Sample Essay scoring 9/9

Evaluate the effectiveness of different energy sources in mitigating climate change on a global scale.

[9]

Climate change is largely caused by the burning of fossil fuels, which releases greenhouse gases (GHGs) such as carbon dioxide (CO_2) and methane (CH_4) into the atmosphere. Energy production accounts for about 75% of global CO_2 emissions, so shifting to low-carbon energy sources is essential. This essay evaluates the effectiveness of renewable energy (solar, wind, hydro, and biofuels) and low-carbon non-renewables (nuclear and natural gas) in mitigating climate change, considering their strengths and limitations.

Renewable energy is widely seen as the best long-term solution to reducing emissions. Solar power, for example, is a zero-emission energy source that has become more affordable in recent years. China, the world's largest emitter, has rapidly expanded solar power, now releasing almost 900 GW of energy, reducing its reliance on coal. However, solar energy is intermittent, meaning it only produces electricity when the sun is shining. This creates a need for battery storage or backup power, which adds costs and infrastructure challenges.

Similarly, wind power is another zero-emission source that has been effective in countries like Germany, where wind farms generate nearly 30% of electricity. However, wind energy is also weather-dependent, requiring storage solutions or backup energy from other sources. While both solar and wind are crucial for reducing emissions, their variability limits their reliability without further technological advancements.

Hydropower is a more stable renewable source, as it generates electricity continuously using flowing water. Norway generates the majority of its electricity from hydropower, mainly through large-scale projects like the Ulla-Førre hydropower complex. This makes Norway's electricity sector almost carbon-neutral. However, hydropower can cause severe environmental disruption. In Norway, damming rivers has altered fish migration patterns and reduced biodiversity in affected areas. Additionally, climate change is causing unpredictable rainfall patterns, which may reduce the reliability of hydropower in the future.

Biofuels, made from organic material, are often used to replace fossil fuels in transport. While they emit less CO_2 than gasoline, growing biofuel crops requires large amounts of land, sometimes leading to deforestation, which offsets their climate benefits. The expansion of soybean biofuel production in Brazil has been linked to deforestation in the Amazon, worsening climate change rather than reducing it.

Nuclear power is one of the most efficient low-carbon energy sources. It provides stable, large-scale electricity without producing CO_2. France generates about 70% of its electricity from nuclear, resulting in a low carbon footprint. However, nuclear power is controversial due to the risk of accidents, such as the Fukushima disaster in Japan (2011), in which a tsunami caused a reactor meltdown, forcing the evacuation of over 150,000 people and releasing radioactive contamination into the environment. The disaster led to long-term health concerns, economic losses, and a decline in public support for nuclear energy. High costs and public opposition also slow its expansion.

Natural gas is often seen as a "transition fuel" because it produces less CO_2 than coal. The United States has lowered emissions by switching from coal to natural gas. However, natural gas

still contributes to climate change, and methane leaks from gas production have a stronger warming effect than CO_2. While better than coal, natural gas is not a long-term solution for full decarbonization.

In conclusion, while no energy source is perfect, renewable energy—particularly solar, wind, and hydropower—offers the best long-term solution for mitigating climate change. However, their success depends on advancements in energy storage and improved grid infrastructure. The use of natural gas as a short-term transition may provide time to make these advancements in technology while limiting carbon emissions. Though nuclear power is arguably the most effective in reducing emissions and providing stable electricity, the concerns over safety, waste disposal, and high costs mean that, on balance, its disadvantages outweigh the benefits.

Note: The above conclusion is subjective. Arguments in favour of nuclear power over renewables are perfectly valid if well justified.

Justification for a 9-Mark Score

Substantial evidence of knowledge and understanding of ESS issues and concepts

The essay clearly explains how different energy sources affect emissions, demonstrating strong knowledge of climate change mitigation. Key concepts like GHGs, intermittency, and energy storage are used correctly.

A wide breadth of knowledge statements that are effectively linked to each other and to the context of the question

The response includes multiple energy sources, compares their effectiveness, and links them to real-world climate change mitigation efforts. It also connects different factors like reliability, environmental impact, and cost.

Consistent, appropriate, and precise use of ESS terminology

Key terms like carbon emissions, greenhouse gases, intermittency, decarbonization, and transition fuel are used accurately. Scientific explanations are concise but clear.

Effective use of pertinent, well-explained examples, showing some originality

The essay integrates strong case studies (e.g., China for solar, Germany for wind, Norway for hydropower, France for nuclear, USA for natural gas, Brazil for biofuels) and clearly explains their relevance. Unlike lower-scoring essays, the examples do not just list facts but support arguments.

Thorough, well-balanced, and insightful analysis

The essay does not just list advantages and disadvantages but compares energy sources (e.g., solar vs. wind, nuclear vs. renewables, natural gas as a temporary solution). It also discusses trade-offs, such as nuclear's low emissions vs. safety risks.

Explicit judgements or conclusions that are well supported by evidence or arguments and include some critical reflection

The conclusion is strongly justified, recognizing that no single energy source is perfect but nonetheless committing to a firm decision on the best approach. It avoids oversimplifications. Acknowledging the limitations of the conclusion ("However, their success depends on advancements in energy storage…") demonstrates critical reflection.