Assessment and Comparative Investigation of Wind Power Density for Ormara and Jiwani - Coast Of Balochistan, Pakistan.

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Abstract— This study presents the comparative investigation of the power density of wind for two coastal areas that is Ormara and Jiwani in Provence Balochistan of Pakistan. 10 years data (1998-2007) have been taken from the Meteorological Department (PMD-Karachi Office). By using five different numerical methods, wind power densities are calculated for Ormara and Jiwani. By the comparison, it is observed that Ormara have higher power density as compared to Jiwani. In the month of April maximum wind power density is predicted.

Index Terms— Wind energy, Weibull distribution, Weibull Parameters, Scale Parameter, Shape Parameter, Wind Power Density.

INTRODUCTION

THE rapid increase in inhabitants, industrialization, materialistic standard of living style and extra ordinary use of energy is the main cause of a huge demand of electricity in Pakistan.

According to Pakistan American Business Association (PABA), Pakistan stands second in the field of economy which is producing 15,886 MW while the demand is around 19,500 MW. The imbalance between supply and demand is 3500 MW (approximately) while in hot weather this disparity increases to 6000 MW or more. As a result the load shading increases and lasts between 8 to 12 hours per day [1, 2]

Not only Pakistan but all over the world countries are facing a tremendous problem of energy crises. After a long research and investigation all developed countries are diverting to the renewable energy resources [3]. It is a great challenge for all the countries around the globe to overcome on energy crises. As for Pakistan it is the greatest menace to tackle with. It is the peak time to take a courage and well-coordinated leap to renewable energy resources as other developed countries are doing. Below is graphical representation of Global Renewable energy report 2018 summary of last ten years from 2007- 2017 [4, 5].

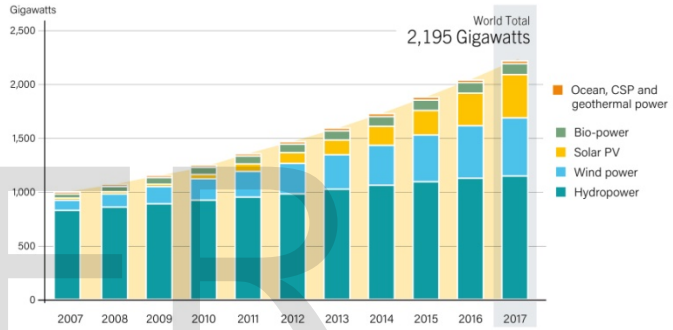
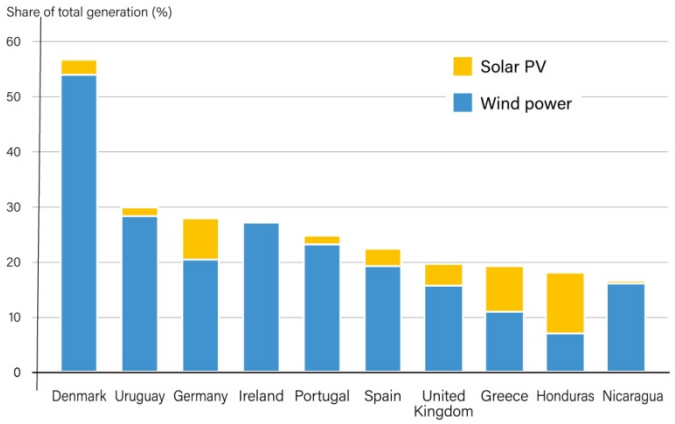


Figure 1: Represent World Usage of Renewable energy from 2007-2017

Above bar graph shows that the world is utilizing around 2,195 GW from renewable resources. Among all or renewable energies only wind and solar are considered the cheapest and the easiest resource for the generation of electricity [5,6].



S. N	Index No.	Name of Station	Latitude	Longitude	Elevation / height (a.m.s.l)
1	41756	Jiwani	25^0 04’	61^0 48’	56 meters
2	41760	Ormara	25^0 12’	64^0 40’	02 meters

Figure 2: Ten top countries representations of Power Generation by Renewable energy reported-2017

Above bar graph represent the percentage composition between wind and solar ratio. From last ten years it is clear that the wind and solar are sources being used as the main sources for the generation of electricity among all of renewable resources [7].

Wind is one of the most important resources for production of electricity. All over the world the wind farm is used rapidly and frequently for power generation and its capacity is increased annually. Below is the representationof the wind power production data graph of recent past ten years.

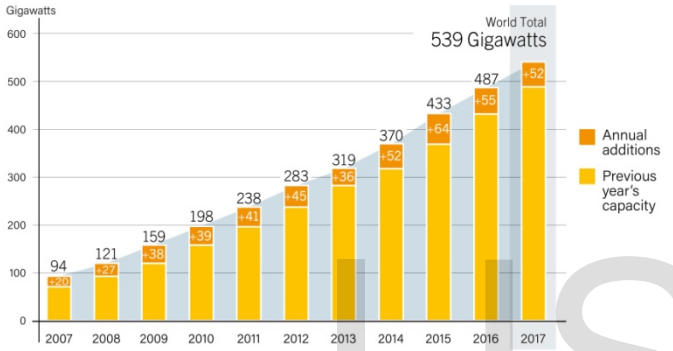


Figure 3: Previous 10 years record Graph of Wind Power generation with annual addition.

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According to the geographical location of Pakistan, Balochistan and Sindh are located on the Ideal position on the coastal belt of Pakistan. The coastal belt is always rich of wind energy and it is considered the best location for wind farm.

This paper represents the comparative study of wind energy production and power density of wind by using weibull formula of two coastal areas of Balochistan, Pakistan.

GEOGRAPHICAL LOCATION OF ORMARA AND JIWANI, BALOCHISTAN PAKISTAN

Ormara and Jiwani are the best location for wind farm. Ormara is situated on coastal belt of Makran while Jiwani is situated in the coastal region of port of Gawader [8]

WEIBULL DISTRIBUTION

Wind data can generally be interpreted by the weibull distribution formula. K and c are the two important parameters of this formula. K is known as shape parameter which is dimensionless while c has a dimension and so called scale parameter[9]. It has a dimension of velocity with standard unit m/s [8]. Different numerical methods and techniques are normally used to determine the calculated values of k and c. In this study enlist five numerical methods are using for the estimation of parameters (k and c) [10].

1. Maximum Likelihood Method
2. Moment Method
3. Empirical Method
4. Modified Maximum Likelihood Method
5. Energy Pattern Factor Method[11-14]

Probability Density function (PDF):

$$f(v) = \frac{k}{c} * 1 * \left(\frac{v}{c}\right)^{k-1} * \exp\left[-1 * \left(\frac{v}{c}\right)^{k}\right]$$

Cumulative Distribution Function (CDF):

$$F(v) = 1 * 1 - * exp\left[-1 * \left(\frac{v}{c}\right)^{k}\right]$$

for the above equation k and c can be determine by using above mentions numerical methods [15].

WIND POWER CALCULATION FORMULA AND WIND POWER DENSITY:

Kinetic energy (K.E) of air mass is called energy of wind [16] [17]. The mathematical equation of kinetic energy is:

$$K.E = ½ * m * v^2$$

Where, m is the mass and v is the velocity.
The product of volume (V) and density(ρ) gives the mass (m) of air [16].

$$m = V * \rho * 1$$

The mass of air can be written as [18]:

$$m = ½ * A * t * \rho * v^3$$

In the specific period of time (t), cross-section area (A) and constant wind velocity (v) produce the mass (m) of air [19].

Wind power density can be calculated by using the equation is give below [20]:

$$\text{Wind power density (WPD)} = \tfrac{1}{2} * \rho * V3$$

Wind Power density depends on three important factor i.e, height from the ground level, pressure of air and temperature of that region [21]. The power density can be calculated annually with the help of Weibull power density formula.

Naturally three important factors depend on the wind power density (WPD):

Altitude (m)

Air Pressure (pa)

Temperature (0C or K) [16].

Weibull density formula can help for the calculation of power density, according to the formula of power density [22-24]:

$$Pw = \tfrac{1}{2} * \rho * V3 * \Gamma * \left(1 + \frac{3}{k}\right)$$

RESULT AND DISCUSSION:

The comparison of wind power density for Ormara and Jiwani is executed in this study. Weibull power density formula has been used to calculate the value of power density. Measured values and five different numerical methods (MMLM, MOM, EmM, EPM and MLM) has been carried out the power density values. Histogram of Power density Comparison of Measured and 5 numerical methods of Ormara and Jiwani also have been produced for the period of 10 years (1998-2007).

WIND POWER DENSITIES FOR ORMARA AND JIWANI.

A table below shows the comparison of measured and predicted power density for 10 years (1998-2007) by using five numerical methods. Histogram have also been plotted to know the predicted power density.

Table 2: Estimation of Power density of Ormara for the period of 10 years (1998-2007)

ORMARA PREDICTED AND MEASURED POWER DENSITY						
1998-2007						
Month	**Measured**	**MMLM**	**MOM**	**EmM**	**EPM**	**MLM**
JAN	396.371	670.921	674.222	669.308	663.4577	668.777
FEB	659.169	1079.087	1085.378	1078.807	1067.641	1082.167
MAR	945.824	1343.593	1347.843	1346.344	1373.562	1346.514
APR	1541.333	2094.943	2101.193	2101.388	2165.413	2098.525
MAY	1334.546	1759.453	1751.368	1753.028	1831.856	1763.709
JUN	817.568	1108.3817	1103.107	1103.486	1145.631	1105.990
JUL	929.108	1240.456	1233.901	1234.766	1286.956	1242.747
AUG	1138.078	1474.493	1455.281	1457.340	1540.590	1477.466
SEP	982.884	1377.509	1358.059	1357.719	1412.505	1374.519
OCT	588.381	894.060	896.437	893.520	901.465	892.2607
NOV	382.653	618.130	619.155	615.809	618.583	616.514
DEC	308.245	559.352	561.091	555.540	552.238	557.871

Table 3: Estimation of Power density of Jiwani for the period of 10 years (1998-2007)

JIWANI PREDICTED AND MEASURED POWER DENSITY						
1998-2007						
Month	**Measured**	**MMLM**	**MOM**	**EmM**	**EPM**	**MLM**
JAN	186.230	442.11	461.4664	452.087	475.1476	443.9504
FEB	327.054	651.5258	663.4062	653.1054	674.2376	648.9142
MAR	393.676	754.3173	759.9887	750.7643	765.5736	756.5554
APR	440.115	713.6632	710.1984	706.4306	720.5913	715.7627
MAY	450.731	700.3231	692.736	690.2746	710.1671	698.4464
JUN	545.898	863.4487	855.0412	851.4324	874.9285	865.697
JUL	560.825	915.5914	915.1124	909.8819	919.799	917.8375
AUG	506.464	821.9128	820.279	815.8164	826.8375	824.4748
SEP	250.070	420.6956	416.7399	414.0275	429.7316	419.5484
OCT	178.782	310.8313	310.7349	308.2141	313.8354	310.0637
NOV	145.494	263.0641	263.4267	260.8754	267.0633	263.7961
DEC	109.265	269.3479	284.3922	278.2752	293.6823	268.2887

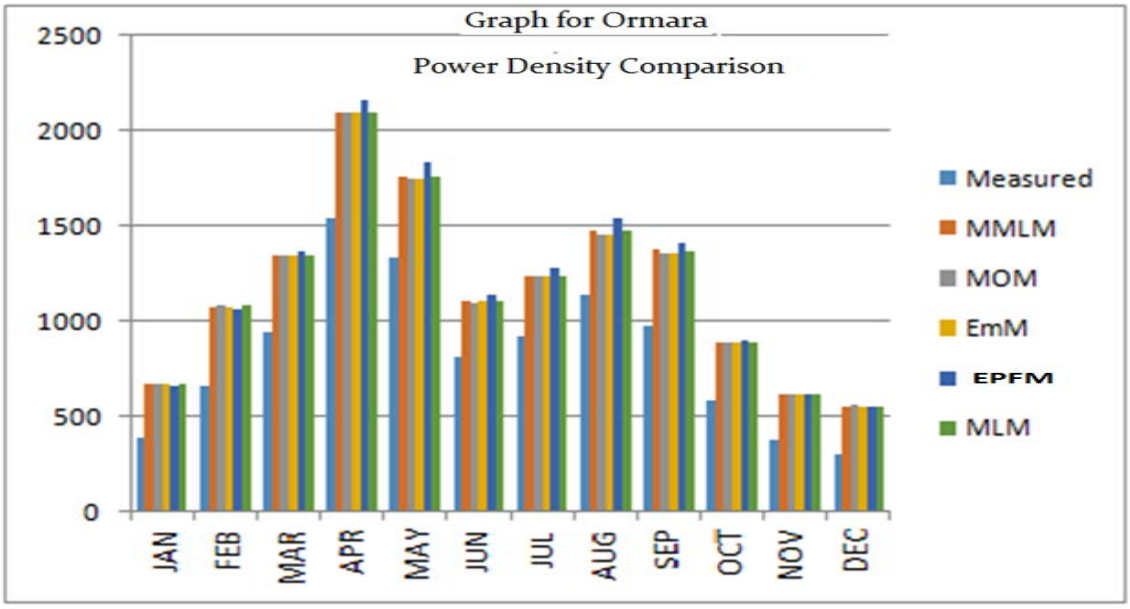

Figure 4: Histogram of Power density Comparison of Measured and 5 numerical methods of Ormara for the period of 10 years (1998-2007).

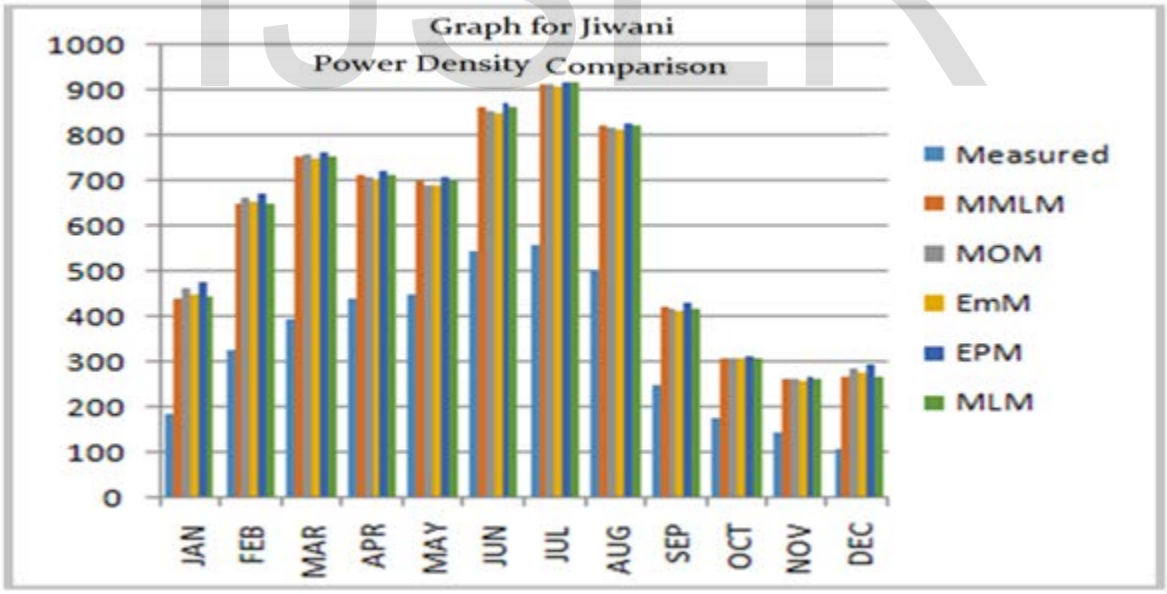

Figure 5: Histogram of Power density Comparison of Measured and 5 numerical methods of Jiwani for the period of 10 years (1998-2007).

For Ormara, top value of power density is measured 1541.333 W/m^2 in the month of April and smaller value is 308.44 W/m2 in December. In the month of April, May, August and September wind farm can generate the maximum power and can give more efficiency as compared to any other month. Mostly in the cold weather, least value of power density has been observed.

For Jiwani, chief power density value is 560.825 W/m2 has been observed in July while the smallest value is 109.262 W/m2 in December. The highest wind power density and maximum efficiency have been observed from February to August.

The result of this investigation on Ormara and Jiwani is that the both locations have the highest value of wind power densities all over the year. Ten year data of wind have been used and it has been justified that as compared to Jiwani, Ormara gives higher power generation value and greater wind power density.

There are different categories for the wind power density. If the power density reach till 150 Watt/m2 is considered as poor power density, from 150W/m2 to 250 W/m2 is fair quality, 250 W/m2 to 350 W/m2 is good one while its range exceeds 350 W/m2 is the excellent. With the help of wind power density, cost efficiency of electric power can be determined [25,26].

CONCLUSION:

Ormara and Jiwani, the two coastal locations of Balochistan, Pakistan have been studied in this work. Parameters of Weibull has been determined, use of five numerical methods and histogram have been drawn. The most important points of this study are below:

1. In Ormara, uppermost value of power density is 1541.333 W/m2 in the month of April and smaller value is 308.44 W/m2 in December.

2. In Jiwani, uppermost power density value is 560.825 W/m2 in month of July while, lowermost value is 109.262 W/m2 in December.

3. It is concluded that air contract in cold while swell in warm season. Histogram of power density shows all the values throughout the period of ten year.

4. It is clear that the coast of Ormara and Jiwani have a high wind potential throughout the year and it can be utilized for the power generation of wind.

5. This investigation result that Ormara can generate higher wind power as compared to Jiwani.

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