Evaluation of the Power Generation from Wind Energy Using Small Wind Turbine in Sudan (Local Model Made)

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Abstract: ***Fossil energy resources become imminent running out and there is a growing demand for energy these reasons prompted the researcher to manufacture a small model of the wind turbine and subjected to practical experiment to generate electricity from wind energy. The wind turbine model putted at top of the building height 15 meter inside the Khartoum city - Sudan, to ensure a high speed wind. The final height of tower and building become 16.75 m and readings were taken over the full six months. The results of the study is founded that the voltage and current which were generated are good and the power also good. From the experiment of this small sample of power generation by wind we can make farmers of power in Sudan, in some places because the wind energy is very good in these 6 months. The average power output is found to be 5.57 watt and the average power input is found to be 92.55 so the efficiency of the system is found to be 4.79×10^{-2} , It's clear that the efficiency is acceptable. All graphs showed a linear relation between wind speed and parameters.***

Keywords: Renewable energy, small wind turbine, power generation, wind energy, local model made turbine

1. Introduction

The use of wind as a power source has a long history. Man has been familiar with the use of windmills and pumps; sailing ships were, in the past, the most significant example of its technical utilisation.(Hamid, Y. H, *et al* ,1981). Wind energy has considerable resources in Sudan where the annual average wind speeds exceeds $5ms^{-1}$ in the most parts north latitude 12° ’N, and along the Nile valley. While the southern regions have the poorest potential because of the prevailing low wind speeds.(Betz, A.1919). Experience in wind energy in Sudan was started since 1950s, where 250 wind pumps from Australian government, had been installed in El Gezira Agricultural Scheme for water pumping. But due to difficulties of obtaining spare-parts and availability of diesel pumps, these machines were not working now. (Omer, A. M, 1998). Energy sources can be classified into two main types:

a) Non Renewable Sources (finite)

This source composed of energy from fossil (oil, coal and natural gas) and nuclear power fossil fuel are dominate and they contribute to the annual world primary energy consumption about 75%. Nuclear energy is relatively minor source contributing less than 6 %, the production transport use and waste disposal of the finite resource of energy plays a major role in the world environmental, health, social and political problems.(John, *et al*,2005).

b) Renewable Sources

This source is completely comes from the nature. It is clear from the definition (the term renewable energy is used to cover the energy flow that occur, naturally and repeatedly in the environment. The ultimate resources of this type are the sun, gravity and earth rotations). (Lysen, E.H.,1983).

That most of the renewable energy sources are derived from the solar radiation including the direct use of solar radiation for heating or electricity generation, and the indirect use such as the energy from wind, waves, hydropower from planets and animals (wood, straw, dung, any other planet waste), tidal energy, geothermal.(G.N.Tiwari, *et al*, 2011). All kinds of waste energy are included under the heading of the renewable energy source. The promise of the renewable energy offers a solution to many environmental and social problems associated with fossil and nuclear fuels. (Ghosh, *et al*, 2009). In Sudan the main sources of energy supply are wood, charcoal, petroleum and hydropower, for example of the renewable energy sources in Sudan solar energy and wind energy.(Van Meel J, *et al*, 1987).

c) Potential and Application of Wind energy in Sudan

Acknowledging the huge potential for renewable energies in Sudan, the Ministry of Electricity and Dams of Sudan (MED) intends to develop renewable energy power project in order to promote sustainable development. In the initial stage, MED has foreseen to focus on wind energy projects and awarded a contract to Lahmeyer International (LI) as consultant for the development of the first three wind farmers.(MED, 2011-2014). This report support the study because this paper actually were licensed for researcher in 2001 as a graduate of the Om durman Ahlia university (BS.c). Sudan is the largest country of the African continent, with an area approximately one million square miles (2.5 x 10^6 km^2). It extending between latitudes 3°’N and 23°’N, and longitudes 21° 45’ ’E and 39°’E. Sudan is a relatively sparsely populated country. The total population according to the census 1996 was (30 x 10^6) inhabitants. The growth rate is 2.8%, and population density is 12 persons per square kilometers(Omer, A. M, 1998).

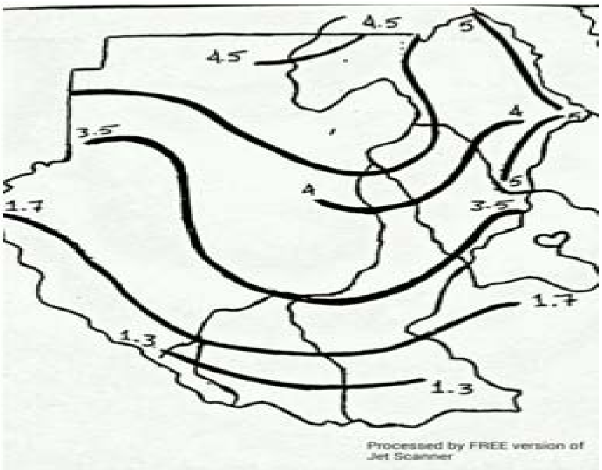

Figure 1: Annual average wind speed in Sudan (ms^{-1})

2. Materials and Methods

This section is devoted for the equipments and instruments used in relating the wind speed and the power to average of parameters for the system generator power test. These parameters include the revolution per minute for free dynamo , revolution per minute with dynamo , voltage output , current output , power input , power output and efficiency. The data is collected at Khartoum city in Sudan, the specification of the generator power system used and the statistical beside mathematical techniques are presented in this section. The data collected and the relation between wind speed and Perceptible variables and other parameters are displayed graphically and in the form of table.

2.1 Instrumentation

The power generator test for wind speed was done by using the small wind turbine (local model made) at Khartoum City, as shown in fig(2), fig(3) and fig(4).

Figure 1: Small wind turbine (local model made)

Figure (3 & 4) represent to sketch drawing for small wind turbine before made:

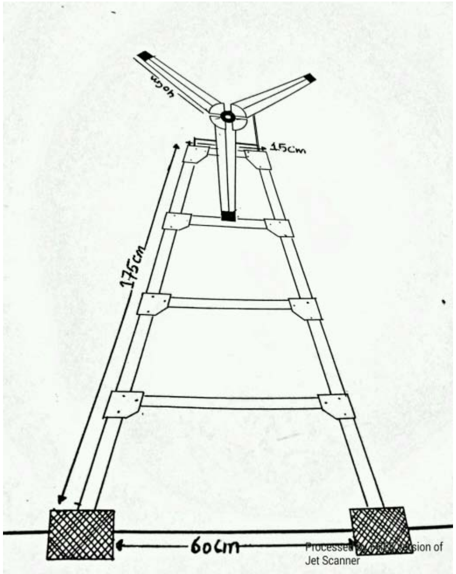

Figure 3: Sketch of small wind turbine (local model made)

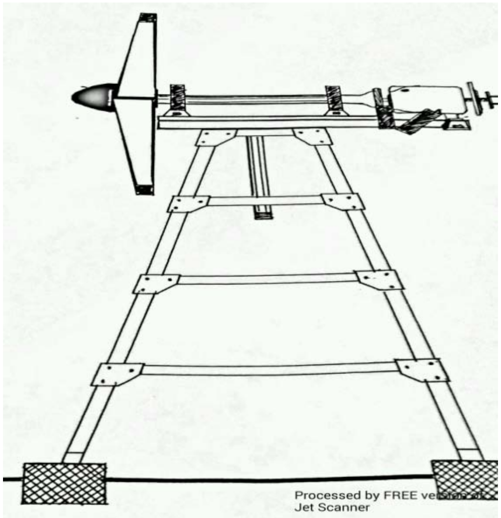

Figure 4: Sketch of small wind turbine (local model made)

The Small Wind Turbine (Local Model Made)

Design and Method of Work

The machine was made in local workshop in Khartoum city - Sudan, by specialized worker and Energy Research Center. The machine was constructed from the following:

Blades: Three blades made from iron sheet, the length of a blade is 40 cm.
Crank: A long metal iron to change the motion of the rotor, the length is 60 cm.
Tower: Made from iron, the height is 175 cm, the base length is 60 cm, on the top the length 15 cm.
Dynamo: Converts the moving of the blades to power.

Apparatus

The devices used to measure the power:
a) Avometer to measure the current and voltage.
b) Tachometer to measure the revolution per minute.
c) Anemometer to measure the wind speed.

The researcher used the small generator (Asynchronous Generator) , and this is due to the high-speed rotation reduces the size and cost of the generator, as the number of poles inversely proportional to the rotational speed, which then begins to generate electricity.

How generator: reach the turbine through the central column rotation with generator contains a large magnetic field and the rotation of the turbine spins central column cut off the magnetic field's we get electricity, which means that the generator converts mechanical energy into electrical energy through the file management in the presence of a magnetic field.

2.2 Coast and Difficulties

The initial coast to construct the wind machine about (1000 American Dollars) in year 2000- 2001. The tower must be taken in high places to obtain good results, and the wind energy be optimum in the final months of Summer (months of rain) and in the Winter and we can use this wind generation machine in these months (about 6 months). The machine now it putted at Omdurman Ahlia University – Sudan.

2.3 Data Collection: Criteria and Requirements

The following study was carried out as applied experimental study in the realm of applied physics science inclusively as renewable energy. The experiment was applied through 6 months, the efficiency of the system compute according to the following equation:

$\Upsilon = (P_{out} / P_{in}) * 100\%$……………………………………….(1)

Υ is the efficiency of wind turbine.

P_{out} is the power output.

P_{in} is the power input.(Paolo F., *et al*, 2011).

To achieve these objectives, the research was carried out at Juba building (5 floors height) at Khartoum city – Sudan under the supervisor of doctor Zainelabdeen Hassan who is assistant professor of physics. During the period from 2000 up to 2001. When reading are subjected to experiment test information such as revolution per minute for free dynamo , revolution per minute with dynamo , voltage output, current output, power input , power input , efficiency are collected.

The obtained data related to wind speed were plotted versus Revolution per minute for free dynamo, Revolution per minute with dynamo, Current, Voltage, P_{in} and P_{out}. The significant relationships are examined by using Statistical Package for Social Science version 11(SPSS – 11) .

3. Results and Discussion

Table and Graph

Table 1

Wind speed	*Revolution per minute for free dynamo*	*Revolution per minute with dynamo*	*Volt output*	*Current output*	*Power input*	*Power output*	*Υ efficiency*
1.5	96	53	0.5	0.14	0.95	0.07	0.07
2	132	92	0.7	0.17	2.26	0.12	0.05
2.5	172	132	0.9	0.19	4.41	0.17	0.04
3	179	139	1.21	0.24	7.63	0.29	0.04
3	172	132	1.21	0.24	7.63	0.29	0.04
3.5	211	171	1.25	0.29	12.11	0.36	0.03
4	241	201	2.1	0.32	18.08	0.67	0.04
4	237	197	2.1	0.32	18.08	0.67	0.04
4.5	284	244	2.4	0.35	25.74	0.84	0.03
5	342	302	3	0.41	35.31	1.23	0.03
5	334	294	3.1	0.44	35.31	1.36	0.04
5.5	381	341	3.5	0.52	47	1.82	0.04
6	401	361	4	0.71	61.02	2.84	0.05
6	406	366	4.1	0.73	61.02	2.99	0.05
6.5	420	380	4.3	0.81	77.58	3.48	0.04
7	425	385	5	1.02	96.9	5.1	0.05
7	469	429	5.2	1.13	96.9	5.88	0.06
8	492	452	5.9	1.51	144.64	8.91	0.06
10	557	517	7.1	2.8	282.5	19.88	0.07
11	606	566	8.2	3.1	376.01	25.42	0.07
13	710	670	9.5	4.2	620.65	39.9	0.07

Graph

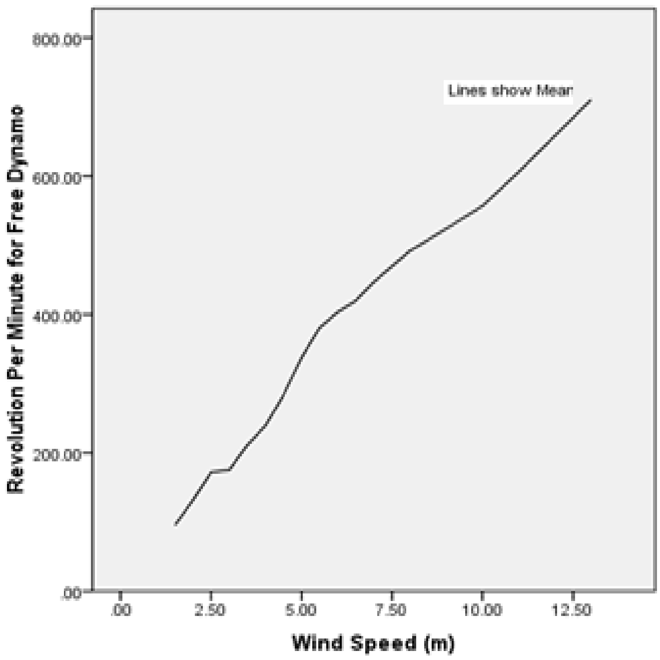

Figure 5: Wind speed versus revolution per minute for free dynamo

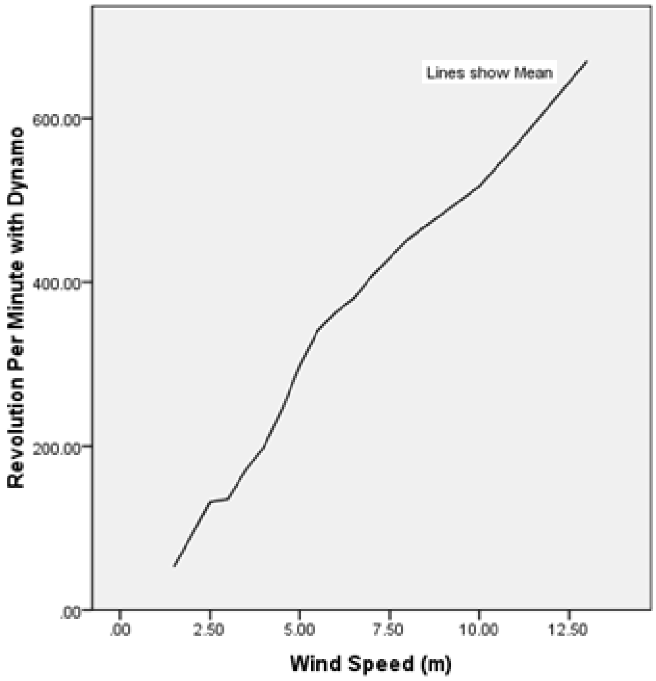

Figure 6: wind speed versus revolution per minute with dynamo

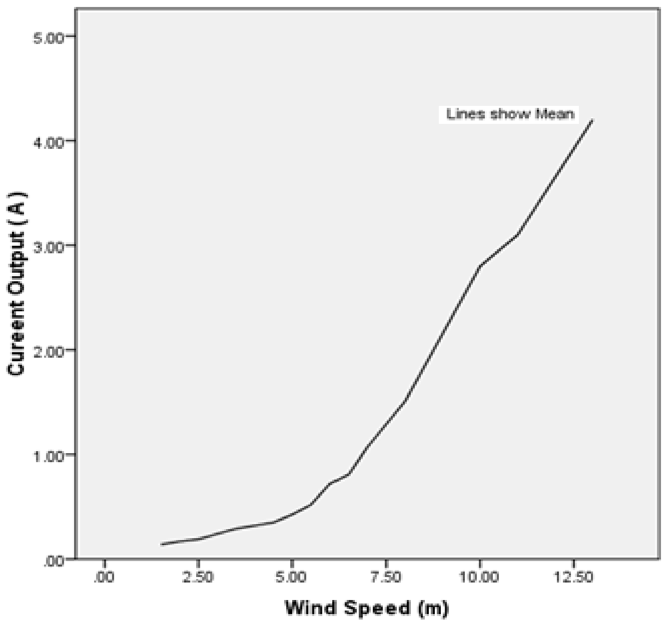

Figure 7: Wind speed versus current output

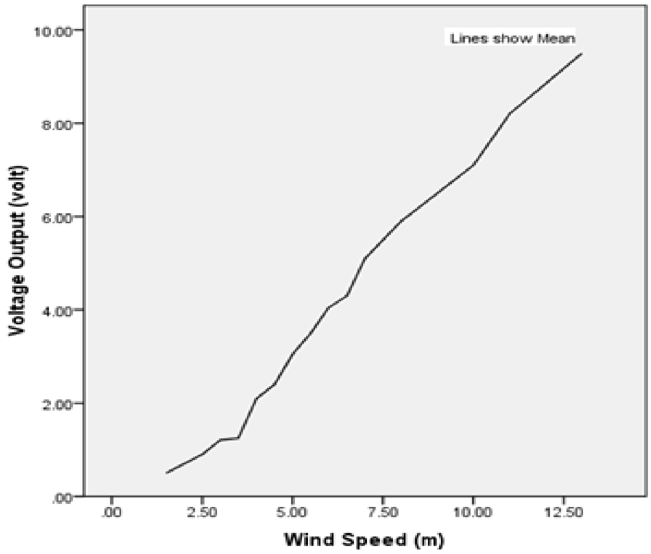

Figure 8: Wind speed versus voltage output

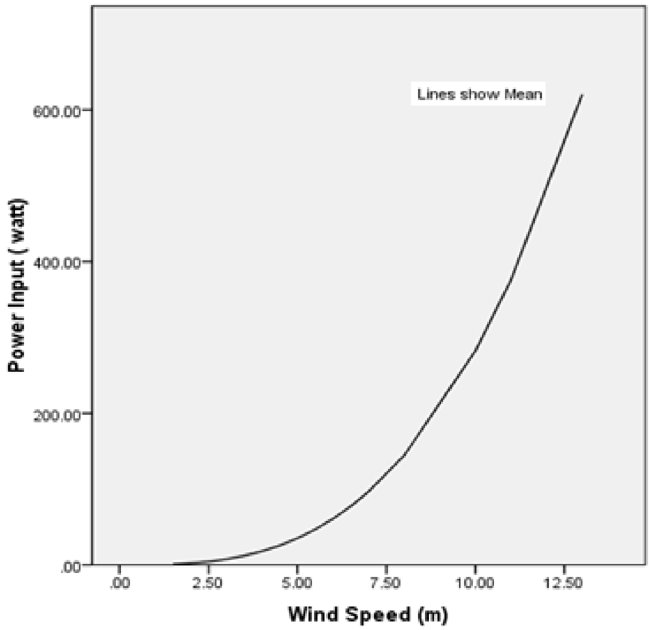

Figure 9: wind speed versus power input

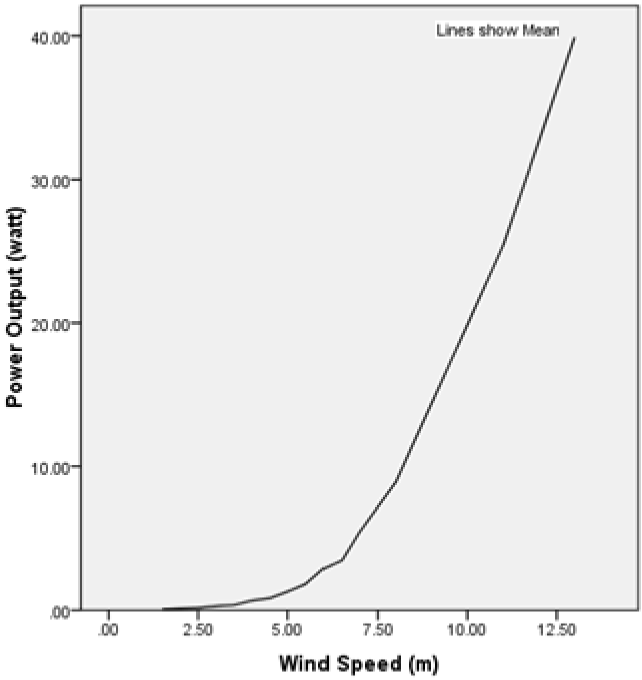

Figure 10: wind speed versus power output

4. Discussion

Table (1) and fig (5) which relates the wind speed and revolution per minute for free dynamo shows a linear relation. For revolution per minute with dynamo is found to be related to the wind speed also shows a linear relation, see fig (6). Table (1) and figs. (7,8,9,10) the wind speed plotted versus the current, voltage, power input and power output respectively shows a linear relation.

From the above results it is found that the voltage and currents which were generated are good and the power also good. The system can use this power to charging the battery and to lighting lamps, which needed to direct current. For all these graphs we see that the curves are not exactly a straight line Finally from the experiment of this small sample of power generation by wind we can make farmers of power in Sudan, in some places because the wind energy is very good in these 6 months. Performance of the results showed that the average power output is found to be 5.57 watt and the average power input is found to be 92.55 so the efficiency of the system $\Upsilon = (P_{out} / P_{in}) * 100\ \% = 4.79\times10^{-2}$.
It's clear that the efficiency is acceptable.

5. Conclusion

1) The efficiency of the system is found to be = 4.79×10^{-2}, and It's clear that the efficiency is acceptable.
2) Mean wind speeds of 4.5 ms^{-1} are available over 50% of Sudan, which well suited for water lifting and intermittent power requirements, while there is one region in the eastern part of Sudan that has a wind speed of 5 ms^{-1} which is suitable for power production.
3) The data presented in this paper can be considered as a nucleus information for executing research and development of wind energy projects; at the same time, they could determine sites that are likely to have a better prospect.
4) All graphs have a linear relation that mean the evaluation of The power generation from wind energy using small wind turbine is good .

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