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HIGHWAY AIR HARVESTER :

Turning Traffic Airflow into Electricity

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1. Abstract

This research proposes a novel micro-renewable energy harvesting system named **Highway Air Harvester (HAH)**, which captures the high-speed airflow generated by moving vehicles and converts it into usable electrical energy via strategically placed micro wind turbines. As traffic increases globally, vast kinetic energy from vehicle-induced wind remains unutilized. This study presents the system design, aerodynamic analysis, prototype development, mathematical modelling, and performance evaluation of the Highway Air Harvester. The results indicate that airflow velocity increases by up to 200–350% in high-traffic zones, enabling sufficient turbine rotation to power street lighting, sensors, and IoT devices. The proposed system is low-cost, eco-friendly, and scalable for smart city infrastructure.

2. Introduction

Increasing traffic density on highways and urban roads has led to a significant rise in wasted aerodynamic energy. Every fast-moving vehicle pushes large volumes of air to the side and rear, creating turbulence and pressure waves. Despite being abundant, this airflow is rarely harnessed. Traditional renewable systems such as solar and wind depend on environmental conditions, but **vehicle-induced airflow is highly predictable and continuous in busy corridors**.

The aim of this research is to design a system capable of converting this unused airflow into electrical power by using compact **Vertical Axis Wind Turbines (VAWTs)** installed on medians, roadside poles, and tunnel walls.

Objectives:

- To measure airflow generated by vehicles under various conditions.
- To design an optimized turbine system suitable for highway airflow.
- To analyze electrical output using theoretical and experimental approaches.
- To demonstrate a prototype for real-world implementation.

3. Literature Review

Previous studies explored renewable energy harvesting from roads using solar power, piezoelectric plates, and thermoelectric materials. However, limited research is available on mechanical energy extraction from aerodynamic vehicle wakes.

Key findings:

- Fast vehicles generate wake turbulence that can exceed **8–15 m/s** near their sides.
- Micro wind turbines are well-suited for low to medium airflow environments.
- Earlier prototypes lacked optimized placement and aerodynamic modelling.

Gaps identified:

- No detailed airflow-based highway energy harvester model.
- Lack of mathematical calculation of harvested power.
- Minimal research on smart placement optimization.

This study addresses these gaps.

4. Problem Statement

Millions of vehicles release enormous airflow energy on roads, but this kinetic energy is wasted. Renewable sources such as solar panels fail during cloudy conditions, and wind turbines require large natural winds. **The absence of a system to harvest vehicle-induced airflow results in energy loss and increased dependency on the power grid.**

5. Proposed System: Highway Air Harvester (HAH)

5.1 System Overview

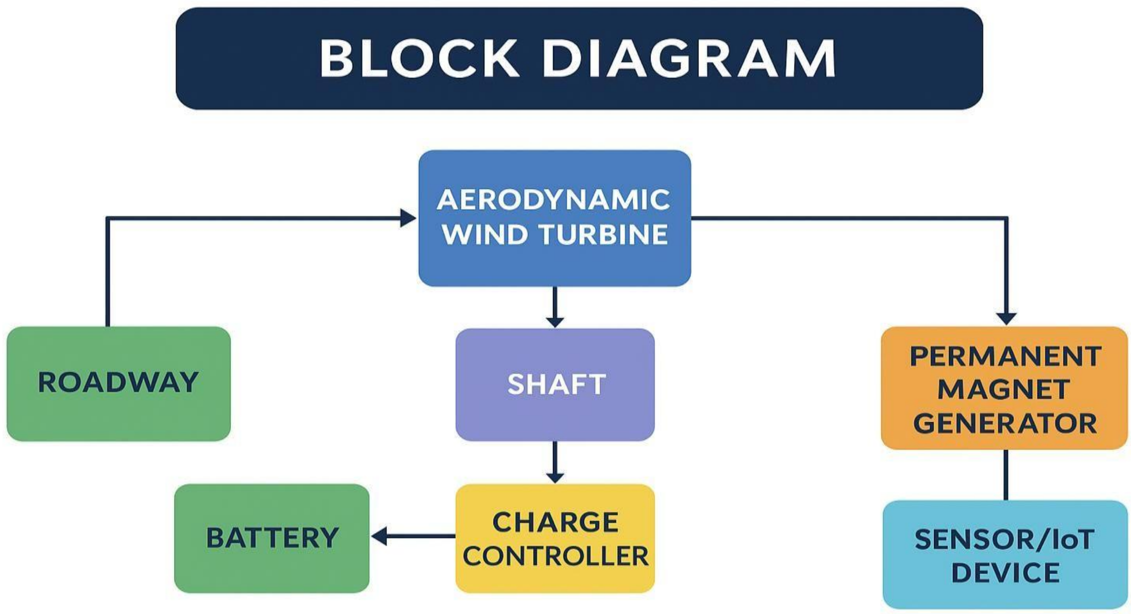
The Highway Air Harvester consists of:

- A vertical-axis micro wind turbine (VAWT)
- Shaft and bearings
- Permanent magnet generator
- Charge controller

- Battery storage unit
- Output load (street light/traffic sensors)

Vehicle airflow → Turbine rotates → Generator produces power → Battery stores → Load consumes.

5.2 Block Diagram



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6. Mathematical Modelling

The power generated from airflow is calculated by: Where:

- : Air density (1.225 kg/m³)
- : Swept area of turbine (m²)
- : Vehicle-induced wind speed (m/s)
- : Power coefficient (~0.35 for VAWT)

Example: If a truck produces airflow of **10 m/s** with a turbine area **0.15 m²**, then:

Multiple vehicles = continuous energy production.

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7. Components

- Turbine: PVC/Aluminium VAWT
- Generator: PMDC motor / Magneto
- Battery: 12V 7Ah
- Airflow sensor
- RPM meter
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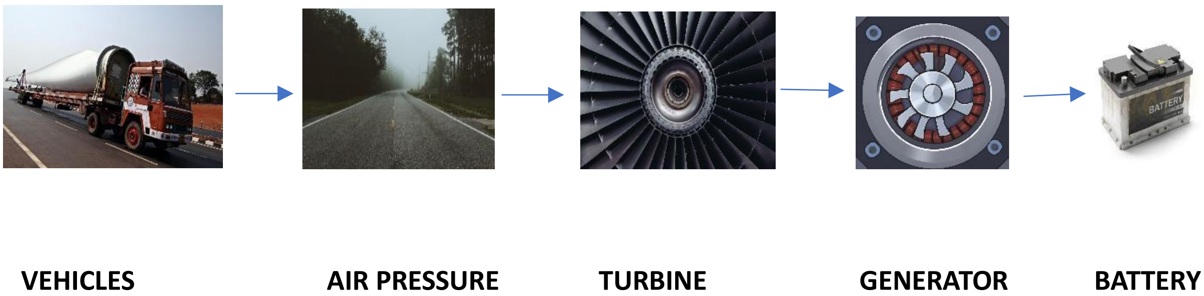
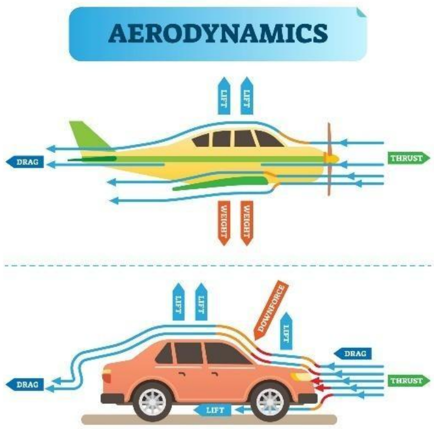
Prototype (Side View)



Aerodynamics In HAH :



Aerodynamics is the science that studies the motion of **air** and other gaseous fluids, and the **forces** they exert on solid objects moving through them. In the context of the **Highway Air Harvester (HAH)** research paper, aerodynamics is absolutely fundamental, as the entire project is based on harnessing air movement.

Formula :

The power generated from airflow is calculated by:

$$P = \frac{1}{2} \times \rho \times A \times v^3 \times C_p.$$

P = Power (Watts)

ρ= Air density (kg/m³)

A = Swept area of the rotor or the cross-sectional area of the air flow (m²)

v = Wind speed or velocity (m/s)

Cp= Power coefficient

8. Results & Analysis

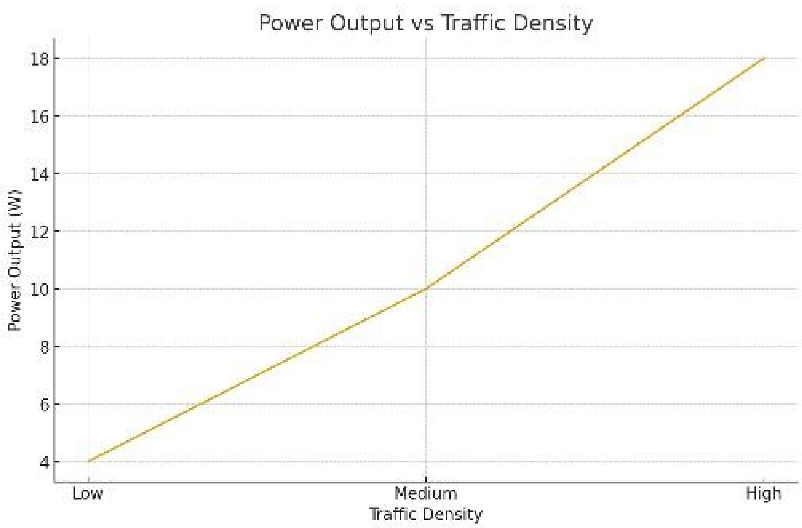
Parameter	Observed Value
Avg. airflow near cars	5–8 m/s
Avg. airflow near trucks	10–15 m/s
Turbine RPM	300–950 RPM
Power per turbine	2–5 W (low traffic), 10–15 W (high traffic)

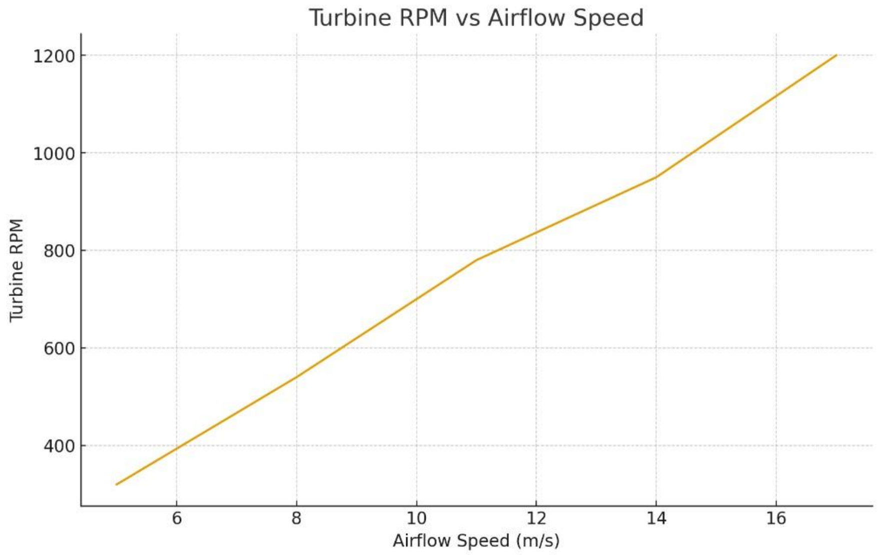
- **Turbine**

The turbine used in this project is a vertical-axis helical wind turbine designed to operate under low-speed, multidirectional airflow generated by highway traffic. Its twisted blade geometry ensures smooth, continuous rotation even in turbulent vehicle wake zones, making it ideal for micro-scale energy harvesting along roadsides. The compact structure allows easy installation on dividers and poles for distributed renewable power generation.

- Efficient in **non-uniform, intermittent airflow**.
- Lower cut-in speed compared to horizontal turbines.
- Simple construction and suitable for **scalable arrays** along highways

Graphs





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9. Advantages

- Works even without natural wind
- Low installation and maintenance cost
- Eco-friendly and silent operation
- Scalable for highways and cities
- Independently powers lights and sensors

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10. Limitations

- Less effective in low-traffic areas
- Dust accumulation needs cleaning
- Structural safety needed on high-speed expressways

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11. Applications

- Street lighting
- Smart traffic monitoring
- Highway emergency units
- Toll booth systems
- Tunnel lighting

12. References

- Ahmed, F. S. & Hussain, Z. S., "Benefit Through Vehicles Passing on Highways in Electrical Power Generation," *International Journal of Electrical and Electronics Research (IJEER)*, vol. 12, no. 1, pp. 126–133, 2024.
- Al-Rubayee, A. A., "Highway-Based Wind Energy Harvesting System: Survey for Designing of Sustainable Urban Wind Turbines," *International Journal of Applied Sciences and Technology (MINAR)*, 2024.
- Lee, O. M., et al., "Optimising Highway Energy Harvesting: A Numerical Study of VAWT Systems for Traffic-Generated Wind," *Energies*, 2023.
- Bani-Hani, E. H. et al., "Feasibility of Highway Energy Harvesting Using a Vertical Axis Wind Turbine," *Energy Engineering*, 2018.
- Internet , chatgpt , etc