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EMERGENCY ENERGY HARVESTING: HARNESSING INDUSTRIAL EXHAUST FANS FOR POWER GENERATION AND CONSERVATION.

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I. ABSTRACT: The world's energy consumption has grown exponentially in recent years. As energy demand rises, traditional energy sources like nuclear and fossil fuels face immense strain. As a result, continuous usage of these energy sources causes a shortage of fossil fuels. This has led to many investigations into alternative energy sources, such as wind, hydro, thermal, etc. The topic of this study is wind energy out of all of them. Although wind energy has many potential and benefits, its availability, unpredictability, and geographic limitations limit its use. Our main objective is to propose a solution that can overcome these obstacles and make the most of wind energy. Exhaust fans, commonly used in industries and households to remove hot air and humidity during production, cooking, bathing, and other activities, provide a consistent stream of high-velocity air. This makes them a valuable source of wind energy. This document elaborates on the creation of a micro-generation electrical system that capitalizes on the wind energy, typically wasted by an exhaust fan, to drive a micro-wind turbine and produce electricity. This document offers an exhaustive review of the system, encompassing aspects such as its structural blueprint, system characterization, and the execution of its hardware components.It also validates the system's operation by considering various parameters and installation factors. In the context of India, where over 70% of the population uses exhaust fans for industrial and household ventilation, the proposed system is particularly beneficial as it allows for the storage of energy for later use.

Keywords — Wind power, exhaust fan, wind turbine, storage, air,industries, household, micro-generation.

II. INTRODUCTION: Economic expansion and energy utilization are closely intertwined. While developed nations are currently the main energy consumers globally, it is anticipated that developing countries will be the primary drivers of future demand due to their emerging populations, economic growth, and enhancements in living standards. As per the International Energy Agency, the global energy consumption across both the developed and the developing nations is forecasted to at least will double by 2040 ("The Outlook for Energy: A view to 2040," 2018). At present, the world's energy generation is heavily dependent on fossil fuels such as coal, crude oil, and natural gas. This dependency has given rise to issues like climate change and exhaustion of oil reserves, leading to a surge in oil prices.Over the last two decades, researchers have been motivated to investigate and develop alternative energy-producing technologies due to the increasing demand for electricity and rising electricity costs around the world. Wind energy serves as a viable alternative, standing as one of the most ancient methods of power generation and playing a substantial role in the production of renewable energy.Exhaust fans, which are commonly used in companies and homes to remove hot air and humidity during production, cooking, bathing, and other activities, provide a continuous stream of high-velocity air, making them an excellent generator of wind energy.

To tackle the problem of energy demand without harming the environment, it is crucial to harness energy from renewable sources. Renewable energy resources hold the capacity to fulfill global energy requirements multiple times over, positioning them as a hopeful resolution. However, their development is still in progress and has not yet reached full maturity.Therefore, it is imperative that researchers and innovators come up with the best possible solutions for clean energy. This paper outlines the creation of a micro-generation electric system that utilizes the wind power wasted by an exhaust fan to However, the majority of current renewable energy generation technologies are still in their early stages of power a micro-wind turbine and generate electricity. Micro-generation of electricity denotes the decentralized production of small-scale power by individuals to fulfill their energy requirements, presenting an alternative to traditional centralized grid-connected power.It is a subset of distributed generation, designed for local use rather than export to the national electric grid. This technology is environmentally friendly, often relying on renewable energy sources instead of fossil fuels, thus preserving the earth's natural resources and reducing carbon dioxide emissions, a major contributor to global warming and climate change.

The paper offers an extensive examination of the system, encompassing its design layout, system description, and hardware implementation.The system is evaluated by considering various factors and installation parameters. The proposed system, which utilizes wind power and exhaust fans for industrial and household ventilation, is particularly beneficial in India, where over 70% of the population relies on these fans. This paper elaborates on the creation of a micro-generation electrical system that harnesses the energy produced by these fans.These fans, which are commonly used to maintain a moderate temperature by drawing in fresh air through cracks or windows and expelling hot and humid air, can create a high-velocity wind source when used in conjunction with the system. This high wind force can generate power equal to or greater than that generated by a wind turbine of the same size when it hits the turbine.

III. THEORY OF WIND POWER AND WIND TURBINE: When windmills were first used to grind bread or pump water back in antiquity, they represented a significant source of free energy. This tendency changed to the production of electrical energy with the invention of electricity at the end of the nineteenth century, and the construction of contemporary wind turbines employing traditional windmill technology to produce electricity was started. The mathematical expression for wind power is

$$p_w = \frac{1}{2}\rho A v^3$$

In this context:

- Pw represents the power contained in the wind, measured in watts (W),
- A denotes the cross-sectional area through which the wind travels, measured in square meters (m^2),
- V is the velocity of the wind perpendicular to A,measured in meters per second (m/s), and
- ρ is the density of the air, measured in kilograms per cubic meter (kg/m^3).

Wind turbines are broadly classified into two main types: horizontal-axis wind turbines (HAWT) and vertical-axis wind turbines (VAWT). HAWT's are further segmented into single-blade, two-blade, three-blade, and other configurations, while VAWTs include S-shaped, Darrieus, H-rotor, and helix-shaped designs. In this project, a vertical-axis wind turbine similar to the S-shaped was selected due to prevailing market conditions. This choice resulted in a modest power output, ranging approximately between 10 and 40 watts.

Fig. 1. Wind Turbine (S-shaped).

IV. THEORY OF EXHUAST FAN: An exhaust fan is designed to eliminate stale air, moisture, and unwanted odors from a particular area, particularly in homes and offices. It pulls air from the room and expels it outside to

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enhance indoor air quality. The fundamental principle of an exhaust fan involves drawing in the "bad" air within your living space and expelling it (exhausting it) to the outside. This expelled air is then replaced with fresh air. The concept is relatively straightforward. When an exhaust fan is activated, the fan blades begin to rotate, creating a region of low pressure behind them. As the fan blades revolve, they draw air from the surrounding area in the direction of the blades.

For this project, we have employed a 12-inch exhaust fan as a wind source, with a power input rating of 230V at 50Hz, an output power rating of 85W, and a rated speed of 2200 rpm. It technical specifications as shown in table 1.

Fig. 2. Exhaust Fan.

TABLE I. TECHNICAL SPECIFICATIONS

Sweep Area (Diameter)		Rated Volt	Power	Speed	Air Delivery
Inch	mm	VAC	Watt	RPM	Ft^3/min
12”	300	230	85	2200	1200

V. DESIGN AND IMPLEMENTATION OF PROPOSED SYSTEM:

A. Layout of System:

The Layout depicts the proposed wind-powered microgeneration system with an exhaust fan in Fig-3. The system is fitted with an exhaust fan as a power source. The wind power system comprises a vertical axis micro-wind turbine, a DC generator, a charge controller, and a battery. The compact wind turbine harnesses the otherwise wasted wind energy from exhaust fans, transforming it into mechanical power. This mechanical power is then employed to operate a DC generator, which in turn converts it into electrical power.The produced electricity powers a charge controller, which supervises the battery's charging process. The battery's stored energy may be used to power illumination or other loads as needed.

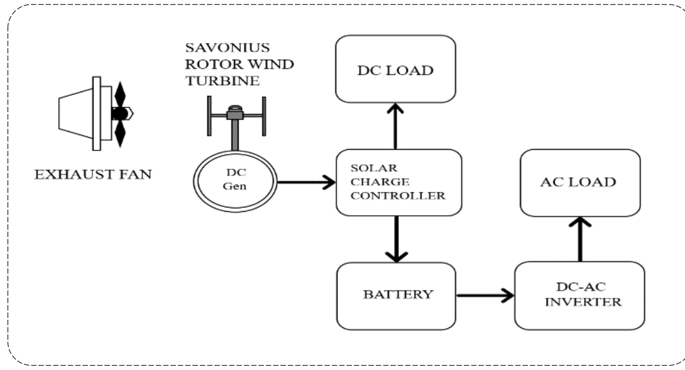

Fig. 3. Layout of the system.

B. System Implementation and Component Description:

In the process of electricity generation, either a direct current (DC) or an alternating current (AC) generator is employed to convert the mechanical energy harnessed by the rotor of the wind turbine into electrical power.The size and selection of a generator depends mainly on the expected power of the wind system, the supply system type (AC/DC), the cost and the availability of generating capacity in the market. As in the case of the proposed system, electricity generation is mainly for charging the DC battery to power the AC load by through DC-AC Inverter such as Illumination when needed. Therefore, in this project, a DC generator has been proposed. DC generator with a rated power output of 230V 40-220Watts is chosen due to the fact that the capacity of this generator is significantly higher than that of the micro-wind turbine. Finding market-available generating capacity that meets the predicted power is challenging in proposed system. Rotating DC machines typically have an efficiency of 80–85 percent. To compute electrical power in this project, consider the DC generator's reduced efficiency of 80% due to a mismatch between needed and available producing capacity. The suggested micro-wind system generates approximately 10-15 Watts of electrical power (Pe), as calculated below.

$$P_e = 0.8 \times P_m$$

The suggested system combines a DC generator and a three-bladed vertical axis micro-wind turbine (S-shaped).
The turbine-generator set is mounted on the front face of an exhaust fan using a supporting structure at a distance of 0.5 - 1.0 feet. Figure.8 shows the hardware prototype for this implementation. The DC generator's output is routed to a 12V, 7 Ah battery via a Solar charge controller. While Figure.5 illustrates the battery that stores the energy produced by the wind power system, which is based on an exhaust fan. The energy output from the battery is directed

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to a DC-AC inverter to provide power to the load.For instance, output of solar charge controller is given to load as well.

Fig. 4. 230V DC Generator**.**

Fig. 5. 12V Battery.

Fig. 6. DC – AC Inverter.

Fig. 7. Solar Charge Controller.

VI. TECHNICAL PARAMETERS OF THE PROPOSED SYSTEM: To assess the technical performance of the proposed system, the constructed prototype (shown in Figure 8) was put through experimental testing. The testing was conducted at the Electrical Projects Laboratory, situated within the Electrical and Electronics Engineering Department at Vignan's Institute of Information Technology in Duvvada, Visakhapatnam.The outcomes of these tests are presented in Table II.

TABLE II. SYSTEM VALIDATION RESULTS

Parameter	**Value**	**Unit**
Wind speed at 1.0 foot distance	8.0	m/s
DC generator output at the time of testing	5.6	V
Charging voltage at the time of testing	2.9	V
Charging current at the time of testing	30	mA

The system validation results can be summarized as follows: The micro-wind power conversion system was tested and validated under specific conditions, yeilding promising results. At a distance of 1.0 foot from the source, the wind speed was measured at 8.0 m/s, indicating a robust airflow suitable for energy conversion. The DC generator's output during testing was 5.6V, which demonstrates its effective operation in converting wind energy into electrical energy. Furthermore, the charging voltage and current at the time of testing were 2.9V and 30mA, respectively, confirming the system's capability to charge the battery storage unit efficiently. The system exhibits a strong potential for harnessing wind energy from exhaust fans, as evidenced by the satisfactory electrical outputs during the validation process. This innovative approach could contribute significantly to sustainable energy solutions by capturing and utilizing wind energy that would otherwise be lost.

VII. CONCLUSION: Exhaust fans, both in industrial and residential settings, are a potent source of wind energy. The velocity of air from these fans often surpasses that of natural wind, potentially leading to the production of more electrical power than that derived from natural wind. This paper introduces a compact wind energy conversion system, integrated with a battery storage unit, designed to harness the otherwise wasted wind energy radiating from ventilation exhausts.

The proposed system was successfully implemented and evaluated at the Department of Electrical and Electronics Engineering, Vignan's Institute of Information Technology, Duvvada, Visakhapatnam. Even though a DC generator with a higher rating than necessary was used due to its unavailability in the market, the system operated efficiently and produced encouraging results, signifying the accomplishment of the project.

Moreover, the effectiveness of this wind energy-based micro-generation system motivates manufacturers of exhaust fans in India to contemplate the commercial production of this system as a component of the exhaust fan, aiding in energy preservation. Consequently, the proposed system is anticipated to be advantageous for both its manufacturers and its users.

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