Solar-powered hydroponic radish garden - A senior student project

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Project Objectives:

To design, build and test a small hydroponic system utilizing renewable energy to grow French dressing radishes.

Constraints:

A minimum yield of 1 kg per m^2 of footprint (in 3 months), fully automatic irrigation pump/fertilization and fully solar/battery powered system. The total cost was limited to USD 250.

Applications and Advantages:

- Vertical farming in outer space
- Growing foods in non-native environments
- Cost and space savings
- Automated farming
- Easier to deter pests and disease

Initial Concept (Figure 1)

Single tank grow system

Pros

- Simple, 2 hose system
- Easy electrical circuit
- Minimal cost and materials

Cons

- Not a lot of grow space available
- Need a lot of water to fill both bins

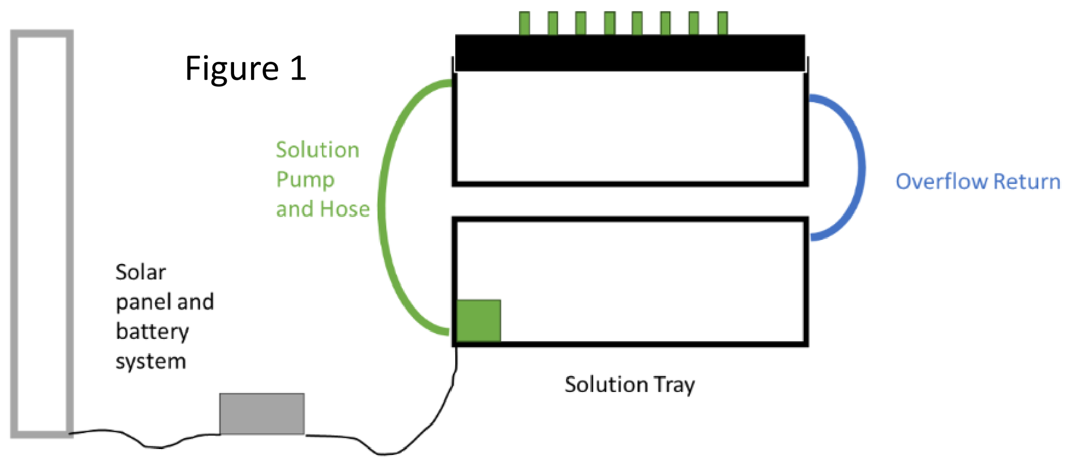

Figure 1

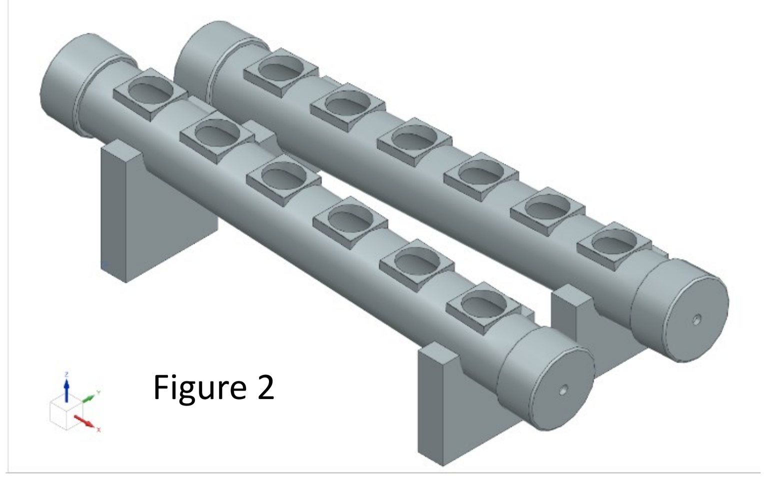
Figure 2

Finalized Concept (Figure 2)

Pros

- Increases grow space available without taking up much floor space
- Less water volume needed per tube to provide nutrients
- Simple easy design with cheap parts

Cons

- Potential for leaky connections
- Pump required can wear out over time
- Required pump head increased with this design

Battery Calculations

Calculated the amount of A.h necessary to power the different pumps we were provided based on the length of time we wanted our system to run without sunlight. The grow lights added significant energy demand. Because of this we selected a design that could work outside.

Pump Calculations

Without the need for grow lights, pump choice became less critical.

- Needed a pump that we knew could handle the demand of the system.
- Even if this pump had an efficiency of 50% it would have provided more than enough flow to ensure the system could be watered at all times.
- This pump even ended up being too powerful, which led to the addition of a manual flow control ball valve.

Midterm progress:

- CAE Model created and 3D printed all tube caps
- Provides flat surface for grow cups to sit on.
- Gathered all materials needed for construction of system including wood for stands, PVC pipe, PVC caps, pipe fittings, and hose.
- Gathered and cut all wood for pipe stands.
- Initial circuitry put in place and tested.
- Began seed germination.

The Build

- Cut PVC pipe to size.
- Took steps to ensure minimal risk for leaks.
- Fitted hose connections into end caps.
- Attached and glued end caps with piping cement.
- Took steps to ensure minimal risk for weather damage.

Planting the Seeds

- Germination on a Damp Cloth: By placing the seeds on a damp cloth for a week we were able to initiate the germination process without risking the loss of seedlings.
- Using Grow Cups and Soil: Once the seeds germinated and were showing signs of growth, we transferred them into grow cups filled with soil.
- Planting Multiple Seeds per Cup: Planting multiple seeds in a single cup is a strategy to increase the chances of at least one seedling growing successfully.
- Damp, Compacted Soil: Planting in damp, compacted soil ensures that the seedlings have access to moisture right from the start.

The Final Product

Placed the entire system outside. Wired solar panel, battery, solar charge controller, and pump together. Tested system for leaks.

Grow Food

- Arguably the most important part of this design
- Provided the radish seedlings with the nutrients they needed to grow.
- As the seeds and plants developed, the volume of grow food changed per the instructions on the bottle.
- With our calculated system water volume, we needed a total of 1.5 teaspoons when we first planted the seeds

Unforeseen Challenges

Bugs

Problem: Insects like grasshoppers were found eating the leaves of some of our just sprouted plants. This reduced our output significantly, as it prevented many radishes from fully developing.

Solution: While bug spray or pesticides were proposed, these were decided against, as we did not want pesticides circulating through the system. Ideally, for a project of this size, a net would work just as well to protect the plants and keep the water clean.

Faulty pump

Problem: Initial plan was to use the lower demand pump provided by Kettering, as we could run this pump longer without worry of battery drainage. However, after powering this pump on, it seemed broken, as it did not pump much water.

Solution: Checked the operation of the other pump and it worked very well, so we did some quick redesign and made the system work just as well, if not better, than it would have with the original pump.

Water damage to battery controller

Problem: Battery controller was not covered during unforeseen weather conditions (rain). This caused the battery controller to not detect the pump, thus stopping system circulation.

Solution: New battery controller ordered, and this time, was covered and protected from weather conditions..

Clogging pipes

Problem: After initial germination and planting of seedlings in dirt filled grow cups, some dirt from the cups would enter the system and become stuck in the tubes of the system, preventing flow downstream.

Solution: Manually check and free clog from system to restart circulation. In the future, designing around this issue would be considered. This was largely an unforeseen issue that our design has a hard time combatting. Future solutions could include picking a different substance inside the grow cups, using different grow cups, or larger piping systems.

Conclusions

With more time, the target of 1 kg of radishes is a possible outcome.

Unfortunately due to the time constraints, we were not able to reach this goal.

Additionally, by extending our project past the limit of this term, engineering a way to set up grow lamps indoors to avoid external risks is also a possibility.

In the future, the team should include netting around the tubes in order to

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