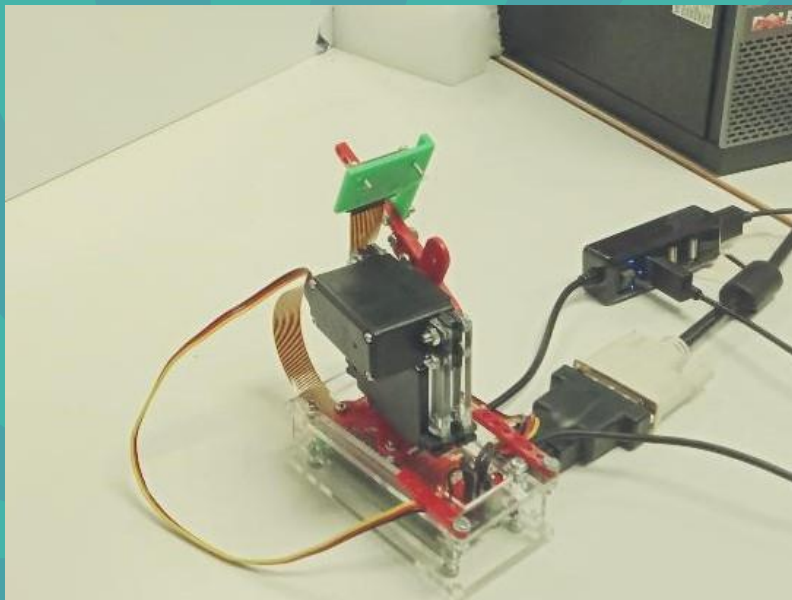


THE FUTURE OF SOLAR POWER



**Invest in a Revolutionary Solar
Tracking Product**

Elgene Menon Leo Anthony

Introduction

Solar Power is incredibly important to the future of human civilization. Currently most of the world's energy is provided by non-renewable energy sources such as oil, natural gas and coal.¹ However, using such energy sources comes at a high price to our planet. The greenhouses gases released by using such sources is greatly contributing to climate change.² There is a global effort (codified by the Paris Agreement) to keep climate change under an increase of 2 degrees Celsius.³ The United Nations Intergovernmental Panel on Climate Change says in order to have a 50% chance of doing this we must not emit more than 275 billion tons of carbon.⁴ This will entail leaving more than 70% of the world's non-renewable energy sources in the ground.⁵ Because of this there will be a massive shortfall of energy sources compared to energy demand in the future.⁶ This is why Solar Power is so important. It is a renewable energy source.⁷ It produces no pollution during its functioning.⁸ It can provide power in locations in areas conventional energy cannot reach as it can be constructed onsite and does not have to be connected to the electrical grid.⁹

A major problem with solar power up to this point has been that solar panels can only face in one direction. The sun however changes position throughout the day. This means that solar panels are creating much less power than they could if could follow the movement of the sun throughout the day.

Therefore, the problem that this invention attempts to solve is – how can a solar panel be made to follow the movement of the sun throughout the day?

¹ Enerdata. (2019). Global Energy Statistical Yearbook 2019. Retrieved from <https://yearbook.enerdata.net/>.

² Hannah Ritchie. (2017, June). How long before we run out of fossil fuels? Retrieved from <https://ourworldindata.org/how-long-before-we-run-out-of-fossil-fuels>

³ Ritchie, 2017.

⁴ Ritchie, 2017

⁵ Ritchie, 2017

⁶ Ritchie, 2017

⁷ National Geographic. (2019). What is Solar Energy? Retrieved from <https://www.nationalgeographic.com/environment/global-warming/solar-power/>

⁸ National Geographic, 2019.

⁹ National Geographic, 2019.

Concept and Proposal

Concept

In order to make a solar panel track the movement of the sun throughout the day two things are necessary – a mechanism to adjust the position of the solar panel and software to visually track the movement of the sun and adjust the position of solar panel accordingly.

The Mechanism

In figure 1 there is a picture of the mechanism that adjusts the position of the solar panel. There are two black boxes – one standing vertically and the other horizontally. These are called servos and they are small electrical motors that are used to move other components. On the top of the horizontal servo you will see a green piece of plastic attached to the horizontal servo by a red rod. The piece of plastic holds a camera (not visible in the Figure 1). It is connected by a gold ribbon to a clear plastic stand at the bottom of the two servos. Inside of this plastic stand is another flat piece of green plastic. This is called a Raspberry Pi which is a type of miniature computer. In Figure 2 to the right of the robot are three cords. The slim black cord leading to a USB hub connects the device to a mouse and keyboard. The other slim black cord provides power to the mechanism. The thick black cord with 1 black and 1 white connection points is used to load the software from a computer onto the Raspberry Pi. In Figure 2 there is a strand of multicolored wires leading from each servo to the Raspberry Pi.

The mechanism functions in the following way. First, the mechanism is turned on by connecting the slim black cord to a power source. The software is loaded onto the Raspberry Pi through the thick black cord from a computer. The software then uses the camera to determine the position of the sun. In a larger model the software would then use this information to adjust the position of the solar panel so that it follows the path of the sun. In this small prototype mechanism however, the software just uses the information to adjust the position of the camera so that it follows the path of the sun. The software adjusts the position of the camera side to side using the bottom servo. The software moves the camera up and down using the top servo which is connected to the camera with the red rod.

Figure 1

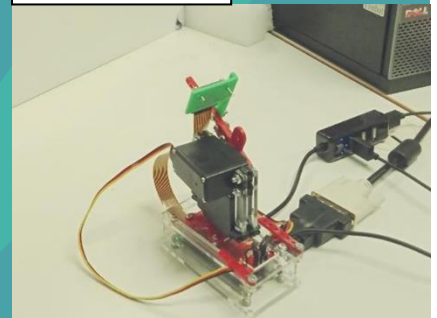
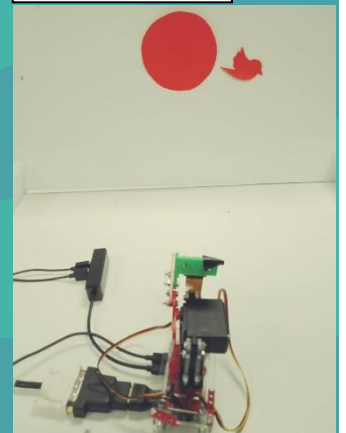


Figure 2



The Software

The most important part of this invention however is the software which allows a solar panel to adjust its position throughout the day to follow the path of the sun. To do this the software must accomplish two critical functions. The software must distinguish the sun from other objects and the software must adjust the solar panel to follow the sun if it changes position. In our experiments we use a red circle instead of the sun and we move a camera instead of a solar panel. Figures 3, 4 and 5 are from the testing phase of this invention and illustrate how the software works.

The software distinguishes the sun from other objects in the following way. The camera captures the image. The software uses computer code to scan the pixels in each image. The images are read by the code as numbers in columns and rows. The computer code looks through the numbers in each column and row to find the numbers representing the maximum red pixel value of the red circle. If you look at Figure 4 you will see how this is valuable. The red circle and the red bird have two different sets of maximum red pixel value. The computer code compares the two maximum red pixel values and chooses the bigger of the two which means it chooses the red circle.

The computer code also has a function called "edge detection." You can see this at work in Figures 3 and 5. The computer code measures the radius of the circle and uses this to determine the edge.

The software also uses computer code to follow the path of the sun. In our experiments we simulated this by moving the red circle to a different position. If the red circle is moved left or right the software will instruct the bottom servo to move in that direction. If the red circle is moved up or down the software will instruct the top servo to move in that direction.

Proposal

If sufficient funding was available, then this invention could be used to make a full sized 300-Watt power with 1-amp solar panel follow the path of the sun throughout the day.

The components of the mechanism would obviously be larger, but the actual software would remain almost the same. The software would simply be adjusted to search for the sun instead of the red circle.

Figure 3

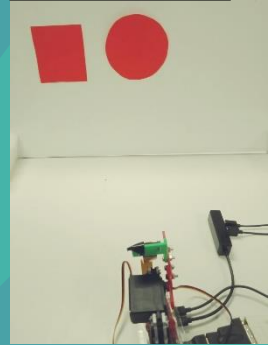


Figure 4

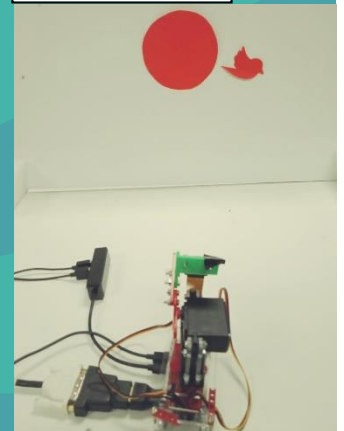


Figure 5



Full Scale Solar Tracker

Additional Energy Generated

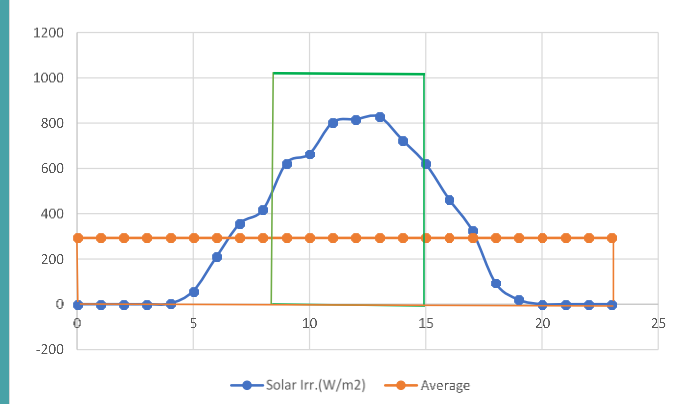
A solar panel that can track the movement of the sun can generate significantly more energy than the same size stationary panel. This is what makes this technology such a great investment. The following equations prove how much power a movable solar panel can generate. These equations were generated with the assumption of using a 300-Watt power with 1-amp of current and two 12 volts servos.

First the solar irradiance must be found. The standard test condition is 1000 W/m². The location used for the calculations is 5013 Point Howard, Lower Hutt. The date is the Summer Solstice. Figure 8 (found on the next page) is a table which shows the solar irradiance and the time. The calculation works by getting the average value of the solar irradiance which is 293. This data is plotted in a chart found in Figure 6. In Figure 6 the blue line is the solar energy W/m², the orange line is average solar energy and the green bar is the solar energy according to the standard test condition (STC).

The value of the green bar is calculated by taking the 1000 W/m² divided by 293 (average value of solar Irradiance) which is 3.41. Then 24 hours are divided by 3.41 which is 7.04 hours. Therefore, the total energy was calculated by taking a 300-Watt solar panel multiplied by 7.04 hours which is 2112 whrs. 2112 whrs is the maximum energy that can be produced by the panel in a stationary position. This is 70% of the energy the panel can produce.

To produce 100% of its energy the panel must rotate to follow the path of the sun. Calculating 100% of the energy use of the moving solar panel is done in the following way. Assume that the panel moves 5 degrees every time the sun moves 5 degrees and it takes the servo ten seconds to rotate the 5 degrees. The calculation is 180 degrees divided by 5 degrees which means the servo moves 36 times a day at 12 volts when it is turned on. To get the hours the mechanism runs for the following equation is used - 36 is multiplied by 10 seconds and multiplied by 2 servos and divided by 60 minutes and divided by 60 seconds. Therefore, the total time the mechanism runs is 0.2 hours. The total energy of the 2 servos is found by 12-watt multiplied by 0.2 hours which gives 2.4 whrs. When using the solar tracking system, you will get the maximum output of 3017 whrs. The increment is 905 whrs minus 2.4 whrs which is 902.6 whrs which is rounded up to 903 whrs. This is 30% higher than when the solar panel is stationary.

Figure 6



Design

Figure 7 shows a sketch of the 300-Watt Solar Panel with the solar tracking system attached. The solar panel is attached to a large upright pole which is supported by smaller pole pressing against it an angle. It sits on a concrete base. The solar panel is mounted on a metal panel support sheet which is attached to the large upright pole. Above the solar panel also mounted to the panel support sheet is the camera which tracks the movement of the sun and the computer system which holds the software the runs entire solar panel, the tracking system and the two servos. The servo that moves the solar panel left to right is mounted perpendicular to the large upright pole. The servo which moves the solar panel and the panel support up and down is mounted at the top of the large upright pole between the pole and the panel support sheet.

Cost Estimate

The estimated cost of the entire system is as follows. Polycrystalline solar panels are being used for this system as they are cheaper. First, two 150-Watt polycrystalline solar panel cost \$580.¹⁰ The energy monitor costs \$11.¹¹ The end stop switch costs \$36.¹² The cost of the 2 servos (linear actuators) is \$12 each meaning \$24 total.¹³ The H bridge is \$15.¹⁴ The microcontroller is \$13.¹⁵ The Dual Axis Solar Panel Tracking Controller is \$ 60.¹⁶ The charger is \$20.¹⁷ The camera is \$250.¹⁸ The labor costs are estimated as follows - \$100 per hour to write the software. The software took 10 hours to create which is \$1000. The manual labor costs to install the system are \$40 an hour for two builders and it takes them 4 hours to install the system. This equals \$320. Which makes the total labor cost \$1320 to design and install the entire system.

This makes the total cost of the system \$2330.

Figure 7

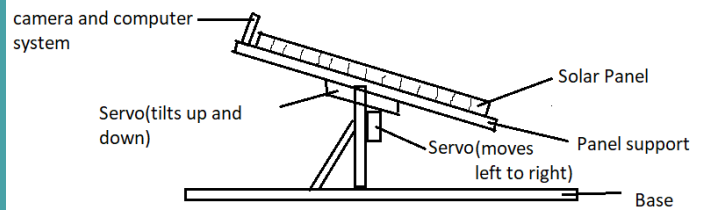


Figure 8

Time (Hour)	Solar Irradiance (W/m ²)
0	0
1	0
2	0
3	0
4	3
5	58
6	209
7	356
8	417
9	622
10	664
11	803
12	817
13	828
14	725
15	620
16	464
17	325
18	94
19	20
20	0
21	0
22	0
23	0

¹⁰ Ebay. (2019). Solar Panels. Retrieved from <https://www.ebay.com/itm/Solar-Panels-Premium-Quality-Eco-PV-Poly-Photo-voltaic-Panel-MC4-Boat-Caravan-/252394102201?var=&hash=item3ac3dc5db9:m:PSs2NtC2h3je5NLXE20Rtw>

¹¹ Ebay. (2019). Energy Monitor. Retrieved from <https://www.ebay.com/itm/Voltage-Current-Power-Energy-Combo-Meter-Car-Battery-Monitor-DC-6-5V-100V-0-100A/113145508572>.

¹² Ebay. (2019). End Stop Switch. Retrieved from <https://www.ebay.com/itm/10X-ME-8108-Momentary-Limit-Switch-Roller-Lever-CNC-Mill-Laser-Plasma-Waterproof/153107053525>.

¹³ Ebay. (2019). Line Actuators. Retrieved from <https://www.ebay.com/itm/DC-12V-Linear-Actuator-750N-Electric-Motor-Lift-50-800mm-For-Medical-Auto-Car/253758380421>.

¹⁴ Ebay. (2019). H Bridge. Retrieved from <https://www.ebay.com/itm/7A-160W-DC-12V-24V-Dual-DC-Motor-Driver-Module-Board-L298-H-bridge-Logic-Control/173966593071>.

¹⁵ Ebay. (2019). Micro Controller. Retrieved from <https://www.ebay.com/itm/NEW-MEGA-2560-R3-Development-Board-CH340G-ATMEGA-2560-Kit-USB-Cable-For-Arduino/123474847782>.

¹⁶ Ebay. (2019). Dual Axis Tracking Controller. Retrieved from <https://www.ebay.com/itm/12V-24V-Single-Dual-Axis-Solar-Panel-Tracking-Tracker-Controller-W-Relay-Module/113862844652?hash=item1a82c120ec:m:mAhTxXR2htqoSswRDluFdQ>

¹⁷ Ebay. (2019). Charger. Retrieved from <https://www.ebay.com/itm/100A-MPPT-60A50A40A-Solar-Panel-Regulator-Battery-Charger-Controller-12V-24V-USB/153403420744>.

¹⁸ Ebay. (2019). Camera. Retrieved from <https://www.ebay.com/itm/Reolink-Arduino-Eco-With-Solar-Panel-And-Rechargeable-Battery-Wire-Free-CAMERA-NEW/202708679855?hash=item2f3260fcac:g:Nz8AAOSwJPVdBehV>

