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Renewable Energy Sources and the Government Strategy for Developing Energy Sector in Jordan

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Abstract. Energy and energy security are strategic goals for various countries of the world because energy is an important component of life. As the energy problem is gradually aggravating worldwide, especially with the increasing demand for it by a large percentage, and it is expected that these percentages will rise significantly during the coming period because of population growth and the significant increase in the number of various industrial and service establishments. Currently, most countries are seeking to rationalize in energy consumption, and to search for alternatives to energy sources. Hence, there is a keen interest in energy sources and their alternatives. In this study, energy sources and their alternatives in Jordan were identified in order to get an adequate idea of what is available in Jordan from this area. Jordan is one of the poor countries in traditional energy sources, and one of the countries most affected by the high prices and the shortage in the production of crude oil and other energy components, and its negative repercussions on the Jordanian economy, as Jordan imports oil and natural gas from neighboring countries 90 % of its needs Energy, which is approximately 8 %-10 % of GDP. This study attempts to shed light on the existing energy sources in Jordan with the aim of exploring ways to improve the energy situation in the country by increasing reliance on renewable energy alternatives such as wind and solar energy instead of relying on imported oil and gas.

Keywords: development, strategy, energy security, renewable energy, solar energy, wind energy, Jordan

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Introduction

Energy is essential to economic growth, social development, and improved quality of life in all countries [1]. Energy security and assurance is a top priority for governments around the world, as energy is the main driver of economic

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development. The International Energy Agency (IEA) defines energy security as the continuous availability of energy sources at an affordable price [2]. Energy of all kinds is considered the first strategic goal for the countries of the world, and with the availability of energy, internal stability is achieved in the countries, as most of the problems of the modern era depend on energy, its sources, and its availability. From here, the interest in energy appeared in terms of sources, as different countries of the world began to pay attention to what it contains of energy sources and try to search for other unexplored sources and new alternative sources [3].

Jordan is one of the energy importing countries, which increases the ratio of imported energy to the gross domestic product and leads to great pressures on the balance of payments and the continued need for foreign currencies to finance the purchase of energy needs in the Kingdom [4]. Jordan is not as rich in natural resources as its neighbors, and therefore depends 94 % of its fuel and energy needs on imports, which equates to about 8.5 % of the country's GDP in 2017 [5]. Energy demand in Jordan is also increasing in part due to the influx of 760,000 Syrian refugees into the country over the past years [6]. Renewable energy in Jordan is considered a lifeline for the country that imports most of its energy needs, amid the outbreak of the energy crisis because of the repercussions of the Corona virus and the Russian-Ukrainian conflict, which caused a significant increase in prices. In general, there has become an urgent need for countries, especially energy importers, to rely on a sustainable mix that includes renewable energy to protect these countries from market fluctuations.

Energy Situation in Jordan

Jordan is facing a high rate of population growth and urban expansion, and this growth and urbanization will increase the rate of energy consumption. As Jordan's population continues to grow and limited amounts of fossil fuels begin to diminish, it may not be possible to provide the amount of energy Jordan needs by using only fossil fuels for energy conversion [7].

Jordan imports more than 90 % of its total oil and gas needs to be able to meet its energy needs [8]. Jordan's imports of crude oil and its derivatives and mineral oils recorded about 1.767 billion Jordanian dinars (2.5 billion dollars), compared to 994.5 million dinars (1.4 billion dollars), during the same period last year, an increase of about 77 % [9]. Jordan seeks to reduce the fuel bill, as it has increased gasoline prices in a record manner in recent months, after the value of imports of crude oil and its derivatives increased by 49.1 % in the first quarter of this year, compared to the same period in 2021. Oil is the country's main energy source, consuming 52 % of the total consumption, followed by natural gas with 38 %. For this reason, in 2020, the Ministry of Energy and Mineral Resources launched the energy strategy for the years 2020–2030, which is based on diversifying energy sources and its forms, in addition to increasing the contribution of local energy sources to the total energy mix. The main axes

of the strategy were: security of energy supply, provision of energy at reasonable prices, reducing energy costs and sustainability, and increasing reliance on local resources. The strategy indicated that “work will be made to increase the storage capacities of oil derivatives by 20 % in 2030, in accordance with international standards. The strategy also focuses on improving the efficiency of energy consumption in various sectors by 9 % in 2030, in addition to improving energy efficiency in the water sector by 15 % in the year 2025 [10].

Energy data. Jordan enjoys one of the highest rates in the world in terms of importing energy from abroad, as it is estimated that more than 90 percent of the country’s energy needs come from the quantities of oil and gas imported from neighboring Arab countries. Figure 1 shows Jordan’s primary energy sources in 2018. It shows us that imported oil and natural gas share the largest 89 % of the total energy needs, and only 8 % of renewable energy [11]. The problem of securing energy sources such as oil and gas are considered one of the most prominent problems of Jordan, which has contributed to regional events in the region recently, in addition to the economic crises that have afflicted Jordan to an imbalance in its availability. For example, the import of Egyptian natural gas has stopped, following the events of January 2011.

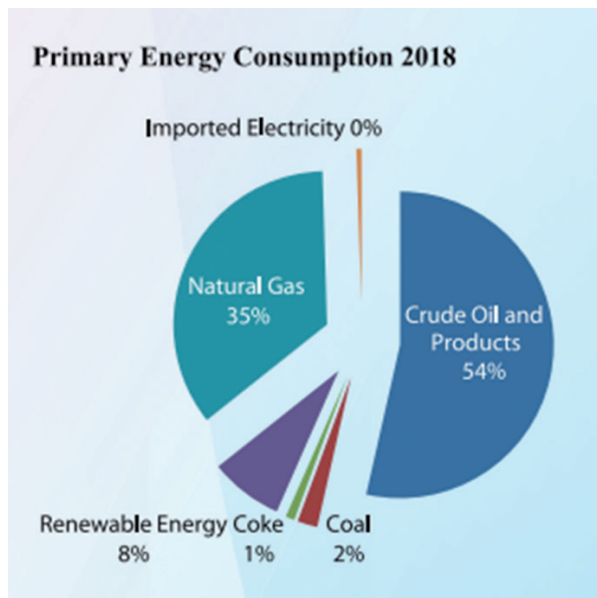


Fig. 1. Primary Energy Consumption

Source: MEMR, 2019 [11]

Energy consumption. Figure 2 represents the distribution of energy by different sectors in Jordan in 2016. This figure shows that the transportation sector contributes about 45 % of the total energy consumption. The domestic sector comes in second place in terms of importance, as its household energy by 23 %, and is distributed mainly between heating, cooling, lighting, and other uses, while the industrial sector comes in third place with 21 % [12].

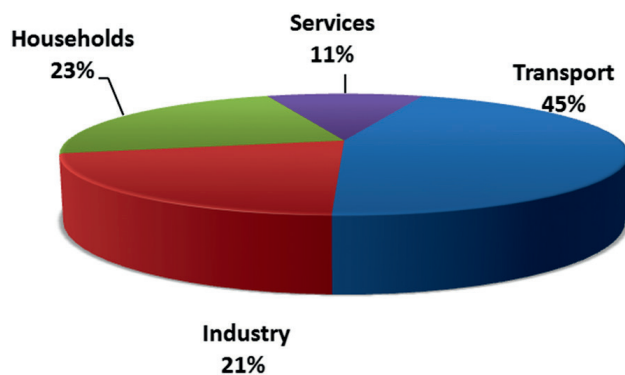


Fig. 2. Sectoral distribution of energy consumption in Jordan

Source: *Dar-Mousa et al., 2019* [12].

Renewable Energy Resources in Jordan

Jordan is considered one of the energy importing countries, which increases the ratio of imported energy to the gross domestic product and leads to great pressure on the balance of payments and the continued need for foreign currencies to finance the purchase of the state’s energy needs, which calls for the search for alternative sources of traditional energy [4]. High refugee influx, growing commercial and industrial sectors, and increasing imported fuel costs and the associated greenhouse emissions have made a clean, sustainable, and affordable energy supply a priority for the country’s decision-makers.

Having abundant resources is a crucial starting point for renewable energy development. Significantly affect the operational performance and financial feasibility of projects. Due to its geographic location, the most available renewable energy resources in Jordan are solar and wind energy, with potential also for bioenergy, hydropower, and geothermal energy [13].

1. Solar energy. Among the sources that are referred to by hands in the current conditions in solar energy, solar energy is the conversion of temperatures from sunlight through mirrors collected to them into electric volts in a way that maintains cleanliness and the environment instead of using oil in huge factories to operate them in what is known as generating electricity. Solar energy does not harm the environment with fumes and other wastes that are produced from factories, so many scientists have formed networks and manufactured them to be suitable for collecting and saving solar energy in special batteries and generators that convert solar energy into electrical energy, i.e., into volts. Jordan is blessed with a 5 to 7 kWh/m² direct solar radiation intensity and averages 310 sunny days annually [13], With very high rates of solar radiation, Jordan is among the most fortunate countries in the world to exploit this energy. Figure 3 shows the average annual solar radiation in Jordan during the period 1994–2010 in kilowatt-hours/m². During the past decade, many solar photovoltaic farms have been implemented in the country, and the installed solar energy capacity is currently 2,063 MW, which is 20 % of the total electric energy consumed in Jordan [14].

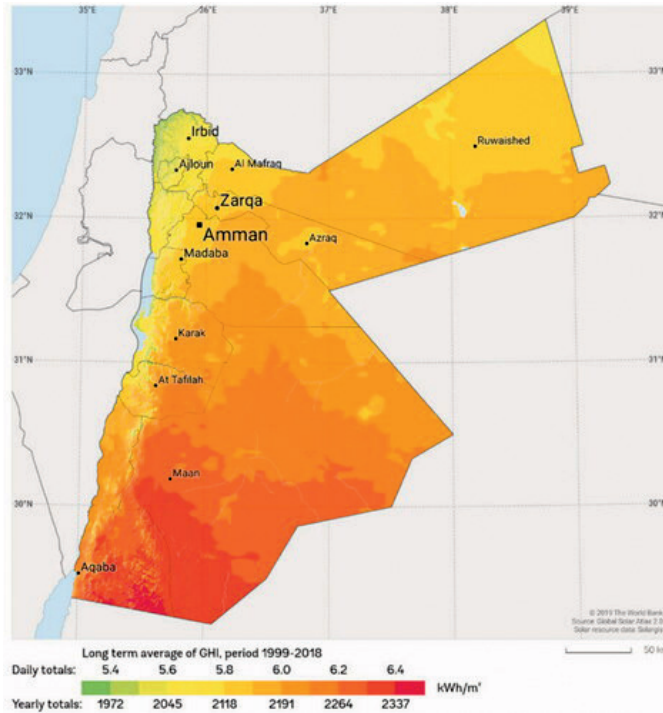


Fig. 3. Map of long-term average of Global Horizontal Irradiation for Jordan (kWh/m²)
 Source: *Shatnawi et al., 2021* [14].

Jordan relies on solar energy as a major alternative source of energy, in order to meet its energy needs and to have the largest role in securing energy instead of other sources. This is evident from the increasing reliance on solar energy in the production of energy needed for various sectors in Jordan. Figure 4 also shows us the role of solar energy in energy production in Jordan, where the maximum participation in 2019 was about 1,100 megawatts [3].

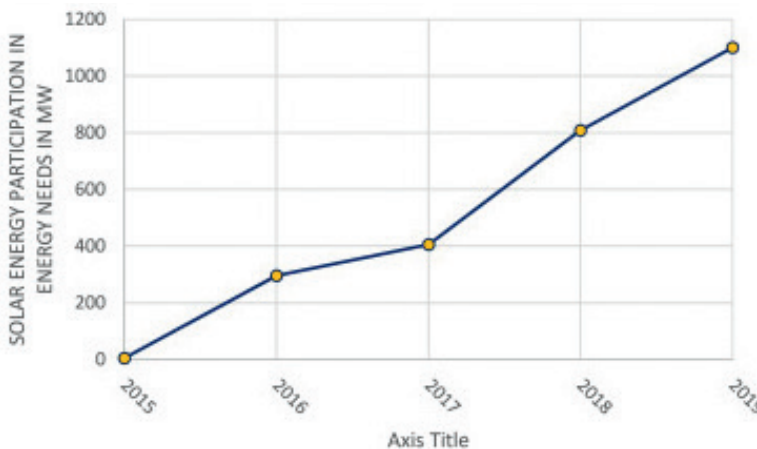


Fig. 4. Solar energy participation in Jordan energy needs
 Source: *Alwashdeh, 2022* [3]

2. Wind energy. Wind is a clean and inexhaustible resource that is used to produce energy, and wind energy is energy extracted from the kinetic energy of the wind by using wind turbines or turbines to produce electrical energy, it is one of the types of electromechanical energy. Wind energy is one of the types of renewable energy that has been widely used as an alternative to fossil fuels. It is abundant and renewable energy and is found in all regions [15]. Jordan’s investment in wind energy as a renewable source of electricity production began in 2015, with the opening of the first 117 MW project in the Al-Tafilah region; It is rich and distinct from the rest of Jordan in terms of wind speed and direction. According to the annual report of the World Wind Energy Council (GWEC), Jordan ranked third in wind energy production in 2019, with a production of 190 megawatts. Renewable energy programs are the right choice for the Kingdom. Lack of hydrocarbon resources and scarcity of water with wind and sun energy [16]. Relying on the values of wind speed in Jordan, it became clear to us that wind energy is one of the most types of renewable energy that can have an effective role in alleviating energy problems in Jordan. As wind energy contributes to covering the energy required for various sectors in Jordan as shown in Figure 5. The maximum participation of wind energy in 2019 was about 400 MW [3].

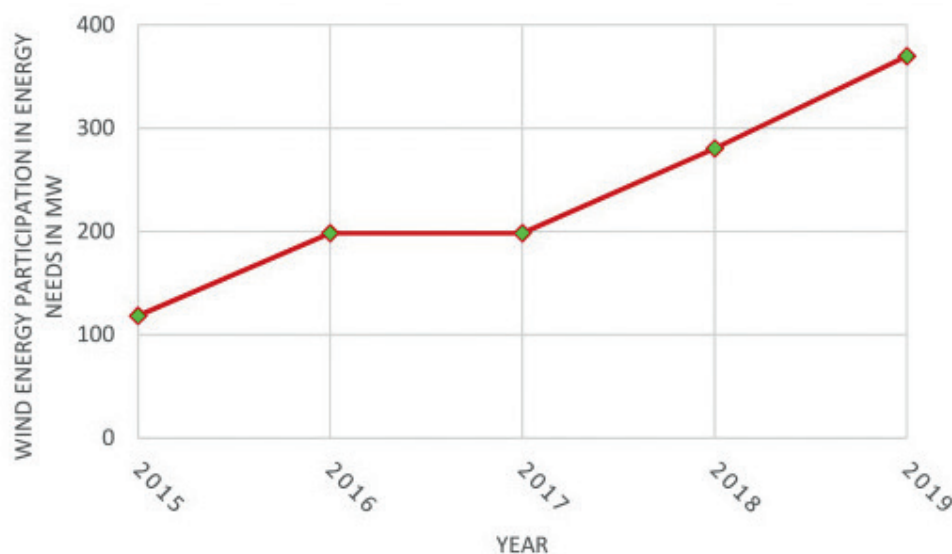


Fig. 5. Wind energy participation in Jordan energy needs
 Source: Alwashdeh, 2022 [3]

Figure 6 shows the average annual wind speed in Jordan measured at a height of 100 meters ranging from 6 to 8 meters per second (m/s), and these high values of wind speed make several locations in Jordan suitable sites for wind-power projects [14].

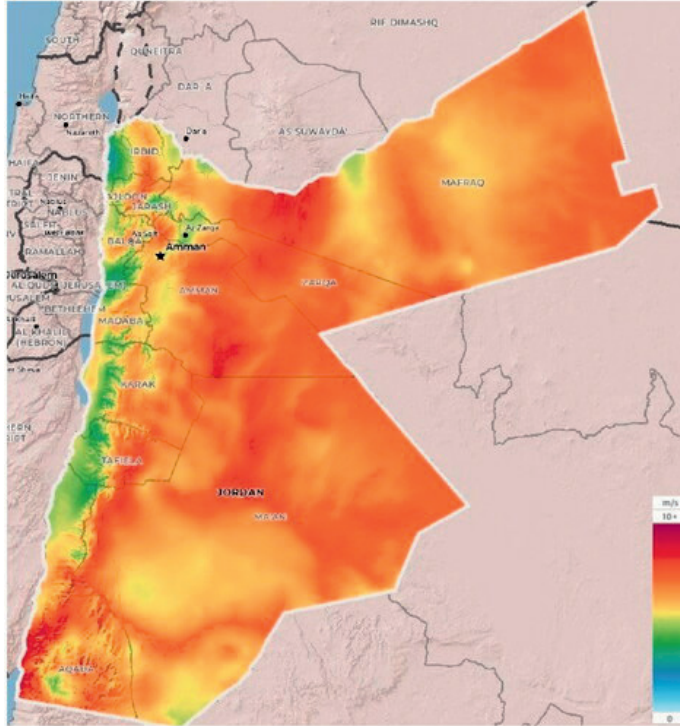


Fig. 6. Mean wind-speed map of Jordan

Source: Shatnawi et al., 2021 [14]

3. Hydropower. Hydropower is a renewable electrical energy that results from the conversion of hydroelectric energy into electricity. The kinetic energy of the water current, natural or resulting from a difference in level, is converted into mechanical energy by a hydraulic turbine, and then into electrical energy by a synchronous electric generator. Jordan is known to lack flowing bodies of water, which can be used to build hydroelectric power stations in vast areas. In Jordan, there are only two small hydroelectric power stations, one in the King Talal Dam in the northern region of the country, which has an annual generating capacity of 7 megawatts, while the other hydroelectric power station is in the thermal power station in Aqaba and generates 6 megawatts [17]. In 2018, the two plants produced 60 gigawatt-hours of electricity, which represented 0.4 % of the electricity generated in Jordan [11]. The elevation difference between the Red Sea and the Dead Sea also provides a potential water resource of 400–800 MW, which can be exploited via the proposed Dead Sea Red Sea Canal Project [17].

Conclusion

We can summarize that Jordan is a poor country in terms of traditional energy sources, and this directly affects its energy needs for various sectors. It is also known that the demand for energy increases year by year, with the increase in population growth and the increase in the number of establishments and industrial sectors. In addition, Jordan has hosted many of Syrian refugees

in recent years, as well as the negative repercussions of the Corona pandemic, as well as the Russian-Ukrainian conflict, all of which have had negative effects on Jordan's energy security.

That is why Jordan seeks to diversify its energy sources, to find other means to meet its energy needs, and this, of course, depends on renewable energy. To this end, the Ministry of Energy and Mineral Resources launched the energy strategy for the years 2020–2030, which is based on diversifying energy sources and forms, in addition to increasing the contribution of local energy sources to the overall energy mix. The main axes of the strategy were: securing energy supplies, providing energy at reasonable prices, reducing energy costs and sustainability, and increasing reliance on local resources.

Jordan has abundant local resources of renewable energy, especially solar and wind energy. Jordan is blessed with a direct solar radiation intensity of 5 to 7 kWh/m² and an average of 310 sunny days annually, which makes this type the first and most important candidate for use to meet the Kingdom's energy needs. In second place is wind energy, which is also widely available in Jordan and is used to produce energy. Relying on the values of wind speed in Jordan, it became clear to us that wind energy is one of the most renewable types of energy that can have an effective role in alleviating energy problems in Jordan. Wind energy contributes to covering the energy required for various sectors in Jordan. We see that Jordan is striving to adopt new projects in the exploration and development of local renewable energy sources, with the aim of increasing self-reliance in the issue of energy security. If the share of renewable energy has increased over the past decade to reach about 20 % of the total electric energy mix, it is expected to reach 30 % by 2030.

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Возобновляемые источники энергии и государственная стратегия развития энергетического сектора в Иордании

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Аннотация. Энергетика и энергетическая безопасность — стратегическая цель для разных стран мира, ведь энергетика — важная составляющая жизни. Поскольку энергетическая проблема постепенно обостряется во всем мире, особенно со значительным увеличением спроса на нее, ожидается, что этот рост в предстоящий период станет еще выше из-за роста населения и увеличения количества различных производственных и сервисных предприятий. В настоящее время большинство стран стремится рационализировать потребление энергии и искать альтернативы ее источникам. Отсюда повышенный интерес к альтернативным источникам энергии. В этом исследовании были определены источники энергии и их альтернативы в Иордании для того, чтобы получить адекватное представление о том, что доступно в этой стране из энергетического сектора. Иордания является одной из бедных стран с точки зрения традиционных источников энергии и одной из наиболее пострадавших от высоких цен и нехватки производства сырой нефти и других энергетических компонентов, а также от их негативных

последствий для экономики страны, поскольку Иордания импортирует нефть и природный газ из соседних стран, что обеспечивает 90 % ее потребностей в энергетике и составляет примерно 8%–10% ВВП. В этом исследовании делается попытка проанализировать существующие источники энергии в Иордании с целью изучения способов улучшения энергетической ситуации в этой стране за счет увеличения использования альтернативных возобновляемых источников энергии, таких как солнечная и ветровая энергия, вместо использования импортируемых нефти и газа.

Ключевые слова: развитие, стратегия, энергетическая безопасность, возобновляемые источники энергии, солнечная энергия, ветровая энергия, Иордания

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