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Electricity Generation for Small Scale Industry by Using Exhaust Air

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Abstract: *The energy demand of the world has become unbridled in the past years and is augmenting by leaps and bounds. With increase in energy demand, the conventional sources of energy (fossil fuels, nuclear) are encumbered with monumental pressure and hence, the unremitting use of it, leads to dearth of fossil fuels. This has provoked an extensive research into the area of non-conventional energy sources like hydro, wind, thermal energy, etc. Out of these, the wind energy is being discussed in this paper. Wind energy has a lot of potential and advantages but its utilization is restricted due to its irregularity, geographical conditions and its availability. Our primary goal is to suggest an idea that can surmount these conundrums and utilize the wind energy to its maximum extent. This paper deals with the wind energy that can be derived from the wasted wind energy from industrial exhaust fans. The wind force from an exhaust fan can drive a small windmill and the energy generated from it will be stored in energy storage unit. The power stored in the battery can be transmuted into ac with the help of an inverter and then it can be supplied to the load and hence, this wasted power from exhaust fan can be utilized to meet the growing energy demand. Abstract - The energy demand of the world has become unbridled in the past years and is augmenting by leaps and bounds. With increase in energy demand, the conventional sources of energy (fossil fuels, nuclear) are encumbered with monumental pressure and hence, the unremitting use of it, leads to dearth of fossil fuels. This has provoked an extensive research into the area of non-conventional energy sources like hydro, wind, thermal energy, etc. Out of these, the wind energy is being discussed in this paper. Wind energy has a lot of potential and advantages but its utilization is restricted due to its irregularity, geographical conditions and its availability. Our primary goal is to suggest an idea that can surmount these conundrums and utilize the wind energy to its maximum extent. This paper deals with the wind energy that can be derived from the wasted wind energy from industrial exhaust fans. The wind force from an exhaust fan can drive a small windmill and the energy generated from it will be stored in energy storage unit. The power stored in the battery can be transmuted into ac with the help of an inverter and then it can be supplied to the load and hence, this wasted power from exhaust fan can be utilized to meet the growing energy demand.*

Keywords: Wind Power, Exhaust Fan, Wind Turbine, Storage

I. INTRODUCTION

Economic growth and energy demand are intertwined. Developed countries are known as the major users of energy globally, however, most of the increasing demand will occur in developing countries, where populations, economic activities and improvements in quality of life are growing most rapidly. Global energy consumption in both developed and developing countries is expected to double or more by the year 2040 ("The Outlook for Energy: A view to 2040," 2018). Currently, the world relies on coal, crude oil and natural gas for energy generation. However, energy crisis such as climate change and depletion of oil (which leads to the oil price inflation) becomes one of the main problems to all countries. For that reason, generating energy from renewable sources remain relevant to be implemented and explored. To meet the energy demand without damaging the planet, the energy generation from renewable sources becomes more widespread. It is proven that the renewable energy sources available can meet many times the present world energy demand, thus their potentials are enormous. However, most of the current technologies on renewable energy generation are still at an early stage of development and not technically mature. Thus, there is an urgent call for researchers and innovators to come out with the best possible solution for clean energy.

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1.1 Problem Statement

In order to reduce the dependence on fossil fuels for energy generation, renewable energy plays a critical role in reducing the greenhouse gases emission leading the world toward fossil fuel independence. Wind energy is the second biggest source of renewable energy after solar energy. It is the fastest growing RE source in the world with an annual growth rate of 30%. The share of wind energy is 14% at the global scale on the total mid-term renewable energy resources potential and this value reflects its maturity in technology. Many researchers have proposed the ideas of wind energy systems that can possibly be installed in urban settings for local energy generation. These systems feature additional augmentation systems, either utilizing the building geometry or retrofitted onto the building or a combination of these. However, the uncertainty in wind energy is the main problem in matching the increasing demand for renewable energy.

The operation of wind power systems is susceptible to changing wind patterns resulting from climate change. Thus, an efficient method is strongly demanded to harness the uncertain wind energy. Besides turning to available alternative resources for generating clean energy, energy recovery from wastes such as heat sink, exhaust air, etc. also have a great potential in helping to address the global energy issue. Energy saving and emission reducing technologies consist of three types, i.e. resource conservation, energy economizing and environment friendly. The available wind source can be divided into natural wind and man-made wind. The man-made wind is considered as unnatural that is available from man-made systems or operations such as cooling tower, exhaust air, etc. The high-speed, consistent and predictable wind produced by the system is good to be recovered into a useful form of energy. Thus, this research investigates the concept of energy recovery systems on cooling towers by using commercially available wind turbines. It is an energy recovery system which may reduce the energy demand by generating energy from waste. This system enables the low wind speed countries especially in urban areas to harness wind energy from exhaust air resources which are consistent and predictable.

1.2 Objectives

This paper presents the design and testing of an exhaust air energy recovery wind turbine generator in order to propose a new system on clean energy generation. The system uses a commercially available wind turbine mounted on a predefined configuration facing the outlet of an exhaust air system.

The objectives of this research are as listed below:

1. Determination of exhaust air energy recovery turbine generator configuration by experimental analysis on wind turbine and exhaust air system performance.
2. Experimental analysis of the diffuser as a power augmentation device for the exhaust air energy recovery turbine generator.
3. Energy estimation of exhaust air energy recovery turbine generator.

The main aim of the project is to prove that the wind from an exhaust air system can be utilized into useful forms of energy. Moreover, the utilization of this manmade wind energy by the energy recovery wind turbine generator is aimed to give no negative effect on the performance of the exhaust air system.

II. NEED OF GENERATION OF ELECTRICITY

2.1 Wind Energy

Wind is a natural phenomenon that is caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth (Bhatia, 2014). Energy available in wind is basically the energy of large masses of air moving over the earth's sun air face. Blades of wind turbine receive this kinetic energy, which is then transformed to mechanical or electrical forms, depending on the end use. The efficiency of converting wind to other useful forms of energy greatly depends on the efficiency with which the rotor interacts with the wind stream (Mathew, 2006). Nowadays the utilization of wind energy for electricity generation has become very popular where the global installed wind power capacity is approximately 370 GW at the end of 2014, a 16% increase from the previous year ("Global Wind Energy Report: Annual Market Update 2014," 2015). Wind energy is one of the earliest sources of energy when it was utilized to propel ships and boats during ancient times. The first documented design of a wind mill dates back to 200 B.C. where the Persians used wind mills for grinding grains. At the end of the 18th century, experiments began in which windmills were used to generate electricity in the United States and Denmark. The research continues until today and wind power generation has become an icon for clean and sustainable energy generation.

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2.2 Exhaust Air System

A. 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.

Most air-conditioning systems and industrial processes generate heat that must be removed and dissipated. Water is commonly used as a heat transfer medium to remove heat from refrigerant condensers or industrial process heat exchangers. Cooling towers are commonly used to dissipate heat from water-cooled refrigeration, air conditioning systems, and industrial process systems. Cooling towers are heat removal devices used to transfer waste heat to the atmosphere; large office buildings, hospitals and schools typically install one or more cooling towers for building ventilation system.

Figure: Exhaust air outlet in Industries

III. Design Description and Methodology

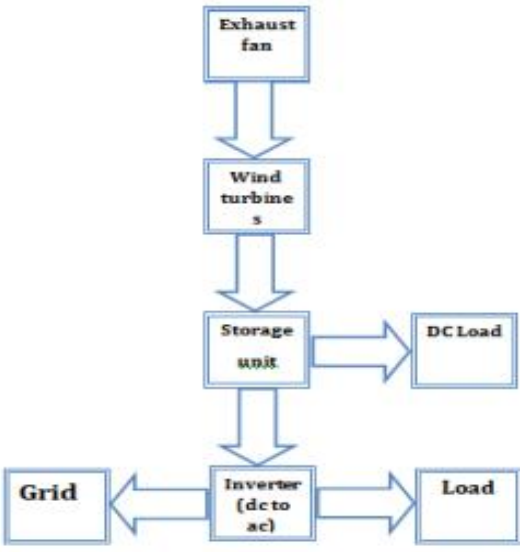

Figure: Block diagram of proposed system

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3.1 Existing System

The exhaust air energy recovery wind turbine generator is a novel idea on generating green energy by harnessing unnatural wind resources using a micro-wind generation system. The unnatural wind resources can be from Exhaust fan of industries or Restaurants ,cooling towers, air ventilation systems, humidification plants or any system that produce strong and consistent winds. However, the integration of the exhaust air energy recovery wind turbine generator is not identical for all the unnatural wind resources. This is due to different systems having different characteristics and geometry. A specific configuration has to be designed in order to recover the maximum amount of energy from the exhaust air system without any significant negative effect to the original system. In this study, the exhaust air energy recovery wind turbine generator is specifically designed.

The exhaust fan in big industries can play a seminal role in producing electrical energy which can surmount the energy demand to certain extent. The wind force from the exhaust fan can be directed towards a small windmill in front of it. The wind thrust from the exhaust fan can drive wind turbine and these wind turbines produce electricity which can be stored in storage unit. The storage unit may vary according to the production of electricity from the wind turbines. Then inverter will convert the stored dc energy into ac. This ac energy can be supplied to the load and grid.

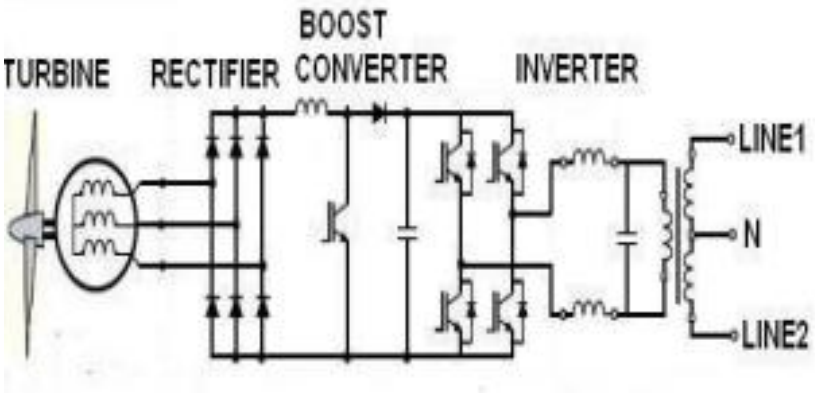

Figure: Wind generation circuit diagram

3.2 Benefits of the Energy Recovery Wind Turbine Generator

This innovative system is aimed at generating on-site clean energy by converting wasted wind energy from a cooling tower to a useful form of energy. The energy generated is predictable and continuous because the exhaust wind is readily available whenever the cooling tower is switched on. In other words, exhaust air consists of wind characteristic that is predictable and consistent. Thus, statistical analysis of wind characteristic over a period of time is not required. In addition, the turbine is expected to spin at a constant rotational speed and therefore, over speed control is not necessary because only minimum rotational speed fluctuation is experienced. For that reason, the energy generation over the lifespan of the turbine is expected to be higher.

A. Merits of Wind Energy

1. It is renewable source of energy.
2. It emits no greenhouse gases and hence nonpolluting.
3. It uses very little land
4. Fuel transportations are not required in wind energy conversion system.

3.4 Variations of Exhaust Air Energy Recovery Wind Turbine

The exhaust air energy recovery turbine generator can be installed in a number of variations. For a big size of exhaust air outlet, more than one turbine can be installed to utilize the discharged air. However, it depends on the space availability, structural strength and most importantly, it should not negatively affect the performance of the original exhaust air system.

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IV. ANALYSIS

4.1 Working Principle

The micro-generation electricity is the small-scale generation of power by individuals to meet their own needs as an alternative to the traditional centralized grid-connected power [1]. It is the subset of distributed generation which is designed for local use rather than being exported to national electric grid [2]. Moreover, it is a green and environment friendly technology and often based on the use of renewable energy and not the fossil fuels. It does not deplete the earth's natural resources and in most instances does not release carbon dioxide into the atmosphere which is currently one of the main causes of global warming and climate change [3]. The wind is one of the most used renewable energy sources for the generation of electricity due to its natural power availability [4]. The harness of wind power for electricity generation has been increasing significantly during the last decade. The wind based micro-generation is low capacity technology and its rated power output lies below 50 kW for small community, and for domestic installation, its power output is less than 3 kW [5]. Thus, owing to its low power capacity, the wind based micro-generation electricity systems also commonly known as micro-wind turbine generators or micro-wind energy conversion systems are one of the simple, clean and an inexhaustible way to exploit the wind energy at domestic or household level to fulfil their electricity needs.

Therefore, this paper presents the development of wind power based micro-generation electricity system by means of household ventilation exhaust fan. The use of exhaust fan is very common for household ventilation specifically in summer. It keeps the household environment cool at a moderate temperature by pulling the fresh air either through cracks and other air-leakage sites or through windows and throws the hot and humid air out of the house [6]. From the outside of the ventilation exhaust fan, the propelled air from inside to outside of the house can be considered as a high velocity wind source as the speed of air/wind coming out of exhaust fan is very high. When such a high wind force strikes the wind turbine, it can generate power either equal to or more than the power generated from atmospheric wind with the same size of wind turbine. Thus, this work gives the design layout and hardware prototype model of a micro-wind power generation system that produces the electricity by using this wastage wind from an exhaust fan deployed in household ventilation. The next sections of the paper are outlined as: section II gives the background and purpose of the project and section III demonstrates the theory of wind power. A description of proposed system development including system layout, air speed measurement of exhaust fan, power estimation, and system implementation and component.

4.2 Procedure for generating electricity from exhaust air

- While switch on the supply first check the inverter is in off position.
- Then Switch on the supply for exhaust fan.
- Exhaust fan will run and dynamo will start run and produced electricity is connected to charge flow converter and connected to battery.
- Battery will stores the electricity.
- Then switch off the exhaust fan supply.
- Now switch on the inverter switch.
- AC Load has given.

4.3 Construction

The unnatural wind resources can be from Exhaust fan of industries or Restaurants ,cooling towers, air ventilation systems, humidification plants or any system that produce strong and consistent winds. However, the integration of the exhaust air energy recovery wind turbine generator is not identical for all the unnatural wind resources. A specific configuration has to be designed in order to recover the maximum amount of energy from the exhaust air system without any significant negative effect to the original system. In this study, the exhaust air energy recovery wind turbine generator is specifically designed.

4.4 Layout of System

The layout of the proposed wind power based micro-generation electricity system using an exhaust fan is shown in Fig. The system is equipped with an exhaust fan as a wind power source, a horizontal axis micro-wind turbine, a DC generator, a charge controller and a battery. The micro-wind turbine transforms the wastage wind power of exhaust fan into mechanical

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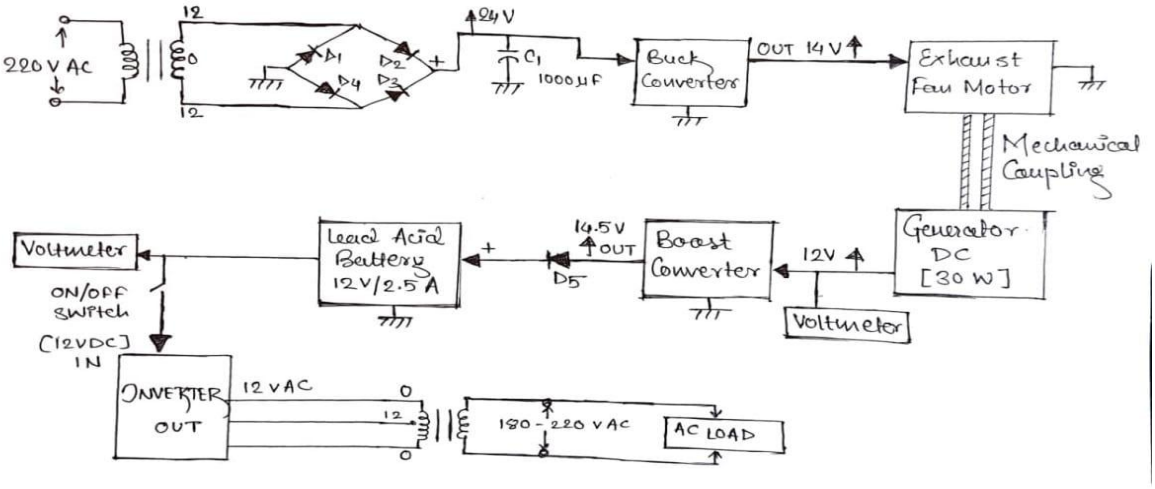
power. The produced mechanical power by micro-wind turbine is then used to drive a DC generator that converts the mechanical power into electrical power. The generated electrical power is then used to charge the battery through a charge controller that manages the charging of the battery. The stored energy in battery is used at any time to power the lightening or other suitable load.

4.5 Circuit Diagram



4.6 Various Components

1. Exhaust Fan
2. Transformer
3. Dynamo Generator
4. Inverter
5. Battery

4.7 Advantages

1. Wasted wind force from the exhaust fan can be utilized to generated electrical power.
2. It will surmount the present day problems of wind energy conversion, that is, it can provide a constant source of wind and the wind fluctuations can be surmounted.
3. It will not be affected by geographical locations and hence can be implemented in many big industries. It will be plentiful, renewable and eco-friendly source of energy.
4. The stored energy can be used when main supply is cut off. Hence, can be used as an Emergency unit.
5. It is renewable source of energy.
6. It emits no greenhouse gases and hence non-polluting.
7. It uses very little land
8. Fuel transportations are not required in wind energy conversion system.

4.8 Disadvantages

1. Owing to its irregularity, the wind energy needs storage.
2. Wind energy conversion is noisy in operation.
3. Maintenance is required.
4. Cost is relatively high.

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V. CONCLUSION

It is observed that the wind from the exhaust can work as a very good source of electricity. The wind speed is sometimes more than the natural air speed and hence can generate even more electrical power than what is produced from natural air. As it is discussed earlier that wind from exhaust fan may get dispersed after some time, there should be some kind of directors/connectors that will guide the wind from the exhaust fan directly to wind turbines without getting the average speed of the wind decreased as the velocity of the wind is most important factor in the system. The wasted wind from exhaust fan can be efficaciously utilized to generate power if proper implementations are done.

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