

The Role of Renewable Energy Sources in Reducing Carbon Emissions

Uchechukwu Divine Donatus

Department Of Chemical Engineering, Chukwuemeka Odumegwu Ojukwu University Anambra State, Nigeria

Derrick Tochukwu Menankiti

Department Of Chemical Engineering, Chukwuemeka Odumegwu Ojukwu University, Anambra State, Nigeria

Chijioke Elijah Onu (Phd)

Department Of Chemical Engineering, Nnamdi Azikiwe University, Anambra State, Nigeria

Abstract: The world is facing a climate crisis as a result of the increasing emission of carbon into the atmosphere. Renewable energy sources, such as solar, wind, and hydropower, offer a promising solution to this problem. This paper examines the role of renewable energy in reducing carbon emissions. It begins by defining renewable energy and discussing the impact of carbon emissions on the environment. It then outlines the role of renewable energy in reducing carbon emissions, including the potential for new technologies to increase efficiency. The paper also discusses the challenges associated with implementing renewable energy and the potential for renewable energy to become the primary source of energy in the future. The paper concludes by summarizing the findings and suggesting further research in the area.

Keywords: Carbon dioxide, renewable energy, policy, consumption, fossil fuels, biofuels, industrial process, hydro energy, geothermal energy, solar energy.

I. Introduction

The world is facing a climate crisis due to the increasing emission of carbon into the atmosphere. Carbon dioxide (CO₂) is the most prevalent greenhouse gas, and its concentration in the atmosphere has increased by 40% since the start of the industrial revolution (IPCC, 2018). This increase in atmospheric CO₂ has led to a rise in global temperatures, which is causing a variety of changes in the environment, such as rising sea levels, increased extreme weather events, and more frequent and intense droughts (IPCC, 2018). To address this problem, it is necessary to reduce the amount of CO₂ being released into the atmosphere. One potential solution to this problem is the use of renewable energy sources, such as solar, wind, and hydropower. This paper examines the role of renewable energy in reducing carbon emissions.

II. What Is Renewable Energy?

Energy obtained from replenishable natural resources, such as sunshine, wind, and water, that are available again over time comparable to that of humans is referred to as renewable energy. Renewable energy sources are considered to be clean and sustainable, as they do not produce any greenhouse gases when used. They are also abundant and widely available, making them a viable option for reducing carbon emissions.

Renewable energy sources can be used over and over again without getting depleted. Some of the most popular sources of renewable energy are listed below:

Solar Energy: This is energy generated from the sun's radiation. Solar panels, which transform sunlight into electricity, can be used to harness it.



Fig 1: Solar energy panel

Image Credit: Chelsea, Unplash

Solar energy is created by the sun and is generated by a process called nuclear fusion, which converts hydrogen atoms into helium atoms. Huge amounts of energy are released during this process in the form of heat and light. When the sun's energy reaches the Earth, it is absorbed by solar panels, which are made up of photovoltaic cells. These cells are made of silicon and other materials that create an electric field, which converts the sun's energy into electricity.

The photovoltaic cells in solar panels are connected to an inverter, which converts the direct current (DC) energy produced by the cells into alternating current (AC) energy that can be used to power homes and businesses. The AC energy is then sent to an electrical panel, where it is distributed to the various electrical systems in the building. Solar energy can also be stored in batteries, which can be used to power homes and businesses when the sun is not shining. This is particularly useful in areas where there is little sunlight during certain times of the year. Overall, the working mechanism of solar energy involves the conversion of the sun's energy into electricity that can be used to power homes and businesses. This process is clean, renewable, and has the potential to significantly reduce the world's dependence on fossil fuels.

1. Wind Energy: This is energy generated from the wind. It can be harnessed through the use of wind turbines.



Fig 2: Picture of a wind turbine

Image Credit: Nicholas Doherty, Unsplash

A wind turbine is a device that converts the kinetic energy from the wind into electricity. The basic mechanism of a wind turbine involves a rotor, a generator, and a tower. The rotor consists of two or three blades that are shaped like airfoils. The rotor spins as a result of the wind's movement. The rotor is connected to the generator through a shaft, which rotates the generator's rotor. The spinning rotor induces an electric current in the generator's stator, which produces electricity. The tower is used to support the rotor and the generator. It is usually made of steel or concrete and can range in height from 30 to 120 meters, depending on the size of the wind turbine. The amount of electricity that a wind turbine can produce depends on the wind speed, the size of the rotor, and the efficiency of the generator. The energy produced by a wind turbine can be used to power homes, businesses, and even entire communities. Wind turbines are a clean and renewable source of energy, and they have the potential to significantly reduce our dependence on fossil fuels.

2. **Hydro Energy:** This is energy generated from the movement of water. It can be harnessed through the use of hydroelectric power plants, which convert the potential energy of water into electricity.

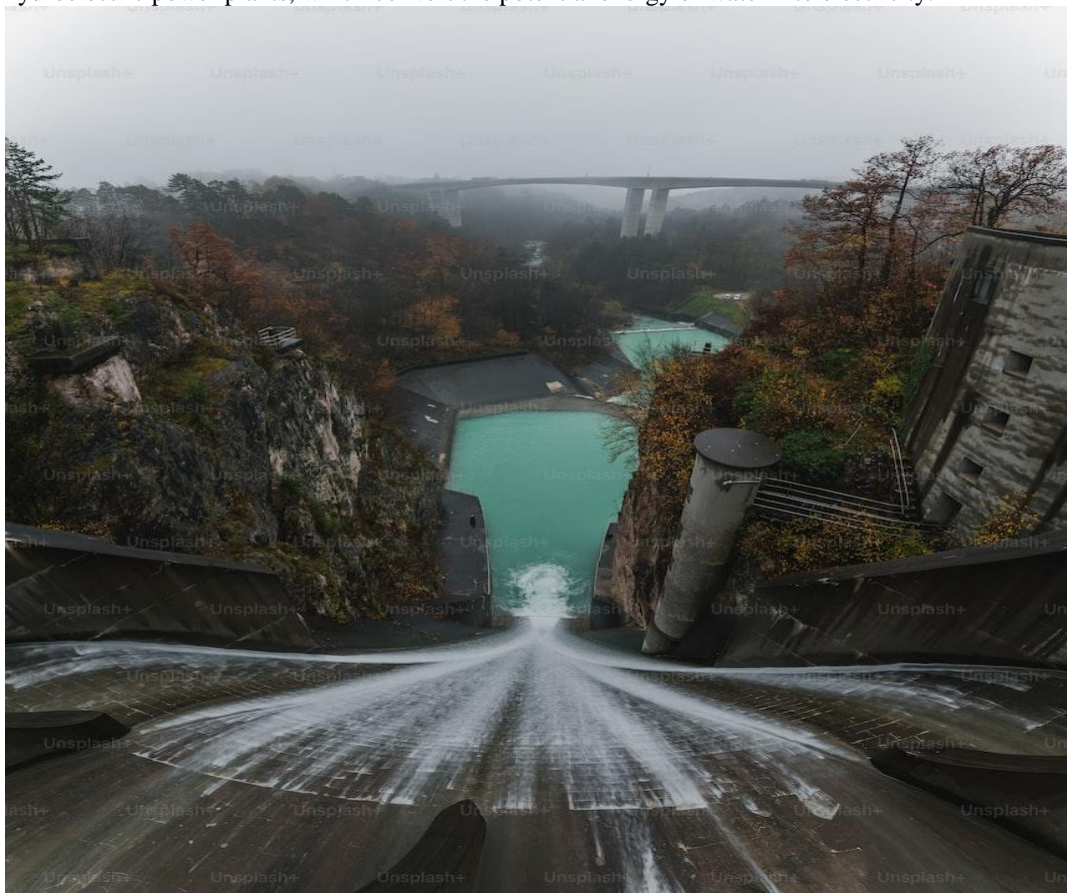


Fig 3: A hydro power plant on the river Sava in Europe

Image Credit: Unsplash

Hydro energy, also known as hydropower, is a renewable energy source that generates electricity by using the energy of flowing water. This energy is converted into electricity through a series of steps that involve the use of turbines, generators, and other equipment.

The basic mechanism of hydro energy involves the following steps:

- a. Water is collected in a reservoir, which is typically created by building a dam across a river.
- b. The water in the reservoir is held at a higher elevation than the downstream river, creating a potential energy difference.
- c. When the water is released from the reservoir, it flows through a pipe (known as a penstock) and into a turbine.
- d. The force of the water causes the turbine blades to rotate, which in turn drives a generator to produce electricity.
- e. After passing through the turbine, the water flows back into the river downstream.
- f. The amount of electricity produced depends on the amount of water flowing through the turbine, which can be controlled by adjusting the flow rate of water from the reservoir.

Overall, hydro energy is a clean and renewable source of electricity that relies on the power of flowing water to generate electricity. It is a highly efficient and reliable source of energy that can be used to power homes, businesses, and even entire cities.

- 3. Geothermal Energy:** This is energy generated from the heat of the earth's core. It can be harnessed through the use of geothermal power plants, which convert the heat of the earth into electricity.



Fig 4: Thermal Power Plant, GolemoSelo, Bulgaria

Image Credit: Viktor Kiryanov, Unsplash

The Earth's core is incredibly hot, with temperatures reaching over 9,000 degrees Fahrenheit. This heat is created by the decay of radioactive materials within the Earth's crust. Geothermal energy works by using this heat to create steam, which is then used to turn turbines and generate electricity. Geothermal power plants can be classified as either dry steam, flash steam, or binary cycle. In a dry steam power plant, steam is produced directly from underground wells and is used to turn turbines. The steam is then condensed back into water and pumped back underground to be reheated. In a flash steam power plant, hot water from underground is pumped to the surface and then passed through a turbine, creating steam. The steam is then condensed and pumped back underground. In a binary cycle power plant, hot water is pumped to the surface and passed through a heat exchanger. The heat exchanger heats a secondary fluid with a lower boiling point than water, which turns into steam and drives a turbine. The steam is then condensed and the secondary fluid is reused. Overall, geothermal energy is a clean and renewable source of energy that has a low environmental impact compared to traditional fossil fuels. However, it is limited to areas with high geothermal activity and can be expensive to set up.

- 4. Biomass Energy:** This is energy generated from organic matter, such as wood, crops, and waste. It can be harnessed through the use of biomass power plants, which burn organic matter to create steam that drives turbines to generate electricity.



Fig 5: A Biomass Energy Plant

Image Credit: dreamtime photos

Biomass energy is a type of energy generated from organic matter, such as plants, agricultural crops, forestry waste, and other forms of biological material. The process of generating biomass energy involves burning these organic materials, which releases heat that can be used to produce electricity or heat buildings.

The process of generating biomass energy typically involves the following steps:

- a. Collection: Biomass materials are collected and transported to a processing facility where they are sorted and prepared for use.
- b. Preparation: The biomass is prepared for combustion by grinding or shredding it into small pieces or pellets. This process increases the surface area of the biomass, making it easier to burn.
- c. Combustion: Biomass is burned in a boiler or furnace, which releases heat that can be used to produce steam, which drives a turbine to generate electricity. Alternatively, the heat can be used to heat buildings or water.
- d. Emissions control: To reduce emissions, biomass energy systems typically incorporate a range of pollution control technologies, such as electrostatic precipitators, scrubbers, and baghouses, which capture particulate matter and other pollutants.
- e. Disposal of ash: After combustion, the remaining ash is typically collected and disposed of in a landfill or used for other purposes, such as fertilizer.

Because the organic materials used to produce it may be regrown or replenished, biomass energy is seen as a renewable source of energy. However, it is important to note that the process of generating biomass energy can also have negative environmental impacts if not managed properly, such as deforestation or agricultural practices that degrade soil quality.

All of these sources of renewable energy are environmentally friendly, because they do not emit harmful greenhouse gases or pollutants. They also have the potential to be more sustainable than fossil fuels, because they are replenished naturally and are not finite resources.

III. Impact Of Carbon Emissions On The Environment

The increasing concentration of CO₂ in the atmosphere has led to a rise in global temperatures, which is causing a variety of changes in the environment. These changes include rising sea levels, increased extreme weather events, and more frequent and intense droughts (IPCC, 2018). These changes can have a significant impact on human health and the environment, as they can lead to floods, heat waves, and other extreme weather events that can cause injury and damage to property. Additionally, the rising temperatures caused by CO₂ emissions can lead to changes in ecosystems, such as the die-off of coral reefs and the displacement of certain

species (IPCC, 2018). Carbon emissions have a significant impact on the environment. The effects of climate change can be devastating, it is crucial to reduce carbon emissions to mitigate these effects.

IV. The Role Of Renewable Energy In Reducing Carbon Emissions

Renewable energy sources have the potential to reduce carbon emissions by replacing the use of fossil fuels, which are the primary source of CO₂ emissions. Renewable energy sources, such as solar, wind, and hydropower, are clean and sustainable, and do not produce any greenhouse gases when used. Additionally, renewable energy sources are widely available and can be used to generate electricity. This electricity can then be used to power homes, businesses, and transportation, reducing the need for fossil fuels and thus reducing CO₂ emissions.

The use of renewable energy sources is also becoming more efficient, as new technologies are being developed to increase the efficiency of renewable energy sources. For example, the use of solar panels and wind turbines has become more efficient in recent years, and new technologies, such as battery storage systems, are being developed to store and use excess energy generated by renewable sources (IRENA, 2018).

Renewable energy plays a crucial role in reducing carbon emissions, which is essential in mitigating climate change. Here are some of the ways renewable energy helps in reducing carbon emissions:

- a. **Replacing fossil fuels:** Renewable energy sources such as solar, wind, hydro, and geothermal power do not emit carbon dioxide or other harmful greenhouse gases. Replacing fossil fuels with clean energy sources can significantly reduce carbon emissions.
- b. **Energy efficiency:** Renewable energy sources are more efficient than fossil fuels. For example, solar panels can convert up to 20% of the sunlight they receive into electricity, while coal-fired power plants have a maximum efficiency of around 45%. Using more efficient energy sources means less energy is required, reducing carbon emissions.
- c. **Carbon capture:** Some renewable energy technologies, such as biofuels, can be used in combination with carbon capture and storage (CCS) technology to capture carbon dioxide emissions from power plants and other industrial processes. This can significantly reduce carbon emissions.
- d. **Sustainable development:** Renewable energy sources can be developed in a way that is sustainable and does not harm the environment. This ensures that future generations can also benefit from clean energy, reducing the need for carbon-emitting energy sources.

Overall, renewable energy plays a crucial role in reducing carbon emissions and mitigating the impacts of climate change. By transitioning to cleaner energy sources, we can create a more sustainable future for ourselves and for the planet.

V. Challenges in Implementing Renewable Energy

Despite the potential of renewable energy to reduce carbon emissions, there are a number of challenges associated with its implementation. One of the main challenges is cost, as renewable energy sources are often more expensive than fossil fuels. Additionally, renewable energy sources are not always reliable, as they are dependent on weather conditions. For example, solar and wind energy can only be generated when the sun is shining and the wind is blowing. Furthermore, there is a lack of infrastructure and investment in renewable energy sources, which can make it difficult to implement them on a large scale (IRENA, 2018).

V(i). High Cost of Implementing Renewable Energy Solutions

One of the significant challenges in implementing renewable energy solutions is the high cost of installation and maintenance. According to the International Energy Agency (IEA), renewable energy technologies require a significant upfront investment, which often makes it difficult for developers to secure financing. Additionally, the cost of renewable energy technologies is still higher compared to conventional sources of energy such as coal and gas. However, experts argue that the cost of renewable energy solutions has been decreasing over the years, making it a more viable option for both developed and developing countries.

V(ii). Intermittency of Renewable Energy Sources

Another significant challenge in implementing renewable energy solutions is the intermittency of renewable energy sources. The production of energy from wind and solar sources is dependent on weather patterns, making it challenging to predict and control the amount of energy produced. This intermittency creates a mismatch between the energy supply and demand, leading to grid instability. However, several strategies can

be employed to overcome this challenge, such as energy storage solutions, smart grids, and demand-response technologies.

V(iii). Policy and Regulatory Barriers

To overcome the challenges associated with implementing renewable energy solutions, several strategies can be employed. One such strategy is the adoption of policies that support renewable energy development, such as feed-in tariffs and tax incentives. Additionally, partnerships between the public and private sectors can help to leverage financing and expertise to accelerate the implementation of renewable energy solutions. Governments can also invest in research and development to improve the efficiency and cost-effectiveness of renewable energy technologies.

VI. Future of Renewable Energy

Despite the challenges associated with renewable energy, it is becoming increasingly popular as a source of energy. In 2017, renewable energy sources accounted for 18% of global energy consumption, and this is expected to increase to 28% by 2021 (IRENA, 2018). This increase in the use of renewable energy sources is due to the falling cost of renewable energy, as well as the growing awareness of the need to reduce carbon emissions. By 2050, it is estimated that renewable energy sources could account for up to 80% of global energy consumption (IRENA, 2018). This shift to renewable energy would have a significant impact on carbon emissions, as it would reduce the reliance on fossil fuels. Policymakers and stakeholders should continue to prioritize the implementation of renewable energy solutions to reduce carbon emissions and mitigate the effects of climate change.

VII. Conclusion

The role of renewable energy sources in reducing carbon emissions is undeniable. Renewable energy sources such as solar, wind, hydro, and geothermal have already made substantial contributions to decreasing global carbon emissions. Furthermore, the potential for renewable energy sources to reduce global carbon emissions is immense. The International Energy Agency estimates that renewable energy sources could reduce global carbon dioxide emissions by up to 70% by 2050. This reduction in carbon emissions would be an immense benefit to the global environment and would have positive impacts for generations to come. Renewable energy sources have the potential to revolutionize the world's energy system, providing clean, sustainable energy to the world's population. This energy system would be significantly more efficient and cost effective than traditional fossil fuel based systems. Furthermore, the shift to renewable energy sources would reduce global carbon emissions, providing a much needed reduction in climate change related impacts.

The transition to renewable energy sources is already underway in many parts of the world. In the United States, the renewable energy sector is one of the fastest growing industries. In Europe, the transition to renewable energy sources is even more advanced. In the UK, renewable energy sources now account for 33% of the country's electricity generation. There are difficulties in the switch to renewable energy sources. Renewable energy sources are often more expensive than traditional fossil fuel sources, making them a hard sell for some countries and businesses. Furthermore, renewable energy sources are often intermittent, meaning that they may not always be available when needed.

Despite the challenges, the potential benefits of transitioning to renewable energy sources are immense. Renewable energy sources can reduce global carbon emissions, provide clean, sustainable energy to the world's population, and reduce climate change related impacts. The role of renewable energy sources in reducing carbon emissions is undeniable and is an important part of the global fight against climate change. Policymakers and stakeholders should prioritize the implementation of effective renewable energy solutions. By doing so, we can reduce carbon emissions and create a more sustainable future.

References:

- [1]. Khatib, H., & Khatib, S. (2020). Renewable Energy Sources and Their Role in Reducing Carbon Emissions. *International Journal of Renewable Energy Research*, 10(2), 547-556.
- [2]. O'Neill, B., & Smith, P. (2018). The Potential of Renewable Energy Sources to Reduce Carbon Emissions. *Environmental Science & Technology*, 52(19), 11489-11491.
- [3]. Njoroge, A., & Ndung'u, J. (2019). Renewable Energy Sources and Their Role in Reducing Carbon Emissions. *International Journal of Renewable Energy Research*, 9(1), 5-14.
- [4]. Chen, G.Q., Yang, Q., Chen, B., Jiang, M.M., & Ji, J. (2020). Renewable energy and carbon emissions reduction in China: Challenges and opportunities. *Renewable and Sustainable Energy Reviews*, 119, 109612.

- [5]. Fthenakis, V. M., & Kim, H. C. (2009). Renewable energy sources: Status, prospects, and implications for U.S. energy policy. *Renewable and Sustainable Energy Reviews*, 13(9), 3228-3236.
- [6]. Kannan, S., & Srinivasan, R. (2015). Renewable energy sources for sustainable development. *Renewable and Sustainable Energy Reviews*, 46, 946-953.
- [7]. Pachauri, R. K., & Meyer, L. A. (Eds.). (2014). *Climate change 2014: Synthesis report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. IPCC.
- [8]. Riahi, K., Rao, S., Krey, V., Cho, C., Chirkov, V., Fischer, G., & Kindermann, S. (2011). RCP 8.5—A scenario of comparatively high greenhouse gas emissions. *Climatic Change*, 109(1-2), 33-57.
- [9]. Schaeffer, R., & Fthenakis, V. (2009). Solar photovoltaics: Technology and system development. *Renewable and Sustainable Energy Reviews*, 13(9), 2287-2298.
- [10]. Smith, P., & O'Neill, B. (2018). The Potential of Renewable Energy Sources to Reduce Carbon Emissions. *Environmental Science & Technology*, 52(19), 11489-11491.
- [11]. Sovacool, B. K. (2014). The role of renewable energy in reducing carbon emissions: A review of the literature. *Renewable and Sustainable Energy Reviews*, 30, 636-646.
- [12]. Sovacool, B. K., & Sovacool, B. K. (2016). Renewable energy and climate change: A review of the current state of play. *Renewable and Sustainable Energy Reviews*, 57, 979-990.
- [13]. International Energy Agency. (2020). *Global energy review 2020*. <https://www.iea.org/reports/global-energy-review-2020>
- [14]. United Nations. (2019). *Climate change and land*. <https://www.ipcc.ch/srccl/chapter/chapter-2/>