HYBRID ARTIFICIAL TREE FOR SOLAR/WIND POWER GENERATION

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Abstract

In today's life, this project introduces the Artificial tree which gives electrical energy and the oxygen. This tree provides an oxygen to be emitted in the air for breathing. For the electrical energy, the renewable sources of Solar and wind is used. The leaves mean solar panels and fans that are used for collecting sunlight and wind which is converted into light energy with the help of PV cell. The collect energy is then stored in battery there it can be used for street lighting. In this project, the artificial tree is designed and with the hybrid sources of Solar PV and wind power generation respectively. Here, the Solar power keeps the surroundings disinfectant and healthier. Photovoltaic cells that strap the solar power are an charming option for grab light and generate electric power. In this system, to identify the sunlight the Light Dependent Resistor (LDR) is used in the tree which directs the sun light and generates the power continuously.

Introduction

One of the biggest problems or challenges that humanity is currently facing is climate change. according to the current figures, this challenge will significantly impact the economy's growth. Increased usage of nonconventional or renewable energy sources is one of the best ways to address these issues. Natural processes continuously produce these unconventional sources. Solar energy, wind energy, geothermal energy, and other renewable energy sources are all used to generate electricity. Renewable natural resources, including sunshine, wind, rain, waves, and geothermal energy, are used to generate power. The primary renewable energy sources are typically solar, wind, hydro, biomass, and bio fuels. Flat or rooftop mountings of photovoltaic systems and wind turbines require a large land area. Scarcity of land is one of the biggest problems in modern societies, i.e., in cities/villages in India. The solar-wind hybrid tree provides a better alternative to conventional solar PV and wind turbine systems. A hybrid tree is an artificial structure that resembles a natural tree and has branches on top of which are mounted solar modules or wind turbines. The hybrid tree can be regarded as a tree generating renewable energy electricity. A PV module system needs ten acres of land to generate 2 MW of power. Solar trees, compared to typical SPV systems installed on buildings, a tall pole-like structure would only require 1% of the available land. It should be taken care that the top panels shouldn't obstruct the bottom panels to receive the most sun during the day. These solar trees can be put on any surface, such as a terrace, a location next to a house, the side of a road or highway, or even a border wall. Additionally, maintenance and dust removal are not significant issues. The generated energy was utilized to power devices like Wi-Fi modules, cold water drinking fountains, computer monitors, decorative night lighting, car parking sheds and smart phones and tablets.

Solar Energy

Solar radiation is light – also known as electromagnetic radiation – that is emitted by the sun. While every location on Earth receives some sunlight over a year, the amount of solar radiation that reaches any one spot on the Earth's surface varies. Solar technologies capture this radiation and turn it in to useful forms of energy. There are two main types of solar energy technologies photovoltaics (PV) and concentrating solar-thermal power (CSP).

Photovoltaics Basics

You're likely most familiar with PV, which is utilized in solar panels. When the sun shines onto a solar panel, energy from the sunlight is absorbed by the PV cells in the panel. This energy creates electrical charges that move in response to an internal electrical field in the cell, causing electricity to flow.

Concentrating Solar-Thermal Power Basics

Concentrating solar-thermal power (CSP) systems use mirrors to reflect and concentrate sunlight onto receivers that collect solar energy and convert it to heat, which can then be used to produce electricity or stored for later use. It is used primarily in very large power plants.

Wind Energy

Wind energy harnesses the kinetic energy of moving air by using large wind turbines located on land (onshore) or in sea- or freshwater (offshore). Wind energy has been used for millennia, but onshore and offshore wind energy technologies have evolved over the last few years to maximize the electricity produced - with taller turbines and larger rotor diameters. Though average wind speeds vary considerably by location, the world's technical potential for wind energy exceeds global electricity production, and ample potential exists in most regions of the world to enable significant wind energy deployment.

Literature View

A review of solar PV tree technologies, designs and potential future research directions was presented by Hyder et al. (2017) . The researchers contrasted the solar PV tree with the flat conventional solar modules and examined current commercial designs and solar tree applications. The researchers compared many solar tree standard structures which was available. The challenges with solar PV tree adoptions were highlighted by Hyder et al. (2018) along with potential solutions. Based on growing layers at varied tilt and orientation angles, the researchers created six distinct semi-dome designs for solar PV tree structures. At three different sites, the performances of these models were compared with a flat PV system using simulation. Based on location and applications, Dey et al. (2018) [28] presented the optimal orientation of solar panels utilized in a solar tree for getting optimal power output. The researchers conducted experiments at 15 distinct sites that covered a wide variety of latitudes in order to first study the direction of single panel optimization. According to the researchers, the orientation of PV modules could not be determined only by the latitude angle. Azimuth angle was also necessary, in that area where the sun irradiation was not uniform throughout the day. For the four separate locations, the researchers created solar trees with 1 kW ratings. By creating solar trees for two distinct locations using ray optic simulation, the researchers proved the shadow effect minimization. Shading loss was obtained as 2%.

Proposed Solar-Wind Hybrid Tree

The proposed design as illustrated in Fig. 1, consists of 3 solar panels and 2 vertical axis wind turbines. Each solar panel is of a rated capacity 250 W at 100 W/m2 . Each vertical axis wind turbine is of rating 200 W at 11 m/s wind speed. The total capacity of the proposed system is 3 kWp. Static structural analysis: Structural analysis of the tree structure is done with the help of the standard IS 875: Part-3. This limits the maximum tension that the branches of the hybrid tree can withstand according to equation $\tau v \leq S$ (22) Where, τv is the computed von Mises stress and S is the material's yield strength. The goal of structural optimization is to employ the least amount of structural material necessary to make the hybrid tree structurally stable at a design wind speed specified for a specific area in accordance with IS: 875 As a result, the hybrid tree structure's price will go down, which will lower the overall cost of the hybrid tree system. According to this equation (23), the tree is made to have a factor of safety of 2. $2\tau v \leq S$. Therefore, the maximum permitted stress at any of the branches or trunk in the hybrid tree structure for the mild steel taken into account in simulation has to be less than 120 MPa

Loading Conditions

The load in the hybrid structure is mainly due to three main things force due to wind, weight due to solar panel or wind turbine and mounting assembly, and self-weight of the structure. The base of the solar tree is then fixed, indicating that there is no base displacement. Additionally, the joints connecting each branch to the trunk are assumed to be welding joints. The hybrid tree structure is being loaded under 3.

Positioning of Solar Panels and Wind Turbines

The limitations in the x-y plane are set to optimization of panel placements for base case hybrid tree design. To determine the outside diameter and thickness, a preliminary optimization of the base case design is performed. Every branch is thought to be the same size. For the Vaddeswaram area vb is 50 m/s as per the guideline. Taking into account the structure's 25-year design life, the risk coefficient (k1) is 0.90. The terrain roughness factor (k2) is taken as 0.91 for terrain category 3 with closely spaced building structures up to a height of 10 m. Topography (K3) and significance (K4) are taken as 1 respectively. The design wind speed for Vaddeswaram location taking into account these variables is 40.95 m/s (about 150 kmph). The weight of 250 W solar panel or 200 W wind turbine roughly comes around 25 kg. Aluminum frames and the appropriate fixtures are part of the mounting system for these solar panels' orientation adjustments. The solar panels or total mass, including the mounting assembly or wind turbine's total mass, will be roughly 50 kg. As a result, Fg Is taken to be 500 N, applied in the z-axis downward direction. At eight locations on the structure that house solar panels or wind turbines, a 500 N load is applied vertically. The static structural analysis was carried out using ANSYS software.

The simulation results obtained from the structural analysis carried out using ANSYS software for the proposed hybrid tree structure for the variation in total deformation, directional deformation, equivalent von- mises stress and safety factor.

Energy Generation Analysis

Energy generation analysis was carried out using the HOMER Pro software. The energy generation from solar-wind hybrid tree system is dependent on solar irradiance, wind speed and temperature data. Yearly average solar irradiance data were obtained from the national renewable energy laboratory (NREL) database. The monthly average global horizontal irradiance (GHI) data for the proposed site location Vaddeswaram. The annual average solar irradiance is 5.11 kWh/m2 /day at this location. Monthly average global horizontal solar radiation was found to be in the range of 4.06–6.72 kWh/m2 /day. Wind speed data for the Vaddeswaram location was obtained from the national aeronautics and space administration (NASA) database. The monthly average wind speed varied from 3.56 to 5.52 m/s and the annual average wind speed was observed as 4.09 m/s at this location. Monthly average wind speed plot is shown in Fig. 15. The temperature data for the Vaddeswaram location was obtained from the NASA database. The annual average temperature at this location is 27.53 ◦C. The monthly average temperature variation plot. The von Mises stress affecting the entire tree structure was analysed. It was found that the stress in every branch was substantially lower than the maximum stress allowed (120 MPa) . It was found that, the overall tree structure's stress is within acceptable bounds. Studies looked at how the solar tree's numerous branches and stem moved under a wind load of 150 kmph while taking the factor of safety into account. The aforementioned displacement found using the simulation study is acceptable because the optimum selected hybrid tree design satisfies von Mises criterion with a factor of safety.

It has been observed that, the variations in all four parameters i. e. total deformation, directional deformation, equivalent von-mises stress and safety factor are well within the acceptable limit.

Conclusion

The idea of solar-wind hybrid tree is quickly gaining popularity since it can produce more energy occupying lesser ground space. Lack of knowledge, high shading losses and increased structural material requirements are significant obstacles that have a negative impact on its wide public acceptance. The high structural material requirements mostly account for the high expense of the existing hybrid tree designs. One of the goals of this review was to present the different designs A 3 kWp hybrid tree consisting of (2 kWp solar and 1 kWp wind) is designed for Vaddeswaram, Andhra Pradesh located at 16◦ 26′ 50′′ N, 80◦ 36′ 42′′ E was pro- posed. The proposed design is capable of producing more energy, at the same time having a lower structural material requirement. The hybrid tree's structural design was optimized for a wind load up to 150 kmph, considering factor of safety as 2. A mathematical model of SPV is presented with relevant character-elastic equations that are developed based on an electrical equivalent

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