



Original Research Article

Identification of Potential Wind Energy places in the coast corridor of Andhra Pradesh, India

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ABSTRACT

Keywords

Wind Energy, Correlation Coefficient, Potential wind energy, Final Reanalysis and Wind farms

We do an experimental design using the weather research and Forecasting (WRF) model by processing the Final Reanalysis (FNL) data to produce 3km and 9 km resolution of wind map. The areas of present study are Visakhapatnam, Kalingapatnam and Kakinada. This wind map can be used to determine an ideal location for wind farm's building. The result of wind shows that the wind farm potentially produces 10.25KW of electricity which can be used as the alternative source of electricity. The advanced study is needed to improve the result for the complex topography. However we expect that present preliminary study could support the study on the renewable energy and in the future could contribute to the blackout adaptation due to disaster or any other reasons. In this study the maximum correlation gets over Visakhapatnam when compared with remaining two stations.

Introduction

Wind energy is the kinetic energy associated with the movement of atmospheric air. It has been used for hundreds of years for sailing, grinding grain, and for irrigation. Wind energy systems convert this kinetic energy to more useful form of power. Wind energy systems for irrigation and milling have been use since ancient time and since the beginning of the 20th century it is being used to generate electric power. Windmills for water pumping have been installed in many countries particularly in the rural areas. Wind turbines trance form the energy in the wind into mechanical power, which can then

be used directly for grinding etc. or further converting to electric power to generate electricity. Wind turbines can be used singly or in clusters called wind farms. Small wind turbines called aero-generators can be used to charge large batteries.

Realizing the growing the importance of wind energy, manufactures have steadily been increasing the unit size of the wind electric generators since the late 1980s. Another important development has been the offshore (i.e.in the sea) wind forms in some regions of Europe, which have several

advantages over the on shore ones. The third major development has been the use of new techniques to assess the wind resource for techno-commercial viability. Five nations – Germany, USA, Denmark, Spain and India – account for 80% of the world's installed wind energy capacity. Wind energy continues to be the fastest growing renewable energy source with worldwide wind power installed capacity reaching 14,000 MW. India ranks 5th in the world with a total wind power capacity of 1080MW out of which 1025M have been established in commercial projects. In India the states of Tamilnadu and Gujarat lead in the field of energy. At the end of March 2000 India had 1080-MWs capacity wind farms, of which Tamilnadu contributed 770-MW capacity. Gujarat has 167MW followed by Andhra Pradesh, which has 88MW installed wind forms. There are about a dozen wind pumps of various designs providing water for agriculture, afforestation, and domestic purposes, all scattered over the country. The design of the Auroville multi-blade wind mill has evolved from the practical experience gained in operating these mills over a period of 20 years or so. It has a high tripod tower and its double – action pump increase water output by about 60% compared to the conventional signal action pumps. This energy is used for: Sailing ships, pumping water/Irrigation, Grinding Grains, Power generation. Some of the gadgets and other devices: Sails, Windmills, Wind turbines.

Wind energy is important: Energy is hot topic in the news today: increased consumption increased cost, depleted natural resources, our dependences on foreign sources, and the impact on the environment and the danger of global warming. Something has to change. Wind energy has great potential to lessen our dependences on traditional resources like oil, gas and coal

and to do it without as much damage to the environment. 3M and discovery education have collaborated to produce this interactive exercise to highlight how wind power can produce clean, inexhaustible energy locally.

Advantages of Wind: Wind is free. No fossil fuels are used to generate electricity. Newer technologies make energy production much more efficient. Wind turbines take up less space than the average power station (a few square feet for the base). The turbines can be placed in remote location, such as offshore, mountains and deserts. When combined with other alternative energy sources, wind can provide a reliable supply of electricity.

Advantage of renewable energy sources: The main advantage of renewable energy sources are as follows: They are practically inexhaustible source of energy and contribute reducing dependence on conventional energy resources.

Chandra babu Naidu is a visionary who looks ahead. Energy is the need of the hour. Andhra Pradesh Government under the stevership of Chief Minister (CM) is not leaving any leaf hundred in order to improve the energy station in the state. The Government is taking steps to increase hidal energy by taking up projects like PATTISAM which gives much needed water to continue the hidal energy projects. Thermal energy projects like Simhadri power project at Visakhapatnam and Narla Thatha Rao super thermal power station (NTTP) at Ibrahimpatnam are an expansion to get more thermal power. The one potential energy source is wind energy which is abundant in AP which is having second largest coast line (first only to Gujarat). In earlier research how point out that there is lot of potential for traffic pollution free wind energy for AP. Besides

this the complex terrain in Eastern Ghats provides confluence of wind streams having high wind energy. The terms like Galikonda actually means the hill with lot of wind (near Araku Valley) clearly indicate that there is lot of potential for wind energy. The need of the ours is to establish the existing wind levels in the coastal corridors with aim and objective to identify areas of potential wind energy. The Government should as first step give a project to concerned department, which are working on wind energy project like the Department of Meteorology & Oceanography.

Data and methodology

In the present study we used the weather research and forecasting with ARW solver (WRF-ARW). WRF is a MesoScale weather prediction model designed for both operational and research purpose. Weather Research and Forecast (WRF/ARW Version 3.1) model (Skamarock et al. 2008) was used for the achievement of the objectives. WRF model is designed to have two-way interactive two nested domains of 9 and 3 km resolution covering the Bay of Bengal and neighborhood region. The domain of 3km covers the Bay of Bengal of NIO and the east coast of India (longitude 74.5⁰E-85⁰E and Latitude of 14.8⁰N-20.1⁰ N). The model is integrated for a period of 96 to 144 hours varying from case to case with the initial, boundary conditions derived from NCEP FNL (Final Analysis) data with 1⁰x 1⁰ resolutions for the year 2014.

The initial and boundary conditions are taken from GFS high resolution data set in NOMADS (NOAA Operational Model Archive and Distribution System). This is available at 0.5x0.5 degree resolution with 3 hr forecast interval. The model topography and land cover for the 9 km domain regions are obtained from the USGS 5', 2' and 30" data sets. The simulation is run for the three

days of May 11-14 2014. The observation data has been taken from the IMD synoptic observations for the three districts of Visakhapatnam, Kalingapatnam and Kakinada. The model output results are validated in qualitative and quantitative approach. The quantitative validation is conducted using statistical methods i.e., RMSE (Root mean square error) and Correlation, and statistical guidance.

Results and Discussion

Simulation result is presented has station wise Visakhapatnam, Kalingapatnam and Kakinada for the month May 2014, and wind roses along with the wind speed probability.

Visakhapatnam: The wind rose illustrates prevailing wind (m/s). fig: 2 (a) shows the wind speed and class distribution in May 11th 2014. The prevailing wind tends to flow southward direction, but it is still in south west region. Wind speed varies from 5.7 to 8.8m/s. The wind speed distribution is relatively high, 38.46% about 5.7 to 8.8m/s. This number represents virtual wind energy in May. Fig: 2(b) shows the wind speed and class distribution for the month May 12th 2014 of Visakhapatnam. The prevailing wind tends to flow eastward direction but it is still in north east region and the wind speed is varies from 5.7 to 8.8m/s. In third day fig: 2(c) (13th May 2014) the wind direction is northward but the wind speed is almost equal to previous day.

Kalingapatnam: The fig. 3(a)-3(c) is the wind speed (m/s) for the Kalingapatnam the prevailing wind to the southward direction is stronger in 11May 2014. The wind direction is same as in 12th May also, but the wind speed is varies. In 13th May 2014 the wind direction is completely changes when compared to previous two days. The wind varies in the frequency of 5.7 to 8.8 at about 46.15%.

Model Name	WRF Model V3.3	
Model type	Primitive equation, Non-hydrostatic	
Vertical resolution	32 sigma levels	
Horizontal resolution	9 km	3 km
Domain of interest	Lon -76 ⁰ E-88.5 ⁰ E Lat- 12 ⁰ N-22.5 ⁰ N	Lon- 74.5 ⁰ E-85 ⁰ E Lat - 14.8 ⁰ N-20.1 ⁰ N
Radiation scheme	Dudhia scheme for short wave radiation Rapid Radiative Transfer Model for long wave radiation	
Surface-layer	Monin-Obukhov (Janjic Eta) scheme,	
Land Surface scheme	Noah Land Surface	
Convection scheme	Kain-Fritsch (new Eta) scheme (KF)	
PBL scheme	Mellor-Yamada-Janjic (MYJ),	
Cloud microphysics	Lin et al. scheme	

Fig.1 WPS domain configuration

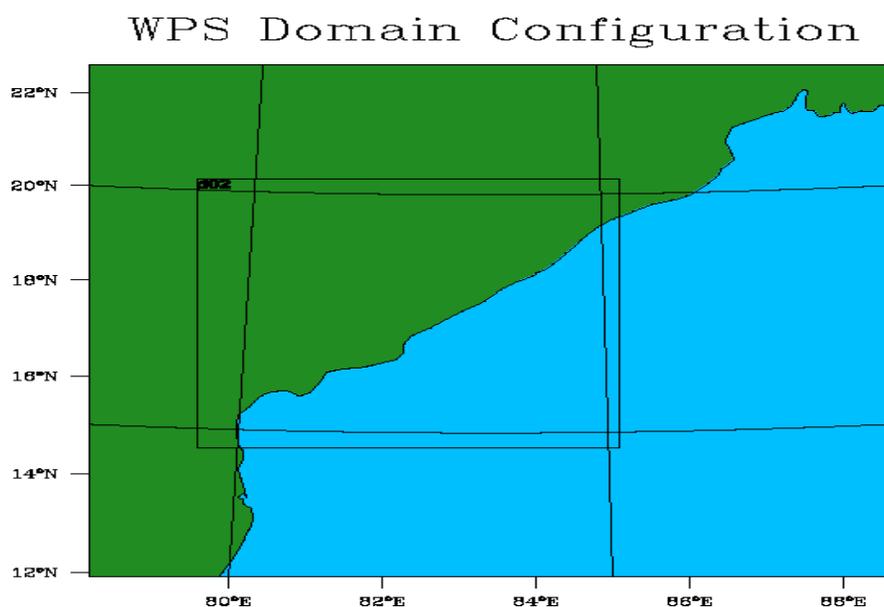


Fig.2 Visakhapatnam (Wind Roses)

11-12th May – 2014

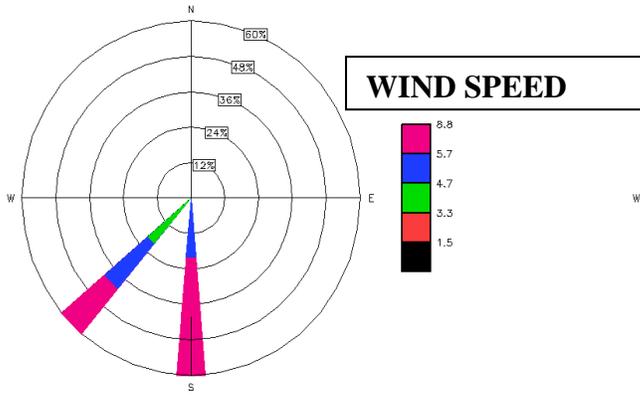


Fig.2(a)

12-13th May-2014

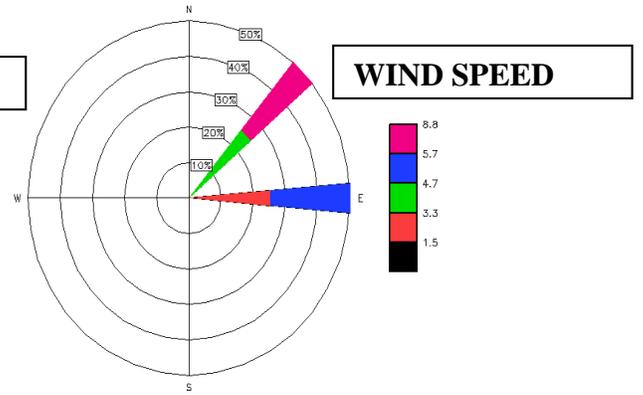


Fig.2(b)

13-14th May-2014

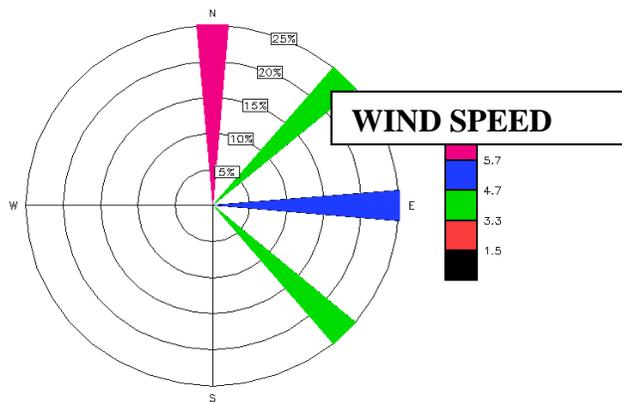


Fig.2(a)

Fig.3 Kalingapatnam (Wind Roses)

11-12th May – 2014

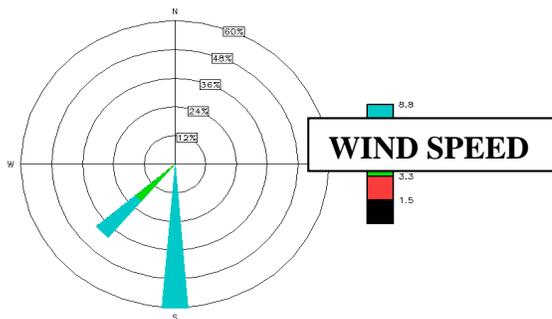


Fig.3(a)

12-13th May-2014

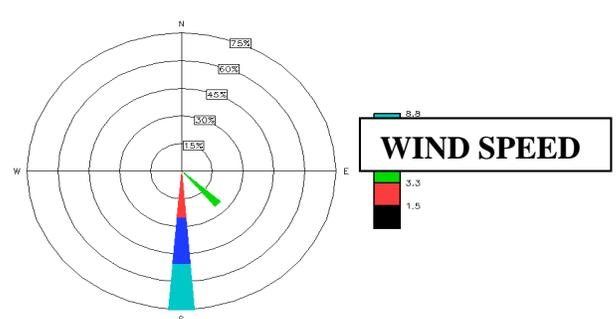


Fig.3(b)

13-14th May-2014

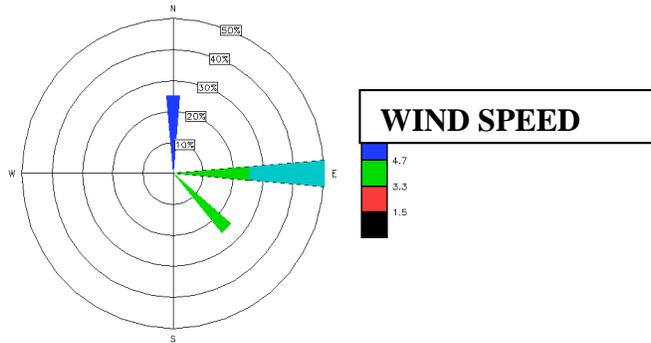


Fig.3(b)

Fig.4 Kakinada (Wind Roses)

11-12th May – 2014

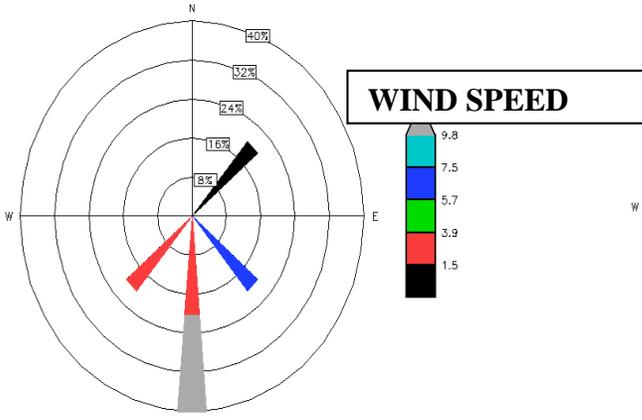


Fig.4(a)

12-13th May-2014

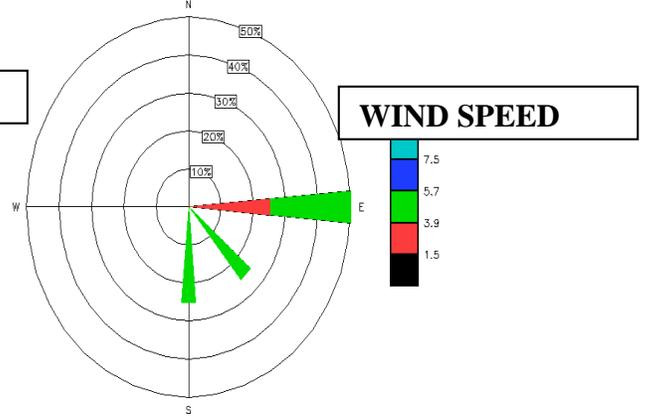


Fig.4(b)

13-14th May-2014

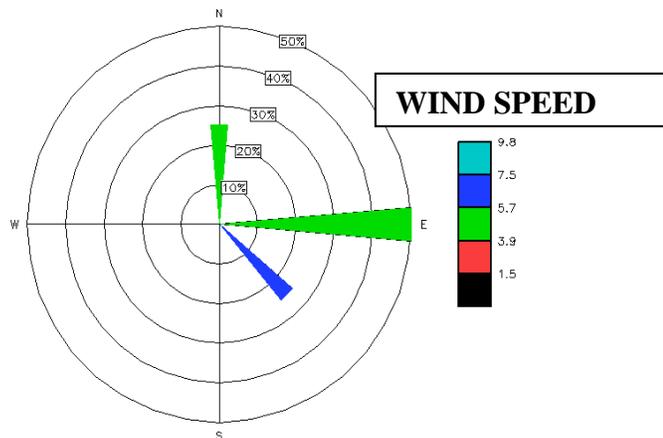
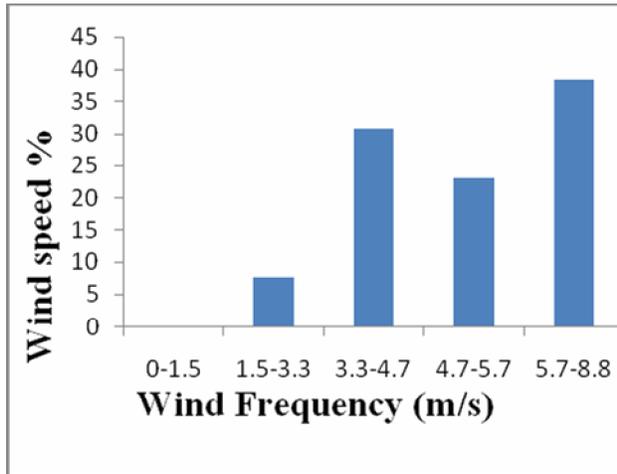


Fig.4(c)

Fig.5 Wind class frequency distribution over stations

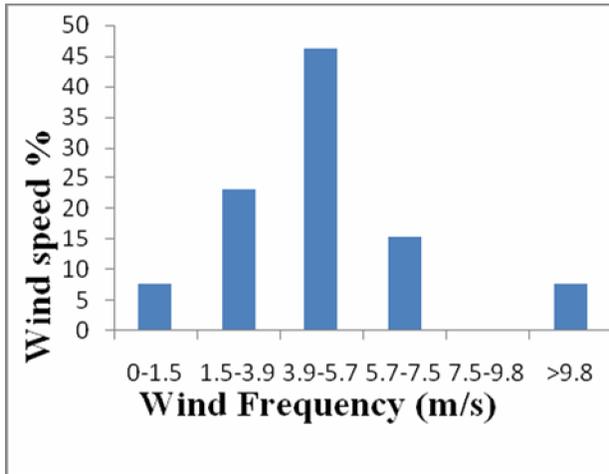
Visakhapatnam

Fig.5(a)



Kakinada

Fig.5(a)



Kalingapatnam

Fig.5(c)

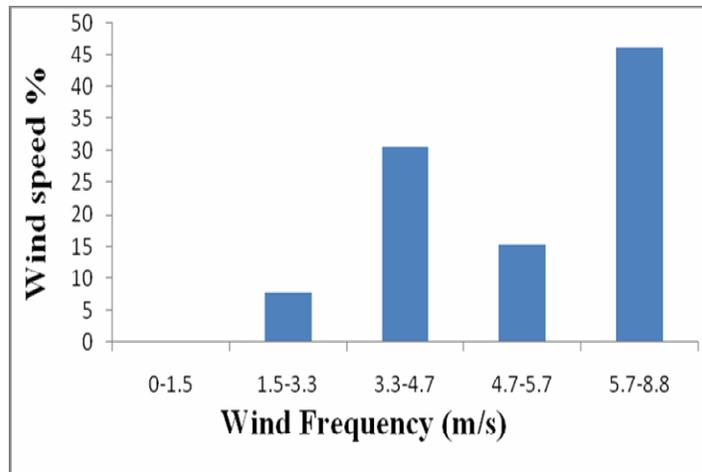
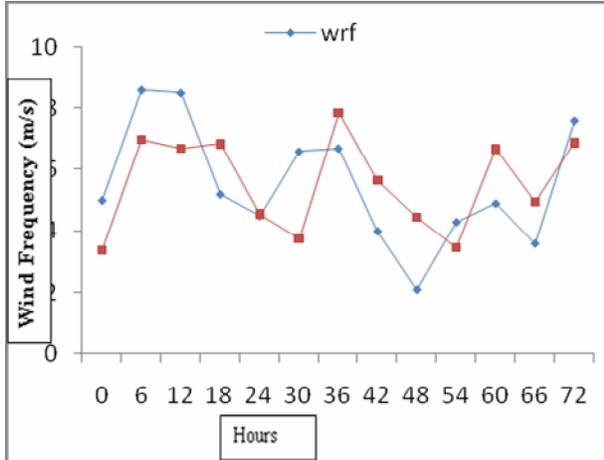
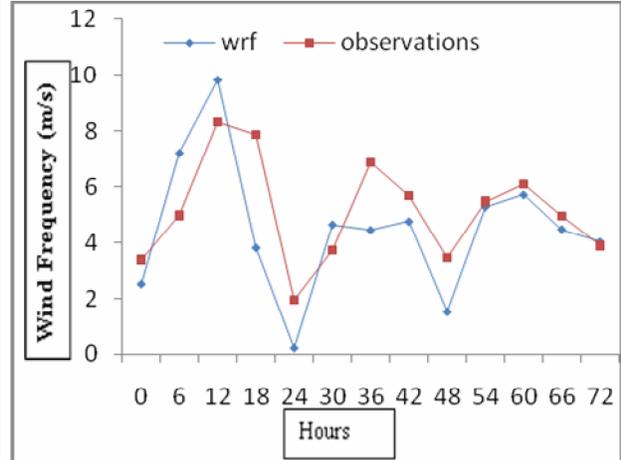


Fig.6 The comparison between WRF output and observations

Visakhapatnam
Fig.6(a)

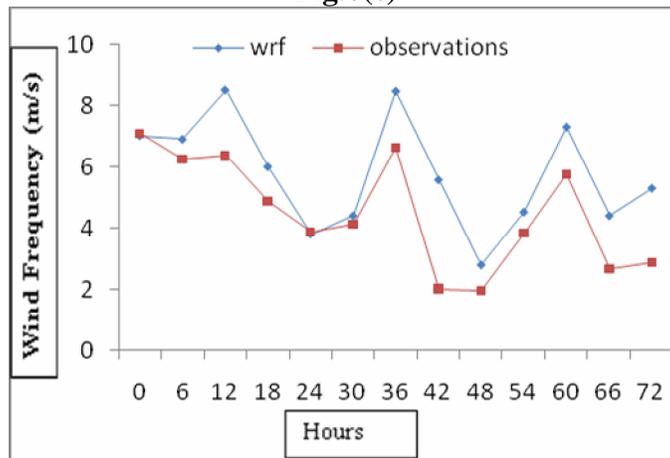


Kakinada
Fig.6(b)



Kalingapatnam

Fig.6(c)



Kakinada: The fig. 4(a)-4(c) is the wind speed (m/s) for the Kakinada the prevailing winds to the southward, the stronger its frequency more than 9.8 (m/s). It is the beginning of the dry season, indicated by wind direction, which is inverted to the south in the southern hemisphere. The wind speed distribution is relatively high, 46.1538% about 3.9 to 5.7m/s. This number represents virtual wind energy in the month of May. The wind direction changes in 12th May and 13th May (Eastward), but the

wind speed is in the range of 3.9 to 5.7m/s. The fig.6(a)-6(c) shows the 6 hourly wind speed of the WRF out of the three stations comparing with the observations. The results show even though there is some differences in several hours, generally both are rather similar in phase. Statistical Guidance Method: Model output statistics (MOS) in present study is used to improve the result of the model. The results of the statistical guidance in each station are calculated. RMSE measure the difference between

value predicted by the model, WRF in this case, and the value observed. Correlation Coefficient shows the degree of relationship between the predicted values and the relationship between the predicted values and the observations. The statistical guidance is used to examine the relationship between predictant and predictor is expected to improve the model output. The RMSE provides information on the short-term performance of a model by comparing the simulated values. The smaller the RMSE value, the better the model's performance. Correlation coefficient measure of the SIGNIFICANCE between two variables as well as its strength. The MOS (Model output statistics) are in Table.2 for the three stations. All the three stations are shown positive correlation but the station Kalingapatnam gives the high correlation 0.83 with the observations. The model showed a better performance having the less RMSE values for all the stations.

Role of wind energy map: The fig. 7 is the WRF simulated Wind energy map for the three days. The WRF simulated WIND energy map that can be used for calculate the mean wind speed and locating the wind farms also. The entire coastal corridor shows the maximum mean wind speed. The simulation results shows the best area for the generating the optimum electricity. The area is in between 16⁰N-18.5⁰N and 81E-83E. Using the mean wind speed and the below formulae we can calculate the power converted from the wind into rotational energy in one turbine. Suppose we assume that the turbine used have blade radius of 1.5m and the mean wind speed is 6.2m/s from the wind energy map.

Formulae

$P = \frac{1}{2} \rho \pi r^2 v^3 C$ (Dyah. A et.al 2013)
Where ρ is density of air

r is the radius of blade

v is speed of wind

c is power coefficient

$P = \frac{1}{2} * 1.23 * 3.14 * (1.5)^2 * (6.2)^3 * 0.4 = 414$
Watt

The simple calculation which gives the optimum electricity for the above areas.

Based on our experiment WRF (Weather Research Forecasting) allows researchers to do wind simulations. We have chosen the May 11-14 these days are maximum sea breeze attained. We have chosen by the observed wind roses. The WRF is well simulated the wind speed for the three stations. The wind energy map reveals the potential zone for the establishing the wind farms for generating the optimum electricity.

This is a preliminary study for the potential application of the WIND energy due to the computational insufficiency we have simulated only for three days in the month of May in 2014. But further in future studies to simulate the entire all months for the east coast of India, especially in the coastal Andhra Pradesh. This gives them a potency of wind energy for the coastal AP. Which can reveals the best area for the establishment of wind farms.

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