Environmental Impact of Noise Generated due to Operation of Wind Turbine Generators– A Case Study

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ABSTRACT— ***Power generation from wind energy has increased to a great extent in India during the recent past. The operation of Wind Turbine Generator (WTG) during power generation process generates noise of two types, one is mechanical noise and other one is Air cut noise. Any undesirable sound is considered as Noise. There are government regulations for the noise generation by any industry/personnel. This paper reveals the range and impact of noise and its effect to the near by dwellings considering a case study approach for the wind farm located in southern part of India. Study records the data related to noise level within and nearby the WTGs and measures it effect for day and night time for wind turbine located in Udumalaipet area of Coimbatore, Tamil Nadu India. Study uses both practical (on site data) and theoretical or standard noise level data prescribed by the Government of India to install any wind turbine generator near the dwellings. It also considers the important parameters like time and distance of measurement to assess the effect of noise considering different ratings of WTGs with different distance from them.***

Keywords— Environmental Impact, Noise range, Wind Turbine Generators, Impact of noise.

1. INTRODUCTION

Wind farm development in India is increasing as per the current Scenario. This development of wind power in India began in the 1990s and has significantly increased in the last few years. Today India is a major player in the global wind energy market. India is the 5th largest wind power producer in the world which provided great business opportunities for both domestic and foreign investors. Diverse incentives supported by a long-term policy and regulatory framework at the central and state levels have played a crucial role in achieving this goal. As of 31 March 2014 the installed capacity of wind power in India was 21231 MW. Wind power currently accounts for almost 70 percent of the total installed capacity in the renewable energy. Wind power is now increasingly accepted as a major complementary energy source for securing a sustainable and clean energy future for India. Having said this, there are few myths with people who live nearby the wind farms which fears them. Now this becomes the responsibility of the WTG manufacturer, experts to understand, clarify and give the right information to the people.

Main objective of the study is to ascertain the impact of noise level near the dwellings in the selected area. Study uses both practical (on site data) and theoretical or standard noise level data prescribed by the Government of India to install any wind turbine generator near the dwellings.

Few of the literature related to the study are, P. Migliore, J. van Dam and A. Huskey [1] of National Renewable Energy Laboratory, USA have analyzed the acoustic test results of small wind turbines and the Test data of machines demonstrated marked progress toward quieter Turbines. Anthony L. Rogers [2] of Renewable Energy Research Laboratory, University of Massachusetts at Amherst, explains different sources of sounds generated by wind turbine, factors affecting the sound generation, assessed the sound generated for a wind turbine project and provided the recommendations for standards, regulations and siting practices. The current paper gives the information on the noise regulations in India and the sound by a wind turbine located in Udumalaipet Coimbatore, Tamil Nadu, India. The noise levels which are detrimental for human health are also graphically explained.

1.1 Noise Definition Related To Wind Turbine Operation

Noise is defined as any loud, discordant or disagreeable sound or sounds. More commonly, in an environmental

context, noise is defined simply as unwanted sound [3]. Certain activities inherently produce sound levels or sound characteristics that have the potential to create noise. The sound generated by proposed or existing facilities may become noise due to land users surrounding the facility. When lands adjoining an existing or proposed facility contain residential, commercial, institutional or recreational uses that are proximal to the facility, noise is likely to be a matter of concern to residents or users of adjacent lands. The characteristics of a sound are also important determining factors for considering it as noise. The amplitude (loudness), frequency (pitch), impulse patterns and duration of sound all affect the potential for a sound to be a noise. Sound intensity, 'I' is defined as the power of the sound per unit area, and so can be measured in watts/m^2, but is more commonly measured in units of decibels, as mentioned in equation 1 [4]:

$$I = 10 \log (- I / I_0) \quad (1)$$

Where the reference intensity, I_0, is often the threshold of hearing at 1000 Hz:

$$I_0 = 10^{-12} W/m^2$$

2. EFFECT OF NOISE AND CONTROL

Numerous environmental factors determine the level or perceptibility of sound at a given point of reception. These factors include: distance from the source of sound to receptor, surrounding terrain, ambient sound level, time of day, wind direction, temperature gradient and relative humidity [5]. The combination of sound characteristics, environmental factors and the physical and mental sensitivity of a receptor to a sound determine whether or not a sound will be perceived as a noise. This guidance uses these factors in assessing the presence of noise and the significance of its impacts. It relies upon qualitative and quantitative sound evaluation techniques and sound pressure level impact modeling presented in accepted references on the subject. Noise health effects are the health consequences of elevated sound levels. Elevated workplace or other noise can cause hearing impairment, hypertension, ischemic heart disease, annoyance and sleep disturbance [6]. Changes in the immune system and birth defects have been attributed to noise exposure

2.1. Control of Noise

Mitigation refers to actions that will be taken to reduce the effects of noise or the noise levels on a receptor. There are four basic principles of noise control:

a) Sound insulation: prevent the transmission of noise by the introduction of a mass barrier. Common materials have high-density properties such as brick, thick glass, concrete, metal etc.

b) Sound absorption: a porous material which acts as a 'noise sponge' by converting the sound energy into heat within the material. Common sound absorption materials include decoupled lead-based tiles, open cell foams and fiberglass

c) Vibration damping: applicable for large vibrating surfaces. The damping mechanism works by extracting the vibration energy from the thin sheet and dissipating it as heat. A common material is sound deadened steel.

d) Vibration isolation: prevents transmission of vibration energy from a source to a receiver by introducing a flexible element or a physical break. Common vibration isolators are springs, rubber mounts, cork etc.

When an assessment of the potential for adverse noise impacts indicates the need for noise mitigation, it is preferred that specifications for such measures be incorporated in operational plan necessary for availing permissions from statutory authorities for the establishment of power plants.

2.2. Regulations

The Noise pollution (Regulation and Control) Rules, 2000 [7,8]. The said rule deals to regulate and control noise producing and generating sources with the objective of maintaining the ambient air quality standards in respect of noise schedule worse than 25dB Vs Age of exposure. Below table provides the information about standard levels of noise that different categories should follow as per the Government of Indian norms.

Table 1: Rules pertaining to noise pollution according to Indian Government

Ambient Air Quality Standards in respect of Noise			
Area Code	**Category of Area/Zone**	**Limits in dB(A) Leq***	
		Day Time	Night time
(A)	Industrial Area	75	70
(B)	Commercial Area	65	55
(C)	Residential Area	55	45
(D)	Silence Zone	50	40

Permissible Noise Exposure

Duration per day, hours	Sound level dBA slow response
8	90
6	92
4	95
3	97
2	100
1½	102
1	105
½	110
¼ or less	115

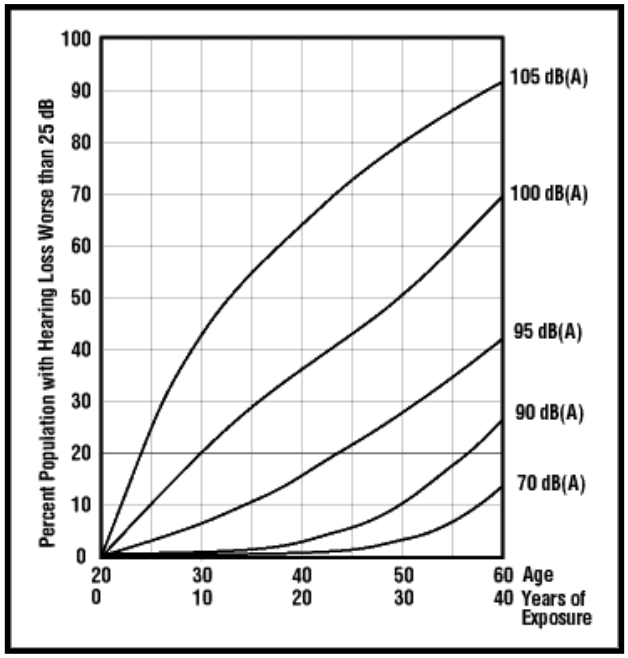


Figure 1: Occupational Noise Exposure Limits and percent Population with Hearing Loss

From Figure 1, it can be seen that 90dBA is the permissible limit of sound for 8hrs of continuous duration and the hearing loss is less than 30% for the population who had undergone this for 40 Years of exposure with an age of 60 Years [9, 10]. Data's were recorded actually from the selected wind farm and the readings were collected for Udumalaipet wind farm, Tamil Nadu, India, at various times (day and night time) for a period of one year and is given in Figures 2, and 4 and in Table 2 also. It can be observed that a maximum Noise Limit is 85 dB which is considerably less than regulatory limits of sound.

However, employees working in this industry are using ear muffs and ear plugs as a safe practice in all routine and non routine maintenance activities.

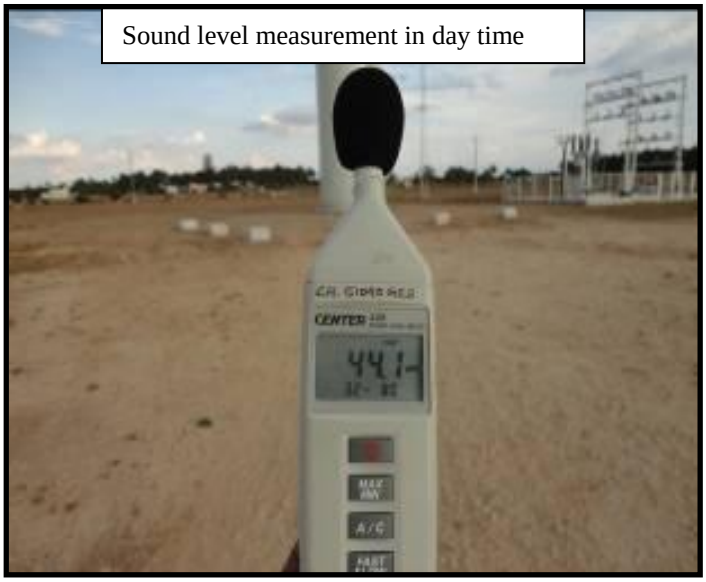


Figure 2: Measurement of sound Levels outside WTG at various distances from WTG

3. EXPERIMENTAL RESULTS AND DISCUSSIONS

Considering the effect of noise on human beings near the dwellings and to the operators working in the area near to the wind turbines with various WTG ratings in a selected wind farm at different levels of height above the ground level, the

results obtained are given below. Results so obtained from the study are represented both in tabulated and in graphical manner.

Table 2: Measurement of sound levels outside WTG at various distances from WTG

Distance (in Mtrs.)	0	20	40	60	80	100
2 MW, Day time	60	52.1	51	49.2	48.3	44.1
2 MW, Night time	69.5	64.4	63.5	62.1	61.2	49.4
0.850 MW, Day time	83.1	66.5	65	64	63	61.3
0.850 MW, Night time	82.2	70.5	69.2	68.1	67.3	65.4

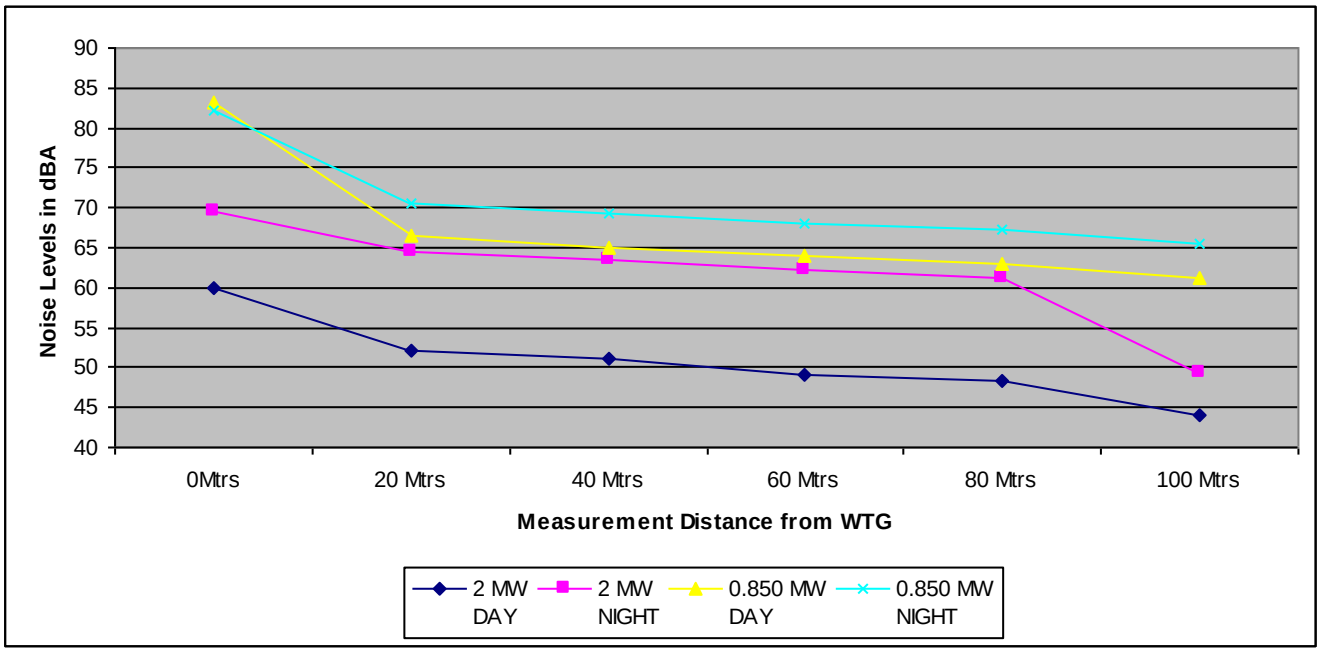


Figure 3: Sound level measurement of different rating WTGs at various distances

Figure 4: Measurement of sound Levels outside WTG at various distances from WTG

Figure 5: Noise monitoring near by dwelling area

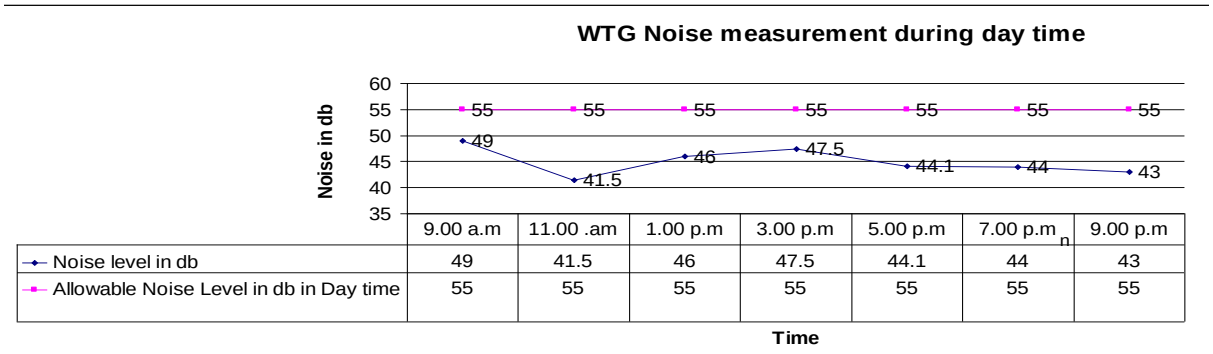
Figure 6: Noise monitoring near by dwelling area

Figure 7: Wind farm located in hilly region

4. CASE STUDY OF A WIND FARM

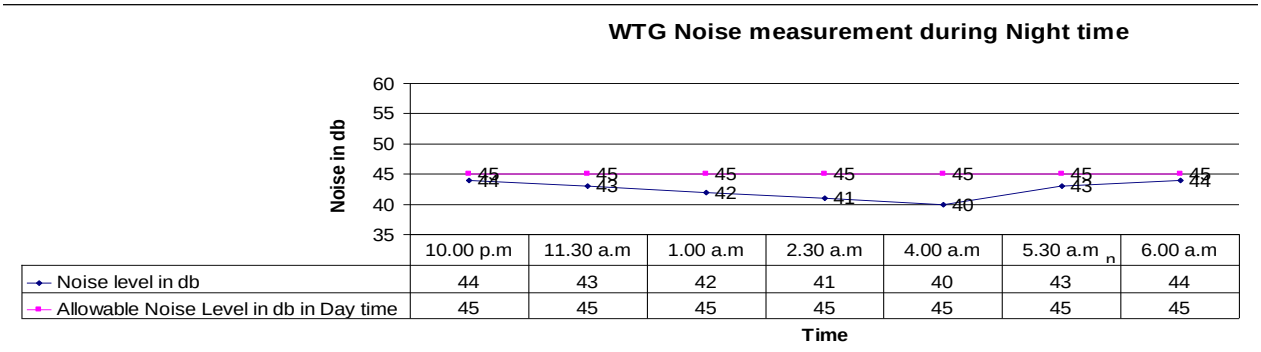
Noise monitoring was carried out at near by residence at Udumalaipet area of Coimbatore, Tamil Nadu-India. This study is done in two different sites at two different locations where WTG's are located close to dwelling areas. The values were observed and recorded during the day time & night time as shown in figure 4 and 5. These values were recorded as per the standard noise level measurement given by International Energy Council (IEC) act 651 [11, 12] of Type: II measuring device.

From the measurements taken in the residential areas (two different machines) it is confirmed that the noise level is well below the limits as per the legal norms under general operating conditions as shown in the figures 2 and 4 for day and in evening time. Figure 5 and 6 represents the location of WTGs near the dwellings or situated near by or in the hilly regions which doesn't cause any effect to the near by dwellings. Figure 7 represents the location of WTGs for away from the dwellings or situated near by or in the hilly regions which doesn't cause any effect to the dwellings.



	9.00 a.m	11.00 .am	1.00 p.m	3.00 p.m	5.00 p.m	7.00 p.m	9.00 p.m
Noise level in db	49	41.5	46	47.5	44.1	44	43
Allowable Noise Level in db in Day time	55	55	55	55	55	55	55

Figure 8: Noise variation in day time



	10.00 p.m	11.30 a.m	1.00 a.m	2.30 a.m	4.00 a.m	5.30 a.m	6.00 a.m
Noise level in db	44	43	42	41	40	43	44
Allowable Noise Level in db in Day time	45	45	45	45	45	45	45

Figure 9: Noise variation in Night time

Figure 8, and 9 represents the variations of noise that was recorded at different timing intervals throughout the day with an interval of one hour. Here, study founds that for different timing, variation of noise level is always less than that for the maximum allowable limit irrespective of the WTG rating capacities.

5. CONCLUSION

The experiment is clear evidence that there is no issue of noise pollution to the neighboring society during the day and night times at different locations pertaining to WTG operation. Hence it can be concluded that the operations of 0.85 MW or 2 MW are environmentally friendly and noise levels are within acceptable level / zone.

Wind Turbine Generators (WTGs) has zero impact on the environment and the energy that is produced does not result in any green house gases or other pollutants.

6. REFERENCES

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