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Design, Development and Analysis of Future Tree and Air Filtration System

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Abstract

Energy plays a crucial role in the economic and social development of any country. Utilizing freely available energy resources requires advanced devices, making the development of such technology a necessity. This is vital for enhancing analysis and development, as well as for investing in the renewable energy sector to meet energy demands and reduce dependence on fossil fuels. The 'Future Tree' concept offers a promising solution by converting natural resources into energy. This paper introduces the design, development, and analysis of the Future Tree. Wind and solar power are becoming increasingly popular due to their abundance, accessibility, and ease of harnessing for electricity generation. With anticipated rises in energy costs and demand, hybrid energy systems combining solar and wind power are essential solutions. This study presents the design of a hybrid electricity generation system that utilizes both solar and wind energy to provide power to remote households not connected to the grid. Hybrid systems have proven to be effective in delivering high-quality power. Global efforts to mitigate public health issues and control acid rain have prompted actions to reduce emissions of CO, SOx, and NOx. This research introduces a pollutant removal filter utilizing a catalytic converter. The filter's purpose is to ensure emission-free air is released into the Atmosphere.

1. Introduction

The demand for energy worldwide is escalating, necessitating renewable energy sources that are both environmentally friendly and readily available, such as sunlight. Solar panels harness sunlight, but as the array expands, so does the land required, posing a challenge. To address this and enhance energy production, solar and wind trees are employed. TREE stands for Tree Generating Renewable Energy and Electricity. Solar and wind energy are pivotal resources for the future, capable of satisfying a significant portion of global energy needs. Examples include solar trees and wind turbines. This paper explores a hybrid tree concept capable of generating energy continuously using sunlight and wind. Energy demand profoundly impacts a country's economy; India, for instance, saw a rapid 6.4% average increase in energy demand from 1990 to 2010, driven by substantial economic growth. This surge has depleted conventional energy sources rapidly, causing environmental and public health issues like

global warming and skin cancer. Consequently, the global scientific community is increasingly focused on renewable energy sources that are renewable and cause minimal environmental harm. The use of renewable energy sources results in lower emissions of greenhouse gases and harmful pollutants such as NOx and CO, which are by-products of fossil fuels and contribute to environmental degradation and health problems. By prioritizing renewable energy, countries can reduce reliance on imported fossil fuels and achieve greater self-sufficiency and energy independence. Therefore, expanding and utilizing renewable energy sources like wind, solar, biomass, hydroelectric power, and waste-to-energy is essential.

1.1 Objectives

- To enhance the efficiency using a three-dimensional structure.
- To reduce the land required for solar and turbine installation.
- To generate renewable energy using wind turbine and Solar Panel.
- To reduce Pollutants from atmospheric air.

2. Literature Review

Idea of renewable energy generating tree was studied in detail. Literature survey was started with keywords like solar Tree, PV panels, solar panel installation & Applications of Renewable Generating tree. Literature involves importance of Solar Tree, different panels that can be used and their applications in different area. Energy demand is increasing day by day. Rural as well as urban areas requires energy. Energy requirement of small houses in India is 1.75 Wh/day. Average family in India consumes about 3.5 KW Energy on daily basis [1]. Traditionally PV panels are used but new idea of solar tree using nano wires in solar cell can be a better approach [2]. Purpose of using nano wires in solar cell is it concentrates 15 times more sunlight. So, to collect maximum sun light height is the main aspect. So, to increase efficiency of solar panel it has to be placed on certain height [3]. That's how height plays an important role in solar tree. Installing Silicon-crystalline Photo-Voltaic (SPV) solar panel on tall poles can generate more electricity than usual. These panels are more Efficient and can convert solar energy directly into Electrical Energy [4]. Installing such type of renewable energy generating tree on streets and on highways can produce certain amount of electricity and can be used in several Applications [5]. Along with PV panels using Wind Turbine is the best approach to make a hybrid tree to make it more efficient. The Solar Tree concept for domestic electrification is a significant step towards reducing electricity bills and reliance on the increasingly unreliable grid power in India. Additionally, it offers a clean energy source, contributing to the reduction of global warming. [6]. The current rooftop solar system can be substituted with solar trees, freeing up rooftop space for recreational use. Solar trees can also be installed on the ground, offering significant advantages in space-saving and greatly increasing power output. This innovation promises substantial energy savings over the long term. The number of solar trees that can be installed in a specific area depends on the required wattage.

3. Methodology

Future tree involves solar system, wind turbine system, Air filtration system and Tree structure [7]. Tree structure has metal branches to hold solar panels and wind turbine so that panel and turbine gets proper height to generate energy using sun rays and wind.

3.1 Solar System

Solar energy is directly produced by the sun, generated through a thermonuclear process converting approximately 65 Crore tons of hydrogen into helium every second. This process generates both heats, crucial for sustaining the thermonuclear reaction within the sun, and electromagnetic radiation. The radiation, which includes visible light, infrared light, and ultraviolet radiation, disperses into space in all directions. [8] Currently, there are various solar techniques available, each based on distinct scientific principles, offering unique advantages. Analyzing and comparing these technologies helps in selecting the most efficient and beneficial option under specific conditions. Generally, the two most mature solar technologies are non-concentrated photovoltaic solar panels (PV) and concentrated solar power (CSP).

3.1.1 Components

1. Solar Panel

Solar Energy is the energy produced directly by the sun. This energy is collected by PV cells and with the help of PV cells Heat and Radiation is converted into electricity [9]. Here 12 V 50 W solar panel is used to make this tree more efficient (Figure 1).

Figure 1 Solar Panel

2. Controlle

Figure 2 Controller

A solar charge controller, often referred to as a regulator, functions similarly to a regular battery charger. It regulates the current flowing from the solar panel into the battery bank to prevent overcharging the batteries (Figure 2).

3. Inverter

An inverter in a solar panel system converts the direct current (DC) electricity generated by the solar panels into alternating current (AC) electricity, making it compatible with the electrical grid and household appliances [10]. It ensures efficient energy conversion and often includes features such as maximum power point tracking (MPPT) to optimize the power output from the solar panels (Figure 3).

Figure 3 Inverter

4. Battery

Figure 4 Battery

Battery is used to store and deliver required amount of current which is generated by solar panel (Figure 4).

3.2 Wind Turbine

Wind is air in motion, and wind energy is a renewable, inexhaustible, and non-polluting source of power [11]. As an environmentally friendly and increasingly popular alternative, wind energy offers a clean solution to our energy needs. In this work, we present the Solar Tree concept for domestic electrification as a significant step toward reducing electricity bills and reliance on the grid, which is becoming less reliable in India. This concept also contributes to reducing global warming by providing a clean energy source. We have considered the energy demand of a small family to determine the capacity and component sizes of the proposed system. This innovative system, which combines solar panels on a tree-like structure with wind turbines, can generate energy more efficiently than traditional systems.

3.2.1 Components

1. Savonius Wind Turbine

Figure 5 Savonius Wind Turbine

2. Dynamo Motor

Figure 6 Dynamo Motor

To generate efficient amount of energy Dynamo is used. This dynamo is capable to produce 220 V AC current and this can be utilized to Glow LED panels.

3. Bridge Rectifier

Figure 7 Bridge Rectifier

A rectifier is an electronic circuit that converts an input AC voltage into a DC voltage at the output terminal, referred to as the rectified output voltage. Rectifiers are mainly used in power supplies to provide the DC voltage necessary for electronic devices to operate [12]. Full-wave rectifiers are especially effective, as they utilize both the positive and negative half-cycles of the input voltage to produce a consistent output voltage (Figure 5 to 7).

3.3 Air Filter

Public health and acid rain control concerns have prompted global efforts to reduce NOx, CO, and other harmful emissions from coal-fired boilers [13]. Currently, the worldwide focus on environmental protection is driving the development of technologies for the removal of NOx and CO. This effort is in response to increasingly stringent regulations that demand further reductions in emission levels (Figure 8).

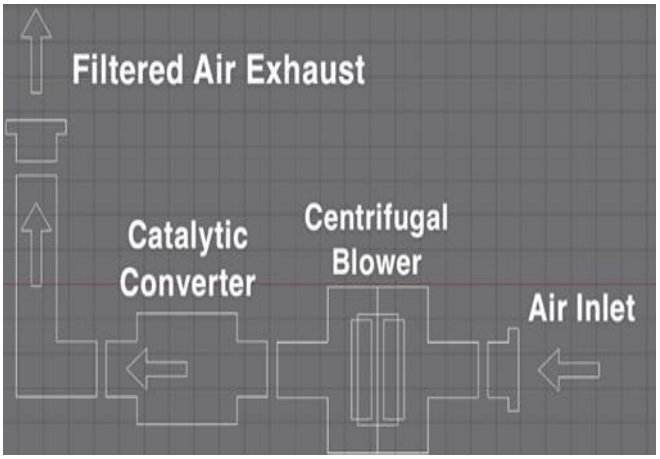

Figure 8 Flow of Air Filter

3.3.1 Components

1. Savonius Turbine

Figure 9 Savonius Turbine Blades

Function of savonius wind turbine in filtration system is to rotate blower fan so that to take air from the atmosphere and deliver to the catalytic converter [14]. This turbine is connected to the wind blower with the help of rod to deliver rotary motion to blower (Figure 9).

2. Cabin Filter

Figure 10 Cabin Filter

The main purpose of cabin air filter in future tree is to clear inlet air from dust. This filter clears about 90% of the dust from the inlet air. It stops dust particle larger than 3 microns (Figure 10).

3. Centrifugal Blower

Figure 11 Cooler Impeller

A centrifugal blower, also known as a centrifugal fan, is a mechanical device designed to move air or other gases radially outward from the Centre of rotation. Unlike axial fans that direct airflow parallel to the fan's axis, centrifugal blowers channel air at a right angle to the intake (Figure 11).

4. Catalytic Converter

A catalytic converter is installed in the exhaust system of a car, positioned between the engine and the exhaust tips. Its purpose is to reduce the number of harmful emissions released from the exhaust system. Specifically, it is designed to trap pollutants such as carbon monoxide, nitrogen dioxide, and hydrocarbons (Figure 12).

Figure 12 BS6 Catalytic Converter

5. Pipes

Figure 13 Connecting Pipes

Metal pipes are used for Transmission of air from Blower to Catalytic converter (Figure 13). The air moved out from catalytic converter is heated air, metal pipes are used to avoid damage to the system due to heat [15].

6. PTC Heater

Positive Temperature Coefficient heater has capacity to produce considerable heat rapidly (Figure 14 & 15). 12 V 200℃ PTC heater is used to heat catalytic converter, so that metals react with pollutants and filter the Air.

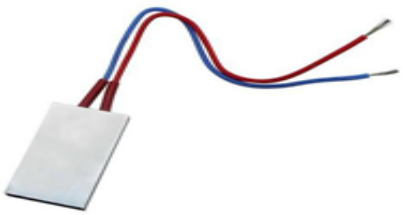

Figure 14 PTC Heater

3.3.2 Design of Catalytic Converter with Pipe

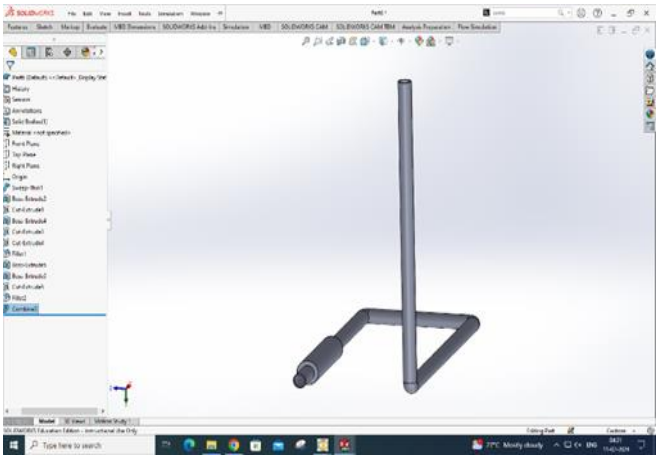

Figure 15 Design of Catalytic Converter with Connecting Pipe

3.4 Structure

1. Base

Base in the tree is designed to give support and the hollow area inside the base is utilized to store air filtration system.

2. Branches

Branches plays an important role in this tree. To hold solar panels and wind turbine these branches are used (Figure 16).

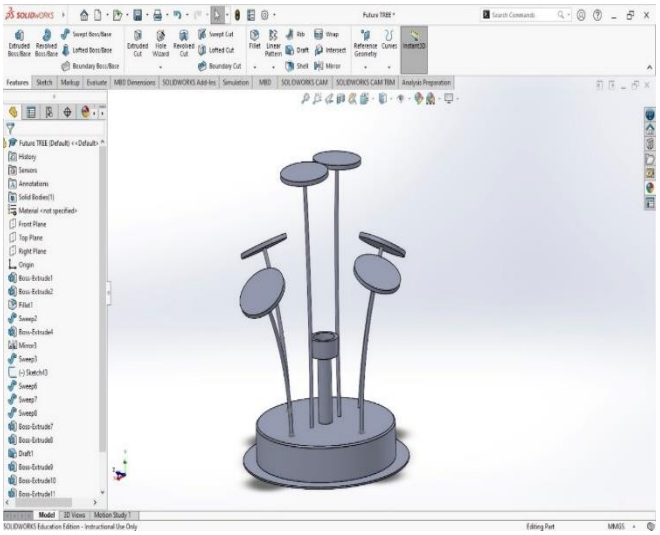

Figure 16 Design of Structure of Tree

3.4.1 Capacity and Material Used

- Tree can hold up to one 12 V 50 W Solar panel.
- 3 Wind Turbines
- Generates up to 220 V
- 259 W
- Material: Mils Steel
- Weight: 25-27 kg

4. Analysis

4.1 Structural Analysis of Tree

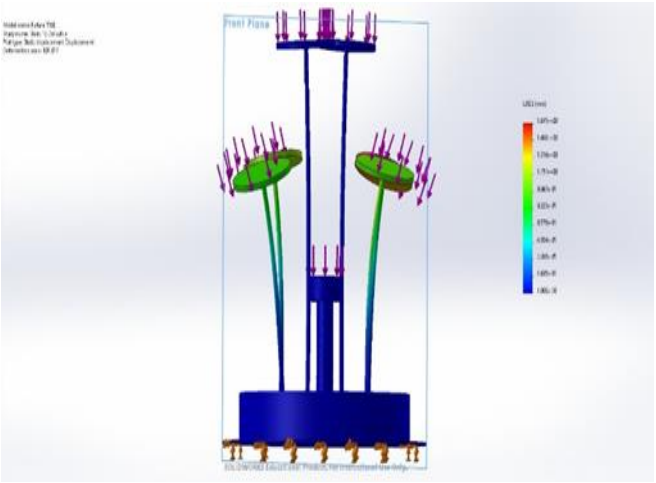

Figure 17 Structural Analysis of Tree

4.1.1 Discussion

It is the Limit that maximum tension that the branches of the hybrid tree can withstand. As per the analysis this tree can withstand load bellow 100 N (Figure 18 & 21).

4.1.2 Mathematical Analysis

- Formula: Eular's Buckling (Pe) = 4 π^2 E I /L e^2
- Le = L/2, I = π/4 (r^4)
- Where, Pe = Buckling
- Le = Effective length
- I = Moment of Inertia
- E = Youngs Modulus (200 for MS)
- Theoretically tree can withstand 1254.97 N

4.2 Air Flow Simulation

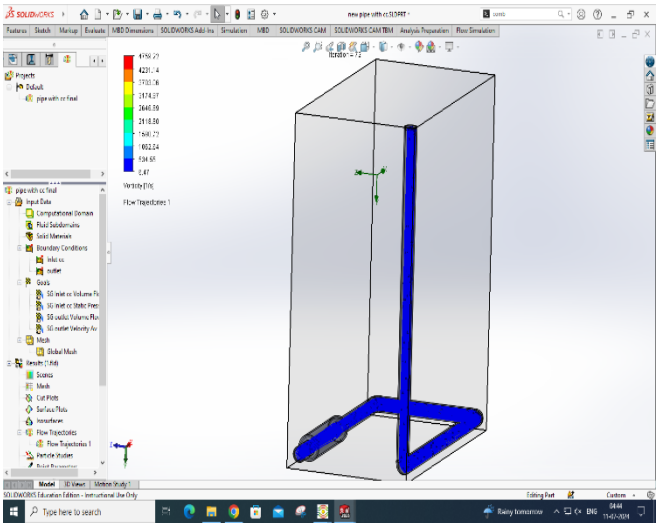

Figure 18 Air Flow Simulation

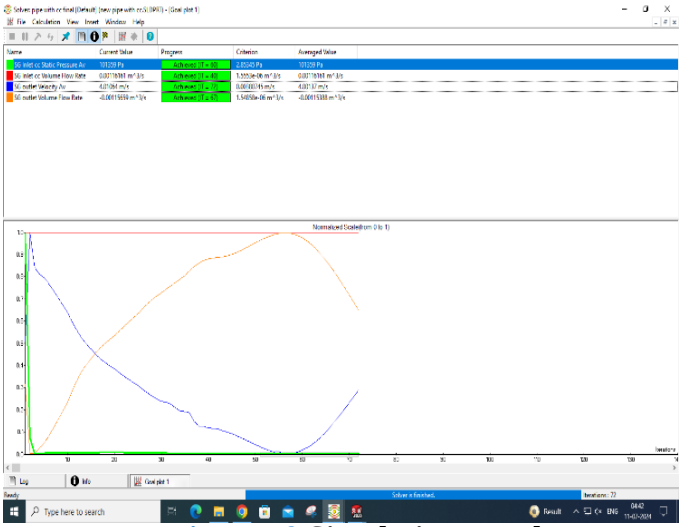

Figure 19 Simulation Results

4.3 Temperature Simulation

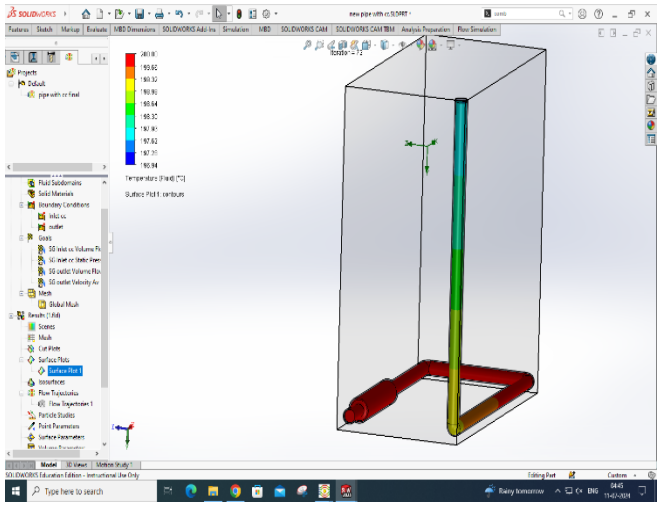

Figure 20 Temperature Simulation

4.4 Pressure Simulation

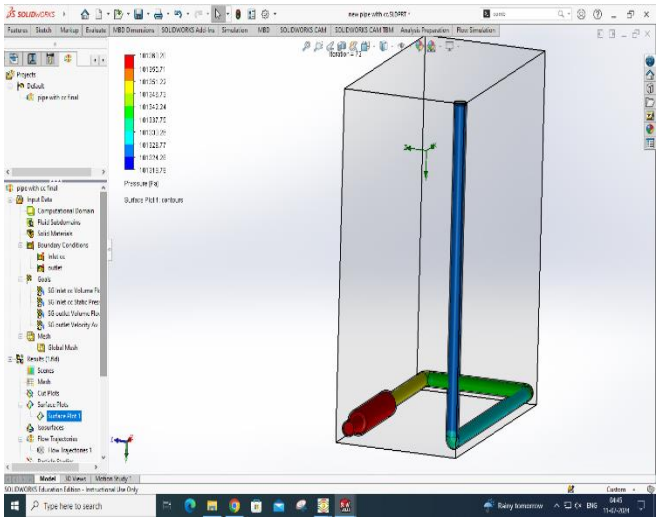

Figure 21 Pressure Simulation

5. Results and Discussion

5.1 Result

Table 1 Flow Simulation Result

Name	Current Valu	Criterion
Inlet Static Pressure	101359 Pa	2.85345 Pa
Inlet Volume Flow Rate	0.00116 m^3/s	1.5553 m^3/s
Outlet Velocity	4.01064 m/s	0.00038 m/s
Outlet Volume Flow Rate	-0.001156 m^3/s	1.5485 m^3/s

5.2 Discussion

Flow simulation through modelling can be used to obtain information such as behavior including Inlet and Outlet Temperature, Inlet and outlet pressure along with behavior of velocity of flow inside the pipe (Table 1). According to goal plot which is done in flow Simulation the inlet Static Pressure of Filtration system is 2.85345 Pa at volume Flow rate of 1.5553 m^3/s. Inlet velocity of atmospheric air is 3.9564 m/s and outlet velocity of filtered air at the outlet of the filtration system is 0.00038 m/s. Outlet Volume Flow rate as per goal plot is 1.5485 m^3/s.

Conclusion

Based on various parameters Future tree has more benefits compared to traditional solar and wind power installation methods. Future tree requires less Space so it is the best solution for requirement of land for installation of solar panels and wind turbine. Future tree is a decorative renewable energy generating thing so it is suitable for highways, streets, street circles, Signals, homes and many more places. The filtration system works efficiently on the street to eliminate pollutants from polluted air and has capacity to deliver filtered air to the atmosphere. Future tree has so many possible ways to upgrade according to Applications. Overall Future tree is economical and efficient way of generating Renewable Energy which is a need.

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