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Renewable Energy Potential and Characteristics in Jordan

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Abstract

The current potential of various renewable energy resources in Jordan is discussed. New sites for wind energy exploitation are assessed and the pre-installation phase is started. On the other hand, it is shown that a large part of electrical load in Jordan is consumed during the daytime, when the solar power can be efficiently used. The pattern of wind energy variation is highly agreed with prevailing peak demands and corresponding peak hours. In this regard, the present paper investigates the degree of agreement between the load variation patterns and the power generated by the renewable energy sources. This includes the bulk power and the home scale consumption. Daily and seasonally load curves will be analyzed and correlated with solar and wind generated power curves. The data from existing wind farms will be used to enhance this study. Finally, the present paper highlights the necessity for reviewing and updating the energy strategies in Jordan

Introduction

Jordan is a key country in the Middle East region. Despite being adjacent to several oil-rich countries, Jordan struggles to secure its resources of energy especially when the prices of oil go up. A large portion of its budget is spent on importing oil from various countries. The problem is aggravated year after year due to the growth in population and increase in electricity demand. The industrial development requires more fuel consumption and continuous operation of power plants. Therefore, the search for alternative energy sources has become an imminent issue in Jordan.

Renewable energy sources are fundamentally different from fossil fuel or nuclear power plants because of their widespread occurrence and abundance. The primary advantage of many renewable energy sources are their lack of greenhouse gas and other emissions in comparison with fossil fuel combustion. Most of the renewable energy sources do not emit any additional carbon dioxide and do not introduce any risk such as nuclear waste.

Concerning the potential of renewable energy sources, they have the ability to supply several times the present world energy demand. They can enhance energy markets, secure long-term sustainable energy supplies, and reduce local and global atmospheric emissions. They can also provide commercially attractive options to meet specific needs for energy services (particularly in developing countries and rural areas), create new employment opportunities, and offer possibilities for local manufacturing of equipment [1].

Despite the significant progress achieved in renewable technologies, many fields are still at an early stage of development and not technically mature. If an effective research is applied in a modern way, renewable energy sources are considered highly responsive to overall energy policy guidelines and environmental, social, and economic goals [2]. One of the renewable energy critical issues is the degree of matching between renewable energy production and load patterns. Therefore, electrical grid storage was one of the most important storage methods advocated by the renewable energy community. With this method, it is possible to deeply exploit these resources in its 24-hour, 7-day cycle by using peak load equipment to meet the daily peaks.In the present work, a special emphasis is devoted to the assessment of renewable energy potential and the possibility of its deep exploitation in Jordan. This includes studying the potential of renewable energy, the variety of load patterns, their characteristics and matching schemes with renewable sources production. The daily and seasonally changes of renewable energy yield are compared with various loading curves for different sectors of consumers.

2.Renewable Energy Characteristics

Solar electric generation is a daylight process, whereas most homes have their peak energy requirements at night.

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Domestic solar generation can thus feed electricity into the grid during grid peaking times during the day, and domestic systems can then draw power from the grid during the night when overall grid loads are down. This results in using the power grid as a domestic energy storage system, and relies on the 'net metering', where electrical companies can only charge customers for the amount of electricity used in the home that is in excess of the electricity and fed back into the grid.

Today's peak-load devices are used to provide infill capacity in a system relying heavily on renewables. The peak capacity would complement large-scale solar thermal and wind generation, providing power when they were unable to. Improved ability to predict the wind avaialability greatly enhances the utilization of this resource. Several countries have shown successful achievements in this field. In Germany, for instance, it is possible to predict wind generation output with 90% certainty 24 hours ahead. This means that it is possible to deploy other plants more effectively so that the economic value of wind contribution is increased.

3.Electrical Load Variation in Jordan

Electrical load forecasting is one of the major tasks, which continuously makes a challenge to the load management engineers in every electrical power system. There are several factors included in the load forecasting system which have demographic, political, climatic and economical attributes. The load curves are produced in daily, monthly and yearly forms. Figure 1 shows the daily load curves for typical working days in January, April, July and October months of the year 2005[3].

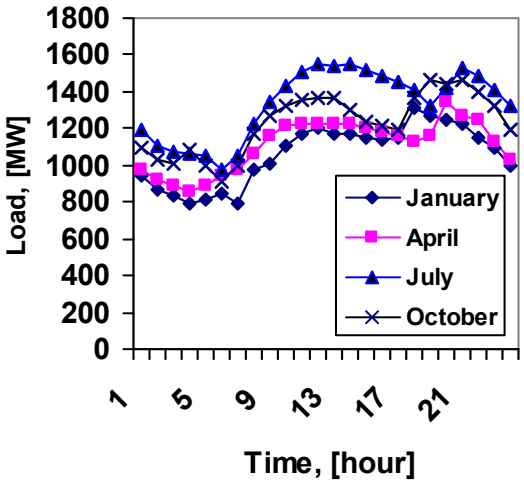

Figure1. Hourly variation of the Jordanian Electrical system load for typical days in different months.

Figure 2 illustrates the monthly variation of the Jordanian electrical load in year 2005, whereas Figure3 elucidates the distribution of this load in sector form. The daily and nightly patterns of load variation are closed to each other. A significant part of industrial, commercial and water pumping loads are mainly daily loads. Most of the organizations, official departments, educational and academic institutions consume their loads during the daytime. Figure 4 shows a sample of an hourly load variation in one of the faculties at Yarmouk University in Jordan [4].

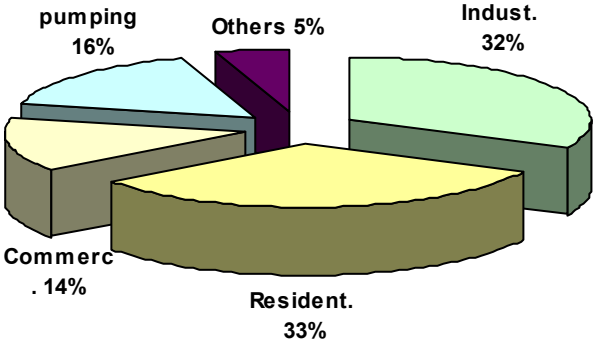

Figure 2. Monthly variation of the Jordanian Electrical system load for the year 2005.

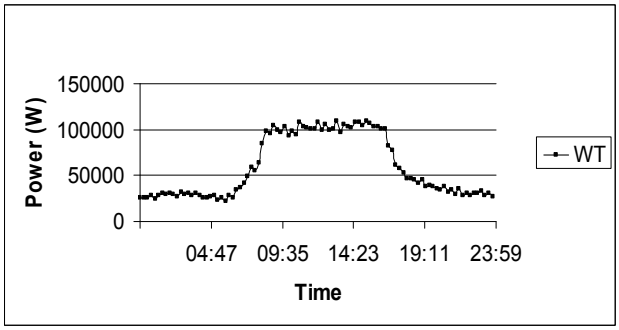

Figure3. The main sectors of the electrical load.

4.Power Supply using Renewables

The attempts to introduce a complete or partial replacement to the conventional sources of electrical energy did not stop since the 1950s. The intermittent nature of renewable energy was the main risk of these sources. However, several remarkable achievements have been done in the last two decades, which make the renewable energy one of the strong alternatives to the conventional sources.

The role of renewable energy in any country depends on the availability of the resources such as wind, solar radiation, geothermal and biomass. The assessment of load variation pattern is important to determine the best way of renewable energy exploitation. Therefore, it is important to find the degree of matching between the local loads and renewable energy generation schedule. In this context, it is known that the hot summer months in general, and July in particular, are associated with a high rate of electricity consumption in Jordan. With a mean temperature of more than 35^{o}C, most of the summer load consists of electric fans, water pumps and air conditioning [5, 6]. Luckily, the

best months for wind energy production in Jordan are the summer months as shown in Figure5. Therefore, the agreement between the wind energy production and the monthly load behaviour increases the importance of existing and planned wind farms. This is a good reason for promoting wind energy projects in Jordan.

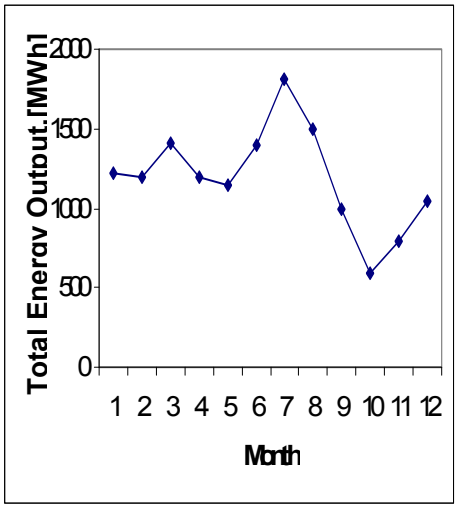

Figure 5. The monthly variation of wind energy production through the studied period

One of the most important factors to be considered in solar energy field is the sun shine period. Long hours of sun shine means more energy received from the sun. This factor is very important when comparing the long daytime in the summer with short days in winter. Table 1 shows Mean Daily Global Solar Energy Radiation KWh / m^2 as measured by the Jordanian Meteorological department stations.

Table 1. Mean Daily Global Solar Energy Radiation KWh / m^2, *JMD –Jordan, 2005*.

Station	J/F	M/A	M/J	J/A	S/O	N/D	Year
Dair ala	2.9/	4.9/	7.0/	7.3/	5.6/	3.1/	
	3.5	6.1	7.5	6.6	4.4	4.9	5.3
Ghor	3.0/	5.1/	7.0/	7.3/	5.7/	2.9/	
safi	3.7	6.2	7.5	6.7	4.4	2.3	5.1
Aqaba	3.5/	6.1/	7.4/	8.1/	6.6/	4.0/	
Airport	4.5	6.9	8.3	7.5	5.1	3.5	6.0
Irbid	3.1/	5.1/	6.9/	7.6/	6.0/	3.3/	
	3.7	6.4	7.7	7.5	4.6	2.9	5.4
Amman	3.2/	5.4/	7.1/	8.1/	6.0/	3.3/	
Airport	4.1	6.8	8.3	7.4	4.5	2.9	5.6
Wadi	3.2/	5.5/	7.5/	8.3/	6.5/	3.3/	
Dhulail	4.1	6.8	8.4	7.7	4.9	2.9	5.8
Rwished	3.3/	5.0/	6.3/	6.6/	5.5/	3.5/	
	3.9	5.9	6.8	6.3	4.4	2.9	5.0
Azraq	3.3/	5.7/	7.5/	8.1/	6.2/	3.7/	
	4.2	6.8	8.4	7.3	4.9	2.9	5.7

The following table shows the mean daily sun shine hours as measured by the Jordanian Meteorological department stations:

Station	J/F	M/A	M/J	J/A	S/O	N/D	Year
Dearalla	5.6/	7.7/	9.3/	12/	10/	6.5/	
	5.9	9.0	12	11.5	9.5	5.7	8.7
Ghorlsafi	5.2/	7.3/	9.7/	11.5/	9.5/	6.3/	
	5.4	8.9	11.7	10.7	8.7	5.1	8.4
Aqaba	6.8/	9/	9.6/	12/	11/	7.8/	
Airport	7.4	9.2	11.3	11.8	9.8	6.4	9.4
Irbid	5.5/	7.5/	9.6/	11.8/	10/	6.3/	
	5.2	9.0	11.3	12.2	8.5	4.2	8.4
Amman	5.1/	7.7/	9.8/	12/	10/	6.2/	
Airport	5.8	9.4	11.8	11.7	8.8	5	8.6
Wadidlail	5.5/	8.6/	9.9/	12/	11/	6.7/	
	6.5	9.7	11.7	11.6	9	5.7	9
Rwaishd	6.2/	7.6/	10/	12.4/	10.7	7.3/	
	6.9	8.5	12.2	11.8	/8.9	6	9.1
Azraq	6/	8.4/	9.6/	11.2/	9.7/	7/	
	6.6	9.3	11.1	11.1	8.7	5.5	8.7

5.Currentprojects in Renewable Energy

The distributed generation is a new trend in power systems, which is seriously looked to it as an alternative to conventional power generation. This concept is important to prevent blackouts, which can be avoided if an area did not depend only on one power plant. Renewable energy makes distributed systems more feasible because energy can be generated near the demand centers, reducing the need for long transmissions lines going through rural and urban landscapes, and by reducing the power loss across those lines. Moreover, the standard size for a new utility plant can be significantly reduced, and utilities are not eager to risk in such long-term investments.

Most renewable forms of energy, other than geothermal and tidal, are in fact stored solar energy. Renewable energy resources may be used directly as energy sources, or used to create other forms of energy. Examples of direct use are solar ovens, geothermal heat pumps and mechanical wind turbines. Examples of indirect use in creating other energy sources are electricity generation through wind turbines and photovoltaic cells.

6.Discussion

The continuous growth in electrical energy demand has put the decision makers in a critical situation. Therefore, the number of people who ask for exploitation new and renewable energy sources are in continuous increase day after day. With the presence of high potential sites, from the renewable energy point of view, there is no excuse for those who oppose this type of energy to wait more time.

The daily load variation has shown two peak-periods, one in the mid of the day and the other in the evening. The first peak period agrees well with the sunshine time in winter, whereas the two peak periods can lie in the long summer sunny hours. Jordan can be divided into five solar radiation regions. The first region is the southern region, which is located 29.0-30.5 N, 35.0-38 E. This region is represented by M'aan and Aqaba areas and has the highest solar

insolation in the country. In this regard, the annual daily average values of global irradiance are estimated between (6-7) KWh/m^2 and (1.2 – 1.35) KWh/m^2 for diffuse irradiance. The second region is the eastern region, which is located 30.5-32.5 N, 36.0-39 E. This region represents the semi desert and (Badia) remote areas in the country. Annual daily average values are about 5.5 and 1.5 KWh/m^2 for global and diffuse irradiance respectively. The annual daily average of sunny hours is about 9 hours. The third region is the middle region which is located at 30.5-32.0 N, 35.5-36.5 E. In comparison with other regions, this area has the highest annual average value of diffuse irradiance ranging between 1.6 and 1.9 KWh/m^2. The global irradiance is about 5.5 KWh/m^2 in this region. The fourth region is the northern region (32.0-33.0 N, 35.5-36.5 E). In this region the annual daily average values of global irradiance are about 5.0 KWh/m^2 and about 1.5 KWh/m^2 for diffuse solar irradiance. The last region is the western region (30.5-33.0 N, 35.0-35.5 E). This region represents the Jordan Rift Valley areas, where the elevation of areas is below the sea level (from –170m at Baqora to –250m at Ghor Safi). This region is very hot in summer and warm in winter.

The high values of solar energy radiation, shown in Table 1, illustrate that the solar energy exploitation in Jordan is possible and gives better results than that in other countries. Unfortunately, the projects in this field are still small and of experimental type rather than of commercial form. The long sunny days, shown in Table 2, add another incentive factor to employ this energy in large scale. It is worth mentioning here that, even the stand alone exploitation of solar energy is technically and commercially viable. The load pattern shown in Figure4 illustrates the possibility of employing solar energy for supplying large sector of loads with fixed pattern.

Concerning wind energy resources in Jordan, there are tens of places known by their high wind speed and long windy times. The existing wind farms in Hofa and Ibrahimia are good examples of wind energy projects. These farms are connected to the national grid and characterized by a high availability and excellent capacity factors. The agreement between the power output of these farms and the annual load curve shows that these farms can significantly participate in reducing the burden on the national grid in summer, when the load reaches its peak.

The preliminary research for new wind energy resources has revealed that tens of places have wind speed greater than 5m/s. Currently, there is a plan for three wind farms with Maximum capacity of 30MW each. These farms are distributed among three sites in the northern and southern regions of Jordan.

The exploitation of biomass and energy from waste was just started in Jordan. There are several projects in different places, mainly close to the big cities with heavy population.

7.Conclutions

The daily load curve of the Jordanian network has two peak periods, in midday and evening hours. Large sector of Jordanian electrical load can greatly benefited from the high irradiance and long sunny days whether these loads are connected to grid or stand alone. The existing and planned projects for small and large wind farms are important for establishing a good alternative for existing conventional sources of energy. The movement from small, pilot and experimental renewable energy projects is a must and inevitable.

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