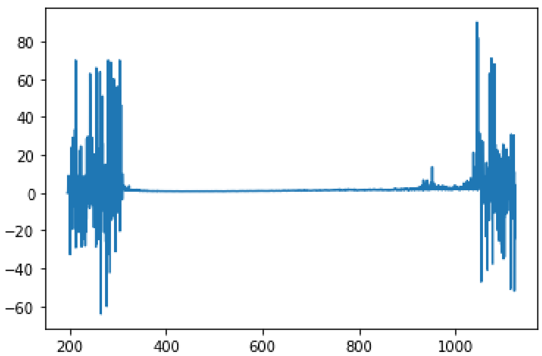
Avery Barnett

Photovoltaic Characterization

Photovoltaic cells is an emerging topic in today's energy sector. Photovoltaic cells are constantly being improved in terms of efficiency and economic feasibility. Therefore, the aim of this project was to understand the intricacies of photovoltaic cells and the necessary steps and conditions needed for their operation.

Photovoltaic cells were discovered in the nineteenth century. There mechanism includes doping which creates a 'p' and a 'n' junction which causes electrons, excited by the energy caused by light, to transcend gaps through the creation and filling of holes. This is what generates a current and thus electricity as a result. In order to understand photovoltaic cells, it started at the base of what causes this excitation - the wavelengths that reach earth through the sun's rays. The photovoltaic cells usually operate under ideal conditions at AM 1.5, where the intensity is 1000W/m^s and that temperature is around 25 degrees Celsius. Under those conditions, the cell is the most efficient. These conditions segues into the first project conducted - graphing the solar spectrum and trying to simulate it within a laboratory setting.

The first project includent using SpectraSuite and a Spectrometer to take the readings of wavelength versus counts of a Xenon lamp. When raw, there is a wide spectrum of wavelengths, including those which do not make it to the Earth's atmosphere. We simulated this experiment with a 12V lamp; however, this lamp does not closely resemble the light which is emitted by the sun. Following these realizations, we utilized an AM 1.5 filter with the Xe lamp, which blocked the wavelengths which would not reach the atmosphere, as well as dampened some of the peaks which came about from the raw lamp. Although the lamp closely resembled the features of the sun, there was still some degree of offset between the lamp and the solar spectra taken when the sun was at AM 1.5 which means that it was at an angle of 41.81degrees above the horizon as calculated by suncalc.org. The integration time had to be adjusted in order for the scale to fit what was capable of the program. These offset could be due to the molecular makeup of the air at the time and the fact that other controls, such as temperature, were not taken into account. The differences of the solar spectra of when it was cloudy versus not cloudy were taken into account and graphed using python (see below).



It was also noted that there was a discrepancy in the peaks when comparing the solar spectra to the Xe lamp with AM1.5 filter. The Xe lamp showcased peaks which had significantly more counts in comparison to the trend of the curve; whereas, the solar spectra showed dips in the data at certain wavelengths. More studies would have to go underway to understand the exact cause of the offset and molecular make-up of the atmosphere which would lead to the peaks and/or dips in the different spectra. There is a high chance that the concentration of water vapour in the atmosphere could play a part in these discrepancies.

The second project included trying to construct a homemade PV cell, which more appropriately could be considered a photochemical cell. The difference between a PV cell and a photochemical cell is that a photochemical cell involves a chemical reaction and the use of an electrolyte. In this case, the electrolyte used was salt water which involved the movement of Na+ and Cl- ions in order to conduct electricity. The excitation of these ions under the condition of light allowed current to flow as they moved from one copper sheet to another. In this experiment, it was important to create cuprous oxide in order for the sheet to act as an anode and a cathode. In this cell, the principles of electrolysis were used for current to flow. For this experiment, many different prototypes were used in order to figure out exactly what needed to happen for the cell to work properly. These prototypes include, using a plastic casing, clamping directly to the copper sheets and wetting the tissue paper in different ways. It could be possible that the plastic casing did not allow light to easily pass through and had a greater effect since the PV cell already generates very little electricity. Moreover, clamping directly to each plate possible affected the transmission of electricity and shorted the cell out to cause there to be no current flow. What ended up being successful, was soldering wires to each plate, using alligator clips to connect them to a multimeter and taping one edge so the plates could be separated in order to effectively wet the tissue. As a result, it was noticed that when covered the current decreased (less light therefore less excitation) and as the tissue paper dried up, the current decreased as well (which is expected as the electrolyte is the cause of the current flow). Further studies would involve testing the cell under different light sources and conditions to see how the intensity of the light affects the cell and if it has similar relationships to an actual PV cell. Moreover, it would be interesting to see if an array of these homemade cells could possibly be used to power anything.

The third project is still in progress and includes using a roughly 19V PV panel to charge a 12V battery. This is a task which has many considerations that have to be accounted for. Some of these considerations include not allowing the current to flow in the other direction, have a load resistor of a sizeable resistance, the ability to monitor the voltage out from the PV panel in order to not overcharge and/or fry the battery, as well as being able to control the output voltage as the battery continuously becomes charged (the battery would need less as it charges up more). These considerations caused the need for many different external supplies that just a PV cell and a battery. The apparatus used include multiple diodes to ensure that the current only flows in one way, a voltage regulator in order to control the output voltage, a 90 ohm load resistor, a fan to prevent the overheating of the voltage regulator and a potentiometer which will be used as an adjustable voltage divider. All these would have to be set up in the circuit with the photovoltaic panel acting as a current supply versus a battery. Moreover, care has to be taken in order to not short out the circuit at any given time due to improper connections and/or the touching of wires. It was enlightening to realize that so many parts go into allowing photovoltaic cells to supply the energy that it does. In order to set up the majority of this experiment, a fair amount of soldering had to be done, as well as understand and maneuver the low-tech instruments that we were using. Going forward, sourcing a suitable potentiometer will be necessary as well as modifying the voltage regulator to suit exactly what we wish to do. Moreover, it would be interesting to conduct this outdoors under authentic sunlight, versus artificial light from roof lighting supplemented by lamps. It would also be interesting to explore further how current and voltage drops when the panel is in a circuit with different strengths of resistors.

This past semester I have learnt about the discipline of using solar power, from the basis of the wavelengths and spectra needed for excitation to attempting to create a circuit using a PV panel. I have learnt that the process is more intricate than what meets the eye and there are many different parts which go into making a panel be utilized effectively. Looking at the different spectra, has caused me to become more inquisitive as to how the atmospheric makeup intertwines with the functioning and maximum efficiency of a cell and if there are very specific conditions that would cause the greatest efficiency for a cell, and if that is achievable in Grinnell. Creating a homemade PV cell, taught me that these things could be manufactured; however, are very inefficient and non-practical for regular use. Lastly, there is still more to uncover in the coming year, which I hope to indulge in the future.