ITNR International Journal of Technology and Research

Windmill Analysis and Design

abdullah usman tariq, zarnam khalid, jaffar kakakhai
abdullah.usmant@gmail.com, zarnam1@gmail.com,humzakkk@yahoo.com

***Abstract*— the globe is drifting on the highway of advancement and there seems to be no stopping to the pace at which it is currently progressing. Now considering the present era energy seems to be a vital element framing the economies, controlling trade and what not. Doing justice to the importance of energy it can be termed as the backbone of a country. In Pakistan we have been dealing with energy crisis for quiet a long time and on top of it poor management and lack of sensible planning has made the condition even more badly. The crisis is taking a dangerous shape and already has started to create bad impact. So in the present scenario a quick reliable and environment friendly solution would serve the cause. This article provides a solution to a problem which seems to be a nightmare for the people of this country. It is the study of gearless wind turbine and its feasibility along with its usefulness in the present crisis. This advanced turbine can work in many coastal areas where wind speed is up to the mark and can contribute to lower down the energy supply and demand difference to a huge extent.**

I. INTRODUCTION

There was a time when the resources present in the earth were considered to be limitless and everybody was enjoying the feast without even the slightest knowledge of depletion of energy reserves. Indeed when man started its journey towards progress there were very few things that require energy. In the beginning survival was the biggest issue for humans. They live a very simple life and nobody really cares about energy at that time. [1] With the advancement in technology the demand for energy increased. This increase in demand was exponential. The world moved towards modernization, globalization and demand for energy kept on increasing, the population is one factor which increased the energy demand to a huge extent.
[2]
According to an estimate the world population will double by the middle of this century and most of this increase will occur in the developing countries. Now with the increase in population the energy demand at domestic level as well as global level will hit new heights. With the exponential population growth in one hand and people's need for their improved life in another, the consumption of energy will play a vital role in framing the economy of the world. [3] There has been a theory about scarcity of energy resources a long time ago. The theory is quit interesting and claims that there is no physical shortage of energy but there are some international forces trying to force people to think in the opposite direction for their own interest. So one thing is for sure, the third world society can easily be driven and being played in the hands of powerful authorities. Well today one thing is quiet clear that even if we consider the resources to be limitless still the third world needs to find a way which is quick as well as efficient in the energy production. The economy of the country is being framed in the energy policy since it is a vital factor controlling all trade and direct interest. [4] Pakistan in facing some serious energy crisis which not only damages the trade but its effects are quiet long lasting. It would be quiet appropriate to say that Pakistan was dragged into this crisis not by lack of resources but due to poor management and incompetent staff. There was not enough planning, new connection and electrical appliances were given but at the back end the energy production was not increased up to the mark. The problem in Pakistan is not only about generation but inefficient transmission system, line losses, theft, and improper recovery from consumers has a great impact on this crisis. Being an under developed country Pakistan cannot afford to produce electricity by expensive means.
According to a survey the household sector has yet been the largest consumer of energy with 41% of the total consumption while industrial and agricultural is believed to be consuming 31% and 14% respectively. Pakistan most likely will face severe damage due to this situation in the coming years which will choke the economy and will create new problems. Energy has now become life line of a country's economy. On one side it is used for industrial purpose which in turn depends on the revenue and on the other side it is used for domestic purpose. Everyday new electrical appliances are being introduced which again put pressure on the energy production. Now in the present condition people needs to be given quick relief from this hopeless condition by not planning any time taking projects but quick and

Reliable projects needs to be introduced which might help solving the problem. [5] Now if Pakistan taking a tough decision decides to shift its energy production to oil it would definitely be a huge burden on countries foreign exchange reserves. Some industries might not take the pressure of running on oil and may face bankruptcy. Ultimately a huge scale irreparable damage might be waiting for us in the coming years. Taking all these vital signs in to consideration and knowing the fact, fossil fuels or nuclear energy cannot cope up with the present supply and demand scenario. Pakistan must develop a quick, reliable and environment friendly solution which might share the burden to a huge extent.
[6]
As discussed earlier Pakistan cannot afford to shift its energy production to fossil fuels as it would be costly. One of the cheapest sources of energy production is wind. Pakistan is fortunate enough to have some sites near cities where the wind speed is adequate for energy production. According to sources in Baluchistan and Sindh the wind energy would be quiet sufficient to provide electricity to villages. The corridor between Gharo and Keti Bandar has a very high wind speed which can also be utilized for energy generation. The Jhimpir wind energy power plant is the very first of its kind in Pakistan and along with this

project there are fourteen more projects in the pipeline to meet the energy needs of the country so renewable energy might just be the right option for Pakistan at this point of time. Renewable energy has been a vital factor in energy production for a long time. Bio gas has been used for various domestic purposes and wind was also used to move ships and there were many other applications too. At present China, India, Germany and USA are using wind energy for energy production. In southern parts of Pakistan which includes the coastal areas of Baluchistan and Sindh there is a good option for installing wind plants as the monthly average speed is reported to be 7-8 m/s.

II. PAKISTAN'S ENERGY CRISIS

Pakistan energy crisis is a big hurdle in economy's progress and stability. There is a huge difference in supply and demand of energy due to which we are facing huge energy problems. The political authorities are not at all helping to pull out the country from this huge crisis. The industrial sector is a big consumer of energy and a source to earn foreign exchange and due to the present scenario this sector is highly affected, in result the country's economy is also not keeping pace.

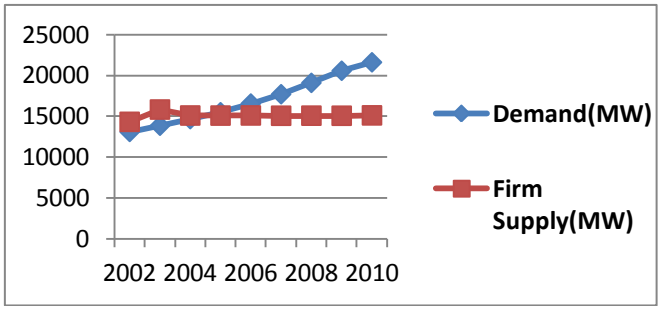

Figure 1: Power Demand and Firm Supply

Total installed capacity of Pakistan is around 21143MW but we are only producing 14500MW (April 2010).Now this clearly draws the picture of poorly managed energy system of our country. One of the main reasons is the unavailability of gas and oil due to which many units are unable to generate power. For a country like Pakistan it is very difficult to manage production of energy on such expensive fuels. We are currently facing a shortfall of more than 2500MW
This is shown in figure (1).

III. PAKISTAN'S ENERGY SECTOR

There are four major power producers in country: WAPDA (Water& Power Development Authority), KESC (Karachi Electric Supply Company), IPPs (Independent Power Producers) and PAEC (Pakistan Atomic Energy Commission). The energy consumption in Pakistan is shown in the following pie chart. The pie chart clearly shows that the domestic sector in our country consume highest percentage of energy produced. Commercial and industrial usage of energy is comparatively less than the domestic usage.

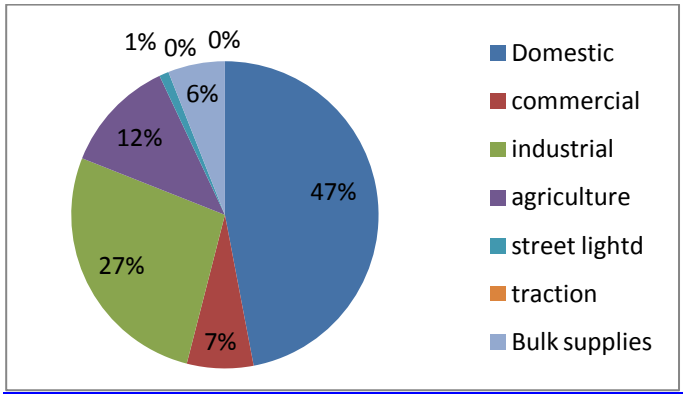

Figure 2: Energy Consumption in Pakistan

IV. WINDMILL

In the present situation getting energy from wind might be a good option. Oil and gas are expensive fuels to use whereas the hydal power projects need a lot of time to be installed and fully operational, and solar panels are also quiet expensive. So to get a quick and long term reliable solution windmill is the best option to opt. To make a wind power plant fully operational it takes comparatively less time and more output can be taken out of it. From the figure 3 we can see the cost on per KWH (kilo watt hour) is less then from other energy sources.

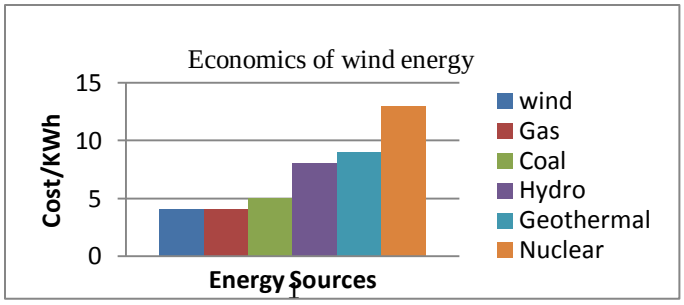

Figure 3: Economics of Wind Energy

A. THE BETZ LAW

Betz' law gives the maximal achievable extraction of wind power by a wind turbine as 59.3% of the total kinetic energy of the air flowing through the turbine.

The losses that occur during the power generation through wind turbine are mainly due to the blade friction and drag, gear box losses and converter losses

B. POWER COEFFICIENT

That power which is generated by kinetic energy on free flowing wind stream is

$P=1/2\rho$ [Watts

There S is the cross-sectional area of blades.
S=π R= radius of blades
V= velocity there v= (-)
= up stream velocity
= downstream velocity
So, the power coefficient =P/W
P= extractable power
So, =16/27

This is 59.3%

C. WIND TURBINE

Windmill is a device used to convert kinetic energy of wind into electrical energy. The main idea behind the design is to get maximum kinetic energy of wind and convert it into the useful form of energy. So to design a compatible windmill structure the following components are needed to be taken care of

a) Design of blades.
b) Structure of hub.
c) Supporting structure and foundation.
d) Generator.

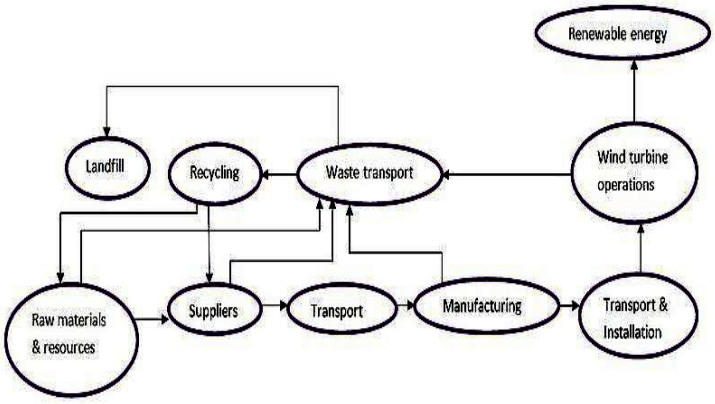

Figure 4: Flow Diagram of Wind Turbine Plant

V. COMPONENTS OF WINDTURBINE

A. a) ROTOR

Blades play the role of being a rotor in wind turbine. They are usually shaped like airplane wings and are connected a hub. There is a low speed shaft that is attached to rotor.

B. b) BRAKE

The mechanism preventing braking effect of the blade at high speeds. They are also used while maintance.

c) *GEARBOX*

Small turbines have a direct drive shaft system which does not require gear box system. But for commercial use the transmission gear help to upgrade the speed which is required to produce electricity.

d) *GENERATOR*

The generator inside windmill converts mechanical energy produced by the rotor into electrical energy. The energy produced may be in a direct or alternating form. The energy on the other end is transferred to power grid for transmission.

e) *CONTROLLER*

Controller plays a vital role in wind mill operation. Diagnostic tests are run by controller and with the results obtained by these tests; adjustments are made for efficient functioning of wind mill. It also helps to tackle the variation in wind speed by making appropriate adjustments. A tachometer measures wind speed and passes it to the controller.

f) *WINDVANE*

The wind vane helps the turbine to keep the right direction. Any information related to direction of wind is passed to the controller by wind vane, so that the position of Yaw can be adjusted in the right direction.

g) *TOWER*

The height of tower is an important element in the production of energy. Wind speed is more on high altitudes so a taller tower allows capturing maximum wind energy in fig the tower parts are shown.

VI. GEARLESSWIND TURBINE

In gearless wind turbine the rotor shaft is directly connected to generator the generator is spin at the same speed as the blades. in the generator the magnets spin around a coil to produce the current if we move it fast the more current will be produced so for more magnetic flux we use permanent magnets in our construction.

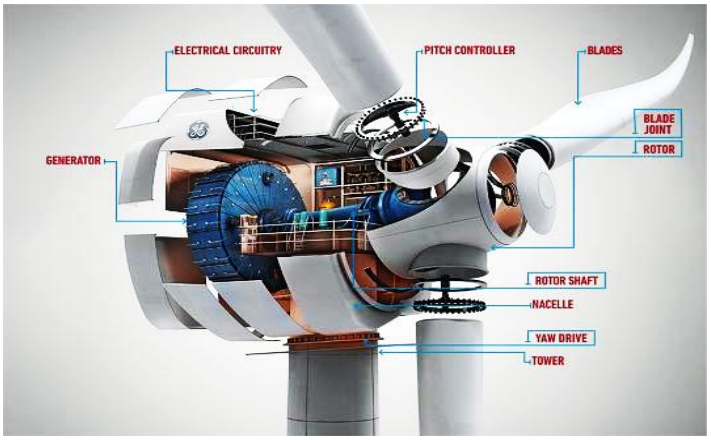

Figure 5: Gearless Wind Turbine

VII. WORKING PRINCIPAL

The working principal of generator depends on Faradays' law, which shows when the conductor cuts the magnetic field it produces emf.

t = change in time

The produced emf depends on the relative motion between coil and flux.

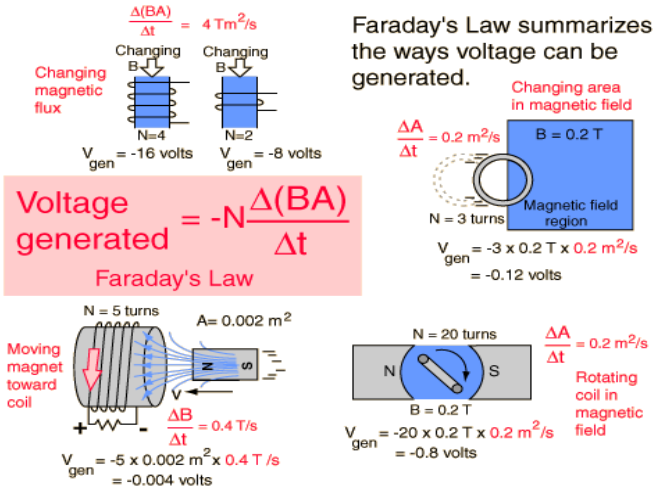

Figure 6: Implementation of Faraday's Law

In our wind turbine model we are using permanent magnets for the production of magnetic flux. We are using coils which are in series (4 coils and 4 magnets). The rotation of blades is caused by wind energy, blades are connected to the main shaft and our permanent magnetics are connected to the shaft. When the shafts rotate the permanent magnet also rotates and that cuts the series winding coil which is fixed. According to the faraday's law when the magnetic flux cuts our coil in that coil the emf is produce and from the coil we take that voltage on the output.

Every generator initially produces AC (alternating current). We use rectifier to convert the produced AC (alternating current) to DC (direct current).

VIII. MODEL

Our model prototype is on wind tribine its working is like a normal wind trbine. The figure 7 is a picture of our proposed model.

A. 11.1. PRINCIPAL

Princapl of our model is simple like other big wind trbines.when the blades of our prototype rotate with external force its rotate the magnet and on our prototype the magnet are movable and coils are fixed, according to Faradays law when the conductor cuts the magnetic field its produce the emf or changing flux produce the emf in a conductor now in our prototype when we rotate the magnets its produce the changing flux and on our fixed coils the emf is produce which we take on output and that output shows on occsilscope.After that we will be using filters and rectifier by using rectifier it converts the AC into DC and by using the filters it remove the ac parts from the output and our output became smooth.

Figure 7: Prototype of Gearless Windmill

B. . PARTS

a) Magnetics
b) Coils

c) Blades
d) Base

C.

D. TYPES OF PERMANENT MAGNET

a. There are main four type of permanent magnet.

Neodymium Iron Boron (NdFeB)

That type of magnet has a high coercive force. In that extremely high energy product range, up to 50 MGOe. Because of this high product energy level, that is usually manufactured to small and compact in size. [7]However, NdFeB magnets have low mechanical strength.Thatare very strong magnets and are difficult to demagnetize.

Samarium Cobalt (SmCo)

SmCo magnets are very strong and difficult to demagnetize. They are highly oxidation-resistant and temperature resistant, withstanding temperatures up to 300 degrees Celsius.[8] Two different groups of SmCo magnets exist divided based on their product energy range. The first series has an energy product range of 15-22 MGOe.The second serieshas a range that falls between 22 and 30 MGOe. However, they can be expensive and have low-mechanical strength.

Alnico

Alnico magnets have three main ingredients: aluminum, nickel, and cobalt. In that temperature resistance is good, they can easily be demagnetized.[9] That can be produced by either sintering or casting, with each process yielding different magnet characteristics.

Ceramic or Ferrite

Those magnets are typically inexpensive and easily produced, either through sintering or pressing.[10] That is one of the most commonly used types of magnet, and is strong and is not easy to demagnetize.

Force between two magnetic poles

$$F=\frac{\mu\, q_{m1} q_{m2}}{4\pi r^2}$$

F	force
qm1, qm2	magnitudes of magnetic poles
μ	permeability
r	distance

In our model we are using klystron magnet. The name "klystron" was suggested by Hermann Frankel, a professor in the classics department at Stanford University. In that magnetic the flux power is greater then the other permanent magnet and that magnet are normaly used in radar, satellite and in diode guns.

Figure 8: Magnetics

a. COILS

According to American wire gauge we want to produce 10 volts so our wire 2.288 Ømm, and the wire cross sectional area is 5.26 mm2. In our model we are using series coiling method and we connect our 4 coils in series.

b. BLADES

In our model we use plastic material and so on in our blades we are also use plastic material.the blades is directly connected to magnetic when the blades rotate it also rotate the magnets on the coil.

c. BASE

On our base we use wood board which gives a support to our prototype model.

E. 11.3. WINDING

There are two basic type of winding

i. LAP WINDING

Lap winding is also called series winding. In that winding successive coils overlap each other hence it is called lap winding. In this winding end of one coil is connected to the commutator segment and start of the adjacent coil situated.[11]Under the same pole as shown in fig. 9. Lap winding is further divided as simplex and duplex lap winding.

ii. WAVE WINDING

In wave winding the end of one coil is not connected to the beginning of the same coil [12]but it is connected to the beginning of another coil of the same polarity as that of the first coil as shown in fig. 9

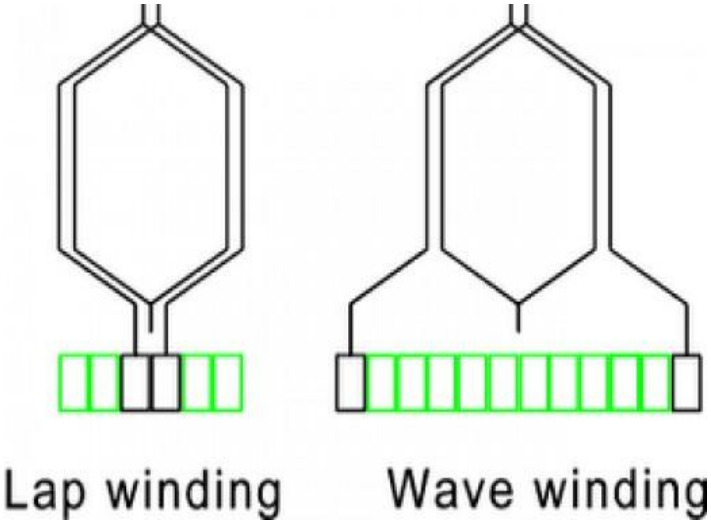

Figure 9: Lap and Wave Winding

IX. READINGS

The graph and readings taken from our proposed model are shown in the following figure 10 and table 1.0 respectively. Connecting the oscilloscope with our model we obtained the graph and readings. With the help of DSO3000 software we transferred the recorded data to a computer and the output can be clearly seen below. The graph shows Vmax to be 4.72V

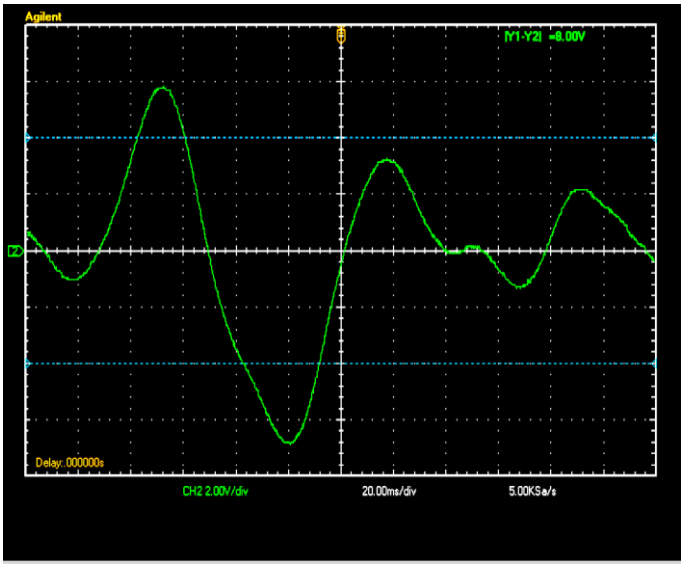

Figure 10: Graph

Vpp	1.04E+01
Vmax	4.72E+00
Vmin	-5.68E+00
Vavg	-2.09E-01
Vamp	7.20E+00
Vtop	1.58E+00
Vbase	-5.63E+00
Vrms	2.43E+00
Vover	4.80%
Vper	0.80%
Rise time	2.05E-02
Fall time	3.02E-02
Pluse width	4.74E-02

Table 1.0: Readings

X. CONCLUSION

We have proposed a new and efficient design for the working of gearless wind turbine. It is simple yet very useful in the present scenario. The series coil winding and permanent magnets are used. The output will further be dealt with low pass filters to supply smooth voltage to the battery.

REFERENCES

[1] Asif, Muhammad, and Tariq Muneer. "*Energy supply, its demand and security issues for developed and emerging economies*." Renewable and Sustainable Energy Reviews 11, no. 7 (2007): 1388-1413.

[2] I. Dincer, M. RosenEnergy, "*Environment and sustainable development Appl Energy*", 64 (1999)

[3] Tanzer, Michael. The energy crisis: *World struggle for power and wealth*. New York: Monthly Review Press, 1974.

[4] Haq, D. N. U., and K. H. A. L. I. D. Hussain. "*Energy crisis in Pakistan*." IPRI Factfile (2008).

[5] Harijan, Khanji, Muhammad Aslam Uqaili, and Mujeebuddin Memon. "*Renewable energy for managing energy crisis in Pakistan*." In Wireless Networks, Information Processing and Systems, pp. 449-455. Springer Berlin Heidelberg, 2009.

[6] Asif, M. "*Sustainable energy options for Pakistan*." Renewable and Sustainable Energy Reviews 13, no. 4 (2009): 903-909.

[7] Lee, R. W., E. G. Brewer, and N. Schaffel. "*Processing of neodymium-iron-boron melt-spun ribbons to fully dense magnets*." Magnetics, IEEE Transactions on 21, no. 5 (1985): 1958-1963.

[8] Perry, A. J. "*The constitution of copper-hardened samarium-cobalt permanent magnets*." Journal of the Less Common Metals 51, no. 1 (1977): 153-162.

[9] Heidenreich, R. D., and E. A. Nesbitt. "*Physical Structure and Magnetic Anisotropy of Alnico 5. Part I*." Journal of Applied Physics 23, no. 3 (2004): 352-365

[10] Kools, F., A. Morel, R. Grössinger, J. M. Le Breton, and P. Tenaud. "*LaCo-substituted ferrite magnets, a new class of high-grade ceramic magnets; intrinsic and microstructural aspects*." Journal of magnetism and magnetic materials 242 (2002): 1270-1276.

[11] Major, Jeffrey T. "*Method of making a multiple open turn lap wound dynamoelectric machine*." U.S. Patent 4,417,388, issued November 29, 1983.

[12] Napierski, Reinhard. "*Method and apparatus for producing a wave winding.*" U.S. Patent 5,492,154, issued February 20, 1996.