Automated Solar Panel for LMU Campus

Loyola Marymount University

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Introduction: Energy defines the climate crisis as the main contributor to greenhouse gas emissions, but also the key to the solution. Fossil fuels make up over 75 percent of global greenhouse gas emissions and nearly 90 percent of all carbon dioxide emissions. To avoid the destruction from climate collapse, emissions must be reduced immediately. To do so, investments must be made in alternative, clean energy sources. Loyola Marymount University [LMU] recognizes that over 50 percent of their carbon footprint comes from energy use, and increasing clean energy production moves them closer to carbon neutrality. LMU's dedication to sustainability is clear, with its many programs for making campus more sustainable. Green LMU, the school's office of sustainability, has an Alternative Energy initiative with a goal of implementing more clean energy sources on-campus. Historically, LMU has been a leader in campus renewable energy sources, but have fallen behind because of their lack of upgrades since 2005. Specifically, they have almost 100,000 square feet of solar panels throughout campus, with the majority atop University Hall. Despite LMU's success in these initiatives in the past, they can, and must, improve in many areas. Such a solution is improving the infrastructure already present on campus. This project aims to create low cost, energy efficient solar panels that track the sun. Such tracking will increase the amount of power each panel can harvest which would vastly improve LMU's sustainability initiative in current and future projects.

Problem Statement: This capstone team will design an automated, sun-tracking solar panel using the same solar cells currently on the roof of University Hall at Loyola Marymount University. The system will be designed so that the current panels can be converted to sun-tracking panels at a low cost and high power efficiency. Testing will be done on the automated panels to find how much more energy they are producing than non-automated panels, comparing their energy and cost efficiencies. Further, the panel's operational energy must not surpass the energy produced because that would be a net negative output. The panel must be designed with ease of use and installation considered for better chances of LMU administration to adopt the design. The experimental results along with the completed design will be shared with LMU administration and the Office of Sustainability with hopes that LMU adopts the new devices to increase the clean energy production on campus.

Design Specifications and Description

Design Specifications

1. The tracking-enabled solar panel system is projected to deliver positive daily net energy output.
2. The system is designed to achieve a return on investment (ROI) with cumulative energy savings projected to exceed the initial capital expenditure.
3. Solar panel design incorporates dual-axis tilting capability up to 45° for maximized solar exposure.
4. Actuator systems are engineered to withstand forces of up to 100 lbs, ensuring operational resilience and longevity.
5. The integrated control systems are programmed to operate at regular intervals, maintaining optimal panel alignment and maximizing energy yield.
6. A Raspberry Pi serves as the central processing unit for the system, managing core functionalities, and an Arduino is used for secondary functionalities, like controlling the actuators.
7. The system includes weather monitoring through a GPS and response capabilities to adapt to changing environmental conditions.
8. An energy-conserving sleep mode is implemented, which suspends non-essential operations while maintaining critical functions.
9. System should have easy installation in addition to quick, infrequent maintenance.
10. The system must abide by ASME Y-14.5 standards.

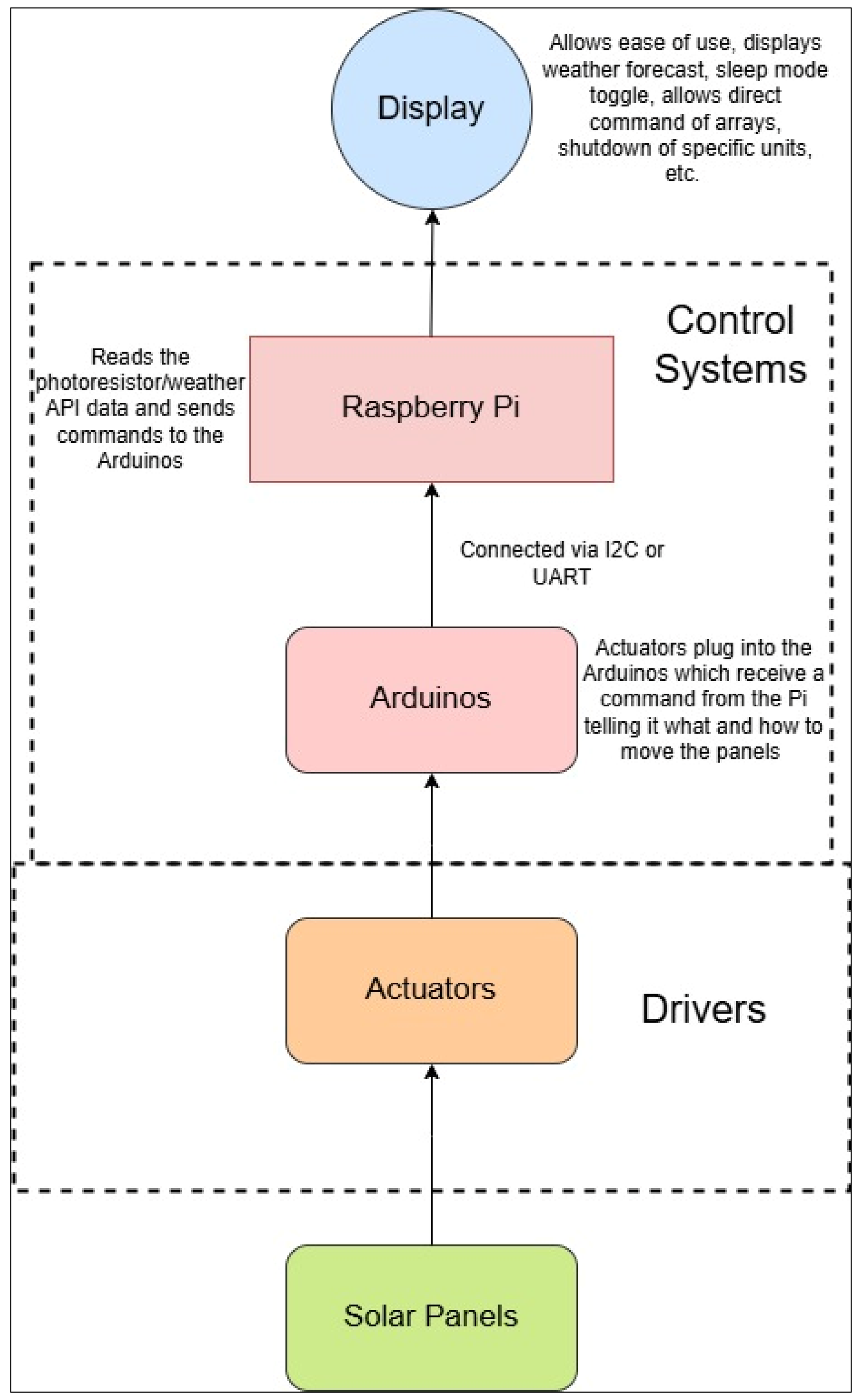
Design Description

Controls: For the control system, a more expansive solution is needed than a single Raspberry Pi. Due to the Raspberry Pi's inherent limitation due to the number of available I/O pins, use of this system in a solar panel array is extremely limited. Thus, for scalability and cost effectiveness, a mixed system combining Arduinos and a Raspberry Pi will be used. The mixed system is depicted in Figure 14, which takes advantage of the low cost and power draw of Arduinos by using them to control a number of actuators while the Raspberry Pi's superior processing power is used to control the entire system while dealing with interacting with a weather API, and outputting critical information to a LCD. This type of system also allows for the Raspberry Pi to control when the Arduinos are turned on or off, lessening the power draw of the system when it is not collecting power.

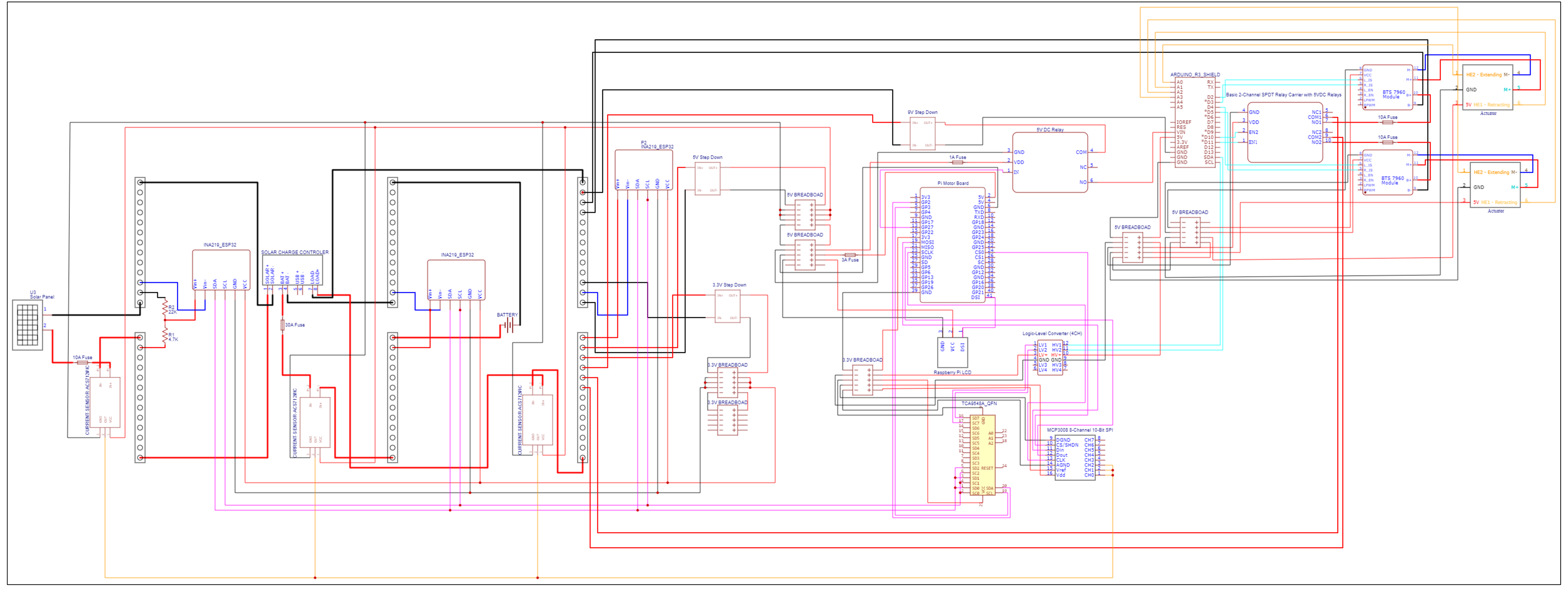
Physical Product: The model consists of a rectangular main base that holds the system up. A bar is attached, which holds the panel frame and one actuator. Two actuators are used, one for the east-west axis, and one for the north-south axis. The base is made from 1020 steel, and the panel frame is made from aluminum 6061.

Ethics: This project is designed around ethics. Specifically, the objective is to increase the production of renewable energy on LMU's campus. By doing so, the university will reduce carbon emissions from other energy sources. Thus, there are positive environmental impacts. The social impacts include educating students about the importance of solar energy and how it can be easily implemented at institutions like LMU. Other impacts include an economic impact by supporting solar panel suppliers and global impacts by encouraging the use of solar panels at Universities and institutions around the world.

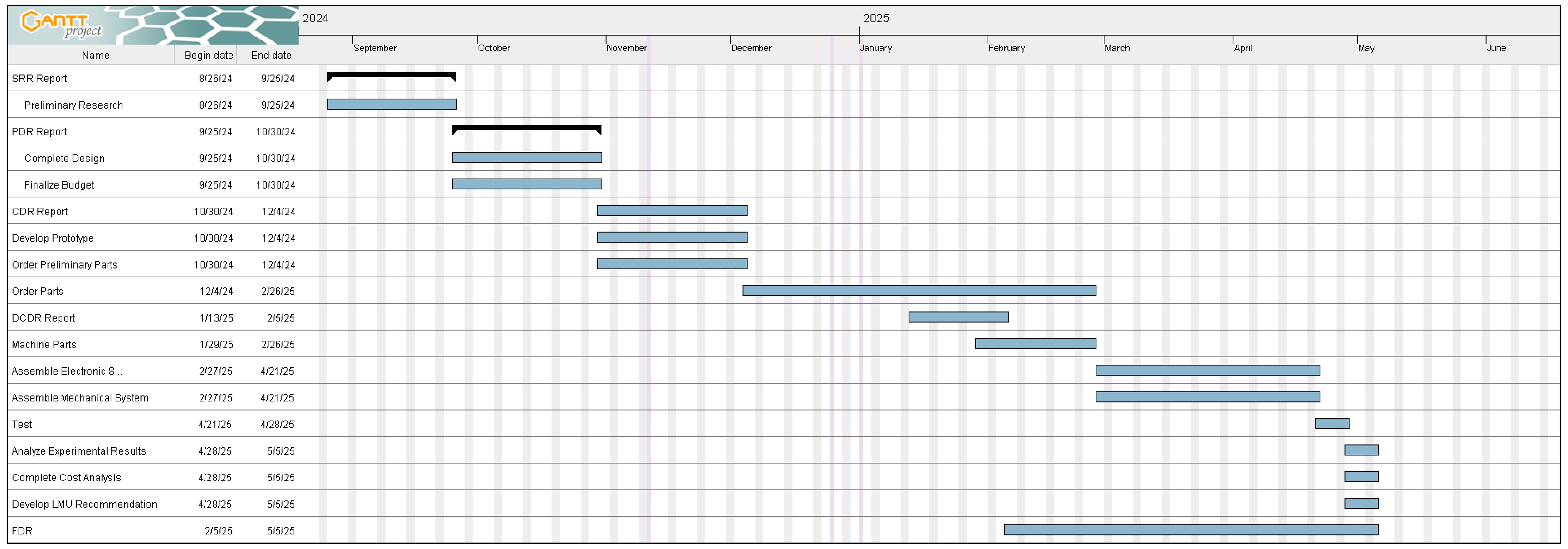
Control System



Wiring Schematic

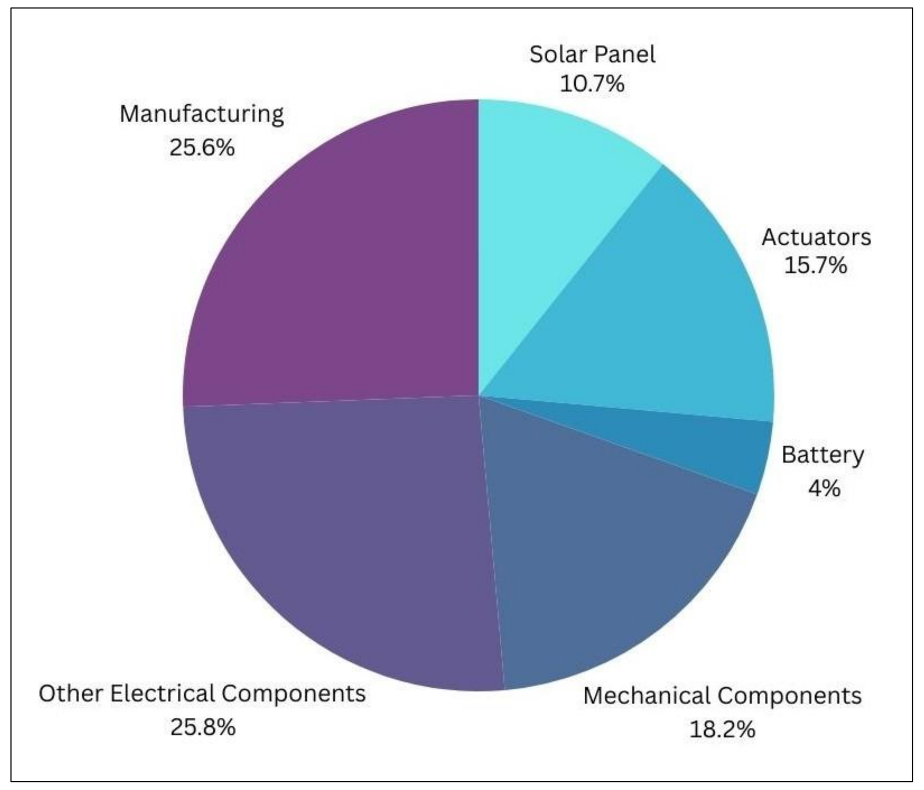


Schedule



Budget

Component	Cost ($)
Solar Panel	239.99
Actuators (x2)	352
Battery	89.99
Mechanical Components	406.83
Other Electrical Components	578.35
Manufacturing	574
Total	**2241.16**



Testing

Testing began after the solar panel and electrical parts necessary to build the system were delivered and assembled. After returning from winter break, the team split into two groups: mechanical and electrical. The mechanical group completed the machining and assembly of the metal pieces and physical structure, while the electrical group assembled and implemented the software for the Raspberry Pi, Arduino, actuators, and complementary items. To keep as controlled of an environment as possible, the dynamic and static panels were tested on simultaneous days. For example, data was collected for the dynamic panel on odd days (March 1, 3, 5, etc.), and data was collected for the static panel on even days (March 2, 4, 6, etc.). This was done by replacing the software to match the day and gathering the data each day. The static and dual axis automated panels could not be tested under the exact same conditions because there is only one panel available for use. Thus, the change in sunlight, clouds, amount of daylight, and weather conditions by the day were considered when analyzing the data. When necessary, the data from one set was multiplied by a factor in order to control the data analysis as best as possible. That factor was determined after analyzing the weather patterns over the dates that testing took place for each panel. Variables that determined this factor included, but are not limited to, length of day, position of sun in the sky, and cloudiness.

Results