

RENEWABLE ENERGY

DEVELOPMENT OF A SOLAR TRACKER SYSTEM FOR PV PLANTS

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Abstract—

Solar energy, amongst other renewable sources still stands out as one of the rosy sources of energy due to its inexhaustible capacity, its cost free and totally environmentally friendly. Conversion of solar energy is through the optimization of Photovoltaic panels (PV), which is not really a new concept. However, though solar possesses these desirable qualities, there still lays a challenge of getting the best out of the systems. Low efficiency of renewable sources serves as a limitation to advance their potential. One of the ways to improve the efficiency of solar energy is through the development and integration of solar tracker system. A solar tracker is a mechanism developed to follow and track the sun's trajectory by focusing the PV panel's perpendicular to the beam of sun rays.

Keywords—

Solar tracker, efficiency, Photovoltaic, single axis, DC motor

1. INTRODUCTION

Solar energy still stands as one of the promising renewable sources of energy of which its optimization can make a significant improvement in promoting a sustainable environment the global village is aiming to achieve. The production of electrical energy from non-renewable resources of energy, in the form of fossil fuels, has not only provided the human race with its needs but also has caused enormous environmental problems the world is facing today. Despite the efforts being made about the need and optimization of renewable energy technologies, there still lies a challenge of getting a relatively high efficiency from these promising sources of energy. Undoubtedly the financial capital needed to set up facilities for the conversion processes still sky rock and this serves as a limitation for the establishment and development of such promising sources of energy.

The conversion of PV systems in conversion of solar energy to electricity is not a very new concept. The challenge with them is the efficiency of the system which represents one of the promising and challenging energetic technologies to both

the researchers and industries (1). Of the ways or technological methods in making significant improvement in these methods for better output is the *solar tracking system*. Though solar trackers are a good way of improving the efficiency of the systems, they however tend to be heavy and subjected to breakdowns.

Developing solar tracking systems is one of the promising technological developments, that has and proven to significantly have an improvement on the efficiency of the Photovoltaic systems. Solar tracking systems can be classified into two classes/categories; according to their moving-axis and their activity type (1), i.e. whether they are active or passively operated. In terms of moving-axis the systems can also be further classified with regards to their rotational axis whether the system is a single-axis or dual axis rotation. A single axis solar tracking system entail a tilted panel mount with a single electric motor to move the panel on a certain trajectory in relation to the sun's position.

Despite the fact that millions of money is channeled towards the development of such renewable technologies in promoting their benefits, as opposed to non- renewable ones, obtaining the optimum efficiency from the system still renders the system not highly effective in terms of getting the best out of the system. This is mostly the case in countries with slow economic growth. However integrating solar tracking mechanisms into fixed PV systems and in already existing systems and yet to be made designs could and will significantly improve on the efficiency of the systems by more than 30% (2). It becomes imperative to develop such methods not only to be innovative but also in the realization of the global efforts of phasing out fossil fuels which have over the past decades enormously given birth to some of the environmental, social and in some instances political problems the world is in the midst of. Advancing solar tracking technology will also assist in plans for attaining green environment but also play a vital role in sustainable development.

2. LITERATURE REVIEW

Renewable energy sources of energy are and still yet to be an important part of power generation that offers decreased negative effects to the environment. Besides their flexibility in

terms of lowered greenhouse gas emissions, they also offer or add to the energy mix thereby helping in cutting the costs of dependency on fossil fuels (3). Solar energy provides a sustainable supply of energy which is inexhaustible and free throughout. The concepts of PV systems as aforementioned before is not a very new thing, however the challenge is in optimizing the efficiency of the system and one way to do just that is the solar tracking system. Tracking of the sun with the mandate of obtaining and absorbing its energy is best achieved when the tilt angle of the panel(s) is synchronized to the seasonal changes of the sun direction (3).



Figure 1: a dual axis solar taking mechanism. Source [10]

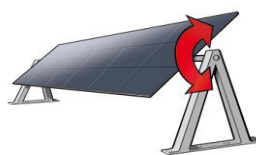
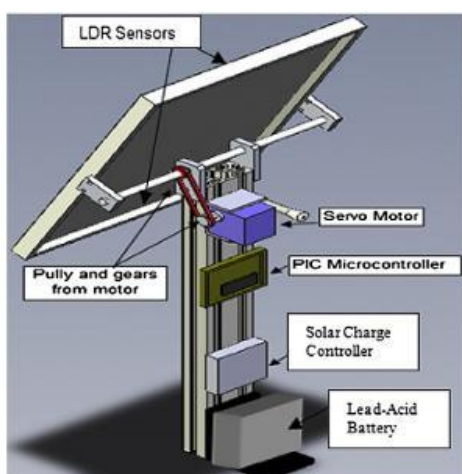


Figure 2: a single axis solar tracking. Source [10]

SOLAR TRACKERS

Solar tracking can be classified as actively or passively operated (1) [fig3 and 4]. Active solar trackers normally are much more electronically designed or integrated, including components such as microprocessor based, computer controlled based and time based, and also programmable logic control (3). Trackers which are microprocessor based would normally consist of a controller connected to the DC motors and also to sensors, i.e. photo sensors. What these sensors do is actually to measure the intensity of the solar irradiance, sends the signal to the microprocessor, and depending on the programming of the microprocessor, the DC motor rotates the panel to the direction of the sun, in which an incident ray or beam of light will be perpendicular to the panel.

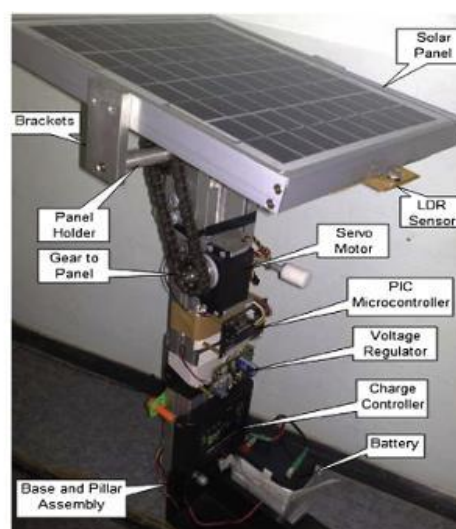


Figure 3: the images above depict a set of active solar tracking system with many electronic components (1)

Another solar tracker system would include a Bifacial Solar cell. Here the bifacial solar cell basically senses and drives the panel to the desired position. In this model, components such as batteries and driving electronics are eliminated (3). Using

the Programmable Logic Control (PLC) would require one to calculate the required position and program it into the PLC in order to adjust the PV panel to the sun's trajectory and direction (3).

According to (4) passive solar tracking devices do not really need to be facing directly at the sun to be effective. Continues to argue that if the degree of aim is off by 10 degrees the output is around 98%. (4) Highlights the use of one passive solar tracking system called the ZOMEWORK MODEL, which is a passive solar tracking product that is said to have installed around 17000 tracking systems since 1980 in different climates. Passive solar tracking systems can generate an output of 25% or more compared to the stationary model (4).

3. METHODOLOGY

Designing and building this single axis solar tracking system, firstly it would require a documentary study of various sources such as journals studied with the aim of acquiring a solid understanding of the operational principle of various

All the software's above will greatly assist in modeling the prototypes before it can be build, which is part of any engineering process in designing of artifacts or prototypes. The MATLAB software which is a high performance language for technical computing will be useful in any programmable job needed. MATLAB is more advantageous than other programming software's in such that it provides an environment that facilitates problems and solutions to be expressed in a more familiar mathematical notation. Its basic data is the matrix and allows graphical output to be optimized for operation. MATLAB will also facilitate the simulation of the design through SIMULINK, which is a block diagram environment for various simulation and model based design. Preference of SIMULINK to other software primarily include; its capability to provide a graphical editor and solve modeling and simulating dynamics system. PV syst is a wonderful

trackers. Methods of investigation in data gathering would include giving out a set of questionnaires to solar contracting companies, personal interviews and incorporating design techniques that would assist in advancing the realization of the project. Questionnaires will be used to capture particular information of need from the aforementioned organization and other relevant stakeholders.

As part of the objective, the project entails modeling and simulation of the tracker system's mechanism. In order to achieve this, a set of software's will be utilized such as:

- ❖ MATLAB
- ❖ Simulink
- ❖ Solid works
- ❖ PV Syst

photovoltaic software tool that will allow for the calculation of solar angles such as tilt and azimuth angles

Basically the use of software's will be optimized during the design and modeling stage

The active solar tracker will exclude the utilization of electronics. However it will include the following components for the positioning mechanism:

Design and methodology helps accomplishing the objectives by defining the tools and processes which are to be utilized throughout the quest of accomplishing.

Table 1: Materials to be used:

Mechanical components	Specifications	Control/Electrical components	Specifications
Stainless steel rods	100mm	PV panel	745 x 350 x25mm polycrystalline panel
Stainless steel square rays	1000mm		
Stainless steel circular plate	Diameter : 500mm		
Worm gears			
Transmission shaft	500mm		
DC motor			
Bolts and nuts			

Justification of materials to be used

- With regards to the materials to be used it was a selection of choice between stainless steel and aluminum. Aluminum is a good choice of material because of its metallurgical qualities such as being light than steel, and cheaper than steel as well. Steel on the other hand is strong, less likely to deform when subjected to weight, or heat, when compared to aluminum. Steel is also denser than aluminum and therefore will its qualities will assist in guarding the system against strong winds, thereby giving it a bit of stability.
- From the literature review, the motor drive system chosen for movement execution was : 24V, 3A, 3000rpm

The modeled concept

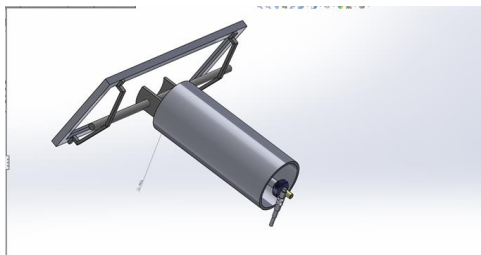


Figure 4: Proposed Concept

This concept uses the gear mechanism to drive the panel, actuated by a motor. It consists of mainly two elements which is the driving element (screw), driven element (helical gear). The driving element in this case is called or referred to as the worm and the driven element called the worm wheel. In this type of gear, power will be transferred from the worm (actuated by a motor) to worm wheel. The shaft will in turn rotate the panel from sunrise to sunset.

The above model was chosen looking at a number of reasons such as trends and the accuracy of which it is far better than the previous concepts. Also the stability of the system was also a factor keyed in.

Advantages

- ✓ Can be used to reduce speed
- ✓ Occupy less space
- ✓ Self- locking

Operates silently and smoothly

4. CONCLUSION

Solar energy, amongst other renewable sources still stands out as one of the rosy sources of energy due to its inexhaustible capacity, its cost free and totally environmentally friendly. Conversion of solar energy is through the optimization of Photovoltaic panels (PV), which is not really a new concept. However, though solar possesses these desirable qualities, there still lays a challenge of getting the best out of the systems. Low efficiency of renewable sources serves as a limitation to advance their potential. One of the ways to improve the efficiency of solar energy is through the development and integration of solar tracker system. A solar tracker is a mechanism developed to follow and track the sun's trajectory by focusing the PV panel's perpendicular to the beam of sun rays. Solar tracking can increase the energy yields by more than 25% compared to stationary solar panels

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