

INVESTIGATION OF WIND ENERGY IN JORDAN

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ABSTRACT

This paper investigates the status of wind energy in Jordan and illustrates the number and the type of the operating wind farms and its share in the total generated power. In addition, it elaborates on the advantages and disadvantages of using wind energy in electrical power generation. Attention is especially drawn to the setting of ambitious targets as well as successful implementation strategies for using wind energy.

KEY WORDS

Wind energy, wind farm, power generation, clean environment, green energy, Jordan.

1. Introduction

Jordan imports approximately ninety seven percent of its primary energy, of which thirty percent is used to generate electrical energy [1]. Renewable-energy sources are becoming more and more attractive especially with the great uncertainty of oil prices. Also, studies show that the oil depletion point has been reached in 2006 [2]. This is a direct result of consuming oil much faster than it is naturally produced. Since formation of new petroleum is a complicated geological process takes millions of years. In addition, energy demands are increasing at alarming rate as shown for example for the electrical energy in Jordan in figure 1 [3: 10].

In the last two decades, the steep development in the industrial, tourism services, commercial and population sectors in Jordan increased such increase in electrical energy demands. For example, the maximum demand of the electrical power at the evening periods in April, 2007 was 1715 MW with 14.33% more than April, 2006. These imposed extra efforts on the electrical energy supplier to meet the maximum required power demands that increase annually by 3.5% [3].

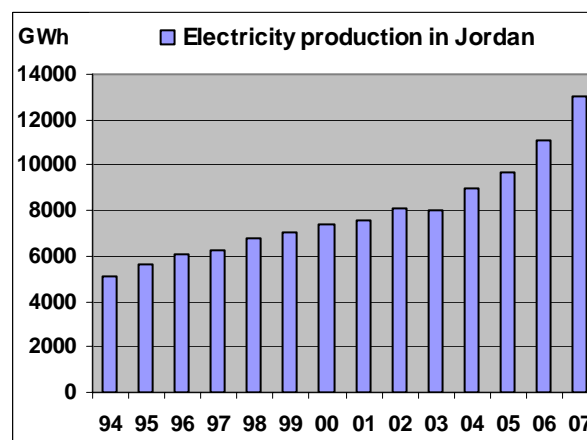


Figure 1: Electricity production in Jordan

Since fossil fuel resources discovered locally are limited and most of the electrical energy in Jordan is generated using imported oil and gas; the Jordanian government gave a special attention towards renewable energy, especially the wind energy. In 1987, an intensive program was created to motivate using wind energy in electrical energy production.

Nowadays, eight wind energy stations are used in different locations distributed from north to south. Only two of them are connected to the main power grid. All these stations were funded and constructed by foreign donations.

The ambitious Jordanian wind energy program collides with many obstacles; especially high initial and production cost, low quality of produced power and low reliability. These obstacles inhibited the zeal toward using wind energy and forced power producers to find other solutions to meet the increasing power demands; like power tie lines with Egypt and Syria.

Even the alternative solutions used to meet the highly increasing demand on electrical energy have their own disadvantages. These disadvantages gave a new hope for the wind energy to be again a possible solution for the power energy increasing demand in Jordan. In this paper, a set of recommendations are introduced to customize

using wind energy in Jordan; in order to overcome its disadvantages.

2. Wind Energy

The idea of exploiting wind energy in Jordan came out of two reasons: the increasing electrical energy demands and the availability of wind energy resources. The growth of economic sectors has shown considerable improvements in the last two decades and such improvements were accompanied by growth of demand for the electricity. The growth rate of the electrical peak load between years 2001 and 2006 was 51.8% [3]. This steep growth rate doubled the bill of energy consumption.

The energy cost at year 2008 is the highest, because of the sever increment in the fossil fuel prices. Both fossil fuel prices and the electrical energy demands will increase in the next few years, where the expected electrical peak load at year 2020 will be around 3910 Mw with 110% more than year 2006 [3].

On the other hand, Jordan possesses high potential of wind energy resources where the annual average wind speed exceeds 7 m/s (at 10 m height) in some areas of the country [11]. Eight main wind farms are used for electricity generation in Hoffa, Al-Ibrahimiyya, Ras Muneef, Shammakh, Safawey, Umari, Twaneh, and Al-Jafr. The total electricity generated using wind energy is 3 GWh, which forms less than 0.04% of the total electricity generated in year 2007 [3].

The wind speed at all these locations is highly fluctuating, and so the generated output power. Figure 2 and Figure 3 show the wind speed and wind output power, respectively in Hoffa, Ras Muneef, Shammakh, Safawey, Umari, Twaneh, and Al-Jafr [11].

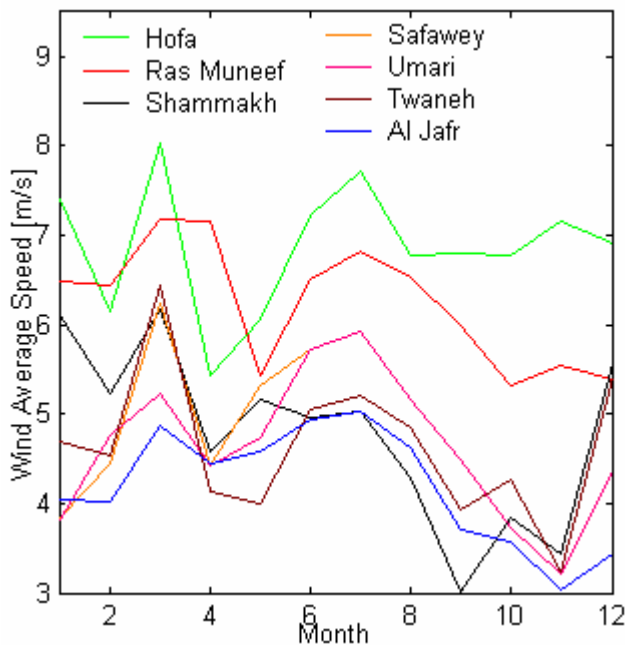


Figure 2: Wind speed in Hoffa, Ras Muneef, Shammakh, Safawey, Umari, Twaneh, and Al-Jafr.

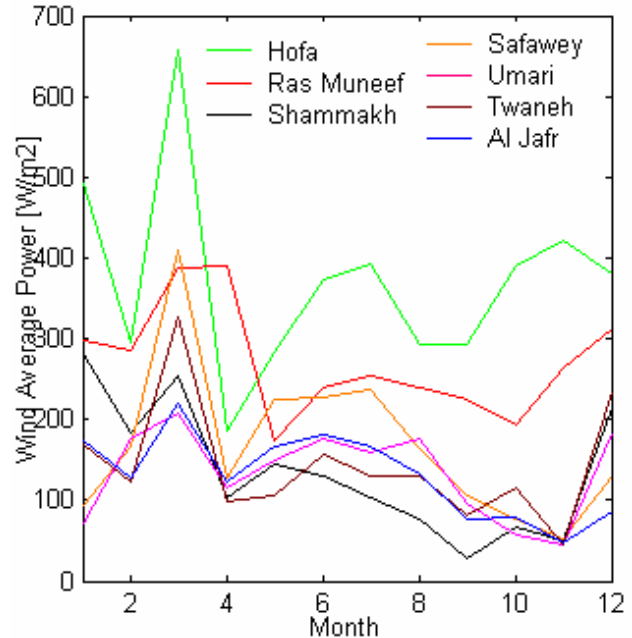


Figure 3: Wind power in Hoffa, Ras Muneef, Shammakh, Safawey, Umari, Twaneh, and Al-Jafr.

The unstable wind speed increases the complications against using wind energy in power generation for various reasons: first intermittent nature of the wind makes wind energy unreliable power source. Second to overcome fluctuation problem, the electrical power must be stored in DC batteries then inverted to AC voltage using inverters. Such process will increase the generation cost. Third, using inverters and switching devices produce harmonics in the grid and reducing harmonics levels requires extra components and imposes extra cost on the generated power.

Accordingly, only two wind farms are connected to the grid in the northern part of the country; one with capacity of 320 kW in Al-Ibrahimiyya, consisting of four wind turbines of 80 kW each, established in 1988 in co-operation with a Danish firm [11]. The other most recent one, has a capacity of 1125 kW in Hoffa, consisting of five wind turbines of 225 kW each, established in 1996 in co-operation with the German government [12].

In 2008, wind power produced about 1.5% of worldwide electricity usage [15]. In Table 1, we have selected top wind-energy producers with amount of energy produced and its percentage in the energy mix, where Denmark is leading this effort and is producing around one fifth of its energy needs from wind power. In Jordan, we are still far away from these countries and wind energy generation has insignificant part of the mix.

Country	Wind power (TWh)	Percentage of wind to the total energy mix
United States	52.0	1.3%
Germany	38.5	6.6%
Spain	31.4	11.1%
China	12.8	0.4%
Denmark	6.9	19.1%
Portugal	5.7	11.3%
Jordan		Insignificant
World total (TWh)	260	1.5%

Table 1 Wind power produced worldwide

Table 2 [15] below illustrates the installed wind-power capacity in the last four for some selected countries. We have some Arab and other neighboring countries that is making good strides in this area, and this should motivate us to follow their footsteps.

Country	2005	2006	2007	2008
United States	9,149	11,603	16,819	25,170
Germany	18,428	20,622	22,247	23,903
Spain	10,028	11,630	15,145	16,740
India	4,430	6,270	7850	9,587
Denmark	3,132	3,140	3,129	3,164
Japan	1,040	1,309	1,528	1,880
Turkey	20	65	207	433
Egypt	145	230	310	390
Morocco	64	64	125	125
Iran	32	47	67	82
Rest of Africa & Middle East	52	52	51	56
World total (MW)	59,024	74,151	93,927	121,188

Table 2: Installed wind-power capacity (MW)

There is a big push to move the wind energy program forward, According to the National Energy Strategy, Jordan should be able to generate 600 megawatts of wind and 600 megawatts of solar energy, 10 per cent of the country's energy consumption by 2020. The wind energy goal is planned to be accomplished as follows:

- ✚ Propose wind project in Kamsha (30-40) MW during 2007-2009.
- ✚ Proposed wind project in Fujajj (60-70) MW during 2007-2010.
- ✚ Proposed wind project in Harir (100-200) MW during 2007-2012.
- ✚ Proposed wind project in Wadi Araba (40-50) MW during 2009-2013.
- ✚ Propose other wind projects (300 MW) in other places after conducting needed studies.

3. Advantages and Disadvantages of Using Wind Energy

Utilizing wind resources in Jordan for electricity generation has many advantages, mainly; Wind energy is a clean power source. It doesn't pollute the air or produce atmospheric emissions that cause acid rain or greenhouse gasses, like power plants that rely on combustion of fossil fuels. Pollution caused by fossil fuel combustion has catastrophic effects on the Jordanian environment. For example; Zarqa city – the second biggest city in Jordan – estimated to have about 70% of pollution in Jordan because of the presence of Al-Hussain power plant and the petrol refinery, which are using fossil fuels. The environmental pollution affect on the arable land, raise the average temperature and change the demographic population by forcing the inhabitants to move to less polluted areas.

Wind is abundant national resource, compared to the fossil fuels resources. At the long run, the steady rising in the fossil fuel prices will overburden the national economy, increase the shortage in balance of trade, and slowdown the developmental projects. On the other hand, wind energy systems reduce Jordan dependence on fossil fuels and enhance national economy and self-sufficiency.

Wind energy is a renewable energy that can't be used up; because wind is a by-product of solar energy and as long as there is sunlight, there will be wind. On contrary, the fossil fuel energy will be used up within the upcoming fifty or sixty years [13].

This means that the power of the country, national sovereignty, and independency is a matter of energy resources availability. Thus, looking for alternative energy resources should be one of the urgent national priorities.

Across Jordan, a large number of small remote villages and faraway military locations are distributed. Wind turbines can be built in remote areas, to avoid high cost of extending utility power lines to these sites. The availability of a relatively low cost electrical energy will contribute effectively in the developing both social life and economy in those villages.

On the other hand wind energy has some drawbacks, such as: Even though the cost of wind power has decreased dramatically in the past 10 years, the technology requires a higher initial investment than fossil-fueled generators [14]. Also the power generated using wind turbines has bad quality because of the highly imposed harmonics from such generators into the main grid. Wind power is not cost competitive with the conventional generation sources.

Wind energy is unreliable power source because the wind is intermittent and it does not always blow when electricity is needed. To overcome such problem, wind energy systems require some storage means to store excess power generated for use when the wind is calm. Also hybrid systems that combine wind with photovoltaic cells and a diesel generator may be used to increase the system's reliability. Adding photovoltaic cells and a fossil-fuel-powered generator makes the system more complex and more expensive [14].

Wind turbines can be built in farms or ranches, where most of the best wind sites are found. Since arable land forms only about 7.8% of Jordan's area; wind resource development may compete with other uses for the land and those alternative uses may be more highly valued than electricity generation.

Wind turbines have their own impact on the environment, such as the noise produced by the rotor blades, aesthetic impacts, and sometimes birds have been killed by flying into the rotors. Although Most of these problems can be resolved or greatly reduced through technological development or by properly siting wind plants, these solutions mean extra efforts and cost added to the system [13].

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This means that the power of the country, national sovereignty, and independency is a matter of energy resources availability. Thus, looking for alternative energy resources should be one of the generation, a set of procedures must be carried out to enhance using wind energy. Recommendations of five clause may be used for this purpose:

Create Jordanian Wind Atlas: Preparing a comprehensive survey study to locate the probable wind farms that can be used in commercial operation, taking into consideration the severe changes in the Jordanian climate in the last two decades. The study must include the assessment of the environmental impact of the proposed wind farms. Also it should compromise between the use of arable land for planting and grazing, and for producing wind energy.

Forming National Strategy for Using Wind Energy: Looking for national strategy to increase the share of renewable energy from the total energy mix in the next decade. This ambitious target requires clear policies and

legislations to promote the utilization and the investment in renewable energy, especially wind energy.

This strategy should include set of legal and regulatory frameworks, which encourage the investments in wind energy; like taxes and customs exemptions on such investments and their equipments and offering grants and technical support to the users of the independent power producers (IPP). These frameworks help the development of wind energy and increase their penetration into the Jordanian market.

Enlightenment for the Benefits of Using Wind Energy: Increasing the awareness about the benefits of using wind energy in both environmental and economical aspects. The government and the wind turbine companies are responsible for spreading this knowledge. The role of the government and the companies in this field is reciprocal. The government encourages the companies to invest in wind energy by showing the facilities and the expected proceeds. On the other hand, wind turbine companies or their local dealers demonstrate the expected share of the wind energy and their benefits on the local environment and national economy.

Both government and wind turbine companies are responsible for the consumer's awareness. They clarify to him that investing in a small wind system, can reduce pollution and reduce his exposure to future fuel shortages and price increases.

Preparing Professional Skills: Wind turbines maintenance is considered one of the major complications against using wind energy in electrical power production. Operating wind energy stations requires continuous maintenance and highly trained technicians and engineers. Furthermore, start to establish graduate green energy programs in some universities around the country to provide future energy projects with needed professionals.

4. Conclusions and Recommendations

Considering the current electrical power generation demands and technologies, wind energy seems the appropriate candidate to face the increasing demands and the increasing prices of fossil fuel. The advantages of wind energy are flawed mainly by the high initial cost and high generation cost, where the generation costs from wind farms almost over twice that of conventional fossil generation [8].

In order to encourage using wind energy in Jordan, the paper suggested a set of recommendations that help the development of wind energy and increase their penetration into the Jordanian market. Create updated Jordan Wind Atlas and comprehensive survey study to locate probable wind farms that can be made available to investors. Also, set doable targets with reasonable time table, and follow up on these targets. Also, break down goals and measure their progress on regular basis. In addition, enact new legislations to

exempt renewable energy equipment and projects from customs and taxes.

Furthermore, Jordan should benefit from the experience of some Arab country like Egypt and Morocco and copy their success in the wind energy area. In addition, Jordan may try to solicit aids from foreign donors for wind projects, as was the case for the Al-Ibrahimiyya and Hoffa projects. Finally, graduate green energy programs should be establish in some universities around the country to provide future energy projects with needed professionals.

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