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Renewable Energy in Lebanon

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1. Introduction

All along the history, the energies included a strong imaginary content. We mention for example, the discovery of fire, the multiple effects of the sun, and the discovery of oil, petrol and natural gas. Therefore, the energy held an important place in the world.
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.
- 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, Switzerland, etc.
- 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.
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 (i.e. combining two or more sources of energy) and it will use the potential of local sources. In the last decades, we remark a great activity in the scientific community, in the first hand, to study the renewable sources and hybrid system of energy (Chedid & Rahman, 1997), (Borowy & Salameh, 1994), (Borowy & Salameh, 1996), (Kellog et al., 1998), (Broe et al., 1999) and, in the second hand, to analyze the potential of renewable sources in some area (Ucar & Balo, 2009).
This chapter is a contribution to renewable energies study and it concerns the case of Lebanon. More precisely, we consider the conversion of photovoltaic and wind energy to electrical one. In this work, annual data are discussed, efficiencies of each conversion source are calculated and their economic costs are compared.

2. Review on renewable energy sources

The human consumption of energy became dangerous for the environment and it is necessary to reconsider our resources notably while making appear the part of the renewable. This section brings us to note that the renewable resources (coming from the sun, the terrestrial core and from the phenomena of tides) are enormous, often comfortably available for our long-term needs.

2.1 Hydraulic energy

Hydraulic power station uses the energy provided by the mass of water in movement to turn a turbine. This one is coupled mechanically to an alternator to produce electricity.
The power of these power stations varies from a few hundreds of Kilowatt to several hundreds of Megawatt. The recoverable energy annually on the planet reaches 40.10^{12} kWh and the technically exploitable value is worth, according to the evaluations, between 15 and 20.10^{12} kWh (Multon et al., 2004). Hydraulic power stations supply 20% of the world electricity and it represents 95% in Norway, 83% in Iceland, 70% in Canada, 67% in Austria, 32.02% in Romania (Ciobanu, 2008) and 10% in Lebanon.

2.2 Solar energy

A photovoltaic cell is a semiconductor component, exposed to light, generates an electric voltage (0.5 V to 1.7 V according to the used matter). The cells are joined between them to constitute a solar panel. The energy received at the surface of the earth (720.10^{15} kWh) varies, by m^2, between 1100 kWh and 2300 kWh/year (Multon et al., 2004).

2.3 Wind energy

The use of the wind to produce electricity from the energy of wind was also exploited for a long time. This energy represents an enormous resource, 32.10^{15} kWh, whose exploitable terrestrial part is estimated to 50.10^{12} kWh/year (Multon et al., 2004). The produced wind energy in 2002 represents 0.4% of the total electricity production.

2.4 Biomass

In the domain of the energy, the term of biomass regroups the set of the organic matters capable to become sources of energy. These organic matters that come from the plants are a shape of storage of the solar energy, captured and used by the plants thanks to the chlorophyll. The biomass is an energy that can be chemically polluting when it is badly used. The annual renewable part represents energy of about 800 to 900.10^{12} kWh of which 60.10^{12} kWh is exploitable (Multon et al., 2004).

2.5 Gravitational interactions Moon-Sun

The tide designates the oscillating movement of the sea level that results from the attraction of the moon and the sun on the liquid particles. The yearly energy of the marine currents represents about 25.10^{12} kWh. The exploitable part is between 270 and 500.10^{9} kWh (Multon et al., 2004).

2.6 Surge energy
It is due to the action of the wind on the surface of the seas and oceans. It is estimated to 8.10^{12} kWh of which 90.10^{9} kWh is technically usable per year (Multon et al., 2004).

2.7 Geothermal energy
The terrestrial core gives a yearly energy of about 300.10^{12} kWh. The exploitable reserves are of about 40.10^{9} kWh (Multon et al., 2004). The most important geothermal plants are: Gheiserele – USA (502 MW), Wairaki - New Zeeland (192 MW), Krafla – Iceland (50 MW).
Ocean thermal energy conversion plant extracts the water temperature between 25°C at surface and 5°C at a depth of 1000m (Ciobanu, 2008).

3. Energy in Lebanon

In the Mediterranean region, the encouragement of the big scale use of renewable energy constitutes the alternative solution for power consumption in rural zones that are occupied by 40% to 50% of the total population. However, in urban zones, a variety of applications of renewable energy are put in action such as: the desalination and water treatment, the solar hot water production, the domestic and industrial garbage treatment, the bioclimatic architecture, etc. Thus, answering the needs of energy while reducing the troubles in the cities of high and medium density. The structural demand of the Mediterranean countries indicates realistically that up to 45% of the energy demand in this area can be fulfilled by renewable energy from now till 2015, about 3 times the yearly consumption of Algeria, Morocco and Tunisia together (Frenn, 2003). This can be achieved by the implementation of a common voluntary strategy for the renewable energies in the region. Effectively, we are lucky in Lebanon to have a climate allowing more than 300 sunny days per year. Thus, Lebanon is known for being 'the 300 sun day country'. Also, Lebanon is favoured naturally with a big hydraulic energy potential, keeping in mind the possibilities arising from the use of wind energy in the mountains and the bioclimatic architecture. This serves in the preservation of the environment and saves in the energy resources while helping up with the incremental tendencies. Highly industrialized nations are witnessing an increase in the number of hydraulic and solar stations, despite the fact that these countries already possess numerous nuclear plants. The situation in Lebanon indicates a wide and increasing public awareness towards the use of solar energy especially in the use of solar water heaters as they are topping almost every roof. This shows that the Lebanese are well receptive of this aspect; especially that in Lebanon, human resources are capable of introducing and applying correctly these types of renewable and natural energy techniques in our homes, factories and establishments. As the technical know how is well available. These resources must be supported and assisted in order to use them for the good of our country. Economically, these techniques are cost effective both in the short and long terms, because expenses related to installation and maintenance are reduced and the raw materials are naturally available. For example: the annual petroleum bill in Lebanon amounts to 750 Million Dollars, of which more than the half goes to electricity production. The pollution resulting from our public power stations, and those of privates generators installed almost everywhere in the country in addition to the absence of a coherent policy of urbanization, aggravates the negative impact on the environment. Unluckily, this gloomy does not seem to show a tendency of improving in the near future (Frenn, 2003).

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, it takes out again of it that:

- 98% of our needs in primary energy have been imported. The renewable energies (solar, wind, etc), 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 USA.
- The invoice of energy increased 20% in 2001 in relation to 2000 and this following the increasing in prices of oil and its derivatives on the international markets.
- 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, but remains even lower to the efficient needs and especially to the level of the seasonal crests and the reserve powers. 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 (0.7 ton of CO_2 per person and per year).

4. A survey on solar and wind energy

4.1 Solar energy

Ancient Egyptians worshiped God Ra' or the Sun God. They granted Ra' the supreme power above all Gods. Most likely, they were not thinking of solar power at the time, but if they did, they would have every good reason to do so since most power resources in our plant earth come from this same Sun once worshiped. Fossil fuel, the arrogant energy source of the era, for example, descended from the very organics eventually ran on solar power! Wood, hydraulic, etc are the outcome of 'Solar power'. One thing in common for the above resources is that they all naturally and 'indirectly' divert, or store, the sun power for our later utilization. It should be worth investigating, however, innovative methods that could utilize solar power as soon as it arrives from the gigantic nuclear plant we used to call SUN.

Enormous researches were conducted in the past to address such direct conversion. Some of these researches did arrive to novel systems including Photovoltaic, or PV, which in no time, directly and smoothly, convert solar photons to electrical current. PV is one kind of PN junction that is a two-semiconductor plates one positive and the other negatively doped and separated by a thin film. While some scientists were doing experiment on PN junctions, they accidentally discovered that if light hits an exposed PN junction some electron will gain energy to jump from one side to the other side. If the circuit was closed from the other side, the missing electron has to be replaced and electron flow will occur. This flow is what we call electric current (Abou Said, 2003).

Thus, the phenomenon named "photovoltaic effect" consists mainly in converting the solar light in electric energy by means of semiconductors devices named photovoltaic cells (Gergaud et al., 2002). The photovoltaic generator is constituted of a series and parallel association of the number of necessary modules to assure the requisite energy to product (De Soto et al., 2005).

The industry of PV modules is still in progress. Besides, they are produced in many forms or types including amorphous, crystalline, and multi-crystalline. They can be made of some particular semiconductor materials but the most are made of Silicon.

To generate sufficient electrical energy, light source must be intense especially because with the current PV'S technologies and material, efficiency of light to current conversion in all PV types is still relatively low, at best just below 20%. Therefore, the light has to have enough intensity that it has to come from the sun to produce effective power. In addition, the sun light intensity varies extensively during the day or in different times of the year and many obstacles may easily shade the sun light, and sometimes for every long, like in case of cloudy days. As a result, additional component should be combined to PV modules to have reliable power sources. Batteries can solve the frequent absence of sunlight and innovative electronics will do the regulating job. These components, when tuned together along with the PV modules construct a system so-called 'Electrical Solar Power Supply'.

Sunlight is free, but, the electrical power produced from it is far from being cheap. In fact, solar electrical power is still one expensive conventional methods of electricity generation. Nevertheless, in many cases, solar power is quite justifiable and it had a wide range of applications in remote places (Abou Said, 2003).

The Sun is a sphere of diameter $139x10^9$ m and at a distance from earth equal to $1.5x10^{11}$ m is called an astronomical unit. The sun as seen from earth may be considered as an equivalent black body with a temperature equal to 57620ºK. The energy is produced in the interior of the solar sphere, at temperature of many millions of degrees. The amount of solar energy received on earth surface is depleted by the atmosphere. 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 (Bernard, 2004). The reason for which the energizing flux received to soil does not pass 1000 W/m^2 is that the atmosphere modifies in an important way the direct radiance of the sun due to the following mechanisms (Ikegami et al., 2001):

- 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 (Bernard, 2004):

- 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 place of solar panel should be cleared well. The orientation of the panel depends on:

- the impact angle: It is the angle formed by the solar panel and the solar rays. The optimal impact angle is an angle of 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.

Besides its great ecological benefits many application demands solar energy, starting from remote communication relays, remote houses, winter and summer resorts, bill boards lighting, remote water pumping, etc. Some of these systems are already in operation at the time being; but most of which are found in hybrid systems where wind and solar power are combined to one system for practical and optimized operation.

4.2 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 (Poitiers, 2003).

Like old fashioned windmills, today's wind machines use blades to collect the wind's kinetic energy. Windmills work because they slow down the speed of the wind. 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 used today: horizontal–axis wind machines and vertical-axis wind machines (Laverdure et al., 2004).

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 (Iov et al., 2004).

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 (Chowdhury & Chellapilla, 2005).

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.

The major potential disadvantages for wind turbines are noise, effect on birds of prey, and aesthetics. Noise is an issue with wind turbines as the mechanical blade and rotor movements tend to produce some noise. With the development of better equipment, the noise issue is being properly handled and noise level is rapidly decreasing. Since most of the appropriate sites are located in uninhabited wind swept, remote areas and sometimes on mountaintops, it is to be expected that the noise factor will be of minor importance. Research has indicated that many people who had originally opposed the presence of wind turbine, had a much more positive feeling after the turbines were installed. As for the effect on birds of prey, it has been found that the probability of a bird hitting the blades is minor and does not present a credible threat to wild species. Finally, the issue of aesthetics is a highly debatable issue. Some people are strongly opposed to the presence of large wind turbines in landscape while others find it attractive. Despite these concerns, it has been positively assured that the presence of wind turbine is a tourist attraction. Actually, wind energy technology is developed well enough to complete with non-renewable sources of electricity (Houri, 2003).

5. Solar and wind energy in Lebanon

5.1 Balance of solar and wind energy

Our study is achieved within the Laboratory of electricity of the Faculty of Engineering in the Lebanese University (Tripoli – Lebanon). The solar experimental part of the system is constituted of a fixed panel and a mobile one of 50 W each one, two batteries and two load voltage regulators. The position control of the mobile panel took place so that its surface is always perpendicular to the solar rays. The wind experimental part is constituted of a wind converter of 400 W, tow batteries, one rectifier and one load voltage regulator. In the global experimental system, a microcontroller is used in order to take data about the solar and wind generated energy and that in order to archive them. Another goal of this microcontroller is to control the functioning of the electric motor moving the mobile solar panel. To make comparison between these two types of renewable energy which should be of the same rated power, we multiplied the data given by the solar panels by eight. Figure 1 shows the generated power, for each month of the year 2006, by solar panels and wind turbine.

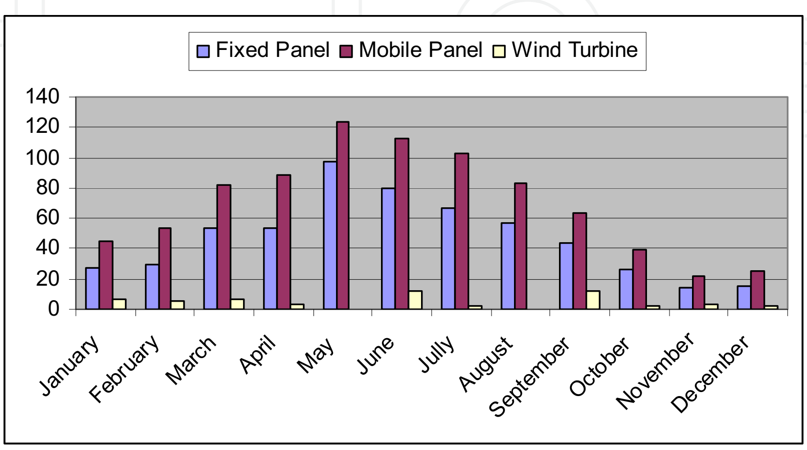

Fig. 1. Comparison between solar and wind energy in kWh

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. Figure 2 represents the percentage of the involvement of these two types of energies, solar and wind, in the production of the total renewable energy.

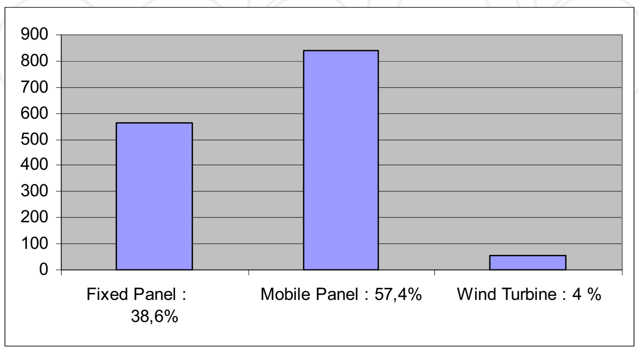

Fig. 2. Percentage value for solar and wind energy

During the year 2006, the energy generated by the wind turbine of 400 W of power is 57 kWh. To do a comparison between the two sources of renewable energy, one multiplies the value obtained by the solar panel by eight. Therefore, the energy produced by eight mobile solar panels of total power 400 W is equal to 840 kWh. Thus, for the same rated power of 400 W, the produced solar energy is very important compared to wind one. 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 places this wind turbine in a windy zone, the produced wind energy will be more important than that obtained in the Faculty of Engineering.

5.2 Efficiency of solar and wind energy conversion

Experimental results indicate that the efficiency of the used solar panel is equal to 10 %. That of the wind turbine is 23 %. Therefore, from these results, one notes that the efficiency of the wind energy conversion is 2.2 times the one of the solar panel.

5.3 Profitability of solar and wind energy conversion

To choose the most profitable type of energy conversion, it should take some hypotheses:

- The 1 kWh is the measurement unit,
- The working duration of each conversion system is estimated to 20 years.

The cost of the eight solar panels of total power equal to 400 W was equal to 6000 USD. This cost includes the installation price. Adding the batteries prices to this cost, the actual value to have this solar station becomes 6500 USD.

The cost of the wind turbine of 400 W was equal to 2000 USD. This cost includes also the installation price. Adding the batteries prices to this cost, the actual value to have this wind station becomes 2500 USD.

Therefore, for the same rated power (400 W), the price of the wind turbine is three times less expensive than that of the solar panels.

6. Conclusion

The Sun is capable of supplying ten thousand times the overall energy needs of humanity. The technological progress is moving at large strips in the development of fire and clean technologies, in particular photovoltaic energy and wind energy. Most developing countries possess renewable sources that ought to be exploited. Wind and solar energy offer a viable, economical alternative to conventional power plants in many areas of the world. Wind and solar are clean fuel; they produce no air or water pollution because no fuel is burned.
This survey consists in creating a data base of the power delivered by the wind machine and solar panels. It permitted during the year 2006 to determine the monthly and yearly balances of these energies in Lebanon.
For the selected zone, experimental results show that the solar panels generated more power than wind turbine. In other hand, the calculation of the efficiency and the profitability of these tow types of conversion are also analyzed. We noted that the wind machine efficiency is 2.2 times than that of a solar panel and its price is three times less expensive than that of the solar panels.

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Renewable Energy is energy generated from natural resources-such as sunlight, wind, rain, tides and geothermal heat-which are naturally replenished. In 2008, about 18% of global final energy consumption came from renewables, with 13% coming from traditional biomass, such as wood burning. Hydroelectricity was the next largest renewable source, providing 3% (15% of global electricity generation), followed by solar hot water/heating, which contributed with 1.3%. Modern technologies, such as geothermal energy, wind power, solar power, and ocean energy together provided some 0.8% of final energy consumption. The book provides a forum for dissemination and exchange of up-to-date scientific information on theoretical, generic and applied areas of knowledge. The topics deal with new devices and circuits for energy systems, photovoltaic and solar thermal, wind energy systems, tidal and wave energy, fuel cell systems, bio energy and geo-energy, sustainable energy resources and systems, energy storage systems, energy market management and economics, off-grid isolated energy systems, energy in transportation systems, energy resources for portable electronics, intelligent energy power transmission, distribution and inter-connectors, energy efficient utilization, environmental issues, energy harvesting, nanotechnology in energy, policy issues on renewable energy, building design, power electronics in energy conversion, new materials for energy resources, and RF and magnetic field energy devices.

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