Solar-Powered Hydroponics System

Feeding our community through the use of recycled materials

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SPONSOR BACKGROUND

The customer for this project is Grow Calgary, a non-profit organization with a farm located near Balzac, Alberta. Grow Calgary is Canada's largest urban community farm. They donate their crops to over 40 Food Access Agencies in Calgary. They ensure that families below the poverty line are provided with healthy, organic food. Founded in 2011, they have had over a decade of growing experience.

PROBLEM

Project Mission:

Redesign and recommission an existing hydroponics system within a sea can at the Grow Calgary farm.
Requirements from the customer for the chosen solution were to include:

1. Increase in crop yield per unit floor area
2. Reuse of onsite materials
3. Solar power integration
4. Automated control
5. Modularity

Project Constraints:

- Fit within a 40-foot sea can and still allow for ergonomic use
- Reuse materials from previous system as much as reasonably possible
- Make the design construction repeatable
- Operate within the power budget of the solar panels
- Operate with the existing pumps and lights

Project Deliverables:

- An optimized design using primarily re-used materials to replace the current hydroponics piping and lighting system
- A power management solution that will enable the system to operate continuously using the existing solar panels – the construction of which is an optional objective that is dependent on the current state of the solar panel system
- A bill of materials and instructions on how to build and implement additional modules
- A prototype of a single module

ABSTRACT

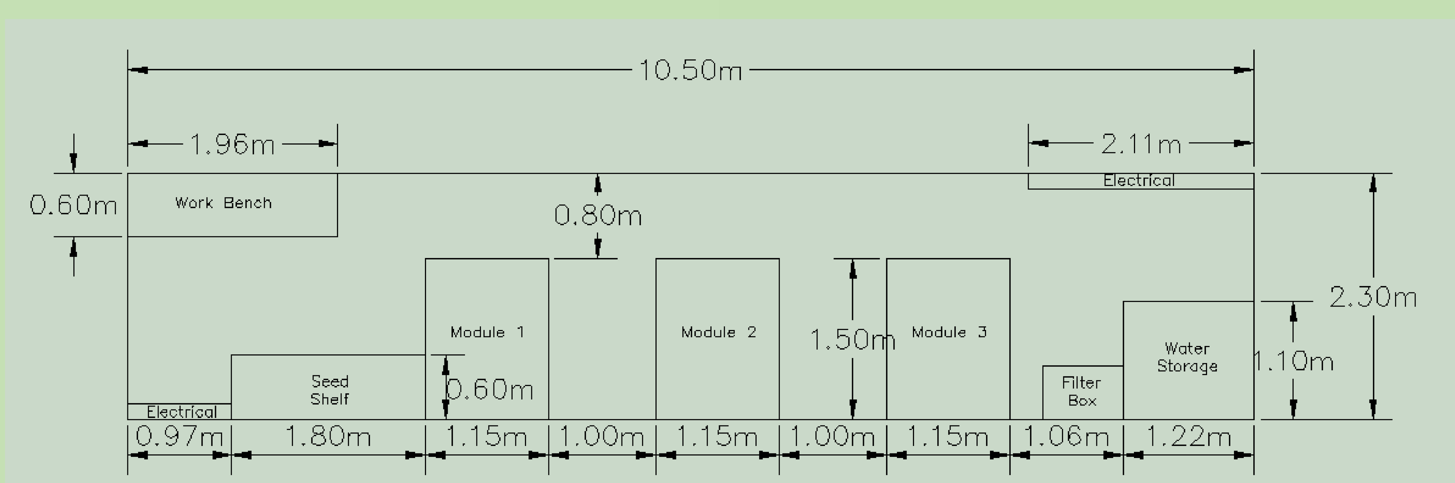
The team designed a hydroponics system for Grow Calgary, a non-profit community farm. Hydroponics is a farming method that cycles a continuous flow of aqueous nutrient solution to the plant roots. The goal of this capstone project was to redesign the decommissioned system to maximize production while minimizing cost. The design was segmented into smaller modules to allow for ease of transport and the ability to upscale production based on resource availability. The module layout was redesigned to increase plant capacity per area by 45%. Additionally, a power management system using solar panels, battery storage, and an Arduino was implemented to allow for off-grid control of lights, fans, and pH levels to optimize growing conditions for the hydroponics system.

FILTER SYSTEM

The filter system of this system consists of two components:

- Several grates are present to prevent large debris from entering pumps and pipes creating clogs or damage.
- An easily replaceable activated carbon filter is installed at the end of the system to help with water impurities created by the plant growth.

SEA CAN LAYOUT



MODULE DESIGN

The full sea can operation was designed to fit three modules, with the team having the capacity to construct one. As requested by the customer, the main goal was to increase production. This was achieved by maximizing the number of pipes and plants in an area. Plants were spaced 20cm apart, the minimum recommended growing conditions. More pipes could be added by allowing space between modules for volunteers to access plants from either side of the module. Layer heights were also adjusted to allow for more ergonomic working conditions.

Watering requirements were met by using a pump system to transport water from a storage tank into a inflow manifold using a pipe system. This water is then distributed to each pipe where it travels to a collection trough and is carried down to the lower level before once again being collected. The outflow is gravity fed through pipes to a filter, then pumped back into the storage tank using a submerged pump.

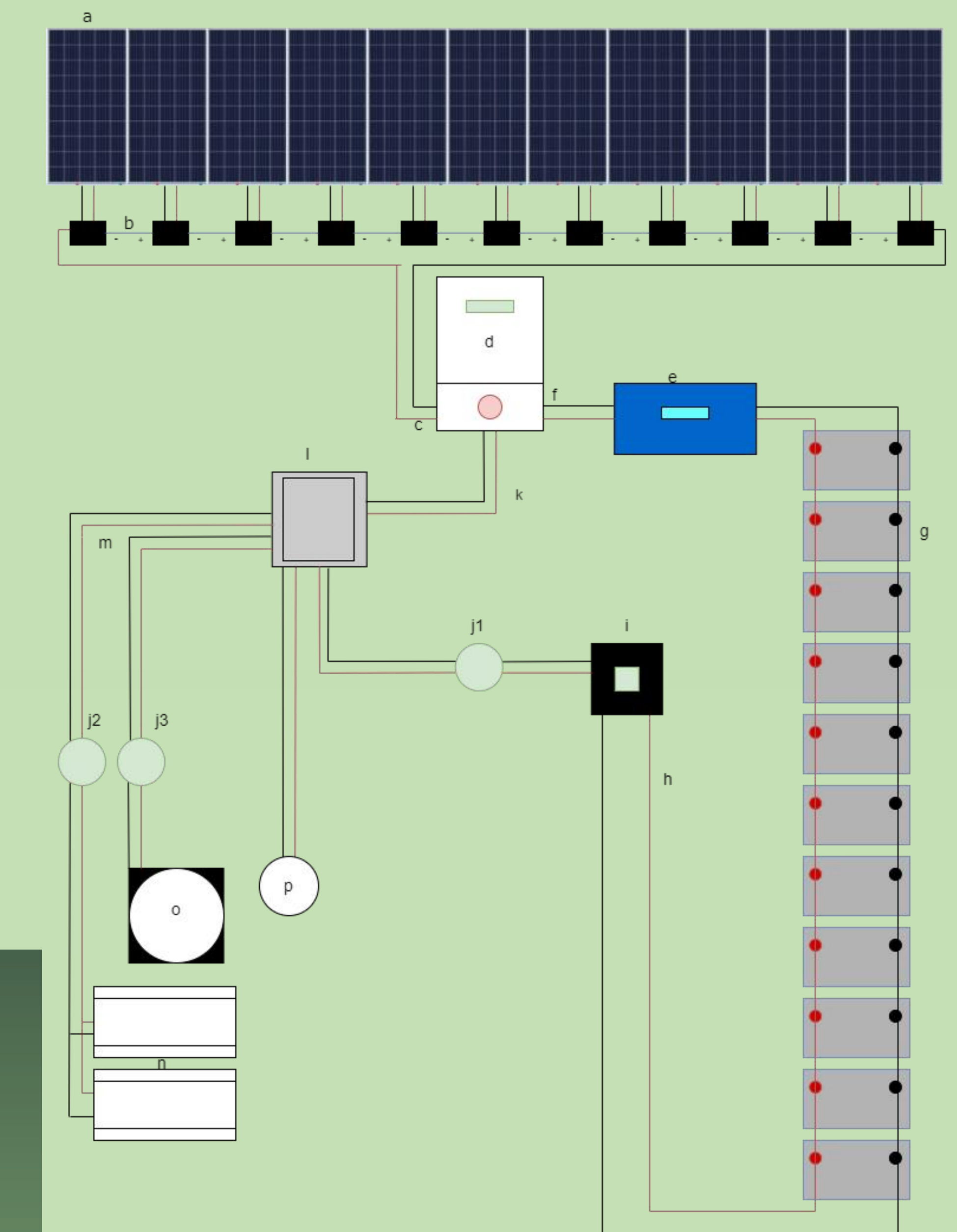
PLANT CAPACITY COMPARISON

Metrics	Initial Design	Engineered Design
Plant Capacity per Module	198	96
Plant Capacity per Sea Can	198	288 (~45% Increase)
Plant Capacity per Square Meter	49	71

OFF GRID SOLAR POWER

The pre-existing solar panel system was modified to make the system capable of running off-grid.

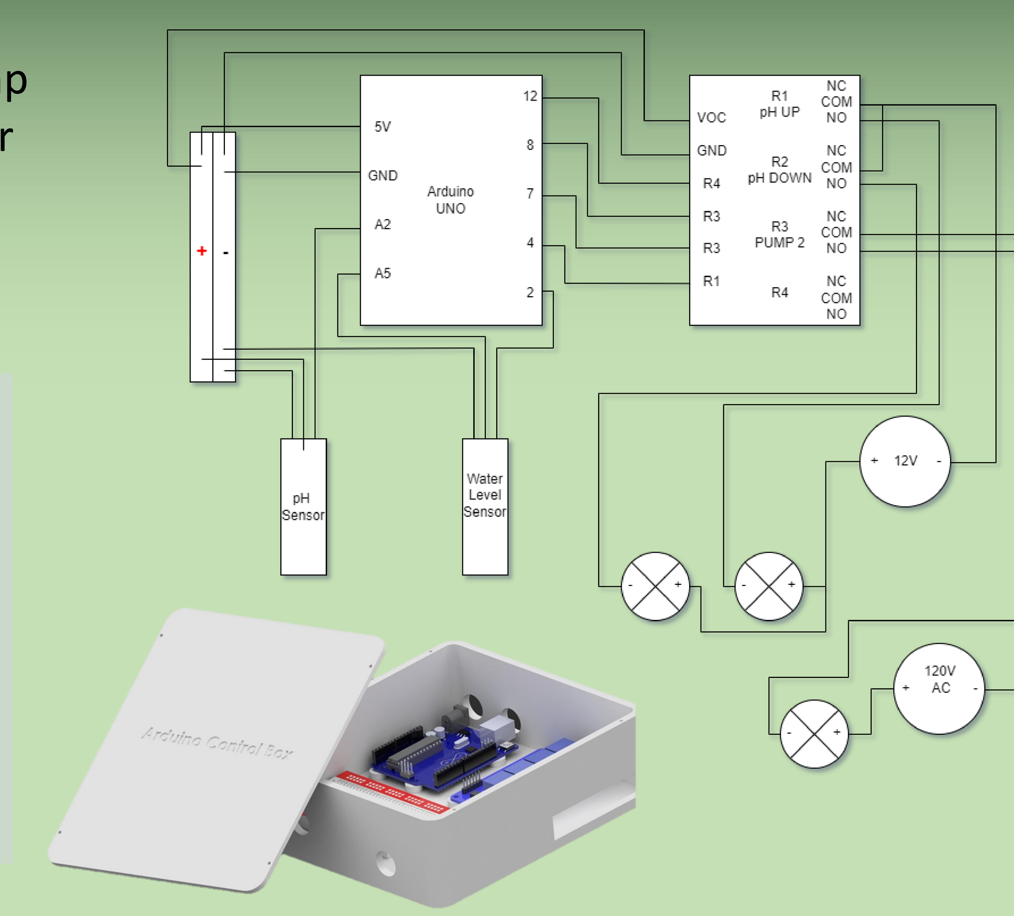
The system operates by sending 120V power to the SolarEdge inverter (d) via inverter (e) from a battery pack (g). This allows the system to run off-grid. This battery pack is charged during the day by sending 120V power to a charger (i) from the SolarEdge solar inverter (d) which is connected to the solar panels (a). The SolarEdge inverter also powers all the hydroponic system (o,n,p).



ARDUINO CONTROL

The automatic Arduino controls were designed to be expanded upon and currently use a relay to:

- Control the solution pH
- Operate the submersible pump to prevent power at low water levels



RESULTS AND CONCLUSION

The capstone group was successful in redesigning the farm hydroponics system to increase the sea can plant capacity by 45% while of the required materials, 79% were reused.

The current module will be installed along with auxiliary piping, solar power modifications and Arduino control following the capstone fair. Grow Calgary will be provided with an operation and maintenance manual, as well as the instructions to complete and install the remaining two modules. Options for expansion and modification will also be provided; to be implemented as the farm sees fit.