TIME-BASED TILTING PHOTOVOLTAIC RE-ROUTER

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ABSTRACT

Energy is an essential input for economic development. Since exhaustible energy sources in the country are limited, there is an urgent need to focus attention on the development of renewable and alternative energy sources. Solar energy is the best natural solution to many problems as the sun usually is providing abundant energy which provides power to almost everything on earth. The primary goal of this Project Development Study was to develop a Time-Based Tilting Photovoltaic Re-router which is a modified way of installing a solar panel. It will be a significant endeavor of the researchers who believed that this would be of great benefit for the users of photovoltaic technology in Batangas province. The project is intended to move the panel at best possible angular position concerning the position of the sun. It is a time-based motion control device which aims to increase the utilization of a solar power generating material by improving the conventional way of installing solar panels. It was designed to make time-based movements of the solar panel. It was primarily, residents from the area in Batangas will be the primary beneficiaries of this project for it will help them to improve their way of living and upgrade their accuracy of generating power. Every household would also be a benefactor of this study, considering solar energy as a source or co-source of electricity and it can lessen the growing payment of commercial electricity. The project was tested and proven to be efficient, safe, durable and can generate higher power rating compared with the conventional installation of solar panels.

Keywords: Renewable Energy Act of 2008 (RA 9513) Project Development Study, Experimental Research, Higher Education, Philippines

INTRODUCTION

Solar energy is the cleanest and most abundant renewable source available. Modern technology can harness this energy for a range of uses, including generating electricity, providing light or a comfortable interior environment. Renewable energy provided 26.44% of the total electricity in the Philippines and 19,903 gigawatt-hours (GWh) of electrical energy out of a total demand of 75,266 gigawatt-hours according to the Philippine Power Statistics (2013). In 2015, three solar farms were constructed in the Philippines. The Philippines receives over 7kWh per square meter per day during its peak month of April and lowest at 3kWH per square meter per day during its off-peak month of December as observed by Schadow1 Expeditions in 33 cities of the country. The Philippine government has passed four laws that seek to improve the state of renewable energy. These are the Electric Power Industry Reform Act of 2001 (RA 9136); the Biofuel Act of 2006 (RA 9367); the Renewable Energy Act of 2008 (RA 9513); and the Climate Change Act of 2009 (RA 9729). The Electric Power Industry Reform Act (2001) also known as EPIRA encourages the use of renewable energy mainly through private sector investment. However, different groups and lawmakers deliberated that it only strengthened monopolies and caused electricity rates to double after a decade of enactment. The Biofuels Act (2006)

tried to reduce the Philippines' dependence on imported fossil fuels. It emboldens investment in biofuels through incentives including a reduced tax on local or imported biofuels. The Renewable Energy Act (2008) mandated a minimum percentage of a generation of electricity from renewable sources. Also under this act, a feed-in tariff system was implemented for electricity produced from renewable sources, giving producers the security of long-term fixed prices. A minimum percentage of electricity from renewable sources for the off-grid missionary electrification system was also mandated. The Climate Change Act (2009) enacted to include a gender-sensitive, pro-children and pro-poor perspective in all climate change and renewable energy efforts. Advanced researches to find more renewable sources are conducted to discover more efficient to find ways, to support the growing needs of humankind. Solar energy is the best natural solution to many problems as the sun is continually providing abundant energy which provides power to almost everything on earth. Previous researchers have found that it's more useful in many places to have solar panels facing west to catch sunlight during electricity peak demand in the afternoon and early evening hours. There are also some studies that fix installation depends upon the location of the establishment. Based from the conventional way of installing solar panels in the Philippines, it must be 29.5° horizontal facing the South from January to June and 5.49° horizontal facing the North from July to December to have a better generation of electricity. Commonly, off-grid solar power systems are fixed-mounted on a frame, ordinarily on the roof of residential houses or commercial establishments, which only harvest sufficient solar energy on specific time when the panel is directly angled at the sun rays, because of this daytime duration is not fully utilized and the efficiency of the solar power system has decreased. The researchers conducted this project development study which is experimental research that proved that the more sunlight reaches the solar panels, the more electricity it can generate for an hour. To generate more electricity, the proponents tried to install the solar panel in the best possible angular position and used a re-router so the panels can move on the best angular position with respect with the position of the sun. The project is a time-based motion control device which aims to increase the utilization of a solar power generating material by improving the conventional way of installing solar panels.

RELATED WORK

Different works of literature and studies gave the foundation and background in the development of the proposed system, the developed Time- Based Tilting Photovoltaic Re-Router

According to Reddy (2011), Converting solar energy into electricity or hydrogen fuel using PV cell is one of the most attractive keys to modern energy issue because solar energy is produced with almost zero carbon emission.

On the study of Ghazali (2012), solar energy absorbed by a solar panel or photovoltaic cell (PV). "Photo" meaning light and "voltaic" meaning electricity. Photovoltaic systems use silicon cells to convert solar radiation into electricity. The PV system captures the sun's energy using solar photovoltaic cells. The cells convert the sunlight into electricity, which can be used to run household appliances and lighting. Each cell is made from one or two layers of semiconducting material, usually silicon. Mostly when the light strikes the cell, a particular portion of it absorbed by semiconductor – energy transferred to the semiconductor. The energy knocks the electron, allowing them to move freely. PV also has an electric field that only allows electron move in a particular direction. This flow of electron we called current.

Moreover, the study of Abdullah (2008) emphasized that solar energy is the light and radiant heat from the sun that influences Earth's climate, weather and sustains life. Solar power of more especially to refer to electricity generated from solar radiation. Solar radiation is secondary resources like as wind and wave power, hydroelectricity and biomass account for most of the available flow of renewable energy on earth. Solar energy technologies can provide electricity generation by heat engine or photovoltaic means,

space heating and cooling in active and passive solar buildings; potable water via distillation and disinfection, daylighting, hot water, thermal energy for cooking, and high-temperature process heat for the industrial process.

The study of Baharin (2010) discussed that a photovoltaic module or photovoltaic panel is a packaged interconnected assembly of photovoltaic cells also known as solar cells. The photovoltaic module, know more commonly as the solar panel, is then used as a component in a larger photovoltaic system to offer electricity for commercial and residential application. The primary difficulty with solar power and indeed with its cause with power has been one of efficiency. There is more than enough energy heating the earth in the form of solar radiation to meet the power needs of species. Estimates indicate that there is four times as much wind energy available for our use as the species uses every year. So, the difficulty has never been the availability of sun and wind, and they are readily available.

Likewise, Collins et al. (2004), stressed that a charge controller is a switching device that can connect and disconnect the charger to the battery and it will take control over charging and to stop charging and regulate the power going from the solar panels to the batteries. A microcontroller in the circuit will read the level of the batteries and then cut off the source of the panels to the batteries. The advantage of having a microcontroller in the system is that it will open a variety of features to add to the system.

OBJECTIVES OF THE STUDY

The primary aim of the study is to design and develop a Time-Based Tilting Photovoltaic Re-router, a modified way of installing a solar panel. Specifically, the researchers seek to achieve the following (1) To evaluate the existing design of panel installation for further improvement. (2) To design and fabricate Time - Based Tilting Photovoltaic Re-router out of locally available materials (3) to evaluate the performance of the equipment by comparing the following with the conventional solar panel (a) Peak Power output (b) Total Power Output (4) to provide an operational manual of the Project.

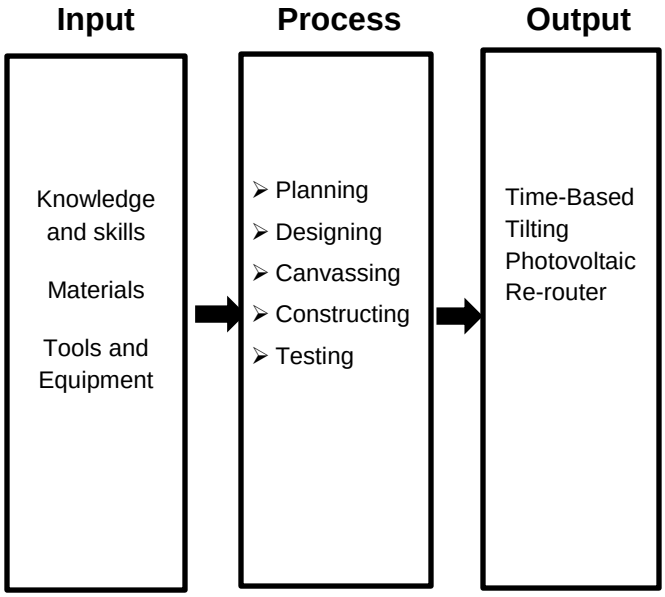


Figure 1. Research Paradigm of the Project

MATERIALS AND METHODS

This presents the research design and methods employed in the completion of the study. This Project Development Study used experimental-qualitative research. The research study divided into four stages these are the pre-design stage, design stage, fabrication and assembly, and testing stage.

1. Pre-design Stage

This stage comprises the methods followed by the proponents in gathering the specific data essential to the completion of the study. Also, in this stage, the researcher obtained data and information by conducting interviews, discussion with professionals about the subject matter, evaluation of the existing systems and designs, and identification of methods to be employed in the study. The proponents set performance indicators. Good design criteria are considered in the research and the following parameters are performance, effectiveness, durability, and safety.

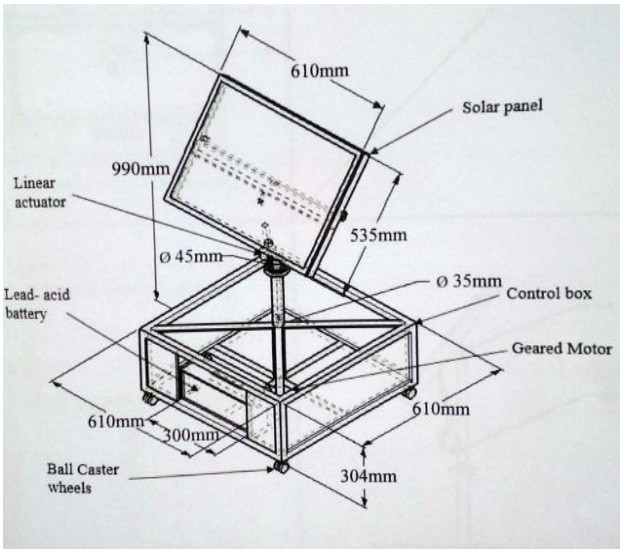


Figure 2. Projected Design of the prototype

2. Design Stage

This design focused on the actual design process. The design of the Time-Based Tilting Photovoltaic Re-router started with the functional requirements. Based on the obtained data and information from the pre-design stage, the researcher will be able to come up with a working layout and schematic diagrams.

3. Fabrication and Assembly

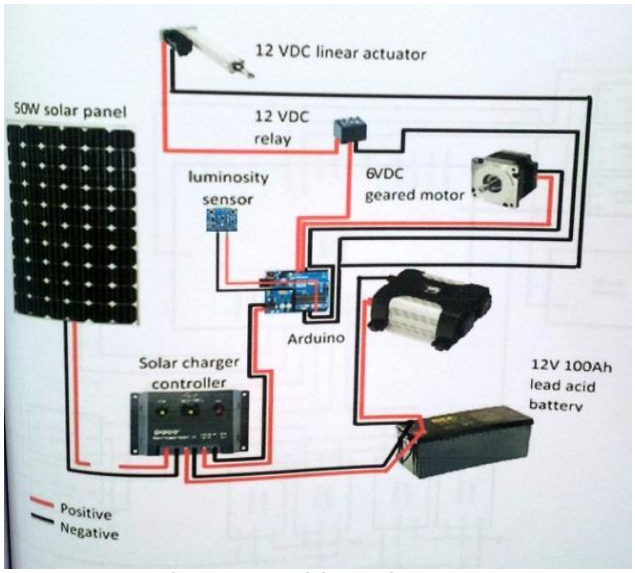


Figure 3. Wiring Diagram

In this part of the study, the project was fabricated. With all the appropriate materials selected, construction followed eventually. The fabrication and assembly were divided into Hardware fabrication and wiring installation.

3.1 Hardware Fabrication

Proper assembly and fabrication of the components were included in the design. The components used for the hardware of the system were chosen under the specifications and desired output. The compatibility of the components to the current device was greatly considered for better performance of the system.

3.2 Wiring Installation

Wiring installation comes after the fabrication of the metal frame wherein the DC motor, solar panel, the battery, and the other components were installed and connected based on the target output.

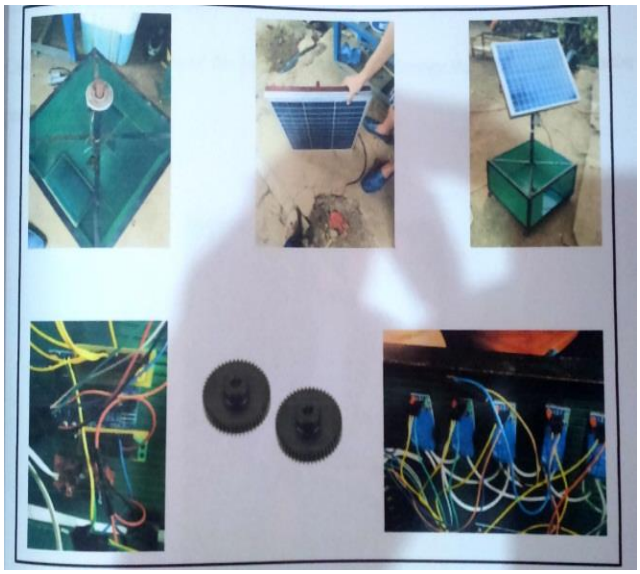


Figure 4. Project Assembly and Wiring

3.3 Testing

The system was tested based on performance indicators stated in the pre-design stage. The system was also tested to ensure the reliability of the instruments used. The

performance of the instruments was evaluated and analyzed to determine the capability of the system to produce the desired output

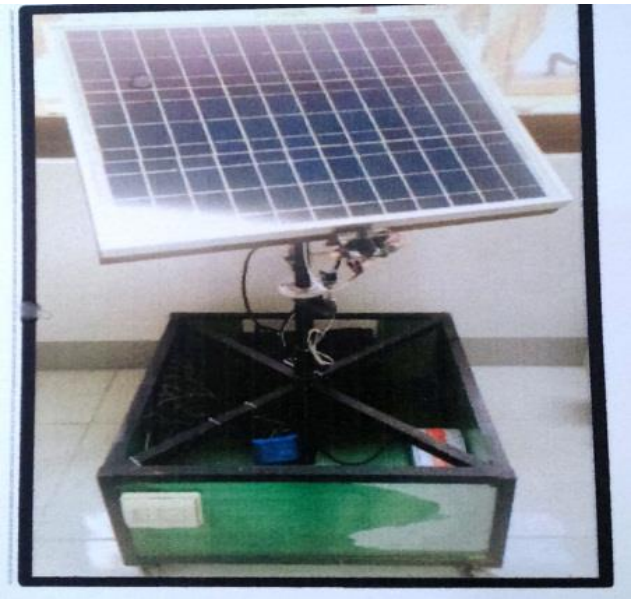


Figure 5. The Completed Time-Based Tilting Photovoltaic Re-router

RESULTS AND DISCUSSIONS

This Section consists of the gathered test results of the researchers. The data gathered were analyzed to measure the reliability and functionality of the system as a whole.

1. Evaluation of the existing design of panel installation

Most solar power systems are fixed mounted on a frame, ordinarily on the roof of residential houses or commercial establishments which only harvest sufficient solar energy on specific time when the panel is directly angled at the sun rays, because of this daytime duration is not fully utilized and the efficiency of the solar power system has decreased.

2. Locally Available Materials

The table 1 below shows the list of locally available materials used in the completion of the project. The materials used in the construction were carefully selected to ensure the quality, performance and the durability of the output. They were selected based on their availability and ease of use.

Table 1. List of Locally Available Materials and their functions

Materials	Function(s)
Battery	The device that produces electricity a chemical reaction.
Solar Panel (200W)	Serves for the collection of solar cells.
Solar Charge controller	Prevents overcharging and may protect against overvoltage.
Inverter	A device used to convert the 220V AC to 24V DC.
Geared motor	Used to move the panel in the x-axis.
Relay	Device responsible for switching the direction of the actuator and geared motor.
Angle bar	Used to build the frame of the prototype.
Linear actuator	Used to move the panel in the Y axis.
Flat Metal Bar	Used to build the supporting frame of the solar panel.
Stranded Wires	Bear mechanical loads or electricity.

3. Comparison of the Conventional Solar Panel with the Time-Based Tilting Photovoltaic Re-router

It can be gleaned from the table below that the peak output is 26 W and its total power output is 182W which is lower than the peak output and total power output from table 3 which is 34W and 247W respectively. The proponents found that the system is highly effective in increasing the output of solar energy harvested compared to fixed frame systems.

Table 2. Performance of the Time-Based Tilting Photovoltaic Re-router

Time	Ambient Temperature (°C)	Cell Temperature (°C)	Solar Panel Efficiency (%)	Power Output (W)
12:00 AM	24.6	24.6	82.1	0
1:00 AM	24.3	24.3	82.3	0
2:00 AM	24.1	24.1	82.4	0
3:00 AM	23.7	23.7	82.6	0
4:00 AM	23.4	23.4	82.7	0
5:00 AM	23.0	23.0	83.0	0
6:00 AM	23.5	23.4	82.8	0.167
7:00 AM	24.0	26.6	81.2	5.978
8:00 AM	25.0	31.7	78.8	16.425
9:00 AM	26.0	30.6	79.3	22.133
10:00 AM	27.2	32.8	78.2	23.693
11:00 AM	27.0	31.3	78.9	26.142
12:00 PM	29.0	33.9	77.7	25.164
1:00 PM	29.4	35.6	76.9	21.183
2:00 PM	29.7	33.6	77.8	19.807
3:00 PM	30.0	34.8	77.2	14.926
4:00 PM	30.0	34.1	77.6	6.571
5:00 PM	29.0	28.3	80.4	0.209
6:00 PM	29.5	29.5	79.8	0
7:00 PM	30.0	30.0	79.6	0
8:00 PM	27.5	27.5	80.8	0
9:00 PM	25.0	25.0	82.0	0
10:00 PM	25.2	25.2	81.9	0
11:00 PM	24.0	24.0	82.5	0

Peak Power Output	**26 W**	**Total Power Output**	**182 W**

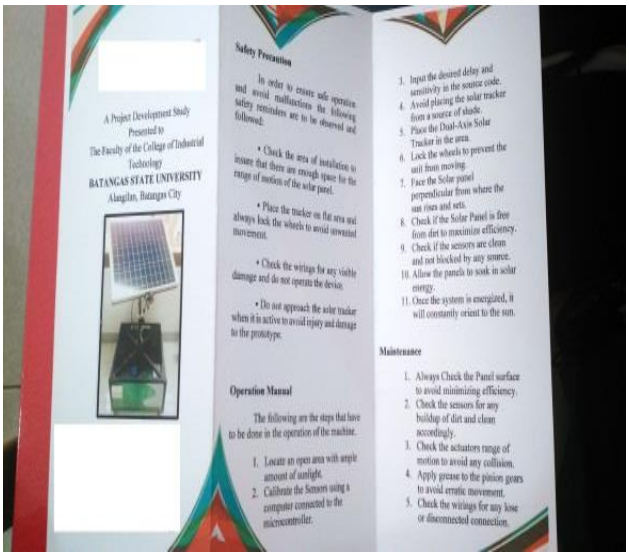
Table 3. Performance of the Time-Based Tilting Photovoltaic Re-router

Time	Ambient Temperature (°C)	Cell Temperature (°C)	Solar Panel Efficiency (%)	Power Output (W)
12:00 AM	24	24.00	82.5	0
1:00 AM	22.2	22.2	83.4	0
2:00 AM	22.2	22.2	83.4	0
3:00 AM	22.2	22.2	83.4	0
4:00 AM	22.2	22.2	83.4	0
5:00 AM	22.1	22.1	83.3	0
6:00 AM	22	20	84.4	0.192
7:00 AM	26.3	31.26	79.0	9.137
8:00 AM	26	42.02	73.8	22.059
9:00 AM	26	38.85	75.3	22.65
10:00 AM	28.1	45.36	72.1	25.931
11:00 AM	30	50.36	69.7	30.138
12:00 PM	31	53.41	68.2	32.388
1:00 PM	30.8	49.93	69.9	34.007
2:00 PM	30	47.48	71.1	31.468
3:00 PM	30	45.15	72.2	25.006
4:00 PM	30.8	38.00	75.7	13.461
5:00 PM	28.9	28.68	80.2	0.528
6:00 PM	27	27	81.0	0
7:00 PM	26.6	26.6	81.2	0
8:00 PM	26.6	26.6	81.2	0
9:00 PM	26	26	81.5	0
10:00 PM	25.7	25.7	81.8	0
11:00 PM	25	25	82.0	0

Peak Power Output	**34 W**	**Total Power Output**	**247**

4. Proposed User's Manual

The user's manual was developed to assure the safety of its user. The manual contains the parts of the Time-Based Tilting Photovoltaic Re-router, the operational procedure of the project and safety measures and its maintenance. The proponents provided an operational manual so anyone can do the proper maintenance and use the Time-Based Tilting Photovoltaic Re-router. Proper maintenance should be done regularly to maintain its excellent performance while in



operation.

Figure 6. User's Manual

CONCLUSIONS

After a series of test and evaluation, the researchers found out that the project was functioning effectively. Any individual could use it. The following were the conclusions formulated anchored from the findings of the study:

1. Conventional installation of solar panels has a limited amount of energy for it has an only specific time of use.
2. The developed project was designed and constructed based on the availability of the materials.
3. The prototype delivered higher power output and efficiency loss due to heat than the conventional solar panels.
4. The operation manual was essential and useful in maintaining and proper operation of the prototype.

RECOMMENDATIONS

Guided by the analyzed findings and conclusions, the following were hereby recommended:

1. Further modifications and development of the project to further increase the efficiency of the system.
2. Series of evaluation as to the extent of solar power generation should be made to identify apparent lapses.

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