Identifying the windy sites in Arunachal Pradesh and feasibility of installing small wind power plant thereof.

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Abstract: ***Wind energy is a clean, eco-friendly, renewable resource and is non-polluting. Wind is an indirect manifestation of solar energy and hence we can say that wind energy is a form of solar energy, about 1 to 2 % of the energy coming from the sun is converted into wind energy. Generation of air currents is a direct effect of the combination of two phenomenons, Circulation of hot air and Earth rotation. Accordingly winds are broadly, local winds and planetary winds. China and U.S. are the two top countries ofhaving highest capacityinstallations of wind power plant. India is one of the blessed countries having an estimated gross potential of 45,000MW power from the wind and is fifth largest installed wind power capacity in the world.***
This paper studies, analyzes and identifies the windy potential sites in one ofIndian Frontier Stateof Arunachal Pradesh and the papercould successfully be able to assess wind resources and identify the windy potential sites like Sela andLikabali in the state for setting up small wind power plant thereof.
Keywords: Anemometer, data logger, m.a.s.l. (metre above sea level).

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1. Introduction

Even today fossil fuels are the main source of power for most of the developing nations-India too being not an exception; oil and coal which form the back bone of the modern society are non-renewable destined to get exhausted someday [1].Apart from that, combustion of fossil fuels releases various types of pollutants in the atmosphere. Continuous burning of fossil fuels at a very large scale has led us to yet another very serious environmental threat. If the trend is not checked by 2100 the average temperature around the globe will rise by 1-3.5 degree Celsius, which will cause a dreadful upsurge in the sea water levels drowning all lands at low elevation along the coastal lines[2].

Considering the above unwholesome factors, scientists and environmentalists all over the world, for the last few decades, have been stressing upon developing more and more ways to generate power from harmless renewable sources. Wind and Solar power system are the prominent renewable source for power generation [3]. Solar based PV energy is the prime source of renewable energy resources on the earth [4].Wind energy is one of the most promising renewable sources of energy, delivers clean energy, which the entire world is looking at today[5-6]. India is one of the blessed countries, where according to a latest survey report by the ministry of non-conventional energy resources, India,we have an estimated gross potential of more than 102772MW power from wind[7].

1.1 Wind Power And Energy Contents on Hills.

The fundamental principles that govern the operation and performance of modern wind turbines from the formula for kinetic energy and the mass of air moving air through unit area, The power in the wind in watts is therefore;

$P = \frac{1}{2} \rho A V^3$ watts. (1)

Where 'ρ' is the density of air in Kg/m^3(≈ $1.225kg/m^3$) 'A' the area intercepting the wind in m^2, and 'V' the wind velocity in m/s. The expression gives the total power available in the wind.Also Wind power density, WPD $= \frac{1}{2} \rho V^3$ W/m^2. The maximum power that can be extracted from wind stream is 16/17 or 0.593 WPD(by Betz Limit effect).

The physical features of the landscape modify the wind pattern drastically. In complex terrain, the study of special features of the land i.e. geomorphology, plays an important role in estimation of wind potential. Certain terrain features such as passes, saddle, gaps, canyon, gorges etc. produce enhanced

wind speed as they tend to channelize winds and become ideal sites for wind power generation.

2. Global Scenario of Wind Energy

Many countries promote the wind-power technology by national program and market incentives. In 2010, China overtook US to become the biggest producer of wind power. Here is a list of the top ten wind power countries. The Latest Countries wise total Installed Wind Power Capacity of the Top 10 Countries in Megawatt(Upto end of 2014)[8-9-10].

- China 145362
- US 74471
- Germany 44947
- India 25088
- Spain 23025
- United Kingdom 13603
- Canada 11205
- France 10358
- Italy 8663
- Brazil 5939

3. Wind Energy Resource in India.

India is one of the blessed countries, where according to a latest survey data available in Sourcesis the fourth largest installed wind power capacity in the world[10].We have an estimated gross wind potential of 102772MW[7].According to a latest survey report by the Ministry of New and Renewable Energy(MNRE), India[7,11-13].,State wiseGross Wind Potential(GWP)Vs installed capacity(IC), upto 31-3-2016 are shown both in Table-I and Figure.1

Table-I: State wiseGross Wind Potentialand installed capacity,upto 31-3-2016

S.No	States	Gross potential (MW)	Installed Capacity (MW)
1	Gujarat	35071	4030.65
2	Andhra Pradesh	14497	1393.5
3	Karnataka	13593	2878.3
4	Madhya Pradesh	5500	2171.9
5	Rajasthan	5050	2994.9
6	Maharashtra	5961	4437
7	Tamil Nadu	14152	7652.15
8	Orissa	1384	42.0
9	Kerala	875	434
10	Telangana	-	77.7
11	West Bengal	22	1.1
12	Arunachal Pradesh	236	
13	Others states	11381	3.2
	Total	102772	25116.4

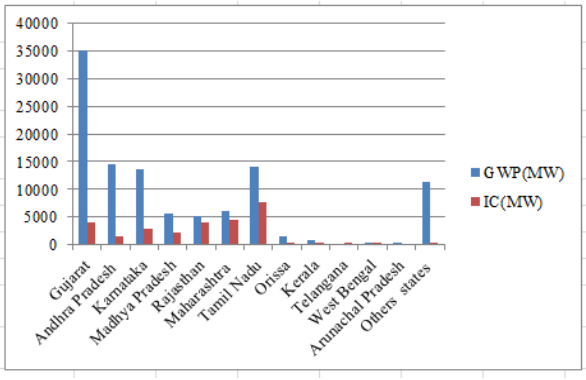

Figure 1: Installed Capacity of Wind Power in the Indian states

4. Wind Power Potential Sites in Arunachal Pradesh.

The state of Arunachal Pradesh has windy sites which on the basis of altitude in metre above sea level(m.a.s.l) are broadly classified into three types namlyElevated sites, Valley Floor sites and Down-slope sites[14]

a) **Elevated sites**.: The elevated peaks helps in getting an access into upper winds.The elevations in Arunachal Pradesh are found to vary as low as 2000 m.a.s.l as high as northern side with the Tibet border 4180 m.a.s.l. Few Sites are SelaPass,Tawangdistrict,Raga in Lower Subansiridistrict,Laju in Changlang district and Hayuliang in Lohit district.

b) **Valleys floors sites**:The valley floors sites helps in getting an access into plateau or slope winds.The elevations in Arunachal Pradesh are found to vary as low as 800 m.a.s.l as high as 1950 m.a.s.l sites Few sites are Mechuka in West Siang district,.Rupa in West Kameng and Shimong(Yangkiong) in Upper Siang district.

c) **Down-Slope Sites**: The sites help in getting an access into downland and adjoin slopes of the mountains The elevations in Arunachal Pradesh are found to vary as low as 100 m.a.s.l and as high as 750 m.a.s.l sites are Pasighat in East Siang district and Likabali in West Siang district.

5. Intensive Survey and data Collection at Windy Locations.

Extensive site surveys were carried out in many locations in Arunachal Pradesh to access presence of wind pattern and thereby identifying the wind potential sites in Arunachal Pradesh. In the state of Arunachal Pradesh, it is found that wind patterns prevailing in it is purely local winds. Because the

hilly regions generally offer good local wind potential as the physical features of the landscape modify the wind pattern drastically.

With the help of Arunachal Pradesh Energy Development Agency(APEDA) and C-WET Chennai,four windy sites have been extensively studied one being at elevated site i.e.,Sela and Raga, Other at valley floors windy site i.e.,Simong and third one being at down slope windy sites. i.e at Likabali and summary of wind datas are provided below.The wind speed or wind data on hourly, monthly and annual average wind speed basis have been recorded in the following tables

After thorough investigation, four local wind potential sites in the state of Arunachal Pradesh vizSela in Tawang,Raga in Lower Subansiri,Likabali in West Siang and Simong in Upper Siang have been identified and suitably recommend thereof installing small electric generating unit for harnessing locally wind energy available in the state for catering the electricity need of nearby rural mass. The details set up for wind measurement[15] is shown below in Figure.2

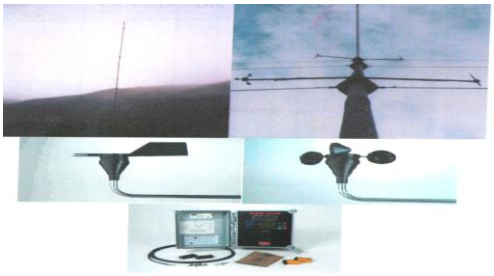

Figure 2: Set up for wind measurements anemometer, wind vane, digital data logger and mounting mast height.

6. Data Collection And Processing

The data stored by the data logger which is in binary format and the storage device could be a non-volatile device where by the ability to store data is not affected by loss of system power. At site data was stored in an EPROM or EEPROM or Flash card. These were brought to a central place and processed through appropriate reader and software to give data in an ASCII format. Alternatively the data from the data logger was downloaded into laptop at the site or send through the modem(remote transferring of data) to a central computer Centre. The data collected needs to be processed either manually or through computer-based programmes. The validity of the data consists of data screening and verification. This process will enable one to make the data fit for analysis purpose. From the verified data the parameters like the average monthly wind speed, joint wind speed and direction distribution and wind speed frequency distribution can be assessed of the site on monthly basis.

7. Initial Estimation cum Designated Wind power.

Using $P = 0.20D^2.V^3$ Watt for wind power, the following sites have wind power potential of few kW(taking say the diameter of Wind blade as 6m).

(i)Designed Wind Power at Sela,

$$P = 0.2(6)^2(4.6)^3 = 700.8W$$

(ii) Designed Wind Power at Likabali,

$$P = 0.2(6)^2(2.9)^3 = 175.6W$$

(iii) Designated Wind Power at Raga

$$P = 0.2(6)^2(1.8)^3 = 42W$$

(iv) Designated Wind Power at Simong

$$P = 0.2(6)^2(1)^3 = 7.2W$$

8. Analysis of Results

The characteristics curves showing the mean hourly wind speed, monthly wind speed and annual wind speed of four windy sites in the state of Arunachal Pradesh have drawn. Graphs showing the comparative study among the four wind sites have also been prepared.The graph of monthly mean wind speed of four locations are provided in Fig.3 below. From the graph it is observed that wind speed of two location namely, Raga &Simong are very low and the sites are not feasible for future installation of small plants at Raga &Simong.However, Sela and Likabali sites have enough annual average wind speed and are feasible for installation of small wind power plant overthere. The details of these two sites are provided from Fig.6 to Fig.32 respectively.

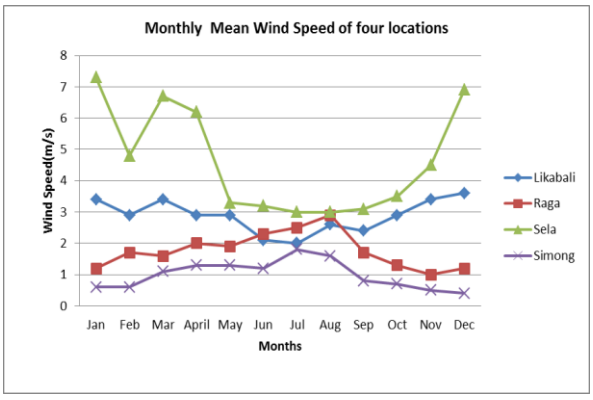

Figure 3: Mean wind speeds at four locations.

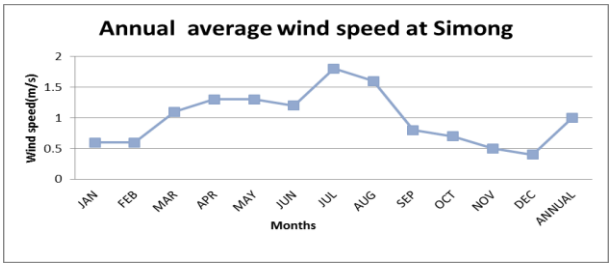

Figure 4: The average wind speed at Simong
Observation :Simong, Upper Siang District
Measured wind speed : 1m/s, P = 7.2 Watts.

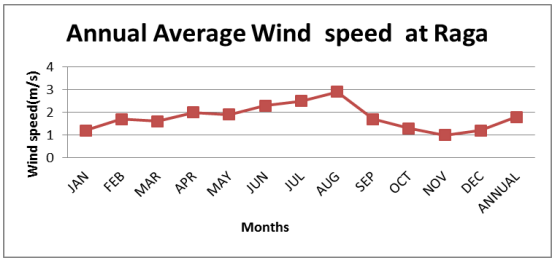

Figure 5: The average wind speed at Raga
Observation :Raga, Lower Subansiri district
Measured wind speed : 1.8 m/s, P = 41.99 Watts.

Graphs: Mean Hourly Wind Speed for all months of year at LIKABALI are given from Fig 6 to Fig.17 respectively

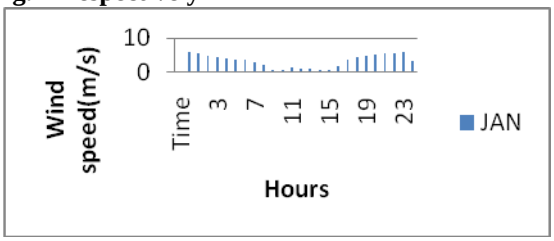

Figure 6: Mean Hourly Wind Speed for January

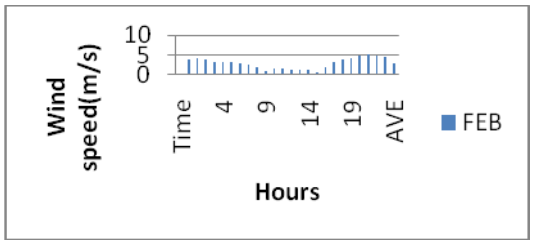

Figure 7: Mean Hourly Wind Speed for February.

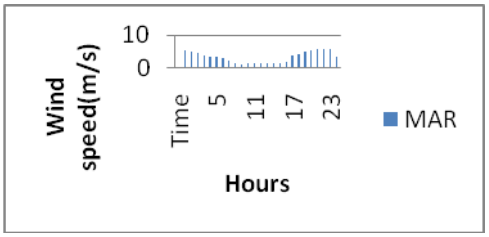

Figure 8: Mean Hourly Wind Speed for March

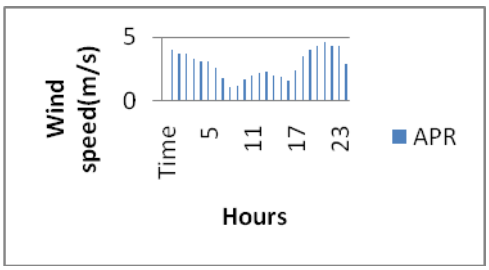

Figure 9: Mean Hourly Wind Speed for April

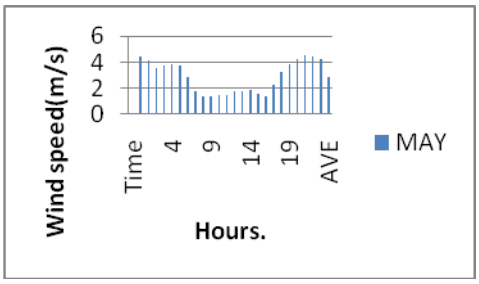

Figure 10: Mean Hourly Wind Speed for May

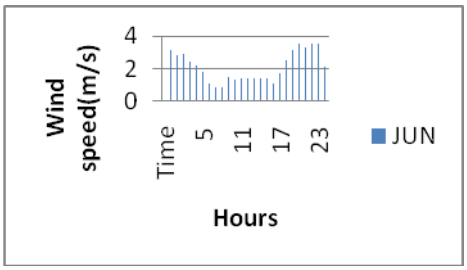

Figure 11: Mean Hourly Wind Speed for June.

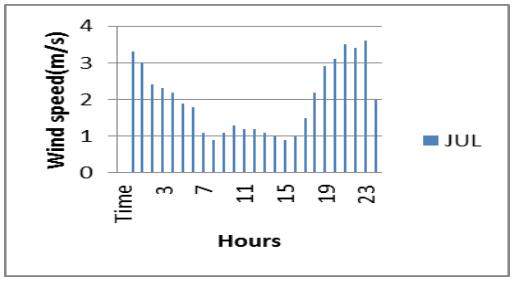

Figure12: Mean Hourly Wind Speed for July.

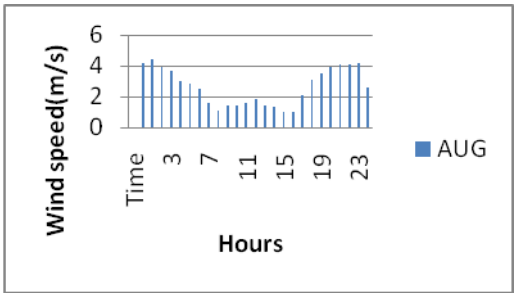

Figure 13: Mean Hourly Wind Speed for August.

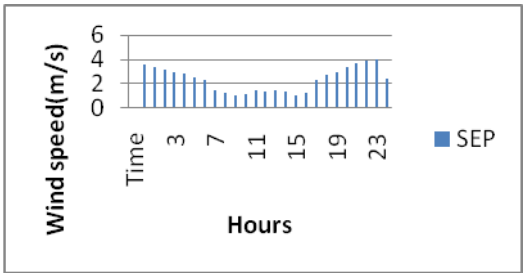

Figure14: Mean Hourly Wind Speed for September.

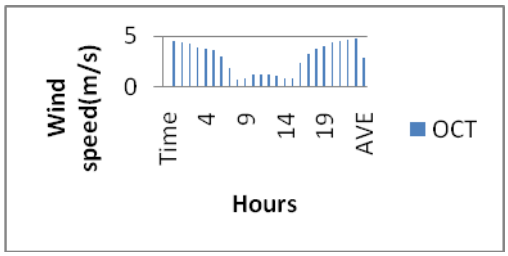

Figure 15: Mean Hourly Wind Speed for October

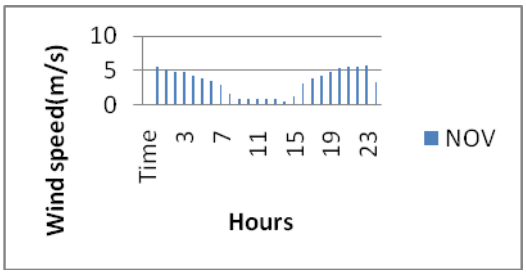

Figure 16: Mean Hourly Wind Speed for November

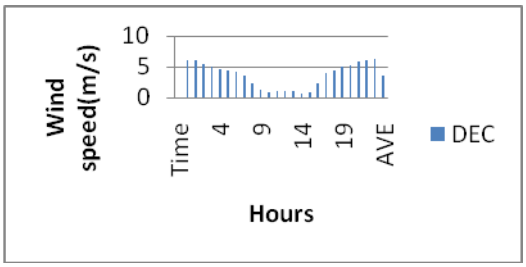

Figure 17: Mean Hourly Wind Speed for December

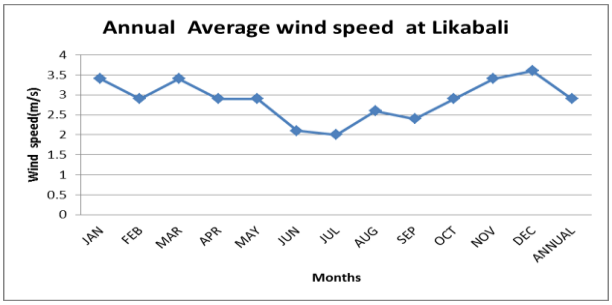

Figure 18: Annual average Wind Speed at Likabali

Observation :Likabali,West Siang District

Measured wind speed : 2.9 m/s, P = 175.6 Watts.

Graphs: Mean Hourly Wind Speed for all months of year at Sela are given from Fig.19 to Figure 30 respectively

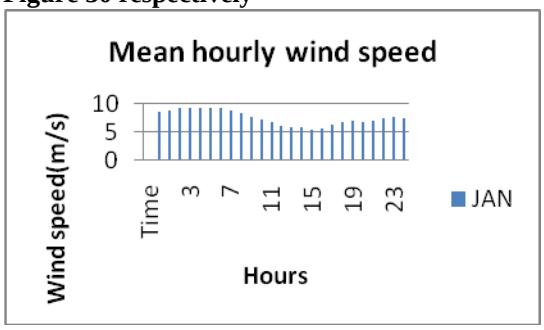

Figure 19: Mean Hourly Wind Speed for January

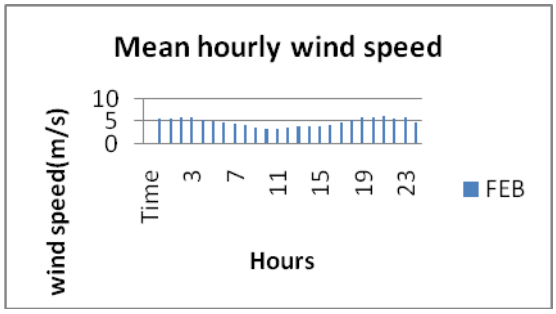

Figure 20: Mean Hourly Wind Speed for Februray

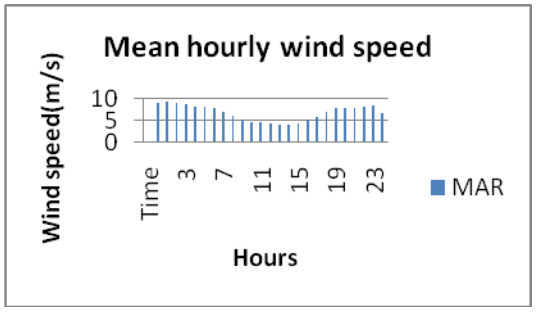

Figure21: Mean Hourly Wind Speed for March

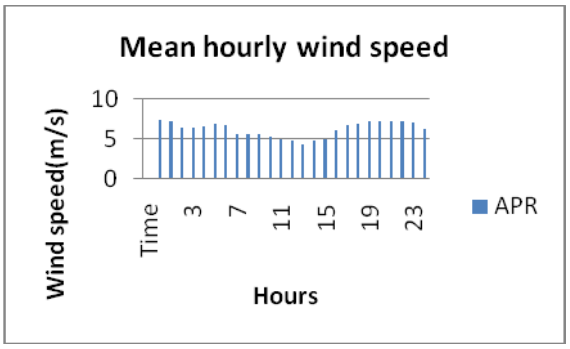

Figure 22: Mean Hourly Wind Speed forApril

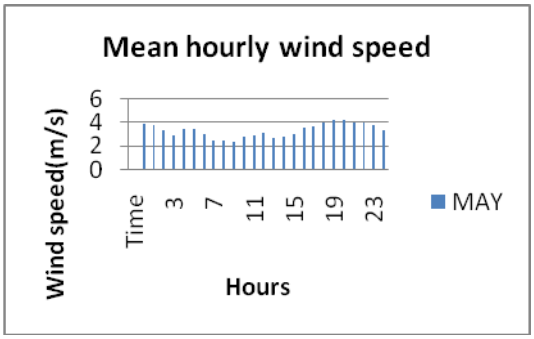

Figure 23: Mean Hourly Wind Speed for May

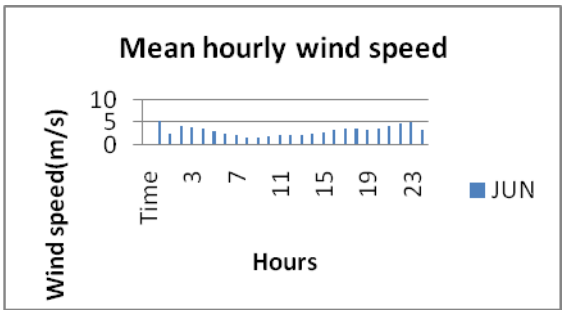

Figure 24: Mean Hourly Wind Speed for June

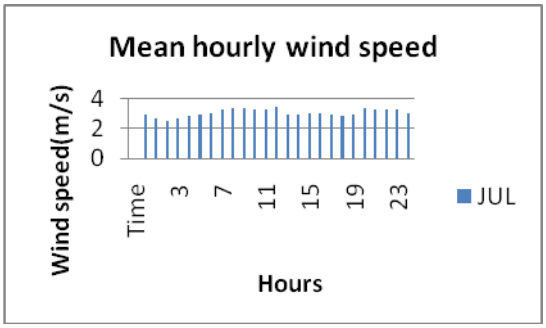

Figure 25: Mean Hourly Wind Speed for July

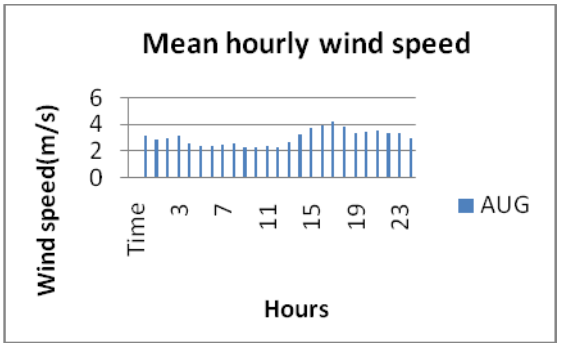

Figure 26: Mean Hourly Wind Speed for August

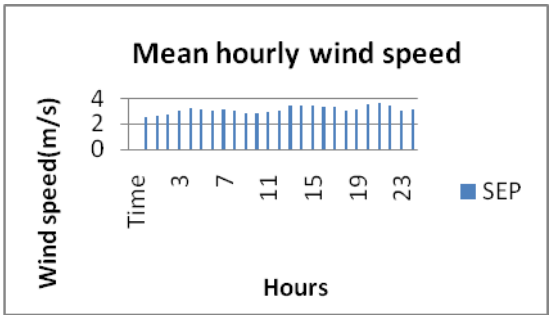

Figure 27: Mean Hourly Wind Speed for September

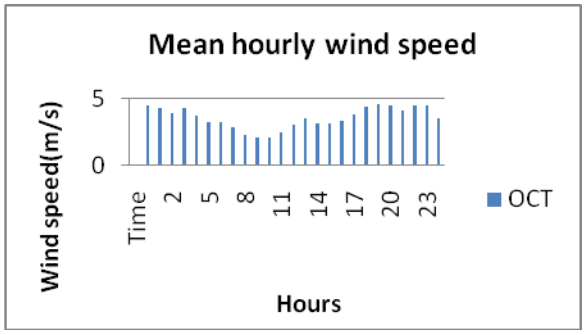

Figure 28: Mean Hourly Wind Speed for October

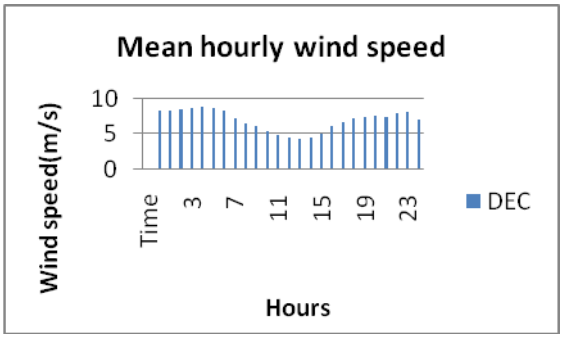

Figure 29: Mean Hourly Wind Speed for December

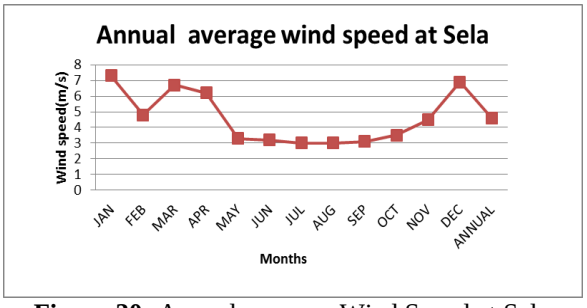

Figure 30: Annual average Wind Speed at Sela Observation:**Sela ,**Tawang District Measured wind speed:4.6 m/s,P= 700.8 Watts,

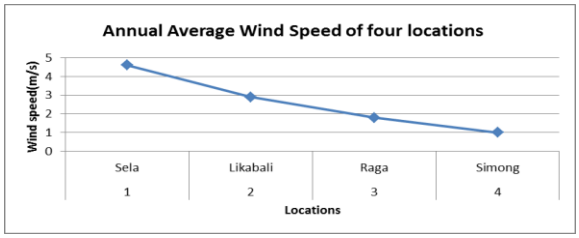

Figure 31: Annual average Wind speed of four Locations

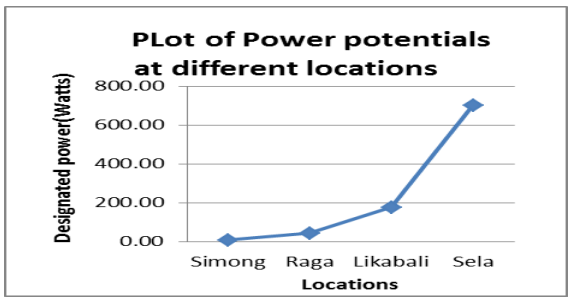

Figure 32: Designtaed Wind Power potential at four locations

From the above graph it is seen that Sela and Likabali are the two best windy sites having enough wind power potentials for installation of small wind power plants thereof

9. Conclusion

Analysis and identification of windy potential sites in the state of Arunachal Pradesh have been carried out. It could successfully be able to assess wind resources and identify the windy potential sites in Arunachal Pradesh. Out of four station namely, Raga,Simong,likabali and Sela,it is seen that Sela and Likabali are the two best windy sites having enough wind power potentials for installation of small wind power plants thereof.This study of windy sites and its wind data collected indicates a lot of information about the wind power potentials sites in the state which may be immensely useful for installation of small wind power plant in the above locations in future.

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