LINEAR WIND FLOW MODEL IN PUTTALAM REGION

[1]W.A.M.K.P.Wickramaarachchi, [2]P.M.A.M.K.Wickramasinghe and [3]M.Narayana, [4]P.W.Vidanage

[1] Department of Chemical and Process Engineering, Faculty of Engineering, University of Moratuwa, Sri Lanka.
Email: kethakiuom@gmail.com
[2] Department of Chemical and Process Engineering, Faculty of Engineering, University of Moratuwa, Sri Lanka.
Email: amiluom@gmail.com
[3] Department of Chemical and Process Engineering, Faculty of Engineering, University of Moratuwa, Sri Lanka.
Email: mahinsasa@uom.lk
[4] Department of Chemical and Process Engineering, Faculty of Engineering, University of Moratuwa, Sri Lanka.
Email: poornaw@uom.lk

ABSTRACT

Availability and reliability are emphasized as key factors of wind power generation. Both factors are varying as a result of long term climatic changes. The focus of this study was to develop linear wind flow model using WAsP software to identify wind power generation potential and local wind climatic changes in North-West coastal region of Sri Lanka. Presently, Ceylon Electricity Board has planned to upgrade the island wide wind potential up to 200 MW. Therefore, it is an important aspect to consider wind climate changes in implementing and operating the wind power plants. Optimum energy production by a wind farm always depends on local wind, properties of turbine site and wind farm layout. Changes in global wind patterns due to various climatic conditions can be identified as a substantial phenomenon because its impacts on wind power generation. This study shows how to monitor the change in power generation of Seguwantivu wind farm by extracting available local wind data in same region. WAsP is a PC program for the prediction of wind climates and power productions from wind turbines and wind farms. WAsP was developed at Risø National Laboratory, Denmark [1].

Key words: Climatic Change, WAsP, Wind Flow Model, Wind Power

1. INTRODUCTION

The good-excellent wind energy potential in Sri Lanka has concentrated largely in North Western coastal region from Kalpitiya Peninsula, North of it up to Mannar Island and Jaffna Peninsula. Considering the availability of this enormous wind potential, Sri Lanka's large wind power project with total installed capacity of 2×10MW has been developed and operated by two joint venture companies which are Seguwantivu wind power (Pvt) Ltd and Vidatamunai wind power (Pvt) Ltd. Wind farms situated at right shore of Puttalam lagoon with the distance of 3 km away from Puttalam town, 123 km from Colombo and occupy 6.5 hectares for the entire plant.

Wind power has a great autocorrelation with wind speed and direction. With time, obtaining power can be fluctuated according to wind characteristics. Subsequently, there is a possibility to change wind patterns over time. It is an intimation that alarms antecedent wind farm layout may not valid for extracting defined wind energy further. Hence, there should be a proper comparison between measured wind power & predicted wind power to observe whether there is a difference or not. Meteorological department has defined four wind seasons as follows [2].

North East Monsoon (December to February)
First Inter Monsoon (March to April)
South West Monsoon (May to September)
Second Inter Monsoon (October to November)

This paper characterizes above climate change phenomena by examining various parameters related to wind power generation of Seguwantivu wind farm - Puttalam. In this region highest wind power generation happens during May to September due to stronger South west monsoon. Seguwantivu wind farm consists with twelve Gamesa AE-59 wind turbines with 800 kW. Tabular tower type turbines have 60 m hub height & 59 m rotor diameter which is able to face class (iii) wind. As well as 3.5 m/s cut in wind speed and 11 m/s rated wind speed confer 9.6 MW capacity for whole Seguwantivu wind farm [3].

For this analysis we have used power generation data of each turbine with its speed for ten minute sampling time within years of 2010, 2011 and 2012 in Seguwantivu wind farm.

Table 1: Technical Parameters of Plant

Installed capacity	2×10MW
Turbine type	800kW (Gamesa AE-59)
Generator	Synchronous
Hub height	60m
Power regulation	100%
Number of turbines	25
Avg. wind speed	6.9m/s (At 60m)
Air density	1.158kg/m^3
Turbine spacing	133m in a single raw

Figure 1: Seguwantivu wind farm lay out, Google maps

2. METHODOLOGY

The evaluation process of 'wind power with respect to time' is based on a comparison. This is done by considering the results obtained between WAsP based method and Actual wind power data method.

2.1. WAsP Based Methodology

WAsP needs pre-prepared additional utility files which are constructed by raw data available. Especially, an accurate digital map and Observed Wind Climate files are required to build a wind atlas. Wind atlas is recognized as highly important utility file which controls the accuracy of whole WAsP project. In this study it was used to absorb data measured at Narakkalliya Met Station which is situated 10.5 km away from Seguwantivu wind farm towards Kalpitiya area. According to global coordinate system, the latitude and longitude of Met Station is 8^0 00.707' & 79^0 43.338'. The measured data by

CEB at Narakkalliya Met Station has wind speeds at three different heights as 10m, 20m & 40m. Data from 40m height were selected because those are more preferable and relate with turbines' hub heights. Anemometer of wind mast consists with sensors to measure direction and speed of wind, with respect to hourly basis [1, 4].

2.2. Observed Wind Climate (OWC)
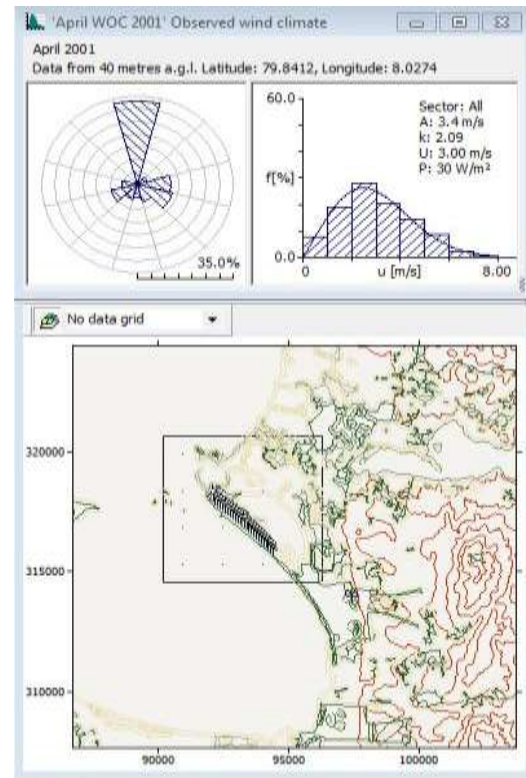
Figure 2: Observed Wind Climate & WAsP digital file

WAsP provides a utility tool to generate Observed Wind Climate file. For that, the anemometer height as well as the global location of wind mast should be inserted. Then the local wind speed and data measured in Narakkalliya Met Station were extracted to software. Next, raw data from year 2000 & 2001 inserted to form an OWC file. Hence twelve numbers of files were created for each month from January to December. Together with Met Station & OWC file, it is capable to generate the wind atlas. It can be emphasized as a site-independent regional wind atlas and able to transform to Puttalam region.

2.3. Digitized Map

Map of pertinent region done by survey department with height contours, obstacles,

surface characteristics was converted into digital form embedding 3D details by WAsP map editor. Here are the roughness values used for digitizing procedure.

Table 2: Roughness Values

Terrain surface characteristics (land use)	Roughness
Tall forest	0.8
Coconut cultivations	0.5
Suburb	0.5
Paddy cultivations	0.1
Mown grass	0.008
Bare soil	0.005
Sand surface	0.0003
Water areas (sea, lakes, rivers, prawn cultivation)	0.0002

Global coordinates of each and every twelve turbines were found using Google Earth & Kandalwala coordinate system to digitally construt Seguwantivu wind farm.

2.4. Turbine Power Curve
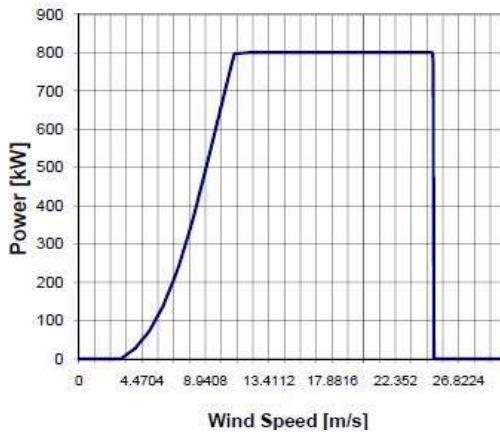
Figure 3: Turbine power curve of Gamesa AE59-800kW

Turbine Editor tool was used to construct the power curve and thrust co-efficient curve with respect to wind speed. Simply the power curve represents power against wind speed; but to construct thrust co-efficient curve, it requires the values calcualted using eq.(1), eq.(2) & eq.(3) [5].

$$C_p = (2P/\rho U^3 A) = 4a (1-a)^2 \qquad (1)$$

$$T = [4\rho U^3 Aa(1-a)] \qquad (2)$$

$$C_T = [2T/(Pu^2 A)] \qquad (3)$$

Where,

C_p = Power coefficient $\qquad$ P = Rotor Power [W]

ρ = Air density [kg/m^3] $\qquad$ U = Wind speed [m/s]

A = Rotor area [m^2] $\qquad$ a = Axial induction factor

T = Thrust force [N] $\qquad$ C_T = Thrust coefficient

2.5. Calculations

Wind atlas results can be found in 'Met Station' section of WAsP workspace project file. And also individual energy production is visible from each & every wind turbine site. But most important result is total wind energy & it can be obtained by 'wind farm' results. Annual Energy Production (AEP) value should be divided by twelve to get average energy production in each month.

2.6. Actual Wind Power

Actual wind energy production data with 10 minutes logging time at Seguwanthivu wind farm in 2012 is used for this comparison study. As well as the energy generation in the wind farm was evaluated by the WAsP model by using Narakkalliya wind data, which was collected in 2000, 2001 and 2002. Comparison of energy generations are tabulated in the Table 3.

3. RESULTS

Table 3: Power generation comparison

Month	WAsP Based Energy Production (GWh)	Actual Energy Production (GWh)	Difference (GWh)
Jan	2.942	0.9379	2.0038
Feb	0.465	1.0061	-0.5415
Mar	0.962	0.4507	0.5111
Apr	1.617	0.8115	0.8054
May	5.324	4.3725	0.9514
Jun	5.798	5.3485	0.4492
Jul	4.931	4.3412	0.5899
Aug	5.324	4.8536	0.4703
Sept	4.114	4.2547	-0.1404
Oct	2.944	1.2415	1.7029
Nov	1.221	0.5963	0.6247
Dec	1.244	1.0763	0.1674
Total Power	36.885	29.2909	7.5941

Table 4: Weibull Parameters Comparison

Turbine No	Shape factor	
	WAsP	Actual
1	3.57	2.43
2	3.58	2.50
3	3.58	2.56
4	3.58	2.50
5	3.56	2.52
6	3.56	2.51
7	3.57	2.47
8	3.57	2.56
9	3.56	2.58
10	3.58	1.21
11	3.58	2.56
12	3.60	2.47

4. CONCLUSION

Availability is a prominent constitutive in power generation. Though, wind power is a substantial part of this, it has a rudimentary reliance. Fluctuations of wind power generation result outweigh stability of grid as power generation is strongly correlated with wind speed [4, 6].

Therefore, as this study presents, WAsP is a convenient tool to predict power generation patterns. Based on above results actual energy production is less than WAsP predicted energy throughout the period except February & September months. As well as January month has the most significant positive difference. The above results show current power generation is less than predicted power generation in many months. This deviation may include a small effect of the time in which some of turbines didn't perform due to maintenance. Even though with obtained results it can ensure that power generation has reduced than it was simulated. In other words it is fair to say that chronological changes of wind patterns have huge impact on this deviation.

Above Weibull parameters also affirm the change of wind patterns. According to WAsP, shape factors of each turbine show higher value than actual value. Real Weibull curves have become more flat. In other words wind speed has decreased with time than it should be. Wind patterns were affected severely by rising temperature conditions. As above results, February & September power generation is higher than expected by WAsP. This implies temperature is increased rapidly during that time in North East & South West regions. That is, at the end of North East monsoon & South West monsoon seasons, the wind speeds are relatively high. It indicates about a climate change. The importance of studying this, the impacts of the global climatic changes have to be critically considered for the implementation of wind power plants. If the wind farm failed to   gain enough power, future demand may not be fulfilled. And also it will affect to the performance of proposed Mannar wind power plant as global wind characteristics change within short time period. Rather than that Puttalam region is developing day by day and new building constructions are taking place. Therefore, forming new obstacles means a barrier to wind flow. When considering meteorological maps with early 2000 time and 2013, there is a difference between roughness values of the area. Areas which contained low roughness values have converted into high roughness value regions. Changes of terrain make obstructions to wind flow and decline energy production. There should be a frequent methodology to modify wind plants with appropriate changes by evaluating predicted wind energy.

Therefore, furthered studies should be carried out to identify the developing scenarios of climate change and the methods to avoid depletion of wind power potential of North Western area of Sri Lanka.

5. REFERENCES

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