Project Summary

For our project, we looked to create a low-cost solar concentrator that could be used to convert solar energy into alternative sources of energy through chemical reactions. On a global scale these concentrators could then be distributed to low income areas in other countries to provide them with a steady source of energy at a low cost. In our project we will be using pyrolysis to convert organic material into biochar. Biochar can be used as a method of carbon sequestration, improve water quality, and improve agricultural productivity when mixed with soil.

The majority of the summer was spent in constructing a solar concentrator capable of reaching and sustaining the temperatures necessary to pyrolyze biomass and generate biochar. Initially, we hoped to create our own parabolic dish using aluminum sheets and Mylar film to minimize the overall cost of the project. However, we were not capable of reaching temperatures adequate for biochar generation. Because of this we were faced with purchasing a parabolic mirror.

After the new mirror was attached, the receiver was able to reach and maintain temperatures as high as 600 °C in as little as 20 minutes. To monitor the solar concentrator, an Arduino board with a thermocouple amplifier was integrated with several thermocouple probes to record the temperature at various points along the receiver. This provided us with a live stream of data to monitor and adjust the concentrator as needed. Eventually, the Arduino will also allow for solar tracking to be incorporated into the current design.

Once the solar concentrator was capable of reaching the required temperatures, the next step of the project was to create biochar. To accomplish this, we placed six steel pipes within an aluminum cylinder. The cylinder consisted of an outer aluminum casing with a layer of insulation along the inside. The bottom consisted of an aluminum plate with a two inch diameter circle cut in the middle to allow for the concentrated light to enter the cavity. This cylinder was placed at the focal point of the parabolic mirror. This allowed us to reach the required temperatures. However, in order to for pyrolysis to occur, the reaction must occur in the absence of oxygen. Each of the six steel pipes was connected to a silicone tube which was placed in a bucket of water. We initially believed that we would need temperatures around 700 °C to generate biochar, but we have been successful in creating biochar at temperatures around 400 °C. Currently, we are only capable of producing several grams of biochar at a time with the reaction vessel attached directly to the frame of the solar concentrator. Next, we plan get the dish to track the sun and to replace the tubes with biomass with a heat transfer fluid. This fluid can then be pumped through the receiver to an external reactor so that biomass can easily be added or
removed throughout the day. This will greatly increase the amount of biochar that our solar concentrator will be able to produce. Further research needs to be done in finding the ideal temperature range to maximize the biochar yield we can obtain from the biomass. Additionally, different biomass materials give the biochar different properties. More research needs to be done to find the most appropriate biomass source for the desired application.

In the long term, the goal is to generate enough biochar so that both the campus and community will be able to use biochar in campus gardens and filter local storm drains. As of yet, we are not able to produce enough biochar to make this possible, but we are in contact with local community individuals and groups to make it a reality as our project continues to develop.

Benefits

The SSI research grant allowed me to finish a major part of this project in the construction of the solar concentrator. Now that the concentrator is constructed, I will be capable of making reliable and structured measurements. Additionally, I have been introduced to a lot of people in the biochar community dealing with both biochar generation and its possible applications. These connections were extremely helpful during the work we have done so far and will continue to be useful as the project continues to develop. I was able to display my project at the Sustainability Festival this fall. Meeting other people involved in sustainability problems and teaching people about different ways they can help was a valuable learning experience for me. In addition, this project was a lot more hands on than any previous projects I had worked on before. The SSI grant also allowed me to see a side of research that I had previously not experienced before.

Reflection

I have learned a lot from this project in regards to both the benefits and difficulties that come along with research. Things rarely worked on the first try and could be extremely frustrating at times. However, when things finally did work out, all of setbacks became worth it. Finally solving a problem you have been dealing with for several weeks is an extremely rewarding feeling. Prior to this project, I had little experience in writing code outside of the classroom environment. I now feel much more comfortable with my coding abilities. I have now experienced the frustrating nature of solar energy with its unreliability. It can make testing extremely difficult unreliable because the weather can change so quickly. It was difficult to differentiate whether or not results were because of changes we made with the solar concentrator or a change in weather. Overall, this project has helped me learn how to apply the skills I have looked in the classroom environment into real-world applications.

Below are several pictures of the dish in action.