Edexcel IAL Geography

Energy Security

Detailed Notes

Energy Sources

There are many different sources of energy used across the globe. Energy sources can be categorised into three groups:

- **Non-renewable fossil fuels** like oil, gas and coal.
- **Recyclable fuels** like nuclear energy and general waste.
- **Renewable energy** like wind, solar and geothermal.

The use of each source varies between countries. This may be due to:

- The **financial cost** of producing a source
- The **technology** required to generate electricity from a source
- The availability of the source: can it be **locally extracted**, or **traded** by a neighbouring country?
- The 'popularity' or **reputation** of a source. Some sources are unfavourable for governments, the public or businesses.

For each primary & secondary source of energy below, some of these factors will be rated (out of five stars) for comparison.

Primary Energy Sources:

Primary energy sources produce energy by using a **raw material**. The **global energy mix** is **dominated by fossil fuels**, which come in three forms:

- **Coal**: 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.

Cost of Production*	⭑⭑⭑⭑⭑
Level of Technology Needed	⭑⭑ Mining is a relatively straight forward process, used since the 18th Century. Coal is burned (combustion) to heat water, which produces steam that turns a turbine within a generator.
Availability across the Globe	⭑⭑⭑⭑ Coal is one of the most abundant sources of fuel in the world.
Biggest Users of Source	China, India, Russia, Japan & the US account for 75% of global coal consumption
Link for more Info	Coal 101

** Based on the Levelised Cost of Energy (LCOE) for the US*

- **Petroleum (Oil)**: 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

Cost of Production*	⭑⭑⭑
Level of Technology Needed	⭑⭑⭑ Drilling can be relatively straightforward process to do if on land. However, if the oil is at sea, added risk demands greater technology to protect workers and the environment.
Availability across the Globe	⭑⭑ The supply of conventional oil is reducing due to over extraction in recent years.
Biggest Users of Source	China, India, Russia, Japan & the US consume 40 million barrels of oil per day. However, comparing consumption per capita, the largest consuming populations are actually Montserrat, Gilbralta and Singapore.
Link for more Info	Oil 101

- **Natural Gas**: 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.

Cost of Production*	⭑⭑⭑
Level of Technology Needed	⭑⭑ Drilling for natural gas is simple. However, refining natural gas involves removing sulfuric acids, water, mercury and then cryogenic distillation, which can be a hazardous and costly process.
Availability across the Globe	⭑⭑⭑⭑ Natural Gas is abundant and available for most countries.
Biggest Users of Source	1.US 2.Russia 3.Iran 4.Quatar 5.Canada 6.China 7.Norway 8.Netherlands 9.Saudi Arabia 10.Algeria
Link for more Info	Gas 101

Recyclable fuels are sources of energy were the source of fuel can be **replenished** or whose supply is affected very little. For example, only 10 tons of Uranium can produce 400 million kWh of electricity.

- **Uranium** - Has a 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.

Cost of Production*	⭑⭑⭑⭑⭑ Nuclear Power Plant = up to £37 billion (based on Hinkley Point C) Decommissioning Cost = $300 million per unit
Level of Technology Needed	⭑⭑⭑⭑⭑ Fission involves the splitting of Uranium-235 into daughter nuclei, which produces large amounts of energy. The monitoring, maintenance of conditions and prevention of explosion requires advanced technology & knowledge.
Availability across the Globe	⭑ Uranium-235 is rarely found naturally and is mined in Canada, Russia and Sub-Saharan Africa.
Biggest Users of Source	France, Slovakia, Ukraine and Hungary rely most of Nuclear for their energy production
Link for more Info	Coal 101

- **Biomass** (May also be secondary): 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 biodiesel. Overall **decrease** in use on a global scale.

Cost of Production*	⭑⭑
Level of Technology Needed	⭑⭑ Biomass can be converted into energy through combustion, in a similar way as coal.
Availability across the Globe	⭑⭑⭑⭑⭑ All countries can grow crops or produce food waste that can be burned as fuel.
Biggest Users of Source	Brazil & Germany
Link for more Info	Biomass 101

Finally, there are several processes of generating energy from naturally occurring resources. These **renewable sources** do not use up any of the source - the Sun's energy doesn't decrease as a result of solar panels!

- **Hydroelectric Power (HEP)**: 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.

Cost of Production*	⋆⋆⋆⋆ A 500kW hydroelectric dam can cost on average £1.6 million
Level of Technology Needed	⋆⋆⋆⋆ The dam contains turbines that generate electricity. It is relatively straightforward to construct, but demands a high level of technology to monitor water levels and control flow through the dam, hence preventing damage.
Availability across the Globe	⋆⋆⋆ HEP is available for countries with rivers and mountainous terrain, to create a difference in height.
Biggest Users of Source	China is the largest producer of HEP, with many dams including the Three Gorges Dam
Link for more Info	Nuclear 101

- **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.

Cost of Production*	⋆⋆⋆
Level of Technology Needed	⋆⋆ Photovoltaic cells are advanced in generating electricity and heat energy for homes and businesses.
Availability across the Globe	⋆⋆⋆⋆ Nearly all countries can generate some energy from solar radiation, especially countries that lie across the Equator. Countries do not need to have direct sunlight all the time, but the cost of the panels for domestic use limits its use.
Biggest Users of Source	The world's biggest solar farms are found in Morocco, India & China.
Link for more Info	Solar 101

- **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.

Cost of Production*	⭑⭑
Level of Technology Needed	⭑⭑⭑
Availability across the Globe	⭑⭑⭑ Wind speed must be above 11km/hour for sufficient power generated, therefore are mainly found out at sea or in areas with wind speed on average above 11km/hr.
Biggest Users of Source	US, China, Spain, Germany, India
Link for more Info	Wind 101

- **Wave**: Very low generation though the **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.

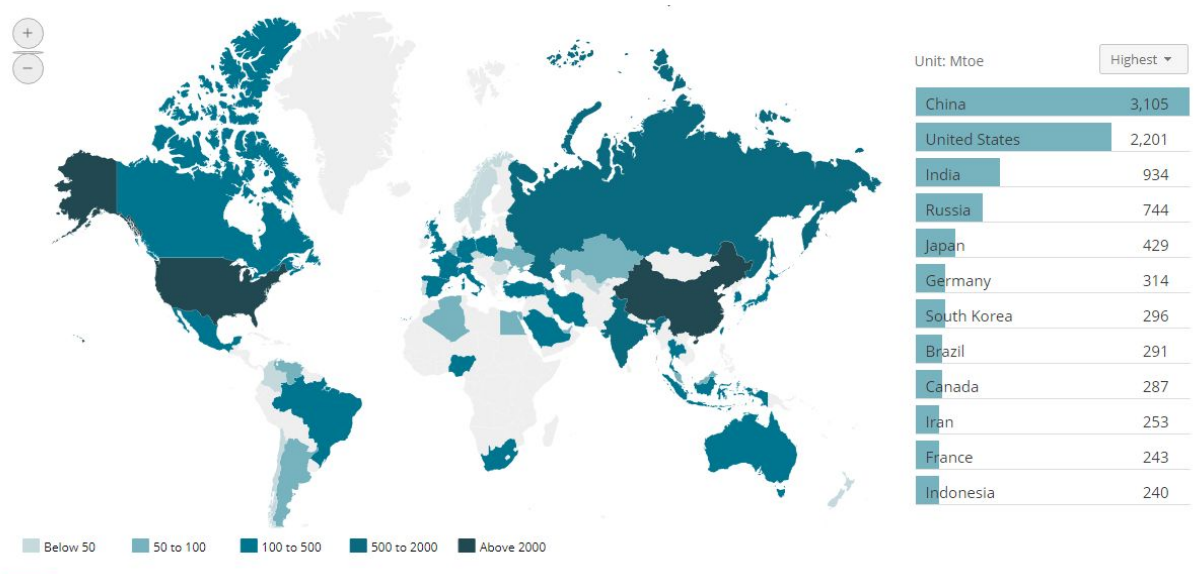
Secondary Energy Sources:

Secondary sources are **modified primary energy sources** which are easier to use. Secondary sources include:

- ➔ Petrol & Diesel, from Oil
- ➔ Biodiesel, from biomass
- ➔ Hydrogen, from water
- ➔ Electricity

Global Energy Consumption

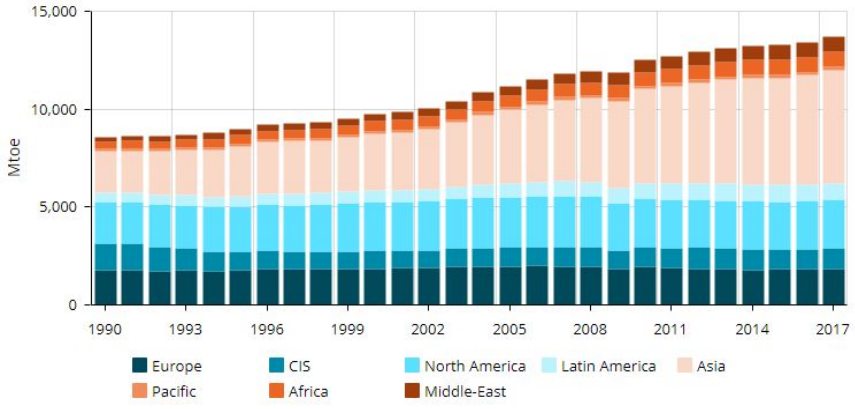
Global energy consumption varies, but is generally **higher in northern hemisphere countries**, which are more developed.

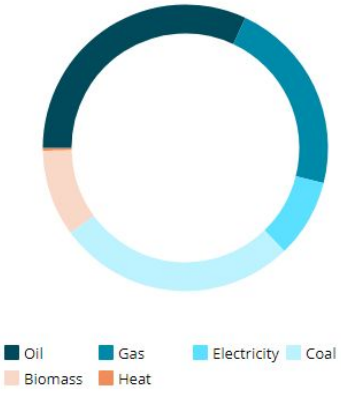


Global energy demands and trends by type of energy production methods are shown in the graphs. You can explore more using these links:

[Global Energy Facts](#)
[Energy Systems Map](#)

[Global Energy Use](#)
[Carbon Impact Map](#)



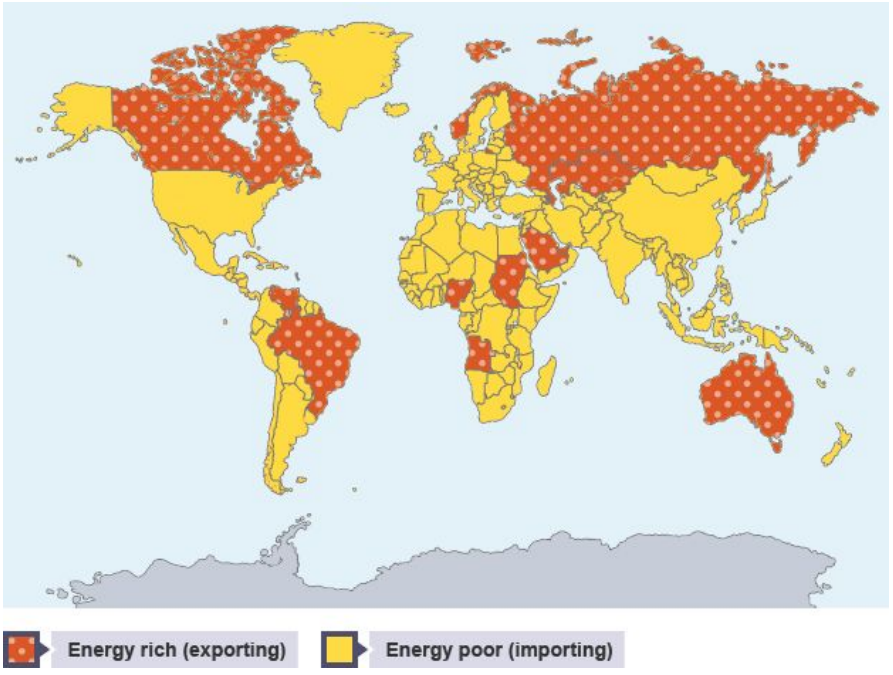


Energy Security

Energy security is how accessible energy resources are: financially affordable, physically available or the amount of trading required to meet demand.

Countries with little energy security may:

- Use **expensive sources**, raising the cost of electricity beyond what the population can afford
- Sources are **intermittent**, such as wind, solar or biofuels (if crops fail). The country may have a **low base flow** of energy - the amount of energy supplied to the national grid steadily.
- There are little resources available to generate electricity
- A developing country has **limited technology** to access resources or generate electricity
- Countries are dependant on others to **trade** for energy



Different countries have different resources available to **exploit**, which can create **inequality** in the supply of energy across the world. Some countries have many resources, which they can sell to make profit (e.g. Russia), they are called **energy rich countries**. Others may have little to use and rely on buying energy from others (e.g. some european countries), called **energy poor countries.**

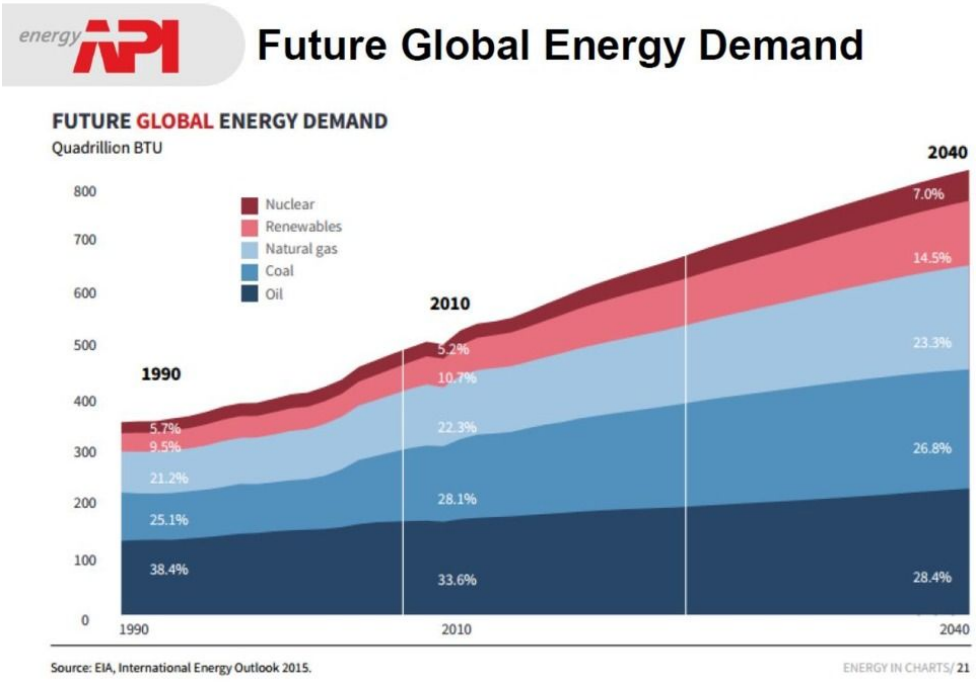
Future Global Energy Demands

The demand for energy is going to **increase** over the next few decades. The primary reason is because the **global population is increasing**, with an additional 1 billion people populating the planet in the next 10 years.

Demand will increase for both emerging and developed countries, for different reasons:

- As families become **more wealthier**, they have more **disposable income** to spend on consumable goods. These **consumable goods** may use energy - electrical appliances such as TVs, mobile phones or online gaming - or use energy to produce them.
- As the **global middle class** continues to grow, the consumption of goods that improve the quality of life such as dishwashers, telephones and electric or gas cookers.

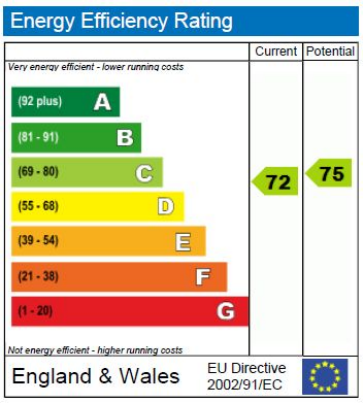
- As industry increases, **manufacturing** and energy consumption will also increase. Industrial carbon emissions is likely to increase also.
- The **volume of vehicles** will increase as families can afford to run their own car/bike/tractor, fuel (diesel or biofuel) becomes more widely available and the need to commute for work increases.



- Developing countries may exceed developed countries in their demand for energy because developing countries have the potential to develop their technology to increase efficiency.

However, demand may reduce as **technology advances** and the **efficiency** of appliances increases, for example:

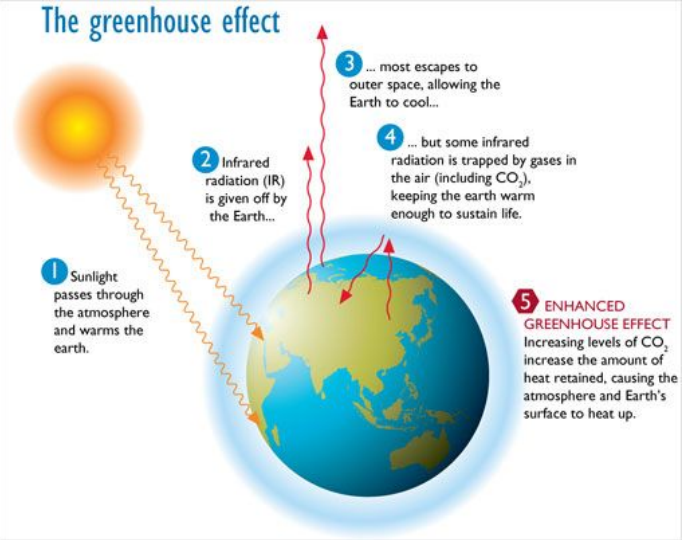
- **Energy efficient light bulbs** - lighting accounts for 15% of a domestic energy bill, and so replacing traditional bulbs to LEDs can save £35 of energy for a UK household.
- Insulation built into houses can **reduce heat loss**, and so reduce energy loss. Insulation may include:
  - using **cavity walls**
  - laying fibre-glass insulation in your loft
  - **draft proofing** doorways and windows
  - replacing windows with **double or triple glazing units**
- Choosing appliances with good efficiency ratings, such as A, A+ or A++



Environmental Implications

Increasing the energy we use does not have **direct implications** on the environment. However, the process of **generating electricity** can have large implications on the environment and global climate.

The primary method of generating energy involves the **combustion** of fossil fuels. Fossil fuels are a store of **terrestrial carbon**, locked up for thousands of years. Since the 1980s, **75%** of carbon emissions have come from **burning fossil fuels**. The combustion of fossil fuels releases carbon dioxide, as well as **sulfur and particulates** being released. This contributes to the **Enhanced Greenhouse Effect**.



Carbon emissions have the largest impact on our environment in the present day. High levels of carbon dioxide in our atmosphere can lead to:

- **Climate Change** - **Global average temperatures** are increasing and the climate of some countries are changing. For example, semi-arid climates such as central Africa will become arid, through **desertification**. Alternatively, maritime climates such as the UK are expected to receive more precipitation annually and experience more **low-pressure weather** systems.

- **Wildlife and biodiversity** is at risk. As climates change, the conditions that a species has adapted to will also change. Fo example,
    - With melting glaciers and ice caps in tundra biomes, many species such as polar bears and seals have further to travel swimming and some species lose their camouflage (e.g. Lynx & Arctic Fox). More species at risk in the tundra here.
    - Marine organisms such as molluscs and types of sea snail may struggle to form shells with limited oxygen available in the ocean water. Also, corals are bleaching; as oceans become more acidic, **corals** cannot absorb alkaline **CaCO3** in order to maintain their skeletons, in turn reefs begin to **dissolve**. Algae provide food to corals through **photosynthesis**. If the water becomes warm enough, the algae leave the coral, leaving the coral to turn white **(Coral bleaching).**

- **Ocean Acidification** - some CO_2 from the atmosphere will naturally by **dissolving** into the water. This process occurs on the surface of the oceans where CO_2 reacts with water to form **carbonic acid**. As the concentration of CO_2 in the atmosphere increases, oceans absorb more CO_2 causing them to become more acidic. This **acidification of the oceans** could have long lasting negative effects. This movement of CO_2 isn't one way, some will go from the water back into the atmosphere.

Other sources of energy (besides fossil fuels) can have environmental implications.

Nuclear plants are a source of radiation, with most plants minimising the amount of radiation released into the surrounding environment. However, **nuclear disasters** can release vast amounts of radiation into the atmosphere - Chernobyl is said to have caused 985,000 deaths from cancer caused by radiation, and the Fukushima Disaster spread 1500 kilometres within a couple of years.

Biomass is sometimes referred to as '**carbon neutral**'. This is because the same amount of carbon taken in through the crop's **photosynthesis** is released during **combustion**, so there is little **net output of carbon**. However, this does not consider the process of growing the crops, which can be costly to the environment and produce carbon emissions:

- The land cleared for biofuel crops may involve the **removal of vegetation** and trees, more long-term stores of carbon. Also, if the land has been cleared using **slash-and-burn techniques** then carbon emissions will be released.
- **Fertilisers** can release greenhouse emissions. If the water is treated before used for irrigation, then energy is consumed to produce clean water.
- The **logistics of transporting** the goods and machinery used to tend to the crops both produce carbon emissions, by **burning fuels**.

SWOT Analysis for Biofuels	
Strengths - Renewable energy source. - Lower emissions (carbon neutral) than fossil fuels. - Can be grown very easily.	**Weaknesses** - Takes land that food can be grown on. - Requires fertilizers and pesticides. - Requires large volumes of water - Loss of carbon sinks as forest destroyed to make way for plantations.
Opportunities - Provides rural inward investment and local development projects. - Positive multiplier effect. - Fuel earns export income.	**Threats** - Biofuel production will reduce food production, leading to future insecurity. - Water sources may become contaminated with chemicals. - Where a biofuel source is also a food supply, food prices can increase when shortages occur.

Providing Energy Security

Energy Players

There are **key players** who have important roles in **securing energy pathways** and controlling prices.

- They explore, **exploit** and distribute energy resources.
- They own supply lines and **invest** in the distribution and processing of raw materials.
- They **respond** to market conditions to increase the profits.

Most **energy players** are TNCs although there are exceptions such as Russia's state run Gazprom. Some names of key energy players include:

Saudi Aramco, Russian Gazprom, BP (UK), Shell (UK-Netherlands), ExxonMobil (USA), Petrobas (Brazil), Gazprom (Russia), PetroChina (China).

TNCs are the most prominent energy players for a variety of reasons:

- Some TNCs have more **economic value** than a small country, enabling the company to take action and invest in **large-scale projects** that a country may not afford.
- TNCs can **bypass political tensions** and access sources otherwise restricted to other countries. In certain parts of the world, an MEDC trying to help to exploit an energy source in an LEDC could be seen as a **direct threat** to the LEDC.

- TNCs may be inclined to **invest in local infrastructure**, logistics and development of workers' villages. This benefits all; the TNC benefits from faster transport links and a happier workforce, whilst the government receives 'free' investment.

Ofcourse, TNCs aren't always beneficial; TNCs may encourage **environmental degradation**, exploiting workers, **unsustainable** transportation (e.g. tankers liable to oil spills).

OPEC

OPEC is an IGO that with member countries which **export oil and petroleum**. OPEC producers control **81%** of the world's discovered oil reserves. Their mission is to unify the petroleum policies of its members to ensure the **stabilisation of oil markets.** They also want to create:

- an efficient and **regular supply** of oil to consumers.
- a **steady income** for producers.
- a fair return for those investing in the industry.

In the past, OPEC set quotas depending on the condition of the world economy. Supplies were boosted when demand rose whilst supplies were cut if demand fell.

Between 2012-2016, oil output was kept high to compete against the USA which produced vast amounts of oil through **fracking**. The flooding market caused a **collapse in global oil prices**. OPEC has also been accused of holding back production in order to increase prices and in turn increase profits for oil exporting nations. This can be detrimental to developing countries, who need vast, cheap amounts of oil to continue **economic development** and manufacturing.

National Governments

Governments try to **secure energy supplies** for their country and they also **regulate** the role of private companies. EU governments are trying to **reduce CO_2 emissions** and reduce **dependency** on fossil fuels.

Consumers

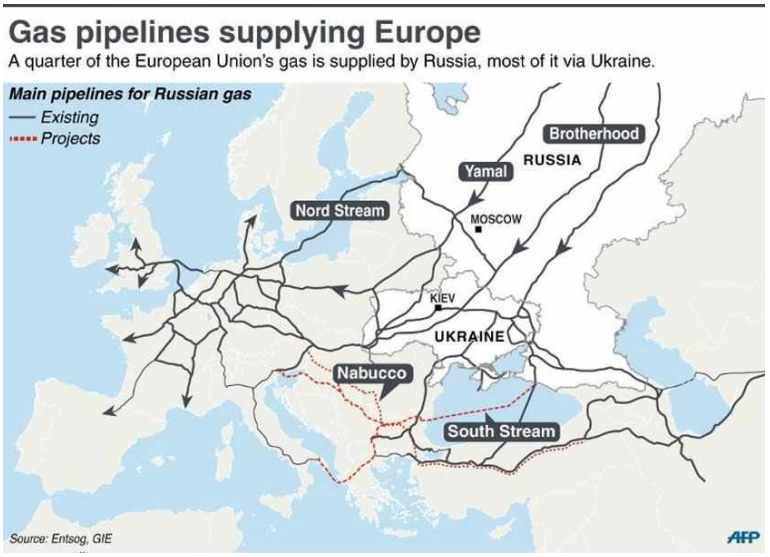
Consumers create **demand** with purchasing choices usually based on price. As a country becomes richer and more educated, the population can **change their shopping habits** to reflect their needs: locally sourced, environmentally friendly, reliable energy supply during winter and extreme weather.

For example, lots of energy companies now have **tariffs** on **imported or non-renewable sources** to reduce energy insecurities or **carbon-offset** their energy. Here, money raised on non-renewable energy can fund environmental work such as afforestation, research into carbon capture and storage, etc.. If consumers change their spending habits and only use these tariffs then companies will be encouraged to move towards more **green energy**. Consumers can have an impact on TNCs.

Energy Pathways

There are many ways of transporting energy between countries. Here are some **energy pathways**, and their weaknesses.

- **Pipelines** are **efficient** in carrying billions of m^3 of oil across the world between countries. Many of these pathways depend on **international agreements**, so influence global politics.
- Around half of the world's oil is transported using **oil tanker** though **choke points** (a key point in the logistics of energy, which can easily be disrupted). If choke points become blocked or threatened, then oil **prices can rise** very quickly and political tensions escalate. In the map below, Ukraine is considered a choke point in the EU's supply of oil - most pipelines from Russia run through Ukraine, and with increasing uncertainty in Ukraine relations with Russia, the EU's supply could become increasingly insecure.



Political Conflict

Conflicts and political altercations can severely limit energy security. For example, military conflict can destroy **infrastructure** which will restrict the flow of energy from source to use.

Disagreements between nations can also limit energy security. This is the case for Russia, who have several **political sanctions** against them. As Russia is a major supplier to Europe, this has caused some **shortages** in electricity.

Alternative Energy Sources

Within the last decade, new and unconventional energy sources have become more realistic. Some alternative sources aim to **increase the supply** of fossil fuels, keeping energy prices low and improving energy security. However, some new alternative sources aim to **reduce CO_2** and greenhouse gas emissions whilst still meeting demand.

With increasing energy **demand**, but dwindling energy source supplies, investment by TNCs and energy players must be made in **alternative sources**. For some, alternative fossil fuels could be used to meet this demand.

Tar Sands

The biggest deposits of tar sands in the world can be found in **Canada**. Commercial scale exploitation of these sands began in 1967 in the Province of Alberta and they currently produce up to **40%** of Canada's oil output.

Most tar sands are extracted through **open-cast mining**; similar to a quarry, there are no underground tunneling and instead, all work is visible from the surface.

1. **Remove all trees and vegetation** and dig up the tar sands beneath.

2. Boil the sands, so the **bitumen** melts away from the soil particles. Extract this bitumen and mix with **diluting chemicals**
3. Bitumen is refined into **synthetic crude oil**. It takes two tons of tar sands to produce one barrel of synthetic crude oil.

Benefits of Tar Sands	Costs of Tar Sands
- Provides an alternative source of oil. - It could help meet 16% of North America's oil demand, which will help to ensure **energy security** for the USA and Canada. - Provides **revenue** for local communities, through jobs, and national governments, through taxes. - Estimated **1.7 trillion barrels** could be produced using tar sand sources.	- Only viable opt when crude oil price exceeds $40/barrel. - **Expensive** process - requires substantial amount of water and energy. - 1.8 million tonnes of **toxic water** produced daily, plus additional waste and atmospheric toxins. Produces greenhouse gas emissions. - Forest land destroyed, often home to **indigenous communities**. - Loss of **carbon sink**, as fewer trees to absorb CO_2

Shale Gas

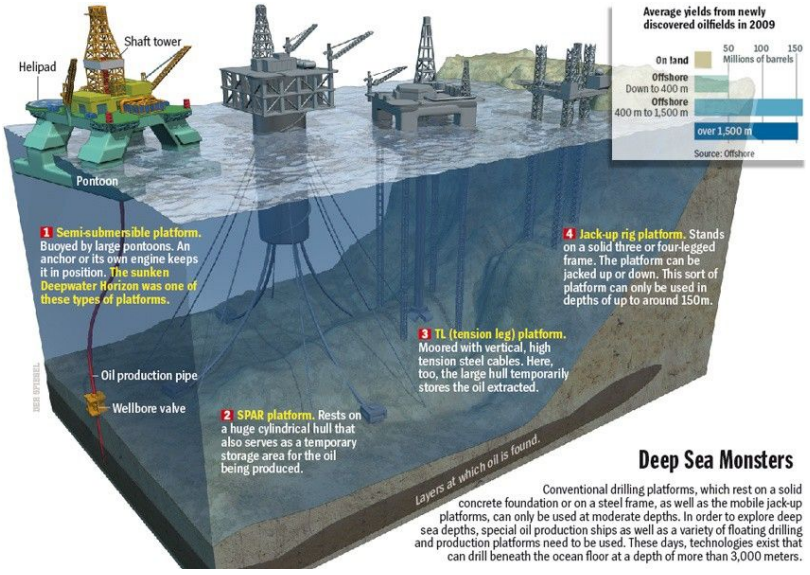
In 2000, 1% of the USA's gas supplies came from shale gas; by 2015 this increased to 25%. The increased production of shale gas has come from the growing use of **hydraulic fracking**.

Hydraulic fracking involves pumping **highly pressurised liquid** into the ground, to form **fractures** in the bedrock. The shale gas is then released and emitted through these fractures. Most fracking is vertical, with the liquid forced downwards from surface to bedrock. However, recent advancements have developed **horizontal fracking**, reducing the number of sites on the surface and increasing the availability of shale gas.

Benefits of Shale Gas	Costs of Shale Gas
- **Large quantity** of shale gas is available with current technology. Shale Gas could provide half of the US's gas demand by 2020. - Shale gas is cleaner and **less environmentally degrading** than coal production. - Shale gas involves a small area of land on the surface, and so has a smaller impact on the natural environment on the surface than tar sand production. - Shale gas industry provides **half a million jobs** per year.	- Through fractures, excessive **methane** could be released which could accelerate Global Warming. - Hydraulic fracking faces much opposition, as it has been linked to causing **small earthquakes.** - It is not well known whether the pressurised liquids contaminate water sources. During fracking, the fluids become **briney** (high salt content) and full of **bacteria and metals**.

Deep Water Oil

Huge oil deposits were found off the coast of **Brazil** in 2006 and as Brazil is an emerging power, its demand for energy is growing rapidly. Similarly, **Mexico** has reserves of deep water oil, which they intend to sell to the USA for economic gain.



Source: https://medium.com/

The extraction of deep water oil is similar to conventional oil drilling. However, there are **greater challenges** with drilling and extracting at greater depths in the ocean.

Benefits of Deep Water Oil	Costs of Deep Water Oil
- Improves the supply of oil, which many appliances and vehicles use. **No adaptation** to existing technology is required to burn deep water oil. - Provides many **jobs**, some skilled for locals. There can be entire villages of workers dedicated to the running of one rig. - The countries that have deep water oil tend to be developing, and so the **increased wealth** produced by selling oil can lead to **rapid development**.	- Due to the **large distance offshore** that rigs are built at, accidents are more **hazardous** and there is a delay for emergency services to get to the rig. - Extraction and transportation can lead to **oil spills**, which are hazardous for the environment and pollutes waterways. - **Small earthquakes** caused by drilling into the seabed are said to interfere with marine life, and may cause dolphins and whales to beach themselves.

Reducing Carbon Emissions

There are several strategies to try to take some CO_2 out of the atmosphere or reduce emissions. However, these tend to be **expensive** and must be carried out on a **national scale** to take effect.

Carbon Capture and Storage (CCS) is a technological strategy used to capture CO_2 emissions from coal fired power stations. The gas collected from the power plant, **compressed and stored** into underground aquifers or disused mines. CCS could help to reduce carbon emissions by **19%** but due to their cost, only 1 scheme exists currently.

Hydrogen fuel cells provides an alternative to the use of oil. Hydrogen is the most abundant element in the atmosphere but it usually combines with other elements, especially carbon. Therefore Hydrogen needs to be separated and stored before use. **Fuel cells** convert chemical energy found in hydrogen into electricity and this produces pure water as a by-product. These fuel cells are much more efficient than petrol engines in vehicles.

Solar Radiation Management is an engineering approach to reduce solar radiation becoming trapped within the Earth, and so reduce Global Warming. There are several strategies to solar radiation management, all of which involve reflecting solar radiation back into space rather than letting it pass through the atmosphere:

1. **Spray seawater** into the atmosphere - the water will condense to form clean clouds. The whiter and cleaner the cloud the produced, the more reflective the cloud will act.
2. Pump **sulphur particles** into the stratosphere
3. Construct little **wafer-thin discs** and put them into **geostationary orbit** around the Earth - the discs will block some solar radiation and be far enough outside the Earth's atmosphere to have no direct effect on living conditions on Earth.

Solar radiation management may be the most effective theoretically at maintaining global climates. However, the suggestions are international projects (difficult to manage) that cost billions of dollars.