Container Farm – HVAC and Hydroponics

Summer Armijo-Rotunno (ME), Kyle Patton (ME/AE), Travis Smith (EE), Darien Salayandia Gardea (ME/AE), Jesus Armando Gil Parra (ME/AE)

NMSU College of ACES

Mission

The NMSU College of ACES asked our team to design and build a container farm competitive to those already on the market. Controlled environment agriculture utilizes hydroponic systems for efficient horticulture production. Benefits include:

- Reduced water usage addressing critical scarcity of water in arid regions.
- Reduced labor requirements, improved working conditions, minimized food miles
- Protection against weather-related crop damage.

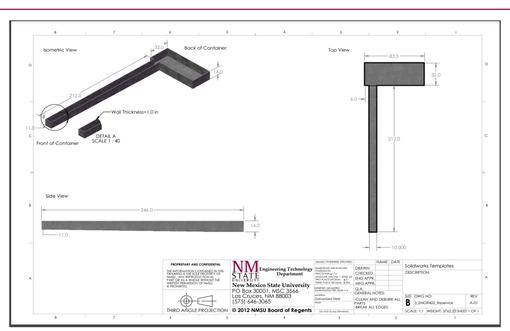
Our goal is to create a container farm with an HVAC and hydroponics system to be more efficient and profitable than container farms currently on the market.

Research

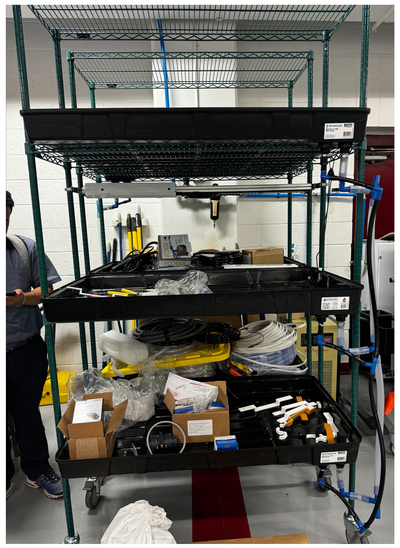
Through our robust research we found that a growing number of suppliers are offering containerized agriculture solutions due to rising concerns of food insecurity.

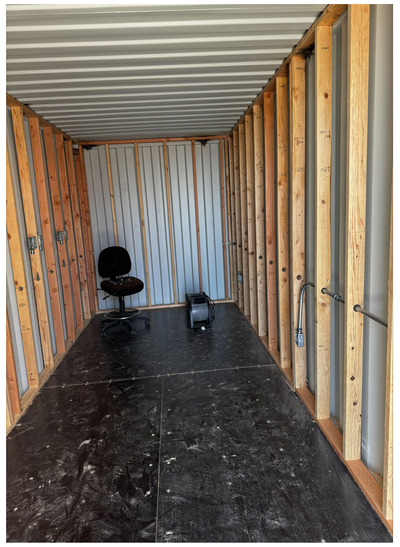
- A climate control system will regulate temperature, humidity, and ventilation to allow optimal plant growth.
- LED lighting is energy efficient and promotes photosynthesis.
- A hydroponics system allows soilless cultivation which improves nutrient delivery and water use.
- A closed loop system and water recycling optimizes water consumption.
- The optimal pH for hydroponics is between 5.0 and 6.0 and optimal temperature is 55° to 75°.

This is optimized by utilizing a two zone air conditioning system. We found that CO2 regulation is important in climate controlled agriculture. In addition, we found insulation is needed to keep the inside of the container at the optimal environment.



Final Design





Our final design incorporated the ebb and flow hydroponic method. The water reservoir sits underneath the grow racks to utilize the most space in the container. Before the water is pumped into the racks, it goes through a reverse osmosis (RO) system to eliminate any contaminants or bacteria. The water is then pumped up into the racks, filling the grow trays. Once the depth sensors are activated, the pumps will stop pumping water into the trays, and water will sit in the substrate for some time. Any extra water will drain out of the tray and back into the reservoir. This closed-loop water system will optimize and reduce water usage by 50-70%.

Unlike most container farms, ours does not include a nursery station. The plants will stay in the racks from the time they are planted until they are harvested, which maximizes labor time, electricity cost, and water consumption. For the growing substrate we decided to use coco coir, which is a natural fiber extracted from coconut husk. Coco coir has sponge-like properties which allows it to effectively soak up water. In addition, using this substrate allows us to plant the seeds directly into the substrate rather than using a solid top to suspend the plants. This also makes it more effective to keep the plants in the substrate from planting to harvest.

The Agrowtek controller that was selected by the Power and Controls team came with a nutrient doser that allows easy dosing of each nutrient, Nitrogen, Phosphorous, and Potassium. The doser also allows for ease of adjusting the pH level of the water, which is crucial for successful growth of the plants. In regard to nutrient selection, we reached out to the sales representative at Agrowtek who recommended the following nutrient suppliers:

- General Hydroponics
- Cutting Edge Solutions
- Farmbox Foods

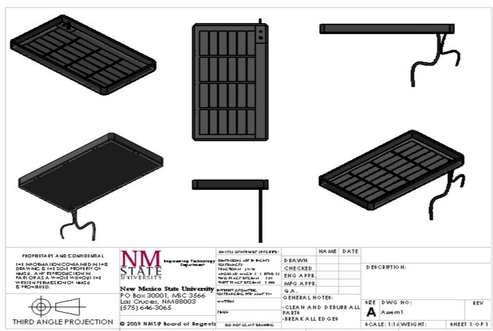
The container was insulated at Dona Ana Community College Workforce Development Center (DAWD). The insulation used was closed-cell spray foam. With the container being located in Las Cruces, the main goal of the HVAC component was to keep the container cool, especially in the hot summer months. The A/C unit that was selected has an output of 30,000 BTU. In addition, we incorporated a fan inside the container to keep the air circulated. We also included a dehumidifier and a CO2 tank, which will be connected to the Agrowtek controller to keep the aerial conditions just right for plant growth.

Concept Development

For our concept development we used many resources including talking to subject matter experts, looking at competitors, looking at the container farm at Hatch High School, and simply using search engines. During our development we took the following into consideration:

- Hydroponics
  - Ebb and Flow System
  - Vertical vs. Horizontal Hydroponics
  - Drip Systems
  - Flood and Drain Systems
- HVAC
  - A/C Units
  - Insulation
  - CO2 Requirements

Finally, we decided to implement a horizontal ebb and flow hydroponics system. This will optimize both the space used by plants to grow, as well as the water used. For the A/C, insulation, and CO2 regulation we took suggestions from subject matter experts and previous reports.



References

ANSI Webstore. (2024). Ansi.org. https://webstore.ansi.org/

IEEE Standards Association. (2024). Retrieved April 19, 2024, from IEEE Standards Association website: https://standards.ieee.org/

List of ASME Codes & Standards - ASME. (2021). Asme.org. https://www.asme.org/codes-standards

CO2 best practice guide: Background | AHDB. (2024). Retrieved March 1, 2024, from Ahdb.org.uk website: https://horticulture.ahdb.org.uk/knowledge-library/co2-best-practice-guide-background#:~:text=A%20lower%20level%20(800%E2%80%931%2C000,violets%20and%20some%20gerbera%20varieties.

Green, E. (2023, July 18). Eden Green. Retrieved March 1, 2024, from Eden Green website: https://www.edengreen.com/blog-collection/how-hydroponic-lights-work

Nutritional Monitoring Series Lettuce (Lactuca sativa). (n.d.). Retrieved from https://hortamericas.com/wp-content/uploads/2018/04/e-gro-Nutritional-Factsheet-Lettuce.pdf

Start container farming - Freight Farms. (2024). Retrieved March 1, 2024, from Freightfarms.com website: https://grow.freightfarms.com/start-your-farm?utm_term=freight%20farms&utm_campaign=Product&utm_source=adwords&utm_medium=ppc&hsa_acc=4729319506&hsa_cam=17614138771&hsa_grp=143879058688&hsa_ad=607278420671&hsa_src=g&hsa_tgt=kwd-334825746199&hsa_kw=freight%20farms&hsa_mt=e&hsa_net=adwords&hsa_ver=3&gad_source=1&gbraid=0AAAADj6CPJPwlQq-tbQ8zyayUbDXw6zA&gclid=EAIaIQobChMIxarn3Z3ShAMVq1hHAR0q_gVkEAAYASAAEgJL8PD_BwE

•Brechner, Melissa, et al. *Cornell Controlled Environment Agriculture Hydroponic Lettuce Handbook*. 2013, bpb-us-e1.wpmucdn.com/blogs.cornell.edu/dist/8/8824/files/2019/06/Cornell-CEA-Lettuce-Handbook-.pdf.

•Freight Farms. *2024 Product Booklet*.

•Jeffery, Luke. *How Many Gallons of Water for 1 Head of Lettuce? | Exploring Hydroponics*. 29 Mar. 2022, sites.psu.edu/rcl2122lukej/2022/03/29/how-many-gallons-of-water-for-1-head-of-lettuce/comment-page-1.