Overall concept/outline (to present at meeting):

- **I am Mohan Hathi, I am working with Chris Stokes**
- **We are building a model solar concentrator (or heliostat) and active sun tracker which uses a multiplex of mirrors to focus light onto a specific focal point.**
- **The goal of our small scale model is to concentrate solar energy to create heat to carry out the reaction of burning clamshells made of calcium carbonate, which can capture CO2. But, the project is also intended to be a model for larger-scale heliostat apparatus in the future, and we also hope that we can design and document the small scale model so that it can be easily and affordably created by DIYers or makers for other applications, and inspire people to learn about solar concentrators and mirrors.**
- **The design we are using is based on a heliostat apparatus patent by Jesse Bunch as well as a concentrator design report.**
- **We have a prototype of the movement mechanism that controls the angle/position of the mirror, which I can show you in a second. Right now it only has 4 mirrors, but in the future, it will be expanded to have around 80 mirrors in 1 m^2 footprint to hopefully achieve a 3" focal point with a temperature of 900 degrees**

- Overall idea: A multiplex of mirrors attached to rods with flexible joints are put into two perforated wood sheets (top one moves, bottom one is stationary). Two stepper motors move one of the wood sheets, to shift/angle the mirrors and concentrate/reflect light into the reactor. This is similar to a Fresnel lens design (for example, if you coated a fresnel lens in a reflective substance, it would basically do what we are doing!) Note, the multiplex of mirrors are arranged in an off-axis parabola shape, to reflect light at an angle into the reactor.
- Angles of the mirror are calibrated individually with set screws. When sun moves 15 degrees, mirror has to shift 7.5 degrees.

7/30/20

We have made some progress on the solar concentrator, specifically researching the overall design and constructing the movement mechanism that controls the angle/position of the mirrors.

Show old iterations of design as walking through

What we have done so far:

- So far it has been ~40 hours of work
- The overall idea is based on a heliostat patent by Jesse C. Bunch and a concentrator report - fresnel based design -- many mirrors at different angles.
- A multiplex of mirrors arranged in a rectangular array attached to rods with flexible joints. The rods are attached on two levels, on the bottom (L1), pressure fit into a rigid support

layer (pegboard since its versatile, cheap, and no CNC required), and on the top (L2) they are attached together into a grid to form an adjustment layer.
    - The mirrors right now are 2.75” square -- so around the size of the focal point -- could also bend them or make smaller
- There are universal joints -- a 3d printed ball joint on the bottom and a universal joint on the top and this allows the whole system to move on the x and y-axis.
    - This was a big consideration, on the bottom we decided to use a print in place ball and socket joint since it had to be holding a lot of weight of the whole assembly, but on top, we used this type of 3d printed joint that has these knubs that are kind of weak. Also could try a flexible coupling.
- There is a stepper motor (so far just for one axis) attached to a belt which moves back and forth and adjusts the top layer.
- Then the mirror are attached to the top at a certain calculated angle (calibrated for when the sun is at noon) and so that the focal point is 1 ft to the left and 1355 mm high. Explain how the mirror angle is corrected to keep the center height the same.
- As you move the top layer with the motors the mirror changes angle and the focal point stays the same.
- About calculating angles: mirrors are attached to an angled block at the top here. I have created a spreadsheet that calculates the angles if you give the number of mirrors and the focal point (also adjusts center height). Uses angle of incidence = angle of reflection and assumes the sun is at noon. So the angle is printed into the block and there are also grooves in here so we can use small set screws to adjust the angle of the mirrors.
- We are trying to make everything 3d printed and easy so it can be scaled up
- One issue is that it can rotate now and that messes up the focal point
- Using smaller dowels so that it can be smaller and faster to print

What is in progress/What we still need to think about:

- Also, read the patent more fully, and maybe there are some other approaches using something like a labyrinth game or putting grooves in the balls -- this could fix the rotation problem. Also maybe needs to just move on one axis?
- Found a website from the national oceanic and atmospheric administration that tells you how to calculate the sun’s position using your lat and longitude and the date/time - they have a spreadsheet.
- Working to write the sun tracking code Arduino code using a teensy and this stepper library called teensy step that can control the machine
- I also found someone online who created the open sun harvesting project -- similar design. Could look at their code for reference, although it was written 10 years ago.
- Then will scale it up to more mirrors.
- Add a second axis -- actually patent doesn’t use one - this is complex since the motor has to move/rotate as well.
- Experiment with other shapes/arrangments for the mirrors.

Questions:

- New idea about a different type of mirror that lets certain wavelengths of light through so plants can grow underneath?
- Presenting the project at a conference at UCSB around August 10?

What Ye Tao had to say:

- He wanted me to present what I was doing at a conference his has every two weeks with all of his students/interns. I gave an overview and then a demo as I showed him, all of his students (25) were supportive and asked good questions
- He wanted me to write an abstract to submit to the UCSB conference -- I should send it to him
- Solar concentrator is a model for building other concentrators. Totally aware that using a 3d printer or laser cutter is not sufficient for big scale, but also important for DIY/backward applications -- open source.
- He is worried about the mirrors casting a shadow on each other -- I should make them smaller
- Dichroic mirrors - let some frequencies of light through to allow plants to grow underneath, while also reflecting sunlight to do the reaction. Possible to use these types of mirrors in the future, although they are super expensive
- He also maybe wants me to create a 3nd device for a plant system. Basically a 3d printed adapter to get from a cylinder with algae growing in it to a dichroic mirror on top. This will allow us to test the effect of dichroic mirrors on plant growth. This is a bit off topic through.