Evaluation of Green Energy Impacts for Achieving Global Economic and Environmental Sustainability

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Abstract. This paper comprehensively investigates the different measurements and results of embracing green energy, with an emphasize on its significance for advancing sustainable financial development and safeguarding ecosystem. It can be concluded from the study that the unfavorable impacts of fossil fuel combustion on climate change can be reduced by focusing on renewable energy sources. The various types of green energy resources that include wind, geothermal, solar, hydro etc. and its current scenarios of utilization across the world has been focused upon. The most abundant and easily extractable source of energy was solar based system. However, the literature confirms that the sector requires further enhancement in the technology to fully extract the power from these resources. The storage solutions of various capacities such as magnetic storage, battery fuel cell etc., can work as a backup to these resources. The major improvements in the field of renewable energy give adaptable ways to decrease the carbon impression of transportation, fabricating, and control systems, which in turn advances the output in terms of available power. The papers gives remarks on the key challenges and solutions for sustainable use of energy which is important for enforcing the balance in the economic growth and ecosystem enhancement.

Keyword-: Green energy, economic development, renewable energy, social benefit development, global trade, solar power.

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1 Introduction

The accessibility, adequacy, as well as the costing of energy are basic to the all-around financial improvement of any area or nation. In any case, the expanding worldwide request utilising fossil fuels is placing noteworthy weight on energy markets. Green energy is characterized as the power produced utilizing reusable energy sources, counting innovations such as photovoltaic sun-based boards, biomass ventures, geothermal ventures, and wind ranches. To a certain degree, the selection of green vitality can accomplish zero poisons and can be utilized specifically in mechanical generation and lifestyle [1]. When we observe that a green energy economy move could be a complicated social problem including innovative, approaches and behavioural changes over frameworks of energy generation and making use of, buildings, and transport. Elective innovation paths are conceivable, but in sum, we make a conceivable presumption that a transport framework within the green power economy in the, timeline 2030 to 2050 which fulfils portability requirements for settings in cities, logically envelops a critical share of electric vehicles [2]. In the guideline, it is anticipated that the greater energy a business or a segment consumes, the more noteworthy the energy potential wastefulness. The decrease in such energy wastefulness is a critical reason for the utilization of green energy advances. The subsequently anticipate of the financial returns to venture into green energy innovations to extend considering the energy expenses of the businesses [3]. The utilization of renewable energy sources and energy efficiency, which could be a portion of the green energy innovations, is exceptionally imperative to decrease worldwide warming and ensure environmental safety concerns. Green innovation will be able to decrease carbon dioxide output. Green energy innovations by utilizing elective energy resources like wind, sun-based power, hydropower, and others diminish CO2 emissions by moving forward green energy sources effectively [4]. Numerous societal benefits can be credited to taking advantage of green energy and energy productivity, counting diminished vitality costs, superior discussion quality and well-being of society, and an increment in work creation and financial development. Moderating green vitality is broadly perceived as a basic component of decreasing carbon impression. There's a carbon engraved on more than two-thirds of the world's energy generation and utilization. Making use of green energy sources has a big effect on reducing the carbon impression of the world [5]. Green energy has a tight relationship with the improvement and advancement of natural innovations, which consider the utilisation of natural sciences in creating modern advances to screen, preserve and diminish the hurtful impacts on people, counting remediation advances, water desalination, cleaner generation, etc. In this way, with the reinforcing of the hypothetical information basis and the improvement of the modern information inaccessible, it is noteworthy to evaluate the state of affairs in the green energy sector and natural innovations [6-9].

2 Green Energy as Economy Purpose

As it is often called, renewable energy or green energy has become an important part of global economic and sustainable development [10]. This paper examines the economic importance of green energy by focusing on its role in driving growth, creating employment opportunities, enhancing innovation and reducing environmental degradation. The use of green energy technologies reduces reliance on imported fossil fuels thus improving independence in the sector and mitigating some risks arising from volatile oil prices [11]. One of the most important economic impacts of green energy is job creation. Renewable energy sector has emerged as a major employer capable of providing jobs at all skill levels and in various industries [12-14]. Jobs in renewable energy are wide-ranging and can include manufacturing, installation, maintenance, research, and development [15]. Investments into renewable energy projects stimulate local economies thus promoting innovation leading to

overall economic growth [16]. Transitioning to green energy drives innovative development and advancement. Over a long time investigations and advancement activities have driven critical taken a toll diminishments as well as progressed proficiency for renewable energy innovations [17]. Progressions in sun-powered photovoltaics, wind turbines, energy capacity frameworks, and network integration innovations are making renewable energy a progressively competitive alternative compared to conventional fossil fuels [18-20]. These strides advance more extensive financial development and competitiveness, which favors not in the same way as the renewable energy industry but every other segment as well [21]. Governments' investments and policies have greatly supported the development of green energy industries [22]. Subsidies, tax credits, feed-in tariffs and renewable energy targets are some of the policy instruments that encourage investment in renewable projects and facilitate a low carbon transition [23]. Since nations trade renewable technologies and expertise internationally, the economic impact of green energy surpasses national boundaries [24-27]. In this regard, World Trade Organization (WTO) records indicate that there has been increasing global trading on renewable energies with different nations specializing at various stages along the supply chain like installation & maintenance or even manufacturing. This interdependence also promotes international collaboration and cooperation while also accelerating economic growth due to export opportunities & job creation [28]. When the economic potential of renewable energy sources utilizes and implement supportive policies and investments, nations can simultaneously achieve their economic development goals while addressing critical and crucial environmental challenges. Table 1 illustrates about financial purpose.

Table 1. Green Energy as Economic Purpose

Aspect	Description	Reference
Less dependency on fossil fuel imports	Green energy technologies reduce dependence on imported fossil fuels, enhancing energy independence and mitigating risks associated with volatile oil prices.	[29]
Job creation	The renewable energy sector is a major employer, providing jobs across various skill levels and industries such as manufacturing, installation, and research.	[30],
Stimulation of the local economy	Investments in renewable energy projects stimulate local economies, fostering innovation and contributing to overall economic growth.	[31],
Technological innovation	Research and development initiatives in green energy lead to cost reductions and efficiency improvements, making renewables increasingly competitive.	[32], [12],
Government support	Policies such as subsidies, tax credits, and renewable energy targets encourage investment in renewable projects and facilitate the low-carbon transition.	[33], [34],
International trade and collaboration	Global trading of renewable energies and international collaboration promote economic growth, export opportunities, and job creation beyond national borders.	[35], [36],

3 Global Perspective on Green Energy

The renewable aspect of green energy that has low environmental impact is a hope in the fight for sustainable development and secure energy in countries all over the world. This radical shift to greener sources of energy has gained considerable traction in recent times, through a combination of technological innovation, supportive policies and increasing public awareness about environmental problems [37]. Understanding that the many advantages of renewable energy is essential to the global shift for the benefits. Apart from reducing GHGs emissions and consequently reducing global climate change, green and clean energy offers numerous economic, environmental, and social benefits [38]. Alternative or renewable energy sources, such as solar, wind, hydroelectric, biomass, and geothermal power, promote energy diversification by improving resilience against fluctuations in energy prices and supply disruptions [39]. As an alternative, decentralized versions of numerous renewable systems empower communities and improve accessibility to power in numerous situations, such as those in isolated locations with little access to electricity and frequently underdeveloped economies due to a lack of energy infrastructure [40].

Innovation still remains at the centre of the green revolution by which it continues to reduce costs and improve efficiency as well as reliability on renewable energy technologies. The fast-paced developments in solar PV and wind turbine technologies have resulted into substantial declines in levelized cost electricity from renewables hence making them more competitive with conventional fossil fuels [41]. Furthermore, break-throughs in storage technologies for electricity such as batteries and pumped hydro storage address the intermittency and variability of renewable sources thereby enabling greater grid integration and flexibility [42]. Despite the progress towards the use of green power, there are still major obstacles in the way of a sustainable energy future. One key hindrance is the variability and intermittence exhibited by renewable resources leading to potential threats against reliability in grid stability as well as supply security during times when they are most needed [43]. On top; these must be addressed, through solutions like which include demand-side management [DSM], smart grids or grid modernization thus realizations will help maximize their potential of renewable energy resources [44]. The costs of green energy infrastructure and the demand or need for supportive policies and financial incentives can present barriers to widespread adoption, particularly in developing countries with limited access to capital and technical expertise [45-47].

The future of green energy appears promising when looking forward to it and with innovative, emerging, and creative solutions it is set to accelerate the shift toward a sustainable energy future. There are several innovative fields, including offshore wind, floating solar, green hydrogen, and advanced bioenergy, that have the potential to significantly expand the green energy portfolio and address current issues with their solution [48]. The integration of digitalization, smart grid technologies, and artificial intelligence will create a path towards a more sustainable and interconnected energy landscape and will enhance and contribute to the usefulness, dependability, and adaptability of reusable energy systems [49]. Fig 1 shows the key points on global perspective of green energy. Table 2 is about different types of green energy produced in different regions with its potential growth [50].

Table 2. Different types of Green Energy Sources and their Global Presence

Green Energy Type	Description	Installed Capacity in Gega Watts (GW)	Major Regions	Potential for Growth
Solar Energy	Energy produced by photovoltaic (PV) or concentrated solar power (CSP) systems using sunlight.	Over 1,000 GW globally	China, USA, Europe, India	High, as a result of supporting policies and declining costs
Wind Energy	Energy produced from wind using wind turbines.	Approximately 800 GW worldwide	China, USA, Germany, India	Strong, especially in projects using offshore wind
Hydro Power Energy	Energy produced by the movement of water through dams.	Over 1,200 GW globally	China, Brazil, USA	Moderate, emphasizing small-scale initiatives and environmental issues
Geothermal Energy	Energy produced by the Earth's heat.	Around 14 GW globally	USA, Indonesia, Philippines	Moderate, with open to increasing the number of applicants
Biomass Energy	Energy produced from organic things (such as wood and agricultural waste).	Varies significantly by region	USA, Brazil, Europe	Variable, with close regard to emissions and sustainability

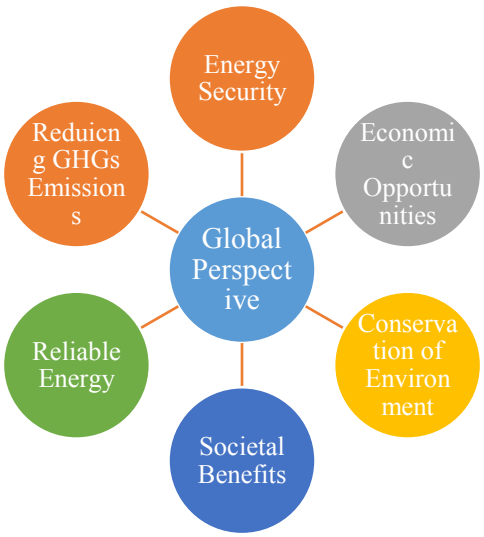

Fig. 1. Global Perspective on Green Energy

4 Future of Green Energy

Transformative growth and innovation is what lies ahead for the future of green energy, boosted by a fusion of technological advancements, changing market dynamics, and mounting environmental imperatives. According to renewable sources of energy like solar power, wind power, hydroelectricity, biomass power generation and geothermal are expected to be used to meet an increasing demand for energy in the world with minimal contribution to climate change [51]. For example, dramatic cost reductions have been witnessed through rapid advances in solar photovoltaic (PV) and wind turbine technologies resulting in renewables becoming increasingly competitive with conventional fossil fuels [52]. Also, recent breakthroughs in battery technology as well as pumped hydro storage are solving the problem of variability and intermittency associated with renewable power while at the same time strengthening reliability and stability on grids [53]. In addition to that same point is made by [54] who state that green or sustainable hydrogen alongside offshore wind and floating solar can further expand the range of renewable options available for energy supply purposes. The integration between digitalization, artificial intelligence and smart grid technologies is projected to bring about a transformation within the energy industry permitting it to function as more efficient," interwoven" and responsive unit [55]. To encourage innovation, investment, and collaboration across borders supportive policies, regulatory frameworks, and international cooperation will be essential in driving the global transition toward green energy [56].

When we look towards the future of green energy, there are several key trends and developments are expected to shape the trajectory of the renewable energy sector. One of the most notable trends is the continued decline in the cost of renewable energy technologies, particularly solar and wind power [57]. The cost of solar PV modules has reduced by around 80% since 2010, while the cost of onshore wind turbines has dropped by about 40% during the same period. In the upcoming years, this trend is expected to continue, driven by economies of scale, technological innovation, improvements in policies, and increasing competition in the renewable and sustainable energy market [58]. The other significant trend is the growing focus on energy storage solutions or methods to reduce the irregular and intermittent nature of renewable energy sources. Energy storage technologies are becoming increasingly cost-effective and efficient like grid-scale storage systems, pumped hydro storage, and lithium-ion batteries it making easy to integrate renewable energy sources into the electrical grid [59]. Table no. 3 shows the comparison between different types of energy storage systems with their Levelized Cost of Energy (LCOE) [60]. Renewable energy sources will become more dependable and flexible as energy storage system deployment increases, and this will lower the need for backup power generation from non-renewable sources.

Green energy adoption will be largely driven by support for policies, technological advancements, and regulatory frameworks worldwide. Several countries have already placed challenging goals for renewable energy and financial incentives to promote the purchase of technologies that produce clean and efficient energy. For example, China wants to boost its percentage of energy produced from non-fossil fuels to 20% by 2030, while the European Union has set a goal of 32% renewable energy sources by that year. Looking ahead, the future of green energy holds immense promise for addressing the dual challenges of environmental weather change and energy security, towards a future with more equitable and sustainable energy for the next generation. Fig 2 shows the future goals of green energy.

Table 3. Energy Storage Systems Comparison

Technology	Power Rating (MW)	Cycle Efficiency (%)	Lifetime (Years)	LCOE ($/kWh)
Compressed Air	110–1000	42–54	20–40	2–120
Pumped Hydro Storage	30–5000	70–87	40–60	5–100
Thermal Energy Storage	0.1–300	30–60	20–30	3–60
Lead Acid Batteries	0–40	63–90	5–15	50–400
Li-ion Batteries	0–100	75–97	14–16	600–3800
Flywheels	0.25–20	90–95	15–20	1000–14,000
Supercapacitors	0–0.3	84–97	10–30	300–2000
Fuel Cells	<58.5	20–66	~20	2–15
Super magnetic Conducting Energy Storage	0.1–10	95–98	20–30	500–72,000

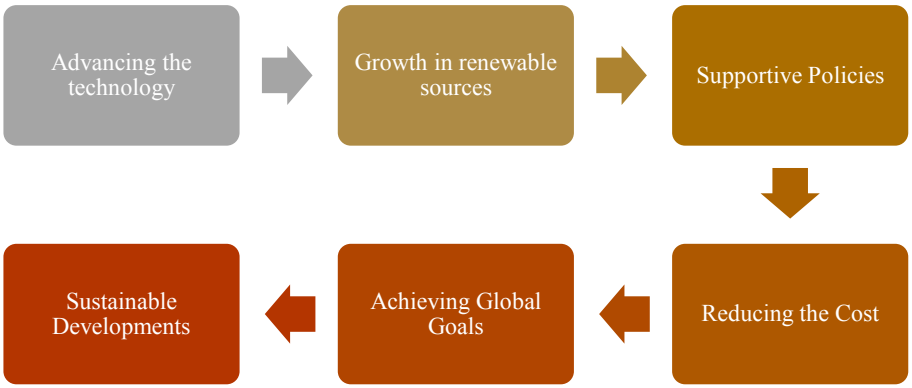

Fig. 2. Future of Green Energy

5 Conclusion

In conclusion, shifting towards green energy is an essential step to tackle the serious effects of rising global energy consumption and environmental damage. This paper has offered an analysis of the various aspects and consequences of adopting green energy, by highlighting the role that green energy adoption plays in promoting sustainable economic development:

- Green energy provides an affordable means to cut carbon emissions and achieve independence from traditional energy sources. Green energy is defined as electricity produced from renewable sources like solar, wind, hydroelectric, biomass, and geothermal power. When a nation uses green energy sources over natural resources it can enhance the quality of air and water and also preserve its natural resources and reduce the negative effects of burning fossil fuels in the environment.
- The government's investments and policies play a critical role in encouraging the growth of the green energy sector. Maximizing the financial potential of renewable energy sources and dealing with global sustainability issues require international cooperation and knowledge exchange which makes a good impact on the green energy sector.

- Making the switch towards green energy improves energy security by lowering dependability on imported fossil fuels and minimizing financial risks caused by volatile oil prices in the market. Carrying out renewable energy technologies into energy portfolios, portfolio diversification improves resilience to price uncertainty and interruptions in the energy supply.
- Shifting toward green energy drives technological innovation and advancement, which results in continuous improvements in renewable energy technologies. These significant advancements in solar photovoltaics, wind turbines, energy storage systems, and grid integration technologies, are efforts of research and development which resulted in increasing the effectiveness and dependability of renewable or reusable energy systems.
- Green energy initiatives empower communities and promote equity by decentralizing energy production and improving energy access. By engaging local communities actively in renewable energy projects, nations can make guaranteeing the advantages of switching to green energy are shared evenly and fairly, which leads to a more resilient future.

In summary, this paper indicates that by prioritizing environmental sustainability, economic growth, and social equity, nations can work together toward green energy to achieve a better, brighter, and greener future for all.

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