Global Trends and Regional Differences in Renewable Energy Adoption-A Brief Review

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***Abstract*—The paper discusses modern trends in the global market for renewable energy development. Despite the dynamic deployment of renewable energy capacity observed worldwide today, the global energy market is still dominated by non-renewable energy sources. The paper analyses the development factors of the global renewable energy market and their impact on the construction of renewable energy options. The analysis showed that the main driving forces behind the growth of the world's renewable energy sector are political factors, especially the implementation of well-thought-out support mechanisms and policies to promote renewable energy production. Since such incentives were introduced mainly in the electricity sector, it is now in a leading position, while insufficient implementation of incentives for transport, heat, and cooling has slowed down its development. In addition, the main challenges that prevent increasing the competitiveness of renewable energy in the global energy market are highlighted. The main factors affecting regional differences are resource availability, political framework, economic conditions, and existing energy infrastructure**.

***Index Terms*—Global Adoption, Policy Framework, Regional Differences, Renewable Energy, Technological Advancements**.

I. INTRODUCTION

Energy is essential to modern society because it drives worldwide economic activity and makes it possible to meet every day needs and basic human needs. The need for renewable energy is growing in the modern world since it reduces climate change and supports sustainable development. The energy production industry's reliance on fossil fuels has been identified as the world's largest source of greenhouse gas (GHG) emissions, accounting for a major share of all GHGs and 80% of carbon dioxide emissions. The Earth's climate balance is severely challenged by this. To decarbonize the global energy systems, combat climate change, and work toward a sustainable future, renewable energy sources are thought to be the only viable choice.

Following a multi-year trend that began in couple of years ago, there has been a significant increase in the usage of renewable energy sources as a commercial substitute for energy generation based on fossil fuels, moving past the proof-of-concept phase. The number of nations having renewable energy legislation has grown in recent years. With policy tools that frequently change according on technology, scale, or other installation characteristics (such as centralized versus decentralized systems), the majority of countries promote renewable energy sources. For doing so nations would enact stricter laws to cut greenhouse gas emissions and promote the use of clean energy sources as part of their efforts to mitigate the effects of climate change. This will have an impact on the industrial sector, which, according to various sources contributed about 29% of global net greenhouse gas emissions in 2021. When indirect emissions from the production of heat and electricity are taken into account, this percentage rises to 34%, the largest share of all industries [1]. Industrial production is anticipated to gradually transition from CO_2-emitting fossil fuel sources to renewable energy sources as a result of efforts to mitigate climate change [2]. Aiming to promote the rising use of renewable energy sources in the industry, recent global initiatives include the US's Inflation Reduction Act [3], the EU's RE Power EU plan [4], and the US's Net Zero Industry Act [5-6]. This could mean that the

availability of renewable energy in a given area plays a bigger role in deciding where energy-intensive firms situate their manufacturing. Figures (a) and (b) below show sector wise global emissions of GHG and country wide emissions of GHG respectively.

The verifiable movement of vitality productivity programs, nearby supportability certifications and benchmarks for buildings have played an essential part in forming the selection scene of building vitality effectiveness and renewable vitality innovations. Innovations that have seen higher selection rates frequently advantage from a combination of administrative back, money-related motivations, moo execution costs, and positive open recognition. Then again, innovations lacking in appropriation ordinarily confront obstructions such as tall payback periods, the need of rigid prerequisites or motivations, restricted advancement, or compatibility issues with existing frameworks. Understanding these elements is significant for recognizing techniques to improve the take-up of maintainable vitality advances, subsequently contributing to the plan and retrofitting of more energy-efficient buildings [7]. Looking towards long run, [8] display a long-term determining system for the introduced capacity and costs of renewable vitality innovations up to 2050. The enquiry about highlights the confinements of conventional determining strategies, which regularly be little the development potential and fetched diminishments of renewable vitality capacities.

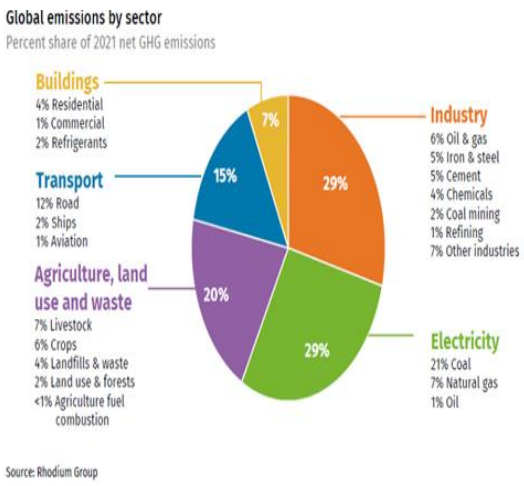

Fig (a)

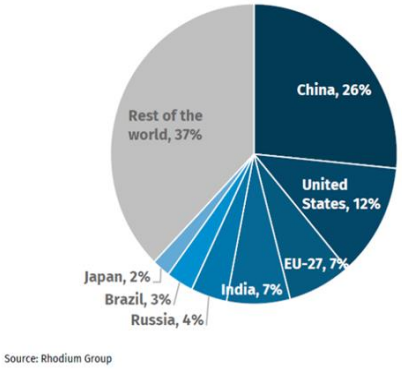

Fig (b)

II. LITERATURE REVIEW

2.1 Systematic Approaches to Evaluating the Effects of Renewable Energy

The evaluation of the effects of renewable energy on the economy and environment requires a strong theoretical framework that can capture the complex nature of these consequences. The creation of these frameworks has benefited greatly from recent academic research, which has shed light on the processes by which the use of renewable energy sources and advancements in technology affect carbon emissions and, consequently, sustainable development [9].

To quantify the effects of international trade, technical advancement, and the use of renewable energy sources on carbon emissions, Hasanov et al. (2021) [10] offer a thorough theoretical framework. Their analysis highlights the beneficial contribution of technology developments and the use of renewable energy sources to the reduction of CO2 emissions, with a particular emphasis on the BRICS nations between 1990 and 2017. Because it takes heterogeneity and cross-country interdependence into account, the framework created by Hasanov et al. (2021) [11] is especially notable for assuring the validity of their findings and the resulting policy advice. The writers support policies, rules, and laws that encourage the advancement of technology and the shift to sustainable energy sources, emphasizing the crucial role that legislation plays in enabling these developments.

In his analysis of the effects of renewable energy, Jenniches (2018) [12] moves the focus from the

national to the regional level, taking into account the decentralization that many renewable energy sources naturally exhibit because of their lower energy densities. The decentralization process bears noteworthy consequences for regional economies, particularly in light of their shift towards renewable energy systems. In reviewing recent research and techniques for evaluating the effects of this shift on regional economies, makes the case that it is important to be clear about the parameters of evaluations, including the periods covered. Several techniques, such as employment ratios, supply chain studies, input-output models, and computable general equilibrium models, are highlighted as appropriate in the proposed guideline for regional effect assessment. Understanding the regional economic dynamics of renewable energy adoption is crucial since these might differ greatly from the national-level implications that are frequently covered in the literature, as this paper makes clear.
In his study published in 2023, Fang [13] investigates the relationship between carbon dioxide emissions in China's provinces between 2005 and 2019 and the energy sector's investments, industrial growth, and introduction of green technologies. The economic complexity index raises CO2 emissions, but investments in renewable energy, green technological innovation, and improvements in the industrial structure significantly reduce these emissions, according to Fang (2023) [13], who uses contemporary econometric techniques that take cross-sectional dependency and co-integration into account. In addition to presenting policy recommendations to support China's carbon abatement ambitions, this study offers a sophisticated knowledge of the different economic and technological elements that interact to influence carbon emissions.

2.2 Technological Comparison of Renewable Energy in Different Regions

To comprehend the dynamics of sustainable growth and the shift to cleaner energy sources in the future, a comparative examination of renewable energy technologies across various geographical locations is important. This analysis throws light on the opportunities and constraints that different regions have in utilizing these resources, in addition to highlighting the potential of diverse renewable energy sources. These authors' studies offer important insights into the energy efficiency of renewable technologies in Europe, the growth and efficiency of hydro, solar, and wind power systems in comparison, and the techno-economic aspects of hybrid renewable energy systems in Turkey.
With an average yearly production capacity of more than two million MW over the last ten years, Ngobeh et al. (2023) [14] focus on the exponential rise in renewable energy. They undertake a thorough examination of the sustainable growth of global hydro, solar, and wind power systems. The report highlights the noteworthy contribution of hydroelectric power, solar power, and wind energy to the worldwide adoption of renewable energy systems. The writers emphasize these renewable energy sources' sustainability and environmental friendliness by using quantitative analyses based on data from the International Renewable Energy Agency (IRENA) for the years 2013 to 2022. Because of the pressing need for de-carbonization and environmental preservation, this comparative analysis bears witness to the dynamics that are shifting in favor of renewable energy.

The techno-economic comparison of islanded and grid-connected hybrid renewable energy systems (HRESs) in seven Turkish climate areas is examined by Ayan &Turkay (2023) [15]. Using the Hybrid Optimization of Multiple Energy Resources software (HOMER PRO), their research assesses the environmental, technological, and economic benefits of HRESs. The study shows that different places have different ideal system topologies depending on solar radiation and wind speed diversity.
This study emphasizes the advantages of using hybrid renewable energy systems that are adapted to the unique climate conditions of each place, both economically and environmentally.

The significance of doing a comparative analysis of renewable energy technologies across different locations is shown by these studies, which also highlight the obstacles and varied potential associated with the global shift towards renewable energy. The observations provide useful advice for academics, policymakers, and stakeholders in creating plans for sustainable energy development in addition to adding to the body of knowledge on renewable energy.

2.3 The Financial Advantages and Difficulties of Adopting Renewable Energy

In addition to providing several economic advantages and reducing environmental effects, the use of renewable energy sources (RES) is essential for sustainable development. There are many obstacles in the way of switching from traditional fossil fuels to renewable energy sources. The works by Hashmi (2023) [16], and Algarni et al. (2023) [17] offer thorough insights into the advantages and difficulties of adopting renewable energy, highlighting the function of renewable energy in public health, sustainable development, and the establishment of an eco-friendly environment.

Renewable energy sources have a great deal of promise to support environmental, social, and economic sustainability, as noted by Algarni et al. (2023) [17]. Reduced pollution emissions, increased energy access, and potential for local socioeconomic growth are all benefits of renewable energy. To achieve sustainable development and reduce poverty, the study emphasizes the importance of energy as a major factor in wealth creation and an essential part of economic development. All countries need to have access to renewable energy sources because of their low environmental impact. Still, the development of sustainable technologies to effectively utilize their energy is necessary to realize the full potential of these resources. To overcome the obstacles in acceptance and execution, Algarni et al. (2023) [17] strongly support the optimal use of renewable energy for sustainable development.

In contrast to conventional energy sources like coal and oil, Hashmi (2023) [16] examines the efficacy and efficiency of renewable energy sources including geothermal, hydro, solar, and wind energy. This study centers on the advantages and disadvantages of renewable energy resources, as well as the obstacles encountered during large-scale implementation of renewable energy. Despite many acceptance and implementation obstacles, Hashmi (2023) [16] concludes that renewable energy sources may successfully and efficiently replace traditional energy sources through thorough literature research and innovative analysis. To encourage the expansion of renewable energy sources, the paper recommends additional research and changes to legislation. The adoption of renewable energy has significant financial advantages and may help with environmental preservation, public health, and sustainable development.

However, financial, policy and technological obstacles make the switch to renewable energy systems difficult. The views expressed by Hashmi (2023) [16], and Algarni et al. (2023) [17] highlight the significance of public awareness and strategic methods in overcoming these obstacles and realizing the full potential of renewable energy for a sustainable future.

2.4 The effects of renewable energy systems on the environment

Considering the global trend towards sustainable and green energy sources, research on the environmental effects of renewable energy systems is essential. Climate change mitigation and emission reduction are acknowledged benefits of renewable energy systems, which include geothermal, hydro, biomass, and wind power. However, these systems also present environmental issues that need to be carefully considered and addressed through mitigation measures. Abid et al. (2023) [18], and Sayed et al. (2020) [19] offer insightful analyses of the environmental effects of renewable energy systems and suggest ways to reduce those effects.

The effects of small and medium-sized renewable energy systems, such as wind, hydro, biomass, and geothermal power, on the environment are thoroughly reviewed by Sayed et al. (2020) [19]. From design and planning to building, installation, service life, and decommissioning, every phase is covered by their examination. Though they have far less detrimental environmental effects than fossil fuels, the study admits that renewable energy sources still need to be carefully considered and the right safety measures taken. Offering technically and ecologically sound recommendations to lessen the impact on animals and natural resources, the writers offer thorough and unambiguous answers for a range of situations. For renewable energy systems to have the least amount of environmental degradation possible, sustainable practices must be used at every stage of the system's existence.

Globalization and the effects of solar photovoltaic (PV) systems on the environment are the main topics of Abid et al.'s (2023) [18] research. Comparing solar PV systems to other energy sources, the study shows how much more advantageous they are in terms of both ecology and sustainable development. The installation of solar PV systems, however, necessitates the usage of a large amount of land, which raises several ecological problems, such as deforestation and effects on the environment, wildlife, and human health. During the phases of building, installation, and destruction, examine how solar PV systems affect the environment in terms of pollution, greenhouse gas emissions, and visual and acoustic intrusions. The report notes that switching to solar energy has good environmental implications despite these obstacles, including decreased greenhouse effects, carbon footprints, and global warming.

With a focus on a location in northern Nigeria, life cycle assessment to estimate the environmental impact of integrating renewable energy technologies into the utility grid. Determining the optimal hybrid options for environmental sustainability is the goal of the study. Utilizing GanzleitlichenBilanz (GaBi) software to model various scenarios and simulate outcomes. According to the results, scenarios based on the conventional approach have the greatest potential for global warming, acidification, human toxicity, and abiotic depletion, while scenarios based on renewable resources have far smaller potential effects. The environmental benefits of implementing hybrid renewable systems are highlighted in this review, especially in terms of lowering the potential for global warming and other environmental problems.

Because of the complexity of the environmental effects of renewable energy sources, a balanced strategy that takes into account both the advantages and disadvantages of these technologies is necessary. To reduce the environmental effects of renewable energy systems, sustainable practices, careful planning, and mitigation methods are essential, according to the insights offered by Sayed et al. (2020) [19], Abid et al. (2023) [18]. These studies provide insightful direction for practitioners, academics, and policymakers in creating and executing ecologically acceptable renewable energy solutions as the globe continues to embrace renewable energy.

2.5 Case Studies of Globally Successful Renewable Energy Projects

The renewable energy sector in the world has a wide range of well-executed examples that all help to solve the issues of climate change and advance sustainable development goals. The cases from Colombia, two Greek and Spanish islands, and the larger developing country context, as offered by Rocha et al. (2022)[20], and Othman &Khallaf (2022) [21], offer illuminating illustrations of the development, difficulties, and viewpoints of renewable energy projects.

Studying the behavior of energy projects that have been presented to the Mining Energy Planning Group (UPME) for the past 15 years, Rocha et al. (2022) [20] examine the renewable energy landscape in Colombia. Their research indicates that the growing population, industrialization, and commerce have resulted in a notable rise in energy demand, which has created several adverse effects on the environment, society, and economy. This paper thoroughly analyzes the development, obstacles, and potential futures of renewable energy projects in Colombia by looking at the research locations with the best technological performance and matching radiation intensity. As a useful resource for future research on the deployment of renewable energy in Colombia and related fields, this case study highlights the significance of new rules and the incentive for implementing projects with renewable energy sources.

The sustainability of regional renewable energy projects is evaluated by Tsagkari et al. (2022) [22] using an innovative framework that assesses the accomplishment of these projects according to the local community's opinions and the project's original goals. Concentrating on the creative local population and the initial ambitions of the projects

The study uses an online questionnaire to collect data on people's opinions about the renewable energy projects in El Hierro, Spain, and TilosIsland, Greece, as well as their desire to support similar projects. The

results show that people's evaluations of the projects are influenced more by technical specifications, institutional considerations, a sense of pride, and environmental benefits than by economic ones. This case study demonstrates the initiatives' perceived success.

Reviewing public-private partnerships (PPPs) for renewable energy is Othman & Khallaf (2022) [21]. Initiatives in underdeveloped nations to create a thorough knowledge of renewable energy initiatives carried out by these collaborations. The research pinpoints the traits of PPP initiatives and the lessons discovered, assisting in identifying crucial success elements required for the effective execution of PPP projects involving renewable energy in developing nations. The potential for renewable energy projects to provide clean, dependable, affordable, and sustainable energy to millions of people is highlighted in this review, which also highlights the role of PPPs in utilizing the capital, innovation, and technology of the private sector to support the public sector in providing sustainable energy services.

2.6 Policy and Financial Restraints

One of the most important aspects of international efforts to prevent climate change and advance sustainable development is the shift to renewable energy or RE. However regionally-specific financial and policy limitations frequently impede this shift. The research by Yi et al. (2022)[23], Chang et al. (2019)[24] highlights the challenges of encouraging the adoption of renewable energy in various contexts and offers insightful information on how credit policies, financial development, and uncertainty in economic policy affect investment in and consumption of renewable energy.

The impact of financial development and uncertain economic policies on the use of renewable energy in the BRICST region is examined by Zhang &Razzaq (2022) [25]. According to their findings, the adoption of renewable energy is greatly aided by financial development, environmental restrictions, and the informal economy, but economic policy uncertainty harmsthe use of renewable energy. The report emphasizes the need of strict environmental rules and stable economic policies in encouraging the use of renewable energy. It implies that the adoption of renewable energy is hampered by a lack of policy stability and financial development and that an integrated ecological governance policy is necessary to control and redirect financial resources toward green energy and sustainable development.

With a focus on the impact of economic globalization, Yi et al. (2022) [23] investigate how financial development and uncertainty in economic policy affect the use of renewable energy. Economic globalization, financial development, and economic growth all have a favorable effect on the amount of renewable energy consumed, while economic policy uncertainty reduces the capacity to produce renewable energy. These findings are supported by their research of the top countries that consume renewable energy. Economic globalization, financial development, and economic expansion are suggested to be the main drivers of renewable energy consumption in the study, which promotes the prioritizing of renewable energy development to assure sustainability and environmental quality. These results underline the necessity of economic globalization and financial development policies to overcome financial and policy barriers to the use of renewable energy.

Financial restraints and credit policies' impact on investments in China's renewable energy sector are examined by Chang et al. (2019)[24]. According to the report, tangible and R&D investments in the renewable energy sector are heavily impacted by firm-specific features, credit regulation, and financial restrictions. The findings indicate that renewable energy enterprises' tangible investments may be encouraged by increased commercial bank credits, more liquid assets, higher returns on assets, and better investment prospects. The results highlight the need for financial support and policy changes to support the expansion of the renewable energy industry, arguing that financial constraints must be addressed and credit regulations must be optimized to encourage investments in renewable energy.

The adoption of renewable energy varies greatly throughout locations due in large part to financial and policy constraints. To overcome these obstacles, stable economic policies, financial development, and lenient lending rules are crucial, as highlighted by the insights offered by Zhang &Razzaq (2022)[25], Yi et al. (2022)[23], and Chang et al. (2019)[24]. To contribute to international efforts to achieve sustainable development and reduce climate change, governments should expedite their shift to renewable energy by tackling these obstacles.

2.7 Limitations in Infrastructure and Technology

To achieve sustainable development and reduce climate change, renewable energy (RE) technologies must be adopted. However widespread adoption of these technologies is severely hampered by infrastructure and technological constraints, especially in areas with less established energy systems. In their 2022 study, Soto and Arboleda investigate how Colombia's transportation infrastructure constraints impact the advancement of initiatives involving non-conventional renewable energy sources (NCRES), such as wind and solar power. Their analysis emphasizes how important it is to have dependable and easily accessible transportation infrastructure to support the implementation of renewable energy projects. The researchers find regions where the transportation infrastructure is inadequate to support the logistics of solar and wind parks by performing a spatial study using geographic information systems (GIS). The necessity for focused expenditures in transportation is shown by this report.

The link between technological advancement and Uluer, Dinçer, and Yüksel (2020) [26] promoting the use of renewable energy, with a G7 concentration. Their findings highlight the importance of technology improvement as a major factor in the adoption of renewable energy. IT infrastructure's significance for investments in renewable energy. According to the study, to boost the usage of renewable energy, nations should give priority to technology advancements. This suggestion emphasizes the need to make investments in innovation and technology to get over the technological obstacles to the adoption of renewable energy sources and make renewable energy technologies more widely available and effective.

The possibility of using renewable energy in distant Canadian communities by 2050 is reviewed by Agu, Tabil and Mupondwa (2023) [27], who also point out the infrastructure and technological obstacles that need to be overcome to make this happen. The research highlights that sustainable infrastructure may be built using renewable resources like wind, solar, hydro, and biomass at subsidized costs. However, making the switch to renewable energy will need substantial breakthroughs in both technology and infrastructure development. Energy efficiency and the integration of social values are crucial for the sustainable development of renewable energy, according to the researchers, who also stress the significance of coordinating the deployment of technology and long-term policy to direct the adoption of renewable energy in rural and Indigenous communities.

Encouraging the broad use of renewable energy technology requires overcoming infrastructure and technological constraints.

III. ELABORATE ANALYSIS AND DISCUSSION

3.1 Analysis of Renewable Energy's Economic Impact

Adoption of renewable energy (RE) has a wide-ranging economic impact that includes multiple aspects such as GDP growth, employment creation, and boosting local R&D. The research carried out by Adeyemi-Kayode, Misra, &Damaševičius (2021) [28], English, Menard, & Wilson (2022) [29], and Khan &FularaGunwant (2023) [30] offers a thorough understanding of the macroeconomic variables influencing the production of renewable energy in South Asia, the supply chain for renewable biofuels and energy in West Africa, particularly Nigeria.

The influence of renewable energy generation in Nigeria is examined by Adeyemi-Kayode, Misra, and Damaševičius (2021) [28], with particular attention paid to solar, biomass, hydropower, pumped storage hydro, and ocean energy. According to their analysis, the use of renewable energy boosts GDP growth, generates employment opportunities, and supports regional R&D, all of which have a substantial positive impact on economic development. The study highlights the role that individual solar and wind projects around Nigeria, as well as enterprises

focused on renewable energy, play in promoting social and economic change. This Nigerian case study demonstrates how renewable energy can help with sustainable development issues and provide energy to all people by 2030.

By utilizing the Renewable Energy Economic Analysis Layers (REEAL) modeling framework, English, Menard, and Wilson (2022) [29] investigate the economic effects of the renewable biofuels/energy business supply chain. Taking into account elements like feedstock setup and production, transportation, and facility operations, their methodology involves modeling the supply chains for technologies that generate liquid and power. This study highlights the role that renewable energy plays in fostering both environmental sustainability and economic growth.

Using an autoregressive distributed lag technique, Khan &Fulara Gunwant (2023) [30] examine how macroeconomic factors affect the production of renewable energy in South Asia. Remittance inflows, literacy rates, energy imports, government spending, and urban population expansion are all identified in the study as important variables affecting the generation of renewable electricity. The results indicate that while government spending, urban population expansion, energy imports, and remittance inflows harm renewable electricity output, literacy rates have a positive and considerable impact. The importance of macroeconomic factors in increasing the output of renewable energy is demonstrated by this study, which also emphasizes the necessity of policies that lower energy imports and guarantee efficient government spending on renewable energy.

The adoption of renewable energy has a huge economic impact and offers opportunities for GDP growth, job creation, and sustainable development. Adeyemi Kayode, Misra, & Damaševičius (2021) [28], English, Menard, & Wilson (2022) [29], and Khan & Faluala Gunwant (2023) [30] offer valuable insights that highlight the multifarious economic advantages of renewable energy initiatives and the significance of policies and investments that support them. Countries can contribute to international efforts to prevent climate change and advance sustainable development by tackling the obstacles and seizing the opportunities provided by renewable energy sources. These actions will also have a significant positive economic and environmental impact.

3.2 Employment Growth, Energy Costs, and Market Dynamics

Incorporating renewable energy (RE) into the world's energy mix is a major force behind economic transformation as well as a calculated reaction to climate change. The dynamics of energy pricing, the creation of jobs, and the general market dynamics within the energy industry all reflect this transition. Pham's (2019) [31] papers offer insightful analyses of these factors, emphasizing the complex economic effects of adopting renewable energy.

The implications of renewable energy across borders are examined by Pham (2019) [31], specifically looking at how the generation of wind and solar power in Germany affects market power and prices in the French electricity market. According to the study, price reductions in the power market can result from the supply of renewable energy sources at low marginal costs. In global electrical markets that are interconnected, regulations and energy output in one nation can impact energy prices and market dynamics in another. This is a noteworthy effect. For interconnected markets to maximize the advantages of renewable energy integration, Pham's findings emphasize the significance of coordinating energy policies and cooperative renewable energy assistance programs.

The ASEAN region's ability to create jobs through the use of renewable energy is the main topic of Bilqis et al.'s (2023) [32] analysis. According to the analysis, there might be 3.9 to 5.5 million jobs related to renewable energy in ASEAN, with Vietnam and Indonesia holding the lion's share.
The substantial societal impact of renewable energy is highlighted by this estimate, especially in terms of job potential. The report highlights that, in the long run, social stability and long-term economic growth depend not only on the quantity but also on the quality and sustainability of jobs created in the renewable energy sector.

Adoption of renewable energy has significant effects on market dynamics, energy prices, and job development. The perspectives offered by Pham (2019) [31] and Bilqis et al. (2023) [32] demonstrate how renewable energy has advantages for the

economy in addition to the environment. These advantages include lowering energy costs, stabilizing the energy markets, and generating long-term job prospects. Policymakers, companies, and communities must all recognize and take advantage of these economic effects as the globe moves closer to a future with more sustainable energy sources.

3.3 Long-Term Financial Gains Compared to Original Investment Expenses

A common feature of the shift to renewable energy (RE) sources is the juxtaposition of substantial upfront investment costs with long-term economic advantages. The global adoption of renewable energy is being shaped in large part by this dynamic interplay between cost and benefit. Orlando et al.'s (2023) [33], Prokopenko et al.'s (2023) [34] studies provide in-depth analyses of the financial and environmental advantages of renewable energy communities, the effect of investments and R&D expenses on business profitability metrics, and the cost-benefit analysis of renewable energy generation in particular applications.

An approach for evaluating the financial and ecological advantages of creating communities powered by renewable energy sources is presented by Orlando et al. (2023) [33], with a focus on solar energy systems. Their analysis emphasizes how shared renewable energy systems can minimize energy drain from the power grid and maximize self-consumption, which lowers maintenance and initial investment costs. Together with encouraging financial savings, this collaborative strategy lowers CO2 emissions, protecting the environment. Orlando et al. (2023) [33] have suggested a paradigm that illustrates how renewable energy communities may accelerate the shift towards a more sustainable energy future by improving the price and accessibility of renewable energy technology.

The financial performance of businesses involved in the renewable energy sector is examined by Prokopenko et al. (2023) [34] in connection to long-term investments and R&D expenses. Results show that spending on R&D and investments in renewable energy have a favorable impact on profitability metrics including net income, return on investment, and earnings before interest, taxes, depreciation, and amortization (EBITDA). The long-term benefits of increased profitability and sustainability, even with the initial expenses, are enormous, according to this report that emphasizes the economic viability of renewable energy investments. As they highlight the significance of these investments in propelling the global energy transition, Prokopenko et al. (2023) [34] call for the development of financial regulations that encourage investments in renewable energy technology.

A cost-benefit analysis is carried out by some scholarsto determine the feasibility of implementing an integrated system in a hotel-style building that consists of a heat pump and a solar system. They examine the environmental advantages, long-term running and maintenance costs, and initial investment costs when comparing this renewable energy option to a traditional wood-fired boiler. According to the study's findings, using renewable energy can have major long-term benefits for the economy and environment, including cheaper energy costs and a decrease in greenhouse gas emissions. This case study highlights the potential for financial savings and environmental advantages by providing an example of how renewable energy technologies are used in real-world settings.

Despite the difficulties caused by high initial investment prices, the economic analysis of the adoption of renewable energy provides a strong case for the long-term benefits of these technologies. The perspectives offered by Orlando et al. (2023) [33], Prokopenko et al. (2023) [34], emphasize the significance of deliberate investments in renewable energy, stressing the possibility of financial gains, increased profitability, and environmental sustainability. The economic justification for adopting renewable energy sources is growing stronger as the globe struggles with the demands of climate change and sustainable development. This provides a route to a more successful and environmentally friendly future.

3.4 Analyzing Renewable Energy's Environmental Impact

A crucial factor in the global transition to sustainable energy sources is the effects that renewable energy (RE) systems have on the environment. This analysis explores the environmental effects of renewable

energy projects, with particular attention to biomass-based renewable energy's economic and environmental assessment, Nigeria as a case study, and wind energy in Western Canada.

The impact of renewable energy-based generation in West Africa, with a particular focus on Nigeria, is evaluated by Adeyemi-Kayode, Misra, and Damaševičius (2021) [28]. The report highlights the potential for GDP growth, job creation, and local research and development as it looks at the economic, social, and environmental aspects of the impact of renewable energy. Beyond the environmental advantages of lowering greenhouse gas emissions, the report also discusses the social ramifications of education and initiatives related to renewable energy. This in-depth analysis offers insightful information for other West African locations while highlighting the diverse advantages of renewable energy adoption in Nigeria.

An economic and environmental impact assessment of renewable energy from biomass is presented by Bacenetti (2020) [35], who emphasizes the significance of taking the two factors into account simultaneously to prevent trade-offs. The study looks into the sustainability of several renewable energy routes using a variety of methodologies, such as life cycle assessment and energy analysis. The findings contribute to a better understanding of the sustainability of various energy sources by highlighting the relationship between the economic and environmental performances of renewable energy from biomass.

Comprehensive evaluations that take into account the economic, social, and environmental aspects are crucial, as demonstrated by the environmental impact study of renewable energy systems. The perspectives offered by Bacenetti (2020) [35] and Adeyemi-Kayode, Misra, &Damaševičius (2021) [28] highlight the necessity of creative mitigation techniques, fair effect assessments, and the fusion of economic and environmental factors. Renewable energy projects can play a major role in promoting sustainable development, environmental conservation, and the worldwide shift towards sustainable energy by considering these factors.

3.5 Reduction in Greenhouse Gas Emissions and Pollution

To mitigate climate change and reduce environmental pollution, there must be a global shift towards renewable energy sources. Study conducted in Germany and South Korea, developing market countries, and the idea of the Energy Internet are used to examine the potential for this shift to considerably reduce pollution and greenhouse gas (GHG) emissions. Comprehensive analyses of the environmental benefits connected with the adoption of renewable energy technology are provided by studies by Maennel & Kim (2018) [36], Bayar &Remeikienė (2020) [37]

Two of the biggest greenhouse gas polluters in the world, Germany and South Korea, have comparable potential reductions in greenhouse gas emissions with the switch to renewable energy, according to Maennel & Kim (2018) [36].

To reduce emissions of air pollutants, their analysis focuses on the tactical measures taken by both nations in the transition to renewable energy. Nuclear power is the main priority of South Korea, while Germany wants to reduce nuclear power and increase the share of renewable energy sources to more than 50% of the energy mix. The report highlights the contribution of renewable energy to climate change mitigation by highlighting the efficiency of these techniques in reaching voluntary GHG reduction targets in the power industry.

The effect of renewable energy and energy efficiency on environmental sustainability in developing market economies is examined by Bayar & Remeikienė (2020) [37]. According to their research, energy efficiency lowers greenhouse gas emissions, while long-term economic expansion raises them. This research indicates that using more renewable energy sources and improving energy efficiency are essential tools for lowering greenhouse gas emissions. It also emphasizes the significant role that renewable energy and energy efficiency play in achieving environmental sustainability.

To facilitate the decentralization of energy systems and the quick growth of the Energy Internet, the study examines how new technologies, smart sensors, photovoltaic panels, and smart grids are integrated. In addition to lowering greenhouse gas emissions, this strategy improves the sustainability and efficiency of energy generation and use.

Utilizing renewable energy to reduce pollution and greenhouse gas emissions is a complex task that calls for the adoption of cutting-edge technologies and comprehensive techniques. The perspectives offered by Bayar &Remeikienė (2020) [37], and Maennel& Kim (2018) [36] highlight the important environmental advantages of switching to renewable energy sources. Countries may significantly reduce their greenhouse gas emissions by utilizing the potential of renewable energy and energy efficiency, which will support international efforts to battle climate change and advance environmental sustainability.

3.7 Environmental Aspects and Biodiversity

One of the main pillars of international efforts to fight climate change is the growth of renewable energy (RE). To prevent negative effects on ecosystems and biodiversity, the implementation of these technologies must be carefully controlled. Important insights into the ecological factors required for the development of sustainable renewable energy are provided by the studies of McClung & Moran (2022) [38], Muzzillo et al. (2020) [39], and Bennun et al. [42] (2021).

The world's desert ecosystems, which are frequently the focus of solar and wind projects because of their enormous resource potential, are examined by McClung & Moran (2022) [40], for possible effects of renewable energy development. Their study demonstrates how regions of biological significance, such as roadless areas biodiversity hotspots, and places with high potential for renewable energy significantly overlap. To reduce habitat disruption and maintain the ecological integrity of these landscapes, the study recommends the strategic placement and design of renewable energy projects. It is possible to considerably lessen the detrimental effects on desert ecosystems by prioritizing development in areas already affected by human activities and implementing mitigating techniques.

The study by Muzzillo et al. (2020) [39], focuses on the spatial relationship between ecosystem services and renewable energy installations, especially as it relates to wind farms in the Italian area of Basilicata. According to their analysis, unchecked growth in renewable energy might result in the loss of ecological services and the degradation of habitats. To manage pressures on ecosystems and preserve their functionality and biodiversity, the study emphasizes how crucial it is to incorporate ecosystem service considerations into land management and planning choices. This strategy is necessary to guarantee that biodiversity and ecological health are not sacrificed in the sake of renewable energy development.

Guidelines for minimizing the effects of biodiversity development on solar and wind energy are given by Bennun et al. (2021) [40]. The recommendations acknowledge that there may be unforeseen environmental effects from even "clean" energy sources. Therefore, they provide project developers with useful guidance on how to control risks and enhance outcomes for ecosystem services and biodiversity. Developers can lower the ecological footprint of their projects dramatically by planning and implementing projects in a way that applies the mitigation hierarchy (avoid, minimize, restore, and offset) to direct, indirect, and cumulative impacts. All throughout the project lifespan, environmental assessment and management must be conducted with a proactive and thorough approach, as these principles underscore.

3.8 Comparative Evaluation of Developed and Developing Regions' Adoption of Renewable Energy

Different opportunities and constraints defined by economic, technological, and policy landscapes are revealed when the adoption of renewable energy is compared between developed and developing regions. A focus on customized approaches to improve energy access and sustainability is highlighted by the research conducted by Ma et al. (2022) [41], Mustafa et al. (2023) [42], and Yan et al. (2023) [43]. These studies offer valuable insights into the dynamics of renewable energy adoption.

With an emphasis on multi-objective optimization and multi-index comprehensive evaluation, Ma et al. (2022) [43], offer a novel data-driven energy planning framework for emerging regions. In emerging nations, where energy supply and demand dynamics require strategic planning for generating expansion, their study highlights the

importance of energy planning. Through the application of this framework to the Chinese province of Hunan, the research highlights the possibility of reducing excess electricity production and increasing energy self-sufficiency by balancing the development of coal power with renewable energy sources like photo-voltaic cells and wind power. The significance of taking local conditions into account and the potential role that renewable energy may play in promoting sustainable development in developing nations are both highlighted by this strategy. Mustafa et al. (2023)) [42], investigate the desire of emerging nations to use renewable wind energy by looking at the socioeconomic and individual aspects impacting family choices. Their moderated mediation model shows that intentions to use renewable energy are significantly shaped by cost value, social influence, environmental understanding, and health consciousness. According to the study, community involvement and focused awareness campaigns are essential for advancing renewable energy in developing nations because they can either strengthen or weaken the correlation between awareness of renewable energy and its adoption.

3.9 Government Policies and International Agreements' Function in Promoting the Adoption of Renewable Energy

Global adoption of sustainable energy systems depends critically on the role that international agreements and government policies play in promoting the use of renewable energy. The research offers valuable perspectives on three key areas: how American counties and towns are implementing clean energy, the dynamics of policy acceptance, and the variables affecting China's farmers' adoption of renewable energy technologies.

Döme (2023) [44] investigates how decisions to adopt renewable energy policies—specifically, Feed-In Tariffs (FIT) and Renewable Portfolio Standards (RPS)—are influenced differently by internal and external diffusion variables. According to the report, there are two different groups of adopting nations: the first group consists of middle-class, non-OECD, non-EU countries with lower CO2 emissions, while the second group is made up of high-income, democratic countries that are predominantly energy importers. This contradiction highlights how important it is to customize policy instruments to successfully negotiate a variety of social, political, and environmental environments, as well as the impact of international accords. The study underscores the necessity for sophisticated policy measures to encourage the adoption of renewable energy sources by underlining the significance of policy spread through normative emulation and social learning. Hess and Gentry (2019) [45] look at the plans and difficulties in putting them into practice of American counties and cities that are devoted to using only renewable energy. According to the study, these towns' local concerns about climate-related risk, air and fossil fuel pollution, and liberal political cultures are all present. The study emphasizes the value of community-wide coalitions, policy entrepreneurs, and framing techniques that prioritize local job growth and solve affordability issues. These results imply that local government initiatives can play a major role in promoting the use of renewable energy when they are backed by national policies and international frameworks. The adoption of renewable energy technologies on Chinese farms is examined by Wang et al. (2023) [46], who emphasize the importance of farmer attitudes, government regulations, and entrepreneurial orientation in shaping adoption choices. The study finds that views about the utility and affordability of renewable energy, farm size, education, and government financial support all have a substantial impact on the uptake of renewable energy technology. To promote the use of renewable energy in the agricultural sector and support efficient and sustainable production, this research highlights the crucial role that government support and targeted policies play.

The adoption of renewable energy across many regions and sectors is greatly aided by government regulations and international agreements. The perspectives offered by many scholarly articles emphasizes on how crucial it is to develop strategic policies, include the community, and have support systems in place to promote renewable energy. By utilizing these tactics, nations can expedite their shift to renewable energy, so supporting worldwide endeavors to tackle climate change and accomplish sustainable development.

3.10 Advancements in Technology and Upcoming Patterns in Renewable Energy

The nexus between emerging technologies and sustainable energy trends is a rapidly evolving sector with the potential to drastically alter the world's energy supply. The studies examine the development of wind energy systems, the future trends in renewable energy, and the integration of renewable energy with computer science, respectively. They provide insights into the difficulties and opportunities associated with using renewable energy sources.

Using upcoming developments in renewable energy and enabling technology, the necessity of sustainable development has been addressed. They draw attention to the growing demand for energy and the capacity constraints of the current generation, highlighting the necessity of secure, reliable, and efficient energy solutions backed by renewable resources. The report highlights the obstacles to the growth of renewable energy, such as price, market share, and regulations, and it concludes that the creation of new markets for renewable energy is crucial for the wholesale and retail sectors. This viewpoint emphasizes how crucial new technologies are to cutting environmental expenses and running energy systems safely and profitably.

Romania's position is highlighted the wind energy market. It is seen that the considerable potential for producing electricity that wind energy, one of the most developed renewable energy sources, possesses. The report stresses the need for upcoming technological advancements to create more reliable, affordable, and efficient wind turbines while discussing the benefits of wind energy, such as its status as a "clean" and renewable energy source with low production costs. The efficiency and availability of wind energy have been enhanced by technological improvement, as this analysis shows.

The integration of computer science and renewable energy is examined by several resources who emphasize the importance of computer science in managing, integrating, and maximizing the performance of renewable energy systems. Many research delves into the latest advancements in solar photo-voltaic cells, wind, hydropower, and geothermal energy, as well as the revolutionary impact of computer science in reducing expenses and promoting scalability. It highlights how renewable energy consumption and system stability may be increased by utilizing smart grid technology, energy storage options, demand-side management, and predictive analytics. A sustainable future depends on future developments in renewable energy and technological advancements. The findings highlight how renewable energy technologies can effectively and sustainably provide the world's expanding energy needs. Through the utilization of technological and computer scientific developments, the renewable energy industry may surmount current obstacles, mitigate its influence on the environment, and assume a crucial part in the worldwide shift towards sustainable energy sources.

IV. CONCLUSION

The adoption of renewable energy has shown significant global growth, driven by advancements in technology, policy initiatives, and increasing environmental awareness. However, regional differences in renewable energy adoption persist due to varying economic capacities, resource availability, and political landscapes. Developed regions, such as Europe and North America, continue to lead in renewable energy investments and deployment, benefiting from established infrastructure and supportive policies. In contrast, developing regions, particularly in Africa and parts of Asia, face challenges including financial constraints, limited infrastructure, and policy barriers. Nevertheless, these regions also present substantial opportunities for renewable energy expansion, given their vast untapped natural resources and growing energy demands.

To bridge the gap, international cooperation, increased investment, and technology transfer must support the global transition to renewable energy. Tailored strategies that consider local contexts and challenges can enhance the effectiveness of renewable energy initiatives. By addressing regional disparities and fostering inclusive growth, the global community can ensure a more sustainable and equitable energy future, mitigating the impacts of climate change and promoting economic development worldwide.

Attaining the Sustainable Development Goals (SDGs)[47] is largely dependent on renewable energy, especially those that address climate change (SDG 13)[49], affordable and clean energy (SDG 7), and sustainable cities and communities (SDG 11)[48]. Adoption of it fosters social inclusiveness, economic expansion, and environmental sustainability in addition to reducing the effects of climate change. The shift to renewable energy is a challenging but essential step toward a sustainable future, requiring coordinated efforts from civil society, businesses, and governments.

ACKNOWLEDGMENT

We thankfully acknowledge all scientists and researchers for their dedication and contribution to enrich us. Additionally special thanks to our head of the institutions for their continuous support and inspiration. The author has no conflict of interest.

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