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Review

Overview of Green Energy as a Real Strategic Option for Sustainable Development

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Abstract: The global renewable energy landscape is changing rapidly. Green energies reduce greenhouse gas emissions, diversify the energy supply, and lower dependence on volatile and uncertain fossil fuel markets. The future looks promising for green energy sources, which are taking on an increasingly important role, especially in the current context, as governments are trying to identify viable solutions to the energy crisis and reduce dependence on fossil fuels. Worldwide, there is a growing interest in and support for green energy sources, a factor that could help accelerate the current energy transition. Despite these positive developments, much remains to be done globally to make the energy transition a reality. In this respect, the European Union member states have committed to a wide neutrality target by establishing an increase in the total share of energy from renewable sources to 55% (by 2030) and, at the same time, reducing the net greenhouse gas effect emissions by at least 55% until 2030 to reach the neutrality target by 2050. Green energy sources are essential for long-term efforts to mitigate climate change and will play an important role in improving energy security and accessibility. The efforts of every country to strengthen the energy sector through the development of green energies will reduce geopolitical risks and disproportionate external costs for society. The large-scale use of green energies will contribute to sustainable development. The objective of our research is to review the literature on green energy in the context of sustainable development by analyzing research conducted by various authors and international organizations on these topics. The period considered for this study is 2011–2020. Our research focused on the EU 27, but the review also took into account the results obtained by other countries worldwide, such as China, the USA, Norway, and Iceland. The main research method used was the analysis of scientific papers, studies developed by international organizations, and a wide set of agreements and political commitments assumed by different states for developing green energy as a solution for sustainable development. The obtained results show an interesting international debate about green energies and how they can contribute to sustainable development. This paper's results also show that in 2019 at the global level, low-carbon energy sources, including nuclear power and renewable energy, accounted for 15.7% of primary energy (solar, wind, hydropower, bioenergy, geothermal and wave and tidal), while in 2021, for the EU 27, the share of energy from renewable sources reached 22%. According to international statistics, more than 90% of the governments of many countries are making investments to efficiently capitalize on green energy sources and to design new models of sustainable economic and social development, in order to lower pollution levels, reduce the dependence on fossil fuel imports and limit the climate change impact.

Keywords: green energy; sustainable development; energy policies; energy agreements

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1. Introduction

The global need for energy and the associated services is growing to keep up with the demands of human, social and economic progress, welfare, and health [1,2]. All states depend on energy services to meet fundamental human needs. In the future, sustainability will guarantee energy supply and will reduce the energy sector's impact on climate change [3,4]. Green energy is an important issue in debates on sustainable development's environmental, social, and economic components [5,6]. This review background is based on the following two coordinates: (1) the research of the studies, scientific articles, statistical data and reports published on green energy related to sustainable development; (2) legislative framework and international agreements that support the increase in green energy production. Starting from their content, it was possible to outline an overview of the use and development of green energies from renewable sources at the EU27 level in particular, but also at the global level. Some of the main research motivations were as follows: (1) green energy is a priority in the context of the global energy crisis; (2) there is a wide and diverse debate regarding green energies, both in specialized literature and in the concerns of international organizations; (3) there is a need to capitalize on the knowledge and research results on green energies developed so far; (4) the challenge for state governments to increase public and private investment in the green energy sector according to their updated energy policies and strategies. Extensive literature on green energy has been published in the last 10 years that was analyzed for this review and from which the most important results obtained by various researchers were selected and discussed. According to the literature [7,8], green energy sources have the potential to significantly reduce greenhouse gas emissions caused by the combustion of fossil fuels in power plants, and this could ultimately lead to a reduction in climate change. Now, more than ever, the energy demand is increasing, yet conventional sources are finite and quickly diminishing [9]. Some types of resources are more difficult and riskier than others to be exploited [10,11]. As a result, the discovery of new sources and the process of extracting the resources have become significantly challenging and expensive [12–14]. In addition to this, the overall quality of people's life is influenced by issues such as climate change, the energy crisis caused mainly by the increase in the price of oil, international tensions between different states [15] and the global lockdown caused by COVID-19.

Over time, a set of pacts, strategies, agreements, laws, and policies regarding renewable and green energy sources, climate change actions, greenhouse emissions, and sustainable development have been adopted at the international level. In this new global context, the continuous development of green energy technologies and market diversification play an important role in the energy sector worldwide [16]. More than 90% of the world's nations are working toward expanding renewable energy sources [17]. As a result, contemporary governments in all nations are being forced to adopt a fresh outlook on the future regarding renewable energy sources, in contrast to what we have witnessed over the past three decades. Energy represents a key source of economic development [18]. Taking into account the current situation all over the world, it is recommended that all countries join forces and efforts to improve the legislative framework, adopt public policies and develop strategies and technologies that produce green energy, and energy from renewable resources [19,20], so as to achieve their economic development objectives, and especially the sustainable development goals. Furthermore, many energy experts believe that renewable energy is one of the key factors in increasing supply security [21–23] and lowering greenhouse gas emissions [24,25]. The cost of energy raw materials (crude oil and natural gas) is one of the primary targets of energy policies [26,27], and it is one of the main causes of the substantial shift in the structure of consumed energy resources [28] and the adoption of new resources, together with the concern of the requirement to preserve the environment [29].

Scientific research, investigations, and new technologies over the past ten years have revealed key distinctions among green, clean, and renewable sources of power. Different authors tend to use these concepts interchangeably; however, a resource can be renewable but not clean or green and this can lead to some confusion [30,31]. Green energy is power generated using natural resources, such as the sun. Renewable energy arises from non-exhaustible sources, such as solar energy, hydropower, and wind power, whereas clean energy does not emit pollutants (carbon dioxide) into the atmosphere. The scientific community is still debating these subtle differences, despite the common perception that renewable energy is identical to the other types of energy (a hydroelectric dam, for example, that diverts waterways and negatively impacts the environment, can hardly be named "green" [32–35]). Instead, wind power is a natural resource that is green, clean, and renewable, because it is eco-friendly, non-polluting and self-renewing [31,36,37]. In other words, renewable energy is derived from continuously renewing and recyclable sources or processes and is recyclable. Examples include solar energy, wind energy, geothermal energy, and hydroelectric power. When green energy and renewable energy, such as solar and wind, are combined, the result is the ideal clean energy mix [38,39].

The market for renewable energy, which was valued at USD 881.7 billion in 2020, is expected to increase at a compound annual growth rate (CAGR) of 8.4% from 2021 to 2030, reaching USD 1977.6 billion [40]. According to market research, the demand for clean energy alternatives is growing at an exponential rate, and supportive government policies are essential for fostering the transition [41,42].

Some of the actual challenges regarding renewable green energy systems come from their specific source [43], meaning the nature of the source, which can make the type of energy intermittent, heavily depending on the weather conditions [44], or the type of technology used [45], the storage capacity, the trained support needed where infrastructure is installed and lack of maintenance systems [46].

In recent years, national policies, strategies, and development plans have increasingly focused on sustainable development. The Open Working Group presented a list of global Sustainable Development Goals (SDGs) to the UN (United Nations) General Assembly in New York, which contained 17 goals and 169 targets [47]. In order to combat climate change, it is necessary to simulate and monitor several social, economic, and environmental elements on a global scale in a coordinated manner [48]. However, the complex notion of sustainable development had an impact on how energy policy has been developed. According to studies [49,50], the world would progressively move toward sustainability if fossil fuel-based energy sources are replaced progressively with renewable ones, such as bioenergy, solar, wind, and ocean energy (tide and wave), geothermal energy and, hydropower. The SDGs in this context work to ensure that global warming in the 21st century and its effects are mitigated so that sustainable development is ensured and left as a legacy for future generations [7,47].

This paper contributes to the overall picture regarding the research in recent years, while also taking into account the content of the updated agreements and regulations. The analysis performed in this paper based on these sources and the content of agreements about green energy may help the governments of the interested states to capitalize on the level of knowledge so far and to identify their own ways of action to increase the production and integration of green energy in the process of sustainable economic and social development. At the same time, it may help some researchers to educate themselves, and others to relate to these results and expand their research by exploring different types of green energy and the different sectors of activity. Therefore, our research reviews the literature on green energy in the context of sustainable development, aiming to answer the following questions:

- What are the components of renewable green energy, their content, and how can they influence sustainable development?
- What are the main advantages and limits of renewable green energy?
- How has the green energy sector evolved in the EU and other states in 2011–2022?
- What is the impact of green energy on different sectors?
- What are the main topics related to green energy that are less addressed in the literature?

Next, the paper contains a second section in which an overview of the recent literature on green energy with its main components and sustainable development is presented. In the third section, based on the data and statistical information provided by the European Union (EU), the International Renewable Energy Agency (IRENA), and other international organizations, as well as research studies identified in the literature, the evolution of green energy for sustainable development in the last decade is presented and analyzed. Then, the impact of green energy on some energy-consuming fields is highlighted, followed by a discussion section, where some of the literature gaps were revealed, along with some suggestions for future research. The paper ends with the main conclusions of this review on renewable green energy.

2. The Main Components of Green Energy and Sustainable Development in the Literature

Green energy sources are renewable and clean sources of energy, depending on the technology and environmental impact, including sun, wind, geothermal, hydroelectricity, tidal and ocean energy, and biomass [51,52]. Green energy refers to any form of energy that is produced using natural resources [53–55]. Despite the fact that there are subtle distinctions between green energy and renewable energy, which will be discussed in this paper, it often emerges from renewable energy sources. The crucial aspect of using these energy sources is ensuring that they do not negatively impact the environment, for example, by emitting greenhouse gases. Green energy is a type of energy that is frequently obtained from renewable energy sources, such as sun, wind, hydroelectricity, geothermal, tidal and ocean energy, biomass, and biofuels. Each of these technologies operates differently, whether it is by harnessing solar energy, as with solar panels, or by generating energy through the wind, water flow, or by obtaining energy from the ocean's surface waves [31,56].

Green energy is fundamental for achieving sustainable development and is environmentally friendly. It is a renewable energy source, but in order to be considered as green energy, it has to have zero impact on the environment, meaning that it does not emit any greenhouse gases, or a very small amount [57,58]. Therefore, not all of the sources employed by the renewable energy sector are ecological and green [59,60]. For instance, while burning organic material derived from sustainably managed forests may be renewable, the CO2 emissions from the burning process make it less likely that the power generated is environmentally friendly; another example, for oil sands, the extraction process requires burning large quantities of natural gas in the refining process. Some REs, such as solar and wind power, can be created on a small scale in people's households [61,62], or they can be produced on a larger scale in industrial settings [63,64].

The main renewable green energy sources, with zero or reduced impact on the environment, are sun, wind, hydroelectricity, geothermal, tidal and ocean energy, biomass, and biofuels. In the literature, these are widely analyzed and researched. Some of the researchers' relevant statements regarding their content are briefly presented in the following subsections.

2.1. Solar Power

This widespread form of renewable energy is often generated by photovoltaic cells, which are designed to absorb light from the sun and convert it into electric current [65,66]. The sun has great potential to supply our energy needs [67], given that enough energy to power the planet for an entire year reaches the earth's surface in only one hour. Nevertheless, the obstacle that has always persisted is figuring out how to tap into and make use of this potential [68,69]. Currently, we heat buildings with solar energy, warm water with it, and use it to power our electronic devices. Solar energy systems are not only environmentally friendly because they produce no greenhouse gases or air pollution, but they are also clean energy sources [70]. From the analysis of the specialized literature emerges the idea that solar panels may also qualify as green energy if they are produced and manufactured in a manner that has minimal negative effects on the environment. The overview's results show that solar energy is used on a global scale and is becoming an increasingly common means of desalinating water, heating homes, and generating power, while the price of producing solar panels has significantly decreased over the past decade. In this context of energy needs, solar panels have become a sustainable and the most cost-effective source of electricity.

2.2. Wind Power

Wind energy harnesses the strength of the air movement around the planet to turn turbines, which in return generate electricity [71]. This type of energy is best utilized in locations that are offshore or on highlands. On land, wind turbines must be located in regions with strong winds, such as hilltops, wide-open spaces, and plains. Wind power offshore has grown steadily over the years, with wind farms offering an excellent way to generate energy, while overcoming most of the concerns about them being noisy or obtrusive on land [72]. Indeed, because of the hostile surroundings the turbines must operate in, offshore operation has its own disadvantages. The reduction in greenhouse gas emissions is an important benefit that receives significant economic and technical attention [73]. It also represents a great solution because wind energy systems do not emit any gaseous pollutants, such as COx, SOx, NOx and particulate matter (PM) such as soot, or any other air pollutants while they are in operation [74]. The normal carbon footprint of a wind energy project is repaid in less than six months, and the plant then produces electricity for decades, with no emissions at all [75]. There is literature on wind as a source of energy that can be harnessed and turned into electricity with zero-net emissions. According to this literature, wind is an energy source that is clean and costs less. Wind turbines harness the kinetic energy of the wind and transform it into usable electricity 24 h a day, every day, all over the world. The generation of electricity through the use of wind plays an increasingly essential part in the way that our planet is powered in a manner that is clean, green and sustainable.

2.3. Hydropower

Similar to wind power, hydroelectric power generates electricity by spinning the turbine blades of a generator [76]. In some states, hydro power is frequently used because it spins turbine blades with fast-moving water from rivers or waterfalls [77]. Although wind energy is quickly closing the gap, hydroelectric power is now the greatest source of renewable power in the US. Even though hydroelectric plants produce renewable energy, they are not necessarily "green" energy sources [78]. The fact that many of the larger dams redirect natural water sources has an adverse effect on both humans and animals, due to the latter's impeded access to their water supply. Smaller hydroelectric power stations ($\leq$40 megawatts) redirect only a small portion of the water flow; therefore, if they are correctly managed, they do not have the same devastating impacts on the local ecology. According to ref. [79], hydropower alone accounts for 17% of the global electricity supply, and among all other technologies, it offers an efficiency of approximately 90% [58]. The use of this type of renewable green energy source is used on a large scale worldwide and contributes to the achievement of Sustainable Development Goal 7 (SDG7). This overview results presents similar ideas, as the provision of the necessary electricity, storage, and flexibility services are all areas in which hydropower and pumped storage continue to play an important part in the global fight against climate change. Moreover, the use of hydropower electricity is versatile. There are hydroelectric facilities that can rapidly transition from producing no electricity to their maximum capacity. The ability of hydropower plants to instantly create power and add it to the grid makes them a crucial source of backup power in the event of significant electrical outages or disturbances. The cost of hydropower is relatively low. In comparison to other types of energy, hydropower generates electricity at a lower cost, while maintaining its stability throughout time. Utilizing current buildings, such as bridges, tunnels, and dams, can even help reduce the overall cost of the construction project. A considerable advantage of this type of renewable green energies (RGEs) is when there is a significant demand for energy, technologies such as pumped storage hydropower, which stores energy, can be used in conjunction with renewable sources of power, such as wind and solar power.

2.4. Geothermal Energy

The thermal energy deposited just under the surface of the ground is utilized by this form of environmentally friendly power. Even though accessing this resource requires drilling, which raises concerns about its potential impact on the environment, once it is exploited, the resource presents great potential. Regarding geothermal energy systems, there are some concerns regarding air and water pollution, as well as the potential for the degradation of ecosystems and the alteration of the habitats of species and flora [80,81]. Geothermal energy has indeed been adopted for hundreds of years to heat hot springs for bathing, and it may also be used to create steam to power turbines and produce electricity. The energy under the US alone could generate ten times more electricity than coal now does. While certain countries, such as Iceland, have readily available geothermal resources, these resources rely on their location for accessibility of use, and careful oversight is required for drilling to truly be green and sustainable. Returning the vapor and hot water into the ground can reduce emissions, making this renewable resource greener [82]. Geothermal energy systems are still significantly cleaner and more ecologically friendly than traditional energy systems, although every technology has unfavorable environmental impact effects that have been studied by many researchers [83,84].

In nations such as El Salvador, New Zealand, Kenya and the Philippines, this essential renewable source meets a large portion of the need for power [85]. In Iceland, for example, it meets more than 90% of the demand for heating [86]. Geothermal power facilities can deliver baseload electricity and, in some situations, auxiliary services for short- and long-term flexibility, due to their key advantages of being weather-independent and their extremely high-capacity factors [87]. Geothermal resources have significant potential to supply electricity that is not only renewable, but also dependable and robust. For these reasons, the generation of geothermal power has the potential to have a favorable impact on the economies of the surrounding areas. Geothermal plants and drilling procedures require a wide variety of job skills and labor categories that are comparable to those used in the fossil energy industry, as well as in mining, building, manufacturing, and other fields. Workers may find it easier to transition between industries if they have a shared skill set.

2.5. Tidal and Ocean Energy

Ocean and sea currents are used to produce tidal energy [88]. Because the generators are similar to those used for wind energy and have the same type of blades that are propelled by currents, they have a less significant influence on ecosystems. This type of energy has the capacity to become a component of the future generation of sources that are used to produce energy, despite the fact that it is not yet commonly used. As the only energy source that relies more on the action of the Moon than it does on the action of the Sun, it should also be stated that tides can be anticipated more readily than wind can. This is an important fact to keep in mind. It is estimated that there are about 20 locations on the planet where the requisite circumstances are met for the effective exploitation of tidal energy. The Atlantic coasts of France, Great Britain, the United States of America, Canada, and eastern China are only a few of the places that fall within this category [89,90]. If it were possible to fully capture this energy in tidal power plants, the quantity of energy that is currently available would produce almost 100,000 times more power than all of the hydropower plants that are currently operating throughout the world. Portugal, Scotland, and Great Britain are the three European nations that already have programs in place for the extraction of this alternate resource. The power created by the ocean and its waves can be harnessed and put to use in a variety of ways, including the production of electricity, the desalination process, and the filling of large reservoirs with water [91]. This new technology will include the use of a floating gadget, similar to a buoy, that will be placed on the water's surface. The production of this type of energy is made more challenging by the fact that the circumstances in which it occurs make it impossible to forecast the path that the waves will take [92]. By taking a look at the present tidal and ocean energy landscape, and especially the continuous development of technology, it becomes clear that sooner rather than later, this type of renewable and green resource will be exploited on a larger scale in the near future. These kinds of renewable resources are preparing the groundwork for a new industrial revolution that will be centered on oceans and seas and the industrialization of those resources. A closer examination of the effects on social, economic, and environmental sustainability is required in order to fully understand the consequences of the promotion and growth of marine renewable energy, which have a number of effects and would necessitate a rethinking of marine areas. These assessments are required to prevent social or economic instability, conserve and safeguard delicate natural habitats, and guarantee the sustainable growth of this energy market in the light of the three sustainability pillars.

2.6. Biomass

Organic material from both plants and animals, such as harvests, trees, and scrap wood, is used in the production of biomass energy. Burning this biomass produces heat, which drives a steam generator and produces electricity [93]. Gasification is another widely used process that converts biomass into energy for the generation of heat and electricity [94]. These processes are essential in the replacement of non-renewable energy sources. Although biomass can indeed be renewable when it is obtained sustainably, there are numerous situations in which this is not green or clean energy [95,96]. Research has demonstrated that biomass from trees can have a negative influence on biodiversity and produce more carbon dioxide emissions than fossil fuels [97]. Despite this, under the right conditions, some types of biomasses do provide a low-carbon alternative [98]. For this renewable resource to qualify as a source of "green energy," proper management is also necessary [99]. Although these materials produce greenhouse gases when burned, their outputs are still significantly smaller than those of fuels based on petroleum. However, by decreasing emissions and offering a viable source of energy and gas, more effective biomass use enabled by advanced technology has the potential to contribute to clean and sustainable environmental development [100]. Therefore, using biomass in conjunction with other renewable energy sources can aid in supplying the world's expanding green energy needs.

2.7. Biofuels

These organic resources can be converted into fuels such as ethanol and biodiesel instead of incinerating biomass, as previously noted. By 2050, it is predicted that the use of biofuel would be able to meet more than 25% of the world's demand for transportation fuel, up from just 2.7% in 2010. It is commonly believed that the usage of biofuels can result in a number of positive outcomes, such as increased sustainability, decreased emissions of greenhouse gases, and a more reliable energy supply [101]. When burned as a fuel, biodiesel considerably cuts down the amount of toxic and other emissions produced, in addition to being non-flammable, nonexplosive, biodegradable, and nontoxic [102]. The benefits of using biodiesel as a diesel fuel include its portability, availability, renewability, higher combustion efficiency, lower sulfur and aromatic content [103], higher cetane percentage, and increased biodegradability. Additionally, biodiesel has a higher cetane number than traditional diesel fuel [104]. Based on the literature [101–104], a number of advantages of biofuel have been identified, which are as follows: (1) they originate from renewable sources; (2) they mitigate the effects of climate change; (3) they are simple to manufacture; (4) they produce less pollution; (5) they are widely available, and (6) they are efficient in terms of energy use. The fact that they only make use of a single crop, the improper management of resources and food, and their reliance on the weather are some of the drawbacks. These minor limits do not reduce the relevance and importance of this green energy source.

2.8. Main Advantages and Disadvantages of Renewable Green Energy Sources

Renewable green energy is crucial for the environment, since it offers environmentally preferable substitutes for the harmful consequences of fossil fuels [105]. Green energy is derived from natural resources and is mostly clean, renewable, and emits little or no greenhouse gases, and, very importantly, it is also accessible and low-cost. As these sources are frequently locally produced and are less impacted by the international crisis, price surges, or supply chain interruptions, they can also result in stable energy prices. The economic advantages also include the development of jobs [106] for those who build the infrastructure that generally helps the neighborhoods where the employees work [107]. Eleven million new jobs were created or transformed worldwide in the renewable energy sector in 2018, and this number is expected to rise as states work to achieve goals such as zero emissions. The energy network infrastructure is now more adaptable, less reliant on centralized sources that could cause disruption, and more resistant to weather-related climate change because of the local nature of energy generation from resources such as solar and wind power [108,109]. However, renewable green energy sources (RGEs) have some limits [110]. The main advantages and disadvantages of renewable green energy sources are shown below in Table 1.

Table 1. Main advantages and disadvantages of renewable green energy sources (RGEs).

Advantages	Disadvantages
Low cost. RGEs are available at a low cost. The use of RGEs provides a source of energy generation that is available at a very low cost or even without a cost [111].	*Discontinuity and variability in weather conditions.* RGEs are dependent on weather conditions. They are not constant. Because they are dependent on the environment and the weather, many forms of renewable green energy might not always be reliable [128].
Energy independence. Greater access to electricity from renewable green sources is another benefit for developing countries [112,113].	*Large space required for setting up and running RGE systems.* RGEs may need a large space to be set up and run. Due to their variable output capacity, renewable resources must have substantial energy storage systems to ensure that there is always adequate electricity when production drops [129,130].
Reduced energy bills for the population and economic agents. The use of renewable green energy sources can also decrease monthly energy costs [114–116].	*RGEs technologies develop at a slow pace.* Technologies are at the beginning of the road to storing renewable green resources so a more flexible supply system is needed to offset drops in production for a particular source [75,131]. They are also very expensive [132].
Clean energy. Some RGEs are also thought of as clean energy sources. One of the most significant advantages of renewable energy sources is that a significant percentage of it also qualifies as green energy and clean energy [117,118].	*Community protests.* The exploitation of RGEs can lead to community protests. Some locals who do not wish to live close to renewable green energy sources, such as solar and wind farms, may protest and criticize them [133,134].
Environmentally friendly. Reduced levels of air pollution are one of the many economic and environmental advantages that may be realized through the use of green and clean energy [119,120].	*High implementation costs.* RGEs have high implementation costs. Mounting, installation, and maintenance of technologies and equipment (infrastructure) is expensive [135].
Reducing the consumption of the main pollutants used for energy production. Long-term, RGEs lower the costs associated with the provision of power. Additionally, a broad green energy supply decreases reliance on foreign fuels and also the resulting expenses, both financial and environmental [121–123].	*Political influence.* RGEs can be politically influenced [136,137].
Inexhaustible resources. Because the resources for green and clean energy naturally replenish themselves, it is not necessary to obtain and transport fuels as is the case with oil or coal. This eliminates a significant cost that would otherwise be incurred [124,125].	*Difficulties regarding storage.* For the storage of green energy, special equipment (accumulator-type batteries) with limited capacity and supplementary costs is required [138].
Reducing waste. RGEs help to reduce waste [126].	*High costs for research and development of RGEs.* The expenses for research and development of the RGE sector are high and are increasing [139].
Safety in exploitation. RGEs have a high degree of safety in exploitation [127].	

Source: processed by the authors.

Starting from the information presented in Table 1, it can be observed that the advantages of the large-scale use of RGEs far outweigh their disadvantages, and it is recommended to continue the application of policies in the field, as well as the development of current technologies, in order to achieve the sustainable development goals established at the global level.

2.9. Sustainable Development

Environmental preservation and economic expansion have been paired together by political and business leaders as the essential components of the concept of sustainable development (SD) [9]. Since the World Commission on Environment and Development (WCED) initially defined the concept more than ten years ago, the expression "sustainable development" has attained an unprecedented level of popularity. Sustainable development, according to the renowned Brundtland report entitled "Our Common Future" [140], aims to ensure that humankind can meet its requirements today without jeopardizing the future generation's capacity to do the same [141]. In other words, the use of energy derived from non-depleting sources is an essential component of SD. This type of development entails not only achieving a greater level of economic growth, but also preserving a clean and healthy environment for both current and future generations [107]. Unfortunately, in order to reach a consensus among a wide variety of parties, the idea of SD was purposefully kept vague and inherently self-contradictory. This created a situation in which, according to ref. [142], an unending stream of scholars and senior officials could spend many enjoyable hours attempting to clarify it without being able to do so. The concept's impact on the design of national and international policies has grown dramatically over time, making it a crucial component of the documents that outline the policies of governments, international organizations, and businesses. This has encouraged the discussion of the notion of SD to become more inclusive, giving rise to a wide range of meanings and interpretations.

It is well acknowledged that the growth of a society is dependent on the availability of a stable supply of energy resources; nevertheless, this criterion alone is insufficient to ensure progress. A sustainable energy supply that is long-term, accessible, affordable, and capable of being used for all necessary tasks without having a detrimental influence on society is also necessary for SD [143]. Even though not all renewable green energies are entirely clean [144], there is a wide variety of options available, meaning that shifting to green renewables within the context of long-term sustainability may result in a system that is significantly cleaner than what could be achieved by enforcing control systems on conventional energy sources.

Renewable green energy sources provide opportunities in relation to SD such as climate change mitigation; energy security and access; and social and economic development [145]. Historically, the concept of sustainability has been theorized using the three-pillar model, which consists of the economy, ecology, and society. The three-pillar model's development goals can be reinforced through RGEs, and their sustainability can be evaluated [146]. Consumption of non-RGEs, such as fossil fuels, immediately lowers natural capital [147,148]. Contrarily, RGEs maintain natural capital so long as the use of resources does not diminish the possibility of a sustainable future. The contribution of RGE technologies to the goals of the three-pillar model, as well as the prioritization of objectives in accordance with the framework of sustainable development, can both be evaluated as part of the process of assessing renewable green energy technologies [149]. Therefore, policymakers can use SD principles as frameworks for evaluating RGE's contribution to SD and developing suitable economic, social, and environmental policies.

The relationship between green energy and SD has also been researched by different authors [150]. In examining this link, ref. [6] represents one of the original studies that referenced this concept. The authors of this study recommended various solutions for SD related to the use of green energy. The SD of energy methods has the potential to make a significant contribution to the economies of those nations that have an abundance and variety of renewable green energy sources (such as solar, wind, hydro, geothermal, tidal and ocean, and biomass). As a result, governments and other authorities should stimulate investment in sustainable green energy production and progress as a means of providing a green energy replacement for fossil fuels, in order to ensure a more environmentally friendly and sustainable future [6].

Integrative and collaborative renewable green energy (RGE) and sustainable development (SD) policies and practices can assist in the removal of obstacles and increase in opportunities for RGE deployment at the international, national, and regional level, as well as in the private and non-profit realms of society. At both the international and national levels, initiatives include the elimination of those activities thought to be counterproductive to SD, internalization of social and environmental externalities through SD mechanisms, and the fusion of RGE and SD techniques. SD programs launched by communities, local governments, private businesses, and non-governmental groups can help communities to overcome local opposition to RGE installations at the local level [151].

With regard to sustainability, RGE has received more attention and is more relevant than other types of energy. Green energy has been recognized as the key to achieving the objectives of SD, due to its capability of reducing emission levels and eliminating unfavorable environmental effects [152]. The effects of the global economic crisis and climate change have immediately increased concerns about the need to restructure the economy in order to achieve environmental sustainability by reducing the detrimental effects on the environment and society, giving rise to the term "Green Energy" [153,154]. In order to maintain the sustainability of the energy sector, it has been widely accepted that RGE practices need to be expanded to a larger scale. This is true not just for industrialized countries, but also for emerging and developing nations. Ref. [155] outlined three main justifications for utilizing RGE as an important tool for SD, and they are as follows: green energy sources have a lower negative impact on the environment; they are perpetual by nature, and producing green energy only requires small-scale equipment and takes less time.

In the following paragraphs, this paper synthesizes the relevant aspects for each of the four goals of sustainable development to which RGE contribute. According to different studies [156], RGE has developed into a crucial international policy goal that is connected to SD. One overall objective and four subthemes of sustainable energy development were identified in the literature [157]. The main objective for the evolution of energy systems was identified as SD. The four main themes are essentially sub-goals of developing sustainable energy and are as follows: (1) social and economic development; (2) energy access; (3) energy security; and (4) combating climate change.

The energy industry has traditionally been thought of as an essential component of social and economic development because there is a significant link between increased economic activity and higher levels of energy consumption [158]. On a global scale, there is a positive correlation between per capita income and per capita energy use [159]. Renewable green energy provides alternatives for social and economic development, and job creation, in addition to decreasing emissions and making progress toward the achievement of the SDGs. Communities that are capable of producing, sharing, selling, and storing renewable green energy can play an important part in the development of a decentralized, digitalized, and decarbonized energy system. However, this requires significant collaboration between local governments and communities [29,160]. In order to decarbonize the energy system, the equilibrium carbon price model was developed in ref. [161] and could be used.

Access to current energy systems, whether derived from renewable or non-renewable sources of energy, has a strong correlation with measures of growth, especially for those countries that are still in the earliest stages of development [162]. The seventh Sustainable Development Goal (SDG7) focuses on the need for energy that is cheap in order to achieve socioeconomic equality and justice at a national level [163]. In addition, the European Pillar of civil and human rights recognizes access to energy as one of the fundamental necessities that should be available to all people [164]. Over the past few years, the European Union (EU) has achieved some headway toward its goal of expanding access to energy at affordable prices. The percentage of persons who could not afford to maintain their homes at a suitable temperature throughout the winter declined substantially from 2012 to 2019, reaching 6.9% in 2019. However, by 2020, the percentage had increased to 8.2% once again [165].

The idea of energy security has expanded beyond its original scope, which was limited to guaranteeing an adequate supply of oil and addressing the macroeconomic repercussions of disruptions in oil production and/or fluctuations in oil prices [166–168]. Compared to fossil fuels, sources of renewable green energy are more uniformly dispersed throughout the world and are generally less exchanged on the market. A reduction in energy imports, a variety in power sources, a reduction in the economy's sensitivity to price volatility, and chances to improve global energy security are all benefits of renewable green energy [169,170]. The implementation of RGEs can contribute to improving the sustainability of energy services.

The use of RGEs in the creation of electricity helps to lower greenhouse gas emissions, which in turn helps to slow the progression of climate change and reduces the environmental and health risks associated with the pollution caused by fossil-based sources of energy [171]. The consumption of all forms of renewable green energy rose by a fourth during this time period. The power sector continues to benefit from the most rapid advancements; the percent of renewable energies in this sector rose from 19.7% in 2010 to 26.2% in 2019 [172].

3. The Dynamics of the Green Energy Sector over Time Based on the International Statistics

By analyzing the literature, various studies, and statistical data from the last 10 years, more precisely the 2011–2020 period, the accelerated dynamics of the renewable green energy sector can be observed. Sections 3.1 and 3.2 in Section 3 answer the question "How has the green energy sector evolved in the EU and other states in the last decade?" and Section 3.3 answers the question "What is the impact of green energy on different sectors?".

3.1. Evolution of Green Energy Sector during 2011–2020

The cheapest and greenest energy source is renewable, and since it can be produced domestically, it minimizes the demand for energy imports [173]. In 2021, the cost of renewable green energy continued its downward trend, as difficulties in the supply chain and escalating commodity prices had not yet fully shown their effect on project costs. When compared to 2020, the price of electricity generated by onshore wind was reduced by 15%, offshore wind dropped by 13%, and solar photovoltaic (PV) dropped by 13%. According to a report published by ref. [174] on the topic of the costs of generating electricity from renewable sources, nearly two-thirds, or 163 gigawatts (GW), of the recently installed renewable sources in 2021 had lower costs than that of the world's cheapest option for producing electricity from coal in the G20. IRENA forecasts that the addition of renewable power in 2021 will save approximately USD 55 billion of the expenses of global energy generation in 2022 [175]. This estimate is based on the present high pricing of fossil fuels.

The majority of the world's economic sectors have been impacted by the COVID-19 global lockdown, and the energy sector is no exception [176]. This has resulted in some emission reductions and air quality improvement, as well as new opportunities and digitalized business practices, and responsible lifestyle choices. However, all of these benefits will be temporary if the world continues to operate its businesses in the same manner as before [29].

In the last decade, it can be observed that the capacity and production of energy from renewable sources as a whole registered an increasing trend. Worldwide, the highest net generating capacity of power stations and other facilities that generate electricity using renewable green energy sources (CAP) has increased by over 50%. In the last 10 years, the largest increase in the capacity of generating energy from renewable sources was recorded by the following countries: China, Costa Rica, France, Germany, Norway, the United Kingdom, and the USA. At the opposite pole were other countries such as the Russian Federation or Bulgaria [177]. Based on the available statistical data for the 2012–2021 period, the evolution of the world net generating capacity of the power plants and other installations that use renewable energy sources to produce electricity (CAP MW—megawatts) was determined and is presented in Figure 1.

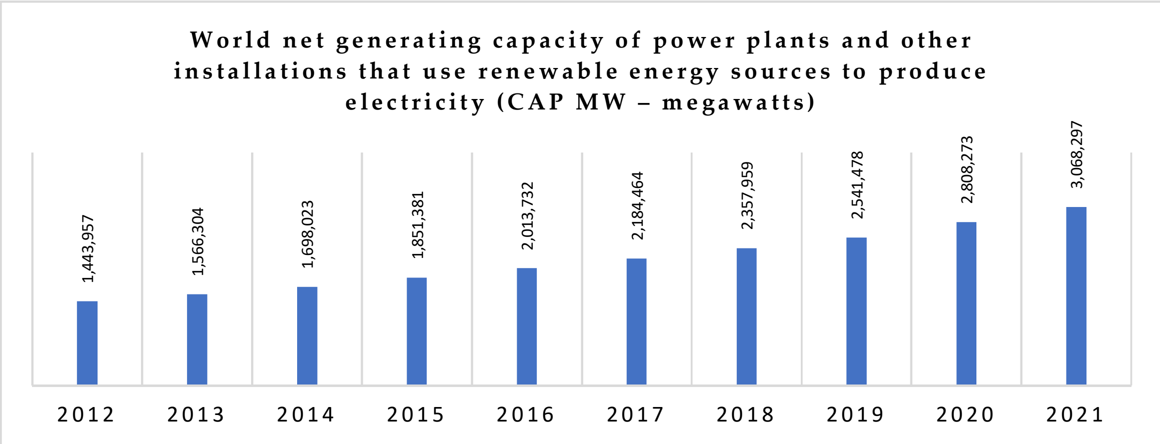

Figure 1. The world net generating capacity of power stations and other facilities that generate electricity using renewable energy sources (CAP), 2012–2021. Source: the authors centralized and adapted data published by ref. [177].

By processing the data published in ref. [177], in Figure 1, it can be observed that the world net generating capacity of power stations and other facilities that generate electricity using renewable energy sources registered an increase of 112.49% from 2012 until 2021. According to ref. [177], the greatest evolution can be observed in regions such as Asia (+204.09%); Africa (+96.38%); EU (+60.61%); or at the state level for China (+237.71%); the UK (+213.75%); the USA (+43.49%). This positive growth trend is due to the decreasing registered costs of generating electricity from renewable sources, the recent RGE technology development and to the international framework that continues to evolve, taking into consideration all the external factors (political, economic, social, legislative and environment).

The analysis was extended to the world net generating capacity of power plants and other installations that use different RGE types to produce electricity (CAP MW—megawatts) for the years 2012–2021. Based on the available statistical data, the evolution of this capacity has been determined and is presented in Figure 2.

It can be observed that both at the global level, as a whole, and also for each type of green energy, there have been clear developments. As can be observed in Figure 2 above, the main RGEs used globally are hydro energy (first), followed by solar energy (second) and wind energy (third). These results show the effects of structural changes in the field of energy as a result of the growth and integration of green energy in the existing energy system.

The world's transition to energy from renewable green sources, as shown in Figures 1 and 2, demonstrates the countries' efforts to reshape the world's energy landscape in order to fulfil the Paris Agreement's objectives, the REPowerEU plan and Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast) and reduction in the rate of climate change. The collaboration of states at the international level in order to achieve SD objectives regarding the population's access to clean energy, as well as the reduction in pollution at the global level, has encouraged countries and regions to invest in new technologies for generating energy from green sources, ultimately leading to the performances presented in previous figures and in Figures 3 and 4.

In Figures 3 and 4, it can be observed that regions such as Asia (+99.80%), or countries such as China (+116.16), doubled in the last decade their power generation from renewable sources, and some countries such as the UK (+225.03) almost tripled it by 2020.

According to ref. [174], by analyzing the total quantity of power generated from renewable sources around the globe in 2020, it is clear that renewable hydropower was responsible for around 59% of this total, which was followed by other forms of energy, such as wind, solar, bioenergy, geothermal and marine energy. The percentage of renewable energy sources used to generate power in 2020 showed a 7.4% increase over 2019 [174]. The growth of the generation was more than in 2019, mostly as a result of a significant increase in both Europe and North America (the US especially). In the year 2020, there was a 22% rise in solar generation and a 12% increase in wind generation. These two forms of renewable energy continue to account for the vast majority of the expansion of the renewable energy sector as a whole, which amounts for 73% of the expansion since 2016. Additionally, the growth of the world's renewable hydropower generation tripled in 2020. Ref. [174] points out that the growth of 27.7% in power from the renewables fraction in 2020 has been the highest ever registered.

At the European level, a growing trend in the share of energy from renewable sources (%) for the majority of states can be observed. In Table 2, it can also be observed that the countries who registered a significant positive evolution of the share of energy from renewable sources (for the year 2020) are Iceland (83%), Sweden (60%), Finland (44%), Latvia (42%), Austria (36.54%) and Portugal (33.98%), while at the opposite pole, the following countries are situated: Malta (11%), Luxembourg (12%), Belgium (13%) and Hungary (13.85%).

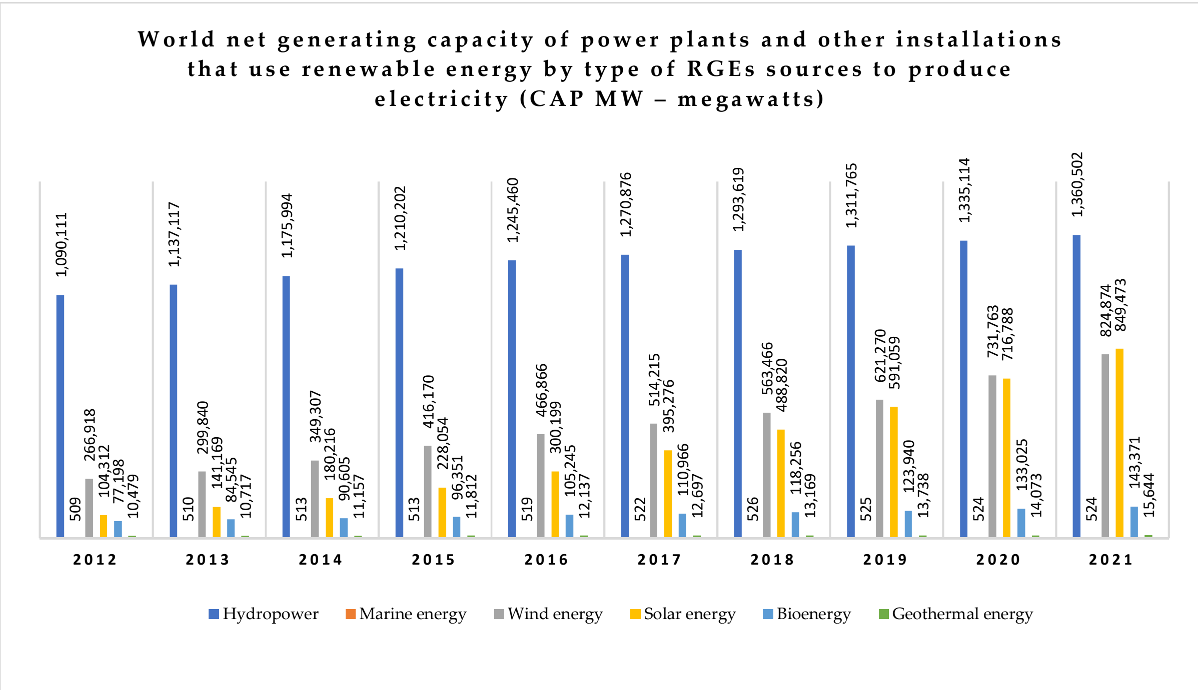

Figure 2. The world net generating capacity of power stations and other facilities that generate electricity using renewable energy sources by type of RGEs (CAP), 2012–2021. Source: the authors centralized and adapted data published by ref. [177].

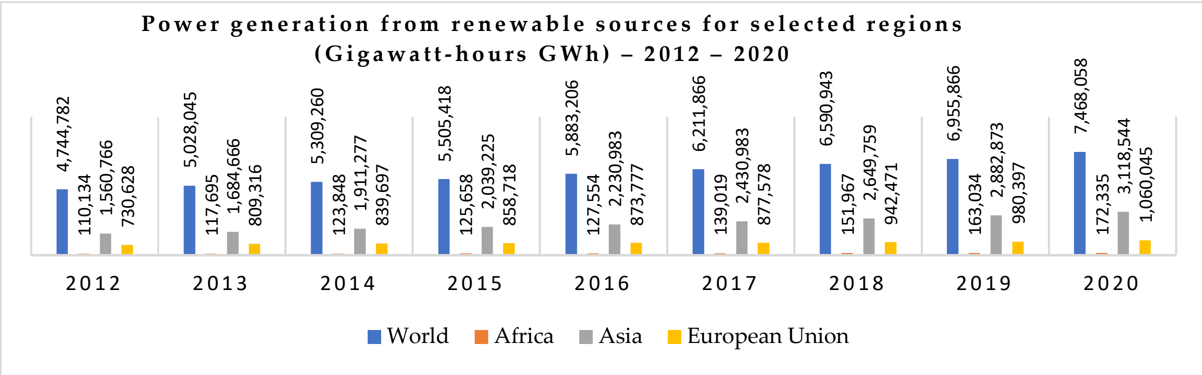

Figure 3. Actual power generation from renewable sources for selected regions (Gigawatt hours GWh)—2012–2020. Source: the authors centralized and adapted data published by ref. [177].

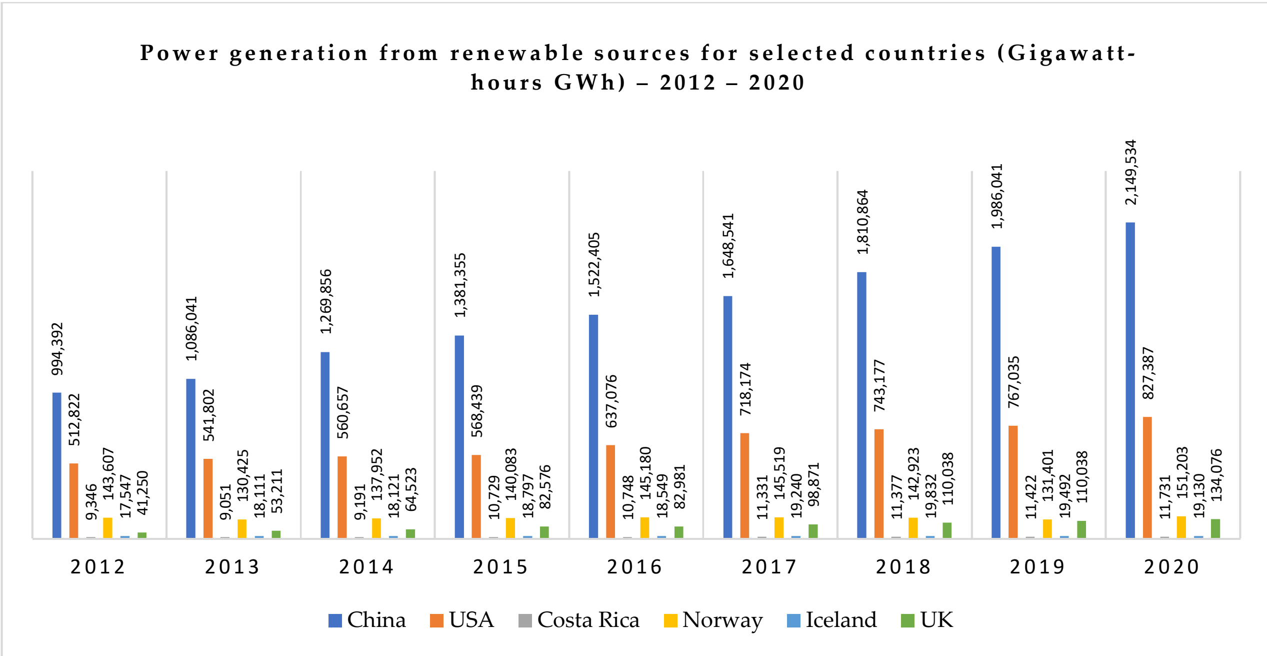

Figure 4. Actual power generation from renewable sources for selected countries (Gigawatt hours GWh)—2012–2020 Source: the authors centralized and adapted data published by ref. [177].

The countries that recorded the lowest increase in the share of energy from renewable green sources will have to undertake additional and considerable efforts to bridge the gap and reach the objectives set at the European level, in addition to those set at the global level. EU member countries have the opportunity to apply for various financial aid schemes that have been specially designed and developed by the European Commission, in order to bridge these gaps. Indeed, political stability must also be taken into account, as well as the commitment that each individual state undertakes.

The development of technologies that allowed the valorization of renewable green sources, the support of research in the field, the industrialization of the supply chain, energy policies and more effective support schemes led to the positive evolution over time of the generation and use of green energy.

Table 2. Share of energy from renewable sources for selected countries, 2011–2020.

	Share of Energy from Renewable Sources									
Regions/Countries	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
European Union—27 countries (from 2020)	14.547	16.002	16.660	17.417	17.821	17.980	18.412	19.096	19.885	22.090
Belgium	6.302	7.086	7.671	8.038	8.060	8.744	9.136	9.472	9.929	13.000
Bulgaria	14.152	15.837	18.898	18.050	18.261	18.760	18.695	20.581	21.546	23.319
Czechia	10.945	12.814	13.927	15.074	15.070	14.926	14.799	15.140	16.239	17.303
Denmark	23.389	25.465	27.173	29.310	30.469	31.715	34.387	35.160	37.020	31.681
Germany	12.470	13.549	13.760	14.385	14.906	14.889	15.476	16.660	17.266	19.312
Estonia	25.515	25.586	25.356	26.130	28.987	29.232	29.538	29.970	31.730	30.069
Ireland	6.605	7.029	7.521	8.516	9.083	9.189	10.520	10.942	11.979	16.160
Greece	11.153	13.741	15.326	15.683	15.690	15.391	17.300	18.001	19.633	21.749
Spain	13.176	14.239	15.081	15.880	16.221	17.015	17.118	17.023	17.852	21.220
France	10.813	13.239	13.880	14.362	14.803	15.451	15.847	16.384	17.174	19.109
Croatia	25.389	26.757	28.040	27.817	28.969	28.266	27.280	28.047	28.466	31.023
Italy	12.881	15.441	16.741	17.082	17.526	17.415	18.267	17.796	18.181	20.359
Cyprus	6.245	7.111	8.428	9.144	9.903	9.833	10.478	13.873	13.777	16.879
Latvia	33.478	35.709	37.037	38.629	37.538	37.138	39.008	40.019	40.929	42.132
Lithuania	19.943	21.437	22.689	23.592	25.748	25.613	26.038	24.695	25.475	26.773
Luxembourg	2.855	3.112	3.494	4.471	4.987	5.364	6.194	8.942	7.046	11.699
Hungary	13.972	15.530	16.205	14.618	14.495	14.377	13.556	12.549	12.634	13.850
Malta	1.850	2.862	3.760	4.744	5.119	6.208	7.219	7.914	8.230	10.714
Netherlands	4.524	4.659	4.691	5.415	5.714	5.846	6.507	7.394	8.886	13.999
Austria	31.552	32.734	32.665	33.550	33.498	33.370	33.137	33.784	33.755	36.545
Poland	10.337	10.955	11.452	11.605	11.881	11.396	11.059	14.936	15.377	16.102
Portugal	24.603	24.574	25.700	29.508	30.514	30.864	30.611	30.203	30.623	33.982
Romania	21.743	22.825	23.886	24.845	24.785	25.032	24.454	23.875	24.290	24.478
Slovenia	20.937	21.551	23.161	22.459	22.879	21.975	21.658	21.378	21.968	25.000
Slovakia	10.348	10.453	10.133	11.713	12.883	12.029	11.465	11.896	16.894	17.345
Finland	32.532	34.222	36.630	38.632	39.228	38.942	40.855	41.182	42.723	43.802
Sweden	47.632	49.403	50.153	51.151	52.220	52.597	53.390	53.916	55.785	60.124
Iceland	72.298	73.727	73.788	73.043	71.949	75.329	74.104	77.173	78.612	83.725
Norway	64.638	64.932	66.480	68.406	68.545	69.235	70.036	71.566	74.406	77.358

Source: the authors centralized and processed data published by ref. [178].

The most significant increase was recorded for the wind and solar green energies [179]. This mix of energy sources also represents sources of clean energy, not only renewable sources. According to the data published by ref. [174], solar and wind energy have continued to lead the expansion of renewable capacity, accounting for a combined 88% of all net additions to renewable capacity in the year 2021.

In Table 3, the evolution of the share of energy from specific renewable resources for EU 27 can be observed. In the following tables (Tables 3–5), the data presented refer only to EU 27 and are available for a decade (2011–2020). In Table 3, one can observe how much energy (%) from different types of renewable sources is used to generate electricity. From the data included in Table 3, one can observe a growing and accelerated trend in using solar and wind as natural green and renewable sources for generating electricity, as it almost tripled the share of energy. Solid biofuels are gaining attention, as technologies evolve. The energy from marine sources is constant, because the current technologies cannot control the waves or their energy. They are still very expensive; therefore, no significant investment has been made in this field. From an economic point of view, regarding the yield, there is no substantiation or justification for investments in this field.

Table 3. Share of energy from different types of renewable sources for electricity in EU 27 in the last 10 years.

	Share of Energy from Different Types of RES-E in EU 27									
Type of RES for Electricity	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Hydro	29,632.8	29,507.7	29,516.8	29,462.8	29,663.7	29,596.6	29,462.6	29,559.8	29,509.6	29,677.2
Wind	13,968.6	15,574.0	17,281.0	18,995.8	21,455.1	23,384.6	25,710.3	27,524.3	29,954.8	32,366.8
Solar	4066.1	6034.1	7231.7	8097.0	8672.2	8687.4	9280.5	9718.7	10,643.4	12,392.0
Solid biofuels	5772.2	6196.9	6062.1	6080.3	6194.9	6223.4	6385.3	6556.5	6926.9	7132.7
All other renewables	5012.3	5760.3	6439.4	6906.3	7262.4	7392.3	7459.2	7447.7	7460.8	7513.2
Total (RES-E Numerator)	58,452.0	63,073.0	66,531.0	69,542.2	73,248.3	75,284.3	78,297.9	80,807.0	84,495.5	89,082.0
Notes: Hydro is normalized and excludes pumping. The wind is normalized. Solar includes solar photovoltaics and solar thermal generation. All other renewables include electricity generation from gaseous and liquid biofuels, renewable municipal waste, geothermal, tide, wave and ocean energy.										
Electricity Generation from all Sources										
Total (RES-E Denominator)	250,862.6	250,905.5	248,539.1	243,143.6	247,004.0	249,515.6	251,732.9	251,466.7	247,887.0	237,667.5
RES-E (%)	23.30%	25.14%	26.77%	28.60%	29.65%	30.17%	31.10%	32.13%	34.09%	37.48%

Source: the authors centralized and processed data published by ref. [178].

Table 4. Share of energy from different types of renewable sources for transport in EU 27 in the last 10 years.

	Share of Energy from Different Types of RES-T in EU 27									
Type of RES for Transport	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Ren. electricity in road transport	10.8	11.0	14.5	17.6	23.5	27.3	34.5	45.0	76.5	112.8
Ren. electricity in rail transport	1033.3	1045.6	1138.4	1191.4	1280.1	1397.0	1459.5	1492.1	1494.9	1392.5
Ren. electricity in all other transport modes	218.7	214.3	227.1	242.2	278.7	291.8	299.7	302.8	309.2	282.1
Compliant biofuels *	7496.9	10,594.5	10,711.2	11,728.0	11,882.6	12,558.3	13,807.0	15,292.9	15,935.2	16,256.5
Other renewable energies	0.0	0.0	0.3	0.3	0.1	0.2	0.1	0.0	0.0	0.0
Total (RES-T Numerator with Multiplicators)	10,879.1	14,737.9	15,301.8	16,732.5	17,555.0	19,022.7	20,244.4	22,470.3	24,110.2	24,762.5
* As of 2011, only those biofuels compliant with Articles 17 and 18 of Directive 2009/28/EC are included in this category.										
Fuel Used in Transport (as defined in Article 3 of Directive 2009/28/EC)										
Total (RES-T Denominator with Multiplicators)	264,345.6	255,574.2	252,070.2	255,377.3	259,945.3	265,487.0	270,958.9	271,882.9	274,111.4	242,287.9
RES-T (%)	4.12%	5.77%	6.07%	6.55%	6.75%	7.17%	7.47%	8.26%	8.80%	10.22%

Source: the authors centralized and processed data published by ref. [178].

The share of energy (Table 4) used in transport from renewable sources registered a growing trend only for road transport. Even though there are more electric cars on the road, the growth in renewable green energy consumption in the case of electrified transportation is still mostly attributable to the growing share of renewable energy in the electricity mix. As a result, the sector of road transportation used over 36.3% more renewable energy in 2020 than in the previous year.

Table 5 shows the EU 27′s final energy consumption for renewable-based heating and cooling during a ten-year period (2011–2020). Because the weather was slightly warmer than in 2019, there was a decline in final energy consumption for heating and cooling. As a result, the proportion of renewables in total final energy consumption for heating and cooling decreased marginally from 76.04% in 2019 to 75.52% in 2020. One of the most serious challenges that the world is currently experiencing is climate change, and one of the most important things that states can do to combat it is to make significant adjustments to the way that energy is generated, distributed, and consumed [180].

Table 5. Share of energy from different types of renewable sources for heating and cooling in EU 27 in the last 10 years.

	Share of Energy from Different Types of RES-H&C in EU 27									
Type of RES for Heating and Cooling	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Final energy consumption	66,457.1	71,560.2	73,132.0	67,886.8	70,667.6	71,361.3	72,496.0	75,303.6	76,045.9	75,520.8
Derived heat	9966.7	11,377.6	12,198.5	12,510.0	13,175.6	14,139.0	14,773.0	14,940.6	15,704.1	15,752.9
Heat pumps	6270.2	6844.5	7370.7	8737.4	9286.2	10,034.4	10,672.4	11,467.2	12,393.1	13,316.0
Total (RES-H&C Numerator)	82,694.0	89,782.4	92,701.1	89,134.1	93,129.3	95,534.7	97,941.4	101,711.4	104,143.1	104,589.7
All fuel consumed for heating and cooling										
Total (RES-H&C Denominator)	474,833.8	483,181.3	486,727.4	447,206.9	458,532.3	468,241.1	470,384.3	470,797.9	464,251.4	452,972.9
RES-H&C (%)	17.42%	18.58%	19.05%	19.93%	20.31%	20.40%	20.82%	21.60%	22.43%	23.09%

Source: the authors centralized and processed data published by ref. [178].

Looking at the global level, according to a recent report in ref. [174], the total percentage of the world's renewable generation capacity in the production of electricity increased from 36.6% in 2020 to 38.3% in 2021. Renewable energy capacity increased by 257 GW by the end of 2021, a rise of 9.1% over the year. The significant annual rise in renewable production capacity was largely driven by geothermal electricity, which demonstrates a greater growth rate than wind and solar. In addition, 3064 GW of renewable energy was used for generation, with 1230 GW of its capacity originating from hydropower. The remaining energy was split evenly between solar and wind power, with capabilities of 849 GW and 825 GW, respectively. In addition, 524 MW of marine energy, 143 GW of biofuel, and 16 GW of geothermal energy were also used. In terms of new renewable capacity, Asia is leading the world. Asia contributed over 60% of the world's new renewable energy capacity in 2021, which brings the total 2020 renewable energy capacity to 1.46 Terawatts (TW). With an addition of 121 GW to the regional energy capacity, China was the major contributor. According to the ref. [174], North America stood in third position, and Europe in second.

3.2. General Framework and Key Targets Assumed by Different States until 2050

Over time, a number of pacts, initiatives, agreements, regulations, and policies pertaining to sustainable development, greenhouse gas emissions, renewable and green energy sources, and international cooperation have been developed. The United Nations General Assembly (UNGA) proclaimed 2012 the international year of "Sustainable Energy for All" (SE4ALL) in an effort to catalyze international collaboration on clean energy reform and adoption [181]. In addition, Agenda 21 posed an early energy policy request to the nations of the world [182]. This request was to encourage research and technology transfer related to renewable energy sources, as well as to conduct an analysis of the various types of energy supplies. Due to the Johannesburg Plan, over 118 nations adopted domestic renewable energy legislation and regulations in 2002 to varying degrees. The Kyoto Protocol (1997) establishes legally enforceable quantified emission limitations or reduced engagements for state parties, but only makes one mention of renewable energy in Article 2(1) (a) [183]. The European Union and Euratom both signed the Energy Charter Treaty (ECT) in 1994. The ECT has set binding duties for its 53 signatory states, one of which is the requirement that by the year 2020, 20% of each state's total energy share must be derived from "renewable sources." [184]. In addition, the Paris Agreement (2015) established important climate objectives, such as a maximum temperature increase of 2 degrees Celsius regarding the Earth's warming [185]. These goals cannot be accomplished unless there is a greater emphasis placed on the use of renewable energy sources and efficient energy practices. At the European level, other important laws and policies were adopted, such as the Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast), Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency (the REPowerEU plan). In 2021, as part of the European Green Deal, the European Union adopted an intermediate aim of reducing emissions by 55% by the year 2030, with the ultimate goal of reaching climate neutrality by 2050 by the achievement of zero net emissions [186]. Between the adoption of the Kyoto and Paris agreements, countries have been working on adopting a wide variety of policies regarding renewable energy sources. At the same time, the membership status for various international organizations, such as the International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA), causes governments to consider investments [187,188] and to fall within the percentages established in international agreements regarding shared energy from renewable and green sources.

According to a careful examination of the current energy landscape (war, health crisis, economic crisis, etc.), states are forced to continue investing large sums of money in the exploitation of fossil fuels on a global scale in order to support this industry and to secure and meet the power needs of stakeholders by storing large amounts of energy. From the point of view of the International Monetary Fund [189], the efficient price of fossil fuels takes into account both the supply and environmental costs of fuel consumption, which is essential for effectively allocating an economy's limited resources and investments among sectors and activities. Undercharging encourages excessive use of fossil fuels, which worsens sustainable environment development issues, such as the loss of life due to local air pollution, excessive traffic, and accidents, and speeds up global warming [190]. In 2020, fossil fuel subsidies accounted for USD 5.9 trillion or 6.8 percent of the global GDP; by 2025, they are projected to reach 7.4 percent of the global GDP as the proportion of fuel consumption in emerging nations (where price discrepancies are often greater) continues to rise. In addition, 8 percent of the 2020 subsidy was attributable to underpriced supply costs (explicit subsidies), whereas 92 percent was attributable to underpaid environmental costs and tax rates (implicit subsidies). The biggest contributor to international fossil fuel subsidies is underpriced local air pollution costs, which account for 42 percent of the total. This is followed by the costs associated with global warming, which account for 29 percent, as well as other local externalities, such as congestion and road accidents, which account for 15 percent, explicit subsidies that also make up for 8 percent and foregone revenue from consumption tax, which accounts for 6 percent [191]. In Table 6, it can be observed how the different nations that signed the Paris Agreement updated their mitigation promises in advance of COP26 in November 2021, and how many of them made significant commitments for 2030 and established carbon neutrality targets for the middle of the century [192].

Table 6. Climate mitigation pledge for Paris Accords and neutrality target for selected countries.

Climate Targets			
Country	**Submission Round**	**Mitigation Pledge for Paris Agreement**	**Neutrality Target**
Canada	First	Reduce GHGs by 40–45% compared to 2005 levels by 2030	2050
China	First	Reduce CO2/GDP by 60–65% compared to 2005 levels by 2030	2060
France	Second	Reduce GHGs by 55% compared to 1990 levels by 2030	2050
Germany	Second	Reduce GHGs by 55% compared to 1990 levels by 2030	2045
India	First	Reduce GHG/GDP by 45% compared to 2005 levels by 2030	2070

Table 6. *Cont.*

Climate Targets			
Country	**Submission Round**	**Mitigation Pledge for Paris Agreement**	**Neutrality Target**
Italy	Second	Reduce GHGs by 55% compared to 1990 levels by 2030	2050
Japan	Second	Reduce GHGs by 25.4% compared to 2005 levels by 2030	2050
United Kingdom	Second	Reduce GHGs by 68% compared to 1990 levels by 2030	2050
United States	Second	Reduce GHGs by 50–52% compared to 2005 levels by 2025	2050

Source: Authors' own adaptation based on data from [193].

As it can be observed in Table 6, some countries sign the pledge for the Paris Accords in the first round in 2015/16, and others in the second round in 2020/21, or some just updated their nationally determined contributions (NDGs). European Union member countries committed to a wide neutrality target established in the European Climate Law and the European Green Deal. The EU member states must increase their share of renewable green energy use in overall energy consumption if they are to fulfil the intermediate goal of lowering net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels [194]. For some nations, such as India, the neutrality target was not applicable, until recently. The data presented in the report in ref. [174] (International Renewable Energy Agency, 2022) reaffirms the vital role that cost-competitive renewables have in tackling today's energy and climate emergency situations by speeding up the transition in alignment with the 1.5 °C warming limit and also the goals of the Paris Agreement [195]. This role is critical in addressing today's energy and climate emergencies. The rapid reduction and eventual phasing out of fossil fuels and the mitigation of the macroeconomic harms they create can be aided by the widespread adoption of RGEs, such as solar and wind power, which have very short project lead times. By supplying clean air, water, healthy soil, and biodiversity; renovated, energy-efficient buildings at an affordable cost; more public transportation; green energy and cutting-edge clean technological innovation; longer-lasting products that can be repaired, recycled, and re-used; prospective jobs and skill building for the transition; and globally competitive and sustainable businesses, the European Green Deal will enhance the wellbeing and health of citizens and future generations [196].

The European Commission recommends that the EU's 2030 renewable energy target is raised from its present 40% to 45%, but as it can be observed in ref. [197], the European Parliament is already suggesting that the target should increase to 55%. By 2030, the REPowerEU Plan should increase the overall generation of renewable energy from green sources to 1236 GW, up from Fit for 55′s projection of 1067 GW [198]. The implementation of photovoltaic energy will be accelerated by the EU Solar Energy Strategy. This strategy, which is a component of the REPowerEU plan, intends to double the solar photovoltaic capacity by 2025 to over 320 GW and to reach over 600 GW by 2030. By 2027, this game-changing extra capacity will replace the yearly use of 9 bcm of natural gas [197]. Over time, the targets for renewable energy were permanently adapted by the European Commission, taking into account the evolution of different factors and risks regarding its capacity for objective achievement. This evolution is presented in Table 7.

Table 7. Evolution of renewable energy targets for EU member states, 2007–2022.

Evolution of Renewable Energy Targets			
Year (When the Target Was Set)	**Value of Set Targets**	**The Achievement Level for Set Targets**	**Documents**
2007	20% (for the overall share of energy from renewable sources by 2020) and 10% target for energy from renewable sources in transport	14% (achieved by 2010) 22% (achieved by 2020)	Commission communication on 19 October 2006—"Action Plan for Energy Efficiency: Realising the Potential"; Commission communication on 10 January 2007—"Renewable Energy Roadmap—Renewable energies in the 21st century: building a more sustainable future"

Table 7. *Cont.*

Evolution of Renewable Energy Targets			
Year (When the Target Was Set)	**Value of Set Targets**	**The Achievement Level for Set Targets**	**Documents**
2009	20% (for the overall share of energy from renewable sources by 2020) and 10% target for energy from renewable sources in transport; the percent was maintained	22% (achieved by 2020)	Directive 2009/28/EC of the European Parliament and of the Council on 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC
2010	20% (for the overall share of energy from renewable sources by 2020)	22% (achieved by 2020)	Because the EU was far from achieving its 20% target, the EC developed a new strategy to reinforce member states' political commitment—Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Energy 2020: A strategy for competitive, sustainable and secure energy/* COM/2010/0639 final*/
2014	27% (for the overall share of energy from renewable sources by 2030)	-	The European Commission proposed that the EU 2030 target for the share of renewable energy consumed in EU is 27% (at least). The proposal was endorsed by the European Council in its conclusions on 23 and 24 October 2014 ("A policy framework for climate and energy in the period from 2020 to 2030")
2018	32% (for the overall share of energy from renewable sources by 2030)	19.7% (share of renewables achieved in 2019 at EU level)	Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast)
2021	40% (for the overall share of energy from renewable sources by 2030)	22% (share of renewables achieved in 2020 at EU level)	The results obtained by the EU member states by 2020 convinced the European Parliament to raise the renewable energy share target to 40% by 2030
2022 (18th of May)	45% (for the overall share of energy from renewable sources by 2030)	≈33% (estimated share of renewables achieved in 2021 at EU level)	The REPowerEU Plan (RPE) of 18 May 2022
2022 (20th of June)	55% (for the overall share of energy from renewable sources by 2030)	-	Non paper on complementary economic modeling undertaken by DG ENER that analyzes the impacts of increasing the overall renewable energy target of 45% to 56% in the context of discussions in the European Parliament on the revision of the Renewable Energy Directive

Source: Authors' own adaptation based on data from [197,199–201].

The REPowerEU plan outlines a number of actions that will help the EU's energy grid to become more resilient, while reducing reliance on fossil fuel imports and advancing the green transition [202]. The foundation of the REPowerEU initiative relies on the following: diversification (the EU is collaborating with worldwide partners to find alternate energy sources. In the short term, the EU needs alternative supplies of gas, oil, and coal as soon as feasible; in the long term, they will also require renewable hydrogen); saving (energy can be saved by every individual, company, and organization. It will also be necessary to take precautions against supply disruptions); speeding up clean energy (in order to lower emissions and dependency, renewable energy sources will lessen the EU's need for energy imports and will make it possible for industry and the transportation sector to quickly replace fossil fuels. REPowerEU will hasten the transition to a greener economy and encourage significant investments in renewable green energy) [197]. Between 2017 and 2027, further investments of EUR 210 billion are required to cut out Russian fossil fuel imports, which already cost European taxpayers almost EUR 100 billion annually. With extra EU funding, the Recovery and Resilience Facility (RRF) is at the center of implementing the REPowerEU Plan.

The social and political perspectives are important considerations for renewable green energy public policies, decision-making and technology development. Long-term plans or decisions on the deployment or development of renewable energy sources may have an impact on society. Public reviews and perceptions are increasingly being taken into account in energy planning and renewable energy policies [203,204]. Globally, deployments of renewable energy must account for current landscape design, particularly in urban environments. Conflicts can lead projects to be considerably delayed or even abandoned [205,206]. Finding societal advantages is essential to the approval of renewable energy projects, according to studies and research from China, Greece, Turkey, the United States, and even around the world [207–209].

Political factors play a special role in the energy market and demonstrate the importance of renewable green energy development and use. All four primary phases of the lifecycle of a renewable green energy project—planning and policy formulation, construction and execution, operation and maintenance, and deactivation or abandonment—have socio-political effects. Governments and politicians are taking into consideration the growing economic advantages of the renewable green energy sector. This sector boosts job creation and business opportunities [210], contributes significantly to the regulation (or deregulation) of the electrical power markets, provides funding for national R&D projects, ensures adherence to regulations and standards, and helps people to understand how electric utilities are viewed [211]. Regarding the political factor, there is a consensus at the global level of the states that have joined those pacts and agreements to reduce dependence on fossil fuel, to no longer be affected by price volatility, and avoid market panic [167].

3.3. Impact of Green Energy on Different Sectors

Early projections from the European Environment Agency (EEA) show that 22% of the energy used in the EU in 2021 came from renewable sources. Significant growth in renewable energy consumption in 2021 was fueled by increasing solar electricity production and the growing implementation of renewables in the heating industry. However, following the COVID-19 epidemic, this was overshadowed by decreasing wind speeds and the quick return of non-renewables. The long-term outlook might not meet the present target of 32% for 2030 outlined in the renewable energy plan. The European energy grid would have to undergo significant changes in order to achieve the recently announced revised objective of 45% [212]. The percentage of renewable energy that was produced in the EU increased by only 0.1 percentage points during the years 2020 and 2021, rising from 22.1% to 22.2% of total energy production. However, when looking at the available data, renewable consumption increased by more than 13 million tonnes of oil equivalent (Mtoe) in 2021. This represents the highest increase since 2012.

According to ref. [213], approximately 76% of all greenhouse emissions are attributed to the electricity, heat, transportation, and industry sectors, with the remaining 24% originating from agricultural and land use. One of the most difficult issues that the world's society is facing is the transition to long-term sustainable energy systems. By 2050, greenhouse gas emissions must not only be minimized from all energy-related sectors, including power, heat, transportation, and industry, but also these sectors must be closely linked to each other for optimum efficiency and synergy. Even in the case of severe weather conditions and an energy-intensive sector, it is still plausible to make the switch to a system that is powered entirely by sustainable and renewable green energy by the year 2050 [214].

The energy system must be further decarbonized in order to meet climate goals for 2030 and 2050. As mentioned previously, more than 75% of the EU's greenhouse gas emissions are attributable to the generation and consumption of energy across all economic sectors. Prioritizing energy efficiency is necessary. It is mandatory to create a power sector that relies mostly on RGEs, with the quick phase-out of coal and decarbonization of gas as backups. New public policies should be developed in order to achieve decarbonization at the lowest cost possible, speed up the investments in green energy and energy efficiency and to reduce energy intensity during times of economic expansion [210], in addition to wisely integrating other sustainable technologies across other sectors. The impact of the deployment of green energy on household energy bills has already been mitigated by the rapid decline in the cost of renewable energy and enhanced support policy design (COM (2019) 640 final—the European Green Deal) [215].

Next, the review presents the evolution of the share of energy from renewable sources in sectors such as electricity, transport, and heating and cooling, since they are the main industry sectors in which renewable green energy sources are used in order to achieve SD targets.

Renewable green energy is one of the more promising types of energy for producing electricity [216]. The increased use of RGEs for the world's electrical supply is necessary due to the negative environmental effects of producing electricity from fossil fuels, climate change, the depletion of fossil fuel reserves, and shifting pricing [217–220]. In Table 8, the growing trend for selected countries in using RGEs for electricity consumption can be observed. The percentage of energy generated from renewable green energy sources has also been steadily increasing [212].

Table 8. Share of energy from renewable sources in gross electricity consumption, transport, and heating and cooling for selected countries and region, 2011–2020 (%)—Directive 2009/28/EC.

Regions/Countries	Share of RGEs in Electricity Consumption, EU		Share of RGEs in Transport, EU		Share of RGEs in Heating and Cooling, EU	
	2011	2020	2011	2020	2011	2020
European Union—27 countries (from 2020)	23.300	37.482	4.115	10.220	17.415	23.090
Belgium	8.989	25.122	4.802	11.035	6.718	8.447
Bulgaria	12.621	23.586	0.898	9.101	24.768	37.178
Czechia	10.610	14.810	1.285	9.383	15.388	23.535
Denmark	35.874	65.323	3.609	9.701	31.889	51.073
Germany	20.930	44.696	6.461	9.918	12.607	14.807
Estonia	12.199	28.293	0.445	12.165	44.550	58.834
Ireland	18.252	39.055	3.844	10.187	4.657	6.264
Greece	13.810	35.856	0.600	5.341	20.111	31.941
Spain	31.530	42.944	0.767	9.528	13.469	17.966
France	16.180	24.819	0.987	9.207	15.263	23.369
Croatia	37.592	53.816	1.029	6.593	33.820	36.928
Italy	23.547	38.081	5.060	10.736	13.818	19.949
Cyprus	3.446	12.041	0.000	7.401	19.977	37.117
Latvia	44.694	53.357	4.090	6.733	44.710	57.094
Lithuania	9.020	20.166	3.828	5.511	32.788	50.350
Luxembourg	4.075	13.887	2.360	12.581	4.736	12.614
Hungary	6.379	11.904	6.174	11.571	20.043	17.720
Malta	0.454	9.489	2.016	10.586	12.026	23.027
Netherlands	9.740	26.407	5.068	12.631	3.688	8.053
Austria	66.779	78.204	10.077	10.283	31.517	34.995
Poland	8.078	16.237	6.918	6.575	13.240	22.144
Portugal	45.780	58.033	0.695	9.701	35.184	41.546
Romania	31.131	43.374	5.535	8.540	24.306	25.327
Slovenia	31.045	35.095	2.477	10.911	31.785	32.141
Slovakia	19.305	23.066	5.727	9.259	9.258	19.427
Finland	28.964	39.564	1.004	13.438	45.732	57.622
Sweden	59.624	74.495	11.938	31.854	58.519	66.381
Iceland	93.915	102.709	0.872	11.959	68.100	80.505
Norway	105.887	113.802	2.683	28.690	34.671	36.126

Source: the authors centralized and processed data published by ref. [178].

The EU average for the share of energy from RGEs in gross electricity consumption is 37.5%, of which 12 out of 27 states are above this average. This is encouraging, especially taking into account the targets set at the EU level. Within the EU, Austria (78.2%) and Sweden (74.5%) produced more than 70% of the power used in 2020 from renewable green sources. Additionally, a significant portion of the electricity used in Denmark (65.3%), Portugal (58%) and Latvia (53.4%) was produced from green sources. On the other end of the spectrum, in Malta (9.5%), Hungary (11.9%), Cyprus (12.0%), Luxembourg (13.9%), and Czechia (14.8%), the proportion of renewable energy generated was 15% or less. In 2020, the EFTA nations of Norway and Iceland generated more power from green sources than they used, resulting in a proportion greater than 100%.

Mobility has been severely limited during the pandemic because of the implemented lockdowns. Globally, the crisis significantly reduced the use of private cars, but the decrease was short-lived. The use of private cars has increased once again as the lockdowns were lifted, and it will likely continue to do so in the near future, as people try to reduce the risk of the virus spreading. Given this transportation method's inefficiency and the detrimental externalities it has on productivity, welfare, environment, and other factors, many authorities are funding the public transportation industry to maintain the availability of its services. Consumption of fuel in the transportation sector has had a negative impact on the total emissions of greenhouse gases and many other gaseous and particle emissions in metropolitan environments [221]. Therefore, it is important to encourage the production of power from RGEs and electrification of the transportation sector in order to fulfill a number of environmental sustainability goals [222,223]. Unfortunately, in contrast to the heating and cooling industry, the share of RGEs in the transportation sector remained relatively the same at 10.2% for much of the study period [212]. In terms of total consumption, more renewables were used in transportation than fossil fuels; however, the yearly increase in fossil fuels was superior to that of RGEs. Regrettably, the expansion of the RGE share in the transportation industry has been uneven.

According to Table 8, the average percentage of energy from renewable green sources used in transportation increased in all EU member states in 2020, except Poland, Austria, Lithuania, and Romania. The largest increases in the last year were observed in Estonia (+11.72%), Luxembourg (+10.22%), Portugal (+9.00%), and Spain (+8.76%) [188]. In order to increase the demand for green energy, the governments of the world ought to promote the use of RGEs in electric vehicles and public transportation. It is true that the road to green energy as a source of sustainable energy is a long and challenging one, but governments should include their commercial sectors by giving unique incentives that would drive companies to commit to green energy projects. This will increase the probability that green energy projects will be developed [224,225]. As a consequence of this, states would eventually achieve the transition goal that is centered on RGEs. As a result, this would contribute to the successful fulfilment of the environmental responsibility promised by the numerous international agreements [32].

At the level of individual industries, the heating and cooling industry witnessed the greatest increase in the use of renewable energy sources in 2021, reaching an RGE share of 23.6% [212]. This was made possible due to the growing use of heat pumps and biomass as energy sources.

The need for energy in buildings will rise over time. A possible increase in work-from-home options could accelerate this trend. These advancements offer a chance to incorporate green energy sources and energy efficiency in the construction sector, along with supporting actions, such as educating various stakeholders and staff members. Energy-efficient construction and refurbishment of existing buildings offer considerable potential for employment development, in addition to lowering energy costs [29].

In Table 8, among the member states of the EU that obtain more than half of their heating and cooling energy from green sources are Sweden (66.4%), Estonia (58.83%), Finland (57.62%), and Latvia (57.1%). On the other end of the spectrum, Ireland (6.26%), the Netherlands (8.1%), and Belgium (8.44%) are the EU member states whose heating and cooling systems use a fraction of energy derived from green sources that is lower than 10% [178].

The data presented in Table 8 indicate that 16 of the 27 member states of the EU, plus Iceland and Norway, experienced an increase in their share of renewable energy between the years 2011 and 2020. Denmark and Estonia stand at the top of this list, after increasing their energy shared from RGEs by more than 15 percentage points throughout the period that was examined. In the case of Denmark, this had been primarily brought about by a rise in the use of bioenergy for purposes including heating, the generation of electric power, and transportation. The use of RGEs in the generation of electricity, in transport, and the heating industry from RGEs experienced notable expansion in Estonia. In contrast, the RES shares of Romania registered a slow growth. In the instance of Romania, a decline in the usage of renewable green energy sources for heating and cooling was accentuated by a significant overall rise in non-renewable energy sources [212]. Denmark, Estonia, and Sweden have witnessed the largest growth in RGEs shares over the long term, with increases of more than 20%. In contrast, there has been a less than 5% increase in Romania and Slovenia.

In conclusion, in ref. [29] and in other researchers' [226] opinions, sustainable development needs a green recovery plan that may put renewables, energy efficiency, and digitalization at the forefront of end-use energy sectors, such as heating and cooling, for buildings, transportation, and the electricity industry.

4. Discussions, Gaps in the Literature, and Future Research

As can be deducted from the analysis above, countries all over the world have taken steps to develop green energy from renewable sources, such as solar power, hydropower, geothermal, wind, tidal wave, biogas, and biomass, in an effort to meet global energy demand [227]. States will be able to achieve sustainable development when green energy can be produced in significant quantities. In this respect, the transition to green energy should be promoted, since it is crucial for lessening the global crisis and achieving sustainability.

Over the course of the past decade, a number of developing countries, but not exclusively, have started making significant investments in the renewable energy sector. The most prominent examples are China, Sweden, Costa Rica, Iceland, India and Brazil [228–230]. These countries are all attempting to combat the excessive pollution that has arisen in recent years as a result of rapid economic growth. In 2020, renewable energy in European Union made up 22.1% of the energy used, exceeding the 2020 goal of 20% by about 2 percentage points [197].

According to ref. [174], the total quantity of power generated from renewable sources around the globe in 2020 was 7468 TWh (terawatt hour), while ref. [231] shows that at the European level, some leading countries have rapidly moved towards an energy system based on renewable resources, such as Sweden (its target for 2040 is to obtain 100% renewable electricity production by combining hydropower with bioenergy), Scotland (97% of its electricity supply is produced from renewable sources), Iceland (nearly 100% of Iceland's electricity requirements are met by a combination of geothermal and hydropower), Germany (its target for 2030 is to obtain 80% of its energy from renewable sources), Denmark (the OECD nation with the highest per-capita wind power generation, and that number is predicted to rise by 16%) and Norway (renewable energy sources provided 98% of Norway's electricity).

In addition, at the international level, there are other states that produce an important quantity of energy from renewable resources, such as Costa Rica (which produces 98% from renewable resources using a mix of hydro, geothermal, wind, biomass, and solar power), Uruguay (it produces enough clean energy that it can export it to its neighbors in South America, Argentina and Brazil. In 2021, renewable energy sources provided 98% of their total electricity), China (leaders in wind and solar energy production), New Zealand (by 2035, it plans to use 100% renewable energy) and Morocco (it is already a global leader in solar power, due to the strength of its natural sunshine) [231].

According to the majority of studies [232–234], green energy seems destined to be a part of the global future as a cleaner and more efficient solution to many of the current energy sources. These energy sources are easily renewed, do not harm the environment, create jobs, and are predicted to become economically feasible as technologies advance. Based on the data analyzed in this review paper, it becomes clear that a fully sustainable future for global energy supplies can be created without harming the planet we all share, by focusing on the development of a wide range of green energy alternatives. This trend will continue to grow as more towns, regions and states commit to the green power agenda in order to ensure the sustainable development of the energy sector for future generations.

At this moment, effective development of the green energy sector requires international cooperation in the areas of research and development, administration policy, monitoring and politics. Legislation and financial frameworks that address the development of technologies that produce green energy and energy from renewable resources need to be coordinated and updated, and policymakers should suggest the creation of a powerful tool for the purpose of accomplishing the goal of sustainable development.

This overview presented the results of researchers who studied a wide variety of renewable green energies and published articles around the globe. However, one of the main gaps in the literature is that the view presented in their research papers does not show the government policymakers' and society's overall research priorities. In the future, it would be valuable to involve different stakeholders and policymakers in the research studies, so that the degree of coordination between groups and scientists may potentially be examined on an ongoing basis to track shifting priorities. The review also discovered other gaps in the analyzed publications, since few studies investigated the following topics: (1) the relation between green energy public policies and anti-corruption measures adopted at a national level for different financial schemes or grids; (2) the transparency level for green energy projects; or (3) the relationship between public trust and renewable green energy policy, including national and regional measures adopted in order to deal with the current energy crisis, and the situation generated by the tensions between the Russian Federation and Ukraine.

Additionally, for future research, it could be interesting and valuable to systematically gather and analyze the top government and other national, regional, and international organizations' priorities for renewable green energy research. Researchers may gain some insight into the degree to which their own scientific priorities are in line with the requirements of society, by gaining an understanding of the variety in priorities held by industry, society, and the government. Furthermore, future research could include key themes that promote sustainable green energy development, by tackling each type of renewable green resource challenge. This review suggests that future research could focus on creating local structures to enhance experience and practice, and extrapolating them to the worldwide level by developing effective regulations for the sustainable management of green energy systems.

5. Conclusions

In the current international context that is strongly marked by the energy crisis and international tensions, the study of various authors [235] led us to the conclusion that green energy solutions from renewable sources offer alternatives for global sustainable development. Unlike other studies [236], this paper views green energy sources as a strategic option for sustainable development. This overview contributes to the literature by identifying RGEs as a fundamental element of sustainable development. The researchers [150,237] show that it is essential to place RGEs at the center of the sustainable development paradigm as a means of meeting the international agreements and SGD 7 challenges.

The paper points out the evolution of RGEs and their main advantages, showing policymakers some steps that can steer the energy system in the direction of a long-term sustainable development route. It can help decisionmakers to identify which strategies and initiatives are ineffective for achieving the various goals related to the economy, energy, sustainability, and climate change. The prospect of the switch to RGEs must be achieved through the promotion of international collaboration in science, science–policy interaction, and information transfer.

This review identified a number of barriers that slow the growth of RGEs, including the following: (1) high investment prices; (2) underdeveloped infrastructure; (3) legislative gaps; (4) difficulties implementing environmental policies; and (5) bureaucracy, among others. However, through collaborative efforts from the public and private sectors, all states may increase the use of RGEs and can achieve better outcomes for the environment, energy security, and for sustainable development.

As shown in this paper, there is an urgent need to intensify the efforts of the states to capitalize on renewable energy sources for the generation of green energy and for sustainable development. Governments must adopt clear strategies to increase the share of their energy supply from green sources. The main aspects derived from the investigated literature [154], which should be carefully analyzed and included in these strategies, refer to the following actions: (1) increasing the level of responsibility that is placed on renewables in international agreements; (2) providing organizational support to the green energy movement; (3) raising awareness of the importance of RGEs in the achievement of SD goals (marketing); and (4) increasing cooperation at the local, national, and international levels in domains such as research and development, in order to improve and create new and cheaper technologies that facilitate the exploitation of green resources in a sustainable manner.

The limits of this review refer to the vast specialized literature that addresses the topic of renewable resources, green energy resources, the energy sector, and green technologies, but also the main international or regional agreements that regulate this field in the context of sustainable development. In our future research, we aim to expand the analysis of each type of green energy separately and to carry out a systematic analysis of their evolution in different states and regions to identify the best practices and key governmental actions, in order to increase the contribution of the green energy sector to their sustainable economic and social development and for the protection of the planet.

The results of this consistent and systematic overview show that in the last few decades, many countries have made significant progress in the production and integration of green energy into their economic and social systems. However, further significant investments are needed to increase the production of green energy, which is necessary to achieve sustainable economic and social development targets.

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