Re-Wind Energy: Air Conditioner Assisted Energy Generation using Micro Wind Turbines

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Abstract - *With the rise in validity of renewable energy systems as well as a positive and significant shift in global perspective over its applications it has become imperative to keep looking for better options in the field of sustainable energy. The aim of the following research paper is to generate wind energy from the air dissipated from the compressor of residential air conditioners and generate electricity for everyday use. This is meant to be achieved by installing a small scale horizontal axis wind turbine (HAWT). The location of the HAWT will be perpendicular to the Face of the outdoor unit of the Air conditioner, which will be made clear by a computer aided model (SolidWorks). The following application will also help to reduce the temperature of the localized area just adjacent to the outlet of the residual air.*

Key Words: **WIND ENERGY, HORIZONTAL AXIS WIND TURBINE, RENEWABLE ENERGY, AIR CONDITIONERS, ENERGY EXTRACTION.**

1. INTRODUCTION

As the sector of Wind Energy continues to grow, more ways of making use of this non-conventional energy source are being chalked up. Wind farms are being developed worldwide for continuous energy extraction with huge success, however as wind turbines get bigger so do some of the problems related to them. Problems of Unwanted Noise, excessive space, Effect on birds in the vicinity of wind farms are some of the problems which need attention. As a result a shift of perspective towards smaller, efficient versions of the wind turbine seems necessary.

Air-Conditioners are widely used on a global scale, they alter the temperature of a confined volume which they are subjected to by the user. This happens by releasing air in the surroundings, thus maintaining the equilibrium. It is this released air from the air conditioner which will be the pith of the Following work.

Compressor, Condenser and the Evaporator are the three key parts which make any air-conditioning unit function. Out of this the compressor and the condenser are located in the outside unit of the air conditioner and we will be focusing mainly on those parts. The evaporator emits the conditioned air and the condenser releases the hot air into the surroundings. This hot air is released with the help of certain fins which run on the provided energy. This released air is of high pressure, high velocity and the idea is to make use of a small scale wind turbine which can make use of the released air and produce energy from it.

Hence, The idea of production of minimal yet significant units of electricity, from electricity itself, might feel rather disruptive and is significantly edgy to begin with, however it can be shown to be highly useful as well as sustainable.

1.1 Brief Literature Review, Wind Energy

Wind Devices have been around for a very long time with some dating right back to the timeframe of about 1875 AD. However with time, Perfection in this field was achieved around the early 19th century particularly in the United States of America, where the technology was used mainly for the purpose of pumping water.

New, updated and advanced technology was made available for the extraction of wind energy throughout the globe. Both onshore and offshore applications were put to use with healthy results.

Only 0.1% of total electricity generated throughout the world was from wind energy, this number sized up to a reasonable 2.5% in 2010 and stands at a respectable 9.4% in as recently as 2018. A host of European countries particularly Denmark which produces about 44% of its total electricity from wind are the Major contributors.

The global wind capacity as of 4 June 2019 as estimated by the world wind energy association (WWEA) is 597 GW. 50.1 GW was added during the whole of 2018. Also in the sector of small wind the overall capacity had reached almost 950 MW by the end of 2016, the growth rate stood at 14% for the same.

1.2 Wind Turbines, an Overview

Horizontal & vertical axis wind turbines (HAWT & VAWT) Are the two main types of design classified Turbines. The former is used more extensively than the latter globally due to differences in design and output variances. Majority of wind farms throughout the globe have installed horizontal axis wind turbines. Wind turbines can also be classified on the basis of sizes.

In order to distinguish the turbines by their size it is important to understand the concept of the rotor swept area of different wind turbines. The rotor swept area of the wind turbine is defined as the area of the circle to be formed by the rotating blades of the wind turbine. Wind turbines are manufactured over a scale of about 2 – 90m in the industry.

In accordance with the previously updated and revised version of the international safety standards of small wind turbines, any Wind turbine which is having a rotor swept area of less than 200m^2, is considered to be a small wind turbine. In the given standard a further division is also made for Micro wind turbines, these turbines are relatively quiet small from the conventional ones and have a rotor swept area of less than 2m^2. They also have a rated power below 500W. These are mainly used for auxiliary power consumption systems. Hence for micro wind turbines the radius of the blade of the turbine will be approximately equal to 0.7m or 70cm, based on the required output of the Turbine.

For the Following Research Work the radius of the turbine blade will be in the similar Range as discussed above, that is 0.3-0.4m.

2. Design

A conventional, residential split air conditioner consists of an outdoor and an indoor unit, here our primary focus will be on the outdoor unit. This outdoor unit is responsible for driving the residual air outwards into the immediate area just outside. On this outdoor unit the wind turbine will be installed.

The wind turbine has been given sufficient clearance from the unit as too large a distance would create a disruptive pattern of flow due to interference of regional air and also incessantly occupy a larger space, on the contrary if the turbine is placed at a seemingly close distance from the unit back pressure might be generated, having a knock on effect on the turbine.

The blades attached to the fan of the outdoor unit have an approximate radius of 320mm, diameter 640mm, hence to attach a wind turbine right after & for it to be feasible taking into consideration constraints of space it is thought that the blades of the wind turbine have a maximum radius of 300mm.

The Parts for the following model are as shown on the computer based model (SolidWorks)

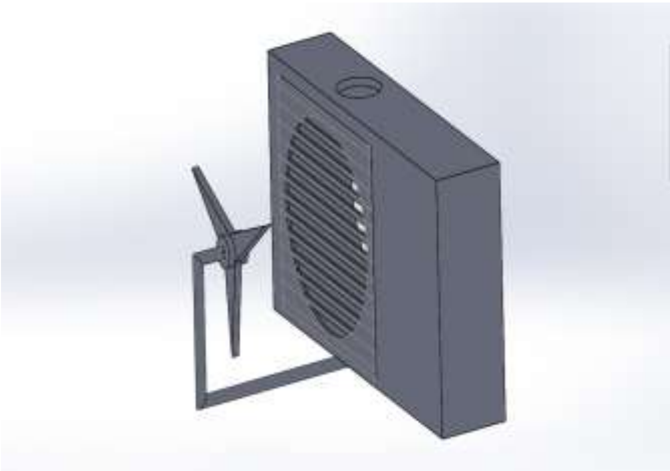
The turbine will be a conventional 3 blade horizontal axis wind turbine attached right behind the fan of the outdoor unit of the air compressor leaving a gap of 100mm in between the actual compressor and the wind turbine this will lead to a better wind flow and optimal use of space. The turbine will be mounted on the outdoor unit with the help of connecting rods, these rods will be responsible to support the turbine with the help of the outdoor unit.

The design of a 3 blade wind turbine was chosen keeping in mind certain concepts which are detailed as follows. Theoretically, the efficiency of the wind turbine can be said to be directly proportional to the number of blades of the turbine. However, when we take into consideration a turbine which has a relatively small swept area then the relationship between efficiency and no of blades as mentioned above changes. This happens due to the fact that if the rotor has too many blades then the flow of the wind through it is disrupted due to small clearance and aerodynamic interferences. Due to this overall efficiency decreases.

Now if we consider a turbine with any less than three blades then the area of contact between the wind and the blade per rotation decreases significantly. Most of the airflow will hence take place without even interfering with the blade and hence the kinetic energy of the wind will not be harnessed completely. We have to avoid this scenario.

Two blades and single blade wind turbines are hence generally less efficient than the one with three blades, Hence a wind turbine with three blades is considered to be the most efficient in the given scenario.

The SolidWorks assembly for the above described model is as shown below.



3. Working

To perform calculations that would be required to find out the amount of energy generated from this project it is necessary to predefine certain terms related to the same. The terms that will be required are as follows:

1. Velocity of the wind coming out of the air compressor (v_0) = 7 m/s
2. Density of air coming out of the Air conditioner (δ) = 1.23 kg/m^3.
3. Radius of the blades of the wind turbine (r_0) = 300mm = 0.3m
4. Swept area of the wind turbine (A_0) = [π $(r_0)^2$]

= 0.2826m^2

The following terms will be of utmost importance while performing calculations for the same.

As soon as the air conditioner starts functioning the blades of the outdoor unit also start rotating at a speed

which is proportional to the indoor temperature set by the user which is usually around 22^o c. at this temperature the air coming out from the outdoor unit does so with a velocity of approximately 7m/s.

Now as this air is also passing through the wind turbine and there is not a lot of space in between them to decrease the air velocity, the air hits the blades of the turbine with the same velocity as mentioned above. Hereafter the kinetic energy of the winds is converted into useful energy with the help of the wind turbine.

Now, in order to find out exactly how much energy does this small system produce, we will make use of the terms as defined above.

Kinetic energy stored in the wind = E = $\frac{1}{2}mv^2$

Where, m = mass of the wind

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v = Velocity of the wind at that instant.

The power (P) in the wind is given by the rate of change of energy, which is

$P = \frac{dE}{dt}$

$\frac{dE}{dt} = \frac{1}{2} v^2 \frac{dm}{dt}$

Now, mass flow rate will be given by,

$\frac{dm}{dt} = \delta \text{ A} \frac{dx}{dt}$

$\frac{dx}{dt} = v$

$\frac{dm}{dt} = \delta \text{ A } v$

Hence, we can define power for the wind turbine as,

$P = \frac{1}{2} \delta A v^3$

The Power therefore obtained is the theoretical maximum of the extractable power of the wind turbine. However, the actual power differs quite significantly. No wind turbine can effectively Capture 100% of the wind power thrown towards it.

You can only convert 59.3% of the kinetic energy by the wind to mechanical energy, as stated by the Betz's law. This is because the wind on the back side of the rotor must have a high enough velocity to move away and allow more wind through the plane of the rotor. 'C' is known as the betz's co-efficient which is equal to 16/17.

C = 16/17 = 0.593, Betz's Co-efficient.

Now we can write the revised formula as,

$P = \frac{1}{2} \delta C A v^3$

The power hence obtained from the term given will be in watts (W).

4. RESULTS

Substituting the before mentioned values into the aforementioned formula, we can calculate the power production in the given modeled setup, the power that will be obtained here, will be the theoretical maximum amount for the turbine.

$P = 0.5*1.23*0.59*0.2826*(6)^3$.

P = 22.1489 Watts

The following amount of power is the power contained in the wind.

Assuming power conversion losses

<u>P = 22 Watts</u>

Although, the power output obtained is significantly less than that produced by regular wind turbines, it can be used for a host of auxiliary functions in an average household.

- Certain LED's with rated power less than 20 W can be easily implemented.
- Energy storage systems can be implemented.
- Smartphones and other low power auxiliary electric accessories can be charged (A typical mobile phone charger is rated at anywhere between 5-10 W)

4.1 Eccentricities of the Model

- Air released from the blades of the outdoor unit is almost always done at a constant velocity, hence there is little fluctuation in power conversion leading to few losses.
- Again due to almost constant velocity, the need for brakes on turbine and the issue of exceeding the wind limit is taken care in itself.
- In commercialized buildings with definitive structures, a power grid can be created by installing multiple wind turbines and then connecting them to a centralized power distribution zone.
- In a case where 100 such turbines are integrated in such a structure, the power obtained can be as close to 2kW which is about 0.12 Megs Watts of energy generated every single hour.
- Temperature impact in the immediate area of the outlet of air flow: In the absence of the wind turbine the high pressurized air release from the air conditioner directly merges in with the surroundings. In the presence of the wind turbine, the high pressurized, high velocity gas will also transmit the excessive heat in tandem with its kinetic energy to make the blades of the turbine move relatively faster, As a result of which there will be a significant temperature drop across the area in consideration.

5. Conclusions

Having reviewed the brief history of wind energy as well as the scope of its development, the following paper focused on the idea of making the energy systems related to it more accessible to a wider array of people, with the help of external air conditioning systems. Using computer aided tools and software it was possible to design and assemble a virtual model of the micro wind turbine which can be implemented in reality.

The mathematical model and calculations for the extractable energy from the wind turbine were also studied based on the design obtained and successful calculations were made based on the verifiable and given data. The paper also highlighted the eccentricities exclusive to the given model and also advantages and shortcomings of the same.

The model is expected to extract a power of about 22W from the wind or the residual air from the outlet of the air conditioner. Hence, it is shown that significant amount of energy can be extracted out from very little resources and if adopted on a grand scale in various sectors, it can successfully lead to profits in the energy sector and at the same time be appreciably sustainable.

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