Affordable Photovoltaic Power for a Developing Planet -- "Smart PV"

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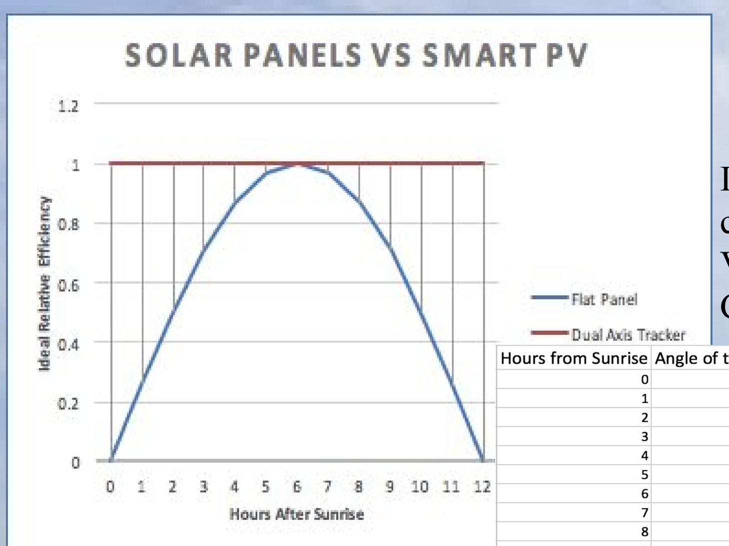
Abstract

The goal of this project is to develop a rugged, reliable photovoltaic power systems that costs a fraction of a traditional flat solar panel, and takes up a much smaller surface area. The system is being developed around high efficiency multi-junction solar cells that can withstand high temperatures. This project is aiming to build a system, based on astrophysical engineering principles, to track the sun, concentrate light onto a PV cell, and achieve even greater efficiency from the larger solid angle of sunlight intercepted. Ideally, the completed system may one day be utilized in developing nations to bring electricity to people around the world.

Introduction

- A large percentage of the population on Planet Earth do not have electricity.
- Electrical power is arguably one of the keystone enablers of growth of a modern civil society.
- Flat solar panels have poor efficiency, they take up lots of real estate, and environmental concerns are slowing growth in some regions.
- The project should ideally use 1/8 of the space of flat panels.
- The goals for this summer project have been to:
  - ➢ Complete the design, construction, and arduino programming for the first prototype.
  - ➢ Scale the model to an energy positive prototype and design it for future progress on this project.
  - ➢ Ideally we will be building the second model over the next few months, with the hopes of shipping it to a village in Uganda or Kenya for field testing.



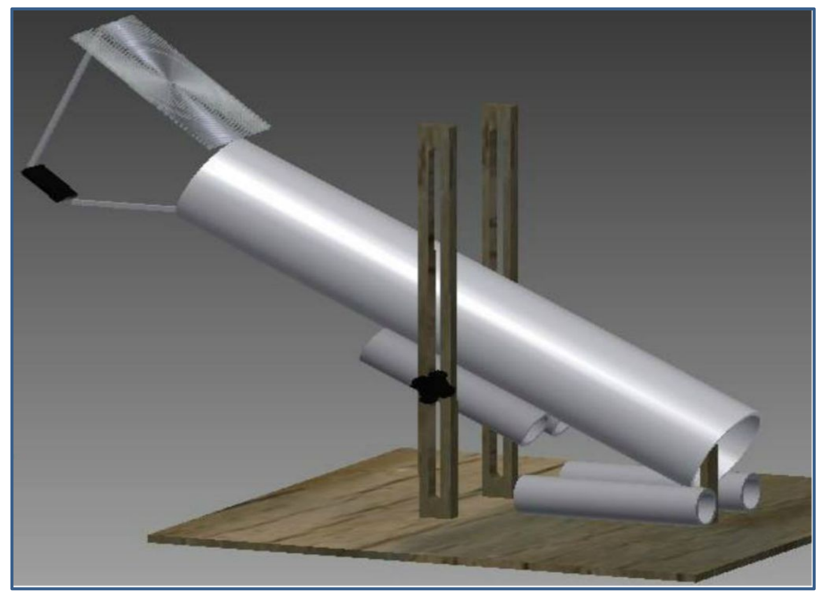
Ideal efficiency chart of Solar Panel Vs. Smart PV by Carl Pennypacker.

Hours from Sunrise	Angle of the sun	Flat panel flux=cos(zenith)	Flux Tracking
0	90	0%	100%
1	75	26%	100%
2	60	50%	100%
3	45	71%	100%
4	30	87%	100%
5	15	97%	100%
6	0	100%	100%
7	-15	97%	100%
8	-30	87%	100%
9	-45	71%	100%
10	-60	50%	100%
11	-75	26%	100%
12	-90	0%	100%

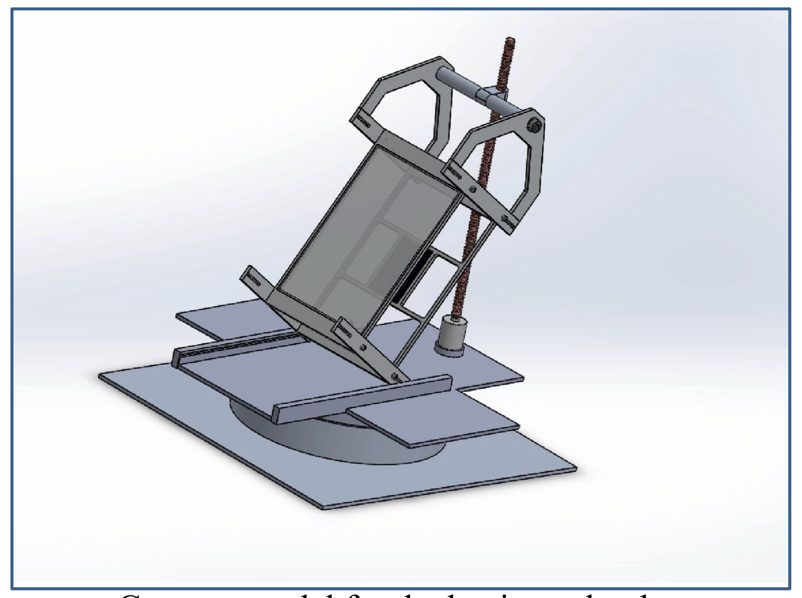
Methods

- This poster explores the designing process for the current prototype including Solidworks, drawing the models, wiring the Arduino, and programming the code.
- Most of the resources used on this project were accessible through either purchasing pieces online, altering the available parts, or designing entirely new pieces to be 3D printed when a 3D printer becomes accessible.
- Considerable help was provided by a machine shop expert, Cory Lee, one of the technicians at LBNL.
- The code was written in Arduino, and will allow the model to track the sun once it is assembled.
- There are many similar projects available online to view, a lot of time was spent researching the format, syntax, and functions used for other solar trackers' programming.
- Another goal of this project was to find a way to make the system respond to high wind conditions in a way that allows the model shift to a more aerodynamic position until the winds died down.
- So far, a viable wind gauge with no moving parts has been acquired and considerable research has gone into using it.
- Progress is being made to write the necessary code to reposition the model while taking into consideration the constraint that it must still be facing the sun to generate electricity.

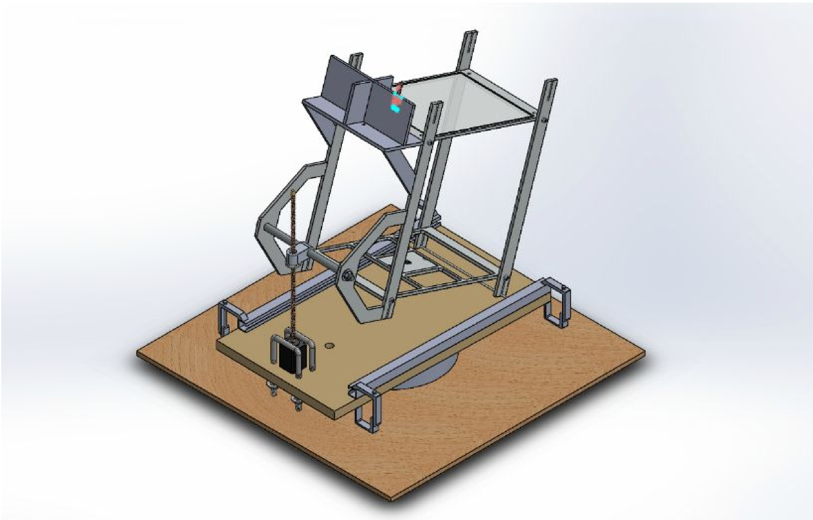
Results



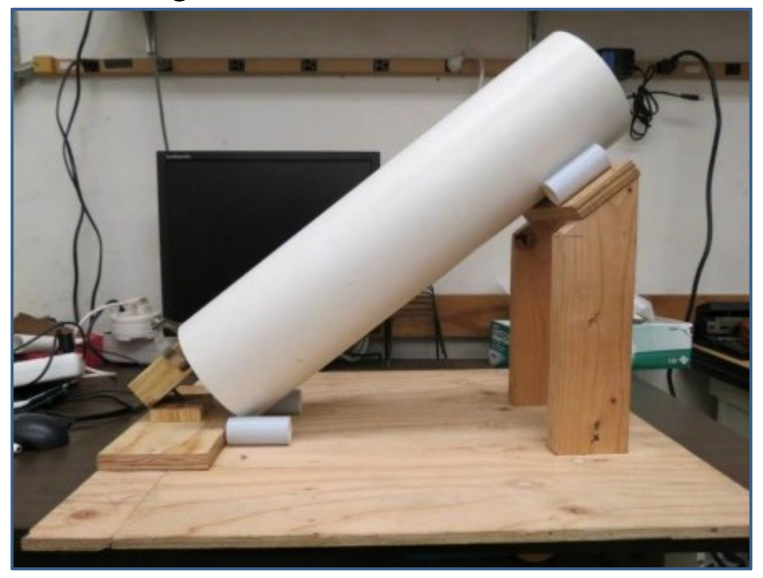
Original concept model for "Solar Telescope" by Laura Peng and Tamir Amitai.



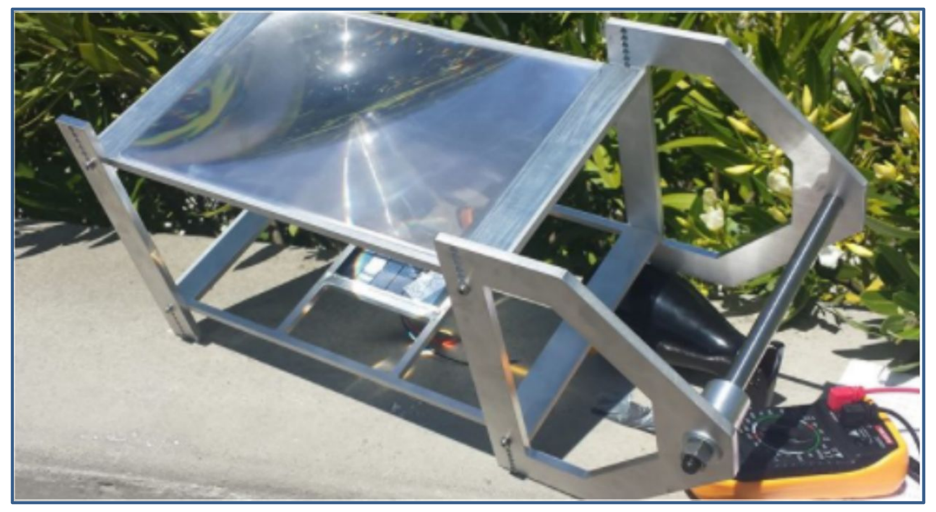
Concept model for dual axis tracker by Vincent Basset, and Bastien Rebulliot.



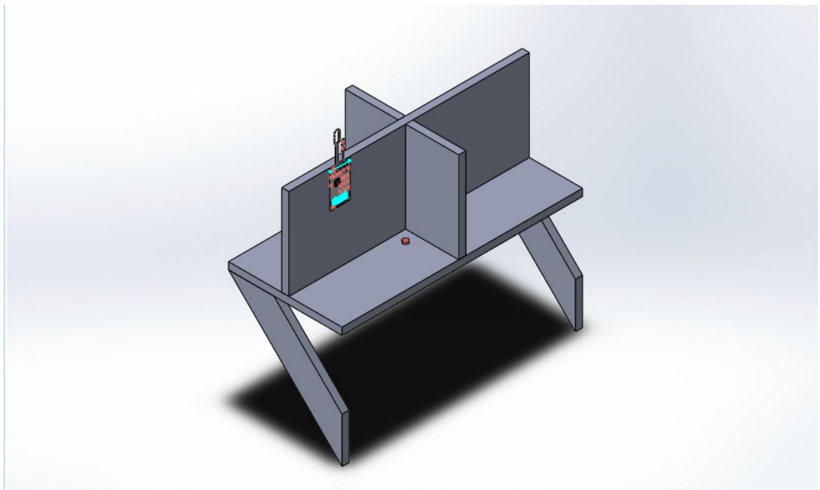
Updated dual axis tracker by Leah Altman and Paul Rynhoud.



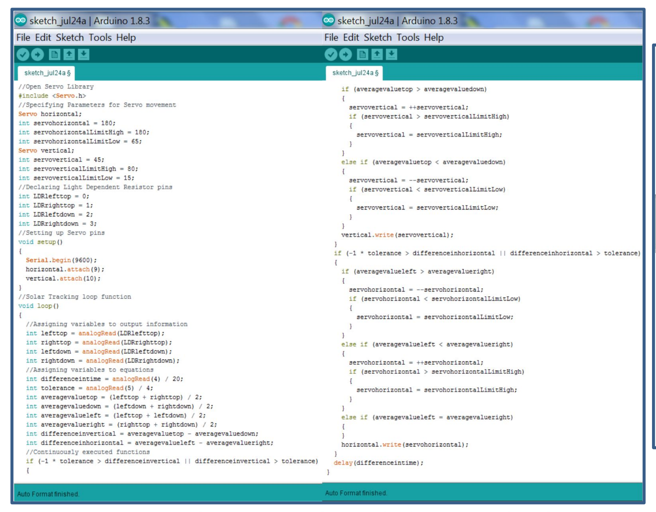
Prototype model built by Laura Peng and Tamir Amitai.



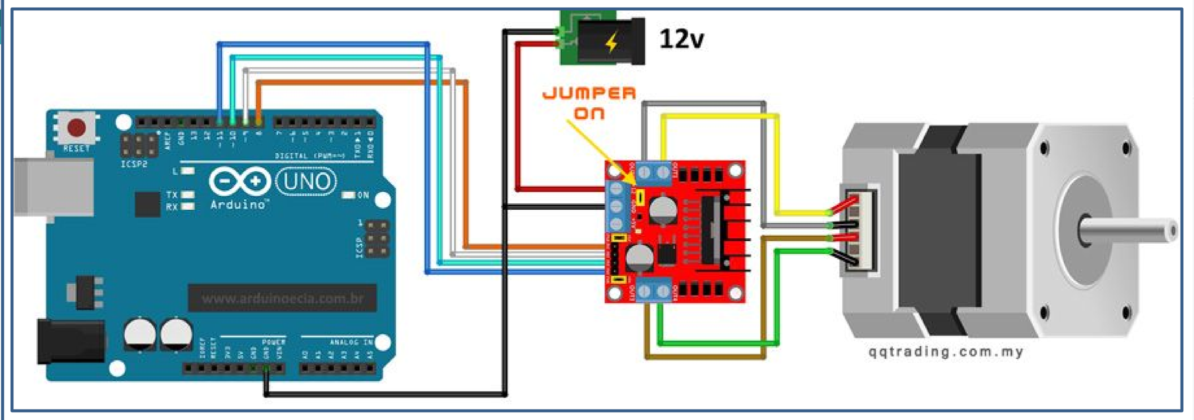
Frame of dual axis tracker concentrating sunlight for data collection.



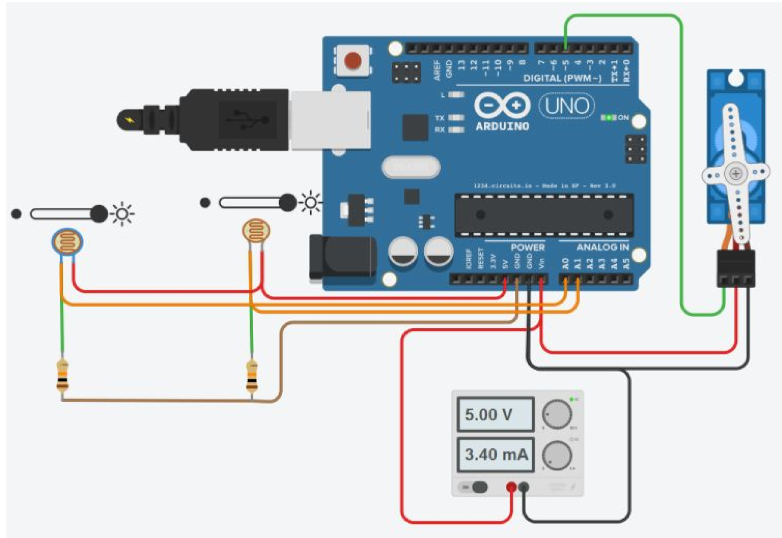
Model of light sensor and wind sensor housing structure by Leah Altman and Paul Rynhoud.



In progress format of Arduino code formulated by Paul Rynhoud.



Sample Stepper motor Arduino wiring.
http://qqtrading.com.my/stepper-motor-driver-module-L298N



Sample layout of light dependent resistor Arduino wiring.

https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&cad=rja&uact=8&ved=0ahUKEwirotPwqsvVAhUHOhoKHSCUC74QjRwIBw&url=http%3A%2F%2Fwww.degerenergie.de%2F&psig=AFQjCNEMeFhWNzpmjra4l-PPekz1X1fIqw&ust=1502408707512106

Discussion

The importance and demand for electricity in undeveloped countries is at an alarming level. Smart PV is a viable solution to meet the demands of these people, as long as an inexpensive model with high efficiency can be produced. Smart PV is unique in the sense that it can be used in every part of the world that there is light, and it will be very effective in countries around the equator, many of which are suffering from energy shortages. I believe that with enough time and effort, this project can be a huge success one day and I am hopeful that I can contribute to it.

One issue with this project has been the feasibility of adding a wind sensing component to the overall system. This has been an issue because the focusing lens needs to be pointing at the sun, in order to generate a valuable amount of electricity, while transitioning to a position that will reduce the force applied on the frame by the wind. The solutions to preventing the system from experiencing high velocity winds generally involve positioning the the system in a manner that prevents adequate light from reach the concentrated photovoltaic cell. In order to solve this problem, the best course of action would be to design the system so that it may be more compact under these conditions. The system should be able to fold up into a more streamlined panel-like configuration, while allowing the system to generate less electricity, but from a large array of angles.

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Conclusions

- Achieving positive energy gain at a small scale like this is very difficult and may require refining the process quite a bit before it becomes a reality.
- This project is quite complex for being so small and cheap. Every time a new challenge appears, the model must be redesigned and entirely new solutions must be found.
- For future planning, there should be a much larger lens ($1m^2$), in order to focus more light.
- The goal should be simplicity, too many unique or moving parts can make the required power input and cost of manufacturing the parts too high.
- Ideally, the aerodynamic efficiency component on this project should focus primarily on allowing a high enough energy output to compensate for the extra strain on the motors due to the high wind speeds.
- Prices should be kept low and parts should be accessible by communities in developing nations.

References

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