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Review Paper / Derleme

Recent Improvements in Various Renewable Energies and Their Effects on the Environment and Economy: A Review Article

Muhammed Sait KANCA[1a], Ibrahim Nazem QADER[2b], Mohammed Nadhim QADIR[3c], Mediha KOK[1d*]

[1]Department of Physics, Faculty of Science, Firat University, Elazig, Turkey
[2]Department of Physics, College of Science, University of Raparin, Sulaymaneyah, Iraq
[3]Department of Chemistry, College of Science, University of Raparin, Sulaymaneyah, Iraq
*msoglu@firat.edu.tr

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Abstract: The increasing populations and expanding industries all over the world led to enhance the need for energy. Since most of the nowadays energies are generated by fossil fuels, so the ratio of greenhouse gases like CO_2 extremely increased that impacted the environment and other sectors. In this study, the renewable energies used globally and in Turkey have been described. Also, the different fields of studies, which covered by different researchers have been highlighted. Besides, the opportunity and the corresponding advantages that can be achieved by harnessing renewable energies have been determined. Consequently, there is good progress in development, and investments have been made in this area, especially by governments, international organizations, and highly advanced and large private companies. Finally, this article provides a detailed review by collecting and examining a variety of renewable energy sources and highlighting prospects for scientists and investors.

Keywords: Renewable energies, Economy, Efficiency

Yenilenebilir Enerjilerde Son Gelişmeler ve Çevre ve Ekonomi Üzerindeki Etkileri: Derleme Makale

Öz: Tüm dünyada artan nüfus ve genişleyen endüstriler, enerji ihtiyacının artmasına yol açtı. Günümüzde enerjilerin çoğu fosil yakıtlar tarafından üretildiğinden, CO_2 gibi sera gazlarının oranı son derece artarak çevreyi ve diğer sektörleri etkiledi. Bu çalışmada, dünyada ve Türkiye'de kullanılan yenilenebilir enerjiler anlatılmıştır. Ayrıca, farklı araştırmacılar tarafından kapsanan farklı çalışma alanları vurgulanmıştır. Bununla birlikte, yenilenebilir enerjilerden yararlanılarak elde edilebilecek fırsat ve buna karşılık gelen avantajlar da belirlendi. Sonuç olarak, kalkınma konusunda iyi bir ilerleme kaydedilmiştir ve bu alanda, özellikle hükümetler, uluslararası kuruluşlar ve çok gelişmiş ve büyük özel şirketler tarafından yatırımlar yapılmıştır. Son olarak, bu makale, çeşitli yenilenebilir enerji kaynaklarını inceler ve bu incelemeler, bilim insanları ve yatırımcıların beklentileri vurgulayan ayrıntılı bir çalışmadır.

Anahtar Kelimeler: Yenilenebilir enerjiler, Ekonomi, Verimlilik

1. Introduction

The 1st industrial revolution started in Britain around 1765. There are three requirements to make big changes in the economy; the first one is a new way of communicating. In this case, it was the fancy ability to print and use the Telegraph; the second one was the new way of shipping and transportation by the invention of locomotives that powered by steam; and the third one is a new

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ORCID ID: [a]0000-0002-2987-4284; [b]0000-0003-1167-3799; [c]0000-0002-8593-9679; [d]0000-0001-7404-4311

power source, in this case, it was the burning of coal. Then the 2nd industrial revolution was happening mainly in the USA around 1870 [1]. For that, a new way of communication emerged, including television, phones, and radio. Cheap oil provided a revolutionary mechanism for moving cars with internal combustion engines and a new energy supply. In the 3rd industrial revolution, the internet is a modern form of communication; hybrid and electric cars are new modes of transportation; and solar, wind, and nuclear power are new sources of energy.

The harnessing of clean energies is possible using modern technologies. Although they are still expensive, the price of these technologies is declining with the increasing advancement of knowledge and performing scientific research. **Figure 1**a shows the published scientific articles that comparably increased in recent years. Improvements in this area have impacted the overall price. For example, a power grid based on renewables, isn't feasible or is too expensive, or would hurt the economy. Nowadays, wind and solar energy have become less expensive and more powerful than fossil fuels, e.g., since 1977 the cost of photovoltaic cells for solar panels has diminished by 15,000%. This is all fine because fossil fuels have achieved their maximum efficiency. Chemical engineers and scientists believe that fossil fuels have reached the end of their useful life and have little potential left to tap, while wind and solar power are becoming more effective every year. It is calculated that 320×10^{18} J/h of energy reaches the earth [2] that, which meets the needs of one year. Wind farms could generate enough electricity to power the global economy if they captured only 20% of the current wind. The aforementioned factors accelerate the transition of the world to the third industrial revolution.

Figure 1b reveals the comparable research was published by top countries based on "Web of Science" and Scopus analysis results. Both the USA and PRC have conducted more than 30% of research about "renewable energy", and likewise, the European Union has the most attention to this area. If the first and second industrial revolutions were spearheaded by Britain and America, it seems that the third is being spearheaded by different countries, however certain countries are fully committed to pushing these numbers much further.

The constant decline in the price of lithium batteries is the main reason for the rapid increase in sales of electric vehicles, which cost $1000, per kilowatt-hour in 2010 however by the end of 2020, it decreased to less than $200 per kilowatt-hour that is around an 80% plunge in price in just a decade [3]. From 1950 to 2010, Electric vehicle batteries' average density is also increasing at a rate of 3 $Wh.kg^{-1}$ [4]. On the other hand, there are still a lot of negative environmental impacts of lithium batteries, and with electric cars, if you are charging your car, using a grid that is powered by fossil fuels, then that electric car becomes a lot less green. Additionally, building out renewables can create new jobs, but with climate change coming and shifting the economy, many people also will lose their jobs [5]. To start a conservative estimate, found that jobs in wind, solar and nuclear, already outnumber fossil fuel jobs by a rate of three to one, but the devastating truth is that people in the fossil fuel industries will lose their jobs, therefore it is essential to help transition them, however, they should still work in the energy sector. The new job opportunities might include building new batteries that are more effective and can keep energy longer for wind and solar, or the creation of more proficient nuclear power plants.

Coronavirus disease (COVID19), as most of this information on energy, is from before this current global pandemic. The pandemic has caused the economy to contract, i.e., by the end of 2020 CO_2 emissions were 17% decreased [6]. A decrease of gigatonnes of CO_2 in the atmosphere, compared to if there was no pandemic at all. This is the biggest annual decrease since 1970. This may seem good, but every down tech is an economic crisis that is followed by a steep increase in CO_2 emissions. But the global stimulus after that financial crisis went into developing and deploying green technologies.

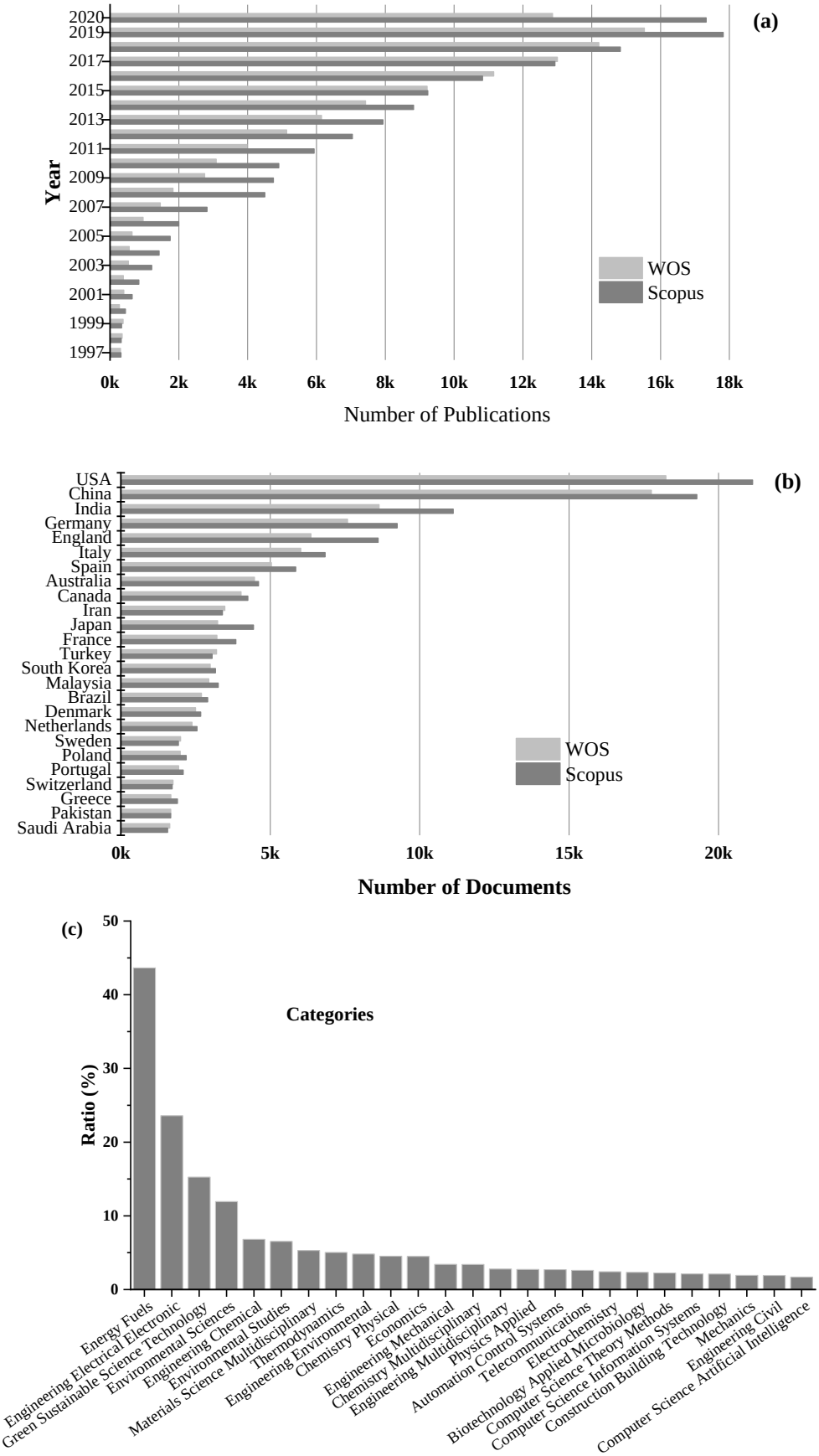

Figure 1. "Renewable energy" publication (a) between 1997 and 2020; by different (b) countries, and (c) categories since 1997 based on Web of Science and Scopus analysis

Many researchers, investigated renewable energy in different views, e.g., economic analysis of PV system and energy storage system [7]; feasibility study of a solar power plant [8]; solar chimney power technologies [9]; optimal operation of a virtual power plant [10]. This study aims to review and highlight the greatest progress in the use of renewable energy and their impact on the economy, environment, and future job and research opportunities.

2. Type and Efficiency

There renewable energy sources that currently are used all around the world are as follows:

1. Hydraulic(hydroelectric) energy
2. Wind energy
3. Geothermal energy
4. Solar energy
5. Biomass-Bioenergy
6. Sea and ocean energy
    a) Tidal energy
    b) Wave energy
    c) Ocean heat energy

With the increasing human population in the world and the gradual decrease in energy resources, the domestic and international orientation have enacted laws and policies towards renewable energy resources. Although the installation costs of renewable energy resources seem to be high, their long-term use and environmental damage are almost negligible.

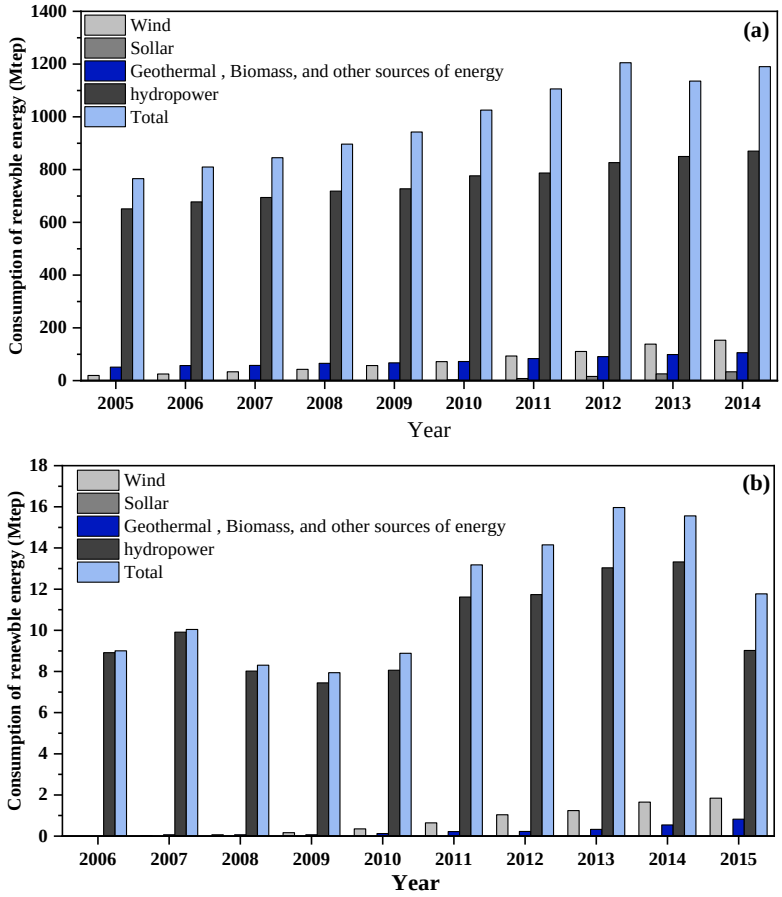

Figure 2. Consumption of renewable energy (a) globally between 2005 and 2014; (b) in Turkey between 2005 and 2014 [11, 12]

As can be seen in **Figure 2**a, the use of renewable energy sources in the world is increasing gradually. For example, Turkey is a country that imports more than 50% of its energy needs, and this situation affects the country's economy adversely, also, fossil energy resources are not enough for daily needs. The lignite coal reserves cause environmental pollution with both low caloric value and sulfur content. Due to the geographical conditions of Turkey, it is also quite convenient to have a potential in terms of renewable energy sources, whereby Turkey has started to harness renewable energy sources. **Figure 2**b reveals the amount of energy produced in Turkey from renewable energy sources in the period between 2006 and 2014. It shows that the most commonly referred renewable energy methods are particularly hydraulic energy (hydroelectric), wind power plants, and geothermal power plants. Also, in recent years, there has been a significant increase in the number of solar power plants installed with the incentives offered by the Turkish government.

2.1. Hydraulic (Hydroelectric) Energy

Hydraulic energy has the most important position among renewable energy resources (**Table 1**). Although its establishment cost is high, it is preferred by the world countries due to its long life (about 100 years) and it is a clean energy source. Turkey processes many revers that have been utilized as a natural source to achieve renewable energy using a hydraulic energy source. According to data from the year 2011, Turkey could get around 14% of its electricity from hydroelectric power plants, however, this rate has been enhanced to 41.3% of the current potential. USA and Norway generated over 80% of their electric power from the same method [13]. In other words, Turkey generates 58.7% of its need from other sources. As it is known, the flow rates of river beds are directly dependent on seasonal precipitation amounts that can be taken into account in some domestic studies.

Table 1. The development of hydropower potential in Turkey collected for 2000, Including the power rating of small powerful plants [13]

Status of HEPP projects	HEPP (piece)	Available installed power (MW)	Average annual production (GWh/year)	Percentage rate (%)	Consecutive rate (%)	Average load factor (%)
In operation as of the beginning of 2001	125	11643	42216	34	34	42
Under construction	36	3538	11547	9	43	36
Unconstructed	385	20129	71563	57	100	40
Overall potential	546	35310(*)	125328	100	-	40

The rate of Hydropower energy produced by some countries in 2011 is given in **Table 2**. It can be seen that China with producing 722 TWh has produced the highest energy from hydropower compared to the other countries. Besides, Norway meets almost all of the energy it needs from hydropower energy. Brazil meets about 81% of the energy that is needed from hydropower. Turkey installed and produced less amount of energy compared to the other country listed in **Table 2**.

2.2. Wind Energy

Wind energy is developing rapidly within renewable energy sources. Wind turbines, used today, convert wind energy into kinetic energy, and this energy is converted into electrical energy. Since the winds in the sea or oceans are stronger than the winds on land, it is important to build wind turbines on the open seas, but, its cost is high. Turkey has significant potential in wind energy supply. However, despite all developments, only a small part of the existing potential has been

utilized. According to data from 2012, the total installed capacity of the potential wind power plant in Turkey is only 2312 MW from the total 48000 MW [16].

Table 2. The domestic hydroelectric power generation rate of some countries and in the world for 2011 [14, 15]

Country	Installed power (GW)	Production (TWh)	World production ratio (%)	Hydroelectric power ratio (%)
China	212	722	19.8	14.8
USA	79	328	9.4	7.4
Brazil	79	430	12.3	80.6
Canada	75	377	10.8	59.0
Japan	28	85	2.4	8.0
Russia	47	165	4.7	15.7
India	42	132	3.8	12.4
Norway	30	122	3.5	95.2
Turkey	17	52	1.5	22.8
Overall	**609**	**2413**	**68.2**	

Figure 3 shows the energy obtained from wind turbines between 2004 and 2013 for Turkey, Europe, and the world. The y-axis is logarithmic to compare the results found in Turkey to the others. It can be seen that there is an increase in all cases. In 2004, both Europe and the world generated approximately 60 GW of energy from this renewable energy source. Turkey, with 20 MW in 2004 to more than 30GW in 2013, had a logarithmic increase in wind energy production. In 2013, this amount exceeded 1GW. Turkey can provide the energy needed by establishing wind farms in coastal areas such as Marmara and the Aegean. Because energy is clean, it will also be an important factor in reducing air pollution.

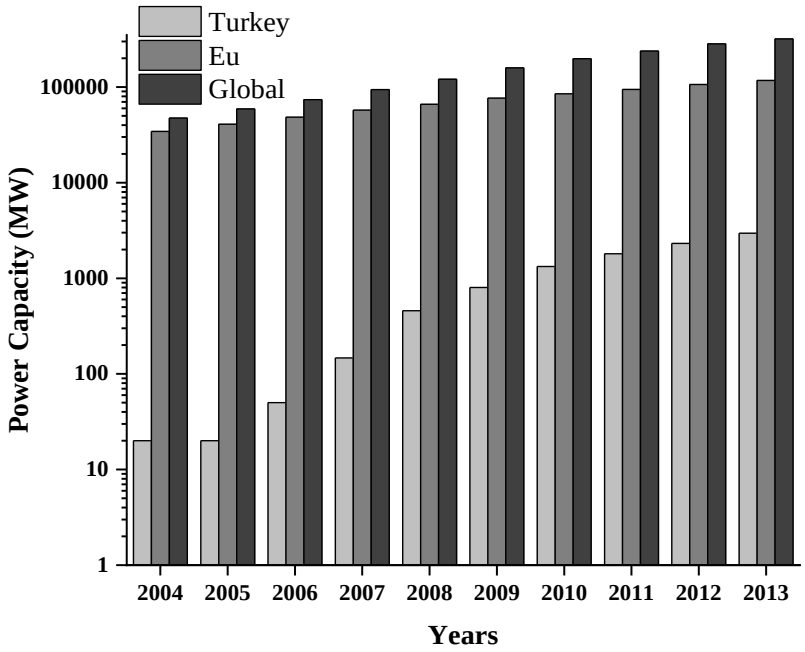

Figure 3. The capacity of the installed wind turbine in Turkey, Europe, and the world [17]

2.3. Geothermal Energy

Geothermal is a source of energy that is based on the internal heat energy stored that comes out in terms of steam and hot gases. This source can be found in some spatial locations on earth. Turkey has significant geothermal energy sources in the world. It has 140 geothermal fields, most of them in western, northwestern, and central Anatolia; 90% of which are above 40 ℃ and of good temperature (**Table 3**). The net geothermal energy potential in this country is 31,500 MW and its technical thermal potential is 7500 MW. However, only 2,843 MW of energy is utilized (approximately one-third). Geothermal energy in the world is not only used in electricity generation. Many countries around the world make extensive use of geothermal energy, including power generation and industry, early greenhouse cultivation, drying of agricultural products, central heating of buildings in cities and heating of water used in these areas, and thermal tourism. **Table 3** shows that the country that uses the most geothermal energy to generate electricity and various heating areas is the United States. Also, countries with geothermal energy sources around the world use energy in heating processes to generate electricity.

Table 3. Geothermal Energy Installed Capacity in the World in 2011 [18]

Countries	Electric (MW)	Heat (MW)
ABD	3112	12611.5
Philippines	1967	3.3
Indonesia	1189	2.3
Mexico	887	155.8
Italy	863	867
New Zealand	769	393.2
Iceland	665	1826
Japan	502	2099.5
Costa Rica	208	12099.5
Elsalvador	204	2
Kenya	170	16
Turkey	**114**	**4078**
Nicaragua	88	0
Russia	82	308.2
China	24	8898
Germany	8	2485.4
Norway	0	3300
Belarus	0	3422
Sweden	0	4460
Total	**11014**	**50583**

2.4. Solar Energy

Today, solar energy is used for electrical energy in solar power plants and solar cells (via photovoltaic cells) and hot water supply with solar collectors. It has a very significant sun exposure potential. Turkey, for example, has an annual average sunshine time of 2640 hours (110 days),

considering it is quite a high potential for making adequate investments in this country, which is about 1,100 square meters per kWh of solar energy (Table 4) [19].

Turkey, particularly the Southeast Anatolia region, Mediterranean, Central Anatolia, and Eastern Anatolia region receives high Solar energy in July, August, June, and September. Although the solar potential of Turkey is at a very good level, unfortunately, there are low investments made in solar power plants, and the incentives are not applied by the state.

Table 4. The monthly solar potential energy in Turkey [19]

Months	**Monthly Overall Solar Energy**		**Sunbathing time (hour/month)**
	(kcal/cm^2 –ay)	(kWh/m^2-ay)	
Jan.	4.45	51.75	103.0
Feb.	5.44	63.27	115.0
Ma.	8.31	96.65	165.0
April	10.51	122.23	197.0
May	13.23	153.86	273.0
Jun.	14.51	168.75	325.0
Jul.	15.08	175.38	365.0
Aug.	13.62	158.4	343.0
Sep.	10.60	123.28	280.0
Oct.	7.73	89.90	214.0
Nov.	5.23	60.82	157.0
Dec.	4.03	46.87	103.0
Overall	112.74	1311.16	2640
Mean	9.395	109.2633	220

2.5. Biomass Energy

Biomass energy is a colorless and flammable gas obtained as a result of the fermentation of carbohydrate wastes of plant and animal origin. It contains around 65% methane, around 30% carbon dioxide, and a small amount of hydrogen, hydrogen sulfide, carbon monoxide, and nitrogen [20]. By using biomass energy, three different basic fuels such as bioethanol, biogas, and biodiesel are obtained. Here, it is the amount of methane in the gas that determines the thermal amount of the gas, i.e. its flammability.

Turkey's annual biomass potential, as seen from the table is 117 million tons (32 Mtep per year). An important part of this potential is annual plants with 55 million tons, followed by forest waste with 18 million tons and perennial plants with 16 million tons, respectively. Biomass energy has a rate of 10% as the primary energy source in the world. An important part of this ratio is used as fuel [16]. This is also true for Turkey. energy obtained by biomass in Turkey, particularly the heating of homes in rural areas, and biodiesel are used in vehicles.

Table 5. Biomass potential in Turkey [16] Mtep (million tons of oil equivalent)

Biomass Varieties	Energy value (Mtep)	Annual biomass production (million tons)
Annual plants	14.9	55
Forest residues	5.4	18
Perennial plants	4.1	16
Agricultural industry waste	3.0	10
Wood industry waste	1.8	6
Animal waste	1.5	7
Other	1.3	5
Total	32	117

3. Research in Different Categories

Since renewable energy gets high attention, many researchers in different fields, such as engineers, chemists, physicists, computer scientists, and economists have studied the subject from different perspectives.

3.1. Energy Resources

Energy resources are the significant category that has been investigated more extensively compared to the other parts. Fossil fuels are the source of pollution so the main goal is to replace them with biomass, geothermal, hydropower, marine, solar, and wind energies (
Figure **4**). Nowadays, many types of free energy resources have found that can be enough for all humans need, but the availability, instability, manufacturability, predictability, affordability, reliability, survivability, and the cost per harnessing of these energies are the main challenges facing engineers [21].

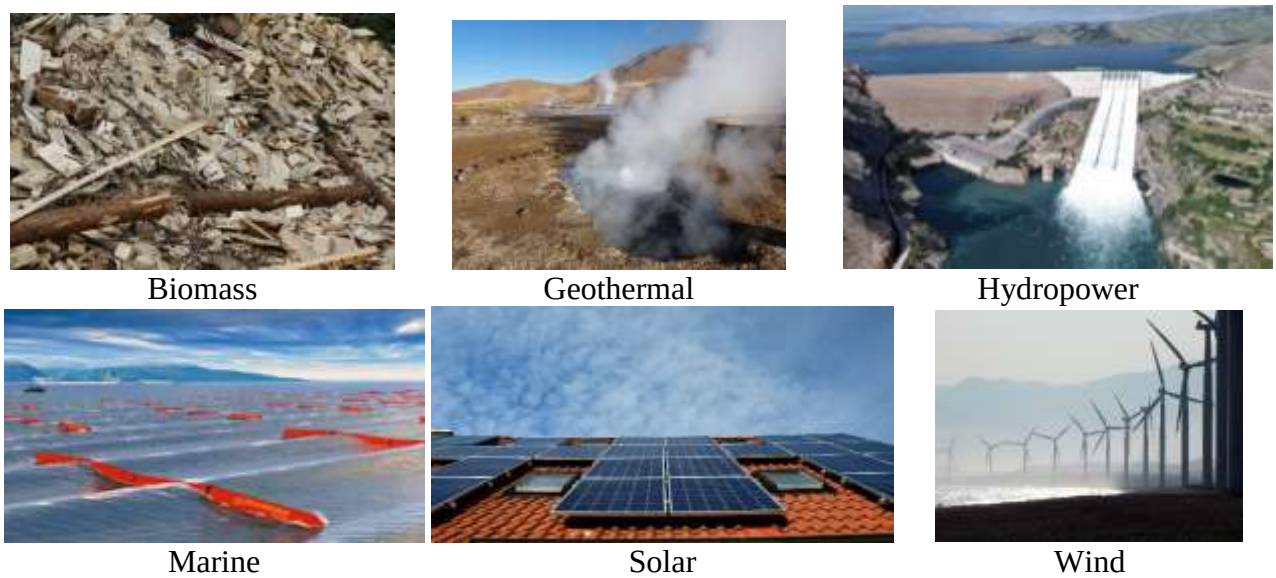

Figure 4. The various known types of renewable energies

3.2. Electrical and Electronic Engineering

Electricity can be easily transported and converted to other types of energies (**Figure 5**). Almost all renewable energies are firstly converted to electricity then stored or transported to consumers. Engineer control structure, writing algorithms, and propose a different mathematical model to enhance storing and increase the efficiency of transferring electric power. Also, researchers work on intelligent controllers that need big data and training, which can be work more efficiently compared to the traditional types, including AC-AC, DC-DC, AC-DC, and DC-AC converters [22].

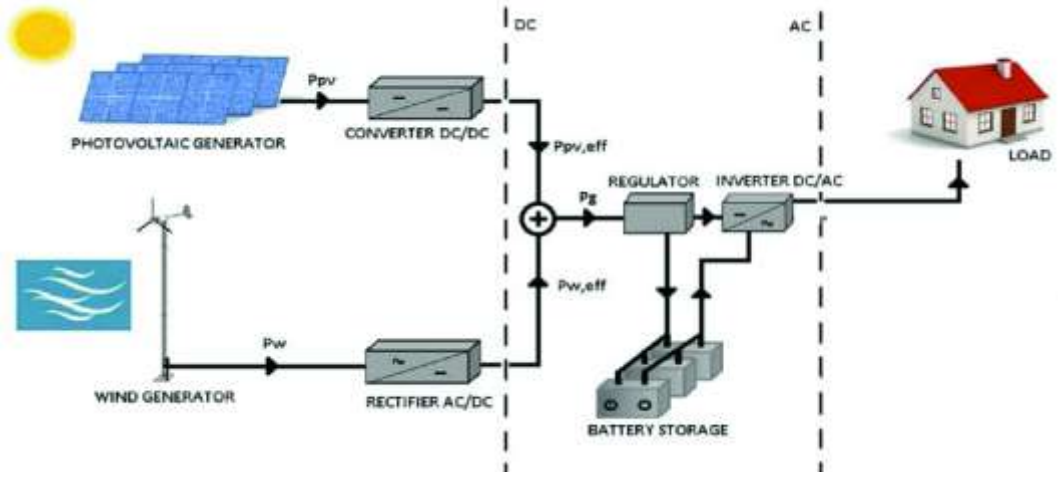

Figure 5. A simple schematic diagram about the role of electrical and electronic engineering [23]

3.3. Green Sustainable Science Technology

It is a category used by the "Web of Science" that deals with green technology in different fields, such as chemistry, nanotechnology, building, materials, engineering, innovative technologies, management, policy, environmental, and agriculture [24]. This field of study also boomed and get more attraction of scientists (**Figure 6**). For example, Li et al. [25] reviewed the Si-based photocatalysis for green chemical fuels and carbon-negative technologies. Since Si is one of the abundant elements in the crust, so it can be used as a sustainable solar energy resource. Additionally, Si can be used even to fabricate photocatalyst for photocatalytic reduction of CO_2 to solar fuel [26].

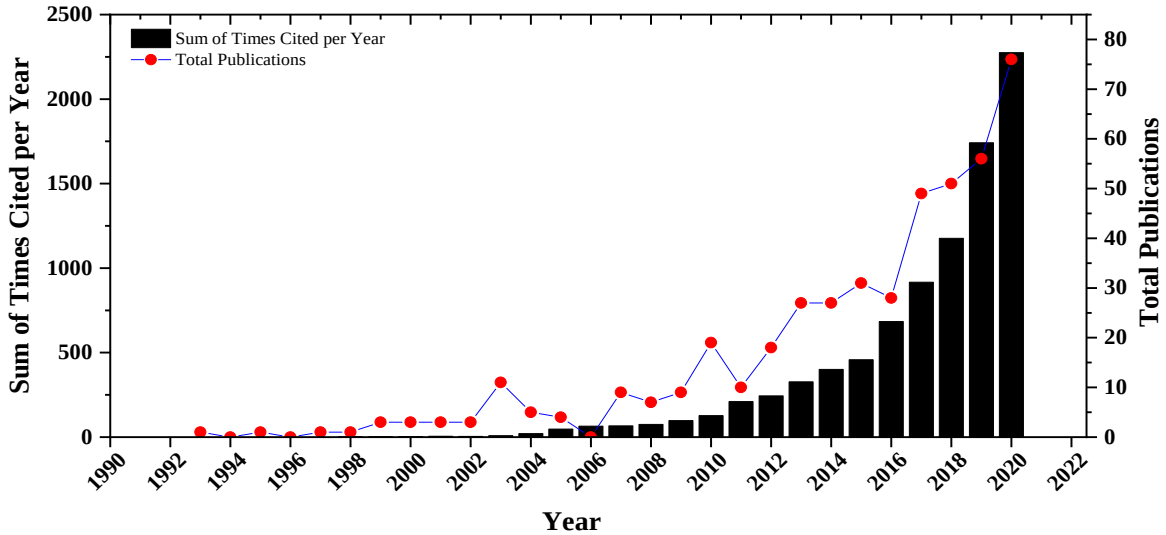

Figure 6. Total publications and citation per year for "Green Sustainable Science Technology" based on "Web of Science" data analysis

3.4. Environmental Sciences

Petroleum, as the main source of modern technologies such as polymers and energy sources, poses many challenges to the environment. The first, environmental problem is the extraction of oil from underground reserves. Additionally, consuming fossil fuel as resource energy expelled greenhouse gases, such as CO_2. Didenko and colleagues proposed a model to find the relation between using oil and environmental side effects, whereby they found that by increasing one-million-tonne (Mt) of oil, approximately 2.636 Mt of CO_2 can be released to the environment [27]. With a probability of 72%, the increasing 0.01 ℃ temperature of global land-ocean temperature anomalies can turn around 15.925 million hectares to desert, globally. Besides, they found that by raising the amount of extracted oils and coal, the global mean sea level was reduced. Also, there is a probability of 50% of desertification by enhancing expelled greenhouse gases. On the other hand, desertification also directly influences the release of CO_2 by 100.616 Mt [27].

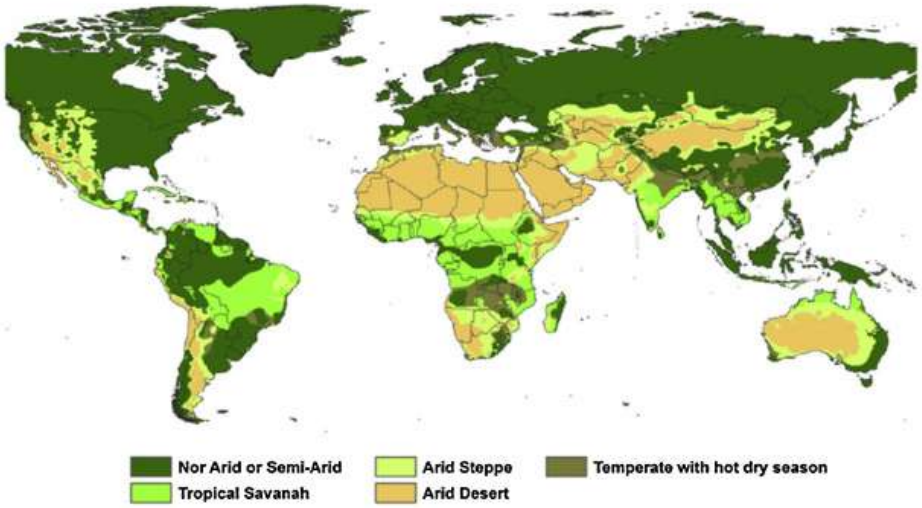

Figure 7. Map-based on Koppel climate classes [31]

Zhenghu et al. researched the amount of CO_2 output from desertified sandyland in China, and they found that about 236.04Mt C was released by soils between 1960-2001 [28]. Desertification can affect 213 million people around the world with 90% of them are people living in developing countries [29] (

Figure 7). There is some proposal to reduce desertification, for example, microbial stabilization of CO_2 in dryland to combat desertification [30].

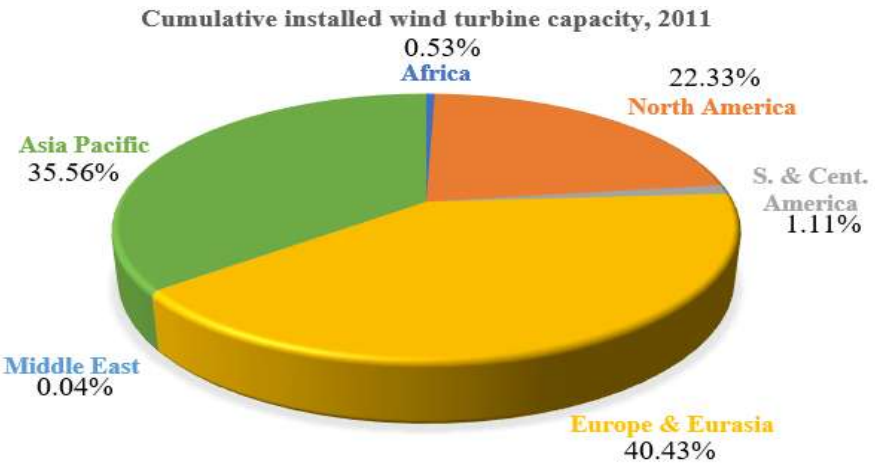

Figure 8. The capacity of the installed cumulative wind turbine for the different continent in 2011 [32]

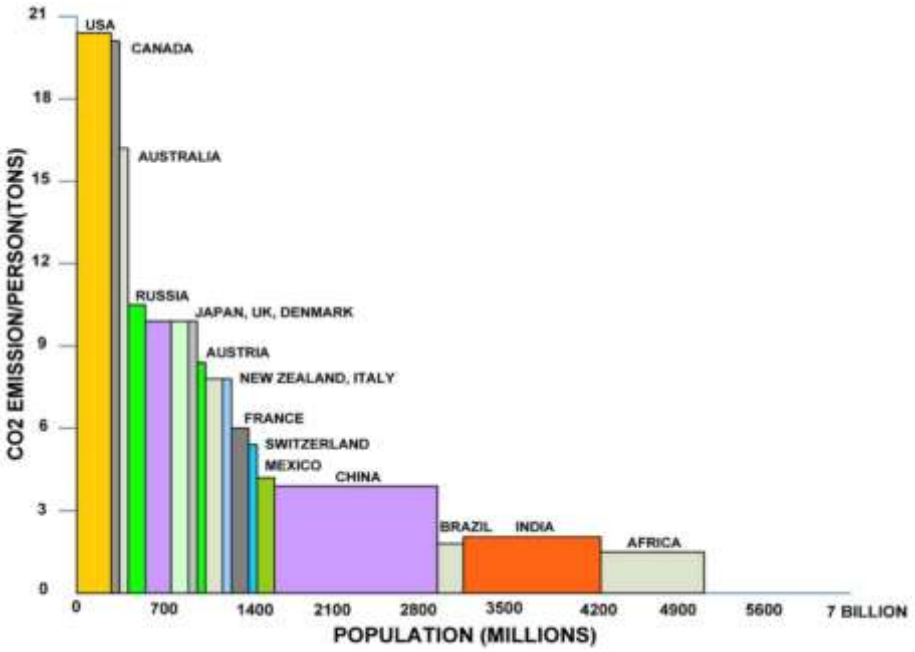

Figure 9. The CO_2 emission versus the population of some particular countries [33]

The best key to struggling with desertification and other adverse effects of climate change is using renewable or clean energy sources. However, as can be seen in **Figure 8**, the developing countries have less contribution to clean energies, for example, the installed wind turbine in the middle east and Africa only generate 0.04 and 0.53% of the total energy generated by this technique [32]. On the other hand, although north America, Asia Pacific, Europe, and Eurasia have worked to improve and progress the clean energies, they have an important role to release CO_2 into the environment.

3.5. Chemical Engineering

The reduction of converting CO_2 and other harmful gases has also helped the environment. Chemical engineers work to produces and develop catalysts that could significantly decrease greenhouse gases. Also, the conversion of CO_2 into fuels through an electrochemical reaction can diminish this gas from the atmosphere and produce another energy source [34].

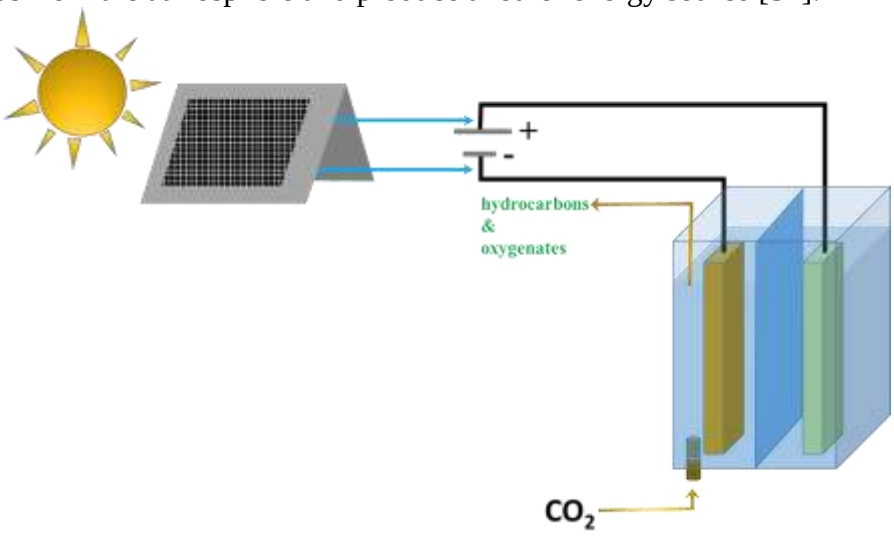

Figure 10. Schematic diagram of electrochemical reduction of CO_2

Figure 10 displays the schematic diagram of the conversion of CO_2 into hydrocarbons, where the electric source is powered by renewable energy. The process can be analog to convert H_2O into its components (hydrogen and oxygen), but there are still some challenges, such as economic viability. Smejkal et al. make an easement about the hydrogenation of CO_2 to liquid fuels [35].

3.6. Materials Science Multidisciplinary

Material science is a multidisciplinary field among physics, engineering, chemistry, biology, environment, and so on. Smart materials [36] are almost progressed in the last 50 years. There are also many engineer types such as piezoelectric materials [37] that are used in a robotic and ultrasound generator, moreover, they are used for power generating sidewalks [38]. Another type is shape memory alloys (SMAs) that their properties have been improved for Cu-based SMAs [39-45], NiTi-based SMAs [46-54], and Fe-based SMAs [55-57]. The aforementioned materials can be used for smart systems that generate clean energies. For example, Riad et al. [58] proposed an SMA-based actuator for solar cell panels that can change their angle throughout a day. Additionally, smart materials can be used for converting free-energies to electricity, e.g. photovoltaic materials (**Figure 11**) are a crucial component in solar cells that convert incident sunlight into electricity [59].

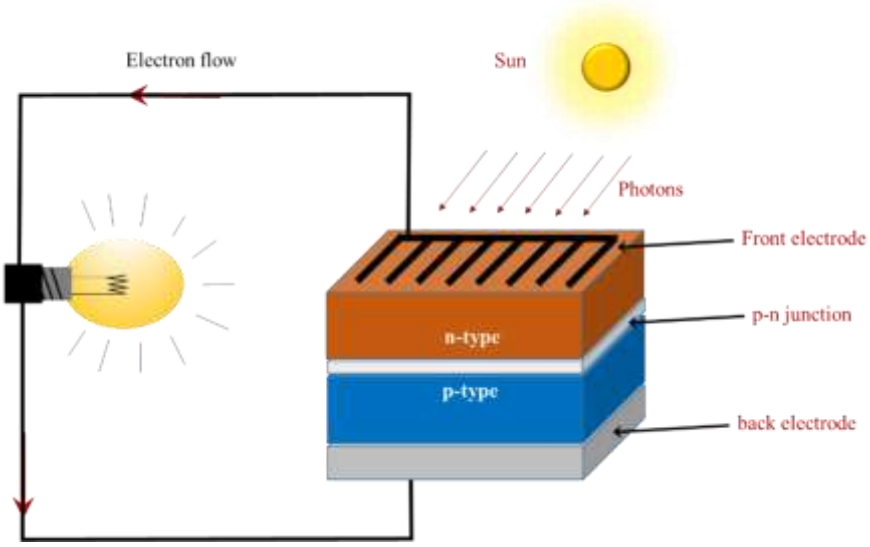

Figure 11. A schematic diagram for a basic semiconductor-based photovoltaic [60]

3.7. Thermodynamics

Thermal energy powered by solar cells can be a good candidate for desalination plants [61], however, until 2010 only 1% of the desalination plants used renewable energies [62]. Solar energy and geothermal can be used for the seawater desalination process. The most absorbed photons radiated by the sun are converted to heat energy. A liquid flowed through pips, which were heated by this energy. Besides, in many countries, includes Turkey, this method is used for storing hot water to be used for routine home use [63], moreover, it has a cost-benefit [64].

3.8. Telecommunications

Today, communication has greatly expanded, and for this purpose, portable devices such as tablets and mobile phones are used, so the internet should be available using wireless services. Many towers are installed all over roads and sometimes in non-residential areas, which is hard to supply

them with electricity. For this, solar cell panels and other kinds of renewable resources are the best candidates that can receive and store energy for the tower

Figure 12.

Figure 12. Various ways to find electric power to cellular base stations [65]

3.9. Electrochemistry

This field studies the conversion of electricity to chemical reaction and contrariwise. In this area, a researcher should know about chemistry and material properties. Electrochemistry mostly used in thin-film manufacturing, such as electrodeposition, and characterization [66]. Modern electrochemistry tried to focus on electrodeposition in atomic range to enhance the efficiency of thin-film used in solar cells [67-69].

3.10. Biotechnology Applied Microbiology

There some sub-fields in biology that can promote renewable energies, such as electro-microbiology [70]. Microbial electrochemical technologies can be handled to reduce wastewater and generate renewable energy. One of the proposed bioelectrochemical systems can be microbial fuel cells.

3.11. Computer Science and Artificial Intelligence

Computers are used for controlling systems through sufficient algorithms. Some robots can learn and behave in the same way as humans, such as Sophia [71]. Artificial intelligence systems approximately work independently. It is often to use computer algorithms to self-monitor and increase the performance of renewable energy systems. In his book, S Kalogirou gives several models about this subject [72]. In general, these systems work based on their history and the data they collect, so trial and error allow them to make daily progress.

3.12. Civil Engineering

Civil engineering has changed a lot throughout history. Civil engineers build dams to generate hydropower; therefore, they contribute to obtaining one of the more popular clean energies.

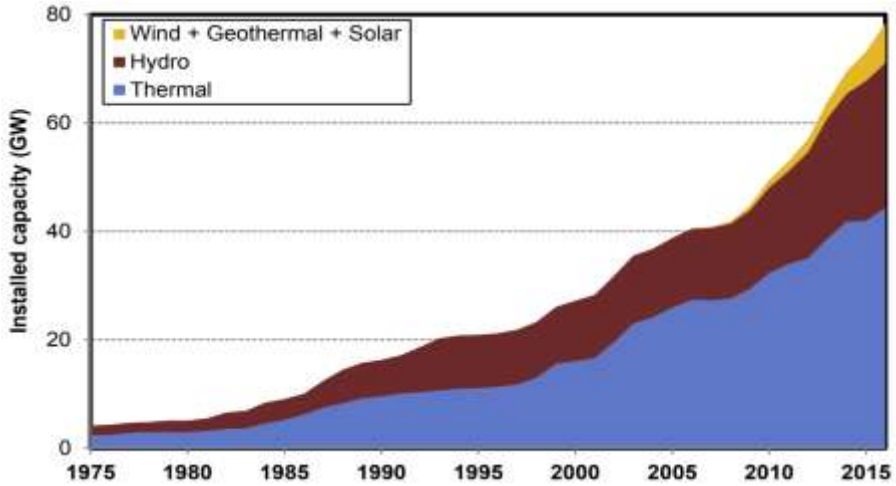

Figure 13. Turkey's capacity to generate different clean energies [73]

They should look at the advantages and disadvantages of a dam and should have a long lifetime. For example, in Turkey, the hydropower capacity is expanded by 35GW per year (**Figure 13**) [73]. Additionally, civil engineering constructions are investigating to improve the landscape green energy [74].

3.13. Economy

Chein and Hu carried out one of the first studies on the relationship between renewable energy and economic development [75] when they said that increased renewable energy is linked to increased economic performance, whereas amplified consumption of conventional energy sources leads to diminished total economic adeptness. The role of expanding use of renewable energy In developing countries has been analyzed through data collected from 1991 to 2012 by Paramati, Sinha, and Dogan [76] for both emission of CO2 and economic activities, they were concluded that the increasing clean renewable energy has a positive effect on increasing economic activities and reducing CO2 emission to the environment. thus, they promoted using more renewable energy in the current network system to increase economic growth and to keep the environment clean. Correspondingly, the same idea is adopted by Bulut and Muratoglu [77]. They considered the effect of using renewable energy on GDP for Turkey for the years 1990 to 2015. Also, they stated that renewable energy did not have a significant impact on GDP. Ocal and Aslan conducted a study that has analyzed the same idea for Turkey, the study revealed that the relation between renewable energy and economic growth is unidirectional, while negative relation indicated by the autoregressive distributive lag (ARDL) test between renewable energy and economic growth [78], while in another study of energy consumption in Pakistan, it is observed that energy consumption and economic development have a bidirectional causal relationship; meantime, using conventional energy leads to environmental degradation [79]. In Eurasia countries, the relationship between both economic growth and renewable energy has been analyzed from 1992 to 2007 by Ref. [80]. authors used heterogeneous panel cointegration test for analysis, the results show that there is a long-term equilibrium between real GDP, consumption of renewable energy, labor, and capital formation. For long and short-term periods there was bidirectional cooperation between consumption of renewable energy and economic growth that indicated by the error correction model. The availability of a large amount of biogas in developing countries which is an important component of renewable energy can improve the established biogas capacity to optimize their supply in the mixing of energy [81]. The result of another study [80] conducted on the Middle East/North Africa (MENA) and net oil-importing countries show that there is a bi-directional relationship between economic growth and consumption of renewable and nonrenewable energy as well as between both kinds of energy source. The results show that both renewable and non-renewable energy sources are crucial for economic growth. A study on Sub-Saharan Africa for the period of 1980–2012 was conducted by

Ref. [82] to show the relation between energy sources and economic growth, results show that there is a long-term association among variables. both kinds of energy sources have been shown to be important for economic growth, while non-renewable resources are economically more significant. Significantly, it was also found that democratic states have more economic development than autocratic states. each of the regime types, political stability, and democracy have critical roles in the economic development of a country. To indicate the fluctuations of economic development, the role of regime type and energy usage along with trade openness has been analyzed by Adams et al. [82] from data obtained from 16 Sub-Saharan countries, they realized that democracy has a positive relationship between economic development and energy usage. A study on 30 Sub-Saharan countries for the period of 1980–2012 was conducted by Ref. [83] to show the impact of both kinds of energy sources for regime type on economic development. The results of different analyses show a long-term relationship among variables and the growth rate of autocratic states is less than in democratic states. Hence, most prior researches have been conducted piecemeal and the role of institutional stability in economic development has not been examined.

3.14. Environment

Since the Late 20th century, technology has been developed steadily that has provided a more comfortable lifestyle for people, but they had negative impacts on the environment such as emitting greenhouse gases (GHG). Fossil fuel is the main source of emissions of GHG to the environment, it is mainly used in transportation, agriculture production, and electricity generation, etc.

Figure 14 shows the emissions of global GHG from various sectors in 2010 [84]. Non-renewable resources are responsible for emissions of an important part of GHG to the environment [85]. Also, global warming, which is caused by the emission of GHG to the environment may lead to raising the level of oceans, changing patterns of precipitation [86]. It is reported that 25% of the GHG of the world emitted from heat production and electricity generation [84], these gases make negative environmental impacts that push policymakers and researchers to pay special attention to renewable energy development.

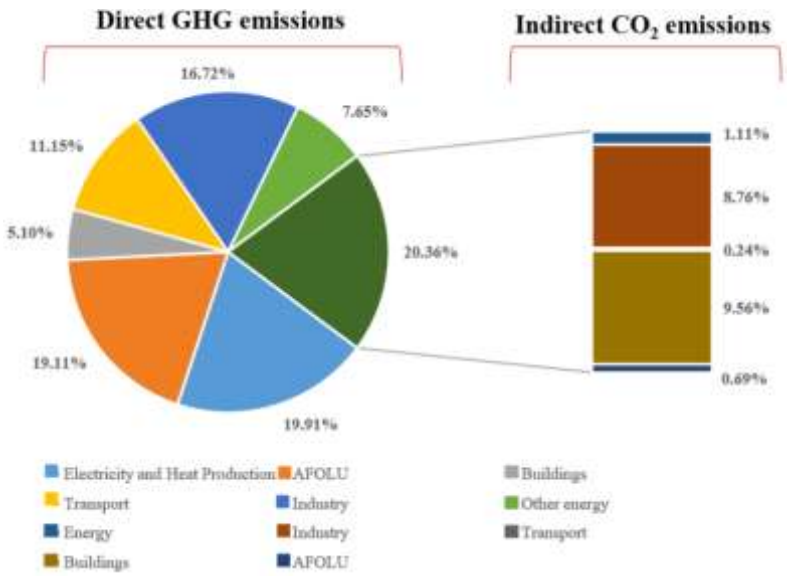

Figure 14. Total man-made emission of greenhouse gases (GHG) from commercial sectors in 2010. Reference [84]

Generally, most of the studies confirm that renewable energy has negative impacts on GHG emissions [87-96]. while there are just some studies that mention the positive impact of renewable energy on emissions [77, 97-99]. Few bodies of the literature also report the non-significant impact

of renewable energy on emissions [100]. Reducing emissions from the use of non-renewable energy can protect the environment from further degradation.

4. Conclusion

In this study, the fast development of renewable energies compared to fossil fuel energies has been reviewed. Global warming due to increasing exhausted gases from vehicles and industries has attracted public attention in different areas. Also, this issue has been investigated by most countries and some international organizations and laws have been enacted to control it. To restrain a different kind of renewable energies, significant steps have been taken in the world. Turkey as a developing country has also taken steps in this regard, which has been addressed in this article. Additionally, based on different categories highlighted by Web of Science and Scopus, this study tried to review the clean energies in different scientific research perspectives. Furthermore, the potential for harnessing renewable energies and economic achievements have been assessed. As a result, significant developments that have been achieved in this field, particularly by governments, foreign organizations, and advanced private companies have been mentioned. In conclusion, this article contributes significantly to the literature as it collects and examines many different sources of renewable energy and highlights opportunities for scientists and investors.

Authors' Contributions

MK introduced the main idea and supervised the project. MSK literature review. INQ collected data and plotted. M. N. QADIR reviewed and write the economic and environmental parts. MSK, INQ and MNQ wrote the manuscript.

All authors read and approved the final manuscript.

Competing Interests

The authors declare that they have no competing interests.

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