GEOGRAPHY

A Level

A2 Unit 4

Section B – Contemporary Themes

4.4 Energy Challenges and Dilemmas

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Part of A2 Unit 4

Section B: Contemporary Themes (two optional topics)

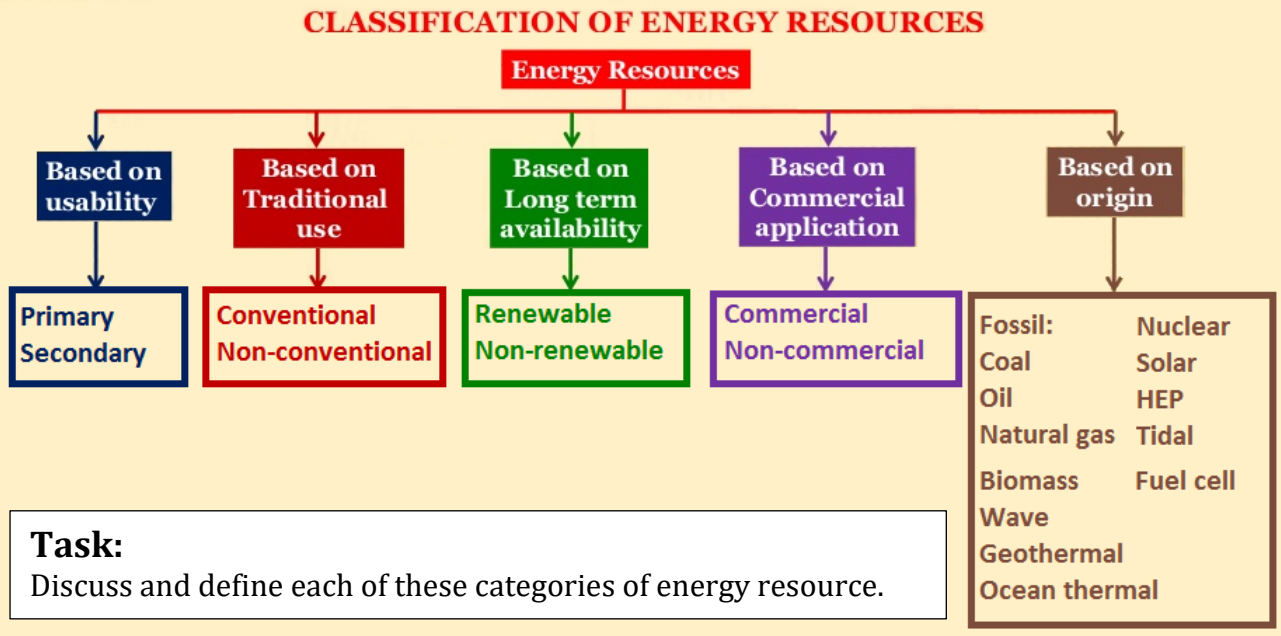
4.4 Energy challenges and dilemmas

Focus	Geographical content	Revision
4.4.1 Classification and distribution of energy resources	• Classification of energy resources	
	• Global distribution of fossil fuel stocks and reserves	
	• Alternatives to conventional fossil fuel sources	
4.4.2 Physical factors affecting energy supply	• Geological factors including physical reserves of fossil fuels and active areas for geothermal energy	
	• Climatic factors including insolation rates and wind strength and reliability	
	• Relief factors including suitable locations for dam construction and hydropower	
	• Locations with favourable conditions for sustainable energy generation from waves, tides and biofuels	
4.4.3 Changing demand for energy	• Changing global patterns of energy demand	
	• Economic factors influencing the demand for energy	
	• Demographic and social factors influencing the demand for energy	
	• Technological factors influencing the demand for energy	
4.4.4 The global management of oil and gas	• Managing the imbalance between the supply of and demand for oil and gas through transfers, storage and pricing	
	• Management of oil and gas exploration and production by MNCs and national governments	
	• Management of oil supplies by OPEC and national governments	
4.4.5 Problems associated with the extraction, transport and use of energy	• Environmental problems associated with fossil fuels and other forms of energy	
	• Political problems associated with fossil fuels and other forms of energy	
	• Technological problems associated with fossil fuels and other forms of energy	
	• Economic problems associated with fossil fuels and other forms of energy	
4.4.6 Energy mixes and development	• At a local scale, the use of appropriate technology for sustainable energy micro-generation in developing countries	
	• At a national scale, factors influencing the energy mix of countries at different stages of development	
	• At the global scale, economic and political factors affecting world energy prices and energy mix	
4.4.7 The need for sustainable solutions to meet the demand for energy	• Policies for demand reduction and increased energy efficiency at the global, national and local scale	
	• Clean technologies for fossil fuels including carbon capture, carbon sequestration and gasification and transport technologies	
	• Sustainability of alternative energy sources	

4.4.1 Classification and distribution of energy resources

Classification of Energy Resources

An energy resource is something that can produce heat, power life, move objects, or produce electricity. Matter that stores energy is called a fuel. Energy resources that are/or can be exploited by people fall into a number of categories:



Task:
Discuss and define each of these categories of energy resource.

Energy resources can also be classified as critical or non-critical

Critical – sustainable energy resources from forests, plants and other biomass; critical resources may be by overused, for example, if they are depleted at a faster rate than they are replaced.

Non critical – everlasting resources such as tides, waves, running water, wind and solar power.

Global distribution of fossil fuel stocks and reserves

Using the link below, describe the distribution of the world's remaining fossil fuel reserves.

https://knoema.com/smsfgud/bp-world-reserves-of-fossil-fuels

Alternatives to conventional fossil fuel sources

Along with the variety of renewable sources of energy there are a number of alternative fuel sources. Remember a fuel refers to a substance that can store energy and that will release it when it undergoes a reaction. The **traditional** sources are the three main fossil fuels that for hundreds of years have been readily available. However, as we have seen previously these stocks are not limitless. There are a number of alternative sources some of which involve the gathering of fossil fuels from newer, more difficult to access locations.

Alternative fuel sources include:

Biofuels (including biodiesel)
Alcohol fuels
Hydrogen
Compressed natural gas (CNG)
Liquefied petroleum gas (LPG)
Nuclear based fuels

Along with fuel sources there are also a number of other forms of alternative energy. These are mostly classified as renewables.

Task:

- Complete the research PowerPoint on the alternative sources of energy from the handout sheets.
- Take notes from the presentations on each of these sources and their potential and their drawbacks.

We are going to look at three sources of energy/fuels in a little more detail:

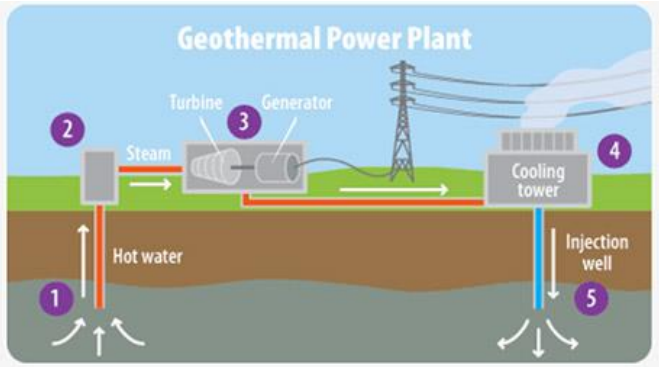
1) Tar/Oil Sands – these are either loose sands or partially consolidated sandstone containing a naturally occurring mixture of sand, clay, and water, saturated with a dense and extremely viscous form of petroleum technically referred to as bitumen (or tar due to its superficially similar appearance to the tar used on roads). Tar sand deposits are reported in many countries, but in particular are found in extremely large quantities in Canada. Other large reserves are located in Kazakhstan, Russia, and Venezuela. These reserves have only recently been considered to be part of the world's oil reserves, as higher oil prices and new technology enable profitable extraction and processing.

Typical wet sand tar deposits

Tar sands are extremely controversial for a number of reasons, not least the environmental damage that their extraction can cause. Canada has allowed widespread extraction of its tar sands and as a result has received worldwide criticism.

Devastation of the region around the Athabasca Oil sand deposit in Alberta, Canada

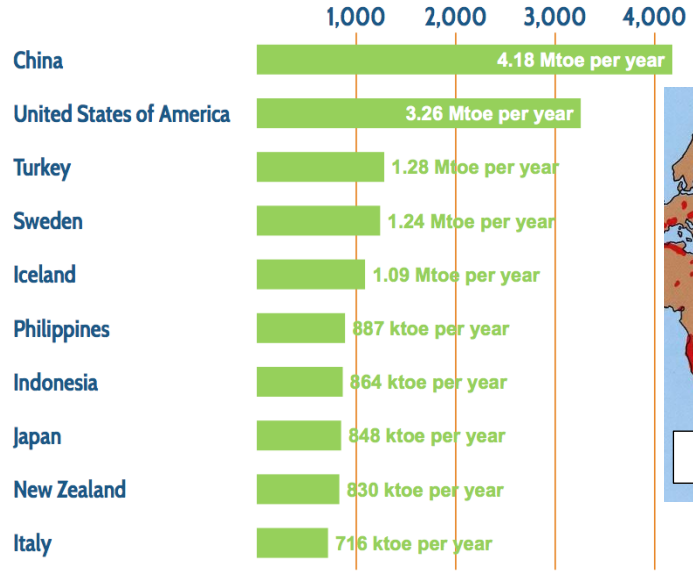
2) Geothermal energy – this is heat energy generated and stored in the Earth.

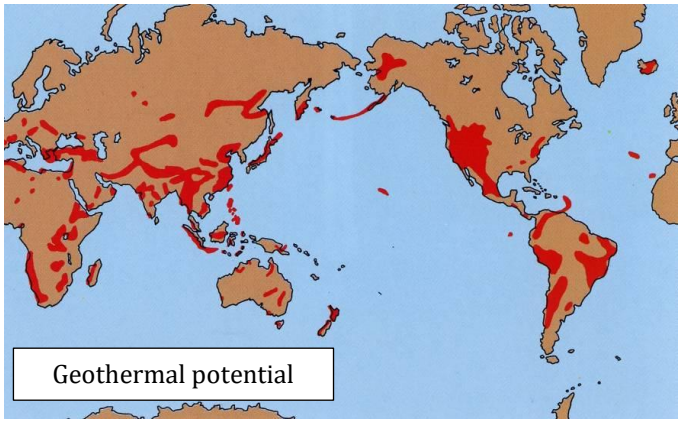


The geothermal energy of the Earth's crust originates from the original formation of the planet and from radioactive decay of elements deep inside the mantle and core. This energy is readily available in many locations where the crust is relatively thin ow where stores of magma are near to

the surface (often near plate boundaries). Iceland is one of the world's leading users of geothermal sources.

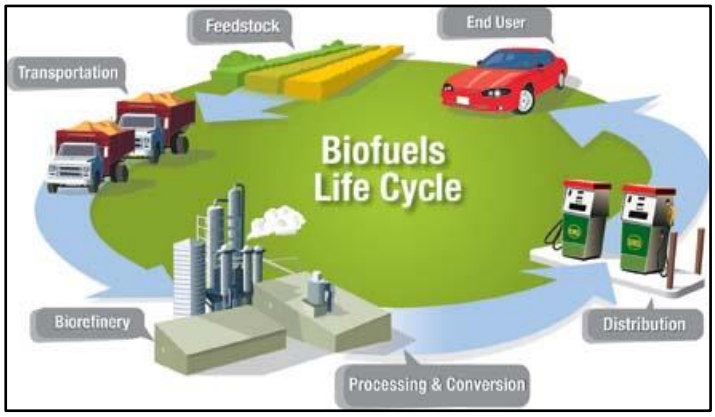
The world's ten largest producers of geothermal energy





Geothermal potential

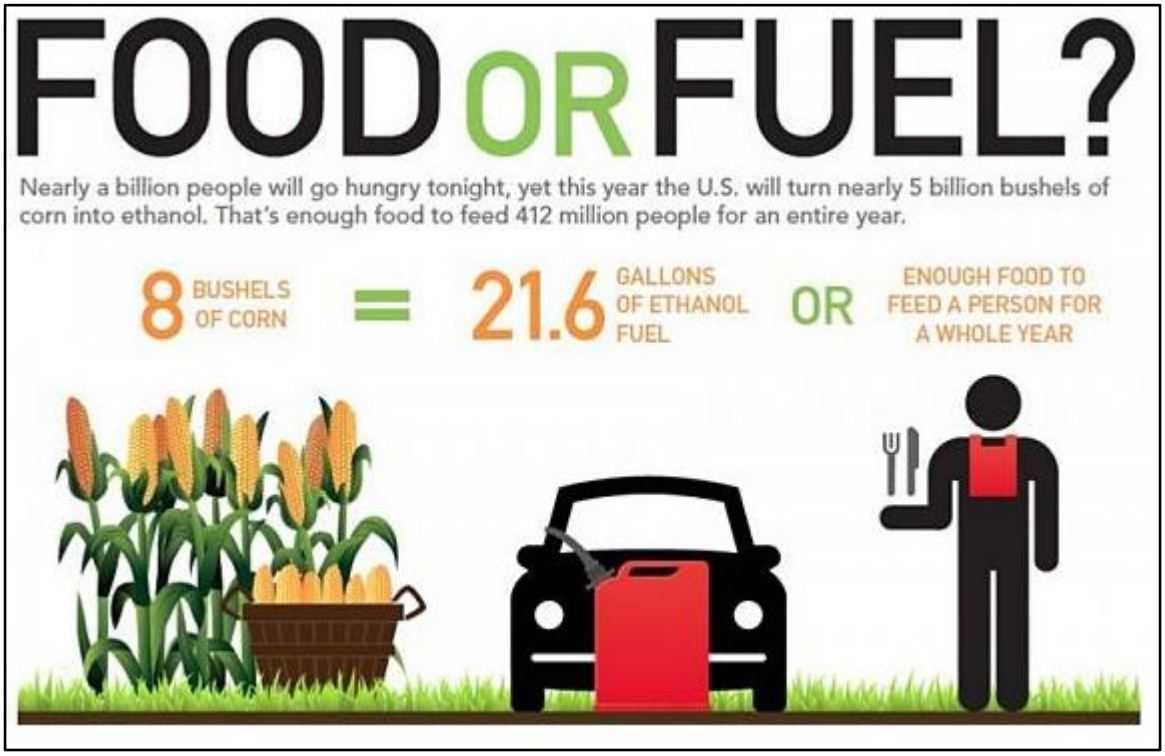
3) Biofuels – Essentially biofuels are any fuel that is produced through recent biological produces, most commonly from crops grown for this very reason. There are many ethical issues surrounding the use of biofuels. For example, crops that could be used to feed people are used to provide the raw materials for biofuels instead. This could cause food shortages or increases in the price of food. There are also environmental issues surrounding the use of biofuels. Biodiesel naturally contains little sulphur. For example, it may be said that they are carbon neutral – the amount of carbon dioxide released when they are used is the same as the amount absorbed by the plants as they grew. If so, this would reduce the production of this greenhouse gas. However, while biofuels produce less carbon dioxide overall, they are not carbon neutral. This is because fossil fuels are used in their production, for example in making fertilisers for the growing plants.



There is currently a huge debate over the ethics of biofuels. Many countries such as Brazil are converting vast areas of their most fertile agricultural land over to the production of biofuels.

Use the link below to produce a report on the issue. Give your opinion on what the Brazilian government should do in the future.

http://news.bbc.co.uk/1/hi/business/4581955.stm



4.4.2 Physical factors determining the supply of energy

There are a range of physical (natural) factors that can affect the supply of energy within a country or region. These are related to the underlying structure of the region or its topography (landscape) and weather and climate.

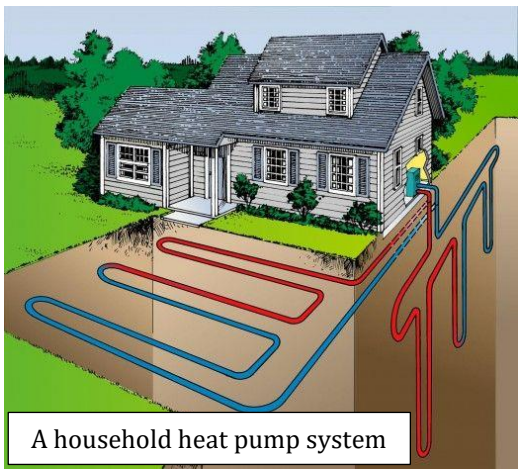
The main factors are:

- The **geology** of the region – this can affect the type of fossil fuel deposits available and the geothermal potential of the area.
- The **vegetation** and **soils** in the region – this can affect the potential for biomass and biofuel production.
- The **weather** and **climate** – differences can lead to the potential for wind, solar or HEP depending on the specific climatic conditions found there.
- The **relief** of the region – this can affect the ability of a location to have the potential for HEP production.
- **Physical location** – many coastal areas have vast potential for tidal, wave and wind power whereas mountainous areas have HEP and wind potential.

1) Geological factors including physical reserves of fossil fuels and active areas for geothermal energy.

a) Geothermal

Heat from the earth can be used as an energy source in many ways, from large and complex power stations to small and relatively simple pumping systems. This heat energy, known as geothermal energy, can be found almost anywhere—as far away as remote deep wells in Indonesia and as close as the dirt in our backyards.

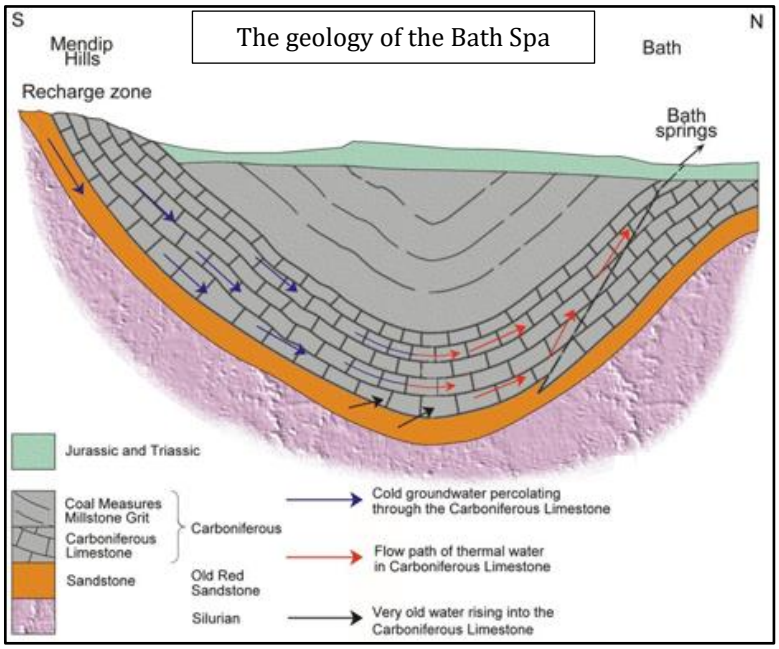


A household heat pump system

The amount of heat within 10,000 metres of Earth's surface contains 50,000 times more energy than all the oil and natural gas resources in the world.

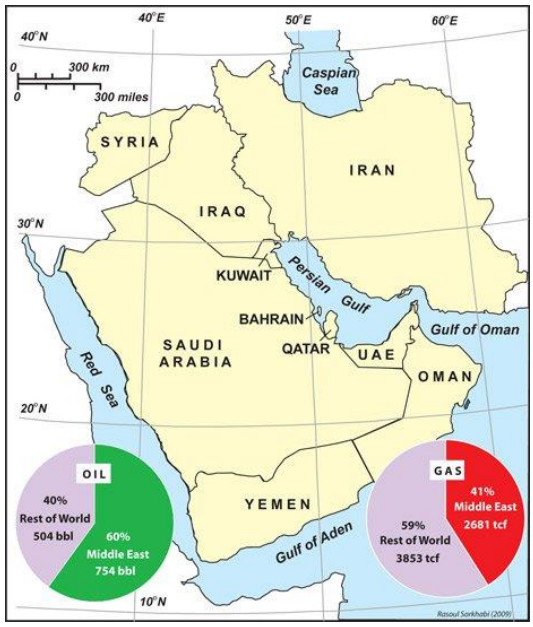
Direct use of geothermal heat. Geothermal springs can also be used directly for heating purposes. Geothermal hot water is used to heat buildings, raise plants in greenhouses, dry out fish and crops, de-ice roads, aid in industrial processes like pasteurising milk, and heat spas and water at fish farms.

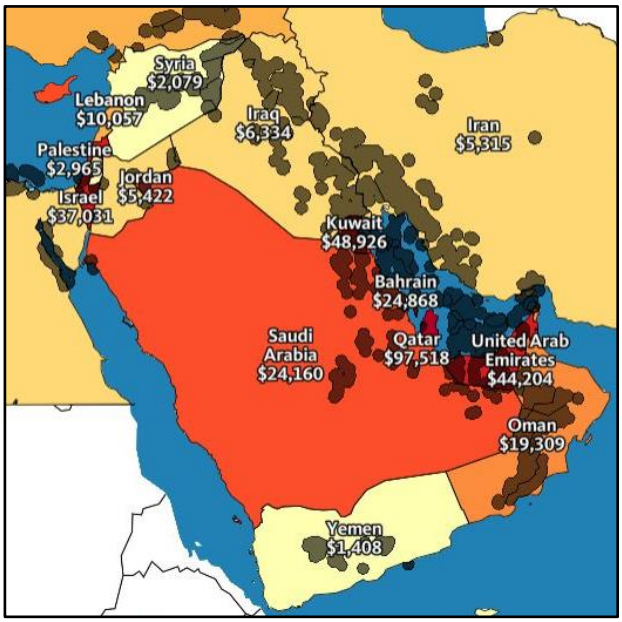
However, the availability of geothermal energy largely depends on how close the heat sources is to the surface of the earth. Locations like Iceland have vast amounts of heat close to the surface. The UK by contrast, has only a few areas where faults allow geothermal water access to the surface e.g. Bath. This does not mean the smaller, more local schemes such as undersoil heat pumps cannot be used in the UK.



b) The Middle East – Oil capital of the World

As the map alongside shows the Middle East has around 50% of all known oil and gas reserves. This is due in most part to its unique geology. The region was once covered by a vast sea where abundant microscopic life survived this formed huge areas of shale that provided the organic source of the oil and gas reserves. Along with this the region has huge numbers of viable gas and oil traps where the migrating fossil fuels can be stored underground. This almost perfect set of circumstances has meant that countries in the region have access to huge, easily recoverable resources. As a result, most countries in the region have benefitted economically. However, not all have. Can you think of any reasons why?





2) The effect of the <u>vegetation</u> and <u>soil</u> on the potential for biomass.

Biomass:

Växjö in Sweden is known as the garden city. It makes use of its very unique geography, as over half of the city is covered by forest, to produce renewable energy. Biomass and biofuels, mostly from wood chips, sawdust, bark and peat (forestry remnants), represent the major forms of energy for the city buildings and buses. The whole city has been planned using this concept and all forestry used for biomass energy is replanted and renewed.

Look at the link below:

https://www.buildinggreen.com/news-article/v%C3%A4xj%C3%B6-sweden-model-sustainability

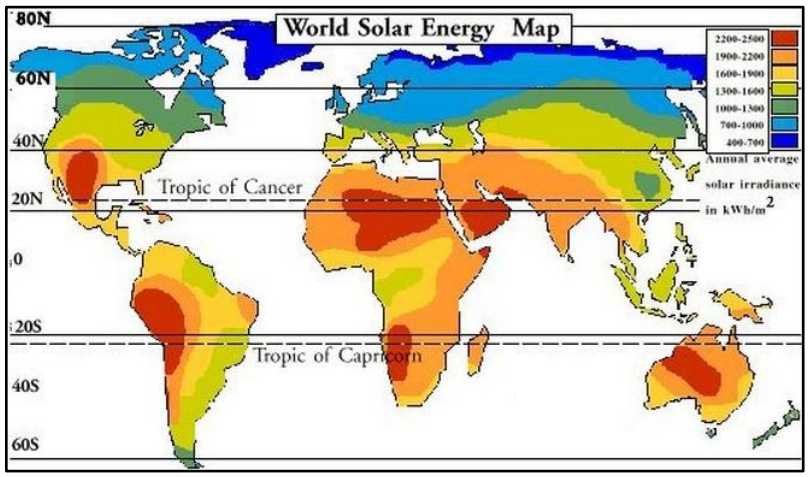
Task:

- Discuss the advantages/ disadvantages of this idea of a city planned around biomass energy.

3) The <u>weather</u> and <u>climate</u> of a region.

It goes without saying that the climate of a region will affect its capacity for certain types of energy production. Although Germany is the world leader in solar production it is not down to its abundance of sunshine, more due to its investment in the technology available. Germany is also thhird in the world in terms of wind power and once again this is due to investment and forward thinking by succesive governments.

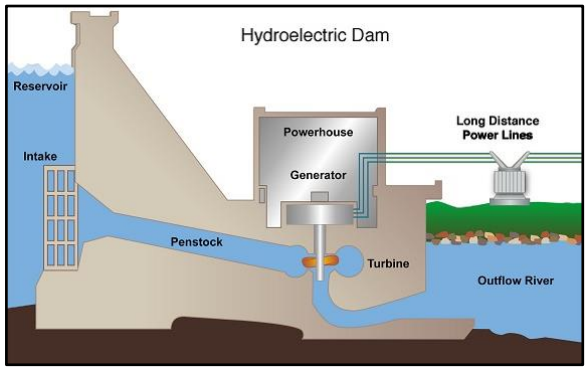
Solar power production



As the map alongside shows, Germany has far lower potential for solar energy production than many other countries. The pattern shown is very closely linked to latitude with countries at lower latitudes general having higher insolation readings than those at a higher latitude, although countries like the UK still have some potential.

Wind power

4) The <u>relief</u> of a region affecting its capacity to produce HEP.



The dam or water reservoir is a crucial part of a hydroelectric power plant. Water stored in the dams is used for generating electricity in hydroelectric power plants. Dams for hydroelectric power plants require three main locational factors:

1) **Good topographical location along the path of river**: The best location along the path of the river is river canyon or at the location where there is narrowing of the river. If the aim is to store maximum amount of water, then the volume of basin above dam should be calculated so that sufficient quantity of water can be stored in it. The perfect site is one where there is wide and flat valley.

2) **Right geological structure**: The rock structure on which the dam will be constructed should be strong enough to sustain the weight of dam and water stored in the dam. The rock structure should be able to sustain all the visible and invisible forces. The rock structure should be stable and there should be least occurrence of the earthquakes in the region. The rock structure should not allow the seepage of water and it should therefore be impermeable.

3) **Abundant surface water**: The area should ideally have high levels of precipitation. This will allow for the recharge of the main reservoir and increase the production capacity of the facility.

5) The <u>location</u> of a region (e.g. coastal)

Oceans can produce two types of energy: **thermal energy** from the sun's heat, and **mechanical energy** from the tides and waves. We are going to focus on mechanical energy.

Case study - *Sihwa Lake Tidal Power Project, South Korea*

Completed in 2011 it became the largest tidal plant in the world with a capacity of 254MW surpassing the Rance plant in France.

- It was built using existing coastal defences and incorporated ten submerged bulb turbines.
- The average tidal range of 5.6m is quite large and allows for year round energy production as the tides do not vary a great deal.
- The scheme is a one-way production scheme, with electricity only being generated by the incoming tide. Water is allowed to slowly drain back to allow for environmental concerns with the surrounding mud flats.

Tidal Barriers: Problems Faced in Exploiting Tidal Energy

- Intermittent supply – tides only occur twice creating spikes in production. Therefore, they only provide power for around 10 hours each day, when the tide is actually moving in or out.
- Cost – plants are very expensive to construct as the turbines, large breakwaters and wall are very costly.
- Interference with the ecosystem – there are many environmental issues that can be created such as reduced flushing of an estuary, winter icing and changes in erosion. All of these can change the flora and fauna and disrupt the balance of the fragile tidal ecosystem. Barrages affect fish migration and other wildlife such as wading birds. Many fish like salmon swim up to the barrages and are killed by the spinning turbines. Fish ladders may be used to allow passage for the fish, but these are never 100% effective.
- Location - tidal energy has several prerequisites that make it only available in a small number of regions. For a tidal power plant to produce electricity effectively (about 85% efficiency), it requires a basin or a gulf that has a mean tidal amplitude (the differences between spring and neap tide) of 6

metres or above. It is also desirable to have semi-diurnal tides where there are two high and low tides every day.

- Technology - present designs do not produce a lot of electricity, although ongoing research into more efficient and robust turbine design continues.
- Transport - barrages may block outlets to open water for ships and pleasure boats. Although locks can be installed, this is often a slow and expensive process.
- Tidal levels - barrages may affect the tidal level on a local scale. The change in tidal level may affect recreation in beach resorts, cause flooding or affect local fishing or other industries.

Look at the two links below:

http://www.tidallagoonpower.com/projects/swansea-bay/
http://www.bbc.co.uk/news/uk-wales-37863807

Task:

- Evaluate the Swansea Bay Tidal Lagoon as a viable solution to Wales' long term energy needs.

Specimen Question 2017

'The technological problems associated with alternative energy sources are greater than the environmental problems associated with fossil fuels.' Discuss. [22]

Introduction

There are a range of environmental problems associated with the extraction, transport and use of fossil fuels and technological problems associated with alternative energy sources.

Likely ideas to discuss include:

Fossils fuels and the environment:

· Coal is the most polluting source of energy (greenhouse gases, acid rain and smog). Mines lead to surface subsidence and toxic waste and water. Opencast pits scar the landscape. Although they are required to be restored, new ecosystems are of low quality.

· Oil infrastructure from large oilfields visually pollutes a large area. Oil spills at production sites (e.g. Gulf of Mexico Deepwater Horizon oil spill) along pipelines and tanker routes are ecologically disastrous. Ecological issues surround oil exploration in fragile, environmentally sensitive areas such as the Arctic (risk). Burning and use of oil products contributes large amounts of GHGs linked climate change.

· Natural gas is generally seen as the cleanest of fossil fuels in greenhouse gas terms, but flare-off as a waste product of oilfields causes major environmental problems. Still produces GHGs.

· Unconventional sources of oil and gas such as tar sands and shale gas (fracking) may lead to water contamination, the threat of earthquakes and environmental degradation.

· Some environmental problems may be overcome as new technologies for dealing with issues created by fossil fuel use are being developed, including carbon capture and sequestration and gasification

Alternative energy sources and technological issues:

· The more electric energy supplied by renewables, the more unstable national grids become as renewables such as wind, solar and tidal only produce electricity intermittently and as more renewables come online it becomes more complex to manage fluctuations in the grid.

· There are many ways of producing power to meet future demands, but most of the technology needed has yet to be developed. Only the most developed countries have the numbers of educated people, the research facilities and the funding to develop new technologies. Many ideas for technological solutions are untested and may prove to be unfeasible.

· Further investment is required in order to make alternative energy sources more cost effective and therefore viable in most countries. This requires businesses, governments and groups of countries to share ideas and research.

· There are spatial variations in the energy mix of countries (LIC vs NIC vs HIC) which will influence the relative importance of the two categories of problem (environmental vs technological).

Mark scheme

The command word 'discuss' requires that candidates offer a considered review that includes a range of factors with more than one side evident and reach a conclusion about the statement that the technological problems associated with alternative energy sources are greater than the environmental problems associated with fossil fuels.

At the upper end, answers that score highly should show application of knowledge and understanding by appraising and judging utility and validity, synthesising information, and come to rational conclusions about the statement that the technological problems associated with alternative energy sources are greater than the environmental problems associated with fossil fuels that are evidence based.

Practise Questions

1) Explain why geothermal energy is unlikely to make a significant contribution to global energy supplies. [10]

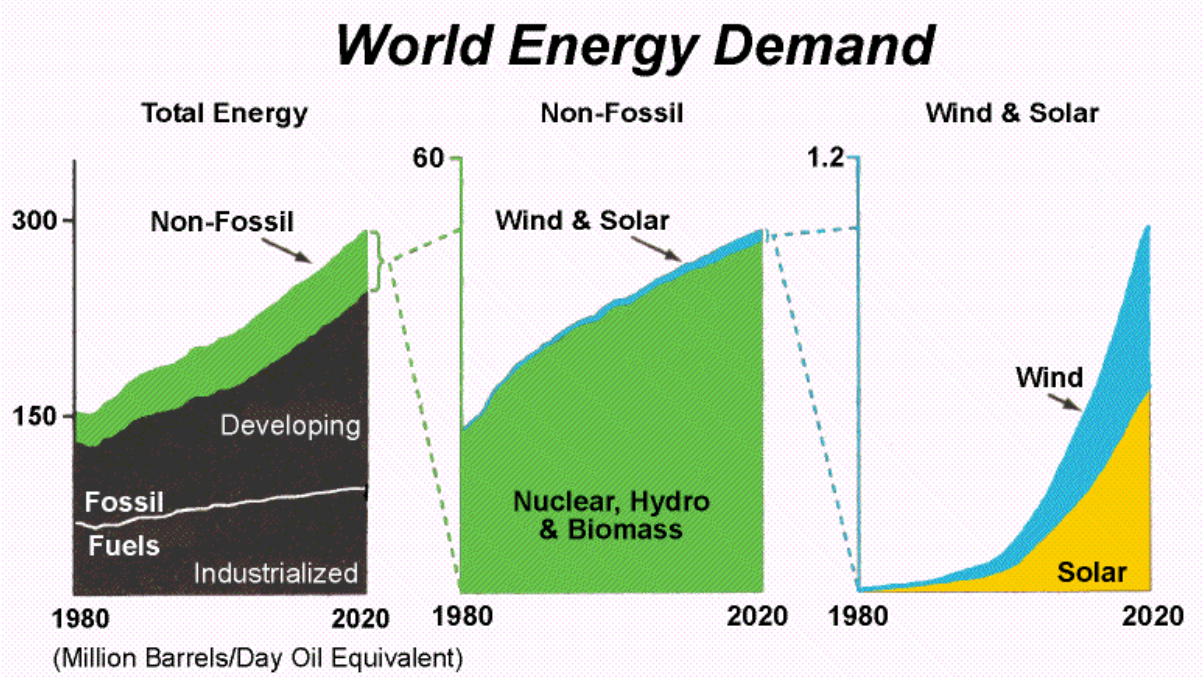
2) Outline ways in which fossil fuels and renewable sources of energy may result in damage to the environment. [10]

3) Describe some of the problems associated with supplying energy.
How far can managing energy demand sustainably help overcome problems of energy supply? [22]

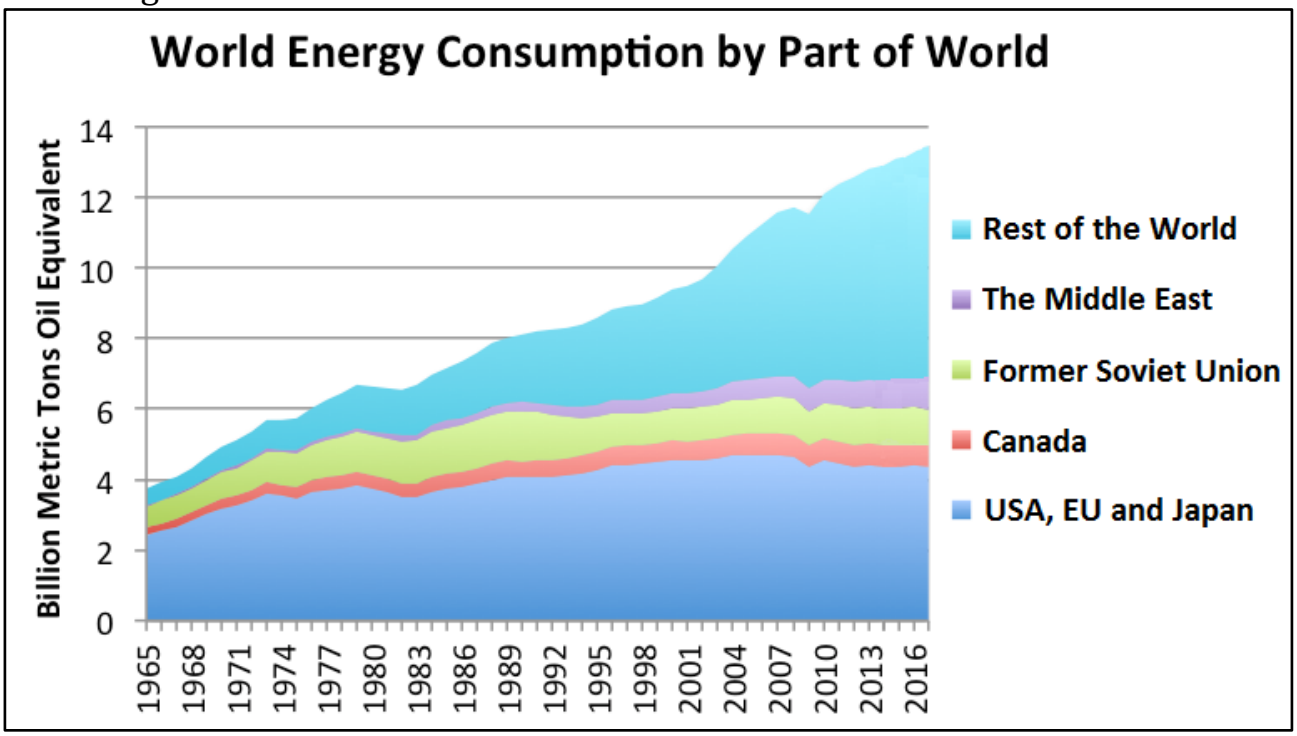
4.4.3 The changing demand for energy

Changing global patterns of energy demand

The total world demand for energy has risen steadily over the past 30 years:



However, the pattern of demand across the world is not consistent and varies according to a number of local factors.



Task:

a) Describe the pattern shown by the graph on the previous page.
b) Begin to explain this pattern using your knowledge of these different parts of the world *(try to use the headings economic, environmental, social and demographic).*

Use the links below to help your answers:

http://www.geo41.com/changing-patterns-of-energy-consumption/#production-and-consumption

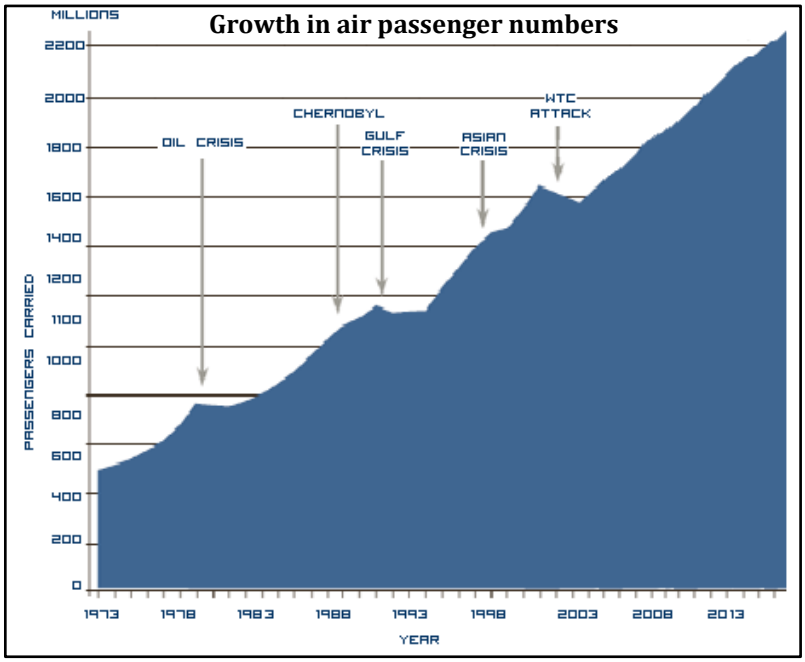
https://www.theguardian.com/business/2016/oct/10/global-demand-for-energy-will-peak-in-2030-says-world-energy-council

http://www.iea.org/newsroom/news/2016/november/world-energy-outlook-2016.html

Factors influencing the demand for energy

Economic Factors

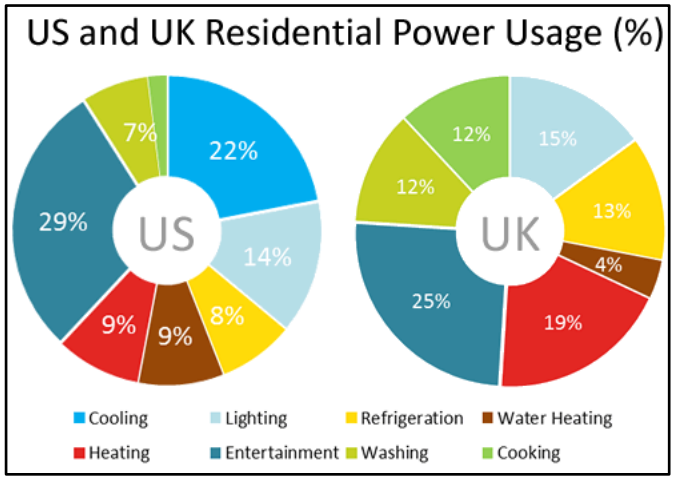
As countries develop so does their demand for energy. Standards of living improve, industries develop and infrastructure is modernised. **Economic** factors strongly influence the demand for energy. All economies are increasing their demands for energy. This is especially true of newly emerging economies, especially the very large countries of Brazil, Russia, India and China (BRICs) where energy for manufacturing is the main growth. In order to be successful, all economies (including those already developed) need to grow each year. In one way or another, that growth needs energy. Growing international trade has led to the transport of goods by air, sea and all forms of land transport. Countries that experience a low level of development need to grow so that large proportions of their populations can rise out of poverty. This growth in demand can be illustrated by the massive growth in air transport in the last 40 years:



Global energy demand is expected to grow by 30% before 2035 driven by increasing prosperity in developing countries. Traditional centres of demand are being overtaken by fast-growing emerging markets. The energy mix is shifting, driven by technological improvements and environmental concerns. While non-fossil fuels are expected to account for half of the growth in energy supplies over the next 20 years, the outlook projects that oil and gas, together with coal, will remain the main source of energy powering the world economy, accounting for more than 75% of total energy supply in 2035, compared with 85% in 2016. Renewables are projected to be the fastest growing fuel source, growing at an average rate of 7.6%/year, quadrupling over the period, driven by increasing competitiveness of both solar and wind.

Demographic, Social and Technological Factors

For all countries, no matter what their present stage of development, the **demand** for energy is rising. The growth in global population is the key **demographic** factor increasing the demand for energy. A range of **social** factors have increased the demand for energy. In developed economies, as well as getting to and from work, people want to travel to see friends, enjoy pastimes and go on holidays. Entertainment, even staying at home and watching TV, requires energy. To make life easier and free up time for leisure, labour saving devices are needed. For many of the social reasons above **technology** has produced equipment that requires energy. Car ownership grows continuously throughout the world. Around the home, washing machines, vacuum cleaners, TVs, computers, games consoles, sound systems and mobile phones have developed. Electronic gadgets are found in almost all activities. Growing populations consume more energy.



Availability of energy allows populations to grow. Energy consumption exerts demands on energy resources making them scarcer. They become harder to extract. Nearby forests are depleted, coal mines must dig deeper, oil has to be drilled in more complex environments. In other words, energy resource extraction experiences declining marginal returns. This has led to the exploitation of new energy sources, which in turn expands the Earth's ***carrying capacity***. Then populations grow once more.

Task:

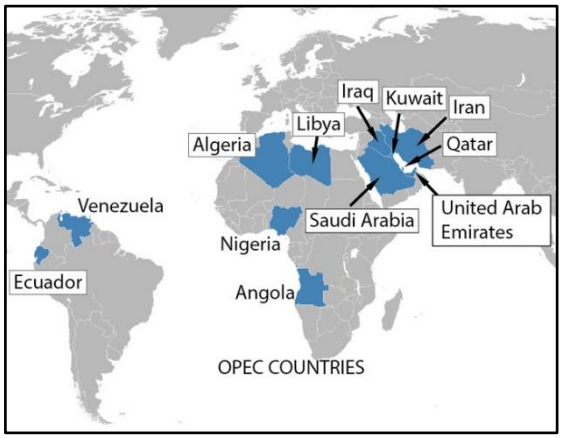
- Make a list of all the ways in which technology has played a role in increasing our energy demands
  e.g. iPhones require electricity to power them.

4.4.4 The global management of oil and gas

Factors affecting the global management of oil and gas

The **imbalance between the supply of and demand for oil and gas** is managed through **transfers, storage and pricing**. Oil and gas exploration and production is managed by MNCs (Multinational companies) and national governments. Oil supplies are managed on a global level by OPEC (Organisation of the petroleum exporting countries) and by national governments.

Who are the key players involved with energy security?



One of the problems facing us is that there is no international organisation responsible for coordinating global energy policies. The interests of the energy importing developed world are represented by the International Energy Agency, which was created by the OECD (Organisation for Economic Co-operation and Development) in 1974 as a result the actions of OPEC, and which represents the interests of some oil exporting states oil. The European Union has an energy strategy, but energy security is the responsibility of each of the 27 member states. There is an Energy Charter Treaty that aims: "to strengthen the rule of law on energy issues, by creating a level playing field of rules to be observed by all participating governments, thereby mitigating risks associated with energy-related investment and trade." But membership is voluntary and it has no real powers. The World Trade Organisation (WTO) is not involved in the energy sector.

In the absence of an effective international organisation, energy security is the business of individual states and their state and privately owned energy companies. In some countries the state owns the energy companies and energy infrastructure (Russia, Saudi Arabia) and in others there is a mixture of state-owned, state-controlled and private companies. The UK is unusual in that the

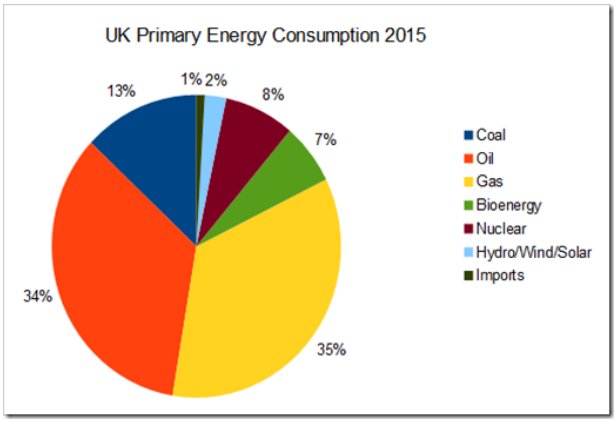
Government no longer owns any of our energy sector, yet it still sees energy security as something it needs to deliver.

The global energy system that enables the production, trade, transportation and delivery of energy resources and services is very complex. In the oil industry there is a global market for crude oil and oil products and supply and demand are matched via that market, though a lot of oil is now subject to longer-term contracts. In the gas industry, which is dependent upon pipelines and liquefied natural gas that requires lots of capital investment, long-term contracts are the norm. Traditionally, the gas market has been segmented into regional markets in Europe, Asia and North America, though there is a trend toward globalisation and the creation of a single gas market. Many of the LICs (Lower Income Countries) can simply not compete on this global market where the highest bidder will almost inevitably win. Much of the world energy market is controlled by the largest energy multinationals such as Exxon, Shell and BP. The majority of these have been traditionally from the HICs but the market now has many multinationals from BRIC countries starting to become more important such as the Russian gas giant Gazprom.

The **imbalance between the supply of and demand for oil and gas** is managed through **transfers, storage and pricing**.

Energy Demand

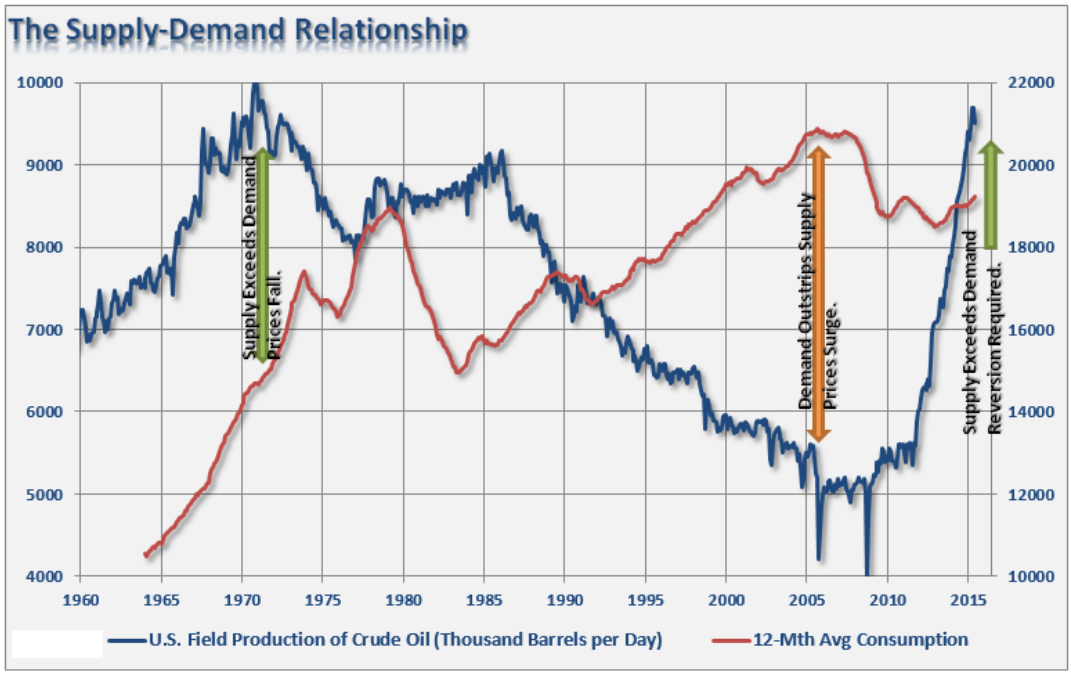
- Oil and gas provided 69% of the UK's total primary energy consumption in 2015, with oil for transport and gas for heating being the dominant uses.
- Global oil demand grew strongly in 2015 by 1.8 million barrels per day. Although demand is expected to continue to rise the rate of growth is expected to slow.



- Gas demand in the UK rose moderately by 2.2% in 2015 to 72 billion cubic metres but is still 30% below the peak in demand in 2004.

Oil and Gas Prices

- The price for Brent oil averaged $41 per barrel over the first eight months of 2016, briefly dropping to a 12-year low of $28 in January.
- The price for Brent oil averaged $52.50 in 2015, almost half the average price in 2014.



Oil prices vary dramatically depending on the supply and demand at any given time. Only when both the flows and stocks of crude and products are in balance can the market find a new sustainable range for crude oil prices, but this is unlikely to happen.

OPEC aims to:

- Protect the interests of the 14 member nations
- Stabilise oil prices by regulating supply
- Ensure efficient, economic and regular supply of oil

OPEC facts:

- Has 78% of the world's oil reserves
- Produces around 45% of crude oil and 15% of natural gas
- Has the power to significantly affect oil prices by increasing or decreasing production.
- OPEC is a **cartel**, with price controlling power.
- Can increase production sharply if global economic conditions allow it.

4.4.5 Problems associated with the extraction, transport and use of energy

Economic Issues

MEDCs can afford to import much of their primary sources and also have the money to invest in technology such as nuclear energy.

Energy imports as a % of requirements for selected countries

Country	%	Country	%
USA	30	Japan	81
UK	13	Venezuela	-236
Italy	85	Iceland	-12
Saudi Arabia	-311	India	22
Brazil	10	Egypt	-24

As the table above illustrates very few countries are self-sufficient in terms of energy. Therefore energy is traded between countries as some cannot produce enough but still consume a lot.

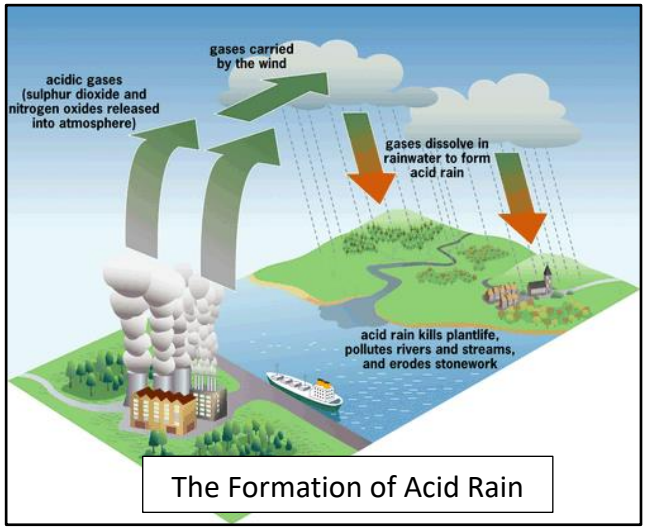
- Countries that can produce large amounts of raw materials export it to others.

Top Oil Producers	%	Top Gas Producers	%	Top Uranium Producers	%
Saudi Arabia	14	Russia	24	Canada	30
Russia	12	Canada	11	Australia	19
UAE	9	Norway	10	Niger	9
Iran	7	Algeria	8	Kazakhstan	9
Norway	6	Turkmenistan	5	Russia	9
Mexico	5	Qatar	4	Namibia	7
Iraq	4	Indonesia	3	Uzbekistan	5
Venezuela	4	Malaysia	3	Ukraine	3

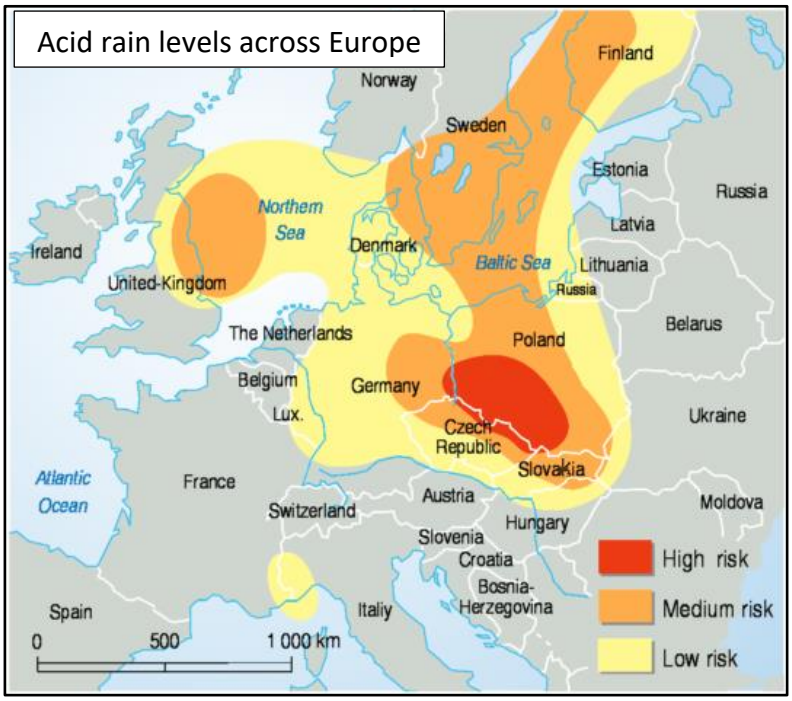
- Other countries have to import huge amounts of energy as they have few raw materials available to them e.g. Ireland, Japan, Italy and Spain.
- Importing of large amounts of energy inevitably involves the transport of those resources either by pipeline or most commonly ship. This is costly in itself and means that the resource becomes more expensive. Many LICs simply cannot afford these resources and have to rely on more low-tech, less efficient, unreliable and unsustainable energy sources.

Environmental Issues

Increasingly environmental issues are affecting national decision making when it comes to energy supplies. Climate change has become linked directly to the use of fossil fuels and the CO_2 and SO_2 that their burning produces. This is leading many countries and individuals to look at their own **Carbon Footprint**. Similarly the production of SO_2 in power stations is linked to the increasing acidity of rainfall in many areas of the World.



The Formation of Acid Rain



Acid rain levels across Europe

Recent international accords such as the Paris climate change agreement (signed in 2016) have set targets for countries to reach in terms of their emissions. At the moment most energy sources used around the world are still carbon based and highly polluting. However, other alternative forms of energy are not without their associated environmental issues.

- Nuclear energy produces long lasting dangerous waste that must be disposed of carefully and contained over many years.
- Some HEP schemes have led to the release of methane from rotting vegetation. Methane is more powerful as a greenhouse gas than CO_2.
- Biofuels can lead to the destruction of forests and the use of agricultural land needed for food.
- The production, transport and refining of fossil fuels causes many potential problems. The Deepwater Horizon disaster in 2010 illustrated many of the severe effects that oil can have on ecosystems.

Some of the environmental problems associated with fossil fuel usage:

The **extraction** of fossil fuels, e.g. by mining, can damage the environment.
Transportation can also cause environmental damage, e.g. through **oil spills**.
The **use** of fossil fuels has **negative impacts** on the **environment** as well, such as **acid rain** and **global warming**.

1 Acid Rain

Burning fossil fuels releases various gases. Some of these **dissolve** in **water vapour** in the atmosphere, which then falls as **acid rain**. Acid rain can:

1) **Kill fish** and other **aquatic life**, which can lead to **reduced biodiversity**.
2) **Kill trees** and other **plant life**, which also **reduces biodiversity**.
3) **Reduce** the **nutrient content** of **soil** so that some species of plants can't grow, or grow more slowly.
4) **Corrode rocks**, e.g. limestone, sandstone.

2 Global Warming

The largest environmental problem created by the use of fossil fuels is **global warming**. **Burning fossil fuels releases** the greenhouse gas **carbon dioxide** into the air. This **enhances** the planet's natural greenhouse effect, **increasing world temperatures** and causing **climate change**. This could lead to:

1) **Rising sea levels** and **increased flooding**.
2) **More frequent** and **severe extreme weather events**, e.g. hurricanes, droughts.
3) **Habitat loss** (which leads to **loss of biodiversity** and the **extinction** of species).

3 Problems Associated with Mining

Coal mining involves disturbing or removing large areas of land, which can lead to:

1) **Wildlife** being **displaced**.
2) **Habitat Loss**.
3) **Reduced air quality** as dust and other particulates are released.
4) **Contamination** of **surface water** with acidic or toxic substances.

4 Oil Spills

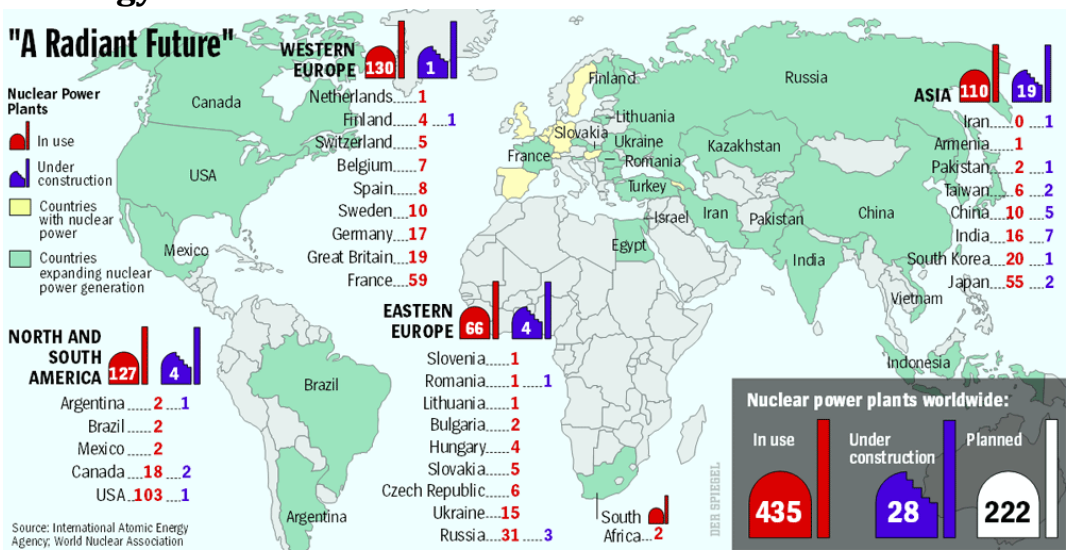
Oil spills happen when **pipes**, **oil wells** or **tankers** transporting oil **leak**, dumping oil onto land or into seas or oceans. The effects of oil spills last for a long time and lead to the **death of wildlife**. There are many reasons for this:

1) **Oil reduces** the **ability** of animals to **move freely**, which makes it more difficult for them to swim, fly or forage.
2) **Hypothermia**. When **feathers** and **fur** become **coated in oil** it reduces the animal's ability to control its body temperature.
3) **Consumption of oil**.

Political and Technological Issues

A number of alternative sources of energy are often limited in their use around the globe either for political (their use is often controversial and sparks debate) or technological reasons. Some countries do not have the expertise to exploit and use these particular resources. Two energy sources that often spark the most heated debates are **nuclear** and **biofuels**.

Nuclear Energy



Task: Use the information on pages 22 and 23 and the link provided.

- Nuclear energy has too many drawbacks to be part of the UK's energy future. Discuss. (10)

In **nuclear power stations heat energy** released from **uranium** or **plutonium** is used to **generate electricity**.
The first commercial nuclear reactor opened in 1956 and there are now 439 reactors in 31 countries around the world.
They supply 15% of the world's electricity, which is 6.3% of the total energy consumption.
There are **advantages** and **disadvantages** of using nuclear power:

Advantages of nuclear power

1) It has **low carbon dioxide emissions**, so contributes little to global warming.
2) **Less toxic waste** is released into the environment than from fossil fuel plants. (Fossil fuel plants release ash containing heavy metals such as mercury, cadmium and lead).
3) **Large amounts of energy** are generated from **small amounts** of **fuel**.
4) **Electricity** produced by nuclear power is **cheap**.

Disadvantages of nuclear power

1) **Nuclear waste** is **highly radioactive** and has to be **stored carefully** for **thousands of years**. This is very **expensive**. Some people argue that as technology improves this problem will be solved, but there's no guarantee of this.
2) **Accidents** causing **radioactive waste** to **leak** into the **environment** can have devastating consequences, e.g. **human, animal** and **plant deaths** and **illnesses, destruction** of the local **environment** and **contamination** of **large areas of land**. The damage lasts for a **long time**. The **explosion** of nuclear power **plants** causes similar problems.
3) There's only **limited amounts** of **uranium** and **plutonium** so it's a **non-renewable** resource.
4) **Decommissioning** power stations at the end of their life is **very expensive**.

Example

In **France 78%** of **electricity** is produced from **nuclear power**. France has the **cleanest air** of any industrialised country and the **cheapest electricity** in Europe.

Example

The 1986 explosion at the **Chernobyl** nuclear power plant in the Ukraine directly caused **56 deaths** and radiation released caused **thousands** of **deaths** and **illnesses**. **Radioactive material** from the disaster was detected as far away as **Ireland**, a **4 km² area of forest** around Chernobyl **died**, **food supplies** (particularly of fish) were affected in **Scandinavia** for several years after the accident and the Chernobyl area is **still heavily contaminated** today.

Look closely at the link below:

https://www.energyinst.org/_uploads/documents/DSI16.pdf

Appropriate technology is vitally important in securing sources of energy for any given country. Whilst nuclear power maybe a viable option in this country, this is not the case all over the World.

A nuclear plant in France

Gathering fuelwood in Mozambique

Biofuels

Biofuels are seen as one of the potentially most important energy sources of the future. Biofuels include any type of fuel made from living things, or from the waste they produce.

There is a very long and diverse list, including:

- wood, wood chippings and straw
- pellets or liquids made from wood
- biogas (methane) from animals' excrement
- ethanol, diesel or liquid fuels made from processed material or waste oil

In recent years, the term "biofuel" has come to mean the last category - ethanol and diesel, made from crops including corn, sugarcane and rapeseed.

However, where are the crops used going to be produced? Many countries could gain valuable investment and money from developing biofuel crops. However will this be at the cost of important farmland that feeds the nation or will it destroy natural habitats. In Brazil there has been a drive towards biofuel production since the 1980s. In Brazil, due to the large production of sugar cane, bioethanol is used occasionally to power cars and in the United States biofuels are used from corn. In Britain, although bioethanol is rarely used, it is available in a number of fuel stations as ethanol can be mixed with either petrol or diesel in small quantities however Citroen released the new C8 in 2006 which is capable of running on 30% ethanol fuel. Engines where ethanol can be mixed have been specially modified. Due to the widespread of interest shown by consumers, researchers in the future aim to invent engines capable of running only on ethanol resulting in greater efficiency.

Despite the Brazilian bioethanol industry having created more than a million direct and indirect jobs, there are still many arguments against their use.

- Waste products – bioethanol production produces two waste products:
  - **Vinasse** is a corrosive liquid by product of ethanol distillation which is often dumped directly into rivers causing environmental damage.
  - **Bagasse** is the leftover sugarcane fibre which is often burned or left to rot in huge waste tips. Both produce GHG emissions.
- The biofuel industry in Brazil has a poor record in regard to worker's rights. Large companies often exploit workers.
- Expansion in sugar cane cultivation has increased food prices.
- Biofuel production has benefitted some large companies but the poorest in Brazil have had to handle most of the negative impacts.

The Geopolitics of Energy is a Big Issue:

Energy security is an **important** issue for **all governments**, for several reasons:

1) **All countries** are **dependent** on **energy supplies**, e.g. for transport, heating, electricity and manufacturing.
2) Global **energy use** is **increasing** and **fossil fuel reserves** are **decreasing**. Many people believe we're coming to an "**energy crisis**", so governments are more concerned than ever about how to **secure future supplies** of energy.
3) To make the situation trickier, the **largest reserves** of **oil** and **gas** are often in areas that are either **politically** or **economically unstable**, e.g. Russia, which means that **energy supplies** are often at risk of being **disrupted**.
4) So in order to **secure supplies**, **agreements** are often reached between **exporting** and **importing regions**. For example, the EU will become increasingly dependent on imports as North Sea oil runs out, so it opened talks with Russia in 2000 to try to guarantee access to Russian gas supplies. In return Russia wanted investment into production of fuel and improved access to EU markets.
5) At times agreements can't be reached and **concerns over energy security** can **lead to conflict** or the **threat of conflict**. E.g. the 1980 Carter Doctrine stated that the USA would use military force if necessary to protect its interests in the Middle East and secure the free movement of oil.
6) As energy consumption increases, so does the **impact** of energy use on the **environment**. **International agreements**, e.g. the Kyoto Protocol, are drawn up to try to **address these problems**, but these too can lead to political **conflict** if environmental protection clashes with other national interests, e.g. economic growth.

Task:

- Complete a table like the one below summarising some of the main issues with the different sources of energy.
- For each point made add the relevant letters:

E = Economic EN = Environmental P = Political T = Technological

Energy source	Advantages	Disadvantages
HEP		
Biofuel		
Solar		
Tidal/Wave		
Geothermal		
Nuclear		
Oil		
Natural Gas		
Coal		

4.4.6 Energy mixes and development

The **energy mix** of an individual country is the particular combination of energy sources used within it for production of power and consumption. Energy mixes will vary on a local, national and global scale.

Local Scale

At the local scale you need to research at least 2 examples of the growing use of **appropriate technology** for sustainable energy micro-generation in developing countries (LICs).

1) Using appropriate technologies to produce energy **isn't always sustainable**, e.g. they could be dependent on local sources of non-renewable energy.
2) Some **appropriate technologies** do produce energy from **renewable sources** though, so it's **sustainable**. Producing energy in a sustainable way contributes to **sustainable development** — growth in a way that doesn't stop future generations getting what they need (i.e. by not depleting resources or permanently damaging the environment).

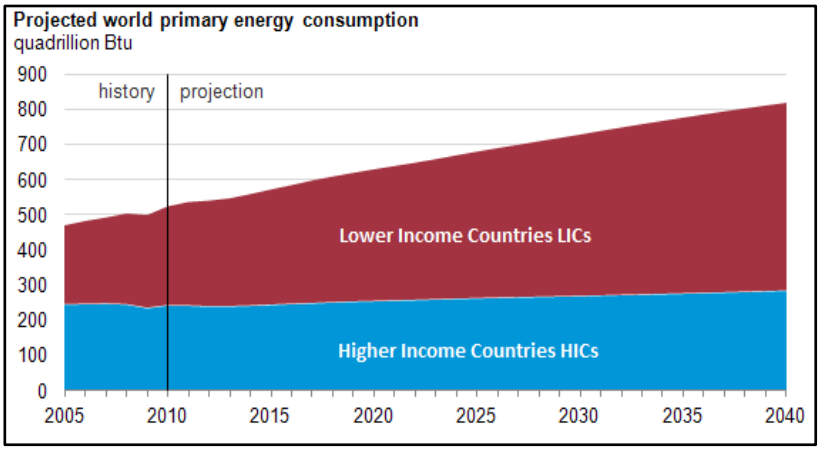
Example In mountainous regions of developing countries clay stoves have been introduced as an appropriate technology that makes energy use for cooking and heating more sustainable.

1) In high altitude areas of developing countries many indigenous people rely on burning biomass on open fires as their main energy source.
2) Fuel is usually straw, crop roots and pasture grass. One family can burn up to 6000 kg a year.
3) At high altitudes the temperature is lower and plants grow more slowly, which often means crops are removed faster than they can be replenished.
4) As energy supplies are depleted there are fewer plant roots in the soil to support it. This causes soil erosion and a decrease in soil productivity.
5) Burning biomass in this way is therefore unsustainable.

Clay stoves are more efficient than open fires and can lead to a 75% reduction in fuel consumption. This means fuel is harvested more slowly, allowing the crops to replenish themselves. This leads to decreased soil erosion and increased soil productivity. Using a stove rather than an open fire also has health benefits, as the smoke from open fires can cause eye and lung diseases.

Clay stoves are an appropriate technology as they can be made by local craftsmen from metal and clay, providing a source of income for local people. They reduce the quantity of biomass burnt and therefore help to maintain the natural cycle of replenishment. This makes the resource renewable and therefore sustainable. So, they contribute to sustainable development.

Developing Countries will Consume 65% of the World's Energy by 2040
About 57% of global greenhouse gas emissions originated in developing countries in 2015, with China and India accounting for a $^1/_3$ of the worldwide CO_2 emissions.



Task: Produce a power point presentation on:

1. Two developing nations (LICs) and their energy sources
2. Two different case studies of local, micro-generation of energy in LICs

http://www.huffingtonpost.co.uk/edward-lowe/leapfrogging-the-grid-how_b_9451608.html

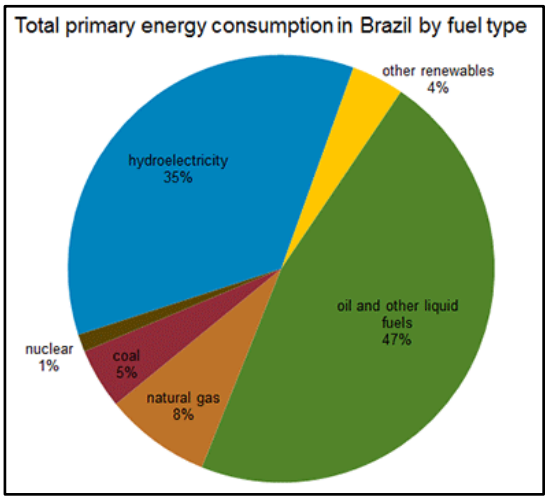
http://link.brightcove.com/services/player/bcpid1659202292001?bckey=AQ%7E%7E,AAAAmtVJIFk%7E,TVGOQ5ZTwJbsT0Mq3k9H8GCa4jV3vL4M&bctid=2669785561001

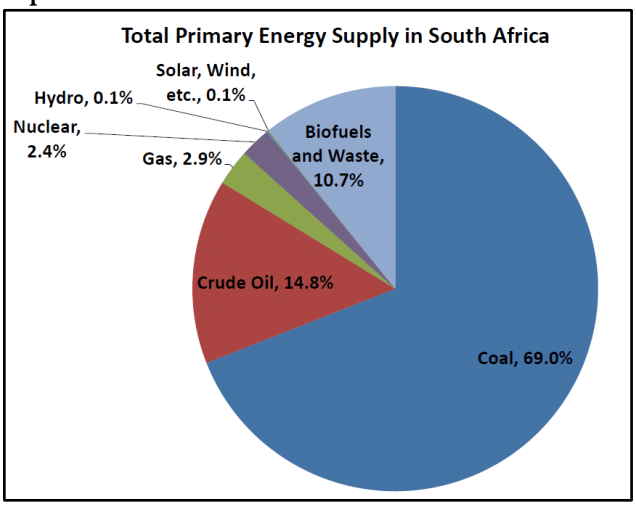
https://www.theguardian.com/global-development-professionals-network/2015/sep/15/five-developing-countries-ditching-fossil-fuels-china-india-costa-rica-afghanistan-albania

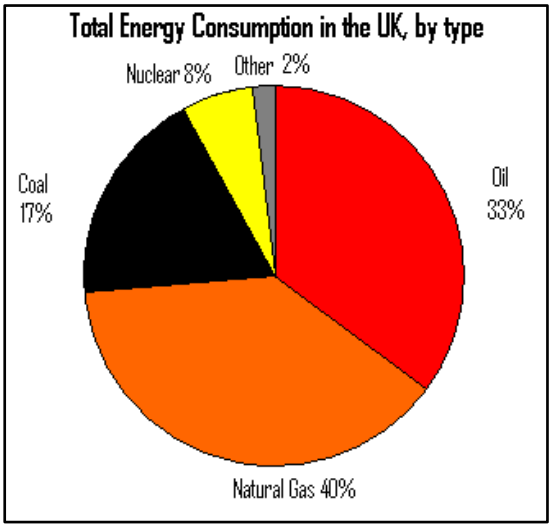
https://www.theguardian.com/sustainable-business/2016/nov/29/small-scale-hydropower-india-clean-energy-climate-change-environmental-impacts

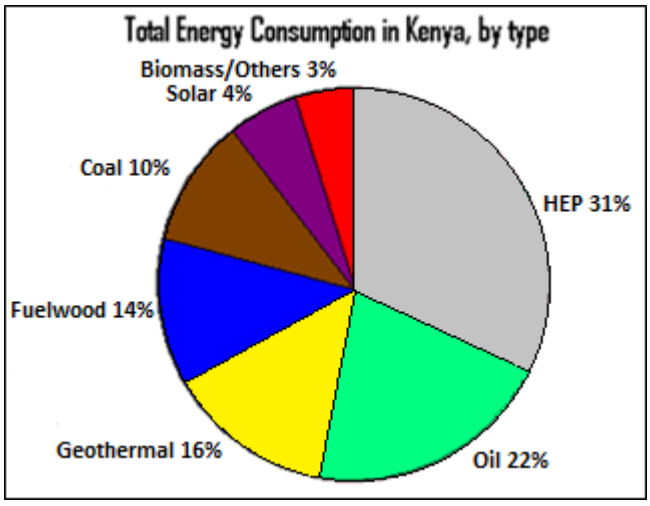
National Scale

Why do different countries at different levels of development have such different energy mixes? Look at the four pie charts below:









Task: Use the pie charts on the previous page to:

- Explain the difference in the primary energy mix between HICs, NICs (emerging economies) and LICs. (10)

https://www.gov.uk/government/publications/2010-to-2015-government-policy-energy-demand-reduction-in-industry-business-and-the-public-sector/2010-to-2015-government-policy-energy-demand-reduction-in-industry-business-and-the-public-sector

http://www.greenpeace.org.uk/climate/reducing-demand

Global Scale

What are the economic and political factors affecting world energy prices and therefore the energy mix that each country chooses to use?

Energy resources have become increasingly politicised, both in their supply and demand. Coal, once the dominant energy source in HICs, is no longer seen as being acceptable due to its association with carbon dioxide emissions and acid rain production, and its role in the enhanced greenhouse effect. In some LICs and NICs, India and China for example, the demand for energy to sustain their developing economies is so high and their domestic supplies of coal so extensive, that politics dictates coal production must proceed unimpeded. Oil is the energy source probably most influenced by political factors. Oil prices are very sensitive to political events in both oil producing and oil consuming regions. Wars between countries such as Iran and Iraq and the Iraqi invasion of Kuwait caused steep rises in prices. Tensions between Russia and the USA have an immediate effect on both oil and gas prices. Recent unrest in Venezuela has mostly been caused by the reduction in the global oil price which has led to huge economic problems on the ground in the country. Venezuela relies on oil for 95% of its export revenue and over 50% of its total GDP. As a result; food shortages have occurred as the government can no longer pay for imports, banks have collapsed as people pull out all of their savings, hyperinflation has hit basic food prices, the currency has collapsed and multinational

The crisis in Venezuela started in 2013

companies such as Ford and Toyota have pulled out creating widespread unemployment. Global decisions are having fundamental impacts on their society.

Because of the dangers posed by nuclear energy and its association with weapons development, the pattern of use of nuclear energy is strongly affected by politics.

Renewables are also subject to international disputes with large HEP schemes affecting water and energy supply in those countries downstream. Biofuels are increasingly demanded by countries keen to meet their climate change targets and reduce emission. As a result LICs are often under pressure to produce and supply these, thus jeopardising food supply in their own country.

4.4.7 Sustainable solutions to the demand for energy

Policies for greater demand reduction and energy efficiency

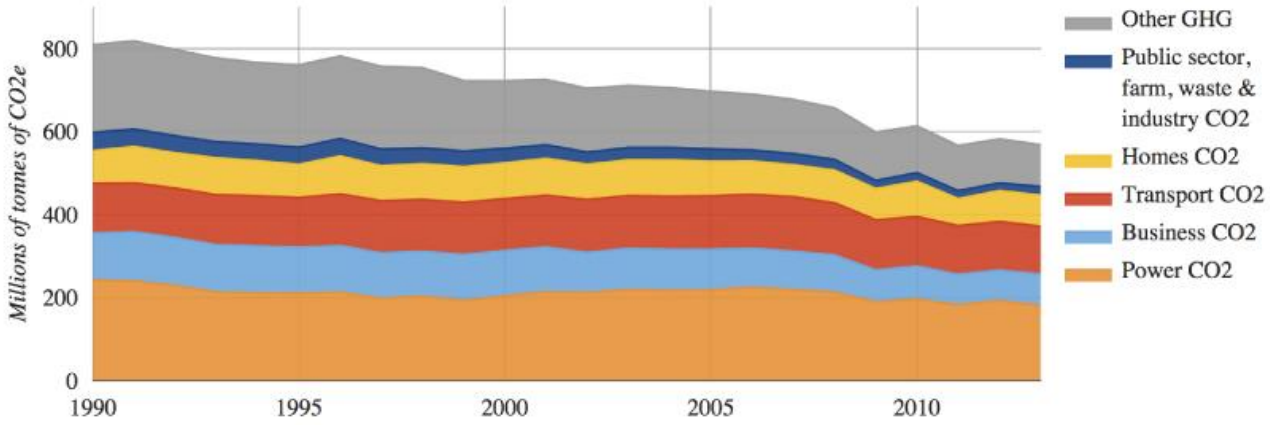
Demand Reduction

Demand reduction means reduction in demand for fossil fuel energy, and reduction in demand for energy services - both of which will contribute to reducing carbon emissions from energy use. Demand reduction will also help to make energy supplies more sustainable as supply should be able to match demand into the future.

Why demand reduction is important?

The graph on the next page shows how CO_2 emissions from various sectors have changed over the period 1990-2015 in the UK. Emissions from personal air travel and personal surface travel (i.e. road and rail) have increased, and those from household energy use have only decreased very slightly. In most cases there have been some improvements in shifting to lower carbon fuels and increasing energy efficiency, but at the same time a significant increase in demand for mobility / energy services. Tackling all three of these factors is important, but reducing demand for mobility / energy services is likely to be the most challenging. It is clear that the total emissions have decreased from over 800 million tons to below 600 million tons. However this will need to decrease further if the UK is to meet its Paris Accord targets by 2030.

UK Greenhouse gas emissions per sector 1990-2015



One of the most effective to meet these targets will be by reducing demand for energy by making all sectors of the UK economy more energy efficient:

Increased Energy Efficiency

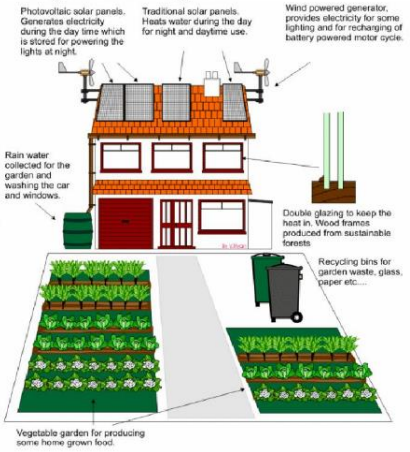
Everyone can play their part in living a more energy efficient lifestyle. Houses can be made sustainable (see below).

Energy supply can be made **more sustainable** by **conserving** as much **energy** as possible. By **reducing overall use of energy** fewer resources are used up and the **environmental effects** of energy use are **limited**, e.g. emission of greenhouse gases. **Homes**, **workplaces** and **transport** can all be **designed** to **conserve energy**:

***Buildings** can be made **more sustainable**...*

Energy can be **conserved** in **homes** and **workplaces** in several ways:

1) **Reducing** the amount of energy needed for **heating** by installing **double glazing**, **draught-proofing**, **loft insulation** and **cavity wall insulation** to **reduce heat loss**.
2) **Installing energy-efficient boilers**. They're more efficient because a greater proportion of the heat energy they generate is used to heat the water in the boiler and **less energy** is **lost** to the surroundings.
3) Using computers, printers and faxes that **turn themselves off** after a period of time instead of staying on (stand-by mode can consume nearly as much energy as being turned on permanently).
4) Building in **features** that help **absorb** and **retain** the **sun's energy** (e.g. **large south-facing windows**) to provide **heat** as well as **light**.



Today all white goods such as fridges, washing machines, dishwashers have energy ratings. Houses are also given ratings so that buyers can compare energy usage. LCD TVs are now up to 75% more efficient than old cathode ray TVs.

Using **energy-saving appliances** wherever possible, e.g. **energy-saving light bulbs**.

Example

The **City of Calgary Water Centre** in Canada was designed to conserve energy. Lots of **south-facing windows** let natural light reach all areas, which **reduces the need** for **electric lighting**. The electric lights only come on when they're needed as they're controlled by **light** and **motion sensors**. The **windows** and the **shape** of the building help to **warm the building** in winter, **reducing the need** for **heating**. An **overhanging roof** keeps the heat out in summer so **less energy** is **needed** for **air-conditioning**. A **radiant ceiling slab cooling system** has been built in to **reduce the need for air-conditioning** further. This system draws cold night air through pipes set into concrete, cooling it down. The cooled concrete helps to keep the building cold throughout the next day. These methods have **reduced** annual **energy consumption** by 58%.

...and so can Transport

Energy can be conserved in **transport** by:

1) Changing to **vehicles that don't need any fuel**, e.g. **bicycles**. Employers receive tax exemptions for loaning or selling bicycles to employees as part of the **Cycle to Work** scheme. This encourages people to switch cars for more sustainable bicycles.
2) Establishing out-of-town **park-and-ride schemes** and **investing in public transport**. This **reduces fuel consumption** by reducing the number of vehicles on the road.
3) Introducing **congestion charges**. This **encourages public transport use** and is used in London, Singapore, Rome and Stockholm.

Example

The **London congestion charge** was **introduced in 2003**. It charges drivers for entering a central zone of the city during normal working hours. It aims to reduce congestion and raise money for public transport improvements. Since the scheme started the **number of vehicles** within the zone has **decreased** by **21%** (70 000 fewer cars each day) and **carbon dioxide emissions** have **decreased** by **20%**. In 2007/2008 **£137 million** was raised, which was **invested in public transport**. **Bicycle use** has **increased** by **12%** since 2003, and use of **public buses** has **increased** by **6%**. There's been an **increase in congestion** in the area **surrounding the central zone** though and some small businesses within the zone (e.g. shops and restaurants) claim that the charge has **reduced trade**.

Transport can also be made more sustainable by using **technologies** that run off **sustainable energy sources**:

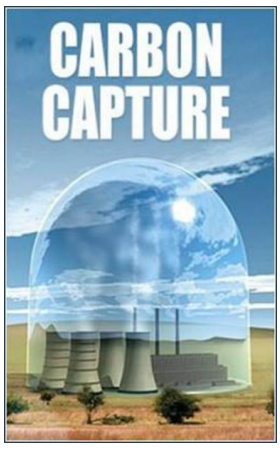
- **Hydrogen fuel cell buses** run on electricity produced from **hydrogen**. The hydrogen that fuels the bus is **made from water**. The process **uses electricity**. So, for hydrogen fuel cells to be sustainable this initial electricity must be produced from **renewable resources**.
- **Electric buses**, e.g. the **Islay Wave Bus** runs off **wave power generated electricity** from LIMPET
- Using **hybrid fuel vehicles** (vehicles that run off a mixture of two fuels). If one fuel is from a **renewable** source then the vehicle is **more sustainable**, e.g. use of **ethanol-petrol hybrid fuel cars** in Brazil

Task: Use the link below to make notes on some of the Welsh Assembly's strategies for reducing demand and increasing energy efficiency in Wales.

http://www.assembly.wales/Laid%20Documents/CR-LD10610/CR-LD10610-e.pdf#search=demand%20reduction

Clean technologies for fossil fuels

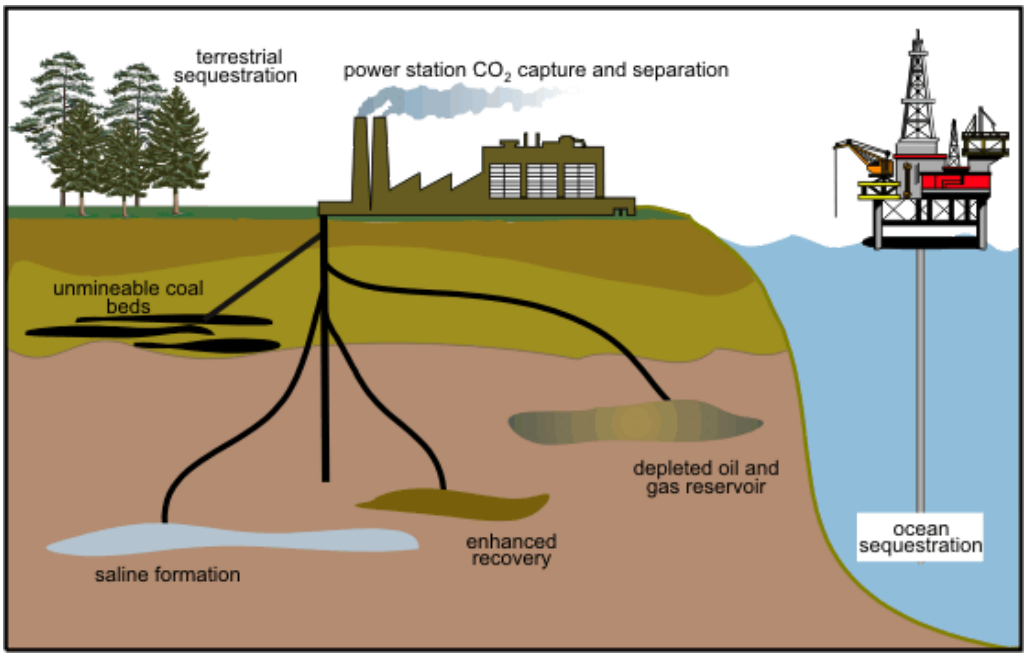
Carbon Capture and Sequestration



Carbon capture and storage (often abbreviated to CCS) is the process of capturing waste carbon dioxide (CO_2) at source (e.g. fossil fuel power plants). The aim being to prevent the release of large quantities of CO_2 into the atmosphere. Carbon Sequestration involves transporting and securely storing carbon dioxide emitted in a number of possible locations thus preventing its future release. There are number of technologies under investigation for sequestering carbon from the atmosphere. These can be discussed under three main categories:

- *Ocean Sequestration:* Carbon stored in oceans through direct injection (into sediments) or fertilisation (using marine plants).

- *Geologic Sequestration:* Natural pore spaces in certain rock formations serve as reservoirs for long-term carbon dioxide storage.
- *Terrestrial Sequestration:* A large amount of carbon is naturally stored in soils and vegetation, which are our natural carbon sinks. Increasing carbon fixation through photosynthesis, slowing down or reducing decomposition of organic matter, and changing land use practices can enhance carbon uptake in these natural sinks.



Task: Use the links below to answer the following questions:

1) Explain how different methods of carbon sequestration can help to reduce CO_2 emissions. (10)
2) Evaluate the two schemes as long term solutions to the problem of climate change. (8)

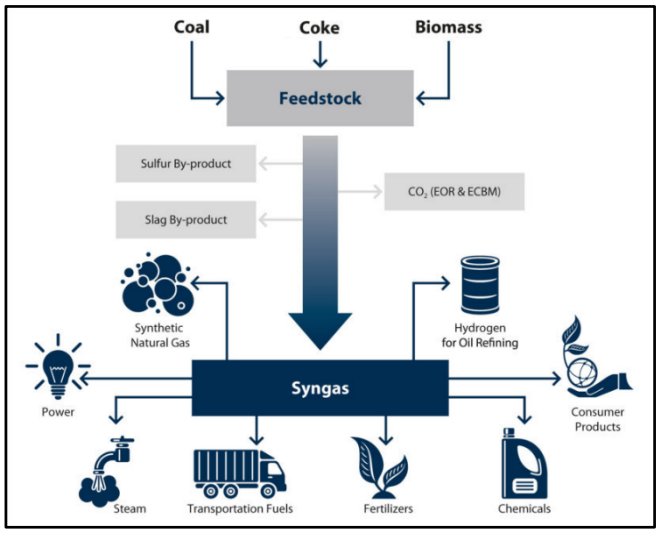
https://www.theguardian.com/environment/2017/jan/03/indian-firm-carbon-capture-breakthrough-carbonclean

https://www.theguardian.com/environment/2016/jun/09/co2-turned-into-stone-in-iceland-in-climate-change-breakthrough

Gasification of Coal or other Organic Material

Gasification processes involve the heating of organic matter (biomass or coal) with little or no oxygen to produce "syngas" (synthetic gas), a mixture of Carbon Monoxide and Hydrogen. This can then be burnt with little or no emissions. The syngas can thus be used to generate energy on an industrial scale. The CO_2 and

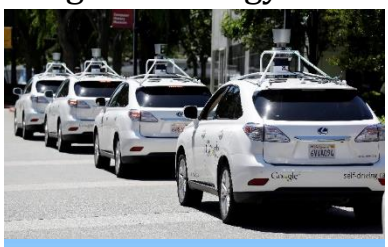
other waste products produced can be captured at sources and sequestered. As it does not involve combusting the fuel it can be achieved in a far more controlled way without the need for vast quantities of emissions. However, there are drawbacks of this technology:

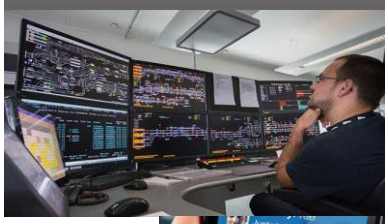


- It could lead to a mass return to coal mining – itself a contributor to CO_2 emissions.
- Without careful controls on plants to ensure that capture and storage of pollutants is taking place, it could lead to a rise in CO_2 emissions.
- It is more expensive than traditional coal fired or gas power plant production and as such is not yet a viable option in LICs.

Transport technologies

New transportation technologies are emerging to meet the global energy challenges. These include:





- Connected and autonomous vehicles – including self-driving vehicles that communicate with one another in order to manage traffic flows and prevent accidents and overuse of fuel.
- Alternative fuels (see previous chapters)
- Keyless fleet management – this involves there being free (keyless) access to fleets of vehicles so that they can be shared. Thus avoiding single person journeys and encourage fuel saving.
- Traffic analytics – better policies and technology for managing traffic flows within urban areas. This will help to reduce congestion and fuel use and increase the efficiency of traffic flow.

- Local planning policies that support transit-oriented development. These will ensure that the best possible mix of transport types are in place in any given location (road, rail, air etc.).

New transport technologies for on-road communication between vehicles will dramatically change how these vehicles operate and provide information for far better, real-time traffic management. As long as the necessary transport and network infrastructure is in place.

Assessing the sustainability of alternative energy sources

Task: Use all of the information in this booklet, the 2016 G4 resource folder and your own research to answer the following question:

Assess the long-term sustainability of two alternative sources of energy. [22]

Notes for this question:

- Show detailed knowledge of two alternative sources of energy and how they work.
- Show understanding of the advantages and disadvantages of the two chosen alternative sources of energy.
- Suggest how the two alternative sources may contribute to a sustainable energy future. Give evidence in support of your answer.
- You should show knowledge of what is involved with each of the two forms and how they may prove to be sustainable. The outline should show some understanding of these two ways, such as newly available areas, environmental benefits, or relative costs.

Level 3 (17 - 25 marks)	Good knowledge of two forms of alternative energy. Clear understanding of advantages/disadvantages related to both forms is shown, depending on choice. Good support is given for most points raised. Sustainability is fully understood and both forms viability as such is discussed.
Level 2 (8 - 16 marks)	Some knowledge of two forms of alternative energy. Understanding of advantages/disadvantages related to both forms is shown, depending on choice. Some support is given for most points raised. Sustainability is understood but both sources are not fully justified as being sustainable.
Level 1 (1 - 7 marks)	Limited knowledge of the advantages/disadvantages of the two sources of energy. Superficial understanding of sustainability, if any, given. Limited support given to justify ideas.