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A REVIEW ON THE ROLE OF ENERGY TECHNOLOGY IN REDUCING CARBON EMISSION IN ATMOSPHERE; RENEWABLE ENERGY AND NUCLEAR ENERGY.

Merodi Sanga, Ruchita Maninani, Dr. Hitesh Solanki

Department of Environmental Science,
University school of sciences, Gujarat University,
Navrangpura, Ahmedabad – 380009
Email: merodisanga@gmail.com
Mobile: +918758010996

Department of Environmental Science,
University school of sciences, Gujarat University,
Navrangpura, Ahmedabad – 380009
Email: ruchitamainani@gujaratuniversity.ac.in
Mobile: +918401212218

Department of Environmental Science,
University school of sciences, Gujarat University,
Navrangpura, Ahmedabad – 380009
Email: hasolanki@gujaratUniversity.ac.in
Mobile: +919898119766

Abstract

The role of technology in reducing carbon emissions has become increasingly important in recent years as the world seeks to mitigate the impacts of climate change. This paper provides an overview of the current state of technology in reducing carbon emissions and explores the potential of renewable energy technologies, and nuclear energy technology. The paper also discusses future trends in technology, including the expected growth in the use of renewable energy sources, the deployment of carbon capture and storage technologies, and the development of new technologies such as artificial intelligence and blockchain. The paper starts with a comprehensive overview of the current state of carbon emissions, emphasizing the damaging environmental consequences of fossil fuel-based energy production. Subsequently, the focus shifts to an extensive examination of renewable energy technologies, encompassing solar, wind, hydro, and geothermal power generation. Through systematic explanations, we evaluate the carbon reduction potential of each technology, shedding light on their deployment challenges and economic implications. The review offers a holistic evaluation of the advantages and limitations and challenges that face renewable and nuclear energy technologies in reducing carbon emissions, considering the socio-political, economic, and environmental factors that influence their adoption. A comprehensive synthesis of findings leads to the identification of potential pathways for policymakers, stakeholders, and industries to exploit the full potential of these technologies in the transition towards a sustainable and decarbonized energy future.This systematic review provides a thorough understanding of the contributions of renewable and nuclear energy technologies to global carbon emission reduction, shedding light on the potential pathways to mitigate the impact of climate change and facilitating informed decision-making in the pursuit of a cleaner and more sustainable energy landscape.The findings of this paper demonstrate the significant potential of technology in reducing carbon emissions and highlight the need for continued investment and support to achieve this critical goal. The conclusion of the paper highlights the importance of technology in reducing carbon emissions and emphasizes the need for continued research, development, and investment to realize its full potential.

Keywords: *Atmosphere, Technology, carbon emission, renewable energy and nuclear energy.*

INTRODUCTION

Climate change and global warming represent two of the most pressing and interconnected challenges facing humanity in the 21st century. Climate change, often used interchangeably with global warming, refers to long-term shifts in temperature, precipitation, and other climate patterns on Earth. Global warming, on the other hand, is a specific aspect of climate change, focusing on the increase in global average temperatures due to the accumulation of greenhouse gases in the atmosphere (Waisman et al., 2019). According to the latest report from the World Meteorological Organization, the concentration of CO2 in the atmosphere reached a record high in 2021. As report of 2021, the average concentration of carbon dioxide (CO2) in the atmosphere was

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around 417 parts per million (ppm). This is an increase from the pre-industrial level of around 280 ppm. The concentration of CO2 in the atmosphere has been increasing since the 1950s and is projected to continue to rise if emissions are not reduced (WMO, 2021).

They primarily result from anthropogenic activities, including the burning of fossil fuels, deforestation, and industrial processes that release greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) into the atmosphere (Huisingh et al., 2015). The consequences of these emissions are profound, encompassing a range of environmental, social, and economic impacts. These include more frequent and severe extreme weather events, rising sea levels, disruptions in ecosystems, and threats to global food and water security (Leggett, 2020) . According (Rahman et al., 2022), another pressing reason for the carbon emissions causing the climatic change is lack of proper policy initiatives, hence leading to the environmental vulnerabilities and degradation that affects the lives of earths living organisms including all animals and plants at all.

The energy sector is the largest contributor to carbon dioxide (CO2) emissions. In particular, the use of fossil fuels such as coal, oil, and natural gas for electricity generation, transportation, and heating is responsible for the majority of CO2 emissions. In recent years, the power sector has been transitioning towards renewable energy sources like wind and solar, however, the transition is not fast enough to make a significant impact in reducing CO2 emissions (Qi et al., 2014).

To mitigate these impacts, it is imperative that we reduce the amount of carbon emissions released into the atmosphere through several ways including Improving Energy Efficiency, switching to Renewable Energy, Carbon Capture and Storage (CCS), encouraging the use of Electric Vehicles, Reforestation, implementing sustainable agricultural practices and iimproving waste management practices. One of the key ways in which we can achieve this goal is through the use of technology (Hsu et al., 2015).

The role of technology in reducing carbon emissions has become increasingly important in recent years, with new advancements and innovations being developed all the time. From renewable energy technologies such as wind and solar power, to more efficient transportation systems and carbon capture and storage, technology offers a range of solutions to help reduce the amount of carbon emissions released into the atmosphere (Wodon et al., 2014).

Renewable energy sources, including solar, wind, and hydropower, have gained substantial attention as environmentally friendly alternatives to fossil fuels. In line with this, the World Energy Outlook by the International Energy Agency (IEA) underscores the potential of renewables to significantly reduce CO2 emissions while promoting energy security and sustainable development (Canton, 2021).

Nuclear energy, despite its complex history and public perception, has reemerged as a viable low-carbon energy source. The International Atomic Energy Agency (IAEA) highlights nuclear power's role in mitigating climate change, citing its capacity to produce large amounts of energy with minimal greenhouse gas emissions (Schneider et al., 2019).In light of these alarming consequences, efforts to mitigate climate change and global warming have gained significant momentum over the past few decades. The purpose of this review paper is to provide a comprehensive overview of the role of technology in this context, with a focus on its significance, potential sources, effects, current and future mitigation solutions, and the directions we should pursue in the battle against climate change and global warming.

1. Renewable energy

Renewable energy is the energy obtained from regenerative or virtually in exhaustible sources of energyy occurring in the natural environment like solar energy, wind energy etc (Ottinger, 2002). This is also referred as non-conventional sources of energy. Renewable energy is nothing but the kind of energy that is obtained from reformative or non exhaustible sources of energy that occurs naturally, those includes solar energy, wind energy and so on. renewable energy is also known as non-conventional sources of energy (Adams & Acheampong, 2019). However, investing in renewable energy is controversial for several reasons. First, not all scientists agree on the degree of environmental damage that can be attributed to fossil fuels. Second, fossil fuels are relatively abundant and cheap energy sources, and have contributed significantly to economic growth (AWEA, 2021). Energy can be defined as the capacity to do work. The unit of measurement used to express the heat contained in energy resources is called a British thermal unit or Btu. One Btu is the heat energy needed to raise the temperature of one pound of water one degree Fahrenheit (Sharma, 2020).

Renewable energy sources are those that can be replenished quickly or that are nondepletable. Examples include solar, hydropower, wind, geothermal, and biomass (Guo et al., 2018).According to (Jordaan et al., 2017) renewable energy sources include those sources that can be reloaded very fast soon after being used and they nondepletable. Examples include solar, hydro-power, wind, geothermal and biomass. The United Nations report of 2023, explained Renewable energy as the energy that produced from natural sources that can be replenished at a higher rate than they are consumed. example, of such sources includes Sunlight and wind, that are constantly being replenished. Renewable energy sources are abundant and all around us compared to non-renewable resources especially fossil fuels including coal, oil and gas that takes very long time to form (Imran et al., 2023).

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Efficiency of renewable energy

renewable energy is very environmentally friendly energy that creates very lower emissions compared to emissions that produced from burning fossil fuels especially coal, oil and even gas that often produces very high emission gases especially carbon gas which acts as a chief ozone depleting gas. Renewable energies are now cheaper and currently available in most countries due to its safely and generate more jobs opportunities to people than fossil fuels. In looking on the efficiency of the renewable energy, as well Renewable energy resources hold great promise for meeting the energy and development needs of countries throughout the world.", "This promise is particularly strong for developing countries where many regions have not yet committed to fossil fuel dominance (Ottinger, 2002).

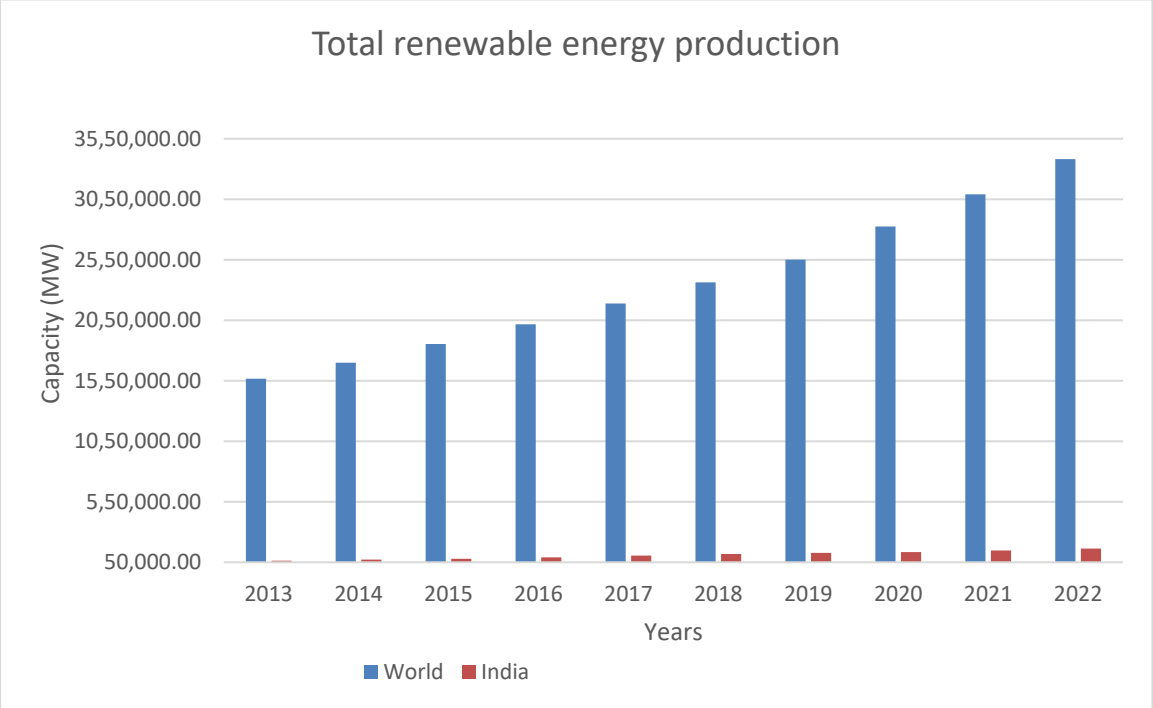

Figure 1

A chart showing the trends of renewable energy production in worldwide and country wise specifically India from 2013 to 2022.

(IRENA, 2023) [©IRENA2023 http://www.irena.org/Statistics/Download-Data]

Renewable energy sources are known for their efficiency in harnessing energy with minimal environmental impact. Solar panels, for example, convert sunlight into electricity with an average efficiency of around 20-22% (*U.S. Department of Energy, 2021)* Wind turbines can convert up to 45% of the wind's kinetic energy into electricity (AWEA, 2021). Although the efficiency of individual systems varies, advancements in technology continue to improve overall renewable energy efficiency. This paper has been summarized and analyzed different information's about various renewable energy sources from various researchers, reports and papers as follows;

a) hydropower

Hydroelectricity is the term referring to electricity generated by hydropower; the production of electrical power through the use of the gravitational force of falling or flowing water. Hydropower is the most important source of renewable electricity generation for about 86.3 %, and very nec essity to operate on the others sources of renewable energy that are random generation(Florentina et al., 2017). According to (Andrade Furtado et al., 2020), Hydroelectric plants (HPPs) produce energy that is renewable, that has low cost and high profitability, with a very low relative level of emissions compared to that produced from burning of fossil fuels especially coal, oil and gas. For example, Brazil has one of the cleanest energy matrices of the planet, mainly due to hydroelectric power. Furthermore, hydropower is generated by the kinetic energy of flowing water, such as rivers and waterfalls (Bogaart, 2023). Large dams and hydroelectric power plants are common structures for harnessing this energy source (EERE, 2020). Hydropower is known for its reliability and consistent energy production, making it a significant source of renewable electricity worldwide. Hydro-power as the form of non convectional energy delivered from moving water it has been used to generate mechanical power through watermills. this form of energy has been used for several centuries to generate electric power for more than 100 years (Andrade Furtado et al., 2020). For the recently years due to economic transformations hydro electric power has been developing rapidly in Asia and Latin America as the main adapting and mitigating factor against climate change (Jordaan et al., 2017).

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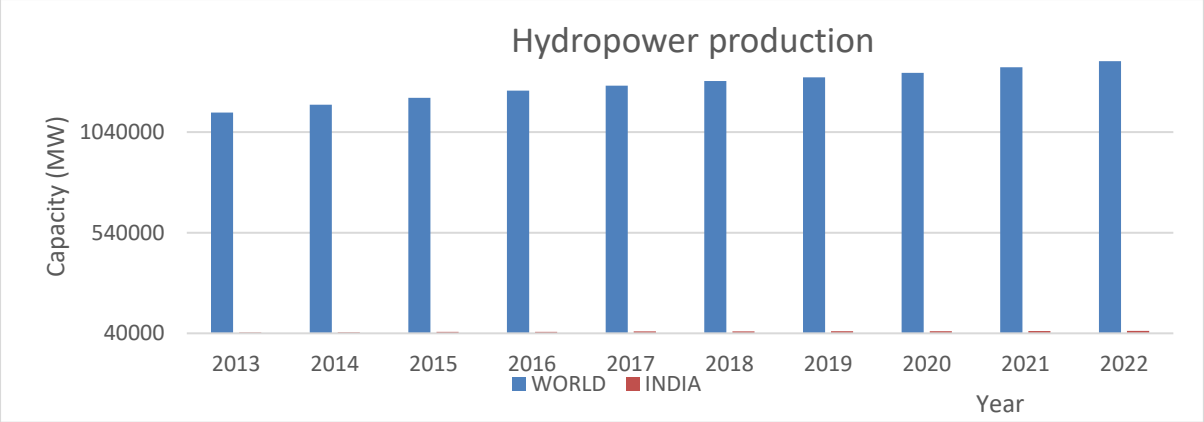

Figure 2

A chart showing the trends of hydropower production in worldwide and country wise specifically India from 2013 to 2022 (IRENA, 2023) [©IRENA2023 http://www.irena.org/Statistics/Download-Data]

b) Solar energy

solar energy this is the solar technology that uses suns energy directly to generate electric energy for various applications especially industrial processes, building activities, transportation activities as well as electricity for general consumptions(Eicher et al., 2012). The energy that is generated from the core of the sun is called solar energy, it happens through a process known as nuclear fusion where the intense heat from the sun breaks hydrogen atoms apart and fuse them together to form helium atoms (IPCC, 2022). During this process only small amount of mass is lost, the lost matter then is emitted as radiant energy that is then captured through the solar to provide the energy we need for different purposes. One of the most abundant sources of renewable energy is solar energy (WEF, 2017). It is harnessed using photovoltaic (PV) cells which convert sunlight into electricity, solar panels are installed on rooftops or in solar farms to capture the energy from the sun (Kabeyi & Olanrewju, 2022).The trend of solar energy production increases day to day in many countries as a climatic change mitigating strategy. Below it is a chart showing the trends of solar energy production in worldwide and country wise specifically India from 2013 to 2022 (IRENA, 2023)

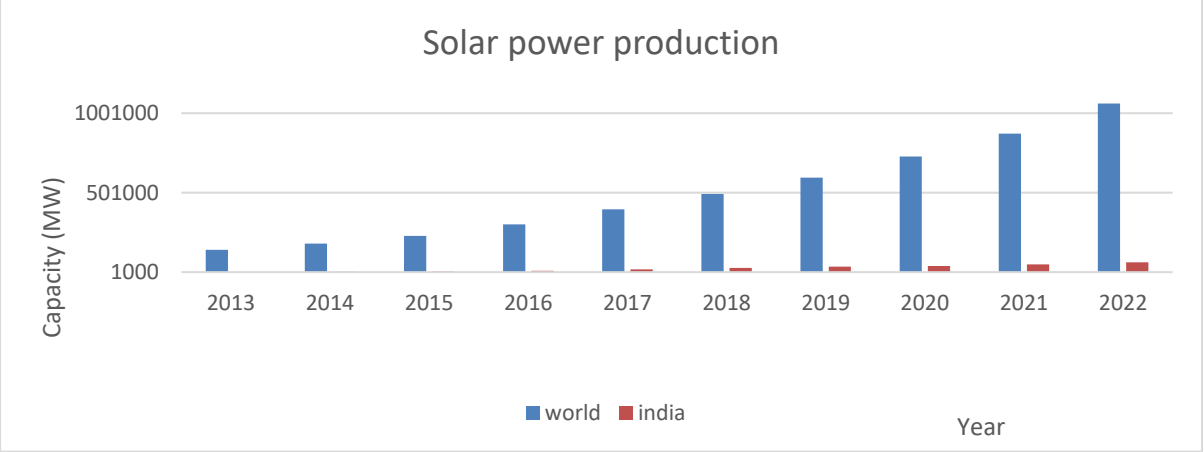

Figure 3

A chart showing the trends of solar power production in worldwide and country wise specifically India from 2013 to 2022. (IRENA, 2023) [©IRENA2023 http://www.irena.org/Statistics/Download-Data]

c) Wind energy

Wind energy is harnessed through wind turbines, which convert the kinetic energy of wind into electricity (AGI, 2017). Wind turbines generate electricity with no direct emissions, making it a sustainable solution (Wodon et al., 2014). Wind farms, located in areas with consistent winds, generate substantial electricity for local grids. The intermittency of wind energy production is mitigated through grid integration and energy storage solutions (Jordaan et al., 2017). The following is the chart showing the trend of wind energy production in worldwide and India from 2013 to 2022.

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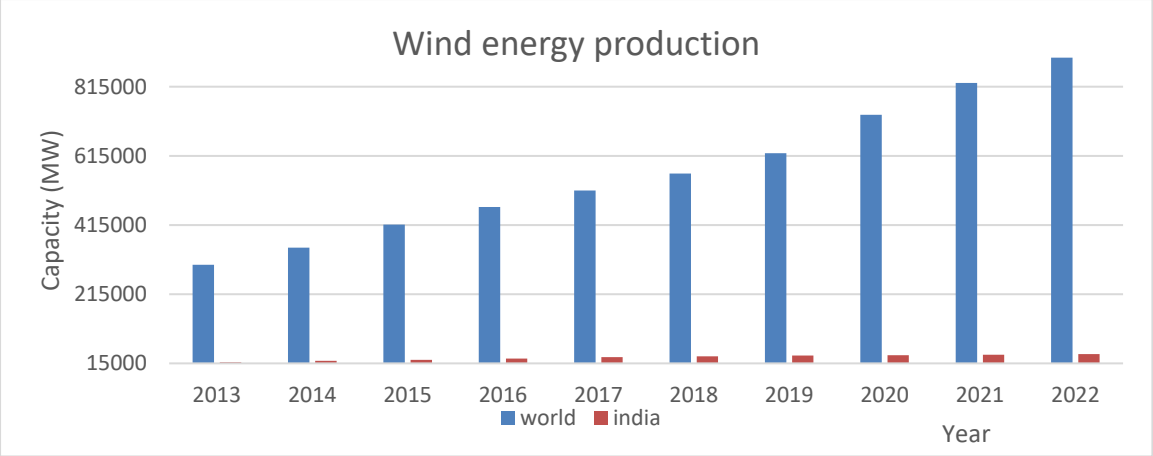

Figure 4
A chart showing the trends of wind energy production in worldwide and country wise specifically India from 2013 to 2022.
(IRENA, 2023) [©IRENA2023 http://www.irena.org/Statistics/Download-Data]

d) Geothermal energy

Geothermal energy is produced by tapping into the Earth's internal heat (Siram et al., 2022). Geothermal power plants extract steam or hot water from underground reservoirs to generate electricity. Geothermal power plants produce minimal greenhouse gas emissions and can contribute to reducing carbon emissions, particularly in regions with suitable geothermal resources (EIA, 2022). The trends in geothermal energy production have been relatively stable worldwide, with moderate capacity growth. In India, geothermal energy remains an underutilized resource, with limited growth from 2013 to 2022. The challenges of harnessing geothermal energy in India have hindered its expansion, but the country's geothermal potential remains a promising avenue for future renewable energy development(International Energy Agency, 2021). The following is the chart showing the trend of geothermal production in worldwide from 2013 to 2022.

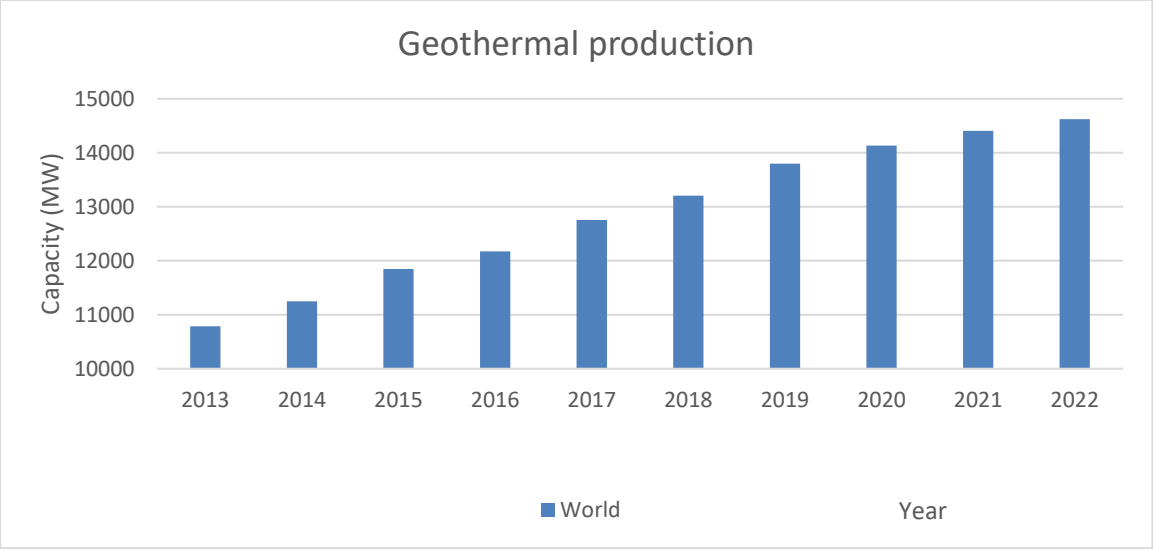

Figure 5
A chart showing the trends of geothermal production in worldwide and country wise specifically India from 2013 to 2022.
(IRENA, 2023) [©IRENA2023 http://www.irena.org/Statistics /Download -Data]

e) Biomass energy

Biomass energy is derived from organic materials, including wood, agricultural residues, and waste (Kumar et al., 2022). These materials are burned or converted into biofuels like ethanol or biodiesel. Biomass energy provides a renewable alternative for heating, electricity generation, and transportation fuels (Gunawardene et al., 2022). Biomass energy has seen steady growth globally from 2013 to 2022. This growth has been driven by increased interest in using organic materials for energy production. In 2013, global biomass energy production was estimated at approximately 84 thousands megawatt (MW) (IEA, 2014). By 2022, this figure had increased to around more than 150000MW (IEA, 2023). The following is the chart showing the trend of bioenergy production in worldwide and India from 2013 to 2022.

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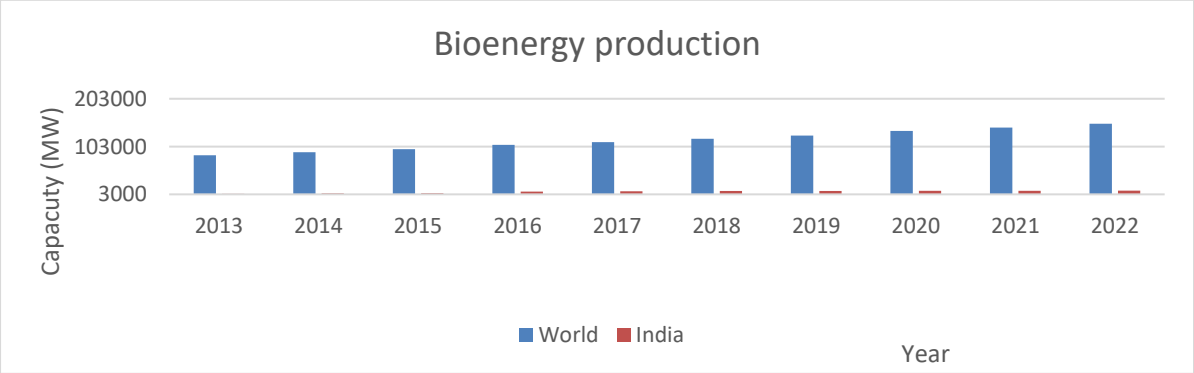

Figure 6
A chart showing the trends of bioenergy production in worldwide and country wise specifically India from 2013 to 2022. (IRENA, 2023) [© IRENA 2023 http://www.irena.org/Statistics/Download-Data]

f) Ocean energy

Ocean energy encompasses various forms of renewable energy, including tidal energy, wave energy, and ocean thermal energy (Kellogg, 2019). Tidal and wave energy systems capture the energy from the movement of water, while ocean thermal energy exploits temperature differences in the ocean (Paredes et al., 2019). Incorporating these renewable energy sources into the global energy mix is crucial for reducing greenhouse gas emissions and mitigating climate change (Brown et al., 2019). These sources contribute to a sustainable energy future while reducing our reliance on finite fossil fuel reserves.

Applicability of renewable energy

Solar panels and wind turbines are increasingly used for residential electricity generation, reducing dependence on grid electricity (Department of Energy, 2021). Many businesses utilize renewable energy sources to reduce operational costs and environmental impact (Ardani et al., 2021). Electric vehicles (EVs) powered by renewable energy sources, such as lithium-ion batteries charged with clean electricity, reduce greenhouse gas emissions(Department of Energy, 2021). Biomass energy is used for heating, electricity generation, and biofuels in the agricultural sector, promoting sustainability (ClarkII & Rong, 2017). Renewable energy sources can be integrated into the electrical grid to provide power to homes and businesses, contributing to a more resilient and sustainable energy system (Department of Energy, 2021).

Dominance of renewable energy

Renewable energy sources contribute to a reduction in greenhouse gas emissions and air pollution, making them a dominant choice for mitigating climate change (IRENA, 2019). The renewable energy sector has shown substantial growth, leading to job creation in manufacturing, installation, and maintenance (Wise, 2021). In recent years, renewables have become a dominant source of electricity generation in some regions. For example, wind and solar energy have surpassed coal in the United States (WEF, 2017)

Nuclear energy

Nuclear energy is a crucial source of power that plays a significant role in the global energy landscape. It is harnessed through nuclear reactions, primarily nuclear fission and fusion, which release a vast amount of energy (CGEP, 2020). This paper explores the meaning, efficiency, applicability, and areas of dominance of nuclear energy. Nuclear energy refers to the form of energy produced through nuclear reactions, such as the splitting (fission) or combining (fusion) of atomic nuclei (Bowen, 2020). Fission, which is the predominant method used in nuclear power plants, involves the splitting of heavy atomic nuclei, typically uranium-235 or plutonium-239, to release a substantial amount of thermal energy. This energy is subsequently converted into electricity through various mechanisms, making nuclear energy a viable alternative to fossil fuels (IAEA, 2019). Nuclear energy is highly efficient due to the immense energy density of nuclear fuel compared to conventional fossil fuels. It generates a large amount of electricity from a relatively small amount of fuel, resulting in reduced greenhouse gas emissions (Wagner, 2021). Nuclear power plants have a high-capacity factor and can operate continuously for long periods, ensuring a stable and reliable energy supply (Aydoğan & Vardar, 2020).

Applicability of nuclear energy

Nuclear energy is applicable in various sectors, primarily for electricity generation, but also extends to other uses. It is a consistent and reliable source of electricity, contributing to baseload power supply (Department of Energy, 2021). Additionally, it finds applications in the production of medical isotopes for cancer treatment, propulsion systems for spacecraft, and desalination plants (IAEA, 2019).

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Dominance of nuclear energy

Nuclear energy has established dominance in specific areas, such as low carbon emissions and energy security. It is considered a crucial component in mitigating climate change due to its minimal greenhouse gas emissions (Yuping et al., 2021). Furthermore, it enhances energy security by reducing reliance on fossil fuels and their associated price fluctuations and geopolitical risks (Calvin et al., 2023).

Policies and Conventions on Carbon Emissions Reduction in India and Worldwide

Policies and conventions on carbon emissions reduction in India and worldwide play crucial roles in mitigating the effects of climate change. India's efforts to reduce emissions are aligned with its sustainable development goals, while international agreements emphasize collective responsibility for a sustainable future (IEA, 2020). India's policies focus on sustainable development and green energy adoption, whereas international agreements like the Paris Agreement aim at global cooperation to limit temperature rise (Aggarwal et al., 2022). This paper explores the policies and conventions related to carbon emissions reduction in India and worldwide. In India, carbon emissions reduction policies have evolved significantly over the years. The National Action Plan on Climate Change (Pandve, 2009), launched in 2008, is India's comprehensive framework to address climate change issues. It includes eight national missions focusing on various aspects of climate change, such as solar energy, water, and agriculture (Sridhar, 2020). India has set ambitious renewable energy targets, aiming to achieve 40% of its power capacity from non-fossil fuel sources by 2030 (NIC, 2009). Globally, numerous conventions and agreements have been established to address carbon emissions on a larger scale. The Paris Agreement, adopted in 2015, is a landmark international accord. It commits countries to limit global warming to well below 2 degrees Celsius above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5 degrees Celsius. India is a signatory and has made commitments to reduce its carbon intensity (UNFCCC, 1992). The Kyoto Protocol, established in 1997, is an earlier international agreement that set binding emission reduction targets for developed countries. While India is not obligated to reduce emissions under this treaty, it actively participates in Clean Development Mechanism projects (WMO, 2021).

CONCLUSION

This paper has explored the vital role that technology, particularly in the form of renewable energy and nuclear energy, plays in mitigating the pressing issue of carbon emissions. As our world grapples with the challenges of climate change and strives for a more sustainable and cleaner energy future, these technological advancements have emerged as powerful tools in our arsenal. Renewable energy sources, such as solar, wind, and hydropower, have shown their capacity to provide clean and abundant energy while significantly reducing carbon emissions. Their growth has not only made steps in reduction of climate change but has also encouraged innovation, created jobs, and enhanced energy security. Nuclear energy, on the other hand, offers a low-carbon alternative with an uninterrupted power supply. It has the potential to meet the increasing global energy demands without substantial greenhouse gas emissions. Nevertheless, it comes with its own set of challenges, including safety concerns and nuclear waste management. To address the climate crisis effectively, it is imperative to harness the strengths of both renewable and nuclear energy while recognizing the limitations and potential risks. Policymakers, scientists, and industry leaders must work in concert to develop sustainable and environmentally responsible energy strategies. In the pursuit of a greener future, it is essential to continuously invest in research and development to improve the efficiency, safety, and environmental impact of these technologies. Public awareness, engagement, and support are equally critical to foster the necessary transition to a low-carbon energy landscape. Therefore, technology embodied by renewable and nuclear energy, serves as a beacon of hope in the battle against carbon emissions and climate change. As we navigate the path forward, the integration of these energy sources into our global energy mix can drive us towards a cleaner and more sustainable future. It is a collective responsibility to ensure that these technologies are harnessed wisely and responsibly for the benefit of our planet and future generations.

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