HYBRID WIND/PV SYSTEM: THE LEBANESE CASE

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Abstract – **Recently, presenting considerable advances in the research and development devoted to renewable energy production is a solution to the global warming and breaking of ozone barrier by exhausting carbon dioxide (CO2) and Freon. Today, there is no a single renewable source which is capable to fill every requirement of energy. Hence, the renewable energy solution of the future will be necessary hybrid and it will use the potential of local sources.**

Solar energy has become a promising alternative source due to its advantages: abundance, pollution free and renewability. With the development of technology, the cost of the solar array is expected to decrease continuously in the future. In addition, controlled methods are applied to dc-dc converters to maximize the power. Wind is simple air in motion. Horizontal–axis wind machines and vertical-axis wind machines are used to generate electricity. Wind speed varies throughout the country. It also varies from season to season. New technologies have decreased the cost of producing electricity from wind, and growth in wind power has been encouraged by using controllers placed between the wind turbine and the used batteries.

This study treats the case of the conversion of wind energy and solar energy for a hybrid wind/PV system to electrical one. For example, in Lebanon, an annual data of the generated power are given.

***Keywords*:** *Renewable energy, Photovoltaic Cell, Wind energy, Hybrid system*

1. INTRODUCTION

All along the history, the energies included a strong imaginary content. On mention for example, the discovery of fire, the multiple effects of the sun, and the discovery of oil, petrol and natural gas, etc. Therefore, the energy held an important place in the world [1].

Nowadays, there is a real need to develop renewable energies and the main reasons are as follows:

- A first reason is, of course, that they are inexhaustible, contrary to the other energies, notably the fossil energies, whose stocks are limited. For example, in the case of petrol, a recent survey has the tendency to prove that the reserve in years would be in reduction what lets foretell a production decreasing from 2010 [2].
- A second reason is the risk that presents the nuclear energy; therefore, many nuclear countries want today to change production of energy to safety methods: United States, Germany, etc [3].
- A third reason, absolutely vital, and short-term, that imposes us to bet on the renewable energies: it is the notion today unanimous recognized of "lasting development", bound to the pollution in the air. One can expect an increase of the number and the power of the cyclones, desertification of subtropical zones, however flooding of some countries (Low Country, Bangladesh), deterioration of the earths by erosion, deviation of the Gulf Stream allowing the polar air mass to arrive to Europe [4].

Even during the same day, in many regions worldwide or in some periods of the year, there are different and opposite wind and solar resource patterns. And those different patterns can make the hybrid systems the best option for electricity production [5],[6]. Thus, this paper is a contribution to renewable energies study and it concerns the case of hybrid wind/PV system in Lebanon. It is organized as follows:

Section 2 presents the energy situation in Lebanon. Section 3 is devoted to a review on solar and wind energy. In the fourth section, a study on the hybrid wind/PV system in Lebanon is discussed. Finally, conclusions are given in section 5.

2. ENERGY IN LEBANON

In Lebanon, and according to an investigation done by the ministries of industry and petrol, the hydraulic and electric resources as well as the statistical administration [7], it takes out again of it that:

- 98% of our needs in primary energy have been imported. The renewable energies, in spite of a geographical and socioeconomic context auspicious to their development, represent even less of 1% in the global energizing balance of this country.
- The yearly consumption in energy per person remained less then the world average and represents 1/5 of the one of the European Community and 1/8 of the one of the United States or Canada.
- The invoice of energy increased 20% in 2001 in relation to 2000 and this following the increasing in prices of oil and its derivatives.
- The analysis of final electricity in relation to the primary resources permits to note that the efficiencies of the thermal power stations don't pass 33% and that the losses on the networks high voltage and of distribution are estimated to 12%.

- The electric consumption rose, in 2001, to 7650 GWh, either in increase of 37% in relation to 2000. The electric production is to 11% hydraulic and 89% thermal.
- The combustion of our based energy on the hydrocarbons (4200 tons) and other primary resources, give out in air harmful substances estimated to more then 15 tons of dusts, 80 tons of SO_2 and as many of organic compounds. It also produced 3.5 millions of tons of CO_2, which is 0.88 ton per person and per year. It is greater then 25% to the average production of the countries of the region (valued to 0.7 ton of CO_2 per person and per year).

3. REVIEW ON SOLAR AND WIND ENERGY

2.1. Solar energy

Generally speaking, the Earth has two global movements that affect the reception of the solar energy to its surface: the rotation that it makes once on itself per day and the yearly revolution that it makes around the sun. The combination of these movements explains the daily changes in the reception of the solar light in particular places [8]. The reason for which the energizing flux received to soil does not pass 1000 W.m2 is that the atmosphere modifies in an important way the direct radiance of the sun due to the following mechanisms [9]:

- absorption of light by the various gases constituent,
- diffusion by their molecules,
- absorption and diffusion by the dusts.

In addition, the solar flux received on a surface depends on [10]:

- the orientation and the slant of the surface,
- the latitude of the place and its degree of pollution,
- the period of the year,
- the time considered in the day,
- the nature of the cloudy layers.

The orientation of solar panels depends on:

- the impact angle: It is the angle formed by the solar panel and the solar rays (the optimal angle is 90°).
- the slant angle: It is the angle formed by the solar panel and the horizontal.
- the zenith angle: It is the angle formed by the solar rays and the horizontal.

The phenomenon named "photovoltaic effect" consists mainly in converting the solar light in electric energy by means of semiconductors devices named photovoltaic cells [11]. The photovoltaic generator is constituted of a series and parallel association of the number of necessary modules to assure the requisite energy to product [12].

2.2. Wind energy

Wind is simple air in motion. It is caused by the uneven heating of the earth's surface by the sun. Since the earth's surface is made of very different types of land and water, it absorbs the sun's heat at different rates. During the day, the air above the land heats up more quickly than the air over water. The warm air over the land expands and rises, and the heavier, cooler air rushes in to take its place, creating winds.

At night, the winds are reversed because the air cools more rapidly over land than over water. In the same way, the large atmospheric winds that circle the earth are created because the land near the earth's equator is heated more by the sun than the land near the North and South Poles. Today, wind energy is mainly used to generate electricity. Wind is called a renewable energy source because the wind will blow as long as the sun shines [13]. Like old fashioned windmills, today's wind machines use blades to collect the wind's kinetic energy. The wind flows over the airfoil shaped blades causing lift, like the effect on airplane wings, causing them to turn. The blades are connected to a drive shaft that turns an electric generator to produce electricity. There are two types of wind machines: horizontal–axis wind machines and vertical-axis wind machines [14].

Wind power plants, or wind farms as they are sometimes called, are clusters of wind machines used to produce electricity. A wind farm usually has dozens of wind machines scattered over a large area. Unlike power plants, many wind plants are not owned by public utility companies. Instead they are owned and operated by business people who sell the electricity produced on the wind farm to electric utilities. Operating a wind power plant is not as simple as just building a windmill in a windy place. Wind plant owners must carefully plan where to locate their machines. One important thing to consider is how fast and how much the wind blows [15]. As a rule, wind speed increases with altitude and over open areas with no windbreaks. Good sites for wind plants are the tops of smooth, rounded hills, open plains or shorelines, and mountain gaps that produce wind funneling. Wind speed varies throughout the country. It also varies from season to season [16]. New technologies have decreased the cost of producing electricity from wind, and growth in wind power has been encouraged by tax breaks for renewable energy.

2.3. Wind/PV hybrid system

Wind/PV hybrid systems (Fig. 1) are encouraged because they increase the reliability and efficiency of the Renewable Energy (RE) system while reducing the cost [17],[18]. In fact, by using wind and solar, the size of the battery bank can be reduced.

As solar panels are sometimes in short supply, wind is an ideal complementary power source for the RE systems. Some benefits of a hybrid system are [19]:

- 20-50% reduction in the initial cost of the system,
- batteries are 20% more efficient if the power is used when it's being produced,
- less cycling in the battery which means a longer battery life,
- use of smaller battery banks while ensuring 24 hour power.

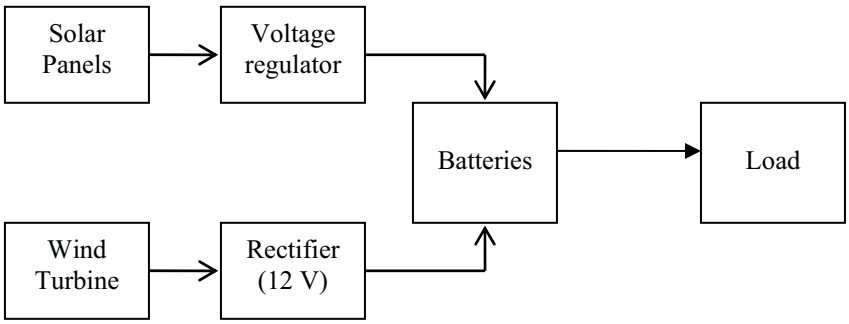

Figure 1: Hybrid Wind/PV system.

4. HYBRID WIND/PV SYSTEM

For 20 years, the power generated in Lebanon depended on thermal and hydraulic groups as illustrated in figure 2. The participation of RE sources in energy production was neglected.

In order to study the importance of solar and wind energy in Lebanon, a wind/PV hybrid system is placed in the Laboratory of Electricity of the Faculty of Engineering at the Lebanese University (Tripoli – Lebanon). This system is composed of eight mobile solar panel of 50 W each, a wind turbine of 400 W, two lead acid batteries of 12 V – 40 A each, one rectifier and one load voltage regulator.

Figure 3 shows the generated power for each month of the 2008 by the solar panels and the wind machine. From this figure, one can see that the solar energy is increasing from January to June and decreasing from June to December, which is a logic variation. Regarding to the wind energy, this one takes a normal values in winter and an important values in June and September. These two months are the most important of the year.

During the year 2008 and for the same rated power of 400 W, the energy generated by the wind turbine was 55.55 kWh and that produced by the array formed by the eight solar panels is equal to 55.175 kWh. Thus, the produced wind energy is nearly identical than that delivered by the solar panels.

It should be noted that the generated solar energy is maximum, because the sky is cleared around the Faculty of Engineering, but, this Faculty is not placed in a windy zone. Consequently, if one installs this wind machine in a windy zone, the produced wind energy will be necessary more important than that delivered by the solar panels.

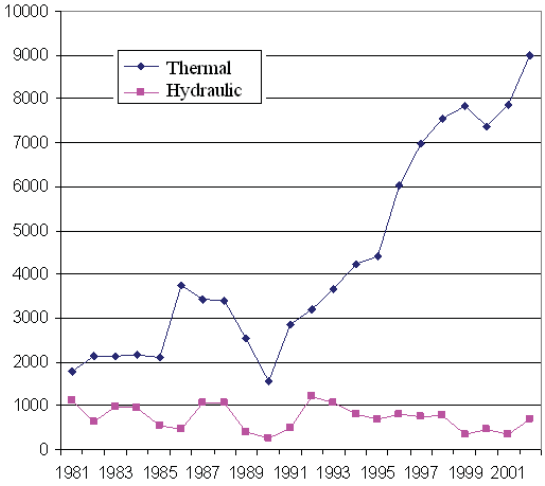

Figure 2: Produced energy variation in GWh.

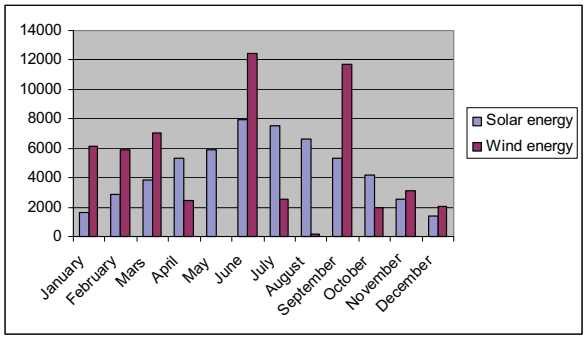

Figure 3: Solar and wind energy in kWh.

5. CONCLUSIONS

Wind and solar energy offer a viable, economical alternative to conventional power plants in many areas of the country. Wind and solar are clean fuel; they produce no air or water pollution because no fuel is burned.

This survey permitted during the year 2008 to determine the monthly and yearly balances of the solar energy and wind energy in a selected zone in Lebanon (Faculty of Engineering). The experimental results show that the wind machine can deliver more power than solar panels if it is placed in a windy zone. This study will be improved by selecting the right zone to place the hybrid system in order to produce the optimal energy from the sun and from the wind. In addition, the next system will contain different wind turbines and solar panels in order to study the functioning of a hybrid solar and wind farms.

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