

## Renewable Energy as a Solution to Meet the Growing Demand of Energy in Jordan

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**Abstract:** The objective of this work, is to assess the potential of Jordan's renewable energy resources, particularly Solar, Wind and Hydro power, through the development of, local climate data sets in most geographical regions, in order to bridge the gap in the growing demand for energy, as well as, to know the role of the Jordanian government to promote, and invest heavily in renewable energy. Various conclusions such as: Jordan's phenomenal population growth as well as an increase in the urban population, has led to an increase in the demand for energy, required to maintain modern life. Furthermore, the crisis in the Arab world, especially the countries surrounding Jordan, as the Syrian and Iraq crisis of displacement, led to an increase in demand for energy. If have been utilization all replacement energy sources, for this reason will become price of residential electricity lower, Jordanian economy will improve, the industry will be competitive, it will add a significant shift in the transport sector, Transportation is becoming more accessible and affordable. In the midst of these challenges, a new concept is emerging called smart energy, which is concerned mainly with the distribution of energy, through the coordination of supply and demand, and achieve a balance between them.

**Keywords:** Renewable energy, Energy, Jordan

Date of Submission: 13-11-2019

Date of Acceptance: 27-11-2019

### I. Introduction

Energy and its resources, are the concern resource of all countries, around the world. Energy is the pole of the economic, and social development process. Recently, this interest in energy has increased, due to the increase in the rate of global economic growth. In addition, to the entry of many countries of the world, in the industrialization field, which is considered as, one of the main energy entries. As a result, the need for energy, rose more than the rate of increase in supply. According to above, it is impossible, to envisage a modern economic life in the absence of such resources.

Because of increased energy consumption, the world's countries, seek to meet their growing energy needs, scientists and experts have warned that the world can be exposed to a real energy crisis. They also warned against excessive accreditation on fossil fuels. Since its incremental consumption led to another problem, in its limited reserves, and the burning of this fuel, caused harmful pollution to the environment.

Energy is considered, the most important problem facing Jordan today. Because, Jordan nearly lacks domestic supplies of power, it buys about 96% of its used power. This dependency on oil coming from abroad, would consumes the bulk of the Jordan's GDP which is 18% yearly. In addition, Imported energy, provides an average of 88% of producing electric energy in Jordan.. As a result, the national treasury, disbursed millions for this purpose, besides burdening the country, with a high energy bill. In view of these circumstances, Jordan makes serious efforts in order to achieve its energy demands [1].

Jordan government, revealed the Energy Master Plan that attempts to improve the sector of energy, investing about \$18 billion. This plan, highlighted the importance of appreciating energy and saving it. Moreover; it stressed making the consumption of local energy supplies particularly Oil Shale, as large as possible, raising the current rate of 4% to 40% by the end of this plan in 2020. It was suggested to improve and encourage programs of renewable energy [2].

Fossil fuel, is the main pillar of energy generation in Jordan. Import fossil fuels is a major financial burden, which consumes about 40% of Jordan's budget [2]. The political situation has become unsafe, in the Middle East as a whole, which could affect Jordan's access, to the amount of energy the country needs, from outside the region. Where Jordan depends, on import oil from Iraq, and natural gas from Egypt, which is delivered through the Arab gas pipeline, passing through Sinai and Syria. Due to the existing political conditions in the Sinai and Syria, the import of natural gas decreased from 89 billion cubic feet, to 17 billion cubic feet, resulting in an increase in oil consumption. This change negatively affected Jordan, where the power plants were modified to burn oil, and bear losses of approximately \$ 5 billion [3].

The objective of this work, is to assess the potential of Jordan's renewable energy resources, particularly solar, wind, and hydro power, in order to bridge the gap, in the growing demand for energy, as well as, to know the role of the Jordanian government, to promote, and invest heavily in renewable energy.

## **II. Background**

There is a worldwide attention, in research in the area of renewable energy. Recently, there has been a significant number of research activities, that have highlighted the renewable energy potential, in various countries. Jordan struggles to secure its resources of energy. In addition, it spends a significant fraction of its budgetary, on importation of oil from different nations. This fact drove the decision makers in Jordan, to shift to renewable energy sources.

As stated in study [4], Jordan depends on foreign resources of energy. Therefore, energy remains number one problem in Jordan. Renewable energy consumption, contributes to accomplish lasting improvements, by combating pollution and achieving economic progress. Moreover; using renewable energy instead of fossil fuel can help in protecting the environment from harmful kinds of contamination. Investing in this kind of energy can help Jordan in reducing its petrol imports and providing new jobs. Although much attention has been paid to the improvement of renewable energy supplies, the use of this power is still at a low level.

The present possibilities of different renewable energy resources in Jordan were studied by [4]. The study demonstrated that a significant portion of electrical load in Jordan is depreciated, when the solar energy is competently utilized. Also. The study, showed that Jordan faces high energy demand that is, anticipated to further rapidly, in the immediate prospective, due to the rapid increase, in its population. This fact urged the Jordanian government, to shift to renewable energies.

In another study [5], the possibilities of using solar and wind energy resources in the biggest cities was evaluated. The study, concluded that Jordan has a very well possibilities for each of wind and solar energies, and that Jordan government, is invited to take part in evolution and installation of renewable energy projects, owing the Jordanian abundance of renewable energy resources, which indicates that the wind and solar electricity generation are able to meet a huge fraction of the daily electricity demand in Jordan.

In a recent study [6], Analysis of Strengths–Weaknesses–Opportunities–Threats (SWOT) was presented by the Young Ecosystem Services Specialists (YESS) member surveys. Strengths describe models that integrate specialties, and are a beneficial liaison tool. Weaknesses describe an imperfect scientific regulation, inconsistent implementation of the spectrum, and compute for the substantial value of nature. Opportunities include harmonization with formed policies and methodologies, and increased environmental consciousness. Threats describe confrontation to change and challenges to multidisciplinary cooperation.

In 2018 A recent study [7], discussed how Indonesia attempts to improve its economic situation by exploiting the available energy, as energy take a key part in economic growth which can also enable Indonesia to compete in the global market. Also, targets for examining the possibility to move toward renewable power by decreasing the reliance on fossil fuel pour to guarantee uninterrupted availability of domestic energy sources over the long run. Moreover; the study is based on using SWOT tool.

As a summary of previous studies, it shows the importance of the exploitation of renewable energy and the need to establish immediate projects to develop the renewable energy sector. In addition to the experiences of other countries with regard to conducting feasibility studies for the implementation of various projects carried out by Countries around the world. It can also be concluded that Jordan is under enormous pressure and challenges to meet demand for all types of energy, especially the urgent need for electricity. It should be noted that the energy sector needs to develop in a way that limits the production of negative impacts, whether it affects the environment, economy or public life. Sustainable and clean energy sources have been used instead of rapidly depleted fossil fuels and their adverse effects on the environment. Renewable energy sources, which are eligible for the sustainable developmental of the energy in Jordan. With the efforts of the Government of Jordan, all legal obstacles have been eliminated by introducing some laws such as the Renewable Energy and Energy Efficiency, It follows from that, the Jordanian market is fully prepared to benefit from renewable energy sources in various economic fields.

## **III. Renewable Energy In Jordan**

In recent years, Jordan has achieved significant achievements in various fields, including the achievements of renewable energy, where the production of this energy increases each year in a row, and the amount of renewable energy production at the end of 2006 was approximately 927 GW h, Equivalent to five per cent of total electricity generated in Jordan from various sources renewable energy. According of words to Dr. Ayoub Abu Dayyeh, head of the Jordan Green Energy and Energy Studies Office. As a result of this continuous growth in produce of renewable energy in Jordan, the amount energy imported from abroad has declined. Jordan

imports two years ago 97% of its energy needs, but now it imports 95% . The renewable energy is considered for Jordan "reality and the future" [8].

Table 1, shows the energy consumed using renewable energy in Jordan. The table shows that the rate of consumption of renewable energy in Jordan is increasing, this is a good indicator, to rise exploitation of renewable energy in Jordan and reducing the import of energy and thus improving the economy of Jordan [8].

**Table 1: Energy consumed using renewable energy in Jordan**

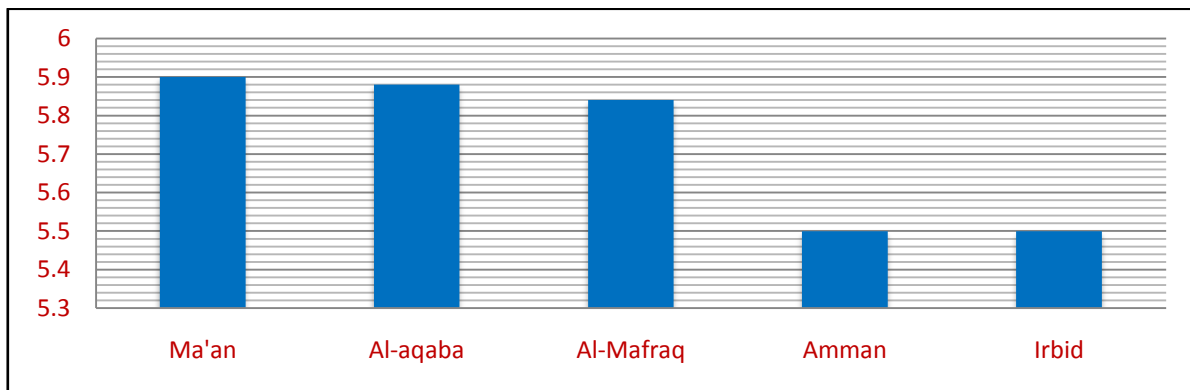
Year	Quantity of consumption ton oil equivalent. (Toe)	Year	Quantity of consumption ton oil equivalent. (Toe)
2000	75	2001	76
2002	79	2003	77
2004	82	2005	83
2006	111	2007	118
2008	128	2009	137
2010	141	2011	146
2012	140	2013	145
2014	152	2015	160
2016	412	2017	515

Table 2, shows energy consumed using solar energy in Jordan, from 2007-2017. It is clear from the table that, the rate of solar energy in Jordan is increasing continuously. This is a good indicator through which solar energy may be exploitation for producing electricity and into many fields in Jordan [8].

**Table 2: Domestic production of solar energy from (2007-2017)**

Year	Domestic production(ton)	Year	Domestic production(ton)
2007	100	2008	110
2009	120	2010	124
2011	130	2012	140
2013	145	2014	152.1
2015	159.1	2016	162.5
2017	168.4		

Figure 1 shows annual radiation in the main cities of Jordan: It is clear from the figure that, the solar radiation in Ma'an is 5.9 kW/m<sup>2</sup>, which is the maximum, followed by Aqaba, Mafraq, Amman and Irbid at a rate of 5.88 kW/m<sup>2</sup>, 5.84 kW/m<sup>2</sup>, 5.5 kW/m<sup>2</sup> and 5.5 kW/m<sup>2</sup>, respectively.



**Figure 1: Solar irradiance of selected cities (KW/m<sup>2</sup>) [9].**

Table 3, shows the amount electricity generated from solar energy in Jordan [8]. It is clear from the table, that the amount of electricity produced, in a significant increase. In 2015 was 1.6 GW h while rising in 2017 to 591.3 GW h, and these increase in the amount of electricity produced is will rise in the years after [8].

**Table 3: The electricity generated (GW h) from solar energy in Jordan**

Year	The amount of energy generated
2015	1.6
2016	267.3
2017	591.3

Table 4, shows the average wind speed in various cities in Jordan. Based on cities selected, Aqaba has the highest wind speed and the average wind speed is 7.63 m/s, thereby, building a larger number of wind farms

in Aqaba, although other the cities have a lower wind speed, but it is suitable for the establishment of wind mills to generate electricity. And so Jordan is characterized by areas with high wind speed, can be exploited in power generation, in the mountain areas, the wind speed approach 11.5 m/s [8].

**Table 4:** Average wind speed (m /s)

City	Average wind speed
Aqaba	7.63
Irbid	6.65
Al-jfoor	6.93
Al-Mafraq	6.35
Al-Ijfive	6.37
Al-Azraq	6.37
Al-jafer	6.12
Al-hasa	6.35

Table 5, shows the wind energy projects implemented (2015-2018) [8]. These projects are within the first stage. The total cost of these projects is 830 million J. D [9].

**Table 5:** Wind energy projects that have been implemented (2015-2018)

Wind farm	Cost in million J. D.	Number of turbines	year of establishment	electricity produced annually (GW h)
Tafileh	287	38	2014-2015	400
Ma'an	148	40	2016	200
Al-Fujij	150	35	2018	350
Al-Rajef	130	41	2018-2016	315
Shobak	115	13	2018	170

Table 6, shows the amount of wind energy generated in Jordan from 2000 to 2017 according to the statistics of the Electricity Department. It is clear from the table that, the amount of energy generated in Jordan from 2000 to 2012 in nearly stable. The maximum energy generated is in 2017 that is equal to 449.2 GW h. It is clear from the table that, the amount of wind generated in Jordan is rising each year, and this is a good indicator to Jordan, the greater the amount of wind generated, the greater the amount of electricity production, the less classical fuel used [10].

**Table 6:** Wind energy generated in the Jordan from 2000-2017.

Year	Energy produced (GW h)
2000-2012	3
2013	2.6
2014	2.4
2015	123.1
2016	390.7
2017	449.2

Electricity production, from solar and wind energies will provide 50 times more electricity demand in 2050. At the end of 2015, 15 renewable energy station were used from wind, solar and biomass. [11]. Jordan has large amounts of renewable energy, this energy if been exploited appropriately by specialists and investors, Jordan is able to produce 100% of electricity and thus add \$12 billion to the state treasury [12].

#### IV. Results And Discussions

Due to Jordan's open economies and its upper level of territorial complementary, Jordan is more confrontational and susceptible to economically and domestic conflict. The political differences that have affected the Arab regions have greatly affected the Jordanian economy, the living conditions and the need of local citizens to meet their needs and services.

Renewable sources of energy are the most heavily capitalized capital, if they have been exploited and applied properly, of the highest variables, that affect on indicative prices are: investment size, ability factor and interest rate. These three factors will be different in each project than others, according to parameters like project site and working conditions, meteorological condition, applied technology and capital strength of promoters.

The Jordanian environment, as well as mapping, and identification wind speed and solar radiation in all regions of Jordan. The renewable energies exists in Jordan and the potential that is available, the Jordanian state possess geographical benefits, these benefits may be exploited to build permanent substitute energy, like solar, wind, and hydro energies. But it was regrettable because the government did not administration these resources fully until this time. Jordan's renewable energy potential is wonderful and available and there are immediate

opportunities to increase the production of clean energy for the environment. If have been utilize all replacement energy sources, will become price of residential electricity lower, Jordanian economy will improve, the industry will be competitive, it will add a significant shift in the transport sector. Transportation is becoming more accessible and affordable, as a result of by the proliferation electric vehicles to be established at that time.

SWOT analyzing possible performed as a section of Strategy Planning.. In the event of such analysis, the strengths will be identified and take advantage from them and employ them in the appropriate manner as well as exceed weaknesses by eliminating or addressing them.

SWOT implemented in the event an assessment the work of any company, institution or otherwise, and this assessment is either internal problems such as strengths and weaknesses, or outer aspects like opportunities and threats and therefore, if any cause is known to affect performance and production from internal or external factors, will give greater clarity on areas of success and failure. This clarification makes it possible to set goals and activities to achieve the following: intensify and strengthen strengths; to identify weaknesses by exceeded from them or to develop solutions to them; take advantage of and exploit opportunities; and prepare for threats to prevent or confront them.

The analysis of SWOT, can give project developers with alerts and tips at any phase of the work [12,13]. This analysis can be utilize to: Explore the capabilities of new opportunities, make resolutions about the finest method for a project: the developer is visible to trends and choices when he identifies opportunities for success under threats to success. Locate possible change: If a project study is at a crossroads, strengths and weaknesses, it can refer most essential and capabilities, and amendment and correction of schemes during the project phases: a new opportunity may open to the project developer broader prospects, while a new threat may lock a trajectory previously. The analysis of SWOT offers a simplistic way to connect project developments with a privileged.

Among most important measures followed by the Jordanian government in collaboration by the Ministry of Energy and Mineral Resources In 2012, a law was issued, (Renewable Energy and Energy Efficiency Law). The objectives of this law is introducing the organizational structure into renewable energy and energy efficiency events, supporting strip special investments, shaping energy sources in Jordan, and building a renewable energy and energy efficiency fund. This Act is starting point for renewable energy projects and private sector participation.

Table 7, shows the results of SWOT analysis of the possibility of developing solar energy,

**Table 7: SWOT analysis for solar energy**

Strengthens	Strengthens	Opportunities	Threats
Jordan's strategic location is constituting a regional hub for future communications, it is characterized by high average solar radiation directly.	The electrical grid must be developed to be a smart grid.	There are actors ready to adoption renewable energy projects, and give them full funding,	Absence of a sufficient awareness of how to apply the different of solar energy technologies.
The political stability in Jordan, where it had developed a major of the main renewable energy plan within specific objectives. their main goal is to reduce the demand for energy needed from abroad, with a view to obtaining 10% of the domestic renewable energy production in Jordan	Some important solar energy technologies are not widespread in Jordan and still have very high cost.	Jordan is joint in electrical with Syria and Egypt. Plans are under way to extend electrical connectivity with six countries, which allows Jordan to participate with the Gulf countries to harness the areas most vulnerable to sunlight	There is a permanent negative view of renewable energy resources, this view includes the fact that renewable energy investments are uncertain, and surrounded by hazard on the one hand Jordanian.

Table 8, shows the results of SWOT analysis, of the possibility of developing wind energy, as a renewable energy in Jordan. The table shows that there are a range of strengths, weaknesses, threats and opportunities . The availability of wind power is one of the most important strengths for the development of renewable energy projects in Jordan.

**Table 8: SWOT analysis for wind energy**

Strengthens	Weakness	Opportunities	Threats
The abundance of wind energy, in the absence of availability of other commercial sources of fossil fuels until this time. There are a lot of graduate engineering studies and a masters for using wind energy as renewable energy.	Despite the use of old technologies, the initial cost of wind energy projects is still very high, and that meant to the capital investment.  Lack of integrated planning among the institutions concerned which have a role in approving wind energy projects and licensing them.	There are a number of wind energy projects under development and a number under implementation  The development of economic and social aspects in Jordan includes rural areas, where the majority of wind energy is located in these areas	Weak in management of funding for scientific research projects, specialized in wind energy.  Lack of domestic funding, and most of the funding of projects from outside Jordan, due to the instability of the weather in Jordan.

Despite the foregoing points, there are weak points and challenges facing the application of wind energy and exploitation in Jordan, such as the use of old technologies because the initial cost of wind projects is still very high, in addition to the lack of integrated plans between the institutions involved in the role of approving projects Wind power and licensing.

In terms of opportunities, there are a number of wind power projects under development and the number under development includes the development of economic and social aspects in Jordan rural and desert areas where the majority of wind energy is located in these areas. It also faces threats such as weak management of wind energy research projects and poor local funding for energy projects in Jordan, where most of the funding is still from outside Jordan.

Table 9, shows the results of SWOT analysis of the possibility of developing Hydro energy as one of the types of renewable energy in Jordan. The table shows that there are a range of strengths, weaknesses, threats and opportunities . The abundance of water resources in Jordan is considered one of the most important strengths for the development of hydropower projects in it. The presence of hydropower resources in a good way meets the continuity of production of electric power and other types of energy such as thermal. In contrast, the lack of intelligent technologies with sufficient knowledge of the use of different hydropower technologies is a weak point in the development of these projects. Hydropower technologies along with other renewable energy systems may also have high material costs in Jordan.

**Table 9: SWOT analysis for hydro energy**

Strengthens	Weakness	Opportunities	Threats
Abundance plenty of Water areas, to establish Hydro energy projects	Absence of intelligent techniques that have sufficient knowledge about the use of various Hydro energy techniques.	The presence of Hydro energy resources as good well that meet the continuity of electricity and other types of energy such as thermal and other.	The presence of Hydro energy resources as good well that meet the continuity of electricity and other types of energy such as thermal and other.

## V. Conclusions

The following conclusions can be drawn from this study:

1. Jordan's phenomenal population growth of 2.2%, as well as an increase in the urban population, has led to an increase in the demand, for energy required to maintain modern life.
2. If Jordan utilize renewable energy available, the price of residential electricity lower, Jordanian economy will improve, the industry will be competitive, it will add a significant shift in the transport sector, Transportation is becoming more accessible and affordable.
3. Jordan needs renewable energy generation pour, to face the rise in prices, rather than relying on imported energy, incumbent status is a perfect ecology, to the development of renewable energy sources, which contain photovoltaic energy projects, wind, and small hydroelectricity, that financial and technological their requirements may be serve.
4. The cost of renewable energy, is highly competitively versus other energy sources, and renewable energy excavation was grew quickly; It also concludes, that there is renewable energy that become option, for persons who understand and care about environment.
5. There are many weaknesses, that affect the support of renewable energy in Jordan. The most important factors are: the insufficient funding, for energy projects, the limitations of renewable energy infrastructure, the limited number of experts, in the field of renewable energy, Jordan's lack of ability to adjust arrangements with private investors.

## VI. Recommendations

1. Development of energy efficiency, to demand side include: Stimulation of structural differences in the industry sector, with the promotion of energy-saving industries, the development of energy efficiency programs and awareness of renewable energy, and the integration and participation of energy efficiency goals with public policies to reduce poverty and support financial system.
2. Reducing energy prices, which is a positive point. It would greatly enhance the functional, and developmental situation of energy operators and producer and will provide a great incentive for energy conservation among all energy consumers.

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Eman J. Al Tarawneh. "Renewable Energy as a Solution to Meet the Growing Demand of Energy in Jordan." *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)* , vol. 16, no. 6, 2019, pp. 37-43