

## Introduction

- **Problem Statement:** Urban highways generate significant wind due to high-speed vehicle motion, but this energy is typically wasted. Traditional wind turbines are unsuitable for urban settings due to space, noise, and wind variability. This project aims to design a compact, modular Horizontal Axis Wind Turbine (HAWT) system that captures traffic-induced wind and converts it into usable electrical energy for smart city infrastructure

## Prototype Design

- Horizontal Axis Wind Turbine optimized for traffic-induced airflow
- Aerodynamic blades 3D-printed for precision
- Compact frame with stable tower base
- Permanent magnet generator for reliable power output
- Integrated sensors for real-time performance tracking
- Modular design enables easy roadside installation

## Specifications and Constraints table

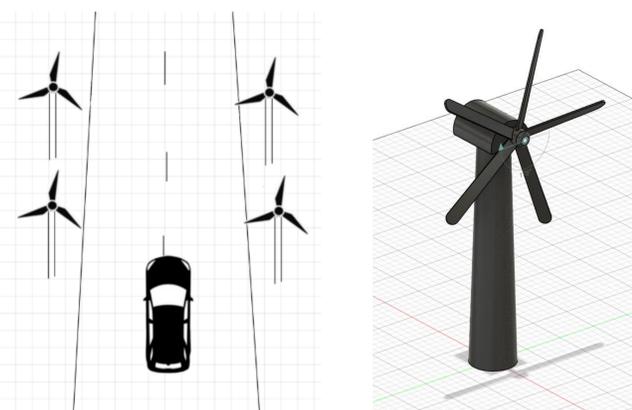
Constraint	Value
Wind Speed	Min 3 m/s
Weatherproofing	IP65+
Operating Temperature	0-60 °C
Area	≤1.5 m <sup>2</sup>
Noise	≤40 dB
Lifespan	≥5 years
Energy Conversion Efficiency	≥30%
Energy Output	≥50 W
Monitoring System	Real-time

## Designing and sketching

- Final target specifications:

Height	≤ 2 m
Weight	≤ 10 kg
Power Output	20-50 W at low wind speeds
Noise	≤ 40 dB
Efficiency	≥ 30%
Weatherproof	IP65 rated
Monitoring System	Real-time via IoT dashboard

- Wind Turbine sketches and design:



## Testing/Validation

- Wind tunnel and vehicle-passing tests validated design effectiveness
- Reached 325.5 W output under 12 m/s airflow (highway condition) Operated at <50 dB noise level, meeting urban standards
- Sensor data logged successfully; visualized via dashboard
- All specifications and constraints met during validation phase

## Conclusion

- The proposed HAWT system successfully demonstrated the potential of traffic-induced wind as a viable renewable energy source. The compact, low-maintenance design is scalable and supports urban sustainability goals. With further refinement and mass production, this solution can contribute to Saudi Arabia's Vision 2030 by integrating clean energy into the national transportation network