



Investing in renewable energy worldwide and its contribution to achieve sustainable development

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Abstract :

This research paper aims to assess the volume of global investments and production in the field of renewable energy, highlight its contribution to achieve the sustainable development goals, using a descriptive analytical approach. The study concludes that most major economic developed countries are investing heavily in the developing and the exploitation renewable energy, unlike developing countries which have not shown much interest in this field. However, statistics on renewable energy production and investment have witnessed a significant increase over the past twenty years, which bodes well for a reassuring future in the field of exploiting environmentally friendly energies. It also demonstrates that investments in renewable energy play a vital role in achieve sustainable development goals, given its contribution to economic, environmental and social aspects. Despite the many benefits, this technology faces environmental and economic challenges that must be addressed to ensure the desired goals are achieved.

Key Words: Renewable Energy; Exploitation of Renewable Energy; Environmental Sustainability ; Global investments; Sustainable Development goals.

JEL Classification : Q42,Q01,O13.

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Introduction :

The world today faces numerous and growing environmental challenges, most notably climate change and the scarcity and depletion of natural resources. The situation is further exacerbated by the growing reliance on fossil fuels and hydrocarbons. This calls for an urgent transition to renewable energy sources and the harnessing of all available resources to invest in them, ensuring environmental safety and preserving natural resources for future generations.

The study prompts us to answer the following question : What is the extent of global investments in renewable energy, and how does it contribute to achieve sustainable development goals ?



To answer this problem, three hypotheses were proposed. The first hypothesis is that there is a steady increase in the volume of global investments in the field of renewable energy. The second indicates that developed countries represent the largest proportion of global investments in this field. The third hypothesis is that investment in renewable energy contributes to achieve sustainable development goals through its impact on economic, social, and environmental aspects.

The importance of the study lies in identifying the size of global investments and production in the field of renewable energy and the extent of their contribution to achieve the Sustainable Development Goals (SDGs). These investments play a pivotal role in providing clean energy, strengthening the economy, and improve the standard of living for countries. A descriptive-analytical approach was used, in addition to conducting a comprehensive survey of various scientific data and sources, include reports issued by international and regional agencies. Among the general objectives of this study is to assess the size of global investments and global production in the field of renewable energy and highlight their contribution to achieve the SDGs. The study was divided into three main axes : the first axis addresses the theoretical framework of sustainable development, including the definition and most important SDGs. The second axis focuses on the theoretical framework of renewable energy, including the definition and various types of renewable energy.

The third axis addresses global investments in renewable energy and its contribution to achieve the SDGs. Global investments and production in this field were reviewed, along with their contribution to achieve the SDGs through three aspects : economic, environmental, and social.

I. Theoretical framework for sustainable development :

This section presents the definition of sustainable development and its most important goals.

1. Definition of sustainable development :

The definition of sustainable development contained in the Brundtland Commission report The Brundtland principle, published by the World Commission on Environment and Development (WCED) in 1987, is the most widely used and well-known, and is defined as development that meets the needs of present generations without compromising the ability of future generations to meet their own needs.(Shebi and Shukri, 2017, p. 51)

It is also known as the United Nations Development Program (UNDP). in its World Human Development Report defines it as a comprehensive process of formulating economic, fiscal, trade, energy, agricultural and industrial policies with the aim of achieve sustainable and balanced development economically, socially and environmentally.(Dr. Kafi, 2016, p. 54)



From the above definitions, it becomes clear that the concept of sustainable development represents a new vision that seeks to improve human quality of life by living within the carrying capacity of ecosystems. The philosophy of sustainable development emphasizes the importance of environmental care as a solid foundation for economic development, as diverse natural resources such as land, minerals, forests, seas, and others form the foundation upon which all industrial and agricultural activities are based. (Dr. Kafi, 2016, p. 56)

2. Sustainable Development Goals :

Sustainable development seeks, through its mechanisms and content, to achieve a set of goals, the most important of which are: (A. Ahmed Salah, et al., 2018)

2.1. Raise population awareness of existing environmental problems:

Sustainable development seeks to raise citizens' awareness of environmental challenges and motivate them to feel responsible for them. This is achieved by encouraging them to actively participate in finding innovative solutions, from proposing and implementing projects to monitoring their outcomes.

2.2. Achieve optimal utilization of resources:

Sustainable development seeks to solve the problem of resource scarcity through the optimal and effective use of available resources, ensuring that future generations have sufficient opportunities to benefit from these resources, thus achieving justice between current and future generations.

2.3. Activate modern technology and linking it to community goals:

Sustainable development relies heavily on modern technology and constantly seeks to develop its uses to achieve societal goals. This is achieved by educating citizens about the importance of various technologies in development and how to use available and new technologies to improve the quality of life for society and achieve its desired goals, while ensuring that any negative environmental risks are avoided.

2.4. Improve quality of life:

Sustainable development is achieved through several integrated and balanced factors, all of which aim to improve the quality of life for individuals and communities at all levels. These include : providing quality education for all, ensuring comprehensive healthcare, equitable distribution of wealth and income, establishing a strong social security system, promoting culture, building just and sound human relations that respect fundamental rights, providing equal opportunities for participation in society, achieving a peaceful transfer of power, and freedom from any form of slavery or subordination. Furthermore, it seeks to liberate individuals from the clutches of ignorance, poverty, and disease. (Jaafar and Rahman, 2019, p. 17).



II. Theoretical framework for renewable energy :

In this section, we will discuss the definition of renewable energy, its different types, and its relationship to sustainable development:

1. Definition of renewable energy :

There is little disagreement about the definition of renewable energy, but there is widespread agreement on its sources. The International Agency for International Development (IEA) defines renewable energy as : energy derived from natural processes that is replenished at a rate faster than it is consumed. Common examples of renewable energy include solar, wind, geothermal, and hydroelectric power.(Harjanne & Korhonen, 2019, p. 335)

It was defined by the United Nations Environment Program (UNEP) as : energy that comes from a fixed and limited supply of natural resources and is periodically renewed at a rate faster than it is consumed. This energy appears in five main forms : biomass, solar radiation, wind, hydropower, and geothermal energy. (Elias Elhannani, 2023, pp. 447-448)

The Intergovernmental Panel on Climate Change (IPCC) recognized that Renewable energy is defined as any energy sourced from the sun, geophysics, or biology that is naturally replenished at a rate equal to or greater than its use. This includes energy from natural sources such as biomass, solar, geothermal, hydropower, ocean tidal, and wind. Various mechanisms exist to convert these sources into primary energy sources such as heat and electricity, and then into kinetic energy using various technologies that provide various energy services such as fuel and electricity.(Zawiya, 2014, p. 123).

2. Types of renewable energy :

There are several types of renewable energy, produced from different sources, the most important of which are the following:

2.1. Solar energy:

Solar energy harnesses sunlight using photovoltaic cells (PV), or solar thermal systems. Photovoltaic cells convert sunlight directly into electricity, while solar thermal systems rely on the sun's heat to generate steam, which drives turbines to produce electricity. This energy is one of the most abundant and widespread renewable resources, and its ability to scale from small rooftop installations to large-scale solar farms makes it versatile for a variety of applications. (Agbakwuru, Ofuje Obidi, Segun Salihu, & Chinelo MaryJane, 2024, p. 15).

2.2. Wind energy:

Wind energy is a very simple process. Wind turbines convert the kinetic energy of the wind into mechanical energy, which is used to generate electricity. The energy is fed through a generator, converted back into electrical energy, and then fed into the grid for transmission to a power plant. (Mohtasham, 2015, p. 1292)



Wind energy has great potential as a global source of clean energy. It is widely available and produces no pollution during power generation. (Herzog, Lipman, & Kammen, p. 25).

2.3. Hydroelectric power

It is a clean and renewable energy source. Given the economic, technical, and environmental benefits of hydropower, most countries prioritize its development. (Mohtasham, 2015, p. 1291)

The process of exploiting this energy relies entirely on the potential energy in water, converting it into kinetic energy through the falling water and its flow from top to bottom, which drives the generating turbines. The generator then begins to rotate, thus producing electrical energy.

(Official website of the Ministry of Energy and Water, Hydropower, 2025).

2.4. Bioenergy:

This energy is produced from a variety of biomass sources, including forest residues, agriculture, livestock, short-cycle forest plantations, energy crops, the organic component of municipal solid waste, and other organic waste streams. These raw materials can be used in several different ways directly to produce electricity or heat, or they can be used to create gaseous, liquid, or solid fuels. (Edenhofer, et al., 2011, p. 8)

2.5. Geothermal energy:

Geothermal energy is used to extract energy from the soil for heating or electricity generation. Heat is primarily transferred from the Earth's surface to its interior, where temperature varies with depth. This temperature is primarily generated by radioactive activity. Obtaining this energy requires geological components within the Earth's interior that contain pores and permeability, as well as layers of aquifers (ground layers containing water or water vapor). (Yousfi, 2023, p. 66).

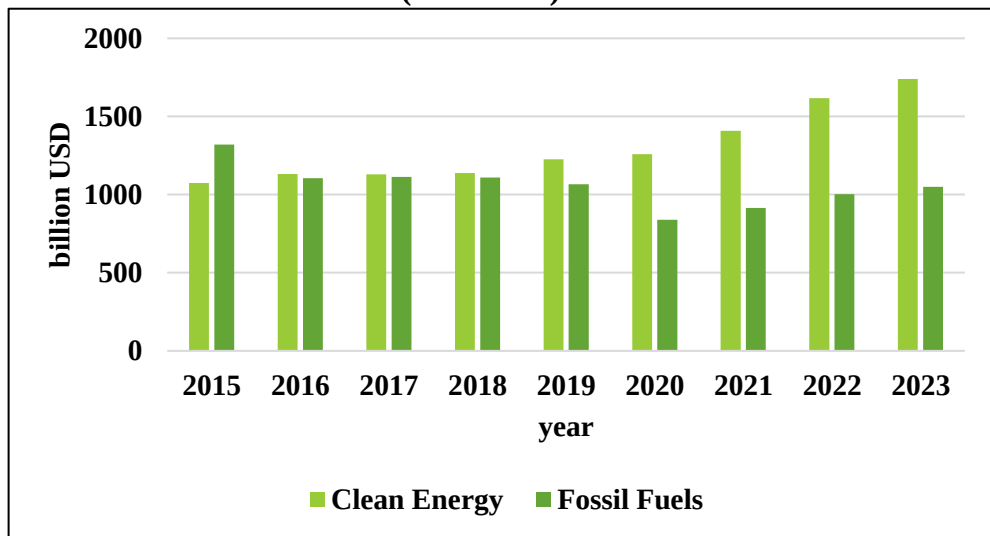


III. Investing in renewable energy worldwide and its contribution to achieve sustainable development :

1. Investing in renewable energy worldwide :

1.1. Global investment in renewable energy and fossil fuels :

Fig. 1 : « Global investment in clean energy and fossil fuels during the period (2015-2023) »



Source : Statistical data of World Energy last updated 22 May 2023
<https://www.iea.org/data-and-statistics/charts/global-energy-investment-in-clean-energy-and-in-fossil-fuels-2015-2023>

The figure above shows the volume of global investments in both the renewable energy and fossil fuel sectors during the period from 2015 to 2023, according to the International Energy Organization. We note from the graph that there has been an increase in the percentage of investment in clean energy at the expense of fossil energy during the nine years.

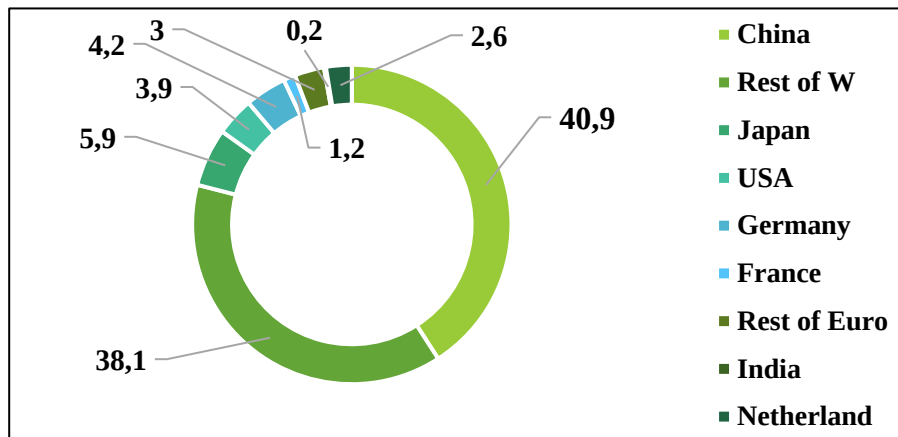
This reflects the new international trend aimed at exploiting clean energy, which has proven its effectiveness in practice. The volume of investment in renewable energy in 2023 reached approximately 1,740 billion US dollars. On the other hand, we note that although the figures for investments in fossil fuels are lower than investments in renewable energy, the volume of these investments remains high, as the volume of investments reached 1,050 billion US dollars in 2023, which advocates of reliance on renewable energy aspire to reduce over the next ten years in order to optimally exploit resources.

1.2. International production of renewable energy by source :

The following set of graphs represents the percentage of international renewable energy production by source:

a. Solar energy :

The following figure represents the percentage of solar energy production at the international level:

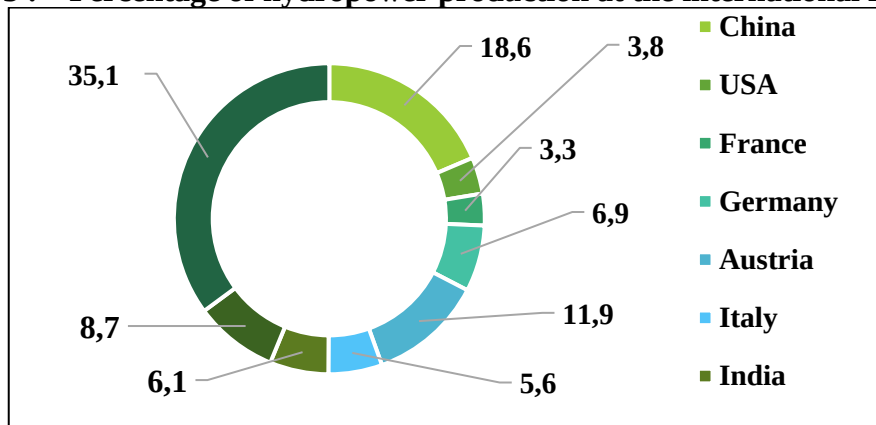
**Fig. 2 : « Percentage of solar energy production globally »**

Source : Renewable Energy and Jobs Annual Review 2022 page 17

We note from the graph that China is superior in the field of solar energy production, as the percentage of Chinese production reached 40.9% of international production, followed by Germany with 5.9%, with a capacity percentage of 49.5% for various countries of the world during the year 2022, according to the International Renewable Energy Agency.IRENA.

b. Hydropower :

The following figure represents the percentage of hydropower production at the international level:

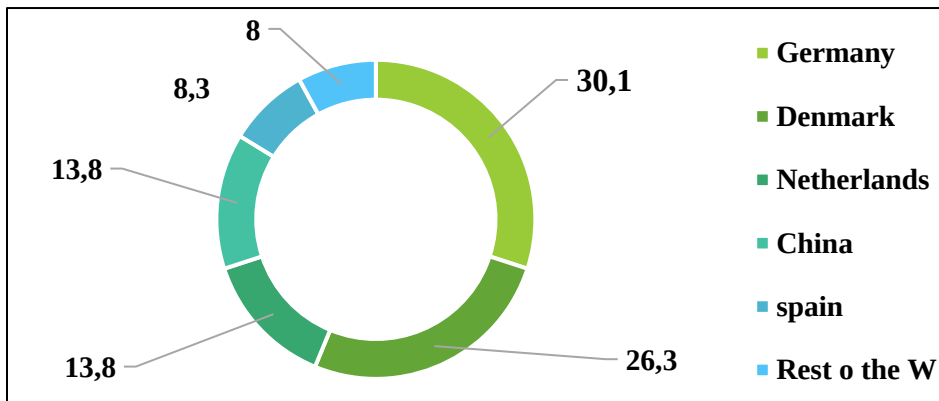
Fig. 3 : « Percentage of hydropower production at the international level »

Source : Renewable Energy and Jobs, IRENA Annual Review 2022 page 23

We note from the graph that China leads in this aspect of production, as China's production rate in this field reached 18.6%, followed by Austria 11.9%, Germany 6.9%, India 6.1%, Italy 5.6%, the United States 3.8%, and France 3.3%, then the rest of the world with 35.1%, according to the International Renewable Energy Agency for the year 2022.

c. Wind energy :

The following figure represents the percentage of wind energy production at the international level.

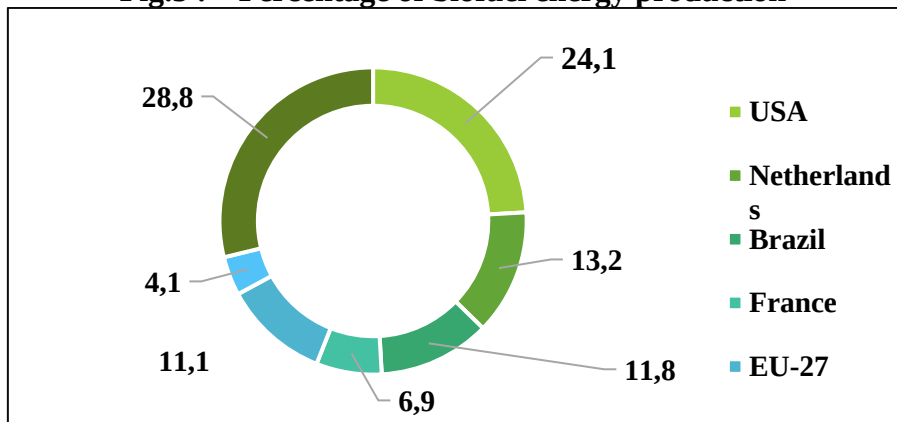
**Fig. 4 : « Percentage of wind energy production globally »**

Source : Renewable Energy and Jobs, IRENA Annual Review 2022 page 2

We note from the graph that Germany leads in the field of wind energy exploitation with a percentage estimated at 30.1%, followed by Denmark with 26.3%, China and the Netherlands with equal percentages of 13.8%, Spain with 8.3%, and the world countries share a percentage of 8%.

d. Organic energy :

The following figure represents the percentage of biofuel energy production at the international level:

Fig.5 : « Percentage of biofuel energy production »

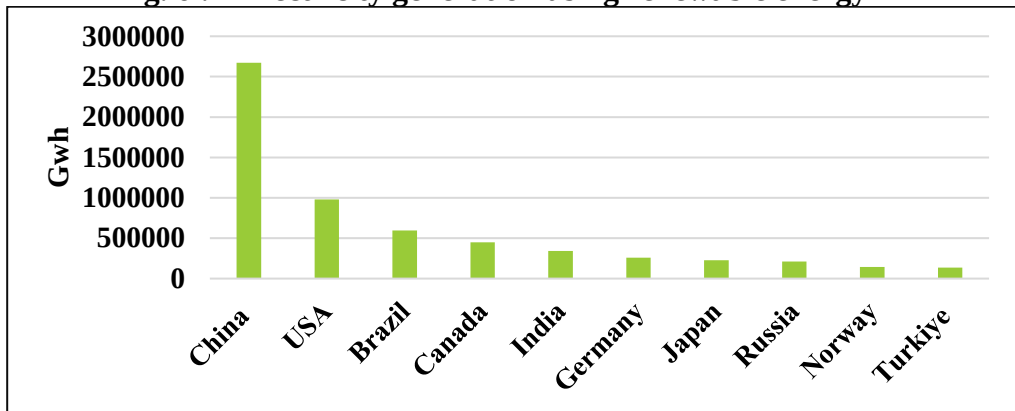
Source : Renewable Energy and Jobs, IRENA Annual Review 2022 p25

We notice from the graph the dominance of the United States. The production rate was estimated at 24.1%, followed by the Netherlands at 13.2%, Brazil at 11.8%, France at 6.9%, Germany at 4.1%, and the rest of the European Union countries at 11.1%. The rest of the world countries also contributed 28.8%, according to the International Renewable Energy Agency for the year 2022.



1.3. Generating electricity using renewable energy :

Fig. 6 : « Electricity generation using renewable energy »



Source: <https://www.irena.org/Data/View-data-by-topic/Capacity-and-Generation/Country-Rankings>

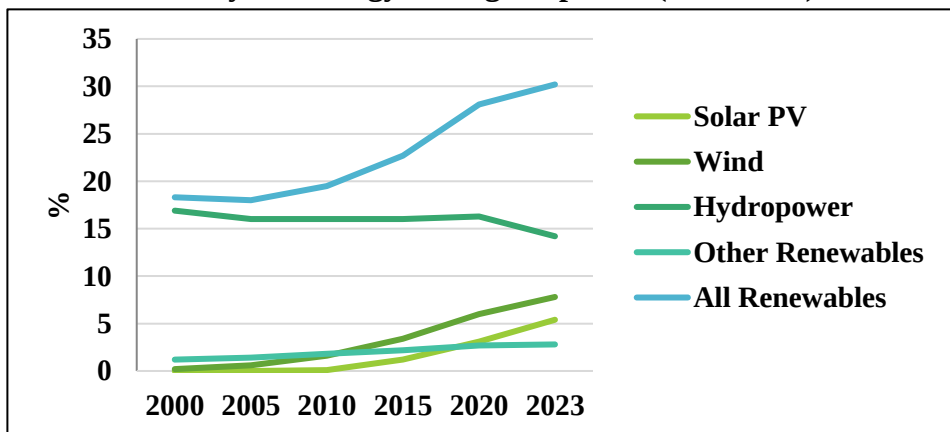
The following chart represents the ranking of countries in the world in terms of electricity generation using various renewable energy sources (solar energy, wind energy, hydropower, and biofuels) for the year 2022.

The figure shows that China is the world's largest renewable energy producer, with a production capacity of 2,673,556 gigawatts in 2022, followed by the United States (GW), Brazil (594,028.3 GW), Canada (449,377 GW), India (343,198 GW), and Germany (449,377 GW). 981,697 GW, 257,038 GW, Japan 227,629 GW, Russia 210,476.6 GW, Norway 144,587.3 GW, and Turkey 137,830 GW.

The volume of electrical energy production based on renewable energy at the international level reached an estimated figure of 8,335,542 gigawatts during the year 2022, according to the International Renewable Energy Agency (IRENA).

1.4. Generating electricity from various renewable energy sources according to technology :

Fig. 7 : « Share of electricity generation from various renewable energy sources by technology during the period (2000-2023) »



Source : International Energy Agency Chart 18 Dec 2023 <https://www.iea.org/data-and-statistics/charts/share-of-renewable-electricity-generation-by-technology-2000-2028>



Generation methods include extracting clean, renewable energy from a variety of sources, such as fossil fuels, solar energy, wind energy, and hydropower. The following chart represents the contribution of each of these sources to electricity generation during the period from 2000 to 2023.

The graph shows an increase in the exploitation of energy production sources over the period, but at varying rates for each source. The most exploited source for electricity production is hydroelectric power, followed by wind and solar energy, in addition to other renewable energy sources such as fossil fuel energy, according to the International Renewable Energy Agency.

2. Contribution of renewable energy investment to achieve sustainable development goals :

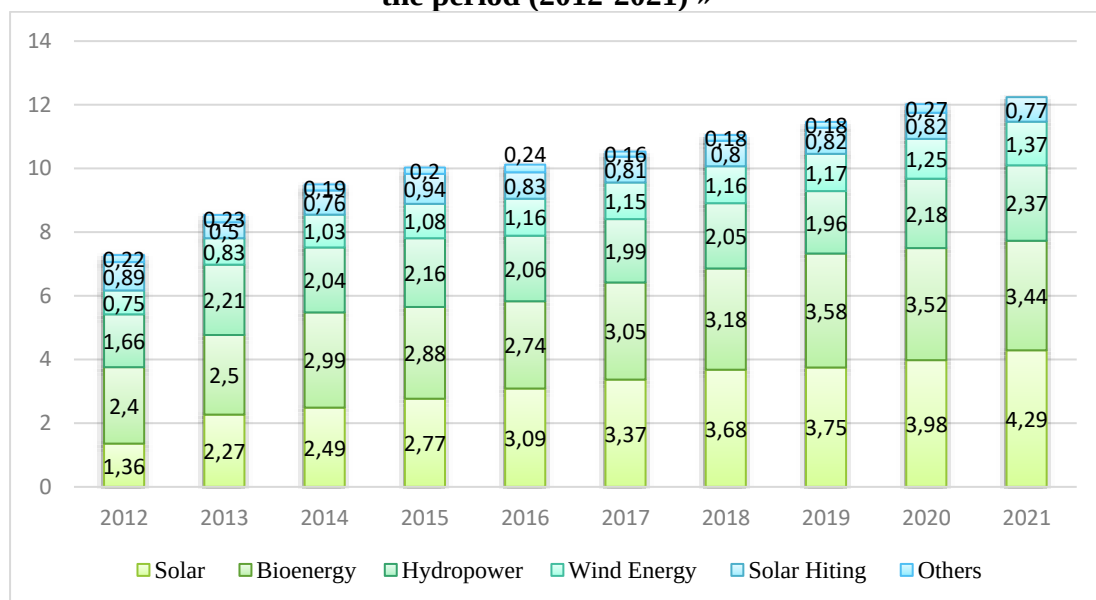
This role has three main aspects :

2.1. Economic aspect :

It contributes to the creation of new labor markets, as the number of workers in various renewable energy industries was estimated at approximately 12.7 million in 2021, according to the International Renewable Energy Agency. Chart No. (8) shows the number of job positions according to each sector of renewable energy production worldwide during the period extending from 2012 to 2021.

This figure shows an increase in the number of workers across all renewable energy production sectors (solar, wind, hydro, and biofuels). The solar power generation sector accounted for the largest number of jobs, estimated at 4.29 million workers in 2021, followed by the biomass energy sector, which employed 3.44 million employees. The hydropower generation sector also accounted for a labor market share estimated at 2.37 million workers in 2021, in addition to other renewable energy sources that provided approximately 2.14 million permanent jobs.

Fig. 8 : « Evolution of renewable energy use worldwide by technology during the period (2012-2021) »



Source : Renewable Energy and Jobs Annual Review 2012-2021



2.2. Environmental aspect :

Renewable energy contributes significantly to reducing greenhouse gas emissions, which harm animals and plants and contribute to climate change, resulting from the use of fossil fuels. (Ruojué & Jingzheng, 2020, p. 4).

Global efforts to combat climate change are accelerating, driven by the growing commitment of governments and communities to building a sustainable future. This commitment is manifested in the adoption of net-zero emissions targets. In 2021, more than 1,100 local, regional, and national governments announced their commitments to net-zero emissions goals, and many cities joined global initiatives such as the Race to Net Zero. As a result of these pledges, nearly 1 billion people were living in cities with net-zero targets by the end of 2021.

Geographically, cities' net-zero emissions goals were most prevalent in Europe, followed by Latin America and the Caribbean, then East Asia and North America. These efforts reflect the global shift toward renewable energy, contributing to a more sustainable and environmentally friendly future. (Renewables Global Status Report p212)

2.3. Social aspect :

Renewable energy technologies improve access to modern energy services, especially for marginalized communities. This access is critical for meeting basic needs such as education, healthcare, and economic opportunities, thereby contributing to poverty alleviation and improving quality of life. (Sathaye, et al., 2011, p. 716) (Aboul-Atta & Hamed Rashed, 2021, p. 2) Switching to renewable energy reduces air pollution caused by traditional fossil fuels, leading to better public health outcomes. Cleaner air can reduce respiratory diseases and other pollution-related health problems, supporting the overall well-being of communities. (Culley, Maier, Zecchin, & Tian, 2024, p. 5).

Conclusion :

Based on the above, the study concluded that the volume of investment in renewable energy has witnessed a significant increase over the past seven years. This reflects global interest in this field with the goal of achieving its full exploitation in the future, unlike hydrocarbons, where investment volume has been shown to be stagnant, indicating the general international trend of reluctance and perhaps even abandonment of this energy source in the near future, especially in developed countries.

It also shows that developed countries are the largest producers and exploiters of alternative and renewable energy from various sources, whether solar energy, wind energy, biofuels, or hydropower. In contrast, less developed countries suffer from their absence from the top positions in this field. We conclude from this that the relationship between the exploitation of renewable energy and growth is a direct relationship, meaning that the more developed a country is, the easier it becomes to aspire to exploit renewable energy. This is due to its financial, economic, and scientific capabilities, which enable it to understand and recognize the various dimensions of renewable energy and overcome all challenges that may hinder its



path to optimal exploitation of clean and environmentally friendly resources. We also intuitively conclude that the slow growth of some countries, their economic backwardness, financial poverty, regulatory obstacles, poor management, and lack of a clear vision regarding methods for exploiting renewable energy may be among the most prominent challenges facing them in achieving optimal exploitation of environmentally sound energies that can achieve sustainable development.

The study also concluded that renewable energy contributes to achieve the Sustainable Development Goals through its impact on economic, environmental, and social aspects. Economically, it contributes to the creation of new job opportunities, with global employment in various renewable energy industries estimated at approximately 12.7 million jobs in 2021.

The solar power generation sector accounted for the largest number of jobs, followed by the biomass energy sector, which enhances the economic growth of countries. Environmentally, it contributes to reduce carbon emissions and protect the environment, thanks to its status as a clean alternative to fossil fuels. Socially, it contributes to improve access to clean energy, which reduces poverty and breaks the isolation of remote areas, thus supporting the well-being of communities. Despite its numerous benefits, this technology faces environmental and economic challenges that must be addressed to ensure the achievement of the desired goals.

Therefore, each country should develop incentive policies that include a range of tax incentives, financial support, and regulatory facilitations to effectively attract investors in the renewable energy sector. It is also essential to enhance international cooperation in the areas of technology and research and development, enabling developing countries to benefit from the successful experiences of developed countries in the field of renewable energy.



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