PROJECT URJA

Project URJA integrates helical vertical axis wind turbine technology into urban infrastructure like the metro and highways. Our product comprises a vertical axis wind turbine with a solar panel atop and a permanent magnet synchronous generator at its base, connected with a gearbox. It converts wind and solar energy into electricity for connection to the main power grid, with analysis conducted using MATLAB.

PROJECT REPORT

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PROBLEM STATEMENT

AIR POLLUTION IN INDIAN CITIES:

India is recognized as a top global emitter, yet its per capita emissions remain relatively low due to its large population. However, this does not mitigate the severe air pollution experienced in cities like Delhi, which is often ranked as one of the most polluted cities in the world. The high levels of pollutants in the air pose a significant health threat to residents, leading to respiratory diseases, cardiovascular issues, and other health complications.

ECONOMIC IMPACT OF AIR POLLUTION:

The economic impact of air pollution in India is substantial. It is estimated that air pollution costs the Indian economy approximately 3% of its GDP annually, equivalent to around $95 billion. Moreover, a study conducted in 2022-23 suggests that 4.5% of India's economy could be at risk by 2030 due to the adverse effects of air pollution. These economic losses encompass healthcare expenditures, productivity losses, environmental damage, and other related costs.

ACCELERATING TRANSITION TO RENEWABLE ENERGY:

Given the detrimental effects of air pollution and the economic burden it imposes, there is a pressing need to accelerate the transition to a lower carbon economy. Innovation in renewable energy sources presents a viable solution to mitigate both air pollution and carbon emissions. By leveraging renewable energy technologies, such as wind and solar power, India can reduce its reliance on fossil fuels and curb the emission of pollutants into the atmosphere.

DESCRIPTION

Project Urja seeks to repurpose dormant wind energy, enhance our existing products, and empower communities, combining upcycling with product development for sustainable growth.
Our product is basically a Vertical-Axis Wind turbine that functions on the principle of utilising the wind from cars as well as from metros along with the natural wind that applies torque on the rotor of our product and makes it rotate the shaft. The solar panels installed on the top of the turbine provide extra electricity to be captured. It upcycles the fuel wasted to overcome aerodynamic drag, utilizes the untapped wind energy sector and thus can possibly supply electricity to the National Grid.

The product proposed by Project URJA offers several key advantages:

1. **Ease of Installation**: It is designed for quick and straightforward installation, facilitating deployment in urban areas like highways and metros.
2. **Low Operating Cost**: Leveraging vertical axis wind turbine technology, the product ensures minimal ongoing expenses, making it economically viable for widespread adoption.
3. **High Power Efficiency**: With optimized design and utilization of wind energy, it delivers exceptional power efficiency, maximizing electricity generation.
4. **Space Efficiency**: Utilizing vertical axis wind turbines, the product requires minimal land area for installation, overcoming space limitations in urban environments.

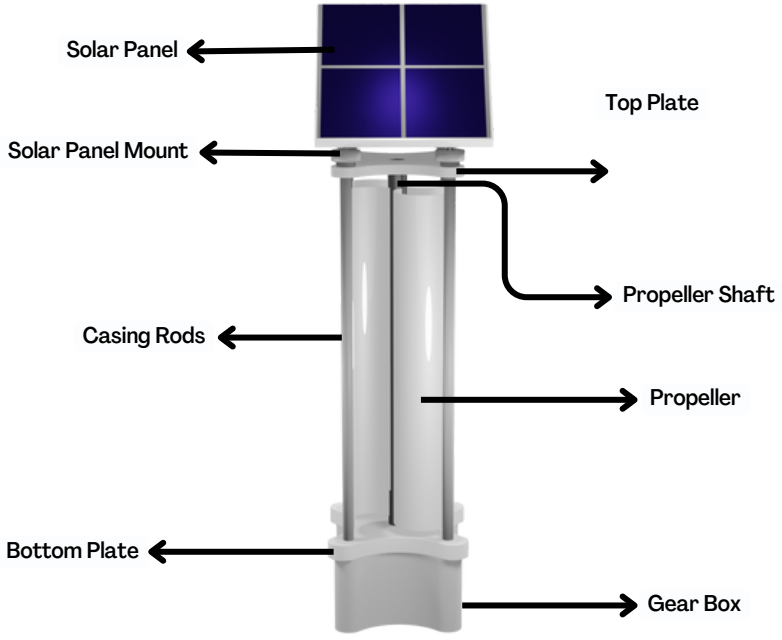

Fig 1: CAD model for Project URJA

APPARATUS REQUIRED

- **Software Used:** MATLAB Version R2023A, Simulink
- **Hardware Used:** MacBook Pro 2.6GHz Intel Core i7, macOS Sonoma 14.2.1.
- **MATLAB Components:**

1. PV array
2. DC generator
3. Wind turbine
4. Multiplexer
5. Current measurement
6. Voltage Measurement
7. Series RLC Branch
8. Scope
9. Display
10. Power gui

SIMULATION MODEL

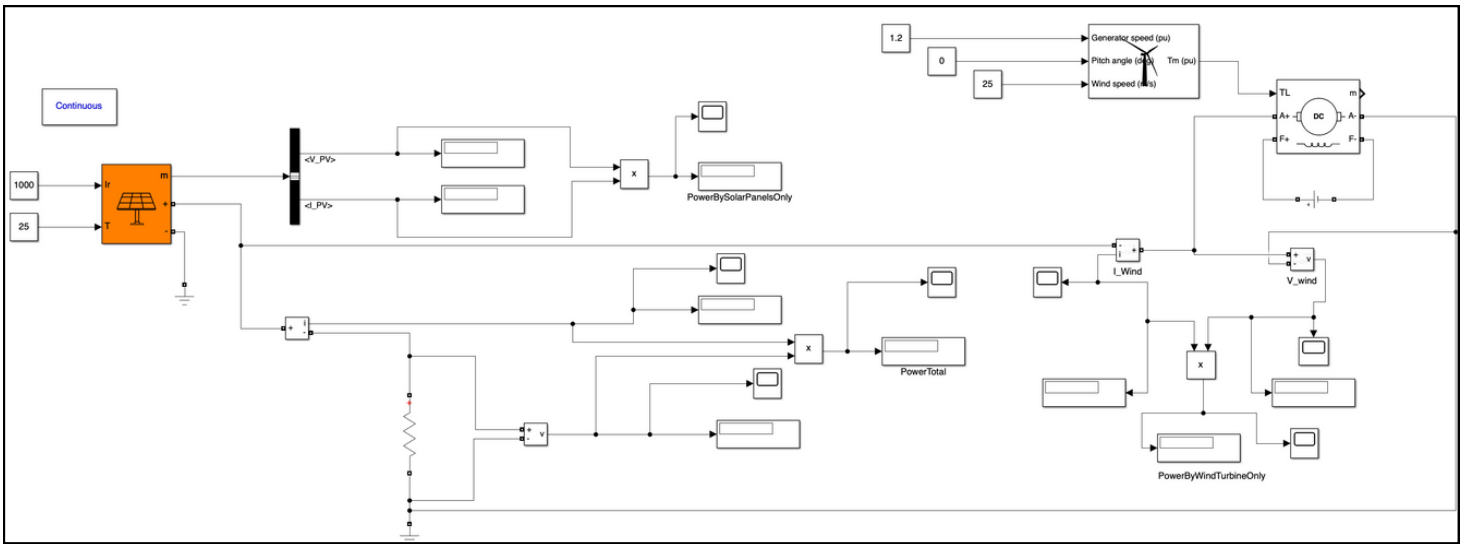

Fig 2: MATLAB model for Project URJA

OBSERVATIONS

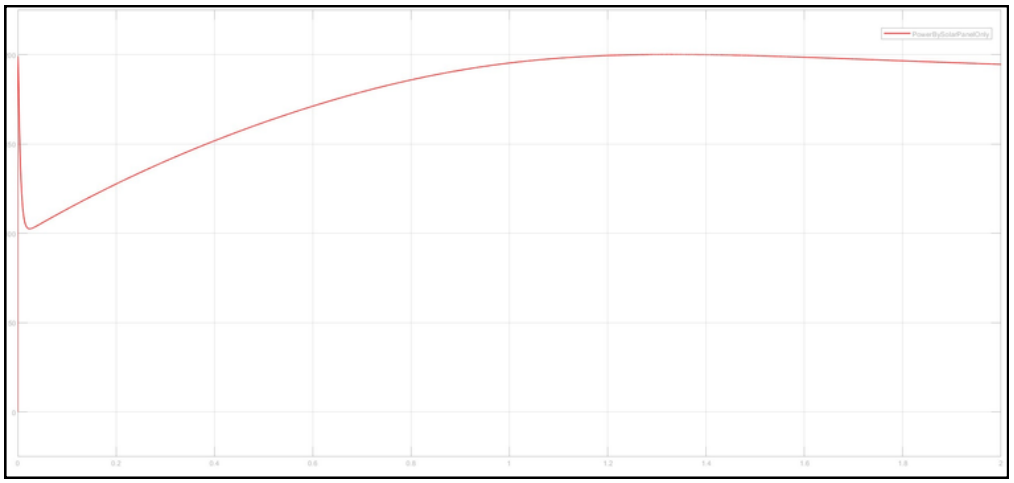

Fig 3: Output Power by Solar Panel only

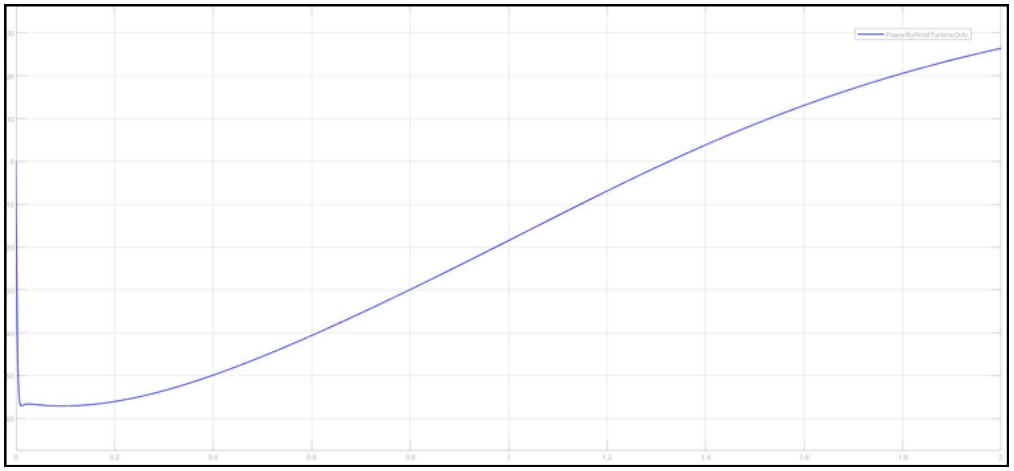

Fig 4: Output Power by Helical Wind turbine only

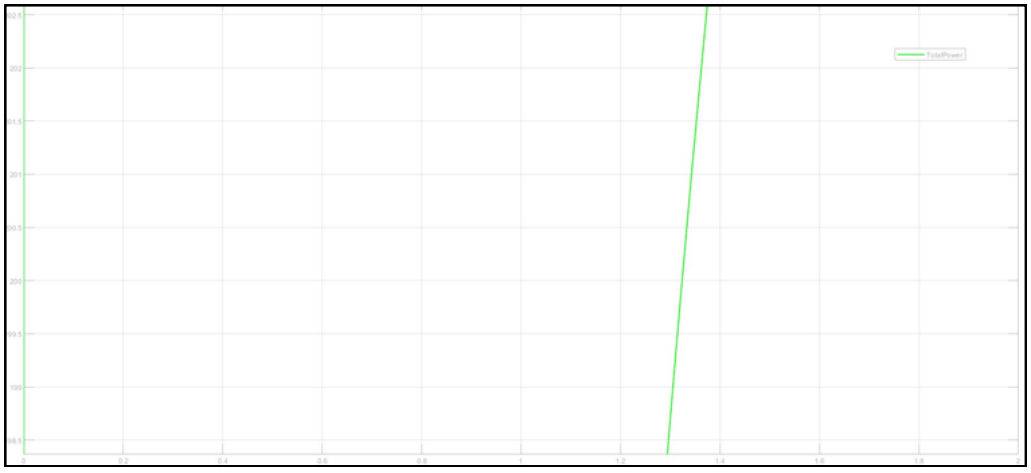

Fig 5: Total Output Power by Project URJA

RESULT

Solar PV Array:
A demux is utilized to segregate the current and voltage readings of the Solar PV array, which are then multiplied using the "Product" block, followed by readings taken using the "Scope."

Wind Turbine:
Constants such as wind speed and pitch angle are assigned to the wind turbine, which is subsequently connected to a DC motor (representing a 3-phase AC motor used in real-life operation), effectively functioning as a generator.
The output of the generator is directed to the load for utilization.

Combined Power Outputs:
Current and voltage readings are superimposed, and the output power is calculated as the product of these quantities, resulting in a rising graph.
It's imperative to clarify that while current and voltages are superimposed, the calculation of power is based on the product of these quantities, not their superimposition.

FUTURE PROJECTIONS

- **Validation and verification**: Mention procedures for validating the MATLAB model against real-world data or theoretical calculations to ensure accuracy and reliability of the simulation results.
- **Sensitivity analysis:** Consider performing sensitivity analysis to assess the impact of variations in parameters such as wind speed, solar irradiance, and load demand on the performance of the hybrid renewable energy system.
- **Economic analysis:** Evaluate the economic feasibility of implementing the proposed system, considering factors such as initial investment, operational costs, and potential savings or revenue generated from electricity generation.
- **Environmental impact assessment:** Discuss the environmental benefits of utilizing renewable energy sources, including reductions in greenhouse gas emissions and dependence on fossil fuels, contributing to climate change mitigation and sustainability goals.

PROBLEMS FACED

- Inability to represent the helical shape of the wind turbine in MATLAB alters the output.

- In the MATLAB Simulink model, both the panels and turbines yield DC outputs, unlike the realistic scenario where 3-phase power lines are utilized. Transitioning to 3-phase AC outputs increases circuit complexity and introduces the risk of out-of-phase outputs, lowering efficiency. To mitigate this, rectification and de-rectification of both outputs before superimposition, necessitating the use of diodes, introduces challenges related to breakdown voltages. This complexity often results in MATLAB crashing, rendering the current representation inaccurate.

- Excessive use of scopes for monitoring purposes consumes resources, making the project resource consuming.

ACCURACY AND ADJUSTMENTS

- Utilizing a constant input for the wind speed of the turbine can serve as an alternative representation of the helical-shaped turbine.

- Despite employing DC instead of AC power lines, as explained in the "Problems Faced" section, the accuracy of the system wouldn't differ significantly. This is because the DC output is the root mean square (RMS) value of the AC output, resulting in a constant difference ($1/\sqrt{2}$ in the case of a sine wave).