

The contribution of applying scientific research in the development of renewable energy globally

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Abstract: Our study aims to clarify the role of scientific research in the development of the renewable energy sector. Scientific research is considered a crucial element for acquiring and advancing technologies, innovating in knowledge development, improving energy efficiency and effectiveness, and developing various technologies related to renewable energy sources, In our study, we relied on the descriptive and analytical approach.

We have found from our study that the development of renewable energy technologies cannot occur without sufficient investment in scientific research and collaboration between universities, research centers, and sectors of production. Our study has shown that the economic situation of Arab countries, where the expenditure on scientific research does not exceed 1% of the total GDP, is weak. In contrast, advanced countries like the United States, China, and others have strong economic positions due to their focus on research and development, allocating a larger percentage of their expenditure to it.

Keywords: Scientific research; development; renewable energy; globally.

JEL codes: Q03; Q56; O13; N05.

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I- Introduction:

The world has been shaken by various crises (water crisis, food crisis, climate change, energy crisis, in addition to the repercussions of using traditional energy sources, as well as, wasting natural resources, and the increasing of poverty rates, etc...). These crises have encouraged the search for new ways to overcome this, because the world needs to transcend and adopt the modern economic model instead of the traditional one, in order to reduce risks and crises. To achieve this, the world must increase interest in renewable energies.

However, this inclination in itself is considered an important challenge for the economies of the world's powerful countries, as well as developing countries, given its lack of investment in this field (renewable energy). Therefore, governments, in cooperation with the private sector, must support this inclination, by embracing a set of policies and systems, through which they ensure instigating the role of universities and scientific research centers related to the field of expanding investment in renewable energy.

The renewable energy sector requires overcoming all the challenges that impede its growth and development, and this can only be achieved through scientific research that reveals scientific facts and

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verifies the findings of specialized researchers in various scientific fields. Thanks to the postgraduate studies systems in universities, successive generations of researchers are being qualified in multiple specialties. Their skills must be taken advantage of to serve the community in order to meet the requirements of economic development.

Despite the importance of scientific research in universities and specialized research centers, it is still confronted with a lot of obstacles impeding it from achieving its effective role in serving both societal and economic matters, especially weak spending and lack of assimilation among key components of research.

Our study shows that Arab countries spend the least on research and development in the world, and that their spending level is still below the average rate of the global level, as it does not exceed 1% of the GDP, with the exception of the UAE and Kuwait. It also demonstrates the non-participation of the private sector in financing except with very small percentages, not exceeding 3%. In this case, these countries must reconstruct an economy based on innovation and knowledge, because they are the safest guarantee to avoid various crises.

To provide an insight into the topic, we proposed the following problematic: Does scientific research contribute to the development of the renewable energy sector at the global level?

Our study aims to explore the concepts related to scientific research, renewable energies, and demarcating the relationship between the two through clarifying the role of scientific research in developing the renewable energy sector. It also explains the extent of the latter's contribution in achieving economic and social growth in light of the modern economic tendency which aims to achieve sustainability. This study also intends to identify the most significant obstacles and challenges that affect the two variables, namely the reasons behind the lack of contribution of scientific research and research centers in solving societal problems.

II- Background of the study:

1- The concept of renewable energy:

Renewable energy has many definitions, including the following: Renewable energy is that which grows or increases over time, whose current consumption rate does not affect its production rate in the future, and its reserves remain persistent, such as: solar energy, wind energy, geothermal heat, biomass energy, and the ocean waves, or hydropower electricity (Al-sheikh, 2007, p. 69).

It is also defined as: the naturally and sustainably generated resources. It is characterized by being inexhaustible and available in nature unlimitedly, yet sometimes limitedly but constantly renewed. In addition to being a clean source of energy, using it does not cause any environmental pollution. These sources include: solar energy, which is the main source of energy on Earth, as well as wind energy, tidal energy (resulting from gravitational forces between the Earth, the moon, and the sun), wave energy, thermal gradient energy in ocean waters, geothermal energy, and hydrothermal energy. (Al-jabouri & Al-jabouri, 2010, p. 28).

Although renewable energy seems to be a relatively new technology, it has been known to humanity for centuries, below are some of the most famous examples of the history related to it:(boris, 2023)

- The emergence of windmills in the Netherlands during the late sixteenth century.
- The first solar farm was built in France in 1860.
- In 1876, electricity was produced from solar energy for the first time in London.

- By the end of the nineteenth century and the beginning of the twentieth century, some wind turbines were built in Europe to generate electricity.
- In 1927, the first sale of wind turbines for a group of American farmers took place.
- In 1978, the first fully solar-powered village appeared in Tohono O'odham, Arizona.
- In 1996, the SOLAR Project was launched in the United States of America, comprising 3 solar power plants, and which allow energy to be stored for longer periods of time.

Therefore, we note that renewable energy has come a long way and continues to grow in the present day, thanks the findings of scientific research.

2- Directing scientific research, and its disruptive factors.

2.1 Definition of scientific research:

Scientific research has several definitions, Scientific research is defined as an organized endeavor in a specific field aimed at discovering facts and principles (Ben Moursli, 2010, p. 12) It is also defined as a group of organized efforts carried out by individuals following the scientific process and the rules of the scientific method in their endeavors to increase control over their environment, discovering its phenomena, and identifying the relationships between these phenomena (Sadek Ismail, 2014, p. 33). Therefore, scientific research is an organized intellectual process conducted by a person called (a researcher), in order to investigate facts regarding a specific issue or problem called (research topic), following an organized scientific method called (research methodology), with the aim of reaching appropriate treatment solutions or results that can be generalized to similar issues or problems, which are called (research results/ findings) (khoudr, 1992, p. 17)

2.2 The Importance of Directing Scientific Research:

Its importance is manifested as follows: The university is the biggest supplier for scientific research institutions with qualified human capital capable of doing scientific work. The university will be unable to meet the needs of scientific institutions, if it is not closely linked to them. This requires a scientific policy that makes the university well aware of the needs of the production and services sectors, and also makes these sectors mindful of the university's competences in serving them (Barbaoui, Slimani, Nechachda, & Bechar, 2018).

2.2.1. Concerning Renewable Energies:

The importance of scientific research is demonstrated as follows: (Deutsche, 2010)

- The importance of scientific research in the field of renewable energies is thought to be an essential investment in the future. Hence, it is not advisable to use only modern means to produce energy; instead, it is necessary to contribute to the development of these means, their forms, and their invention.
- The importance of looking to the future in light of the global economic and financial crisis, because those who would emerge powerful from this crisis are the ones who shall create new focal points in the fields of research and development, and this will only be achieved by increasing allocations for scientific research.

2.2.2. Concerning Sustainable Development:

The importance of scientific research is identified as follows: (Barbaoui, Slimani, Nechachda, & Bechar, 2018).

- Conducting research that aims to preserve and improve the natural resource base, create more alternative energies, and harness scientific research to make alternative strategies for exploiting resources.
- Conducting the most urgent research at the local and international levels related to sustainable development.
- Offering training in magister, master and doctoral programs in the topics of sustainable and environmental development.
- Conducting research on climate adaptation strategies, and on analyzing the impact of human and economic risks on the environment.
- Conducting research in the fields of electricity generation, energy, building and construction materials, water, sustainable transportation, preventing pollution, and climate change.
- Conducting research that provides solutions to climate change risks.
- Establishing research centers concerned with sustainable development.
- Searching for new materials to replace existing materials, making changes in new devices to increase product efficiency and reduce material consumption, decreasing demand for non-renewable resources, and new energy storing methods for future generations.

2.2.3. Concerning Knowledge Production:

The importance of scientific research is manifested in that it is the main tool for producing knowledge and delving deeper into it. Universities are the institutions most competent of achieving this given that they comprise of high and specialized scientific competencies, and thus they pay special attention to it. The researches carried out by universities throughout history have had a great impact in the fields of industry, agriculture, and various aspects of life. Despite the fact that a large number of research centers have been established independently from the university, the university's researches remain vastly more important and more rigorous than other researches (Eldaradji & Bin AL-Cheikh, 2018).

2.3. Components of Scientific Research:

It is a system with four chief components (BasIouni, April 2020, pp. 22-23), an administration represented by the Ministry of Higher Education and the Academy of Scientific Research which is interested in the development and modernization of graduate studies programs through formulating policies that serve society, keep pace with contemporary developments and changes, and encourage creativity and innovation; the second is the human resources (the human element), and providing the appropriate atmosphere to increase their ability to create and innovate via training and qualification. The third element is financing (whether funding provided by the government, the private sector, or the productive institutions and companies, or grants and donations). Finally, the entities that benefit from scientific research are the productive sectors (agriculture, industry and commerce) which receive the findings of the research process and they stimulate that system with new research problems.

In order for this system to achieve the greatest benefit possible, it must operate within a suitable atmosphere and environment, and understand the nature and importance of scientific research and scientists. Scientific research is invaluable if it is not employed to serve the country and the society in which it exists. If this system is accomplished, scientific research can advance and contribute in the growth of the country's economy whose goal is to achieve the transition into the investment in clean (renewable) energies, and thus, achieve sustainable development.

These components are possessed by the developed countries as a result of their awareness of the significance of scientific research in the development of nations, their untiring efforts to advance this system, develop the scientific and intellectual capabilities of its offspring, and introduce radical changes to its educational programs and administrative, economic and social systems, in order to maximize the benefit of scientific research in all fields (Baslouni, April 2020, p. 23). However, these key components are lacking in the field of scientific research in the Arab countries because there is no clear strategy, which is concerned with developing and updating training programs for postgraduate studies, keeps up with modern developments and encourages creativity and innovation. There is, also, no independent budget for scientific research. Additionally, most scientific institutions lack specialized equipment to market research and its results, and to transform them into economic projects with added value according to an economic plan to the beneficiaries. This indicates weak coordination between research centers and the private sector, which has been reflected in the weak contributions of scientific research in sustainable development in the Arab countries. (Baslouni, April 2020, p. 23)

2.4 Disruptive Factors Affecting Scientific Research:

Disruptive factors refer to all factors that have a negative impact on scientific research, among these factors:

2.4.1 The Number of Researchers (lack of researchers):

The number of researchers is determined by the number of researchers working in the field of research and development per million people. The number of researchers in the Arab world was estimated at about 318 researchers, including university professors, per million people, compared to 3600 researchers per million people in developed countries in 2012. (Boloudoni, BElouahem, & Bedda, 2018, p. 226). The results on Table 2 Shows that the number of researchers in the United States of America reached 4821.23, Britain 4683.77, Germany 5393.15, France 4926.19, and Korea 8713.59 researchers per million people. We also notice that the number of Arab researchers is very small in comparison with developed countries, for instance, in the UAE the number of researchers is 2442.54 researchers Per million people, this affects scientific productivity in the Arab world negatively.

2.4.2 Scientific Publication:

Scientific publication is an indicator of the status of the research institution working within the framework of the university or as an independent institution. Published research papers are considered among the most important results and findings of research, just like technical expertise. The philosophy of research and development is based on the fact that scientific knowledge is a stock of intellectual experience, and for a work to become part of this stock of knowledge, it must be published and documented, and as a matter of fact, the publication content is subject to quality control through systems determined by scientific journals (Mahmoudi & Hedjazi, January 2022, p. 213)

The number of publications per million people reached 3356 in Britain, 2302 in Germany, 2130 in the United States of America, 1850 in Korea, and 1847 in France. As for the remaining countries, the number of publications is smaller, due to their seriousness and interest in scientific research, and the proof is the lack of spending on scientific research. Table (1) demonstrates that.

Table (1): Expenditures, researchers, and scientific publications in Arab countries and reference countries in 2022

Country	Number/ million inhabitants	Population (million)	Number of posts scientific	Number of researchers/ million inhabitants	Percentage of research and development expenditures out of gross product
Algeria	191	43	8 397	819.34	0.53
Bahrein	676	1.7	1 151	—	—
Comoros	—	0.869	—	—	—
Djibouti	—	0.988	—	—	—
Egypt	309	102	31 582	677.10	0.96
Iraq	479	40	19 250	105.92	0.04
Jordan	662	10.2	6 758	595.96	0.70
Kuwait	586	4.2	2 501	501.57	0.19
Lebanon	668	6.8	709	—	—
Libya	103	6.8	91	—	—
Mauritania	20	4.6	—	—	—
Morocco	274	36.9	10 125	1073.54	—
Oman	543	5.1	2 771	242.41	0.37
Palestine	263	4.8	1 265	—	—
Qatar	1881	2.8	5 419	583.98	0.53
Saudi Arabia	1085	34	37 788	453.15	0.52
Somalia	-	15.8	-	-	-
Sudan	29	43.8	1 273	-	-
Syria	45	17.5	782	90.96	0.02
Tunisia	731	11.8	8 638	1945.52	0.75
UAE	1101	9.8	10 887	2442.54	1.45
Yemen	37	29.8	1 094	-	-
Average/Arab ic number	-	436	-	579.00	0.64
Average/glob al number	-	7 763	-	1215.12	1.93
China	546	1 411	770 825	1584.87	2.40
USA	2130	331	706 000	4821.23	3.45
UK	3356	67	225 108	4683.77	1.71
Germany	2302	83	191 424	5393.15	3.14
France	1847	67	124 460	4926.19	2.35
Korea	1850	51	95 889	8713.59	4.81

Source: (Bin yousef, December 2022, p. 10)

By comparing the results of the two indicators (the number of researchers per million people and the number of scientific publications issued by Arab countries per million people) as shown in Table 1? we notice that there is a discrepancy between the two indicators in some Arab countries, with the exception of Algeria (819.34 researchers per million people, 191 scientific publications per million people), Morocco (1073.54 - 274), Tunisia (1945.52 - 731) and Egypt (309 – 677.1). This discrepancy between the two indicators is explained by counting all university professors as scientific researchers, which may often be unrealistic.

Meanwhile, other countries recorded an inverse discrepancy between the two indicators, as the number of publications per million people was high vis-à-vis the number of researchers per million people. The following statistics were recorded in Iraq (106 researchers - 309 publications), Oman (242.4 - 543) and Qatar (584 - 1881), and Saudi Arabia (453 - 1085), noting that the rate of research and

development expenditures of GDP is equal to 0.04% in Iraq, and it represents the lowest percentage of spending in the Arab countries. This indicates that Iraq can produce more publications if it increases research and development expenditures. If we compare these results with the reference countries in the world in 2022, shown in Table N°. 02, we notice that China produces the largest number of scientific publications (770825 publications), while the number of scientific publications is approximately 546 per million people in China, which is close to what was recorded in some Arab countries. Regarding the rest of the reference countries, we notice that Britain, Germany, and the United States of America are at the forefront globally in terms of the number of publications per million people, followed by South Korea and France.

2.4.3 Low Spending on Scientific Research:

There is a predominant theory, among researchers working in the field of scientific research, which links the amount of expenditure with growth rates and levels all around the world. This theory suggests that if spending is less than 1% the GDP, the extent of the impact of these researches will be very weak, if spending is between 1-1.6%, it is at a critical level, and if it ranges between 1.6 to 2%, scientific research is at an ideal level. (Mehmoudi & Hejazi, January 2022, p. 213) , Accordingly, the results of Table (1) can be summed up as follows:

Table 2: Order of countries according to the effectiveness of spending on scientific research

Criterion	Spending on scientific research less than 1%	Spending on scientific research (1-1.6%)	Spending on scientific research (1.6-2%)
Countries	Algeria, Egypt, Iraq, Jordan, Saudi Arabia, Syria, Oman, Tunisia	Kuwait and UAE	China, USA, Britain, Germany, France, Korea
Results	Scientific research level: Low	Scientific research level: Critical	Scientific research level: High

Source: Prepared by the researchers based on the results of Table (1).

The increase in spending on scientific research is primarily due to the large funds invested by Korea, the USA, Germany, China, France, and Britain, which represent the bright side in spending on scientific research, whereas the remaining countries represent the down side, with about 80% of countries not exceeding the threshold of 1% of their general revenue.

According to Figure 01, it is clear that the regions that show so much of interest in scientific research and development in 2020 are, respectively: North America (303%) taking the lead, then East and Southeast Asia (2.3%) and Europe (2.0%), while the percentage of spending on research and development is 1.1% the GDP, in Central and West Asia, whereas the Arab rate does not exceed 0.6%, as is the case in South Asia, Latin America, and the Caribbean, in African and sub-Saharan countries, however, the rate does not exceed 0.3%. (Bin youssef, December 2022, p. 3)

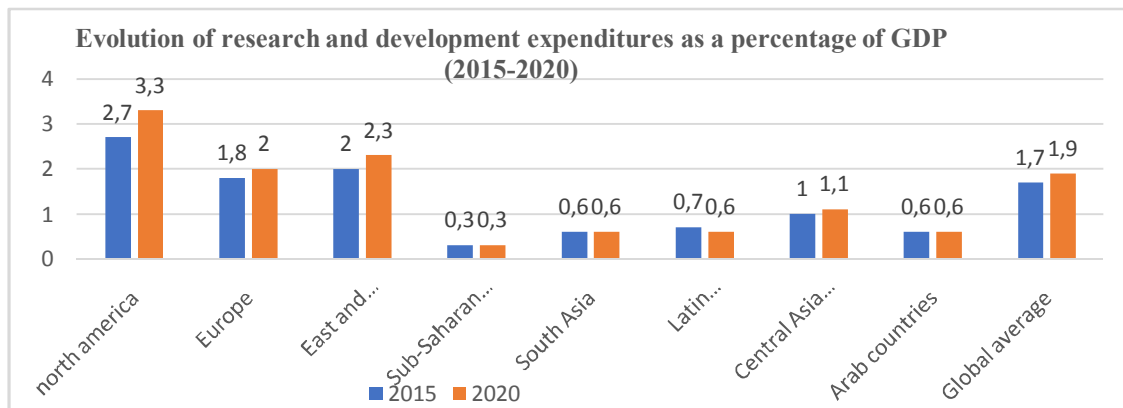


Figure 1: Evolution of research and development spending as (%) GDP (2015-2020)

Source: Prepared by the researchers based on (Bin youssef, December 2022, p. 4)

III- Results and discussion:

In this part of the research, we will discuss the results related to the research, and these results define and show us the reality of applying scientific research in renewable energies globally.

The growing tendency of investing in renewable energy technologies was thanks to several factors including: the strong economic growth of some countries, as well as fluctuations in oil prices, which raised concerns of many countries regarding energy security, in addition to various policies like the US Inflation Reduction Act, and the different initiatives in Europe, Japan and China, other places were also of great importance in accelerating this growth. That is why these countries have got the largest share in terms of renewable energy projects and the exploitation of renewable energy technologies.

3.1 Spending on Research and Development in the Energy Sector Globally

Spending on energy creations is an indicator of the seriousness of the world countries in implementing the policies and promises concerning the shift to clean energy and reducing emissions. Spending on energy innovations was not affected by the circumstances of the Ukrainian war in 2021, instead it maintained its continuous growth since 2022, with a larger amount being designated to research and development in the renewable energy sector (Rajab, 2023) Figure 2 shows that spending on scientific research, in the energy sector, is persistent and continuing to grow.

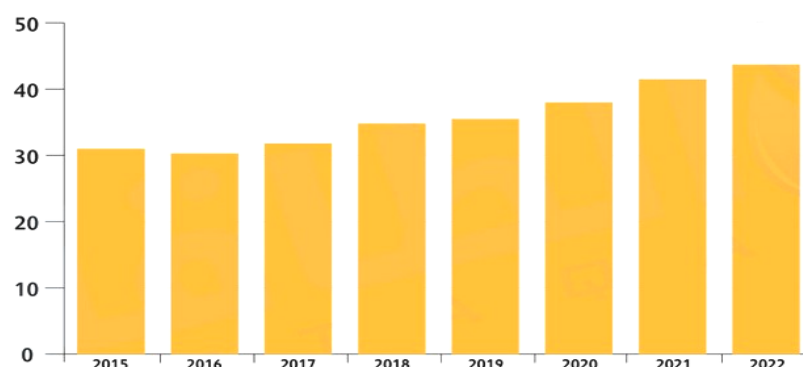


Figure 2: Government spending on research and development in the energy sector

Source: (Rajab, 2023)

We notice from the figure that general spending on research and development in the energy sector was increased to a record level of nearly 44 billion \$ during 2022, with a growth rate of 10% compared to 2021. The spending on clean energy inventions amounted to about 35.2 billion \$, which is equal to 80% of the total investments recorded in 2022, at the governmental level, which shows a significant predominance compared to fuel fossil.

The amount of spending on energy inventions in developed countries has become high, given that China alone spending approximately 14.9 billion \$, followed by Europe with 11.7 billion \$, then North America with 10.7 billion \$, whereas the total spending in Japan, South Korea, Australia and New Zealand amounted to about 3.5 billion \$, while spending on energy inventions in the rest of the world did not exceed \$2.9 billion in 2022. Spending on energy inventions globally increased by approximately 37% during the seven years ranging from 2015 (32 billion \$) and 2022 (44 billion \$). Concerning spending on energy inventions by companies (in the private sector), and specifically the companies listed in energy-related sectors, preliminary data shows a similar increase in research and development budgets by 10% in 2022. Generally, this growth in spending on energy inventions results from the response to the threats and opportunities resulting from the energy shift, and it is expected that the abundant revenues achieved by energy companies will contribute to increasing spending on energy inventions in the upcoming years. (Rajab, 2023)

Companies benefiting from the generous government financial support programs offered in the USA and Europe for clean energy inventions have an opportunity to make their investments in scientific research more economically beneficial. Thus, companies can benefit from the accelerating surge of international funding for start-ups in the field of energy. In 2022, the world witnessed the largest early-stage company funding campaign ever. (Rajab, 2023)

However, in developing countries spending is still low. It is expected that industrial policies in America and Europe of favoring the national value of clean energy will contribute in attracting huge capital and increasing competition between leading companies to secure contracts and win larger shares in these markets. The latter ensures very generous motivations, especially in the USA, and promised to support companies pioneering in the development of renewable energy technologies, and its distribution nationwide, with remarkable tax motivations, worth 370 billion \$ until 2030, according to the Inflation Reduction Law.

Countries including China, Europe, and North America, in addition to Japan and South Korea, still account for the majority of spending on global energy inventions, while emerging markets and developing countries accounted for only 5% of total public spending on energy of the total general spending on research and development in the field of energy, and 3% at the corporate level.

3.2 Global Renewable Energy Investments:

Investments in clean energy projects (with its different types) witness rapid growth in 2022, exceeding the spending on fossil fuel projects in 2023. The amount of global spending on energy is expected to increase to a record level approaching 2.8 trillion \$ in 2023, of which 1.74 trillion \$ will be devoted to clean energy technologies, and about 1.05 trillion \$ to fossil fuel projects.

Figure (3) shows the continuous development in the global renewable energy investments from 2004 to 2022.

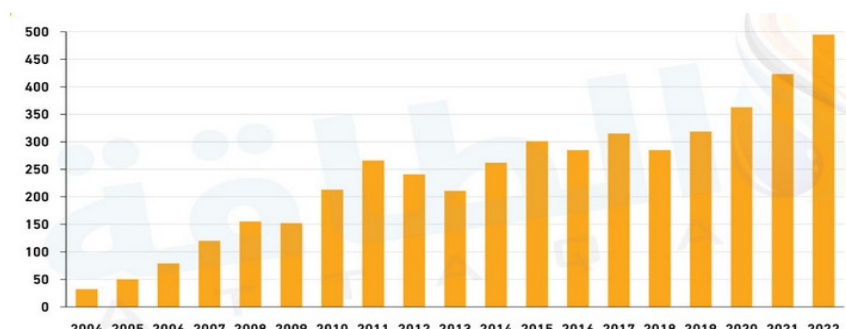


Figure 3: Development in global renewable energy investments (2004-2022)

Source: (Rajab, 2023)

We notice from the figure that global renewable energy investments increased to 382 billion \$, hence exceeding the spending on oil production which is likely to reach 371 billion \$ in 2023. This is unprecedented, and these clean technologies that the agency is betting on increasing their investments, include: renewable energy sources, electric vehicles, nuclear energy, networks and storage batteries, low-emission fuels, in addition to energy efficiency improvement technologies, and heat pumps(Chaouki, 2023)

Renewable energy sources account for 659 billion \$ of the total clean energy investments expected for 2023 (1.7 trillion \$), followed by spending on energy efficiency at about 377 billion \$.

Among the most important results of scientific research, we mention the following:

- Developing solar panels to heat water and generate electricity.
- Creating solar panels that support the cultivation of vegetables and fruits in greenhouses.
- Developing solar panels to produce clean potable water.

Global spending on low-carbon energy projects is expected to increase by about 60 billion \$ in 2023, reaching 620 billion \$, compared to investments of 560 billion \$ in 2022, and this increase is reinforced by the growth in wind energy projects, and investments directed to funding carbon collection and storage projects. In order to achieve the goal of reaching net zero emissions in 2050, the world needs 4 trillion \$ per year of investments in renewable energy sectors until 2030. Thus, reducing emissions and pollution can contribute in saving 4.2 trillion \$ annually(Faraj, 2023)

3.3 Funding Renewable Energy Sources:

Renewable energy projects require huge financial support in order for the world to shift from fossil fuels. However, it seems that global banks have not yet strengthened their standing in this regard, and renewable energy has accounted only to 7% total of 2.5 trillion \$ of bank loans and bonds delivered for energy activities between 2016 and 2022, along with other environmental institutions. This means that renewable energy activities received only 178 billion \$ vis-à-vis 2.3 trillion \$ for fossil fuel production. On the other hand, it seems crucial for banks to fund fossil fuel projects given the global energy needs, with the emphasis on providing financial support to companies on their way to shift to clean energy. Renewable energy companies often benefit from private and government financing.(Ahmed, 2023)

In 2022, the funding amount has doubled for the start-ups specialized in the fields of carbon collection and storage, energy efficiency, and nuclear energy, exceeding the average funding during the previous decade. Start-ups also faced banking challenges during 2023, with banks tightening loan operations,

which likely increases their competition to obtain early funding from energy companies outside of the banking sector(Rajab, 2023)

Subsequently, global investments in the shift to sustainable energy have amounted to about 1.1 trillion \$, which approximately equals the amount invested in the production of fossil fuels, although the amount invested represents an increase of 31% as compared to 2021, which is a small amount of what is required to reduce gas emissions and fight global warming(Environment Center for Arab Cities, 2023).

3.4 Accomplished Revenues from Applying Scientific Research in Renewable Energy Projects Investments

By the end of 2022, the total generation capacity of renewable energy sources has reached 3372 gigawatts, an increase of 295 gigawatts (9.6% compared to 2021). The record increase in electricity generation capacity from renewable energy was centered in a small number of countries and regions, such as: Asia, the United States of America, and Europe. Asia attained 175 gigawatts, more than half the added capacity globally in 2022 in Asia, bringing the cumulative total to 1.63 terawatts, with the leadership of China. The latter witnessed the generation of 141 gigawatts of renewable electricity. Also, in Europe and North America, the capacity of generating electricity from renewable energy increased by 57.3 and 29.1 gigawatts, respectively (2022). Additionally, Africa added 2.7 gigawatts, Oceania and South America 18.2 gigawatts, and the Middle East region recorded the highest ratio of increase in renewable energy sources ever, as 3.2 gigawatts were generated, an increase of 12.8%. Renewable energy plants constituted 83% of the total electricity generation stations added for 2021, compared to traditional power generation stations.(Internatio Renevable Energy Agency) The following table sums up these results

Table 3: Statistics on the capacity of renewable energy sources globally in 2022

Renewable energy sources	Addition amount of renewable energy sources in 2022 (GW)	Total generation capacity with renewable energy globally until the end of 2022 (GW)
Hydropower	21	1256
solar energy	192	1053
Wind Energy	75	899
Bioenergy	8	149
Geothermal energy	0.18	15
the total	295	3372

Source: Prepared by the researchers based on (Internatio Renevable Energy Agency).

According to the table above, the most important results achieved from investing in renewable energy are summed up as follows: (Abdessanade, 2023)

- **Hydropower:** hydropower capacity augmented by 21 gigawatts (a growth of 2% compared to 2021).
- **Wind energy:** an augmentation of 75 gigawatts (which represents an increase of 9% in 2022 a propos 2021), this growth in wind energy has noticeably declined compared to the last two years.
- **Solar energy:** solar photovoltaic (PV) energy accounted for most of the increase and new additions to the capacity of renewable energy sources in 2022, which reached 191 gigawatts.

- **Bioenergy:** bioenergy expanded slowly in 2022 with an increase rate of 7.6 gigawatts compared to 8.1 gigawatts in 2021.

- **Geothermal energy:** geothermal energy increased by a very small amount equal to 181 megawatts.

As far as the augmentation in renewable energy sources aside from the electrical network is concerned, the capacity increased by 1237 megawatts in 2022 (which is equivalent to an 11% increase compared to 2021), bringing the total capacity to a gigawatt.

The most significant shortcomings of investment in renewable energy has been recorded in emerging and developing economies, despite the record statistics achieved by some developing countries, including: India's high investments in solar energy, and Brazil's in renewable energy sources, and parts of the Middle East such as the UAE, Saudi Arabia, Oman, Morocco, Egypt and Jordan. Nonetheless, investment declined in several countries contrary to expectations due to several factors including: high interest rates, unclear policies and market designs, weak network infrastructure, financial pressures on some economic sectors, and the increase of capital cost (Abderrahman, 2023)

3.5 Scientific Publication in the Field of Renewable Energy:

in the field of renewable energy, scientific publications have increased, despite not being at the same level as the other fields. They witnessed an increase from about 71000 publications in 2011 to more than 108000 in 2019. India was in the lead globally in the number of research papers in 2019, while Saudi Arabia came first at the Arab level, followed by Egypt. China ranked first in the number of patents at the global level, with a rate of 29%, followed by America with 20%, then Japan with 18.4%, then Europe 14.4%. The field of sustainable energy remains insufficiently explored, since in 2019 the rate of publications in this field reached 2.5% globally. There is still a long way to go before science can contribute its full potential to serve sustainable development (Boumajout, 2021)

According to a recent study conducted at Tianjin University in China, entitled Evolutionary trends and characteristics of renewable energy researches in Africa during the period 1999-2021, which was published in the Journal of Research in Environmental Sciences and Pollution during 2022. It considered the Algerian Renewable Energy Development Center a model in scientific production and the most influential in Africa, given the fact that it is the most productive and influential institution. The results of the study confirmed that Algeria is one of the most contributing countries in this field, following South Africa and the United States of America. South Africa ranks first in terms of the number of scientific publications by % 14.5 the total publications, followed by the United States of America with 9.18% and Algeria with 8.47% (Algerian News Agency, 2023)

Conclusion:

Investment in scientific research has become of great importance in the process of economic development and the development of human societies, due to the benefits it reaps, and because it contributes to finding solutions to the various problems facing society.

The four key components of scientific research must be available in order for it to achieve good results. These key components form what is known as the research system (the productive sectors, qualified individuals capable of creativity and innovation, and an administration represented by the sector of higher education, research centers, and funding).

This system must provide the appropriate atmosphere in order to accomplish these four elements.

Scientific research sometimes encounters several challenges, including, for instance, spending on scientific research. It is noted that, the larger the spending rate on research in terms of GDP, the stronger the influence, and vice versa. This was proved by our study, given that Arab countries spend less than developed countries, the reason for the strength of these countries is the increasing concentration on rising spending on various scientific research, including renewable energies.

The findings of our study:

- Scientific research is considered an essential foundation for developing the technologies of renewable energy sources (solar, wind, water, electricity transmission, energy storage, waste recycling, etc.)
- Research groups in universities and research centers are described as an important source of knowledge and the transfer of experience among researchers in prestigious universities, and that' achieved through carrying out joint research works which are beneficial to society.
- Establishing a research group and its scientific construction requires scientific regulations, conditions for accepting research papers by research groups, and their financial funding budget in order to maintain the continuity of research work.
- It is necessary to introduce modules to be taught in universities, which focus on the “environment and climate change”, in order to educate students and provide them with knowledge related to preserving the environment, reducing carbon dioxide emissions and global warming, and encouraging postgraduate students to conduct practical experiments related to solar energy, wind energy, and other projects, in addition to educating future generations on these concepts.
- Scientific research enables one to learn knowledge related to the latest technologies and the most efficient and effective methods from an economic and environmental standpoint.
- Supporting creative ideas in the fields of renewable energy by the government and the private sector reduces the gap between research activities and applied reality.

From the previous findings, we recommend the following:

- Weak countries must improve and develop the sector of scientific research, by providing a strong infrastructure and research centers, allocating enough budgets for research needs, the participation of various sectors in the country, in addition to formulating policies and issuing laws to regulate and encourage research and innovation.
- About 70% of scientific publications are not accessible to most scientific researchers in the world, and this is an example of the lack of equal opportunities among researchers in the world. Therefore, governments must work to eliminate this obstacle, and must work with new models for distributing scientific knowledge and disseminate it in society.
- Reducing inequalities in the field of sciences, and encouraging a greater degree of cooperation and openness in order to confront various crises, whether related to climate change, the loss of biodiversity, the oceans welfare, or pandemics. All this requires mobilizing the efforts of scientists and researchers from all over the world.
- Encouraging scientific partnership between various government institutions and the private sector, and publishing research papers, with a global impact, in scientific journals that are listed in global databases and have an impact factor.

- Encouraging research and development in the field of technologies of exploiting renewable energies, employing the latest leading global technologies, and benefiting from international expertise in order to acquire knowledge, experience and skills in the field.
- Increasing the spending on research and development, and encouraging cooperation between the public and private sectors in the field of developing different renewable energy sources technologies.
- Encouraging investment in private projects and businesses of an economic nature related to new energy, and that contribute to the process of sustainable development.

References:

- Abderrahman, B. (2023, July 2). *Global investment in clean energy technologies is on track to rise to nearly \$1.7 trillion in 2023, and solar energy has the largest share.*
- Abdessanade, M. (2023, March 28). *IRENA: Global renewable energy investments require \$5 trillion annually to achieve carbon neutrality.*
- Ahmed, C. (2023, January 24). *Renewable energy accounts for 7% of bank financing.*
- Algerian News Agency. (2023, September 7). *Algeria is among the countries that most produce scientific publications related to renewable energies.*
- Al-jabouri, O., & Al-jabouri, A. (2010). *Principles of renewable energy*. Technical Institute, Renewable Energy Research Unit.
- Al-sheikh, H. (2007). *Economics of natural resources and the environment* (1st ed.). Obeikan Library.
- Baslouni, A. D. (2020, April). *The role of scientific research as a driving force towards a green economy to achieve economic development*. The Fourth Scientific Conference of the Faculty of Commerce, Tanta University, on: Financing and Managing Entrepreneurship Projects and their Role in Achieving Economic Development. Faculty of Commerce, Tanta University.
- Ben Moursli, A. (2010). *Scientific research methods in media and communication sciences* (1st ed.). Office of University Publications.
- Bin Youssef, T. (2022, December). *ALSCO Observatory, the eighth statistical bulletin for the year 2022: The reality of scientific research in Arab countries compared to the rest of the regions and countries of the world*. Arab League Educational, Cultural and Scientific Organization.
- Boloudoni, K., BELouahem, A. E., & Bedda, F. (2018). Social research in the Arab world between reality and hopes. In *Proceedings of the international forum on: the university and openness to the external environment (expectations and bets)* (No. 01). Council Publications, University of Guelma.
- Boris, P. (2023, May 23). *Renewable energy investment guide 2023*.
- Boumajout, H. (2021, June 17). *UNESCO: A global increase in interest in science and the Arab world continues its journey*.
- Chaouki, A. (2023, May 25). *International Energy Agency: Solar energy investments may exceed oil for the first time in 2023*.
- Deutsche, F. (2010, February 1). *Merkel stresses the importance of scientific research in renewable energy*.

Eldaradji, L., & Bin AL-Cheikh, T. (2018). The university and its contribution to economic development in Algeria. In *Proceedings of the international forum on: the university and openness to the external environment (expectations and bets)* (No. 01). Council Publications, University of May 8, 1945, Guelma.

Environment Center for Arab Cities. (2023, July 6). *Billions of dollars of investment go into solar energy every day*.

Faraj, M. (2023, January 16). *In numbers... How much will the world spend on “clean energy” in 2023?*.

Internatio Renewable Energy Agency. (n.d.). *The production capacity of renewable energy sources achieves record growth*.

Khourdr, A. (1992). *The crisis of scientific research in the Arab world* (3rd ed.). Salah Al-Hejailan Law Office and Legal Consultations.

Mahmoudi, H., & Hedjazi, M. (2022, January). A vision for developing obstacles to scientific research in the Arab world. *Arab Journal of Measurement and Evaluation*, (05).

Rajab, A.-E. (2023, June 16). *Spending on energy innovation hits a record \$44 billion in 2022*.

Sadek Ismail, M. (2014). *Scientific research between the Arab East and the Western world: How did they rise...? Why did we retreat?* Arab Group for Training and Publishing.