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The Reality and Challenges of Renewable Energy in Arab Countries

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Abstract:
The aim of this study is to clarify the concept of renewable energy and its importance, as well as to examine the most important types of renewable energy sources. Additionally, it seeks to determine the global standing of Arab countries in the development of these vital and rapidly advancing elements.

To assess the impact of renewable energy in Arab countries, we relied on statistics provided by official bodies and conducted an analysis. The study reveals that Arab countries possess abundant renewable energy resources, which should motivate them to harness this vital energy source. However, through the empirical study, it became clear that Arab countries are still far behind in utilizing these renewable energies, as they account for only 1% of the total global renewable energy production. This reflects the significant delay of Arab countries in exploiting renewable energy compared to major economies. This delay is attributed to the reliance of Arab countries on fossil fuels to meet energy needs. Nevertheless, some countries, such as Egypt, the United Arab Emirates, and Morocco, have started investing seriously in renewable energy projects, indicating their desire to diversify energy sources and achieve environmental and economic sustainability. Despite the abundance of renewable energy sources in these countries, much remains to be done.

Keywords: Renewable Energy; Conventional Energy; Fossil Fuels; Energy Sources; Arab Countries.

I. INTRODUCTION

Energy is an essential requirement for sustainable economic development. Its provision and accessibility have become one of the most critical global issues, especially with the rising oil prices. Countries now face no other option but to seek alternative energy sources that are both cost-effective and clean, particularly in light of concerns about global warming and climate change.

Renewable energy refers to energy derived from sources that can naturally generate energy continuously, such as solar energy, wind energy, hydropower, geothermal energy, and biomass energy. These sources have gained significant importance in recent years, as countries around the world rush to transition to the era of renewable energy. This transition is supported by various policies and strategies aimed at promoting the widespread adoption of renewable energy to ensure energy security for industrialized nations and reduce dependence on oil-exporting countries, such as the Arab nations.

Studies on the potential for electricity generation from renewable sources in the Arab region have demonstrated that it enjoys abundant resources, particularly in solar and wind energy. Most Arab countries are located in the solar belt and have vast potential for wind energy generation. Additionally, some countries, like Egypt and Sudan, benefit from hydropower resources, along with biomass energy sources. Therefore, the solution lies in diversifying energy sources by harnessing the available renewable resources and transferring relevant technologies from developed countries. This solution presents an attractive option for the Arab region to secure and diversify its energy sources.

Based on the above, the following issue arises:

What is the status of renewable energy in the Arab world compared to other countries globally?

The significance of this study lies in its attempt to address the posed issue, aiming to shed light on the current state of renewable energy in the Arab world. It examines the extent to which Arab countries are utilizing these resources to diversify energy sources and reduce dependence on fossil fuels, while also attempting to keep pace with developed nations in acquiring the technology and means to exploit abundant resources.

This study aims to introduce renewable energy, define the key players in the field of renewable energy, and explore its importance. Additionally, the study seeks to examine the characteristics and sources of renewable energy. Through the applied aspect, we aim to highlight the reality of renewable energy in the Arab world by exploring the available potentials and capacities possessed by Arab countries, as well as assessing their ability to keep up with global developments.

1. The Concept and Importance of Renewable Energy

1.1 Definition of Renewable Energy

Renewable energy is defined as energy derived from natural resources that are inexhaustible and continuously replenished. It is also defined as energy generated from natural sources that renew at a rate faster than their consumption. Renewable energy is often referred to by several terms, including clean energy and friendly energy (Suleiman, 2024, p. 05).

The United Nations defines renewable energy as energy derived from natural sources that renew at a rate faster than their consumption. Examples include solar and wind energy, which are continuously replenished. Renewable energy sources are abundant and available everywhere around us (United Nations, 2024, p. 01).

According to the International Energy Agency (IEA), "Renewable energy is formed from sources resulting from the natural processes, such as sunlight and wind, which renew in nature at a rate higher than their rate of consumption" (Rawaiqia, 2019, p. 105).

The Intergovernmental Panel on Climate Change (IPCC) defines renewable energy as "Energy generated from continuous and ongoing natural flows. There are many mechanisms that allow the conversion of these sources into primary energy" (Takwacht & Ghazzazi, 2020, p. 84).

The United Nations Environment Programme (UNEP) defines renewable energy as "Energy that does not come from fixed and limited resources in nature; it replenishes itself periodically, faster than its consumption rate" (Muammar, 2019, p. 146).

1.2 The Importance of Renewable Energy

The importance of renewable energy for most countries in the Middle East and North Africa can be summarized as follows (Saham, 2020, p. 55):

- Renewable energy plays a crucial role in meeting the electricity needs of the Middle East and North Africa region.
- Renewable energy helps reduce greenhouse gas emissions and addresses climate change. It also assists in solving other environmental problems in the region.
- One of the benefits of renewable energy is reducing the quantities of oil and gas used in electricity production, which allows for the use of these resources in other more productive sectors. If renewable energy can replace gas and oil in local electricity production, it can open up new opportunities.
- Fossil fuels will remain the primary energy source in the near future, as forecasts indicate that OPEC's share of global oil production will rise from 42% to 52% by 2030. Therefore, renewable energy projects can help free up more of these resources for export, which will help solidify the position of these countries globally as major energy exporters.
- Renewable energy contributes to economic diversification and the creation of jobs.

Given the significant importance of renewable energy in modern life, it is increasingly clear that its use is not just desirable but necessary. Predictions suggest that we will eventually be forced to rely on it as it becomes the only viable energy source. Renewable energy is inexhaustible, low-cost, and accessible to everyone, whether individuals or organizations. It plays a key role in economic security, technological control in the future, and is the only solution to

reduce conflicts and ambitions arising from the use of traditional energy. Additionally, it has a significant role in preserving the environment and the surrounding ecosystem in which we live.

2. Characteristics of Renewable Energy

Renewable energy has several characteristics, the most important of which are as follows (Belkouch, 2020, pp. 36-37):

- It is available in most countries around the world.
- It ensures continuous availability, even if intermittently, and at an affordable price.
- It helps shield the economy from crises resulting from fluctuations in traditional energy prices.
- It is not subject to the control of international or local political systems, which could limit the expansion of its utilization.
- Energy can be generated from renewable sources wherever they exist.
- It can be exploited by any individual or company worldwide, as it is not an exclusive resource like oil fields that cannot be privately owned or invested in (Fatiha Ben Al-Hajj, 2016, p. 82).
- It uses non-complex technologies, and therefore can be locally manufactured in developing countries.
- The energy generated from renewable sources is not highly concentrated, thus its exploitation requires large-scale equipment and extensive land areas, which is one reason for the high initial costs of renewable energy devices.
- Renewable energy is a clean source, producing no harmful emissions and does not harm human health or the ecosystem, unlike fossil fuels, which are characterized by high emissions that negatively impact the environment.
- Renewable energy is one means of promoting greater global equity between developed and developing countries. It is not exclusive to current generations; maximizing the use of solar and wind energy will not reduce future generations' access to these resources. In fact, relying on renewable energy will make the future safer for upcoming generations, as it is inexhaustible and environmentally friendly.
- Accelerating the use of renewable energy helps reduce costs and contributes to combating global warming. It also helps mitigate environmental damage caused by activities like deforestation for cooking and heating, as well as soil erosion and the extinction of wildlife (Nawal, 2016, p. 172).

3. Sources of Renewable Energy

Among the most important sources of renewable energy in the world, we find:

3.1 Solar Energy

Solar energy is considered one of the most crucial types of energy that humans can exploit, as it is constant, renewable, and clean. It shines every day with a fixed and known amount and is expected to continue until the end of the world. The sun is a glowing sphere of gas with a diameter of 1.39 million kilometers, and its surface temperature is approximately 5762 degrees Kelvin. This tremendous energy is derived from nuclear fusion reactions occurring between hydrogen atom nuclei, which ultimately transform into helium atoms (Fatiha, 2018, p. 13).

Solar energy is the strongest source of renewable energy and can use solar radiation for heating, lighting, cooling homes and buildings, in addition to generating electricity and heating water, among a variety of industrial processes. The methods used in harvesting solar energy are continually evolving and becoming more efficient with technological advancements. Among these methods are water heating tubes on rooftops, solar cells, and reflective mirrors (Belasal, 2023, pp. 70-71). Solar energy is used to directly produce electricity through photovoltaic cells. Due to advancements in this field, the cost of producing energy has decreased from 100 cents per kWh in 1980 to about 15 cents per kWh in 2006 (Khater & Warda, 2021, p. 17).

3.2 Hydropower

Hydropower is categorized as a renewable energy source in the modern sense and is a focus of researchers aiming to develop it as a replacement for oil-based energy. The use of water as an energy source dates back to before the discovery of steam power in the 18th century. Until then, humans used river waters to operate waterwheels that powered textile machinery. In the present day, it is used for generating electricity (Muammar, 2019, p. 147).

3.3 Wind Energy

Wind energy is derived from the wind by converting its motion into power. The effectiveness of wind energy depends on the wind's strength, which must average at least 8 miles per hour but should not exceed a certain threshold. This upper limit is determined based on the type of equipment used for the conversion process, as well as the height and location where the equipment is installed. Wind energy is primarily caused by the uneven heating of the earth's surface by the sun (Fatiha, 2018, p. 14).

The importance of wind energy lies in its cost-effectiveness, as it requires simpler and less complex technologies compared to other energy sources (Bakhta & Abdelkader, 2024, p. 290).

3.4 Nuclear Energy

Nuclear energy is generated from the fission of uranium atom nuclei, which leads to the breaking of bonds and the production of significant thermal energy. It is widely used by countries for generating electricity (Nawal, 2016, p. 17). After the attacks on Hiroshima and Nagasaki at the end of World War II, the tremendous potential of nuclear energy became apparent. This led both the Eastern and Western blocs to pursue its development for civilian industrial use to improve human living standards. However, in reality, it has been directed more towards military purposes than civilian ones. In non-military applications, this energy is used in nuclear power plants to heat water to produce steam, which is then used to generate electricity. In 2009, nuclear power accounted for 14.13% of global electricity production (Rawaiqia, 2019, pp. 117-118).

3.5 Geothermal Energy

Geothermal energy is the heat from the Earth, where the high temperatures underground are harnessed by extracting this energy and converting it into other forms. In some areas with faults and fractures, groundwater can seep through these openings to great depths, coming into contact with extremely hot regions.

3.6 Biomass Energy

This energy is produced from a variety of organic materials known as biomass, such as wood, coal, animal waste, and other forms of natural manure, for generating heat and energy. It also includes agricultural crops used to produce liquid biofuel (Suleiman, 2024, p. 11).

II. METHODOLOGY AND TOOLS

To assess the reality of renewable energy in the Arab world, a sample consisting of all Arab countries was selected to identify differences both within these countries and between them and other nations globally. To grasp the true state of renewable energy exploitation in the Arab world, we relied on collecting statistical data from official sources. This data was meticulously analyzed, and then compared with countries that have significant experience in this field. Subsequently, this statistical data was incorporated into graphical representations along with analysis and explanations.

III. RESULTS AND DISCUSSION

1. Solar Energy Production in Arab Countries for 2023

The following table illustrates the volume of solar energy production in Arab countries for the year 2023.

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Table 1: Solar Energy Production in Arab Countries for 2023

Country	Production (Megawatts)	Share of Total Arab Production	Share of Global Production
UAE	5,925	%34.76	%0.42
Saudi Arabia	2,285	%13.40	%0.16
Jordan	1,987	%11.64	%0.14
Egypt	1,970	%11.56	%0.14
Lebanon	1,000	%5.86	%0.07
Morocco	911	%5.34	%0.06
Qatar	805	%4.72	%0.06
Oman	672	%3.93	%0.05
Tunisia	499	%2.93	%0.04
Algeria	413	%2.42	%0.03
Yemen	290	%1.70	%0.02
Occupied Palestine	190	%1.11	%0.01
Kuwait	102	%0.60	%0.01
Syria	58	%0.34	%0.00
Bahrain	56.6	%0.33	%0.00
Sudan	54.3	%0.32	%0.00
Iraq	2.6	%0.02	%0.00
Libya	2	%0.01	%0.00
Total Arab Production	17,041.50	%100	%1.20
Global Production	1,418,969		%100

Source: Prepared by the researcher based on data from: The 50th Annual Report of the Organization of Arab Petroleum Exporting Countries, pages 135-136.

The total Arab solar energy production increased from 11,500 megawatts in 2022 to 17,041.5 megawatts in 2023, marking a growth rate of 48.17%. The total Arab production for 2023 accounts for only 1.20% of the global solar energy output, which is estimated at 1.41 million megawatts.

The United Arab Emirates leads Arab countries with a production of 5,925 megawatts, while Libya ranks last with a production of just 2 megawatts. Notably, despite possessing significant oil and gas reserves, the UAE and Saudi Arabia together account for approximately 50% of the Arab solar energy production. This reflects the desire of these countries to transition towards energy transformation and reduce reliance on traditional energy sources.

2. Wind Energy Production in Arab Countries for 2023

The following data outlines the wind energy production across Arab countries for the year 2023, demonstrating significant growth and the strategic shift towards alternative energy sources by countries with limited oil resources.

European Economic Letters
ISSN 2323-5233
Vol 15, Issue 1 (2025)
http://eelet.org.uk

Table 2: Wind Energy Production in Arab Countries for 2023

Country	Production (Megawatts)	Share of Total Arab Production	Share of Global Production
Egypt	1,885	36.49%	0.19%
Morocco	1,853	35.86%	0.18%
Jordan	614	11.88%	0.06%
Saudi Arabia	403	7.80%	0.04%
Tunisia	245	4.74%	0.02%
UAE	104	5.34%	0.01%
Oman	50	2%	0.01%
Kuwait	10	0.19%	0.00%
Bahrain	3	0.05%	0.00%
Total Arab Production	5,166	100%	0.51%
Global Production	1,017,199		100%

Source: Prepared by the researcher based on data from: The 50th Annual Report of the Organization of Arab Petroleum Exporting Countries, page 134.

The total Arab wind energy production increased from 4,200 megawatts in 2022 to 5,166.4 megawatts in 2023, marking a growth rate of 22.85%. The total Arab production for 2023 represents only 0.508% of the global wind energy output, which is estimated at 1.017 million megawatts.

Egypt leads the Arab world in wind energy production with 1,885 megawatts, while Bahrain ranks last with a production of just 2.7 megawatts. Notably, Egypt and Morocco together account for more than 72% of the Arab wind energy production in 2023. This significant contribution by these two countries, both of which lack sufficient oil resources, underscores their commitment to exploring alternative sources for energy production.

3. Hydropower Production in Arab Countries for 2023

The following data highlights the hydropower production across various Arab countries for the year 2023, demonstrating a decrease in production compared to the previous year.

Table 3: Hydropower Production in Arab Countries for 2023

Country	Production (Megawatts)	Share of Total Arab Production	Share of Global Production
Egypt	2,832	30.96%	0.22%
Iraq	1,556	17.01%	0.12%
Syria	1,490	16.29%	0.12%
Sudan	1,482	16.20%	0.12%
Morocco	1,306	14.27%	0.10%
Lebanon	282	3.08%	0.02%
Algeria	129	1.41%	0.01%
Tunisia	66	0.72%	0.01%
Jordan	3.6	0.04%	0.00%

Total Arab Production	9,146	100%	0.72%
Global Production	1,267,903		100%

Source: Prepared by the researcher based on data from: The 50th Annual Report of the Organization of Arab Petroleum Exporting Countries, pages 136-137.

The total Arab hydropower production decreased from 9,960 megawatts in 2022 to 9,146 megawatts in 2023, marking a decline of 8.23%. The total Arab production for 2023 represents only 0.721% of the global hydropower output, which is estimated at 1.26 million megawatts.

Egypt leads the Arab world in hydropower production with 2,832 megawatts, while Jordan ranks last with a production of just 3.6 megawatts. It is also noteworthy that more than 80% of the hydropower produced in the Arab countries in 2023 was generated by countries through which the Nile, Euphrates, and Tigris rivers flow, namely Egypt, Sudan, Iraq, and Syria. This underscores the lack of suitable water resources in other Arab countries for generating this type of energy.

4. Biomass Energy Production in Arab Countries for 2023

The following data details the biomass energy production across Arab countries for the year 2023, indicating a modest increase and highlighting the underutilization of this renewable energy source in the region compared to its potential.

Table 4: Biomass Energy Production in Arab Countries for 2023

Country	Production (Megawatts)	Share of Total Arab Production	Share of Global Production
Sudan	199	48.79%	0.13%
Egypt	131	32.12%	0.09%
UAE	24.4	5.98%	0.02%
Qatar	19	4.65%	0.01%
Jordan	13	3.18%	0.01%
Morocco	7.4	1.81%	0.00%
Lebanon	7	1.71%	0.00%
Syria	6.7	1.64%	0.00%
Occupied Palestine	0.34	0.08%	0.00%
Yemen	0.015	0.00%	0%
Total Arab Production	407.8	100%	0.27%
Global Production	150,261		100%

Source: Prepared by the researcher based on data from: The 50th Annual Report of the Organization of Arab Petroleum Exporting Countries, pages 137-138.

The total Arab biomass energy production increased from 353 megawatts in 2022 to 407.80 megawatts in 2023, marking a growth rate of 15.52%. The total Arab production for 2023 represents only 0.271% of the global biomass energy output, which is estimated at 1,017 gigawatts.

Sudan leads the Arab world in biomass energy production with 199 megawatts, while Yemen ranks last with a production of just 0.015 megawatts. It is evident that, while biomass energy receives significant attention in major developed countries, it has not yet gained substantial importance in Arab countries, suggesting a significant area for development and investment, especially considering the renewable nature and sustainability benefits of biomass energy.

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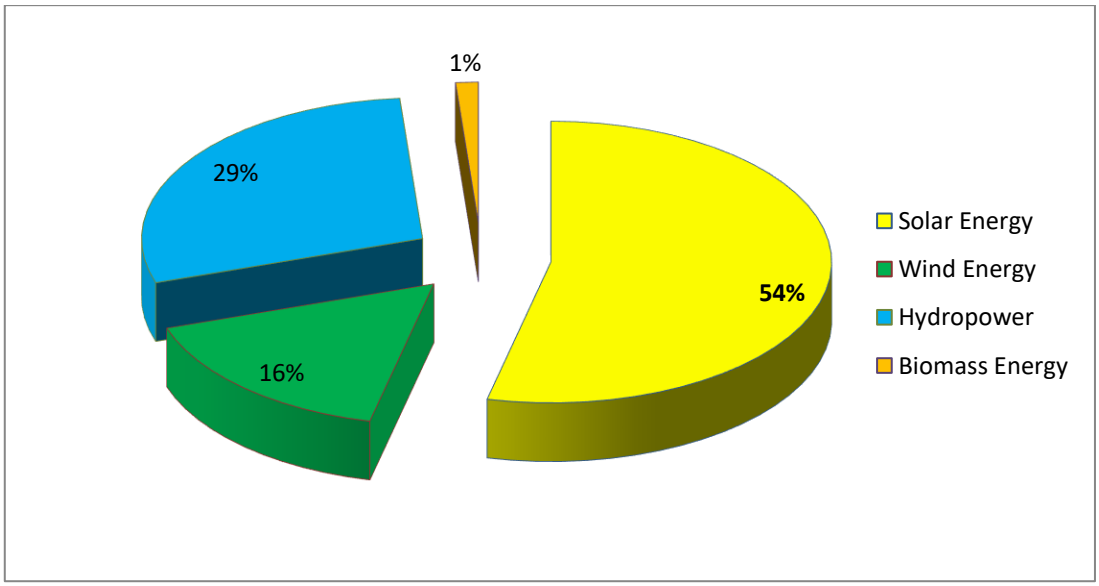
http://eelet.org.uk

The following figure also shows us the distribution of renewable energy produced by type for the year 2023 in Arab countries.

Figure 1: Distribution of Renewable Energy Production by Type in Arab Countries for 2023



Source: Prepared by the researcher based on data from: The 50th Annual Report of the Organization of Arab Petroleum Exporting Countries, pages 134-138.

From the provided information, it is evident that solar energy emerges as the primary source of energy generation in the Arab countries for 2023, accounting for 54% of the total renewable energy produced. This significant share underscores the abundance of sunlight in Arab countries, making them ideally suited for solar energy production.

Hydropower accounts for 29% of the total renewable energy production in 2023, indicating the limited use of water resources for energy generation in the region. Despite having the suitable environment for wind energy production, it only represents 16% of the total renewable energy production. This suggests that there is room for growth and further exploitation of wind resources.

Biomass energy comprises only about 1% of the renewable energy production, highlighting that this energy type still requires significant development to realize its potential fully in the Arab countries.

This distribution reflects the current state of renewable energy in the Arab region and suggests areas where development and investment could be increased to enhance the diversity and capacity of renewable energy sources.

As the following table illustrates, it ranks the Arab countries according to their total production of renewable energies for the year 2023.

Table 5: Ranking of Arab countries according to the total production of renewable energies for the year 2023

Rank	Country	Production (Megawatts)	Percentage of Total Arab Production
1	Egypt	6,818 MW	21.34%
2	UAE	6,052.9 MW	18.95%
3	Morocco	4,077.4 MW	12.76%
4	Saudi Arabia	2,688.3 MW	8.41%
5	Jordan	2,617.6 MW	8.20%

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http://eelet.org.uk

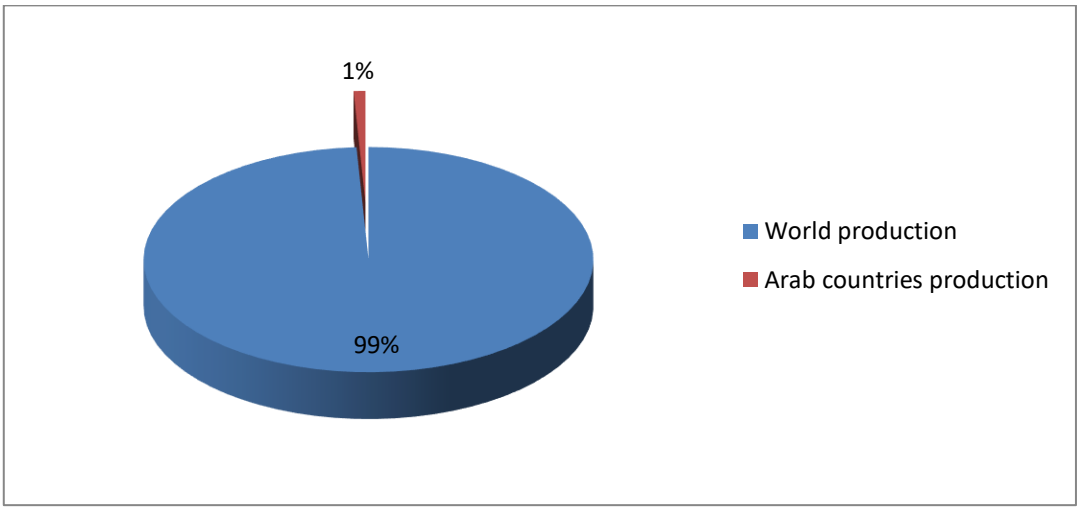
6	Sudan	1,735.3 MW	5.43%
7	Iraq	1,558.6 MW	4.88%
8	Syria	1,554.7 MW	4.86%
9	Lebanon	1,289 MW	4.03%
10	Qatar	824 MW	2.58%
11	Tunisia	810 MW	2.53%
12	Oman	722 MW	2.26%
13	Algeria	541.6 MW	1.70%
14	Yemen	290.015 MW	0.90%
15	Occupied Palestine	190.34 MW	0.59%
16	Kuwait	112 MW	0.35%
17	Libya	2 MW	0.01%
Total	Arab Countries	31,943.055 MW	100%

Source: Prepared by the researcher based on: The 50th Annual Report of the Organization of Arab Petroleum Exporting Countries, pages 134-138

The total production of renewable energies by the Arab countries reached 31,943.055 megawatts for the year 2023, where Egypt occupied the first rank Arabically with a production capacity of 6,818 megawatts, representing more than a fifth of the Arab countries' production, while Libya occupied the last rank Arabically with a production capacity of only 2 megawatts. We also notice from the previous table that Egypt, the UAE, and Morocco produce more than half of the total production of renewable energies by the Arab countries combined for the year 2023, and that many Arab countries have almost no production of renewable energies, such as Libya, Kuwait, and Yemen. The following figure illustrates the share of the Arab countries from the total global production of renewable energies for the year 2023.

The following figure illustrates the share of Arab countries in the total global production of renewable energies for the year 2023.

Figure 2: The Share of Arab Countries in Global Renewable Energy Production for 2023



Source: Prepared by the researcher based on: The 50th Annual Report of the Organization of Arab Petroleum Exporting Countries, pages 134-138

From the previous figure, it is clear that the combined share of the Arab countries from the total global production of renewable energies for the year 2023 is only about 1%. This reflects the significant delay of the Arab countries in exploiting renewable energies compared to major economies. This is due to the reliance on fossil fuels as a primary source of energy. However, some Arab countries such as Egypt, the UAE, and Morocco have started to seriously invest in renewable energy projects, showing their desire to diversify energy sources and achieve environmental and economic sustainability.

It is also worth noting that the Arab countries have not exploited ocean energy, which globally had a total installed capacity of over 526 megawatts in 2023. Additionally, the installed capacity via geothermal energy globally exceeded 148,000 megawatts in 2023. Despite the increasing importance of this source, the Arab countries have not yet initiated the exploitation of this type of renewable energy, with the exception of the UAE, which began some experimental projects in mid-August 2023.

IV. CONCLUSION

In conclusion, it is clear that renewable energies play a significant role in helping countries achieve their energy needs and reducing dependence on oil; they are crucial for sustainable development that preserves the environmental heritage for future generations. This reflects the necessity for countries and governments to adopt a development strategy based on renewable energies.

Arab countries are rich in renewable energy resources, especially solar energy, due to their location within the solar belt. Most Arab countries also possess wind energy resources, and some, like Egypt, Sudan, and Iraq, have significant hydropower resources due to their river systems. Therefore, many Arab countries, particularly the United Arab Emirates and Morocco, have directed efforts toward exploiting these resources to diversify their energy sources. Many countries have invested in this sector, striving to keep pace with developed countries in owning technologies to exploit these available and abundant resources.

However, despite the earnest efforts to diversify energy sources in Arab countries, they are still far behind compared to developed countries, representing only 1% of the total global energy; this reflects the significant reliance of these countries on oil, which remains the primary energy source in the Arab world. Through this study, we have reached the following conclusions:

- Renewable energies represent the future of the Arab world’s economy; they are the optimal solution to move away from dependency on the oil sector, characterized by its instability and externally driven price fluctuations.
- Renewable energy is a true and complementary alternative to fossil fuels because it combines economic and environmental benefits.
- Arab countries possess diverse and significant sources of renewable energy, especially solar energy, followed by wind energy.
- Despite some countries making progress in developing these industries, Arab countries are still far behind in exploiting renewable energies.
- The production of renewable energies is very weak compared to the natural wealth possessed by Arab countries.

Therefore, we put forward the following recommendations:

- Arab countries should rely more on renewable energies to mitigate global warming and preserve the environment.
- Oil-exporting Arab countries should diversify their economies to reduce their near-total reliance on oil, transforming oil income into locally developed and owned technology and investing in renewable energies.
- Increase research and laboratories in the field of renewable energies that serve the economies of Arab countries and maintain environmental security, and reduce global warming.

- Pay attention to geothermal energy, especially in active areas such as the Gulf of Suez and the Gulf of Aqaba, and to tidal energy along the extensive Arab coastlines on the Mediterranean, Red Sea, Arabian Gulf, and the Arabian Sea.
- Encourage Arab and foreign investment and joint projects between the public and private sectors in the field of renewable energies.
- Prepare for the future by entering the field of hydrogen energy, considering it the safest, cleanest, and most environmentally friendly energy of the future.

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