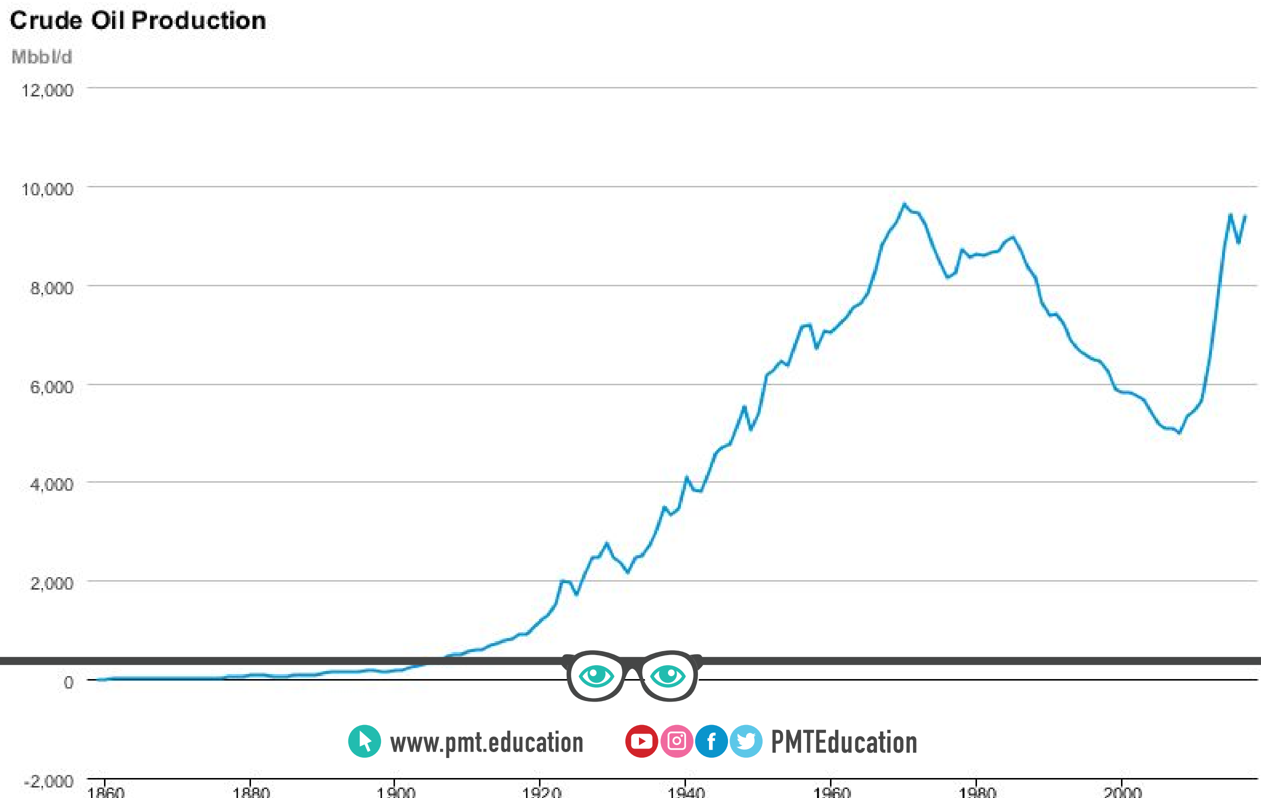


Source: The NR Group



Global Oil Production - Source: BP

Not all production follows this curve precisely, as demonstrated by the graph showing US crude oil production. However, on a global scale, the production will follow the **bell-shaped** curve. There will be **fluctuations from the expected curve** and recent data on global oil production demonstrates this. It is predicted that **in 2030, peak oil** will occur.



The time at which **peak production** occurs is dependent on:

- The **availability and discovery** of reserves
- Development of **new technologies**
- **Demand** for the resource (may decrease or increase suddenly as a result of research into a material or new uses that are found for a material). How will electric vehicles affect the demand for oil in ten years time?
- **Grade of available resources**

Sustainable Resource Development

Sustainable refers to the ability to **keep something going** in the long-term. It can refer to the production of a stock resource and involve **environmental, social, economic and political** factors. A **sustainable resource development** therefore involves **long-term planning** that ensures extraction does not increase too quickly or rise to **unsustainable levels**. It will ensure that **workers are protected** in future and there is a plan for when the resource can no longer be exploited and the facility will close, though the aim is to **prolong this point** for as long as possible. Sustainable Resource Development will include a **long-term environmental plan**, **(EIA)**.

Environmental Impact Assessment (EIA)

EIA's are used to assess the possible **environmental impacts** of a **resource development project** and should be **completed before the project is approved**. It states the **potential environmental disturbances** caused by a project across **different areas of the environment**, from the flora and fauna to the physical landscape. It suggests ways to **mitigate and reduce** any environmental impacts. A project may **not be approved** if the environmental costs are too high, though **money** for a project is likely to **dominate over any environmental worries**. An **EIA** leads to an **Environmental Impacts Statement (EIS)**. An **EIS** and **EIA** are mandatory in many developed countries and in some less developed countries, though it depends on the project type and company proposing the project. An **EIA** should include:

- Project description
- Consideration of alternatives
- Description of the environment
- Environmental impacts of the project
- Mitigation of potential issues and monitoring strategies
- Non-technical summary to be understandable by the general public
- Areas for further research into the potential impacts, where there are gaps in current knowledge

Companies such as the mining **TNC Rio Tinto**, also create a **Social and Environmental Impact Assessment (SEIA)**. You can see how detailed they are by looking at this example here - the **non-technical summary** is the easiest to read.

Mineral Security

A **mineral** is a **naturally occuring compound** formed by chemical processes. They are **not organic**, so whilst c**opper, iron and diamond are minerals, fossil fuels such as coal are not**. Minerals are often found in **veins** (lines of material) in rock and most commonly in **igneous rock**, but also in some **metamorphic rock**. Some minerals such as diamond need intense heat to form so only form on **cratons** (old sections of continental crust which extend deep into the **lithosphere**).

Global Mineral Distribution

You should know the **locations of global deposits of minerals** and maps to explore this can be found here. This map here shows **global distribution** of specific mineral types. When you create a case study about a specific mineral such as iron, you could use this map to identify the **global distribution of iron reserves**.

Technological advances and the development of LIC countries has **increased the global demand for resources and changed trading patterns**. Manufacturing of technological devices mostly occurs in **Asian NIC's** such as Taiwan, though the majority of consumption is in North America, Europe and developed Asian countries. This creates a **global trading network**, where minerals are **shipped from all over the world to Asia for manufacturing and then shipped back across the world for consumption**. Historically the USA and Europe were the largest manufacturers of minerals, but due to **comparative labour costs** and globalisation, this is no longer true. This **increases the importance of geopolitics** (the combination of the ways that **political and geographical factors** influence the use of land and resources).

To **reduce the environmental impacts** of a **mineral resource project**, strategies are implemented at **each stage of the process**. The examples refer to various minerals, but you should create a case study based on a single mineral (see PMT case studies):

Extraction:
- Water sprayed on mine roads to reduce toxic dust in the air
- Choosing not to mine environmentally sensitive areas
- On-site processing reduces emissions of transportation as waste material is not transported

Transport:
- Driverless trains and trucks are being used by Rio Tinto mining operations in Australia, which are more efficient than human drivers, decreasing carbon emissions from transport
- Increasing capacity of ships and using more efficient fuels

Processing:
- Rio Tinto have created a new process for making aluminium which produces only oxygen as a bi-product, so is carbon neutral to a certain extent
- Efficiency of all mining processes is constantly being improved
- Powering processing plants by solar power is more sustainable

Site Restoration:
- Planting trees and restoring the environment around a mine
- Stabilising overburden (waste material above desired mineral) and tailings (waste materials from the ore). Tailing Management Facilities (TMF's) are used to store tailings. The piles are vegetated with plants that remove any harmful toxins from the ground

Recycling:
- Copper and aluminium are widely recycled, reducing the amount of mining required
- Increasing recycling, reduces demands on mines so they can be exploited more sustainably

Mining companies **work with community projects, governments and train workers after a mine closes to ensure economic, social and political sustainability**. The following links give an overview of Rio Tinto to the issues discussed above. The sustainable development video is particularly useful. There are Youtube playlists for specific minerals.

Rio Tinto Positives
Rio Tinto Negatives
Rio Tinto Youtube

Water Security

Unlike fossil fuels and mineral reserves, we **cannot survive without water**. **Global renewable internal freshwater resources per capita** (cubic meters) have decreased from **13,206 in 1962 to 5,925 in 2014**. This trend is continuing due to development and population growth, which is predicted to increase water demand up to **55% by 2050** as economic activities such as manufacturing and agriculture increase. The following terms relate to **water security**:

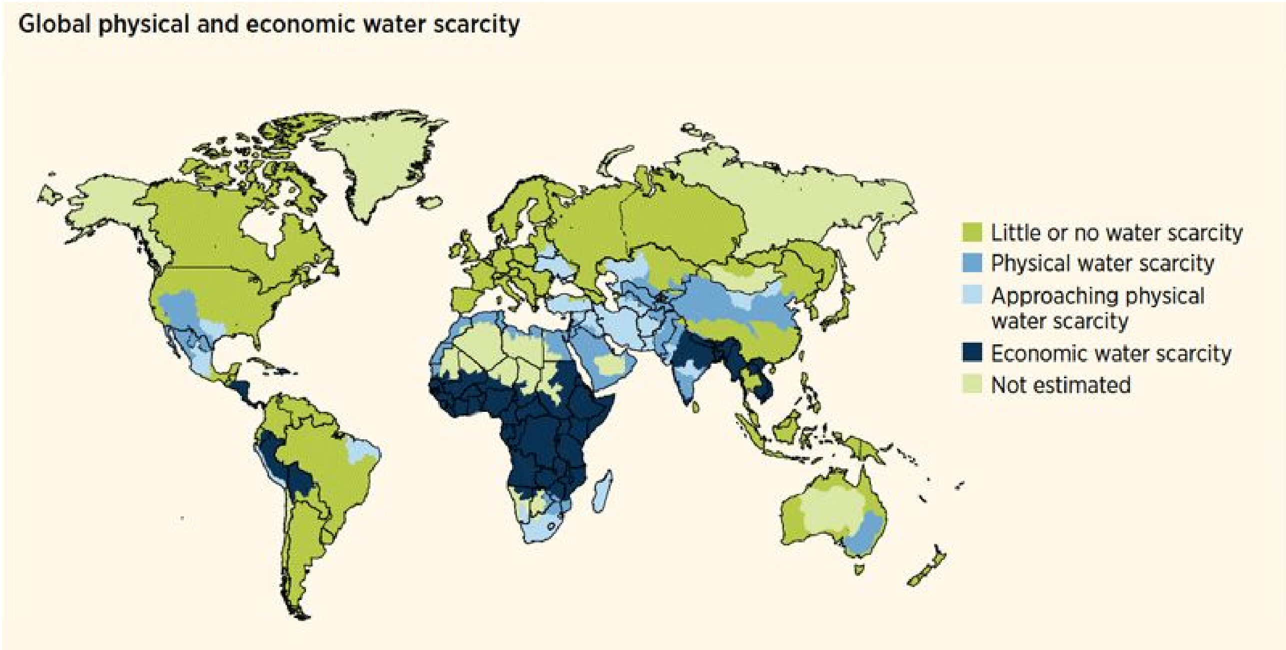
Water Stress: **Demand exceeds** the available amount of **clean, non-polluted water** during a certain period. Leads to **over-exploitation of long-term water stores** such as aquifers. Quality of available water decreases due to **eutrophication**. Renewable water in a country decreases to **less than 1700m^3 per capita**.

Water Scarcity
When annual renewable water supplies in a country drop below 1000m³ per capita. When water needs cannot be fully satisfied across different sectors

Economic Scarcity
Countries have enough available water supplies, but due to economic restrictions cannot exploit these reserves of water e.g. Sub-Saharan Africa and the underground rivers. Some LIC's have water reserves, but no resources to exploit them

Physical Scarcity
Demand of the population exceeds the available water resources of a region e.g. Yemen. Affects more than 1.2 billion people

Absolute Scarcity
Less than 500m³ of water per person in a country per year e.g. Egypt. By 2025, 1.8 billion people could be affected by absolute water scarcity



Water Inequality and Insecurity

Water is **distributed unevenly** across the globe. 66% of the world's population only have access to 25% of the world's annual rainfall. **Conflict** can further limit accessibility to water sources.

Demand for water has increased due to:

- **Population Growth** - More people requires more water
- **Socio-Economic Factors** - Growing middle class population
- **Development** - Greater demand in industry and agriculture

Supply cannot meet demand because:

- Aquifers are being over-exploited
- Water is being utilised in long-term stores, faster than it is being recharged
- Climate change is causing extended drought periods
- Water tables are decreasing

Water Supply and Physical Geography

The **quantity and quality** of a water supply can be **affected by physical geography**. E.g. a wet climate will increase water supply and porous rocks will filter the water to increase supply quality.

Climate 🌎
Seasonal variations affect water supply. The **soil water budget** shows that **water storage and precipitation** are greatest in winter and autumn. In some countries, the **monsoon season** is significant for replenishing water supply and in others, **spring snowmelt**. Some areas have **drier climates**, which reduce their overall water supply. **El Niño events** may decrease water supply in some areas. Climate change is predicted to **decrease summer rainfall**, but **increase winter rainfall and storm events**. Storm events are **less effective at recharging groundwater stores**.

Geology

Permeable rocks can be infiltrated and water stored underground in **aquifers**, providing a long-term water store useful during the summer months. If the ground is **impermeable**, **surface storage** is more important as there is no **groundwater storage**, increasing the **risk of drought**. Water quality in surface stores is likely to be lower, with **pollution and eutrophication risks** if the water is not flowing. **Alternating bands** of **impermeable and permeable rock**, create natural underground water basins. **Groundwater flow** through these basins provides a constant supply of water. The water is filtered through the rock so is good quality. Mountainous regions encourage **relief rainfall** increasing water supply, though a **rain shadow** created by the mountains may reduce water supply in nearby areas.

Drainage

A greater **drainage density** and number of inputs to a river helps ensure a **consistent water supply**. If one supply of water decreases, the other water sources (e.g. **groundwater flow**) ensure the overall impact on the **drainage basin** is not significant. However, in basins such as the Nile where the source of the water is primarily from **mountainous areas of Ethiopia** and other African countries, **droughts upstream can decrease supplies downstream**. Egypt has little rainfall that supplies the Nile. This could lead to **water conflict** as Egypt rely on other countries for their water.

Methods of Increasing Water Supply

Storage	Diversion	Water Transfer	Desalination	Catchment
• Constructing dams to raise upstream water levels and create reservoirs • Reservoirs may be created by other means • Dams may be temporary (inflatable coffer dams), which are raised in the wet season to store water that can then be used for irrigation during the dry season	• Water is moved from one area to another, within the same drainage basin • This can provide water for cities, or irrigation for fields • Can have significant environmental impacts as seen on the Colorado River in America • Due to over abstraction, no water from the Colorado River ever enters the sea	• Water is moved from areas of surplus to areas of deficit. It usually means transporting water between different drainage basins • Engineering advances have allowed mega-transfer projects in China and Lesotho • Can dry up water source areas	• Converting sea water (or saline groundwater) into freshwater for drinking • High energy demand, but is a viable in desert countries such as Saudi Arabia, where other options don't exist • Expensive due to the advanced technology involved • Causes environmental damage if it sucks marine life and may pollute other groundwater • If solar or wind energy was used to power a plant, it would be a more sustainable option	• Wetland restoration improves supply and quality of the water by filtering the water • Afforestation can have similar benefits and helps to create important wildlife habitats • Blocking drainage channels such as on UK moorland • Farmers shifting to arable farming to reduce runoff and increase infiltration • Potentially the most sustainable method of increasing water supply as it aims to restore the natural environment through the process of rewilding

Overall, human actions over the past 200 years have decreased global water supply through **deforestation, urbanisation and groundwater abstraction**.

Environmental Impacts of Major Water Supply Schemes

You will need **at least one case study** concerning the **environmental impacts of a major water supply scheme**. Hydropower is a popular renewable energy and there are over 20,000 dams in China alone. Dams may also use **canals, channels and tunnels** to supply water to different areas. There are **significant environmental impacts** of these schemes:

- Dams **flood upstream areas**, creating **large lakes** which **submerge settlements** and plants. The **organic matter decomposes** releasing **greenhouse gases**. Populations are forced to relocate, often with little or **no compensation**
- They **prevent sediment from travelling downstream** reducing nutrients for fish and affecting coastal areas that rely on rivers for a sediment input. It may increase the need for fertilisers if the land is not naturally nourished by sediment and mineral deposition
- **Prevent fish from travelling further upstream**, thus destroying their habitats
- Impact the river regime by increasing river flow during the summer and decreasing it in winter. **Flood plains** no longer flood downstream **affecting major wildlife habitats**. Lakes downstream dry out, removing a potential water supply
- In many cases dams provide no benefit for water management as they **dry out wetlands** and other stores downstream
- Need **expensive end of life decommissioning projects** which have a **large environmental impact** and associated high cost
- **Reduce drinking water supply downstream** to many rural areas, even if cities benefit
- **Trap nutrients leading to eutrophication** in dam reservoirs and spreads diseases such as **schistosomiasis** which now affects 200 million people in 75 countries worldwide
- May **promote earthquakes** which could lead to floods downstream and dam collapse, with threat to thousands of lives

This video and news article show the impacts of two seperate dams in Laos on the Mekong river.

Sustainable Water Management

We must devise solutions to **use water more efficiently** and reduce the demand for water. Water is very important in economic productivity, crop yield and manufacturing capacity. **Agriculture accounts for around 67% of all water extracted** and industrial water consumption is increasing, especially in **developing and industrialising countries**. Over 20% of all extracted water is used in industries and for energy production. Water management solutions:

- **Recycling Wastewater** - Most cost-effective in areas of high demand
- **GM Crops** - Crops which are tolerant of dry and saline conditions
- **Plasticulture** - Plastics are used to help reduce water usage by 50-70%. Also using micro-irrigation can help increase crop productivity by 30-100%
- **Catchment** - Restoration of damaged lakes, rivers and wetlands to increase storage
- **Reduce Leakages** - In the UK leakages represent 10-20% of water used every day. More water may be wasted through leakages in developing countries
- **Food Consumption** - Sourcing food from regions not suffering from water stress and purchasing food seasonally
- **Appliances** - More efficient washing machines and dishwashers
- **Water Meter** - Fitting a water meter could reduce water use by 10-15% in every household

Reducing Your Water Footprint

In the UK on average we use **141 litres per person per day**, but including **virtual water** this is 4500+ litres. **Virtual water or water footprint** is the water demand of the services you use and products you buy. It takes 6,840 litres of water to produce a pair of jeans, 120,000 litres of water to produce a car and 200 litres of water to produce one litre of milk. **Reducing your footprint**:

- Shower for shorter periods of time and use an eco shower head
- Buy less clothing. Not buying a pair of jeans could save an equivalent of 50 days of normal water usage
- Reuse water where possible
- Research the environmental impact of the clothes you buy: https://goodonyou.eco/
- Water gardens early in the morning or late in the evening to reduce water loss to evaporation

Greywater recycling is the process of **reusing water from washing machines, showers and sinks**, that may be dirty, but is **clean enough** to be used for irrigating plants in gardens. **Greywater** may be cleaned for reuse as water in washing machines and toilets, but this is **expensive**, so most users are industrial who have **more money and/or a larger water demand**.

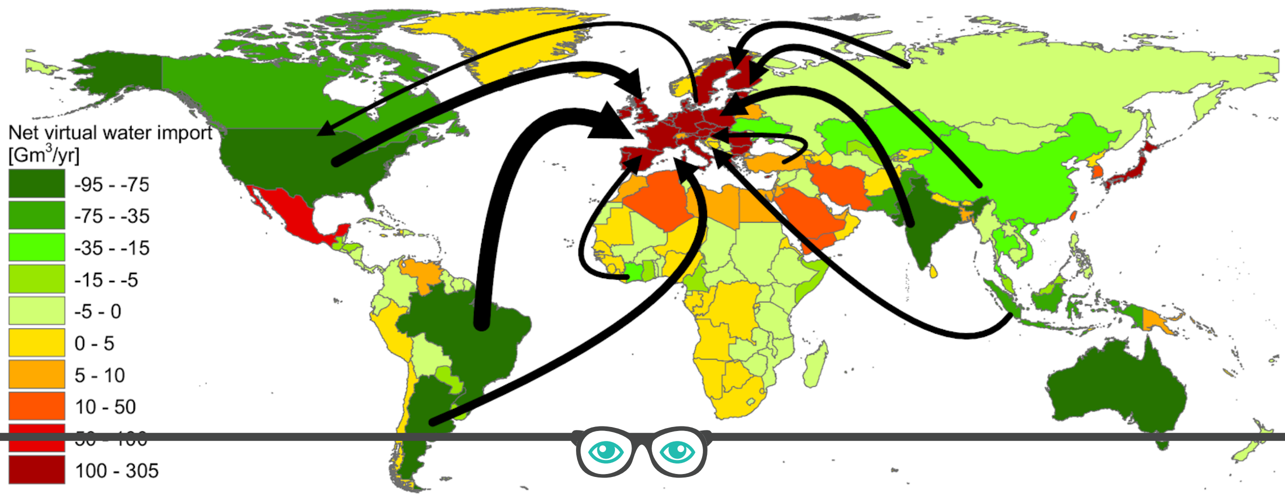
Rainwater Harvesting Systems (RHS) store water collected by roofs, clean it (if necessary) and transfer it to the mains supply of a home. **Rainwater** is cleaner and safer to use than **greywater**.

New technologies such as the Lifestraw may be a human method to increase water supply on a smaller scale, or NGO's improving water supply.

Eat less meat on a daily basis. A 2010 study by the **UNESCO Institute for Water Education** found that bovine meat (which includes beef) requires **15,415 litres of water to produce 1kg of produce**, compared to an average of **322 litres per kg for vegetables**. Whilst certain vegetables have a greater water footprint than this average and nuts have a large water footprint too, the overall benefit of a plant-based diet is significant, both on water and carbon footprint as well as having additional health benefits.

Virtual Water Trade

Virtual water trade refers to the process of **trading items that have a water footprint.** For example, western countries import significant amounts of cotton. Due to the high water footprint of cotton, this places **stress on water resources in the LIC countries** it grows in. In countries where **water scarcity** exists, water intensive products are imported to preserve domestic supplies.



LIC countries suffering from water shortages such as India, are ironically **exporting** the greatest amount of **water intensive products**. In future these **patterns may change**, so that countries under **water stress** import water through the products they trade, to **reduce water stress**.

Integrated Water Resources Management (IWRM)

The **IWRM** approach (not required learning but beneficial) uses a **river basin** to **holistically plan water management strategies** which protect the environment and **ensure fair distribution of water**. It is **similar to an ICZM**, as the managed area may cross national borders and therefore requires **intergovernmental cooperation**. It aims to protect the environment of all water supplies and ecosystems to ensure food and water security for poorer communities. There are measures in place to prevent corruption. It is likely **IWRM schemes** will be utilised in future to help prevent and mitigate **water conflict** between nations when a water source flows through multiple countries.

Water Conflict

Water conflict concerns any disagreement between countries or different groups over water resources, and may lead to **violence at any level**, from protests to war. You should be aware of different **scales of conflict** (local, national and international) and have case studies for them.

Water conflict may occur as a **result of diminishing water supplies** which, make the **resource more valuable**. People are willing to **fight over water resources**. **Causes of conflict**:

- **Terrorism** - Attacking water infrastructure such as dams for terrorism related motives
- **Development** - Communities may oppose infrastructure such as dams
- **Water Shortages** - Protests over water shortages if water is distributed unevenly between different community groups
- **Political** - Water supplies cut off to create a political tool for use in negotiations

Water conflict kills many people each year and is being **used as a weapon of war**. **WaterAid** explain that water is being used as a method to wage conflict around the globe:

- Attacks on Water and Sanitation Infrastructure
- Stopping the Flow of Water
- Contaminating Water
- Attacks on Water and Sanitation Workers
- Denial of Humanitarian Access

Energy Security

We can produce energy as **electricity** using **stock (non-renewable, finite)** and **flow (renewable, infinite)** resources using **primary and secondary** methods of production. The **energy mix** refers to the **range and proportion** of energy produced by methods of production. The **global energy mix** is **dominated by fossil fuels**. **Primary energy** sources produce energy by using a **raw material**, whereas **secondary sources** are **modified primary energy sources** which are easier to use. E.g. oil into petrol and coal into electricity.

Primary Energy Sources:

Coal: **Stock resource** that accounts for 27% of global energy production. Usage is **decreasing** as China shifts its energy mix away from coal and less polluting energy sources are used. Most production occurring in China, ahead of the USA and India.

Petroleum (Oil): **Stock resource** that accounts for 32% of global energy production. Usage is still **increasing** as global energy demand increases. Most usage in USA, China and India and greatest production in the USA, Saudi Arabia and Russia

Natural Gas: **Stock resource**, with only 50% of the carbon emissions of coal and accounts for 22% of global energy production, which is **increasing** year on year. Highest production in USA, Russia and Iran and greatest consumption in USA, Russia and China.

Uranium - **Stock resource** with very low carbon footprint that accounts for around 4% of global energy production, with most production in Kazakhstan and greatest amount of nuclear fission energy produced in the USA. Production likely to **increase** in future.

Biomass (May also be secondary): **Flow resource**. In many LIC's biomass is burned to produce energy. Burning organic matter such as wood is very inefficient. However biomass produces a large proportion of energy in LIC's, though it makes up a low proportion of worldwide energy consumption. In HIC countries, biomass is being used more efficiently to produce energy, such as in biodiesel. Overall **decrease** in use on a global scale.

Hydroelectric Power (HEP): **Flow resource**. Water drives turbines to produce electricity and is **very efficient**. Hydropower has been used for many years as a **renewable energy**, but only accounts for a small percentage of global energy production. Expected to **increase** globally, but with decreases in some HIC's.

Secondary Energy Sources (All Flow Resources):

Solar: Solar energy usage is **increasing** rapidly year on year as the technologies for solar power become cheaper. China has the largest installed capacity, though production is much lower due to climatic conditions. Growth in LIC countries as technology becomes cheaper.

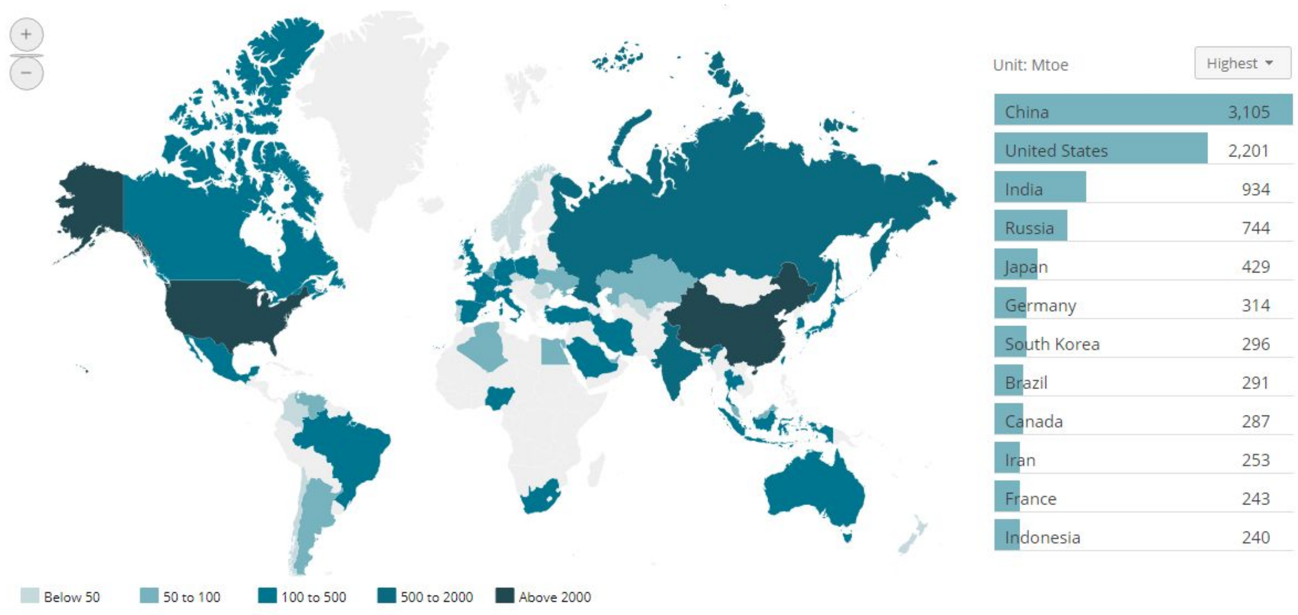
Wind: Other than hydropower and biomass, produces the most energy of renewable sources, with greatest production and capacity in China. Technology is also spreading to LIC countries and offshore is **increasing** too.

Wave: Very low generation, though **technology is developing** and a similar trend may be seen to that of solar and wind when the technology becomes cheaper.

Tidal: So expensive that there is currently only a handful of installed tidal power schemes on a global scale. The Swansea bay scheme was abandoned due to the potential costs that it would induce. One successful project may lead to a multiplier effect.

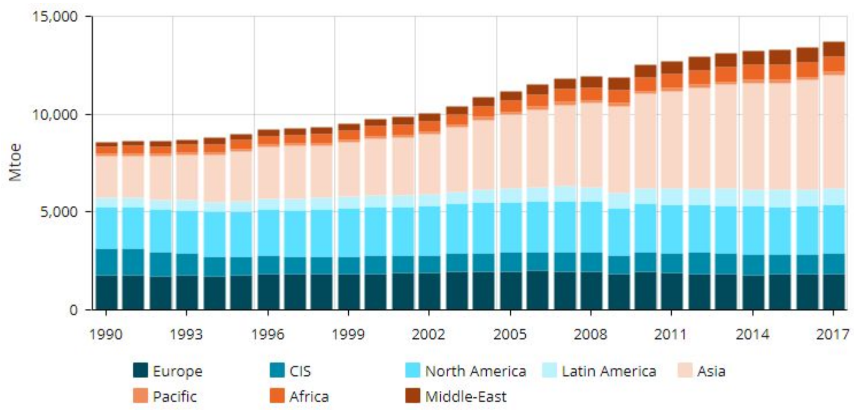
Geothermal Energy: Very efficient and reliable and operates all year round day and night. Popular in countries with volcanic setting and likely to **increase** as technology spreads to LIC's. Currently does not contribute a large amount to the global energy mix.

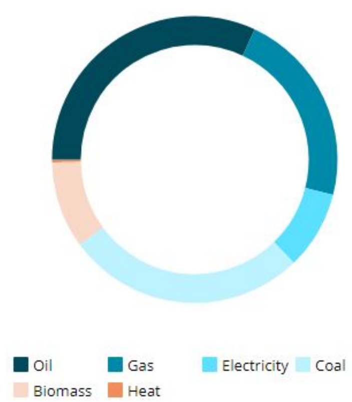
Global energy consumption varies, but is generally **higher in northern hemisphere countries**, which are more developed.



Global energy demands and trends by type of energy production methods are shown in the graphs. You can explore more using these links:

Global Energy Facts
Energy Systems Map
Global Energy Use
Carbon Impact Map





The Effect of Physical Geography on Energy Supply

Physical geography will impact a country's energy mix:

- **Geology**
- **Climate**
- **Drainage**

Larger countries are likely to have a **diverse physical environment**, which influences the **energy mix**. The USA has significant potential for a variety of energy production methods. In Alaska, **oil** is abundant due to **geological** formations and past ecosystems. In Arizona, **solar power** is possible using 195 clear days of sunshine **climate**. In Washington, **dams** are popular due to the mountainous relief and high **drainage** of the state. The USA is **mostly energy secure** as it relies on **domestic sources for energy**, though it still **imports** large amounts of oil and uranium which threaten this security. Using a **range of energy sources** assure there is no reliance on one source, so if **market prices** shifted for fossil fuels, or a **drought** occured, the impact on the **energy mix** would not be as severe.

A **good quality energy supply** is **consistent and secure** and can be **relied upon** year round. There is unlikely to be any **geopolitical problems** and there is little risk from changing **climatic conditions** or **natural hazards**. A good quality energy supply involves **different sources** which contribute to the energy mix.

The Effect of Human Geography on Energy Supply

Most countries are **interdependent** for energy sources - they import energy from other countries. This has **geopolitical implications** and **requires the cooperation** of other countries:

Production
Energy is produced in the areas where the physical geography is suitable. On the Mekong river in south-east Asia, there is the appropriate drainage for hydropower

Processing
Energy is either processed on site, or there may be no need for processing. Fossil fuels may need refining before or after being distributed

Distribution
Energy is distributed by pipeline, transportation or in the form of electricity. Distribution methods may cross international borders, leading to geopolitical implications

Any stage in the energy supply chain may be used by countries as a **political tool**, to **cause or resolve tension** between countries. Different countries have varying '**national interests**'.

Example: Country (🌇) may want to **import gas** from country (🌅) to shift their **energy mix** away from coal at a **low cost**. This may require a **pipeline** passing through country (🌄) who do not want their **natural landscape** to be **spoilt by a pipeline**. Additionally 🌅 want the best price possible for their **natural gas**. This leads to **complicated geopolitical negotiations**.

TNCs can help with these geopolitical negotiations:
- If the TNC has strong links with 🌄, they may be able to **compensate** 🌄 for building a pipeline through their landscape.
- **TNCs** may be **forced by powerful governments** in 🌇 to spend additional money on protecting the natural landscape in 🌄, because if the landscape is protected then 🌄 is more likely to co-operate 🌇's plans to import gas.
- Although it makes no **economic sense** to the TNC to spend more money, it would provide a **natural gas pipeline** and **improve political relationships** between 🌇 + 🌅.

Energy supply can be a very confusing process, influenced by **physical and human geography, TNCs, geopolitics, community groups and activists**!
You will need a **case study** that concerns energy supply and these factors.

Environmental Impacts of Different Energy Sources

Many factors concern the environmental impacts of energy sources and everyone has a **subjective opinion** on what is best. Some consider **hydropower** as a positive renewable energy, but others believe it **destroys the environment** that dams are supposed to be protecting.

At each stage of the energy supply process there are **environmental impacts**. When the energy is being **produced**, CO_2 emissions may occur, or habitats disturbed by infrastructure projects. During **distribution**, pipelines may have to be laid across environmentally sensitive areas. During **processing**, further CO_2 emissions may cause environmental damage.

Strategies of Increasing Energy Supply

Global energy demand is likely to increase until it **peaks** between **2035 and 2050**. Energy demand will be affected by **growing populations** and the **development of LIC countries**, leading to more **energy intensive lifestyles** and a **greater need for manufacturing**. The greatest growth in energy demand will be in developing countries. In developing countries a current reliance on biofuel and other polluting fuel types such as kerosene will change with **globalisation**.

1.2 billion people currently have no electricity. If these people come to rely on fossil fuels, then it could have a significant negative impact on the environment. However, projects and products are being developed to help ensure a sustainable energy security for these people:

Honnold Foundation Gravity Light

"Working to eradicate kerosene lanterns and create a sustainable market for solar energy in Africa"
Honnold Foundation

It is likely that **renewable energy will double in the energy mix** by 2035 and **natural gas use will increase** as countries such as China move away from coal. However **coal is likely to increase**, as it is currently the cheapest available fuel for many countries, despite the subsequent costs related to **climate change and air pollution**. **Nuclear power is likely to increase** as the technology spreads to developing countries.

Oil and Gas Exploration

As reserves of oil and gas begin to diminish, new reserves and technologies are being developed to **support further resource exploitation**. Currently new reserves are being discovered at a **lower rate than they are being exploited**. Environmental groups suggest that fossil fuel exploration should stop immediately and renewable energy used instead. In countries like Bahrain which are 75% reliant on oil for their GDP, this is not an economically viable or sustainable solution.

Fracking is a new source of energy that involves exploiting **natural gas** found in **shale reserves** across the world. Water, chemicals and sand are pumped into the ground to break up the shale, access the hydrocarbons and force them to the surface. **Horizontal drilling** helps to remove the gas reserves. There are **benefits and costs** of fracking:

Advantages:

- Less polluting than coal or oil
- Requires large amounts of water
- Could provide boost to the economy
- In the UK, the Royal Academy of Engineers believe we can make fracking safe

Disadvantages:

- Wastewater needs treating due to chemical contents
- May pollute groundwater aquifers. In the USA the water has become flammable due to pollution by fracking
- Earthquakes of low magnitude may occur, though they are not usually strong enough to pose a risk to humans. They may damage fracking infrastructure, causing further leakages
- The IPCC suggest it would be irresponsible to use shale gas

Nuclear Power

Nuclear power is a contentious issue and its popularity varies widely. One tonne of uranium produces the same energy as 25,000 tonnes of coal. The potential environmental consequences of a **nuclear disaster** are significant, but **global warming** caused by burning fossil fuels has a greater environmental impact. Nuclear disasters such as **Fukushima and Chernobyl** have had significant impacts on health and caused **1000's of deaths**. But global warming as a result of burning fossil fuels may cause **billions of deaths**. Do the needs of the many outweigh the needs of the few? Whilst it is not 'right' that people still die due to nuclear power, it may have **long-term benefits**. Due to **media portrayal** of nuclear bombs, the public are concerned about nuclear power and this impacts upon its use.

Nuclear Power

Advantages	Disadvantages
Very low carbon footprint	Large-scale disasters do occur
High efficiency	Produces radioactive waste which is difficult to dispose of
Safety always improving	Very high cost
May have fewer negative impacts than fossil fuels	Lack of support from general public
Technology becoming more affordable and accessible for NIC's	

Development of Renewable Resources

Renewable energy is likely to be an important component of the future energy mix as it has a low carbon footprint (in most cases), the technology is always improving and becoming more efficient. Each renewable resource has **advantages and disadvantages**, though as time progresses the **disadvantages will decrease** as the technologies are improved. All have the disadvantage of being **visually unappealing** and causing **minor disturbances to the local environment.**

Examples of **new developments** in renewable technologies to research further are listed below:

- **Solar**: Concentrated Solar Power, Solar Powered Roads, Solar Power Roof Tiles
- **Wind Power**: Vortex Bladeless, Larger Blades, Offshore
- **Wave Power**: Eco Wave Power, Pelamis Wave Power

- **Tidal Power**: Swansea Bay (Defunct), Tidal Stream, MeyGen Tidal Stream Project
- **Geothermal**: FORGE, Enhanced Geothermal Systems (EGS)

Solar Power

Source: Green Energy Times

Description: Panels that convert the sun's energy into electricity

- 👍 Costs are decreasing rapidly
- 👍 Large potential in desert areas
- 👎 Not very efficient yet (15-20%)
- 👎 Effectiveness dependent on climate and time of the year and day

Wind Power

Source: The Balance

Description: Wind drives large turbines and generators that produce electricity

- 👍 Low running costs
- 👍 Can be used year round
- 👍 Plenty of suitable sites
- 👎 Bird life can be affected
- 👎 Weather dependent

Wave Power

Source: E360 Yale University

Description: Waves force a turbine to rotate and produce energy - or other similar method

- 👍 Produce most electricity during winter when demand is highest
- 👍 Pioneer projects are commencing across the globe

Tidal Power

Source: Renewable Energy World

Description: Incoming tides drive turbines in similar way to hydropower

- 👍 Has significant potential
- 👍 Reliable source of energy once installed
- 👎 Very expensive

👎 Very expensive and a 'perfect' solution is yet to be created 👎 Needs to survive storms	👎 Few schemes currently operating in the world 👎 Impact on marine life

Geothermal

Source: Daniel Allen Description: Water is pumped beneath the ground to hot areas and the steam from the water drives turbines to produce electricity 👍 Low maintenance costs 👍 Suitable where other technologies might not be 👎 High installation cost 👎 Risk during earthquakes etc.

Managing Energy Consumption

Energy demand management reduces the overall consumption of energy by consumers. Shifting a countries' **energy mix** away from **low efficiency** sources such as coal, to **more efficient resources** such as **nuclear power**. Additionally, energy consumption may be managed by the inclusion of **subsidies from governments** that provide financial aid to economic sectors (or renewable technologies) to make them more affordable and encourage their use. The UK renewables subsidies have now been **significantly decreased**, but they did help solar panels become **affordable for consumers** and increased production to decrease the overall cost of panels. The world over, **more subsidies are paid into fossil than into renewables**, encouraging fossil fuel exploration projects that are destroying our planet.

G7 Fossil Fuels Subsidy   UK Council Fossil Fuel Investment

The **UK Climate Change Levy** was created in 2002 as a **mandatory tax** that all businesses have to pay. Businesses receive incentives for **improving their environmental credibility**. As a result, more businesses are **investing in green technology** to save their business money in the long-term and improve their public image which may boost sales. Some business are involved in '**greenwashing**' - appearing to care about the environment but in reality taking little action.

Decentralised Energy (DE) Production

DE is produced away from the **national grid** and close to where it will be used. This reduces energy losses during transmission to **maximise the overall efficiency** of production. **Energy security is increased** as there is more reliance on a greater number of energy sources. DE schemes are often powered by **Combined Heating and Power (CHP)** systems that allow production of energy and then reuse of surplus heat in **District Heating (DH)** schemes that distribute hot water to power radiators and other heating systems. There are small schemes throughout the UK, but much larger schemes exist in Denmark. This is an improvement on the traditional grid system where excess heat would otherwise be wasted: CHP

Carbon Trading

Encourages organisations to **reduce their carbon emissions** by introducing a **carbon emissions cap**. If factories, countries, etc are above this cap, they have to **trade** with other groups who are below the cap, so they too are below the cap. In a simplified form:

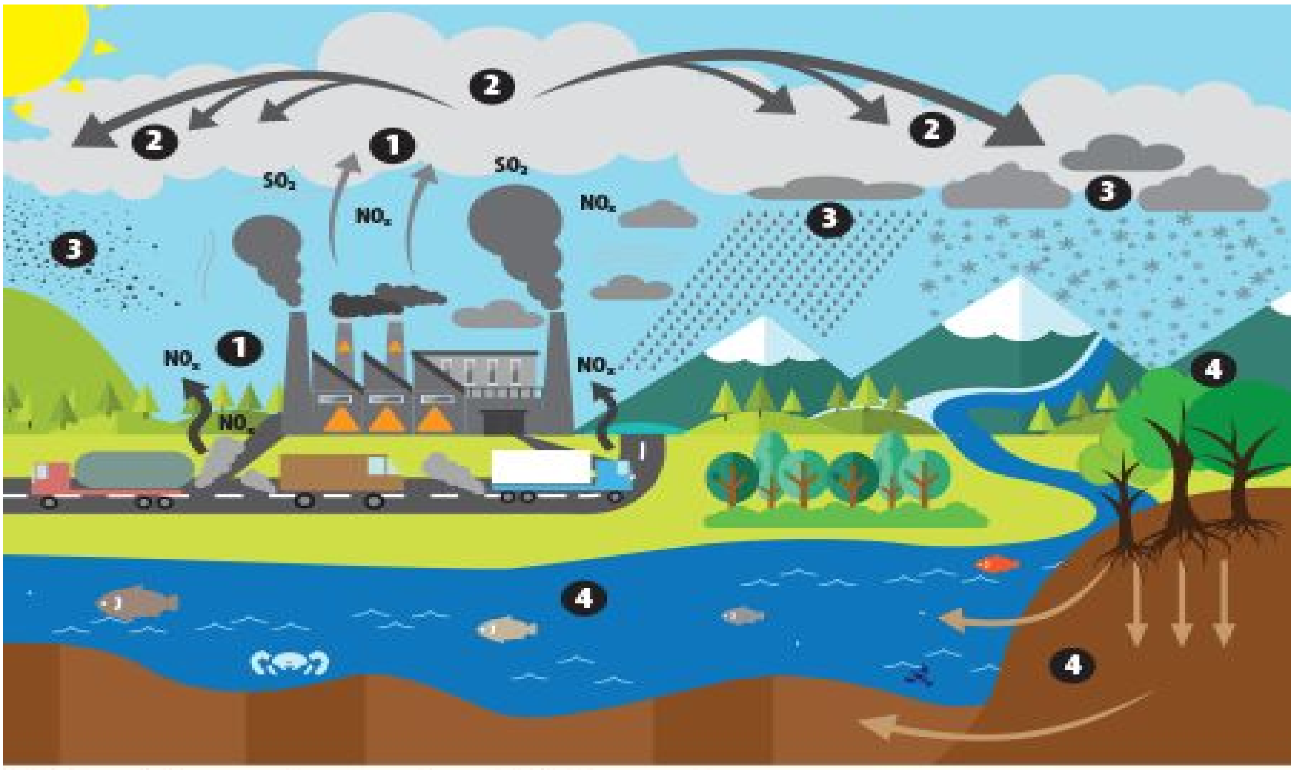
- Company 🔰 had 5 tonnes of CO_2 emissions
- Company 🔱 had 15 tonnes of CO_2 emissions
- The cap was 10 tonnes
- 🔱 trades with 🔰 and purchases the 5 tonnes of CO_2 under the limit that 🔰 had, so that 🔱 can pollute 5 tonnes over the limit
- The cap is lowered each year to encourage companies to reduce their CO_2 emissions
- It allows companies and countries to continue polluting as long as they pay

The **Kyoto protocol** proposed **emission controls** at the international level for the first time and started in 2008 with the aim is to **reduce greenhouse emissions by an average of 5%** (1990 levels) by 2012. It ended in 2012 and was fairly successful in the countries where it operated, though **overall emissions were not reduced** as emissions of developing countries such as China inevitably increased. Attempts to create a **second protocol** have been unsuccessful as yet.

Sustainability of Energy Production

Acid Rain

Acid rain occurs when **Sulfur Dioxide and Nitrogen Oxides** enter the atmosphere as fossil fuels are burned to produce energy. This is absorbed by clouds making **rain water acidic** and causing environmental damage when rainfall occurs. Acid rain can **destabilise whole ecosystems** when the rain decreases the pH level in the rivers. It can cause forests to die as seen across Europe in the 1970's. This lead to the **1979 Geneva Convention, Clean Air Acts** and the development of technical solutions such as **catalytic converters** in car exhausts and **sulphur dioxide** scrubbing systems in power stations. Whilst these measures were successful, **developing countries** such as India are now experiencing **acid rain**, which is threatening both the environment and national landmarks such as the Taj Mahal. Acid rain is a **transboundary pollution event**, requiring international solutions as countries which are not responsible for emissions may also be affected.



This image illustrates the pathway for acid rain in our environment:
(1) Emissions of SO_2 and NO_x are released into the air, where (2) the pollutants are transformed into acid particles that may be transported long distances. (3) These acid particles then fall to the earth as wet and dry deposition (dust, rain, snow, etc.) and (4) may cause harmful effects on soil, forests, streams and lakes.

Nuclear Waste

Nuclear waste is a major problem with nuclear energy as there is no ideal solution for its disposal. Processing plants exist for high-level radioactive waste **(HLW)** which poses the greatest risk to the general public as it takes **40-50 years** for the levels of radioactivity to decrease below safe levels. After **reusable uranium has been extracted** at processing plants, remaining waste needs to be stored or buried deep underground where it can safely emit any remaining radiation. Currently, no **HLW** is buried, only intermediate level waste **(ILW)**. **HLW** must be stored in an area that is secure and will be **safe from terrorism and natural hazards**. The impact of storing nuclear waste on the **local economy** must also be considered. This leads to higher costs which have limited the spread of nuclear power as a **viable technology**. **Transportation** of radioactive waste is also considered as it occurs when the levels of **radioactivity** of the nuclear fuel is highest.

Energy Conservation

Homes and buildings, may account for **more than 30% of total greenhouse gas emissions**, so conserving energy by improving the **sustainability of their design** could contribute significantly to mitigating global warming. New technologies are constantly being developed that improve the efficiency of energy production methods, allow for more energy to be produced (photovoltaic windows) and reduce energy consumption through better insulation. Companies such as **Tesla** are developing home battery packs that will allow renewable energy to be used when the demand for energy is highest. Appliances are also becoming more efficient and LED bulbs use four times less energy than traditional filament lights. The UK government have introduced schemes such as the **Zero Carbon Homes Strategy** and the **Code for Sustainable Homes**, though both have now been withdrawn. Without legal incentive, the sustainability of UK housing is the responsibility of architects and developers. As people, we can all take more steps to improve our sustainability, such as by **reducing food miles by buying local, organic and seasonal food, switching devices off at the wall, recycling and using public transport** as often as possible.

Resource Futures

You should be aware of **current and contemporary developments relating to mineral, water and energy security and new technologies, political agreements, economic strategies and environmental policies**. Whilst they are discussed in detail throughout these notes (and in our case studies) it is advisory that you conduct further research into each resource. You could use the following table to help format your findings:

Resource Type:	Environmental	Political	Economic	Technology
Current Problems				
Current Solutions				
Future Problems				
Future Solutions				