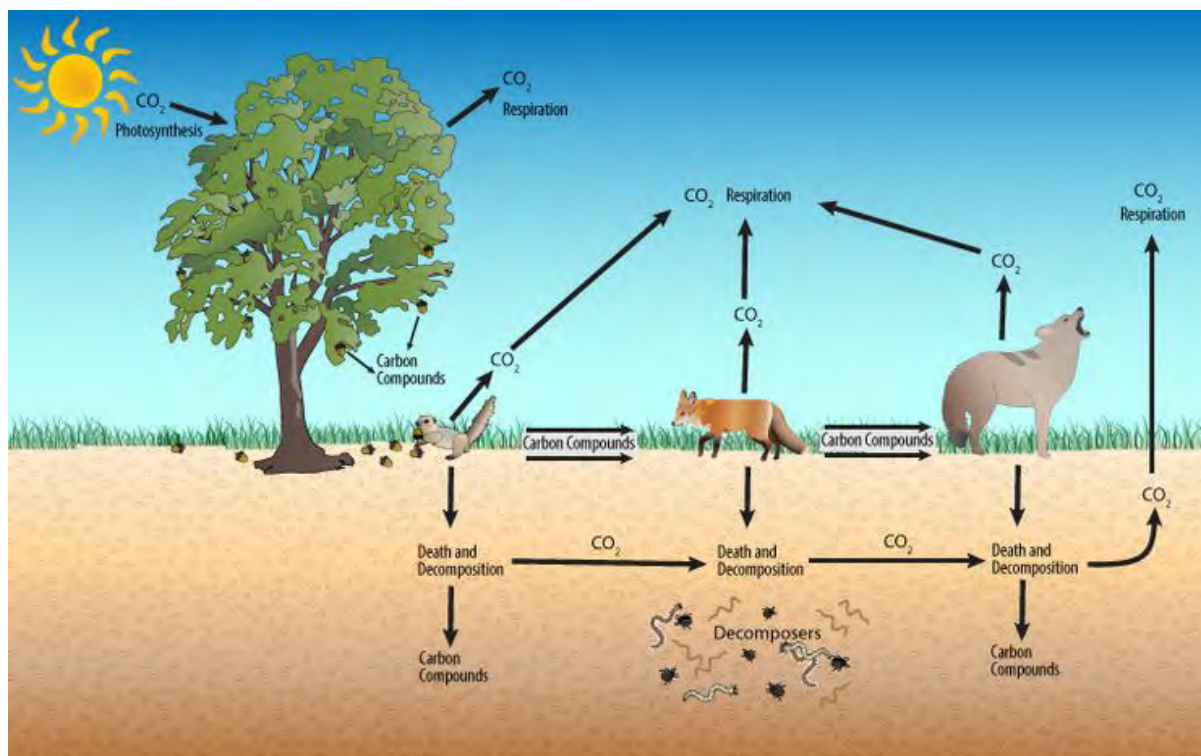


Edexcel Geography A-level

The Carbon Cycle and Energy Security **Essential Notes**

The Carbon Cycle

- The carbon cycle needs to be balanced to support **planetary health**. Physical processes control the movement of carbon between stores on **land, the oceans and the atmosphere**.
- Most global carbon is locked in **terrestrial stores** as part of the long-term geological cycle. Yet, reliance on fossil fuels has caused significant changes to carbon stores and amplified climate change.
- There is a consensus that **anthropogenic climate change** (caused by human activities) poses a great threat to the planet's health and is caused by accelerating some parts of the carbon cycle, leading to **imbalances**.



Source: <https://serc.carleton.edu/eslabs/carbon/1a.html>

- The natural carbon cycle consists of carbon stores of different sizes; the terrestrial (earth), oceans and atmosphere. There are **annual variations** between stores of varying sizes and rates.
- Most of earth's carbon is **geological**, having formed from **sedimentary carbonate rocks** in the oceans and biologically derived carbon in shale, coal and other rocks.
- In the sea, **marine animals** convert some of their carbon in their diet to **calcium carbonate**, used to make shells. Overtime, these shells collect on the sea bed and form limestone which, when exposed to air, become **weathered** and release carbon dioxide back into the atmosphere.
- Geological processes also release carbon into the atmosphere through **volcanic outgassing** at **ocean ridges** and **subduction zones** as well as from the chemical weathering of rocks, creating a global balance of carbon.
- Carbon enters the atmosphere as **carbon dioxide** from **respiration and combustion**. It is absorbed by producers via **photosynthesis**. Animals consume plants and the carbon

compounds travel through the **food chain**, released via respiration. The animal dies and is eaten by decomposers which return the carbon to the atmosphere.

Biological Processes

- **Phytoplankton** absorb atmospheric carbon during photosynthesis in surface ocean waters. Carbonate shells move into deep ocean water through the **carbonate pump** (the cycling of organic matter in the ocean) and action of the **thermohaline circulation** (the movement of seawater according to temperature).
- Terrestrial primary producers sequester carbon during photosynthesis which is then returned through respiration of consumer organisms.
- Biological carbon is stored as **dead organic matter** in soils and returned through biological **decomposition and respiration** by decomposers, forming the final component of the carbon cycle discussed above.



Anthropogenic (Human) Influence on the Carbon Cycle

- The concentration of carbon in the atmosphere influences the natural greenhouse effect which is enhanced by **fossil fuel combustion**. The natural greenhouse effect is vital in regulating earth's temperature and precipitation but anthropogenic climate change has altered the balance of carbon pathways and stores, having implications on **climate, ecosystems** and the **hydrological cycle**.
- Ocean and terrestrial photosynthesis **regulate the composition** of gases in the atmosphere.
- Soil health is influenced by stored carbon which is vital for **ecosystem productivity**, and so the intake of carbon dioxide through ecosystem photosynthesis. **Deforestation** interrupts this natural regulation by causing soil erosion.

Energy Security & Demand



- **Primary energy** sources are the natural sources found naturally, such as coal, oil and gas. **Secondary energy** converts these sources into other forms, such as electricity, for convenience and easy use.
- A rich **energy mix** is made up of domestic and foreign sources; a country will have its own energy sources as well as importing from other nations, having a diverse mix of renewable and non-renewable sources.
- Energy consumption is greater for **newly industrialised countries**, such as India and China, whilst countries in the later stages of **The Demographic Transition Model** (being more developed) will be more sustainable and conscious of their consumption.

- Access and consumption of energy resources depends on:
- **Physical Availability:** Fossil fuels, solar, wind, tidal and geothermal power depend upon location. Large power stations require flat and stable land to function correctly. There is a mismatch between locations that are abundant in fossil fuels and places which have high demand.
 - **Cost:** As supply decreases, costs increase. Prices are constantly fluctuating. Onshore oil deposits tend to be cheaper than offshore whilst HEP sites situated near transport routes will be more economical.
 - **Technology:** New technological developments have allowed oil to be extracted from deeper and more technically difficult environments. There are plans to extract oil from tar sands in Canada and Venezuela.
 - **Public Perception:** There are cultural preferences around the world, some may be reluctant to adapt to new technology, such as the Amish tribe. Others have doubts over nuclear power after Chernobyl.
 - **Level of Economic Development:** France can afford 78% of its energy to come from nuclear sources whilst poorer regions, such as Ethiopia, use sources like dung and crops for energy. It may be free but combustion of these sources can cause serious health effects.
 - **Environmental Priority:** Some states - through public lobbying and government policies - aim to become completely renewable and self-sufficient (e.g. Germany, Costa Rica, Denmark). Other governments prioritise the use of cheap fossil fuels to accelerate their economic development (e.g. China)



- Energy players have different roles in **securing pathways** and energy supplies. Energy TNCs, such as Shell, are incredibly **profitable** but are **challenged** by the recent rise of OPEC and other environmental groups.
- **OPEC** consists of 12 oil producing countries founded in 1960. They aim to **stabilise oil prices** whilst limiting environmental damage. Though they help compensate the poor and reduce environmental degradation for energy, significant energy producers (e.g. Russia) refuse to be part of the bloc.
- Governments can influence **conservation** through movements such as increasing taxes for large emitting companies. Consumers have a role in voicing their needs through **protests**, such as the UK riots over mining in the 20th century.



Reliance on Fossil Fuels

- Energy pathways, which can be **pipelines, transmission lines or shipping routes**, are vital in transporting energy sources from producers to consumers. These pathways can become high-risk, prone to **piracy, theft, disruption and damage**.
- One high-risk pathway is the pipeline connecting Europe to Russia. Russia's energy company, Gazprom, is a state owned company and one of the country's best assets. However, in 2006, Gazprom quadrupled the price of gas for Ukraine and then in 2009, Gazprom completely stopped supplying gas, claiming that Ukraine failed to



pay in time. This caused a two week dispute and led to a 16% increase in gas prices for the UK as gas passes through Ukraine to reach the UK.

- In 2007, Belarus cut off Russia's oil pipeline because of the high prices Russia demanded. This affected Germany and Poland, the latter being 96% dependent on imports.
- **Accidents** can also cause disruption, such as the Buncefield Oil Depot fires. It is likely that as supply decreases, more conflicts and tensions will arise, slowing the flow of energy between producers and consumers.

Alternative Energy Sources & Pathways

With the **rising political tensions** causing energy insecurity and conflict, some have looked to **unconventional fossil fuels**. However, some wish to stop using fossil fuels to gain energy security, instead looking towards **alternative renewable solutions**.

Unconventional Fossil Fuels

- The development of unconventional fossil fuel energy resources, such as tar sands, oil shale, shale gas and deep water oil, have a myriad of **costs and benefits**:
 - **Tar Sands in Alberta**: There are rich tar deposits within Canada which could **reduce the nation's dependency** on imports whilst providing 33,000 jobs. However, the extraction method for one barrel of tar sand oil is 3 times more **energy extensive** than producing one barrel of conventional oil. The process is also **water intensive**; each barrel of oil needs 4 barrels of water which then becomes **polluted** and cannot be reused. The extraction of tar sands would result in the **removal of The Boreal Forest**, which is home to 45 unique species.
 - **The Arctic Circle**: Estimated that **25% of the world's undiscovered oil and gas** are present under this **pristine environment**, which would evidently be destroyed and degraded. There are **territorial claims** involving Russia so future exploration could cause serious competition and so tensions and political conflicts. There are also high risks of **oil spills** in logistics.

Alternative Energy Sources

- Renewable and recyclable energy, including nuclear (as uranium is reused), wind and solar power, could reduce reliance on fossil fuels but come with their own costs and benefits. Ideally, a diverse mix of sources is needed for energy security.
 - **Nuclear Power**: Zero greenhouse emissions and reduced reliance on fossil fuels but **toxic waste and nuclear disasters** such as Chernobyl causes dislike amongst the public. New fast breeder technology will increase production but is based on some aspects of a nuclear weapon, further harming its **perception**.
 - **Solar Power**: This is **location dependent**, suitable for deserts. Solar power heats and provides air conditioning in the Mediterranean. It is expensive but a long-term option.
 - **Wind Power**: Costs 10% of what it did 20 years ago. **Prices will decrease** further as new technology is created. There are issues of **NIMBYs** but this is now controlled due to new developments, such as the mega-watt turbine, which is more efficient, less noisy and more visually pleasing. Wind turbines do impact property levels, affect TV reception and **work better offshore** albeit this being expensive and disruptive to radar signals.

- **Biofuels** are increasing globally but have **implications over food security** as land is used to grow biofuels instead of food crops, having led to previous **riots** in Mexico and India as food prices have consequently increased. There are also debates over the **carbon neutrality** of biofuels as carbon is emitted in the transportation and production of biofuels.

Radical Technology

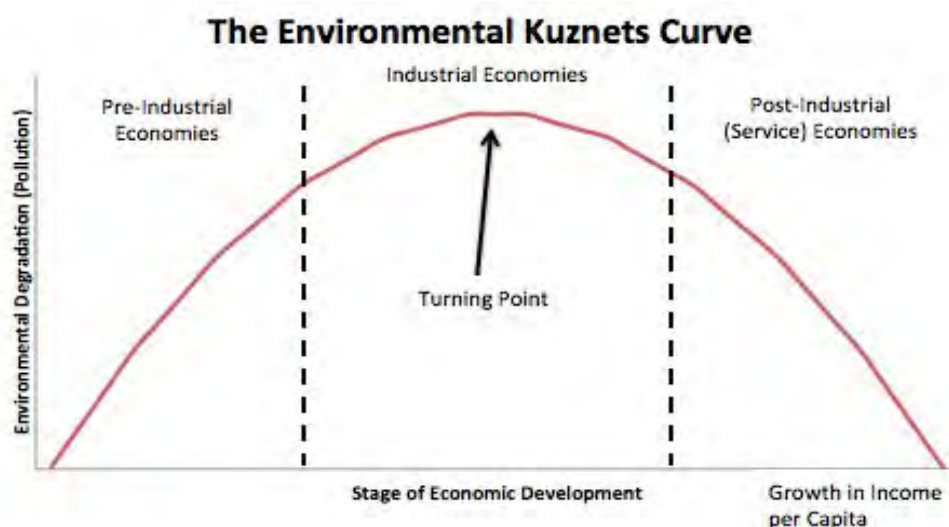
- Radical technologies include **carbon capture and storage (CCS)** and alternative energy sources such as **hydrogen fuel cells** and electric vehicles. These could reduce carbon emissions but great **uncertainty** exists over their effectiveness and ability to work.

Water Cycle & Carbon Cycle

- As population has **grown exponentially**, there has been **growing demand** for food, fuel and other resources globally. This has led to contrasting regional trends in land use cover as **deforestation, afforestation** and conversion of **grassland to farmland** has affected terrestrial carbon stores. This affects the water cycle and soil health.
- **Ocean acidification** refers to the reduction in the pH of the ocean due to the uptake of carbon dioxide from the atmosphere. The ocean's role as a **carbon sink** is increasing due to surges in fossil fuel combustion which has caused a decline in the **health of coral reefs and other marine ecosystems**.
- Climate change, due to the enhanced greenhouse effect (which is largely anthropogenic), may increase the **frequency of extreme weather events** such as droughts and floods because shifts to the climate belts. This is likely to impact the health of forests as carbon stores, as well as pressure from the human population on existing resources..

Implications for Human Wellbeing

- **Forest loss** has implications on human wellbeing. Forests provide shelter, forestry, food, medicinal plants and stabilise the earth and atmosphere.
- Though deforestation is a growing problem in developing countries, there is evidence to suggest that forest stores are being more consciously protected and expanded.
- This is especially the case for more developed countries, such as the UK, where **conservation** is a governmental priority. Additionally, schemes such as 'debt for nature swaps' help to conserve forest stores in developing countries.
- These trends support **Kuznets' Curve model** which concludes that, as a country's GDP and development improves past the **turning point**, they will take more actions to conserve and protect the environment.



- Increases in temperature affect **evaporation rates** and the quantity of water vapour in the atmosphere. This has implications on **precipitation patterns, river regimes and water stores** which can affect the amount of water available for human consumption.
- Rising temperatures will mean that less water is stored in the **cryosphere**. Melting of glaciers will lead to flooding and a loss of freshwater. This will be detrimental for locals who rely on freshwater from glaciers, such as the Himalayan tribes. It must however be remembered that great **uncertainty** lies in future predictions and impacts.
- Threats to ocean health can impact the **fishing industry, tourist industry** and spoil coastal protection **defences**.

Future Risks, Players and Scales

- Future emissions, atmospheric conditions and climate warming are **uncertain** due to natural factors, such as the role of sinks, and human factors such as the rate of economic growth, population and energy sources.
- The role of **feedback mechanisms** and **tipping points** which can amplify change are also unknown.
- **Adaptation strategies** for a changed climate involve water conservation, resilient agriculture schemes, land use planning and solar radiation management. Yet these vary in effectiveness, cost and have secondary impacts, such as a reduction in food production and water availability.
- The carbon cycle could be **rebalanced** through **mitigation techniques** such as carbon taxation, renewable switching, energy efficient and CCS but these require **global management and player integration**.