THE EFFECT OF OBSTACLES CLOSE TO THE ANEMOMETER MAST LOCATED ON A BUILDING ON WIND FLOW IN THE WASP MODEL

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Abstract - Wind Atlas Analysis and Application Program (WAsP) is a powerful software package which is used for wind energy assessment for any location using the data of a nearby location under the same climatic condition. In this work WAsP has been used to predict potential areas of Kutubdia, an Island of Bangladesh, for installation of wind generators. As the mast is on the roof of Bangladesh Meteorological Department (BMD) station the hill effect has been introduced. If full heights of obstacles are used the predicted speed for another location becomes high and therefore the height parameter of the obstacles has been adjusted. It appears that those with height below or equal to the slope should not be considered and an obstacle with height greater then the slope should be taken as around h/2 where h is the height above the slope towards the wind direction. The computation shows that the speed difference for one year period between the measured and predicted annual values is 0.3m/s.

Keywords: Obstacle effect, mast on building, wind assessment, Kutubdia-Bangladesh

1. INTRODUCTION

Most of the meteorological stations are situated in built up localities with wind monitoring masts placed on the roof of buildings. Due to such localities, buildings and trees act as obstacles which may be very close to the met stations and therefore speed measured at the met mast is low. Hence wind energy prediction for any location using meteorological data poses a serious problem.

Under the SWERA project we are trying to develop wind energy resource maps for Bangladesh and for this purpose we are using Wind Atlas Analysis and Application Program (WAsP) to generate the wind atlas (10 x 10 km^2). For a start on our assessments, we have taken a coastal location Kutubdia (91.85^0 E, 21.82^0 N) where the wind monitoring mast of Bangladesh Meteorological Department (BMD) is located at the top of a roof. The building dimension is $(6x5x11)m^3$, surface elevation is 3masl and mast height is 2m above the roof. In this case BMD wind data (3 hourly) have been used for the period from Oct 96 to Sept 97 and a comparison has been done with the monthly average data of Bangladesh Centre for Advanced Studies (BCAS) station at 25m anemometer height. BCAS has measured speed and direction at 10 minute interval (reading was taken every 3 seconds and ten minute averaging time) and calculated monthly average speed and direction rose from their raw data. BCAS station is located around 4km distances from the BMD station and at the sea side. The effect of obstacles was far less for the BCAS location compared to BMD location. The positions of the stations have been shown in the map as given in the appendix1.

The WAsP is based on the physical principles of flows in the atmospheric boundary layer and takes into account the effects of different surface roughness conditions, sheltering effects due to buildings and other obstacles, and the modification of the wind imposed by the specific terrain height variations around the met station.

2. EFFECT OF MAST ON THE ROOF

As the mast is on the roof of the building, according to the report “The mast on the House” by Lars Landberg, the building should be considered as a hill. To introduce the “artificial hill” effect in the WAsP model the ground is modified by the 1:5 slope and it is done by drawing two separate contour lines one for the building height and another one for the ground. According to Lars Landberg the inner contour line indicates the elevation of building height from the ground and the outer contour line indicates 0m (figure 2). But as the contour lines indicate the elevation above the sea level, the 0m contour line makes another slope to the ground above the sea level (figure 1) and it affects the wind speed for the atlas. Therefore we consider that the building height should be taken as the height of the building above the sea level. And the zero contour line should be replaced by the elevation of the ground above the sea level (Fig 3)

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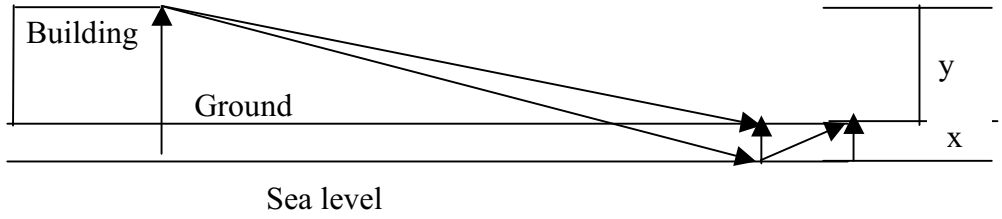

Figure 1: Slope for the building to the ground and sea

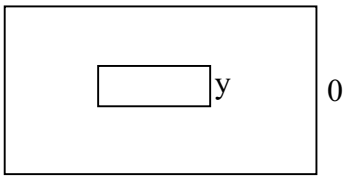

Figure 2: contour lines for the building height (y) from ground and 0m

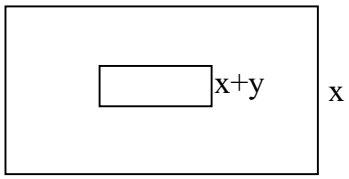

Figure 3: contour lines for the building and ground above sea level

3. EFFECT OF OBSTACLES CLOSE TO THE BUILDING

Hill effect of building introduces another problem concerning the obstacles around the met station which fall within the range of 1:5 slope. In that case, WAsP model calculates the hill effect as well as sheltering effect within the range of the slope. As a result wind speed and power density for the generated atlas become higher. Obstacle models for the BMD and BCAS stations are given in the appendix 1.

To overcome the problem associated with the mast station and obstacles closest to the station we have tried to analyze the obstacle model and hill effect in the following ways. Finally a comparative study has been done for the measured values of monthly average wind speed at BCAS station and the predicted values using the generated BMD wind atlas for the 25m height.

In all cases we have considered three conditions for the slope;

Condition:

1. contour lines for building height above sea level and 0m
2. contour lines for building height above ground level and 0m
3. contour lines for building height and ground above the sea level.

3.1 With obstacles (full height) within the 1:5 slope range

In this case if all of the conditions for the slope are considered then for all conditions the speed and power density is much higher and the predicted wind climate is also higher.

3.2 Without obstacles within the 1:5 slope range

Here the obstacles within the slope range have been removed and only the hill effect has been considered for all the three conditions. The predicted results are given below;

Table1: Measured and predicted wind speed at BCAS location for three elevation conditions without obstacles within the slope range

	Measured value			WAsP predicted value (without obstacles)					
				Condition 1		Condition 2		Condition 3	
BCAS	Speed (m/s)	Dir	Dev	Speed (m/s)	Error	Speed (m/s)	Error	Speed (m/s)	Error
Jan-97	**3.67**	NW/NE	0.41	**2.5**	1.17	**2.85**	0.82	**2.79**	0.88
Feb-97	**3.29**	NW	0.35	**2.7**	0.59	**3.06**	0.23	**2.98**	0.31
Mar-97	**3.53**	S/SW	0.41	**3.26**	0.27	**3.7**	-0.17	**3.6**	-0.07
Apr-97	**3.11**	SE	0.42	**2.63**	0.48	**2.99**	0.12	**2.91**	0.2
May-97	**4.89**	S	0.61	**4.13**	0.76	**4.7**	0.19	**4.58**	0.31
Jun-97	**5.9**	SE	0.76	**4.49**	1.41	**5.13**	0.77	**5**	0.9
Jul-97	**6.17**	SE	0.78	**4.51**	1.66	**5.1**	1.07	**5.04**	1.13
Aug-97	**5.34**	SE	0.75	**3.83**	1.51	**4.37**	0.97	**4.23**	1.11
Sep-97	**3.97**	SE	0.57	**3.02**	0.95	**3.45**	0.52	**3.33**	0.64
Oct-96	**4.02**	NW/NE	0.48	**2.31**	1.71	**2.62**	1.4	**2.54**	1.48
Nov-96	**3.23**	NW/NE	0.37	**1.95**	1.28	**2.21**	1.02	**2.16**	1.07
Dec-96	**3.38**	NW	0.38	**2.4**	0.98	**2.74**	0.64	**2.67**	0.71
Ave	**4.21**		0.16	**3.14**	0.47	**3.58**	0.40	**3.49**	0.42

From the above analysis it appears that we should use condition no. 3 to get better result and condition 3 may be followed to draw contour lines to develop the terrain model. In this case it also has been found that the predicted values are less to the measured values for Kutubdia and it is due to remove of large obstacles closest to the building.

3.3 With obstacles (rising above the slope) within the 1:5 slope range

If we draw the 1:5 slope between the building height and the ground then it is found that some obstacles lie under the slope and some obstacles just cross the slope and some rises slightly above the slope. One obstacle is higher then the building height.

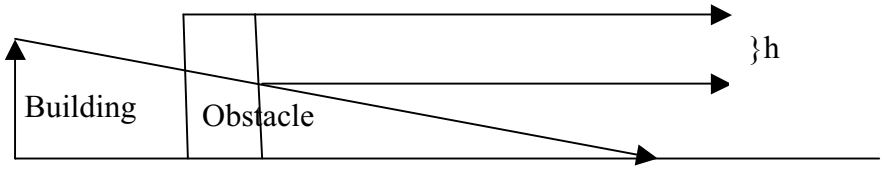

Figure 4: Effect of obstacles close to the building and rising above the slope

To obtain the height parameter of the obstacles in the model using an artificial hill for the met station building, we have considered the average distance of the obstacles from the building and extended the distance by the depth of the obstacles and considered the upper portion (h), cut by the slope, of the obstacle towards the wind direction (figure 4).

Table2: Measured and predicted values at BCAS location for different height parameter of obstacles within the slope range.

	Measured value			WAsP predicted value					
				Type 1		Type 2		Type 3	
				obs2_1m, obs3_1m, obs6_1m, obs9_1m		obs2_2m, obs3_2m, obs6_1m, obs9_1m		obs2_1m, obs3_3m, obs6_1m, obs9_1m	
BCAS	Speed (m/s)	Dir	Dev	Speed (m/s)	Error	Speed (m/s)	Error	Speed (m/s)	Error
Jan-97	**3.67**	NW/NE	0.41	2.94	0.73	3.32	0.35	3.55	0.12
Feb-97	**3.29**	NW	0.35	3.15	0.14	3.73	-0.44	3.54	-0.25
Mar-97	**3.53**	S/SW	0.41	3.82	-0.29	4.59	-1.06	4.09	-0.56
Apr-97	**3.11**	SE	0.42	3.07	0.04	3.62	-0.51	3.18	-0.07
May-97	**4.89**	S	0.61	4.78	0.11	5.40	-0.51	4.84	0.05
Jun-97	**5.9**	SE	0.76	5.22	0.68	5.74	0.16	5.23	0.67
Jul-97	**6.17**	SE	0.78	5.24	0.93	5.86	0.31	5.24	0.93
Aug-97	**5.34**	SE	0.75	4.42	0.92	4.91	0.43	4.43	0.91
Sep-97	**3.97**	SE	0.57	3.48	0.49	4.05	-0.08	3.49	0.48
Oct-96	**4.02**	NW/NE	0.48	2.65	1.37	2.92	1.10	2.85	1.17
Nov-96	**3.23**	NW/NE	0.37	2.27	0.96	2.58	0.65	2.71	0.52
Dec-96	**3.38**	NW	0.38	2.83	0.55	3.22	0.16	3.57	-0.19
Ave	**4.21**		0.52	**3.66**	0.39	**4.16**	0.53	**3.89**	0.40

4. CONCLUSION

It has been found that if we consider the height of obstacles as around h/2 or average height above the slope, then the predicted values are fairly close to the measured values. As conservative estimates should be considered for months with good wind speeds, type 3 of the obstacles have been chosen

5. ACKNOWLEDGEMENT

We are very much thankful to UNEP / GEF to provide us the fund for Solar and Wind Energy Resource Assessment (http://swera.unep.net) project under which we are doing this analysis.

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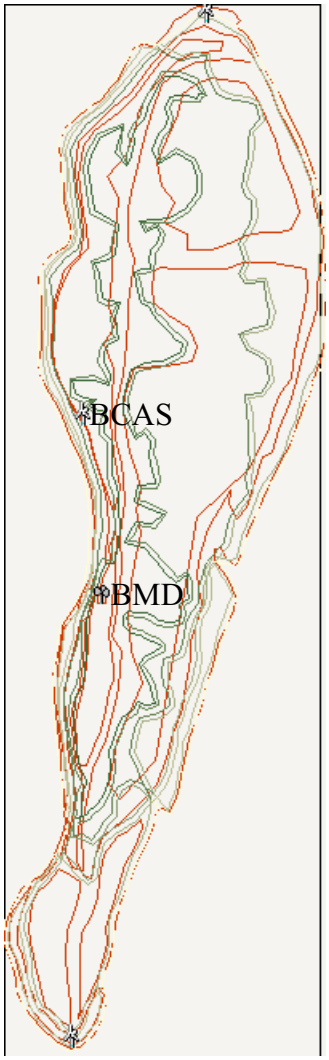
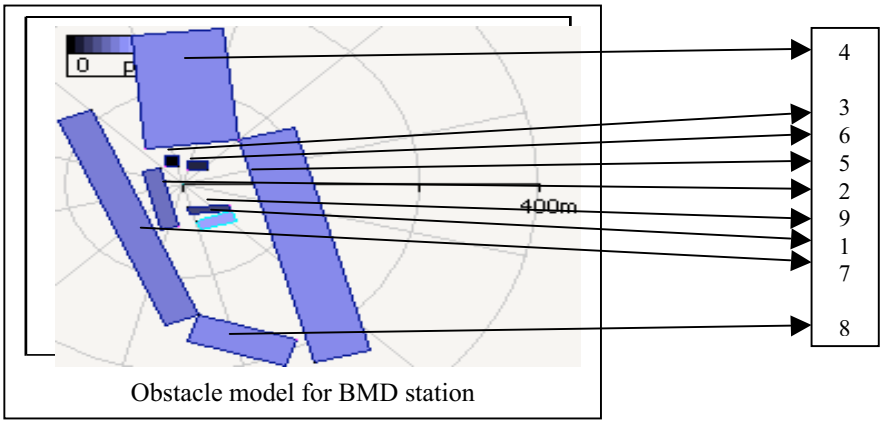
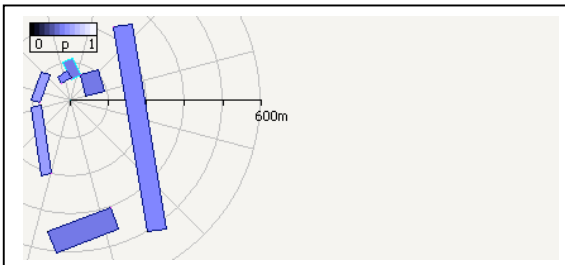
APPENDIX 1



Map of Kutubdia Island



Obstacle model for BMD station



Obstacle model for BCAS station