

# Generation of Electricity from Turbo-Ventilator

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**Abstract—** In this world of depleting resources, renewable energy plays an important role. Wind energy is one of the major renewable energy sources. In this paper we intend to study and review various research papers on generating electricity from wind energy using turbo ventilators. This method is economical and feasible by applying various electrical and mechanical techniques. In this paper we also intend to improve the efficiency of the system by using various materials for the fabrication of turbo ventilators. We have reviewed the papers on this topic published by various authors. We have compared their designs and concluded into an efficient model by combining all the designs into one. Turbo ventilators are widely used on industrial sheds and warehouses for natural ventilation without consuming electrical energy. They operate on the principle of wind velocity and stack effect, where hot air rises and rotates the turbine blades. The present project explores the potential of utilizing this otherwise wasted rotational energy of turbo ventilators for generating electricity. The working concept involves coupling the rotating shaft of a turbo ventilator with a low-rpm DC generator or alternator through a suitable gear mechanism. As the ventilator rotates due to wind or thermal convection, mechanical energy is converted into electrical energy. The output is generally low voltage DC, which can be stored in batteries using a charging circuit and later used for small-scale applications like LED lighting, mobile charging, or powering sensors. The study includes design considerations such as selection of generator, gear ratio optimization, mounting arrangement, and electrical load calculation. Experimental results show that a standard 24-inch turbo ventilator can generate 5V–12V under moderate wind speeds of 3–6 m/s, producing power in the range of 3–10 W. Though the output is small, it is continuous and free of cost, making it suitable for sustainable energy harvesting. In conclusion, electricity generation from turbo ventilators provides a cost-effective and eco-friendly solution for auxiliary power needs in industries. It utilizes existing infrastructure, requires low maintenance, and contributes to green energy initiatives. The concept can be further improved by using efficient generators, MPPT circuits, and multiple units in parallel for higher output.

**Keywords—** Turbo Ventilator, Roof Turbine Ventilator, Wind Energy Harvesting, Renewable Energy, Electricity Generation, Vertical Axis Turbine

## I. INTRODUCTION

Energy generation from sustainable sources has become a major global focus due to the growing concerns over environmental pollution, rising energy demand, and depletion of fossil fuel resources. Among the various renewable energy systems, harvesting energy from naturally available wind through cost-effective mechanisms has attracted key interest. One such innovative approach is the generation of electricity using a turbo ventilator. Traditionally, turbo ventilators are widely installed on industrial sheds, warehouses, and residential buildings to enhance natural ventilation by extracting hot and stale air from indoors. These ventilators operate solely based on wind flow and pressure differences, without requiring any external power source. By integrating a small electrical generator with the rotational motion of the ventilator, the device can serve a dual purpose—ventilation and clean energy generation.

Turbo ventilator-based electricity generation relies on the aerodynamic design of the ventilator fins, which rotate when exposed to wind or rising hot air inside buildings. This rotational mechanical energy can be converted into electrical energy using permanent magnet DC generators or alternators coupled to the ventilator shaft. The amount of electricity generated depends on wind speed, ventilator size, mechanical design, and generator efficiency. Even though the power output may be relatively small compared to large-scale wind turbines, it proves highly beneficial for powering low-energy devices such as LED lights, sensors, small electronic appliances, and emergency lighting systems in remote or urban locations.

This concept contributes significantly to energy conservation by utilizing existing roof ventilators that would otherwise serve only one function. It promotes green building initiatives and helps industries reduce utility bills while improving indoor air quality. Additionally, the system requires minimal maintenance, produces zero emissions, and can operate continuously as long as air movement is present. With

advancements in lightweight materials, improved blade design, and smart energy storage systems, turbo ventilator-based electricity generation has strong potential for future development.

### Applications of Wind Energy in India

Wind energy is one of the fastest-growing renewable energy sources in India due to its abundance, sustainability, and eco-friendly nature. The country has a long coastline and several high-wind potential regions, making wind power highly suitable for electricity generation. Wind energy plays a crucial role in reducing dependence on fossil fuels and supporting clean energy initiatives. The major applications of wind energy in India include:

#### Electricity Generation for Grid Supply

The primary application of wind energy is the large-scale production of electricity. Wind farms are established in high wind potential states like Tamil Nadu, Gujarat, Maharashtra, Karnataka, and Rajasthan. The generated power is transmitted to the national electricity grid, contributing significantly to the country's total energy production.

#### Rural and Remote Area Electrification

Wind power systems are deployed in remote or off-grid locations where conventional electricity infrastructure is difficult or expensive to install. Small wind turbines provide energy to rural households, schools, health centers, and communication stations.

#### Hybrid Renewable Energy Systems

Wind energy is often combined with solar power to form hybrid systems. This ensures stable power generation throughout the day and varying seasons. Hybrid systems are used for:

- Street lighting
- Agricultural water pumping
- Telecom towers and remote monitoring stations

#### Industrial and Commercial Power Needs

Industries and commercial buildings are installing captive wind turbines to meet internal electricity demand. This helps lower energy costs and supports green energy certification.

#### Water Pumping for Agriculture

Wind-powered water pumping systems are used for irrigation, drinking water supply in rural areas, and livestock watering. These systems eliminate the need for diesel pumps and improve agricultural sustainability.

### Offshore Wind Power Development

India is expanding into offshore wind projects, especially along coastal regions like Gujarat and Tamil Nadu, to tap into stronger and more consistent sea winds.

### Job Creation and Economic Development

Wind energy projects create jobs in manufacturing, installation, operation, and maintenance, promoting industrial growth and technological development in the renewable sector.

### Power generation

Turbo ventilators are typically mounted on rooftops and rotate due to the flow of wind or hot air rising from inside a building. By connecting a small generator to the rotating shaft of the ventilator, mechanical rotation can be converted into electrical power. The output power mainly depends on factors such as:

- Wind speed
- Size and design of the ventilator blades
- Efficiency of the generator
- Bearing and frictional losses
- Continuous airflow availability

In typical real-world conditions, a roof-mounted turbo ventilator rotates at speeds ranging from 150 to 700 rpm, depending on wind speed. When a suitable permanent magnet DC generator (PMDC) or small alternator is attached, it can generate practical electrical power.

For example:

- At low wind speeds (2–4 m/s) → around 1–3 watts
- At moderate wind speeds (5–7 m/s) → around 3–10 watts
- At high wind speeds (8–12 m/s) → up to 10–20 watts or more (depending on design) This level of power is sufficient for:
  - LED lighting systems
  - Emergency lights in industrial sheds
  - Battery charging (mobile gadgets, sensors, etc.)
  - Powering low-consumption devices like exhaust fans or security cameras

Even though the power generation is small compared to standard wind turbines, it offers dual benefits providing natural ventilation while generating renewable electricity at no additional running cost. This makes it a very effective energy-harvesting solution in buildings where turbo ventilators are already installed.

### Industrial Application

The concept of integrating a power-generating mechanism with turbo ventilators has strong potential in industrial sectors,

where large buildings and factories frequently rely on natural ventilation systems. This technology not only improves indoor air quality but also enhances energy efficiency by harnessing wind energy for useful electrical power. Major industrial applications include:

#### Power Supply for Lighting Systems

Industries can utilize the generated electricity to power:

- LED lights inside warehouses and workshops
- Emergency exit lighting
- Security lights around industrial premises

This helps reduce dependency on grid supply and lowers electricity bills.

#### Operation of Monitoring and Control Devices

Small electronic equipment such as:

- Temperature and humidity sensors
- Industrial wireless monitoring systems

#### Charging of Backup Batteries

The produced electricity can charge:

- Battery storage units
- Emergency inverter systems

This ensures uninterrupted operation during power outages.  
Support for Green Building Initiatives

#### Industries adopting this technology gain

- Improved sustainability scores
- Reduced carbon emissions

#### Reduction of Peak Load Demand

As ventilator-generated electricity supports auxiliary loads, industries experience:

- Reduced peak energy usage
- Lower operational costs
- Off-Grid and Remote Industrial Facilities

Factories in remote areas without reliable electricity supply can implement this system

- Basic power needs
- Ventilation and lighting
- Enhancing working condition

## II. TURBO VENTILATOR

A turbo ventilator is a wind-driven exhaust device commonly installed on rooftops to improve natural ventilation inside buildings. It consists of a light-weight, dome-shaped rotating

turbine with multiple curved fins. When wind blows over the ventilator or when warm air rises from inside the building, the fins rotate and create suction. This suction effect pulls out hot, stale air, smoke, humidity, and pollutants from indoors and allows fresh air to flow inside through natural openings.

#### Key Features of Turbo Ventilator

- Works without electricity — fully wind and thermal powered
- Provides continuous ventilation
- Made of aluminum or stainless steel, ensuring rust resistance
- Designed to rotate even at low wind speeds
- Suitable for factories, warehouses, workshops, homes, and schools

#### Components

- Turbine head (rotating part)
- Curved fins (extract air)
- Shaft and bearings
- Ventilator base/neck
- Weatherproof cap/hood

#### How it Works

- Wind strikes the fins or hot air moves upward inside the building.
- Turbine rotates due to pressure difference.
- Rotation causes suction → pulls indoor air out.
- Fresh outdoor air enters through doors, windows, or vents.
- Ventilation continues as long as wind or airflow exists.

#### Functions

- Removes heat and trapped hot air
- Reduces moisture and prevents mold
- Removes dust, fumes, gases, and odors
- Improves indoor air quality
- Enhances worker comfort and safety

#### Advantages

- Zero electricity consumption → energy saving
- Low maintenance and long service life
- Eco-friendly and noiseless operation
- Prevents heat buildup in roof spaces
- Suitable for all climates

### III. TURBO VENTILATOR + ELECTRICITY GENERATION

By attaching a generator to the ventilator shaft, the rotation can be converted into usable electrical energy — useful for LEDs, sensors, and small devices.



Fig 1 Ventilator



Fig 2 Roof Ventilators

#### Generator

A generator is a machine that converts mechanical energy into electrical energy using the principle of electromagnetic induction. In simple terms, when a conductor (like a coil of wire) moves inside a magnetic field, it generates electricity. Generators are widely used in power stations, industries, vehicles, and renewable energy systems.

Working Principle

Generators work based on Faraday's Law of Electromagnetic Induction:

“Whenever a conductor cuts a magnetic field, an electromotive force (EMF) is

Mechanical rotation → rotates coil or magnet → induces voltage → electricity flows through load.

#### Main Components

- Rotor / Armature → rotating part that produces mechanical motion
- Stator → stationary part containing magnetic field coils
- Prime mover → provides mechanical energy (wind, steam turbine, diesel engine.)
- Slip rings / Commutator → helps transfer current from rotor
- Bearings → smooth rotation
- Shaft → connects rotor to prime mover

#### Based on Excitation

- Permanent Magnet Generator (PMG)
- Self-excited generator
- Separately excited generator

#### Applications

- Power generation plants
- Backup power supply (DG sets)
- Renewable energy systems (wind, hydro, turbo ventilator projects)
- Vehicles for battery charging
- Portable devices and emergency systems

#### Using Generator in Turbo Ventilator System

Turbo ventilator rotation → rotates generator → electrical energy generated Recommended generator type:

- Permanent Magnet DC (PMDC) generator
- Small bicycle dynamo style generators
- Low RPM high-torque alternators (if geared)

#### Advantages of Using a Generator

- Reliable and consistent electrical output
- Long lifespan and durable
- Can operate in various environments

#### Specifications of Generator

Parameter Specification

Type	Permanent Magnet DC (PMDC) Generator Rated	
Voltage Output	12 V DC (typical range 6–24 V based on model)	
Rated Power Output	10–50 W (depending on ventilator speed and wind conditions)	
Rated Speed (RPM)	300–1500 RPM	
Rated Current	1– 4 A	
Starting Torque	Low, designed for small prime movers like ventilators	
Efficiency	60–80% (approx.)	
Magnet Type	Neodymium permanent magnet	
Shaft Diameter	6–10 mm (compatible with ventilator shaft)	
Bearing Type	Double-sealed ball bearings for smooth rotation	
Weight	0.5–1.2 kg (lightweight for rooftop installation)	
Cooling Method	Natural air-cooled	
Mounting Method	Bracket or flange mounting	
Output Terminals	Two-wire DC output	
Material	Aluminum/steel housing with corrosion protection	
Operating Temperature	10°C to 60°C	
Protection	IP54 or above (dust & moderate water resistance)	

rotational motion is converted into another form of useful work— often for energy generation or speed regulation.

Turbo ventilators are usually wind-driven roof ventilators with spinning fins that exhaust hot air naturally. In a standard ventilator, no pulley is used because it rotates freely with wind. But when converting the rotation into electricity or integrating with a mechanical drive, a pulley becomes essential.

**Role of Pulley in Turbo Ventilator Energy System**

A pulley helps:

- Transfer rotation from ventilator shaft to a generator
- Increase rotational speed by using a step-up pulley ratio
- Reduce load on ventilator to keep it spinning freely
- Provide mechanical advantage and smooth power transmission

**Pulley Arrangement**

Typically includes:

- Small Pulley on generator shaft
  - Rotates faster to generate more electricity
  - Large Pulley on turbo ventilator shaft
  - Converts low-speed wind rotation into high-speed output
- A belt connects both pulleys.

Generator speed =  $50 \times 6 = 300$  RPM or more  
 (Still may require further gearing for standard generators ~1000–1500 RPM)

**Benefits**

- Enables power generation from wind ventilators
- Improves speed and energy output
- Adds minimal weight if designed properly

**Challenges**

- Increased load may reduce airflow performance
- Frictional losses in belt drive
- Requires precise balancing to avoid vibration
- Limited power output in low wind

**Applications**

- Rooftop renewable energy systems
- Smart ventilation with energy recovery
- Research projects on small-scale green power

**DC GENERATOR**

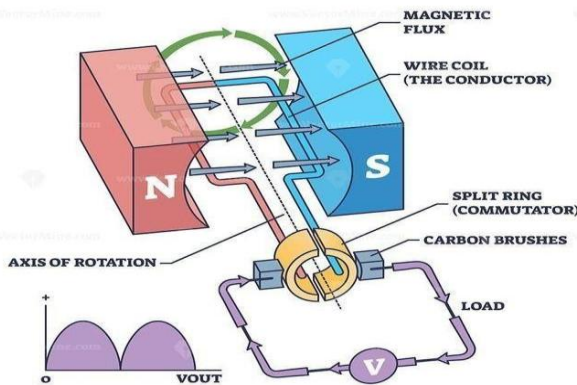


Fig 3 Structure of DC Generator



Fig 4 DC Generator

**Pulley**

A turbo ventilator pulley is a mechanical component used in some modified or hybrid turbo ventilator systems where



Fig 5 Pulley

### Research and Development

The concept of generating electricity from turbo ventilators has emerged from the growing need for sustainable energy solutions and green building technologies. Traditionally, turbo ventilators have been used only for ventilation purposes in warehouses, industrial sheds, schools, and residential buildings. They operate without external energy by utilizing natural wind or temperature-induced air movement. Research in this field began with the idea of harnessing the unused rotational mechanical energy of these ventilators to produce small-scale electrical power.

In the early development phase, studies focused on integrating small permanent magnet generators with the ventilator shaft to convert mechanical energy into electrical power. Experimental prototypes demonstrated that even at low wind speeds, a measurable amount of electrical output could be generated to power energy-efficient devices such as LED lights or monitoring systems. Later research improved coupling mechanisms to minimize friction and gear losses, allowing the ventilator to rotate smoothly without reducing ventilation performance.

Developments in aerodynamics have played a crucial role in enhancing efficiency. Blade shape optimization, lightweight aluminum and polymer fins, and advanced bearing systems have been researched to achieve higher rotational speeds under minimal airflow. Additionally, computational fluid dynamics (CFD) has been used to analyze airflow and predict performance under various environmental conditions.

Another major research area includes energy storage and power conditioning. Systems such as DC-DC converters, small rechargeable batteries, and supercapacitors have been incorporated to store the fluctuating power generated due to

varying wind speed. Smart controllers have been developed to improve reliability, stabilize voltage output, and allow hybrid integration with solar panels or grid supply.

Recent advancements focus on increasing power efficiency using magnetic levitation (maglev) supports to reduce frictional losses. Researchers are also exploring cost-effective designs for large-scale industrial deployment and standalone systems for remote areas where grid access is limited. Overall, continuous research and innovation in materials, aerodynamics, generator technology, and hybrid renewable integration are pushing turbo-ventilator electricity generation toward greater commercial applicability.

## IV. LITERATURE REVIEW

Sirichai Dangeam et al., (2011) investigated energy recovery using exhaust air from central air conditioning systems in their study titled "Energy recovery by using exhaust air energy of central air conditioning system". The researchers designed a system where a roof ventilator was coupled with a DC generator to convert kinetic energy of waste exhaust airflow into electrical energy. Their experiments showed that continuous exhaust air from HVAC systems has enough velocity to rotate the ventilator and produce usable power for small-scale applications like battery charging and lighting.

Akshay S. Zagade, Rahul P. Sadagar et al., (2015) carried out a study titled "Generation of Electricity by Using Roof Top Ventilator" to explore renewable energy harvesting from natural wind. Their work focused on modifying a conventional roof top turbo ventilator by attaching a permanent magnet DC generator to the central shaft of the ventilator. When natural wind rotates the ventilator blades, the coupled generator converts mechanical energy into electrical energy without any fuel consumption.

Dr. P. M. Ghanegaonkar, Mr. Ganesh K. Jadhav et al., (2015) presented a study on "Power Generation from Roof Top Ventilator" focusing on renewable energy utilization in buildings. The authors modified a standard turbo ventilator by integrating a low RPM permanent magnet DC generator with a gear mechanism to increase rotational speed. Their design aimed to convert wind-induced rotation of the ventilator into electrical energy for domestic applications. Test results showed that the system could produce sufficient voltage to charge a 12V battery and operate small DC loads like LED lights and fans.

I Daut, C. Shatri, M. Irwanto, A. N. Syafawati, and S. S. Shema (2011) presented a study titled "Power Generation Roof Ventilator" at the International Conference on Environment and

Industrial Innovation. The research explored the concept of converting the rotational energy of a roof turbo ventilator into electrical energy using a DC generator.

Sonali J. Naiknaware, Pravin S. Phutane, and co-authors (2016) presented a review on “Micro-generation of Electricity Using Rooftop Turbine Ventilator (R.T.V)” in IJAREEIE. The study focused on utilizing free wind energy from roof-mounted turbo ventilators to drive small DC generators for power generation. Their work analyzed the feasibility of converting rotational motion of the ventilator into electrical energy suitable for low-power applications. The authors highlighted that the system is cost-effective, requires minimal maintenance, and can contribute to sustainable energy solutions in industries. They emphasized that although output is limited, it is useful for auxiliary loads like LED lighting and battery charging. The review concluded that R.T.V-based micro-generation is a promising approach for green energy harvesting from existing ventilation infrastructure.

Ming Chun Hsieh, David King Jair, and Huann Ming Chou (2013) developed “A New Type Rooftop Ventilator Turbine” published in Engineering journal. Their research focused on integrating an Axial-Flux Permanent Magnet (AFPM) coreless generator with a rooftop ventilator for renewable power generation. The study emphasized improving energy conversion efficiency by reducing cogging torque and optimizing the ventilator blade design. They proposed that the modified ventilator turbine could harness low wind speeds effectively and serve as a micro-power source for buildings. The work contributed to advancing ventilator-based energy harvesting by introducing generator design innovations for better performance under variable wind conditions.

Chonmapat Torasaa, Nichanant Sermsrib, and co-authors (2016) designed and tested a roof ventilator for electricity generation using a DC generator integrated into the ventilation ball. Their system placed the generator close to the axis and used a 1:4 gear ratio between the ventilator ball and the generator rotor to increase rotational speed under wind flow. Since the raw output voltage from the generator was insufficient for battery charging, they added a DC step-up converter using a LM555 Timer IC in astable mode to create a square wave, stepped up via transformer, and rectified with a bridge diode. The study focused on wind energy as a clean renewable source to replace fossil fuels and reduce pollution. Their work demonstrated that existing roof ventilators can be modified for micro-power generation with suitable electronic conditioning. This research provides a practical framework for low-cost energy harvesting in residential and industrial buildings.

### Objectives

- To utilize the rotational motion of an existing turbo ventilator for generating clean and renewable electrical energy..
- To evaluate the performance of the system under different wind speeds and environmental conditions.

## V. METHODOLOGY

The methodology adopted for generating electricity from a turbo ventilator involves a systematic process starting from design analysis to experimental validation. The following steps outline the complete procedure:

### Problem Identification and Objective Setting

- Identify the limitation of traditional turbo ventilators which rotate freely without capturing useful energy.
- Define project objectives: integration of a generator with turbo ventilator without compromising ventilation performance.

### Conceptual Design

- Evaluate the mechanical power available from rotational motion of the turbo ventilator.
- Select a suitable method to convert rotational energy into electrical power (e.g., mini permanent magnet generator).
- Sketch mechanical layouts for generator mounting and coupling.

### Component Selection

- Turbo Ventilator (Roof-mounted type, typically stainless steel or aluminum)
- Generator (DC or PMG, 12/24V output depending on requirement)
- Mechanical Coupling Shaft or Gear System
- Bearings and Support Frame
- Rectifier and Charge Controller (if charging battery)
- Wiring and Load (LEDs, small DC appliances)

### Mechanical Integration

- Install shaft extension from ventilator turbine to generator.
- Use flexible/gear coupling to ensure smooth transmission of torque.
- Check balance to reduce vibration and maintain free ventilation.

### Electrical System Development

- Connect generator output to rectifier to convert AC to DC (if required).
- Integrate charge controller to regulate voltage.

- Provide battery storage or direct load connection depending on power demand.

**Experimental Setup and Testing**

- Install the modified ventilator on a rooftop exposed to natural wind.
- Measure key performance data using instruments:
- Test under varying wind conditions and record output.

**Performance Evaluation**

- Calculate power output using formula
- Determine efficiency of conversion from mechanical to electrical energy.
- Compare performance with and without load.
- Analyze ventilation effectiveness to ensure airflow is not reduced significantly

**Safety and Reliability Assessment**

- Check structural stability and weather resistance.
- Ensure overcharging protection and electrical insulation.
- Evaluate long-term operation with minimal maintenance.

**Data Analysis and Optimization**

- Study relationships between wind speed, RPM, and electrical output.
- Optimize generator size, gear ratio, and bearing type for maximum power.
- Suggest design improvements for higher efficiency.

**Flow Chart**

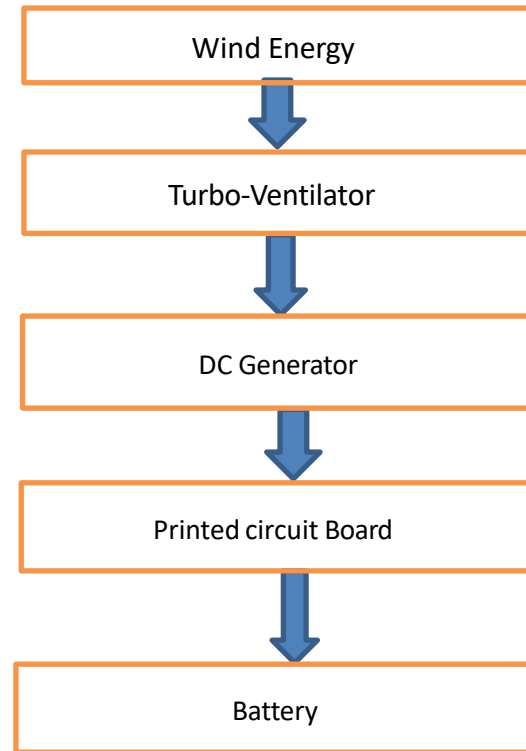


Fig 7 Flow Chart

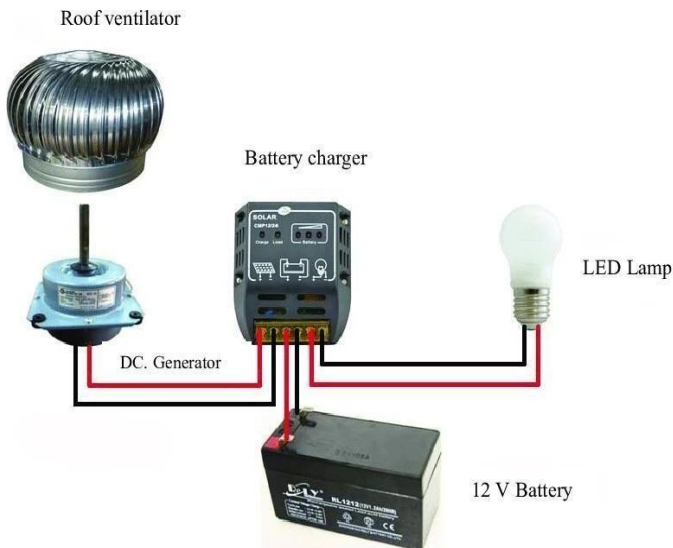


Fig 6 Working Diagram

**Electricity Generation**

AC generators have the capability to produce DC power through the use of rectification, which can be achieved electronically using diodes that allow current flow in one direction. For instance, the alternator in an automobile is an AC generator that utilizes a set of diodes to rectify its output. Similarly, small residential wind turbines, which employ AC generators, often employ rectification techniques to convert the output into DC power. By utilizing DC power from the wind turbine, it eliminates the necessity of regulating its speed to generate power at 60 Hz and enables the turbine to operate at the most efficient speed for power production. Although we do not possess a generator for demonstration purposes in the classroom due to their large size and cost, we do have several small, affordable electric motors available. These electric motors, as they operate in reverse, provide valuable insights into the functioning of generators.

### **Advantages**

#### **Dual Functionality**

It performs both natural ventilation and electricity generation simultaneously, making the system multifunctional.

#### **Utilization of Available Resource**

Makes use of freely available wind energy that is already driving the turbo ventilator, reducing energy wastage.

#### **Renewable and Sustainable Energy Source**

No fossil fuel consumption and zero greenhouse gas emissions contribute to environmental conservation.

#### **Cost-Effective Implementation**

Requires only modification of existing turbo ventilators with a generator, resulting in lower installation and maintenance cost.

#### **Energy Independence for Buildings**

Provides a decentralized power source for small electrical loads like LED lighting, sensors, or exhaust fans.

#### **No Electricity Required for Operation**

Naturally driven by wind, so no external power input is needed to rotate the ventilator.

#### **Reduced Heat Accumulation**

Maintains indoor air circulation while generating electricity, improving comfort and productivity inside buildings.

#### **Low Noise and Vibration**

Operation is smooth and quiet, suitable for residential, industrial, and commercial roofs.

#### **Simple Construction and Easy Maintenance**

Mechanical components are simple and robust, making it reliable with minimal upkeep.

#### **Scalability**

Multiple ventilators can be installed on large buildings to increase power output collectively.

#### **Application**

##### **Industrial Buildings**

Powering small monitoring systems, LED lighting, and exhaust control units in factories and warehouses.

##### **Commercial Establishments**

Used in shopping malls, supermarkets, and offices to support emergency lights or signage.

##### **Residential Buildings**

Roof-mounted ventilators can generate electricity for household needs such as charging small devices or lighting.

##### **Educational Institutions**

Schools, colleges, and laboratories use the generated power for safety indicators and environmental monitoring equipment.

##### **Remote and Rural Areas**

Effective solution for off-grid locations where conventional electricity supply is limited or unavailable.

##### **Agricultural Facilities**

Suitable for barns, poultry farms, and greenhouses to power temperature sensors, fans, and LED lamps.

##### **Public Utility Buildings**

Bus stands, railway shelters, and community halls can benefit from low-cost, renewable power.

##### **Industrial Sheds and Workshops**

Continuous ventilation and electricity for small electronic equipment enhance working environment and productivity.

##### **Smart Building Systems**

Can integrate with IoT sensors and wireless devices for energy-efficient automation.

##### **Disaster Relief Shelters**

Provides emergency lighting and ventilation during power outages caused by natural disasters.

##### **Parking Sheds**

Can operate motion-sensor lights or CCTV systems in parking basements and open parking areas.

##### **Cold Storage and Warehouses**

Maintains airflow while powering temperature monitoring and safety alarms.

##### **Eco-Friendly Construction Projects**

Promotes green building standards like IGBC, LEED, and GRIHA certifications.

##### **Commercial Kitchens**

Improves ventilation in large kitchens while generating auxiliary power for indication lights.

##### **Small-Scale Backup Power Systems**

Can act as supplemental energy for battery charging and load management in hybrid energy setups.

### Future scope

#### Improved Power Generation Efficiency

Development of advanced generators and low-friction mechanisms can increase electrical output from natural airflow.

#### Integration with Smart Energy Systems

Can be connected with IoT-based monitoring to analyze wind speed, power output, and system health in real-time.

#### Hybrid Renewable Systems

Can be combined with solar panels on roofs to create hybrid ventilation energy systems for continuous power generation.

#### Advanced Aerodynamic Design

Blade design enhancement using computational fluid dynamics (CFD) can extract more rotational energy even at low wind speeds.

#### Lightweight and Durable Materials

Use of composites and corrosion-resistant materials will increase lifespan and reduce maintenance needs.

#### Energy Storage Enhancement

Better battery integration and supercapacitors will support efficient storage for night-time or low-wind conditions.

#### Scalable Urban Infrastructure

Future green buildings can incorporate multiple units to significantly contribute to overall energy demand reduction.

#### Adoption in Smart Cities

Potential to supply power for street lights, surveillance systems, and public utilities in sustainable city planning.

#### Cost Reduction via Mass Production

Economies of scale and local manufacturing can make this technology affordable and commercially viable.

#### Noise and Vibration Optimization

Further improvements in balancing and mounting will ensure high performance in residential areas.

#### Automatic Pitch and Speed Control

Adaptive control systems can regulate rotation to avoid mechanical stress during high wind speeds and improve efficiency.

#### Research in Low-Wind Regions

Enhancing performance in moderate and low-wind zones will widen geographical applicability.

### Grid Connectivity Development

Future versions may contribute excess power to the grid in microgrid setups.

### AI-Based Predictive Maintenance

Machine learning can help monitor wear and tear, reducing downtime and repair cost.

### Broader Applications in Public Buildings

Increased adoption in hospitals, schools, and transportation hubs for clean and reliable energy.

### Scope for Future Work

#### Efficiency Improvement of Generator Coupling

Future work can focus on optimizing the gear ratio, magnetic coupling, or direct-drive AFPM generators to minimize mechanical losses and improve power output at low wind speeds. Design of low-cogging torque generators specifically for ventilator RPM ranges will enhance performance.

#### Hybrid Energy Systems

Integration of turbo ventilator generators with solar PV panels on rooftops can be explored to develop hybrid renewable systems. This will ensure continuous power generation during both windy and sunny conditions, improving reliability.

#### Energy Storage & Power Conditioning

Research can be done on compact battery storage, supercapacitors, and efficient MPPT-based charge controllers to store irregular power output. Development of low-cost DC-DC boost converters and inverters for grid-tie or standalone applications is another key area.

#### Smart Monitoring & IoT Integration

Incorporating IoT sensors for real-time monitoring of wind speed, RPM, voltage, and current will help in performance analysis. Data logging and remote diagnostics can enable predictive maintenance of ventilator-generator units.

#### Material & Aerodynamic Design Optimization

Future studies can improve ventilator blade profiles using CFD analysis to increase rotational speed under low airflow. Use of lightweight composite materials can reduce inertia and improve startup wind velocity.

#### Scale-up for Industrial Applications

Scope exists to design multi-unit ventilator arrays for factories, warehouses, and commercial buildings. Feasibility of feeding generated power into building microgrids or for powering IoT devices, sensors, and LED lighting can be tested.

### Cost-Benefit & Commercial Viability

Detailed techno-economic analysis for mass adoption, payback period, and government subsidy models should be carried out.

### Noise & Vibration Reduction

Further work is needed to minimize noise and mechanical vibration caused by generator loading on the ventilator, ensuring occupant comfort in residential applications.

### Design of Turbo-ventilator

Designing a turbo ventilator to generate electricity is basically turning a roof ventilator into a small vertical-axis wind turbine. It won't replace solar, but it can trickle-charge a 12V battery for LED lights or a fan.

### Basic Design Concept

A turbo ventilator is a VAWT - Vertical Axis Wind Turbine. You attach a small DC generator or BLDC hub motor to the central shaft. The wind spins the turbine blades, which spins the generator to produce DC power.

### Typical components:

- Turbine rotor: Existing ventilator blades + housing
- Generator: 12V/24V BLDC hub motor used in e-bikes, 50-200W rated Charge controller: 12V PWM controller to protect battery
- Battery: 12V 7Ah - 20Ah lead acid or LiFePO4 Load: LED lights, DC fan, phone charging

### Key Design Calculations

Step A: Power available in wind The power in wind is given by:  $P_{wind} = \frac{1}{2} \rho A V^3 C_p$

Where:

$P_{wind}$  = Power in watts

$\rho$  = Air density = 1.225 kg/m<sup>3</sup> at sea level, 25°C A = Swept area =  $\pi r^2$  for circular turbine, m<sup>2</sup> V = Wind velocity, m/s

$C_p$  = Coefficient of power = 0.2-0.35 for turbo ventilator VAWT. Betz limit is 0.59 but small roof turbines are ~0.25

Step B: Swept area for 24" ventilator

24" diameter = 0.61 m radius = 0.305 m  $A = \pi (0.305)^2 = 0.29 \text{ m}^2$

### Step C: Generator mechanical output

$P_{mech} = P_{wind} \times \eta_{mech} \times \eta_{gen}$

$\eta_{mech}$  = Mechanical efficiency of bearings = ~0.85

$\eta_{gen}$  = Generator efficiency = ~0.5 for small BLDC

Step D: Electrical output

$P_{electrical} = P_{mech} \times \eta_{charge\ controller} = P_{mech} \times 0.9$

Worked Example: 24" Turbo Ventilator Assumptions for Mysore rooftop: Average wind speed  $V = 3 \text{ m/s}$ . Rooftop winds are lower than open field. Blade diameter = 0.61 m  $\rightarrow A = 0.29 \text{ m}^2$

$C_p = 0.25$

### Available wind power

$P_{wind} = 0.5 \times 1.225 \times 0.29 \times (3)^3 \times 0.25 = 1.20 \text{ W}$

Electrical power after losses:

$P_{electrical} = 1.20 \times 0.85 \times 0.5 \times 0.9 = 0.46 \text{ W}$

1-month generation:

$0.46 \text{ W} \times 12 \text{ hrs/day} \times 30 \text{ days} = 165.6 \text{ Wh} = 0.17 \text{ kWh/month}$

### Why the output is so low

Low wind speed: Power varies with  $V^3$ . At 6 m/s instead of 3 m/s, power becomes  $0.46 \times 8 = 3.68 \text{ W}$ .

Small swept area: A 24" turbine has only  $0.29 \text{ m}^2$ . A 1m diameter turbine has  $0.79 \text{ m}^2 \rightarrow 2.7 \times$  more power.

Turbulence: Roof edges create turbulent, non-laminar flow which kills  $C_p$ .

at low RPM vs stock turbine blades

\*Mounting height\* 1-1.5m above roof ridge Reduces turbulence from roof surface

\*Battery\* 12V 7Ah + 5A PWM controller Prevents overcharging and handles load mismatch

\*Cut-in speed\* Design for 2.5 m/s Below this, generator won't overcome friction

5. To get useful power ~20-30W average You need:

- Diameter  $\geq 1 \text{ m} \rightarrow A = 0.785 \text{ m}^2$

- Wind speed  $\geq 5 \text{ m/s} \rightarrow$  common in open industrial areas

- Modified blade profile  $\rightarrow$  Savonius or Darrieus instead of stock louvered blades

That gives:

$P_{wind} = 0.5 \times 1.225 \times 0.785 \times 5^3 \times 0.25 = 30 \text{ W}$

$P_{electrical} = 30 \times 0.85 \times 0.5 \times 0.9 = 11.5 \text{ W}$

$\rightarrow \sim 4.1 \text{ kWh/month}$

### Hybrid is more practical

Most commercial products combine a 30-50W solar panel on top + 20W turbine. The solar gives steady output, turbine gives extra at night/windy days.

Bottom line: A stock 24" turbo ventilator will give <1 kWh/month. To make it worthwhile you need 1m+ diameter + blade redesign + good open wind location.

**Cost Analysis**

Components	Price
Turbo Ventilator	3000
Battery	1000
Dynamo	6000
Micro-meter	200
Remaining Components	500
<b>Total</b>	<b>10,700</b>

**Calculation**

Size	Radius	Area (m <sup>2</sup> )	Wind Power In	Electrical Power Out	Energy/Day	What it can run
300 mm / 12"	0.15 m	0.071	4.33 w	0.23 w	1.4 wh	1 LED for 1.5 hrs
600 mm / 24"	0.30 m	0.283	17.3 w	0.94 w	5.6 wh	Phone charge 15%
900 mm / 36"	0.45 m	0.636	39.0 w	2.11 w	12.7 wh	3W LED for 4 hrs
1200 mm / 48"	0.60 m	1.131	69.3 w	3.75 w	22.5 wh	5W router for 4.5 hrs

Impact of Wind Speed – Same 900mm Ventilator Because power depends on v<sup>3</sup>, wind speed dominates.

Wind Speed	Power Out	Energy/Day (6 hrs)	Current @12V
3 m/s	0.46 w	2.7 wh	0.038 A
5 m/s	2.11 w	12.7 wh	0.176 A
7 m/s	5.79 w	34.7 wh	0.483 A
10 m/s	16.9 w	101 wh	1.41 A

**Practical Output**

Power output from turbo ventilator at a speed of 3 m/s  $P = 0.5 * \rho * A * V^3 * C_p * \eta$   
 $P = 0.5 * 1.225 * 3.14 * 0.6 * 3^3 * 0.25 * 0.5$   
 $P = 3.89 \text{ W}$   
 Power output from turbo ventilator at a speed of 5 m/s  $P = 0.5 * \rho * A * V^3 * C_p * \eta$   
 $P = 0.5 * 1.225 * 3.14 * 0.6 * 5^3 * 0.25 * 0.5$   
 $P = 18.03 \text{ W}$   
 Power output from turbo ventilator at a speed of 7 m/s  $P = 0.5 * \rho * A * V^3 * C_p * \eta$   
 $P = 0.5 * 1.225 * 3.14 * 0.6 * 7^3 * 0.25 * 0.5$   
 $P = 49.47 \text{ W}$

**The Formula**

Power output from ventilator  
 $P = 0.5 * \rho * A * v^3 * C_p * \eta$   
 $\rho = 1.225 \text{ kg/m}^3$ , air density  
 $A = \pi r^2$ , swept area from radius r in meters v = wind speed in m/s  
 $C_p = 0.25-0.35$  for turbo ventilators. They're designed for ventilation, not power  
 $\eta = 0.5-0.7$  for small generator + gear losses  
 Energy per day  
 Energy (Wh/day) = Pout × hours of useful wind per day  
 Electricity Generation for Common Turbo Ventilator Sizes  
 Assumptions:  
 Wind speed = 5 m/s,  $C_p = 0.3$ ,  $\eta_{total} = 0.6$ , 6 hours/day of usable wind

**VI. CONCLUSION**

Electricity generation from a turbo-ventilator is an innovative and sustainable method of utilizing wind energy that would otherwise go unused. By converting the rotational motion of the ventilator into electrical energy using a generator or dynamo, the system provides a clean and renewable source of power for small-scale applications. Experimental observations show that the output voltage and current increase with wind speed, making the system effective under moderate environmental conditions. Although the generated power is limited, it is sufficient for operating low-power devices such as LED lights, mobile charging units, sensors, and IoT-based equipment. One of the major benefits of this system is its dual functionality. Along with generating electricity, the turbo-ventilator continues to improve air circulation and reduce heat inside buildings, making it both practical and energy-efficient. The

setup is economical, easy to install, requires minimal maintenance, and uses commonly available materials, wh

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