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Solar Tracker System for Monitoring the Maximum Sun Potential that can be Produced in a Specific Place

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ABSTRACT

Power grids have been the mainstay of power systems for more than a century, supporting economic activity by bringing power to homes, industry and services. As the transition to green energy advances, the role of electricity will become more important, making power grids even more special to society and economies. The energy sector is going through essential changes such as decarbonization, digitalization, climate change etc. and as a solution, governments, industries and other stakeholders will need to establish new policies, regulations and updated market models for a new system in the future. Therefore, our purpose was to develop a system that can track the sun from sunrise to sunset, which can be placed in a specific location to record and store data about the maximum potential sun that can be produced. The solar tracker is guided by two step-by-step motors, creating horizontal and vertical movement so that the rising sun will fall perpendicular to the solar panel. The two motors are controlled with the mobile phone which stores data about the amount of energy that is produced. A prototype was made using parts from reused materials such as bicycle wheel, concrete mixer crown, computer elements, parts for chairs, etc. The system is independent of electricity, so it can be placed anywhere without being connected to an outlet. The motors and the data controller are powered by the energy produced by the solar panel in the form of a closed circuit.

Key words: *Solar tracker, Green energy, Independent system, Sun potential, Reused materials*

Introduction

The energy sector is going through essential changes such as decarbonization, digitalization, climate change, etc. and as a solution, governments, industries and other stakeholders will have to establish new policies, regulations and updated market designs for a new system in the future (IEA, 2023).

It is very difficult to live in a modern society without a reliable supply of electricity. The difficulties caused by the Covid-19 pandemic have reminded us of the importance of electricity in all aspects of our lives from keeping medical equipment in hospitals functional and IT systems available for teleworking and video conferencing. Following the studies, it was demonstrated that the effects of a prolonged interruption of the electricity supply far exceed the supply system or the value of the lost energy purchase itself.

Renewable energy sources such as wind and solar photovoltaic systems have become much cheaper than thermal energy generation and are increasing their share of supply. This development is welcome as countries seek to decarbonise the electricity sector.

According to IEA the International Energy

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Agency in the STEPS*, global solar PV deployment continues to expand from around 220 GW in 2022 to about 500 GW in 2030, but planned manufacturing expansion means that the utilisation rate of solar manufacturing remains below 40% through to 2030. The scope to make fuller use of solar manufacturing capacity represents an enormous opportunity to accelerate the deployment of solar PV around the world and accelerate energy transitions (IEA, 2023).

Solar energy is the most abundant renewable energy on earth. Every day, the earth's surface receives a sufficient amount of energy to meet the ever-increasing need for electricity for many years, without affecting the environment (IEA, 2017a; H.C. *et al*., 2024).

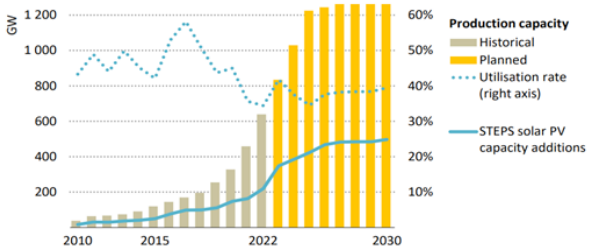

Fig. 1. Global solar module manufacturing and solar PV capacity additions in the STEPS, 2010-2030 [8]

Solar energy is exploited either through photovoltaic systems that transform solar radiation into electric current, or through solar thermal energy that produces electricity in a similar way to coal, gas and nuclear power plants, etc.

The use of solar energy appeared as a necessity of society to produce clean energy, offering numerous technical, environmental, ecological and financial advantages. Among the new solar energy conversion methods, photovoltaic solar cells have become the most popular. They are widely used for various applications, but they face significant limitations such as the land surfaces used for the implementation of solar panels, their fixed orientation, orientation that prevents the capture of sunlight throughout the day, this being realized only in certain hours of the day when the angle of incidence matches the optimal alignment of the panels (U.M. and N.T. 2023).

Thus, the energy efficiency obtained from solar systems is determined by the daily variations of sunlight.

Among the modern solar energy conversion methods, photovoltaic solar cells are the most popular and widely used for a variety of solar energy applications. Although a solar photovoltaic panel has proven to be one of the most efficient sources of green energy, collecting sunlight has become very expensive.

Solar energy, unlike the energy obtained from fossil fuels, is renewable and does not emit harmful emissions that affect the environment and human health, which makes it an attractive choice for reducing carbon emissions and preventing climate change. The electricity production obtained by the photovoltaic panels will be diminished if they are not directed towards the sun (A.A.O. *et al*., 2023.

Photovoltaic systems are often installed as fixed flat systems with predefined angles. This work focuses on building a solar tracking system that can accurately measure sunlight from sunrise to sunset.

The key to the successful implementation of energy policies is the inclusion of people at the center of all transitions to green energy. An increasing number of countries are allocating substantial financial means to support projects based on the transition to clean energy by individuals. Following the studies, it has been shown that Italy has implemented a national recovery and resilience plan in which it has allocated 2.2 billion EURO to support energy communities and self-consumption, which has led to an increase in the amount of green energy produced individually and used or loaded into the national energy system. This produced a decrease in energy production through other classical methods (IEA, 2023).

The system designed, uses sensors and motors to follow the course of the sun on the sky and to change the location of the solar panels depending on the location of the sun at a certain moment. This allows the maximum possible daytime amount of sunlight to be recorded, resulting in a very high production of electricity

Materials and Methods

The goal of our research was to create a completely autonomous system, with low costs using reusable materials, a system that will store solar energy throughout the day. Thus, we managed to create a solar tracker prototype, independent from the use of electricity, controlled with a mobile phone and capable of producing and storing energy. Wishing to use materials with the lowest possible cost and which do not affect the environment, we decided to

create the prototype using parts of various household components, which could be reused.

The principle according to which this project was carried out was based on the theory of the moment of force (Fig. 2) (R.B.I., 2022).

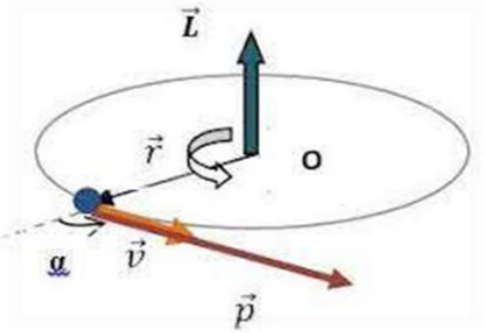

Fig. 2. Theory of the moment of force

To make the prototype we used a solar panel, two step-by-step motors, a car battery, an Arduino Uno board, sensors and reusable materials. Reused materials for this prototype were a bicycle wheel, concrete mixer crown, elements from a central unit of a computer, parts from an office chair, etc (Fig. 3).

Fig. 3. Parts from an office chair, Bicycle wheel, Concrete mixer crown, Elements from a central unit of a computer

The solar tracker is moved by two step-by-step motors. These motors made the system move horizontally and vertically, so that the sunrise will fall perpendicular to the solar panel. The two motors were programmed with the help of the Arduino board, which offered the possibility of creating an application and a database.

The application gives the possibility to guide the system or to restart it in case of an error with the help of the mobile, and to create a database that will store information about the amount of energy that is produced.

The chair leg provided stability to the project by becoming its base. The step-by- step motors were mounted on it, which actuated the bicycle wheel and the crown of the concrete mixer, thus realizing the movement of the system horizontally and vertically. For its stability, an iron frame was also created, on which the computer case containing the sensors and control plates was attached. A solar panel was placed at the top of the system, and a battery was installed at its base.

The system is electrically independent, so it can be placed anywhere without being plugged into an electrical outlet. The motors and the data controller will be powered by the energy produced by the solar panel in the form of a closed circuit. The data will be used to estimate whether investments in solar panel systems are profitable and can provide information on the energy produced on a daily, weekly, monthly or yearly basis.

The task of the system is to capture solar rays and produce energy. In order to increase the efficiency of this solar tracker so that it records and produces energy even on sunny or cloudy days, changing the orientation of the panel was considered. Thus, on sunny days, the panel is programmed to follow the position of the sun in the sky so that its surface collects all its rays, and on cloudy days, a search algorithm was created that controls the orientation of the panel to extract the greatest possible power from the light.

Fig.4. Solar tracker

Thus, with the help of a controller that combines an open-loop sun monitoring system with a dynamic feedback controller built on an active search algorithm, it helped to increase the possibility of producing electricity regardless of the weather.

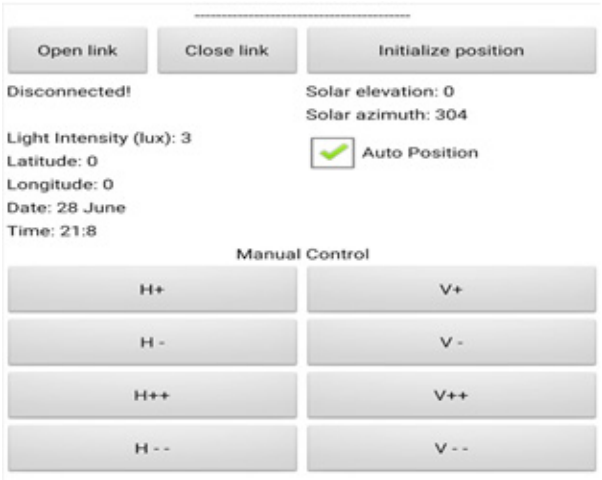

Fig. 5. The application that control the system with the phone

After the tests, it was found that the system is independent of electricity, so it can be placed anywhere, it does not need to be connected to the outlet. The motors and the data controller will be powered by the energy produced by the solar panel in the form of a closed circuit.

The data will be used to estimate whether investments in solar panel systems are profitable and can provide information on the energy produced on a daily, weekly, monthly or yearly basis. The advantage of the project is that we can control with the mobile phone and all data will be stored automatically without losing any information due to its own power supply.

Following the tests carried out on the prototype, it was established that it produces electricity, it can support itself independently, without the need to connect it to an outlet, and the data recorded by it were exported in the form of a graph that can be seen in Figure 6.

Results and Discussion

The paper describes the successful development of a solar tracker prototype capable of autonomously following the sun from sunrise to sunset. The prototype is designed to maximize the amount of sunlight captured by adjusting the orientation of the solar panels throughout the day. Two step-by-step motors are used to move the solar tracker horizontally and vertically, ensuring that the solar panels are perpendicular to the sun's rays for maximum efficiency.

Fig. 6. Values recorded in the database

The system is controlled using an Arduino Uno board and a mobile application, providing users with the ability to guide the system and monitor energy production.

The solar tracker prototype is constructed using reusable materials, including parts from household components such as a bicycle wheel, concrete mixer crown, elements from a computer central unit, and parts from an office chair. The goal was to create a cost-effective system that minimizes environmental impact by utilizing readily available materials.

The use of recyclable materials highlights the potential for sustainable engineering practices in renewable energy technology development.

Tests conducted on the prototype demonstrate its ability to produce electricity independently of external power sources, utilizing energy generated by the solar panels. The system is capable of storing energy throughout the day, ensuring continuous operation even in the absence of direct sunlight. Recorded data, including energy production levels, are stored automatically and can be accessed via a mobile application, allowing users to monitor system performance over time.

The paper emphasizes the environmental benefits of renewable energy sources, particularly solar energy, which does not emit harmful emissions and helps reduce carbon emissions. By providing a cost-effective solution for solar energy production, the prototype contributes to the transition towards cleaner and more sustainable energy systems.

The use of recycled materials and low-cost design strategies further supports the economic viability of renewable energy technologies.

The successful development of the solar tracker

prototype opens up possibilities for further research and innovation in the field of renewable energy technology.

The system's adaptability allows for potential enhancements, such as integrating additional sensors for monitoring environmental conditions or optimizing performance in response to meteorological phenomena.

The paper concludes by highlighting the importance of investing in renewable energy systems and the potential for continued growth in the renewable energy sector.

Overall, the results presented in the paper demonstrate the feasibility and effectiveness of the solar tracker prototype in harnessing solar energy for electricity production, while also emphasizing the importance of sustainability and innovation in addressing current and future energy challenges.

Conclusion

Future trends in the electricity sector such as energy transition and climate change require a rethinking of traditional ideas for ensuring electrical security. Many countries have begun to implement policy rules and practices that address unconventional ideas in the energy sectors, offering important options for obtaining electricity.

Thus, our idea to create an independent system for producing and storing electricity represents a way to fulfil the current requirements in the field of electricity.

The paper presents the results obtained following the development of a system that follows the sun from sunrise to sunset, which was placed in a certain location to record and store data about the maximum potential of the sun that can be produced. The solar tracker is made of 90% recyclable materials. The prototype was built through two ideas, one to develop a system that can be used by investors who want to build large scale systems and the second was to reuse materials that are easily to obtain from the house surroundings that are usually thrown. As it was seen due to the energy demand and the energy outlook the next years are concentrated to develop more systems that use renewable sources and, in the future, will be more investments in this field.

The system is powered by the energy produced by the solar panel in the form of a closed circuit. The data is used to estimate whether investments in solar panel systems in our area are profitable and can provide information on the energy produced on a daily, weekly, monthly or yearly basis. The advantage of the project is that we can control it with our mobile phone and all data is stored automatically without losing any information thanks to its own power supply.

Starting from the program interface guided by the phone, it can be adapted through different sort of sensors by recording and storing other types of data, connecting different sensors. Due to its accessibility the system can by changed and can by improved through the investors demands and can by adapted to meteorological phenomenon as hail, wind, snow, frost etc.

Conflict of Interests

The authors declare that they have no conflict of interests.

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