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WIND SPEED FORECASTING BASED ON TIME SERIES ANALYSIS, WAVELET ANALYSIS AND GARCH ANALYSIS.

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Abstract--- Now days wind energy is one of the sources of electricity production due to its intermittent nature there is need for an accurate wind forecasting technique.lot of research has been done to improve the precision of wind speed prediction. In this paper ARIMA, Wavelet theory and GARCH analysis are used to forecast the wind speed. In this paper ARIMA approach is used to forecast wind speed using available previous year wind speed measurements. In this paper wavelet theory is used to decompose highly variable wind speed measurements in to several approximate stationary time series. ARIMA models are developed for each decomposed approximate stationary time series and then forecasting results are obtained by this hybrid method. In order to remove the volatility from the forecasted results of ARIMA model GARCH method is used and then obtaining the forecasting results. By comparing the MAPE of all the three methods we found GARCH method is the best method for wind speed forecasting. For this analysis the wind measurements are obtained from Basaveshwar engineering college, Bagalkot wind site.

Keywords- ARIMA(Autoregressive integrated moving average),GARCH (Generalized auto regressive conditional Heteroscedascity),forecasting.

I. INTRODUCTION

The fastest developing renewable energy in the world is wind energy .It is essential to have the perfect and resourceful wind forecasting technique when wind energy penetration increases. The wind power developers will be in profit if and only if the wind velocity is constantly forecasted up to numerous hours which in turn increase the power generation. Estimation of upcoming wind velocity is purely based on the preceding year data this process is said to be wind forecasting. At different time scales the forecasting of wind speed is considered which is dependent on the intended application. . Forecasting is differentiated in three types, short term forecast which lasts for one hour to one week, medium term forecast lasts for one week to one month, and long term forecast lasts for one month to one year. By wind speed measures it shows some correlation among the measured data for these recorded data time series models are developed in this time series method the data have internal structures like seasonal variation or trend, autocorrelation. The basic impulsion of the approach is to correctly gathering an available data in a similar pattern and then getting the predicted value with respect to hourly, daily or monthly basis using the recognized model. In this paper it mainly focus on ARIMA model is used to forecast the wind speed, here wavelet analysis is used to decompose the highly nonlinear data .to remove the volatility from the ARIMA model results GARCH analysis is used.

II LITERATURE REVIEW

In the paper(1) wind speed is decomposed using EMD technique and for the respective IMF models ARIMA models are developed. In the following paper (2) to predict speed up to 24 hours A innovative wavelet coefficient predictor technique is developed. This proposed technique is applied on the wind speed data collected from Colorado public utility place. The predicted values of the proposed methods are compared with the basic Persistent method. Paper(3) tells the combination of auto regression(AR) and wavelet transform to predict the wind speed .The original wind speed is managed by wavelet transform and for the decayed data is AR model is used . For each decayed data AR model is developed and by restructuring the decayed original wind speed data forecasted results are obtained. The combination of AR-WT gives the excellent results speed. The combination of AR-WT gives the excellent results speed. In order to decay the highly discontinue time series data in to an approximate time series wavelet method is approached (4). By decomposing wind speed using Wavelet the approximate and detailed information of wind speed is obtained ,by this difficulty of forecasting will be reduced. For decayed time series of different resolution ARMA models are developed respectively, by integrating the outputs of ARMA prediction results are acquired. This method is used for medium term of forecasting, by this here they conclude that preprocessing of the wind speed by wavelet and getting the predicted results from the proposed method gives the best results (5).

III. **Methodology**

A) A time series is an order of notes of indiscriminate variable. Predicting time series information is an essential part of research oriented programs. In order to select the perfect model for predicting the future time series plays an essential role. The supreme basic approach of the time series models are the Autoregressive and moving average model.

Autoregressive integrated moving average model (ARIMA):
This is an arrangement of AR and MA. This is a stationery process in which variance and mean does not change with time. ARMA model is a tool which is used for indulgent and predicting the future values based on the previous values of time series data X_t .This model formed of two parts Auto regressive(AR) and moving average(MA) therefore this model is referred as ARMA(p, q). Here ARIMA is an extension of an ARMA to decompose the highly nonlinear data another variable (d) is used for differencing. ARIMA determines the best model which accurately represents the preceding and upcoming pattern of the time series and it also determines the how much past value required to predict the future wind speed.

$$\phi(B)\nabla^d X_t = \theta(B)\varepsilon \tag{1}$$

Where $\theta_1 \ldots \theta_q$ are the parameters of the model

ε_t, ε_{t-1},... are indiscriminate_error terms

B) Another new tool for Frequency analysis is wavelet transformation. There is a technique called "Multi resolution by wavelet basis functions" which is used to represent the function on many scales, which are generated by translated and scaled mother wavelet. After the dilation and translation the mother wavelet is defined as a

$$\Psi_{a,b}(t) = \frac{1}{\sqrt{|a|}}\Psi\left(\frac{t-b}{a}\right) a, b \in R; a \neq 0 \tag{2}$$

Here a represents the scale factor,

b represents the conversion factor.

Continuous wavelet transform

Mother wavelet is oscillating function with fixed energy and an average of zero in which Continuous wavelet transform deduces the wavelet analysis.

$$CWT_f(a,b) = \langle f(t), \Psi_{a,b}(t)\rangle = a^{-1/2}\int_R f(t)\,\Psi^*\left(\frac{t-b}{a}\right)dt \tag{3}$$

Discrete wavelet transform

Discrete wavelet is a digitally execute counterpart of Continuous wavelet transform. DWT will decay a signal in dissimilar resolutions. DWT is better than CWT in decaying and reconstructing the most of the wind velocity conflict. It reduces the processing time and gives the enough and sufficient data.

$$\Psi_{j,k}(t) = a_0^{-\frac{j}{2}}\Psi(2^{-j}\,t - k) \qquad (4)$$

Here $a = 2^{-j}, b = k2^{-j}$

So, square integrals of a signal f (t) can be thought as demerit of step-by-step estimation.

C) In an ARCH (1) approach, next phase variance is only non independent on last phase squared remaining so a disaster that affected a huge residual would not have the class of persistence that we inspect the authentic disasters. Because of this reason there is the addition of the ARCH approach to a GARCH, or indiscriminate ARCH approach Was initially implemented by Bollerslev (1986), which is identical to ARMA approach, in a GARCH (1, 1) approach. The forecasted results of the GARCH (1, 1) can be written as

$$\hat{\sigma}_{t+1}^2 = \alpha_0 + (\alpha_1 + \beta_1)(\sigma_t^2 - \sigma^2) \qquad (5)$$

From the upper expression we can observe that $\hat{\sigma}_{t+1}^2 \to \infty$ as $l \to \infty$ so as to predict horizon which is set to ∞.

IV. Results and Discussion

The wind speed is recorded for the current work from the wind site positioned at Basaveshwar engineering college Bagalkot, Karnataka, India. The selected wind site is outfitted with 50m galvanized guyed tubular wind post, with gin pole monitoring at 50m, 30m and 10m point.NRG symponie Data logger is used to recur the data from the site considered. For our present work the wind speed considered from May-2010 to December 2011.the data logger records the data at three different levels those are 50m, 30m and 10m.it recurs the data at an average of 10minutes interval data.NRG# 40 anemometer is used to measure the wind speed in meter per second, NRG symponie software is used for data retrieving. The wind speed data obtained from the site is used for short term prediction. Using that data time series analysis, wavelet analysis and GARCH analysis is done using software MATLAB (programming).using that data suitable model is generated for the all the three methods, and finding MAPE for all the three methods.

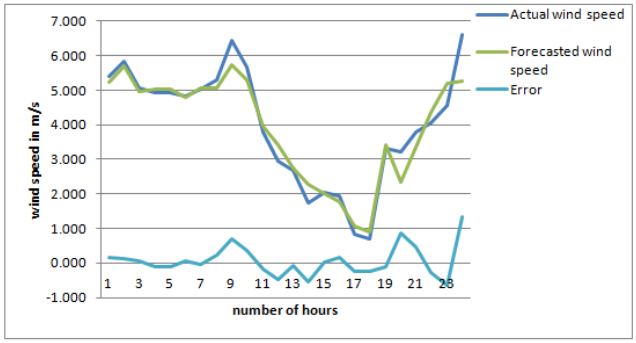

Fig no1: represents the comparison of actual with the forecasted results of the day 2/6/10 obtained from Time series method.

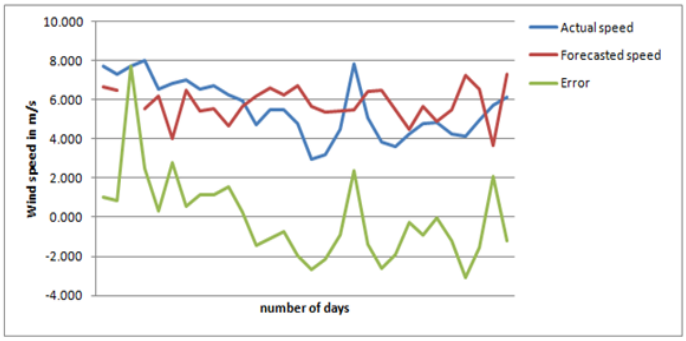

Fig no2: represents the comparison actual with the forecasted results of the month July 2010 obtained from time series method

Using the combination of ARIMA-wavelet method the forecasting results are obtained for the month of july 2010 using the jun2010data.

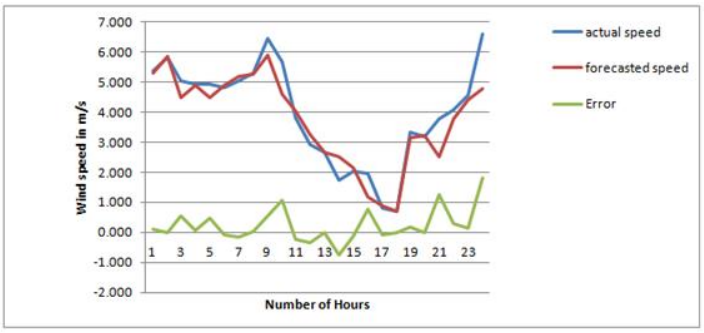

Fig no3: represents the comparison of actual with the forecasted results of the day 2/6/10 obtained from ARIMA-wavelet method.

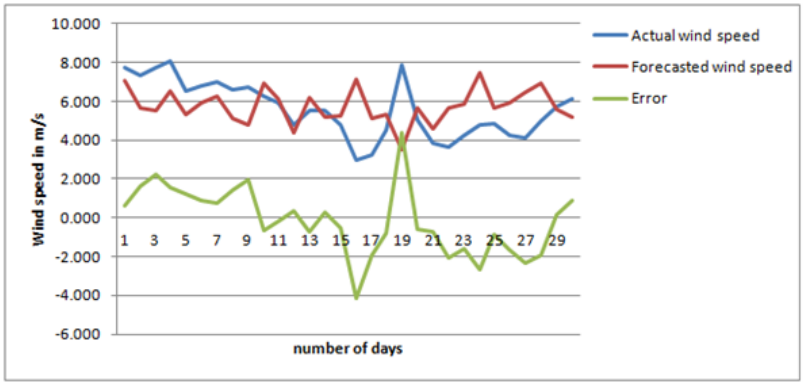

Fig no4: represents the comparison actual with the forecasted results of the month July 2010 obtained from ARIMA-wavelet method.

From the GARCH method the volatility of the Time series is reduced the forecasting result obtained from this method are shown in the below figures.

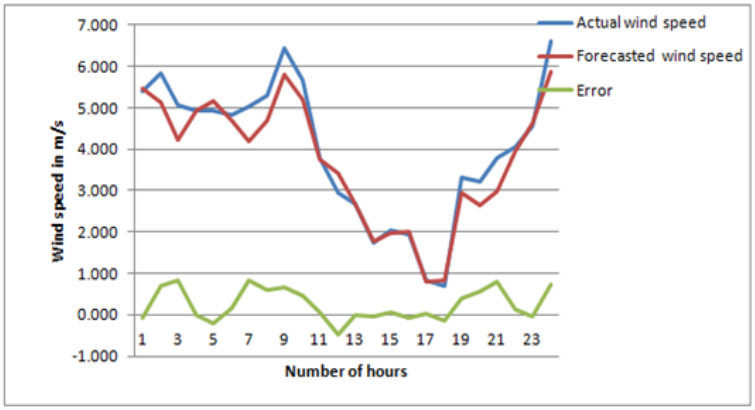

Fig no3: represents the comparison of actual with the forecasted results of the day 2/6/10 obtained from GARCH (1, 1) method.

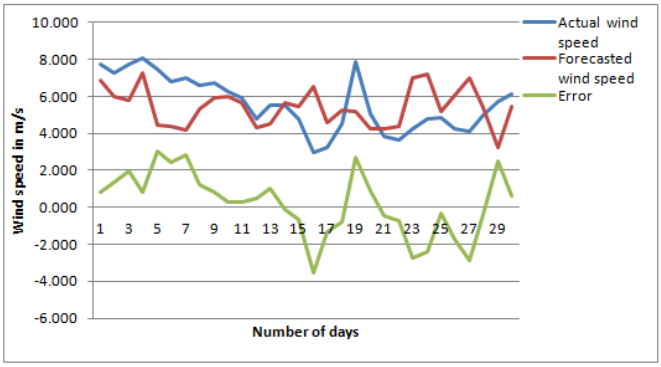

Fig no4: represents the comparison actual with the forecasted results of the month July 2010 obtained from GARCH (1,1) method.

Comparison of all the methods: For one day data

Method	MAPE
Time Series analysis	16.47817%.
Wavelet analysis	15.7876%,
GARCH analysis	13.52585%

Table .no.1.MAPE calculation for one day data

For one month data

Method	MAPE
Time Series analysis	45.72755%
Wavelet analysis	37.11457%,
GARCH analysis	**32.869085%.**

Table .no.2.MAPE calculation for one month data

Conclusion: Using the time series method wind speed is forecasted for that MAPE is calculated **11.860%** for one day data, **31.578%** for one month data and for ARIMA -wavelet MAPE calculated is **10.37%** for one day data,

28.127% for one month data. And for GARCH method MAPE calculated is **8.342**% for one day data and **27.316**% for one month data. By comparing MAPE of the entire three methods GARCH model is the accurate method for forecasting the wind speed.

Future scope: Wind energy is the one of the renewable energy which generates the energy without any harm to the environment. Due to its volatility and intermittency better forecasting method is required, to find out the best method we compared here ARIMA, ARIMA-wavelet and GARCH model for short-term forecast. We found GARCH method is the best method for forecast. It can also be used for medium and long term forecasting. And also to improve the efficiency of the wind energy generation. Using the other factors such as temperature, humidity which affect the wind power generation is can be considered.

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