ISSN 2229-5518

# Producing Electrical Energy by using wastage wind energy from exhaust fans of industries

Md. Abir Hasan+, Mohammad Tanvir Hossain, Ratul Paul, Nilufer Akter

+Corresponding author email:abir.cuet08@gmail.com

**ABSTRACT**
Crisis of an electric power is a common phenomenon in a developing country. Day by day it's become serious issue due to various factors, such as increasing demand, lower production capacity and transmission losses, etc. As a developing country, Many Industries are running on in our surroundings & also so many are being installed every day. We can see so many exhaust fans are being used to keep the working environment at a moderate temperature of an industry. These fans circulate air from inside to outside. From outside we can consider it as a high velocity wind source. In this Paper, we will show a process to use this wastage energy source. In this process, wind from all exhaust fans will be collected and driven through a single tunnel which will give a huge wind flow to the wind turbine. And then wind turbine will convert it into effective electrical energy. We will measure the velocity by using anemometer. This paper also consists of analyzed data of the wind velocity of the different industries of Bangladesh. We also analyze these produced electricity are whether profitable or not from the existing system. Thus we can utilize the wastage wind energy from the exhaust fans of the industries and producing electrical energy we can reduce the load of national grid.

**Index Terms:** Exhaust Fan, Wind Energy, Wind Turbine, Electrical Energy, Duct system.

IJSER

## 1. INTRODUCTION

The interest in renewable energy has been revived over last few years, especially after global awareness regarding the ill effects of fossil fuel burning. The use of renewable energy technology to meet the energy demands has been steadily increasing for the past few years [1] For this purpose we have worked on a different idea. We considered exhaust fans using in industries as a high velocity & steady wind source. By using this steady & high velocity wind, we can rotate a turbine to produce a reasonable amount of electrical energy. This paper will show you a statistical analysis of velocity of exhaust fans, mathematical analysis, and model design with calculation, rate of production & economic analysis etc.

## 2. Wind Energy:

Today, wind energy is the most mature of the renewable energy technologies apart from hydro. This wind technology is much safer than other renewable energy source. In the wind mill a wind turbine is used where wind turbines - capture the air flow by converting it into a rotational movement, which subsequently drives a conventional generator for electricity [2].

### 2.1 Wind Energy Equation :

When air mass is flowing through an area A with speed

$$P(t) = \frac{1}{2}\rho A\, v(t)^3 \qquad (1)$$

v, the power of that air movement at time t is given by:

Where ϱ is the density of air, which is around 1.22kg/m³. The energy (kWh) is the product of power and time:

$$E = PT = \frac{1}{2}\rho A\, \Delta t \sum_{i=1}^{N} v_i^{\,3} \qquad (2)$$

To take account of wind fluctuations, the energy from an air flow over a time period P is made up of the sum of wind speeds of small time intervals. Often, average hourly wind speeds are measured, thus providing 24 time buckets per day.

While the air density is more or less constant, the two parameters to watch out for are the wind swept area A and the wind speed v. The latter is even more critical, as it is cubed. A location with double average wind speed has 8 times the power for the same area. Or to capture the same energy, the blades of the wind turbine in the low wind speed location would have to be almost 3 times as long. [2]

So, we can see from the data that velocity is the most important factor of wind energy equation. Higher velocity gives us higher power.

ISSN 2229-5518

## 2.2 Wind Energy Data Analysis:

Now we will analyze & compare the data from some windmills exist in different location where shore wind is used as a source with the data of exhaust fan of our designed system.

Table 1: Some wind energy data around the world.

| Location | Average wind speed | Power Density |
|---|---|---|
| Munich *(inland)* | 3.2 $\frac{m}{s}$ | 20 $\frac{W}{m^2}$ |
| Helgoland *(North Sea Island)* | 7.2 $\frac{m}{s}$ | 227 $\frac{W}{m^2}$ |
| Off-Shore *(North Sea)* | 10.0 $\frac{m}{s}$ | 610 $\frac{W}{m^2}$ |

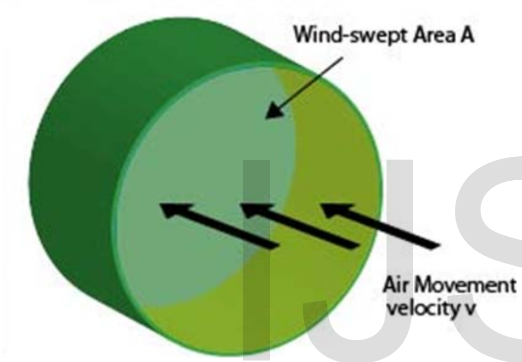



Fig.1: Wind Energy [2]

Now, we consider yearly average speeds measured at 30m height at different locations Of Bangladesh. [3]

Table 2: yearly average speeds measured at 30m height

| Location | Average Wind speed | Power Density |
|---|---|---|
| Saint Martin | 4.96 m/s | 74.43 W/m² |
| Cox's Bazar | 4.38 m/s | 51.37 W/m² |
| Patenga | 4.06 m/s | 40.87 W/s² |

Now, from our measured data we can see,
For Exhaust Fan, we got,
The average wind speed = **15.4** m/s;
Power Density = **2227.88** w/m²

So, this power density is almost four times greater than off shore (North Sea) & almost 30 times greater than Saint Martin with only one fan. After installing the plant with combination of more than one fan the power density will increase with the increase of mass density of air, ϱ & velocity, V.

## 3. Exhaust Fan :

Exhaust Fan are heat removal devices used to transfer waste heat to the atmosphere; large office, buildings and Industries premises typically install one or more exhaust fans for building ventilation system. This type of Exhaust fans relies on power-driven fans to draw or force the air through the blades.

We took some measurement about an exhaust fan in kaltimexbangla factory in Dhaka.

Table 3: The details of the fan:

| Variable | Measured Value | Variable | Measured Value |
|---|---|---|---|
| K.W. | 2.2 | Fan Diameter | 900 mm |
| H.P | 3 | Fan Air Flow | 15.38 m/s |
| Voltage | 415 V | U phase current | 5.5 A |
| Current | 5.1 A | V phase current | 5.5 A |
| R.P.M | 935 | W phase current | 5.4 A |

Table 4: The velocity found at 0.3m distance in different eight positions.

| Position no. | Velocity(m/s) |
|---|---|
| 1 | 16.1 |
| 2 | 14.9 |
| 3 | 17.2 |
| 4 | 13.5 |
| 5 | 15.9 |
| 6 | 14.1 |
| 7 | 16.5 |
| 8 | 14.8 |

IJSER

ISSN 2229-5518

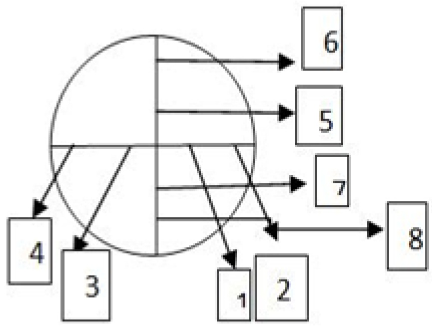



Fig.2: Different measuring point of exhaust fan

From these eight positions the calculated value 15.38 m/s is found for only one fan. Generally, in any premises i.e. industries there are approximately 20-100 exhaust fans are exist. By directing these exhaust fan's wind into one single tunnel, we developed the input of wind turbine.

## 4. Design Description:

### 4.1 Duct Design:

As far as our concern is to carry out the wind from exhaust fan to turbine, proper duct network is very essential. To minimize the losses (velocity drop, pressure drop etc.) duct design considerations need to maintain. Such as, using round duct, avoiding sharp edge (Tee, elbow), noise & fire isolation, abundant reinforced to prevent collapsing at any static pressure and most importantly duct length must be as shortage as possible with minimum numbers of fittings in order to economize on energy cost material and space. Also for corrosive conditions, corrosive resistant metals, PVC or other plastics or coatings may be used for duct construction. [4] At the end of the duct a diffuser is used to increase the velocity just before hitting the turbine blade.

### 4.2 Diffuser Design:

With a simple momentum theory, developed along the lines of momentum theory for bare wind turbines, it was shown that power augmentation is proportional to the mass flow rate generated at the nozzle of the diffuser augmented wind turbine (DAWT). Such mass flow augmentation can be achieved through two basic principles: increase in the diffuser exit to inlet area ratio and/or by decreasing the negative back pressure at the exit [6].

The first principle to increase the exit to inlet area ratio is applied in the design as shown in Fig. 1, thus more energy can be harvested by utilizing this system.

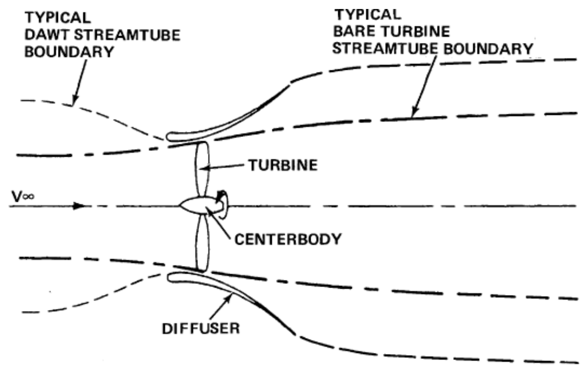
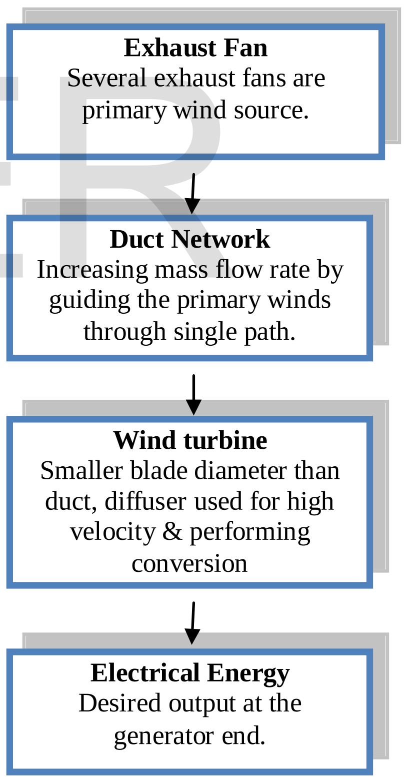



Fig. 3: Basic schematic drawing of the DAWT on the flow field boundaries [5].

### 4.3 Flow chart:




### 4.4 Estimated Output:

We got from proceeding; average velocity of an exhaust fan (swept area 0.63585m$^2$) is 15.38 m/s. The primary diameter of a duct is equal to the diameter of a fan. Considering three exhaust fans, each primary duct conveys 9.778m$^3$/s air, which is equivalent to mass flow rate 9778.51 kg/s. In the final

IJSER

duct the flow rate is the summation of these three primary ducts and that is 29,335.53$m^3$/s. This is the approximate input of the turbine blade.

Converting it into power we get 3.47 MW. Where mass flow rate dm/dt= $\rho$Av.

Consideration of power coefficient:
A German physicist Albert Betz concluded that no wind turbine can convert more than 16/27 (59.3%) of the kinetic energy of the wind into mechanical energy turning a rotor. To this day, this is known as the Betz Limit or Betz' Law. The theoretical maximum power efficiency of any design of wind turbine is 0.59 (i.e. no more than 59% of the energy carried by the wind can be extracted by a wind turbine). This is called the "power coefficient" and is defined as: $C_{pmax}$= 0.59. Also, wind turbines cannot operate at this maximum limit. The *Cp* value is unique to each turbine type and is a function of wind speed that the turbine is operating in. Once we incorporate various engineering requirements of a wind turbine - strength and durability in particular – the real world limit is well below the *Betz Limit* with values of 0.35-0.45 common even in the best designed wind turbines.[7]
So, the power equation becomes

$$P_{avail}=1/2*\rho*A*v^3*C_p \quad (3)$$

Now, assuming $C_p$=0.40 we get 1.40 MW electrical power. Though we considered the power coefficient but some factors ignored like velocity deviation, density of air, temperature effect etc. Practically these factors may affect this system and our result may be deviated slightly.

## 5. CONCLUSIONS

Till now, this paper is a theoretical idea to install a windmill in an industry. But we may have a great success from this assumption. Though the output power is not quite enough in quantity because of some factor but step by step improvement can make a dynamic change in energy resources. Our future work could be focused on how could the velocity be increased as we see that the power production is largely depend upon the velocity of air.

## REFERENCES

[1] International Energy Agency, 1995, *"Wind Energy Annual Report,"* International Energy Agency Report by NREL, March 1995.

[2]www.greenrhinoenergy.com/renewable/wind, December 2012.

[3] M.A. Hossain, M. M. Ali, M. R. I. Sheikh, M. A. A. Humayun. Feasibility study for wind power stations at different locations in Bangladesh. International Conference on mechanical engineering and renewrable energy,2011-PI-005.

[4] Refrigeration & Airconditioning. P. L. Bellamy. 13th edition.

[5] K. M. Foreman. Preliminary Design and Economic Investigations of Diffuser Augmented Wind Turbines
(DAWT). Research Department Grumman Aerospace Corporation Bethpage, New York, 1981.

[6] G. J. W. V. Bussel. The Science of Making More Torque from Wind. *Journal of Physics: Conference Series*. 2007,
**75**: 1-13.

[7] Wind Turbine Power Calculations, RWE npower renewables, Mechanical and Electrical Engineering Power Industry, The Royal Academy of Engineering, December 2012.

## NOMENCLATURE

**Symbol**

| | | |
|---|---|---|
| A | Area | ($m/s^2$) |
| $\rho$ | Density | ($kg/m^3$) |
| P | Power | (W) |
| V | Velocity | (m/s) |
| E | Energy | (KWh) |
| T | Time | (s) |
| C | Co-efficient | |

**Subscripts**

| | |
|---|---|
| p | power |

IJSER