Divide and Conquer 1.0

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Self-Sustaining Hydroponic Greenhouse

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Group 5 - Fall 2022

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1.0 Project Narrative

1.1 Problem Statement

Over the last forty years, municipalities across the state have undergone rapid development because of the rapid influx of residents that has more than doubled the population of Florida. The steady growth of the state has resulted in unchecked urban sprawl, sudden gentrification, and diminished access to fresh organic foods. As these problems become more prevalent, city residents are faced with rising prices that make living a happy, healthy lifestyle unaffordable for an average family. While concerns grow, localities are falling behind on implementing sustainable agricultural initiatives, such as community gardens, to combat these issues. Failures to implement community gardens as a potential solution can be attributed to three main concerns: lack of knowledge, resources, and people.

1.2 Motivation

The motivation behind this project is derived directly from the problem statement. We are seeking to overcome the three main concerns hindering community gardens to combat the larger issues of food insecurity, sustainable agriculture, and diminished quality of life. Having identified the aforementioned issues in the nearby city of Oviedo, we intend to develop a self-sufficient hydroponic greenhouse requiring minimal human contributions with affordable fixed costs and low variable costs. We will make this a smart, self-monitoring system so that we can effectively eliminate the potential lack of knowledge, resources, or people that may inhibit the implementation of these initiatives.

1.3 Function

Our greenhouse will be an entirely self-contained system with many sub-systems involved in ensuring it has all the resources necessary to continue operation. The primary function of the greenhouse is to house three independent hydroponic systems, each growing a different crop using the nutrient film technique for growth. The second function of the greenhouse is to collect and divert rainwater into a purification reservoir to be distributed to each of the plant systems with the proper nutrient concentrations specified for each plant. The third function of the greenhouse is to utilize photovoltaic cells to capture solar energy and provide power for the systems. Upon completion, this self-sufficient greenhouse will function as a source of affordable organic produce for the community as well as an educational tool for residents on the benefits of sustainable agriculture.

1.4 Previous Project Inspirations

We have identified several former projects that we plan to expand upon to enhance their features, efficiency, and size. The two projects we are taking inspiration from for our hydroponic systems are the "Automated Home Hydroponics System" from Group E in Fall 202 and the "Pocket 'Ponics" in Fall 2019. For the rainwater collection system and photovoltaic system, we are taking inspiration from the "UV Water Analysis System" from Group 5 in Fall 2020 and the "Solar Powered Water Filtration System" from Group 24 in Fall 2019. Each of these projects provide essential knowledge necessary to developing the numerous sub-systems we intend to include in our greenhouse.

1.5 Goals and Objectives

Hydroponic System	
Goal	**Objective**
Grow many plants of the same species according to a specific plant profile	Program plant profiles
	Automate the water and nutrient pumps for according to profile
	Build a cascading housing
	Monitor the pH-balance, nutrient concentration, and cycles
Rainwater Collection System	
Goal	**Objective**
Monitor water content for contaminants, purify water, and pump into the plant system	Integrate a spectrophotometer to detect contaminants
	Implement a UV purifier inside the reservoir
	Pump water into the hydroponic systems as needed
	Trigger the pH balance pumps and nutrient pumps
Photovoltaic System	
Goal	**Objective**
Generate power for the system and store excess power	Optimize solar collection of panels outside the greenhouse
	Channel surplus power into a battery
	Include power channels to all electronic devices
Greenhouse	
Goal	**Objective**
Ensure connectivity between all internal systems for automated	Develop a LAN network for monitoring and system control
	Internal sensors connect to microcontroller to create mesh
	Scale independent system sizes within housing

2.0 Requirements Specifications

2.1 Power

- Clean Energy: The greenhouse should be able to sustain itself using only energy it collects from the connected solar panels.
- Energy Storage: There must be a constant, reliable source of energy for the pumps and sensors. Surplus energy should be stored efficiently for later use (ex. night).
- Voltage Regulation: PCB should regulate the incoming and outcoming voltage according to the needs of individual systems and sensors.

2.2 Microcontroller

- Low Power: The microcontroller should be able to function at low power to reduce electric usage.
- Data Collection: Must be able to quickly collect and store sensor data.
- Communication: Microcontroller must be compatible with chosen local network connection.

2.3 Hydroponic System

- Materials: Beds should be made of affordable, durable PVC material.
- Size: The system (bed, water, and nutrients) should be large enough to hold the various plants and vegetables but also compact enough to optimize space.

2.4 Sensors

- Low Power: The sensor playground should process and interpret data while consuming minimal electricity.
- Accuracy: Sensors should report accurate data to the microcontroller with high accuracy and minimal error.
- Maintenance: The sensor mesh will operate through extended periods of time without the need for support.
- Size: The sensors must be of a scale small enough to be housed within the sub-systems.
- Compatibility: Each sensor must be compatible with the microcontroller to ensure they are properly integrated within the mesh network.

Component	Parameter	Specification
Solar Panels	Power	100 Watts $\leq$ P < 300 Watts
Battery	Time	≈ 12-hour battery life
UV Water Purifier	Effectiveness	99% Efficiency on viruses, bacteria and protozoa

2.5 Constraints

- Cost: This is the largest constraint. Minimizing cost without losing quality will be very important.
- Energy: If this project is to run entirely on solar energy, limiting power usage is a large priority.

3.0 Block Diagrams

3.1 Overview

1. Greenhouse: Houses the plants and other systems.
2. Hydroponic System: Maintains supply of nutrients to plants.
3. Control System: Monitors all the sensors and provides and determines the actions taken. Provides users access to the greenhouse data and settings via an interface.
4. Rainwater Collection System: Provides purified water to the plants in the greenhouse.
5. Nutrient System: Provides specific nutrients to the plants in the greenhouse.
6. Photovoltaic System: Provides electricity to the greenhouse.

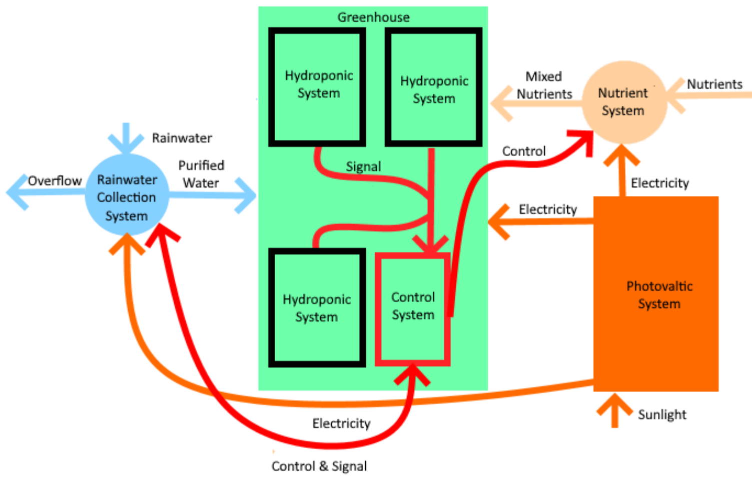

Figure 1. Overview

3.2 Photovoltaic System (Research) – George; Connor

1. Solar Panel: Converts sunlight into DC electricity.
2. Charge Controller: Limits the rate at which electric current is added to or drawn from batteries.
3. Batteries: Store the electricity.
4. Inverter: Converts DC electricity to usable AC electricity.
5. Breaker Panel: Switches to control the flow of electricity.

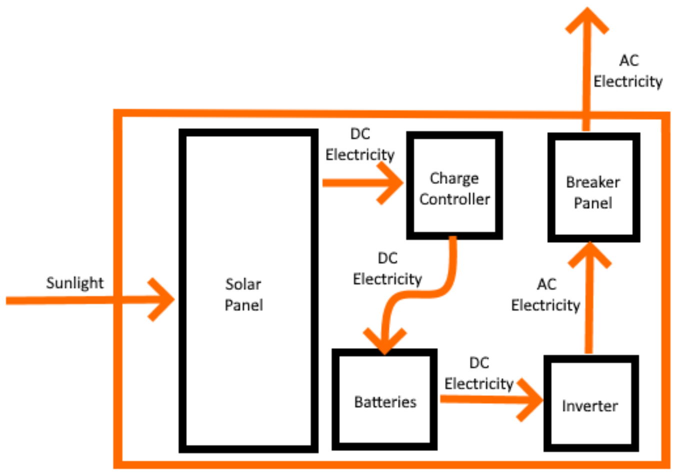

Figure 2. Photovoltaic System

3.3 Rainwater Collection System (Research) - George; Connor

1. Screening: Remove objects from the water.
2. Initial Reservoir: Stores the rainwater after it has been screened.
3. Spectrophotometer: Monitors the level of water contaminants.
4. UV Purification: Purifies the water using UV light.
5. Purified Water Reservoir: Stores purified water.
6. Pump: Moves the purified water from the reservoir to the greenhouse.

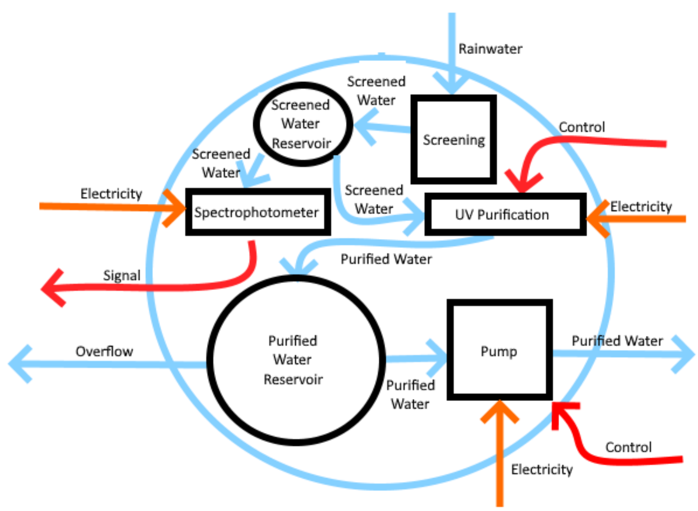

Figure 3. Rainwater Collection System

3.4 Nutrient System (Research) - George; Connor; Kaleb; Morgan

1. Phosphorus Reservoir: Stores phosphorus.
2. Nitrogen Reservoir: Stores nitrogen.
3. Potassium Reservoir: Stores potassium.
4. Calcium Reservoir: Stores calcium.
5. Magnesium Reservoir: Stores magnesium.
6. Pump: Moves the nutrients to the greenhouse

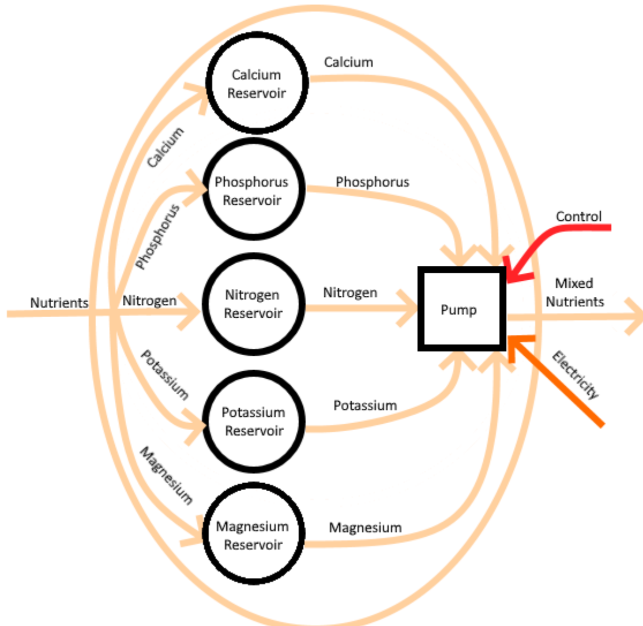

Figure 4. Nutrient System

3.5 Hydroponic System (Research)-George; Connor; Kaleb; Morgan

1. Air Pump: Moves air to the air stone.
2. Air Stone: Diffuses air into the water.
3. Nutrient Solution Reservoir: Stores the nutrient solution for plants.
4. EC or TDS Meter/Spectrometer: Measure the concentrations of the nutrients in the nutrient solution reservoir
5. Pump: Moves the nutrient solution to the plants.
6. Plants: Grow and make food.

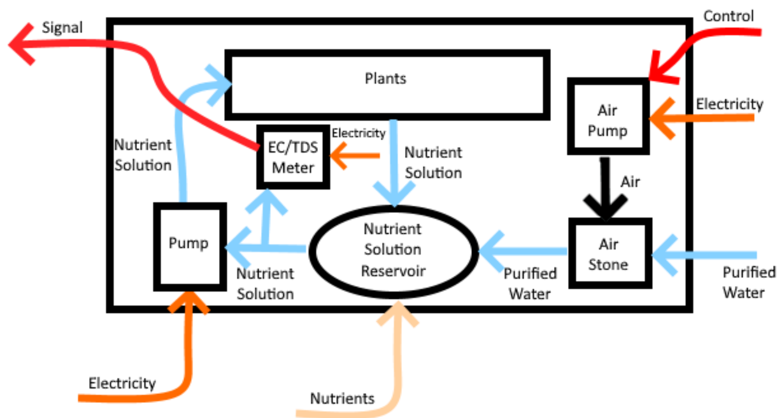

Figure 5. Hydroponic System

3.6 Control System (Research) - Kaleb; Morgan

1. Controller: Takes in signals from sensors and tells the system what to do. Sends and receives data from Local Area Network.
2. Local Area Network: Facilitates communication between devices within a small range.
3. Device: Examine data from the greenhouse and make changes to the settings.

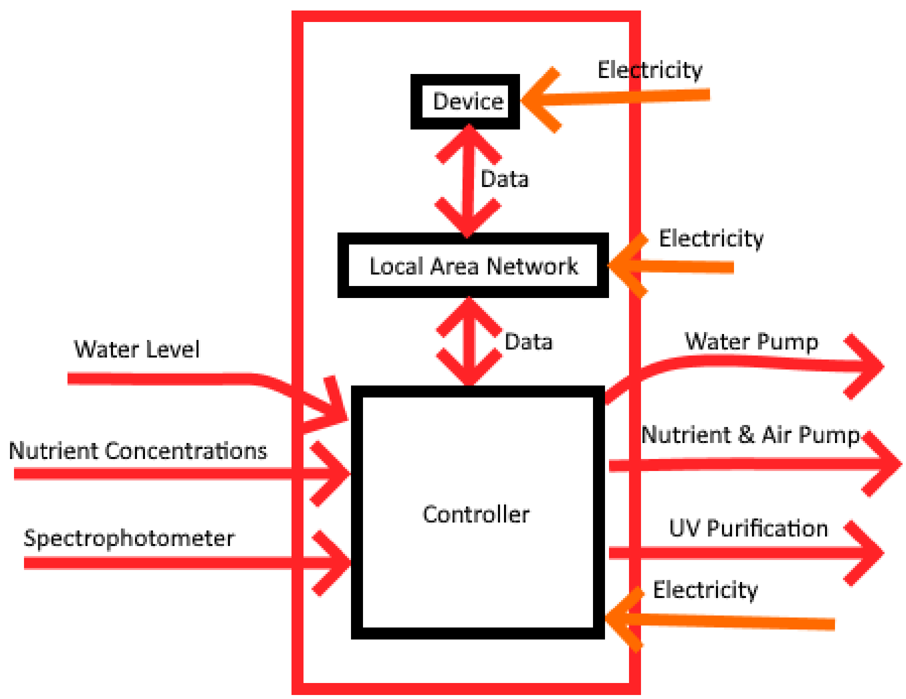

Figure 6. Control System

4.0 Estimated Budget

This budget is proposed for the design and construction of a Self-Sustaining Hydroponic Greenhouse. When drafting the initial budget estimate, we estimated the major components based on the current average price of the different units. The components are itemized in the budget. Most of our funding will be from sponsors. The remaining funding will be provided by project team members. A contingency of $300 was included in the budget; this will be in case of emergencies, unplanned minor expenses and possible instrument repair or replacement.

Part	Estimated Cost ($)
Spectrophotometer	1500
Green House	800
Photovoltaic system	500
Nutrient Film Technique (Hydroponic)	300
UV water purification	150
Flow meter	100
Water pump	60
Nutrient dispenser	60
Nutrients	35
Microcontroller and PCB	30
Reservoirs	30
LED growth lighting	15
Humidity sensor	15
Screening (Water)	5
Seeds/starters	20
Miscellaneous / Emergency	300
Total	3920

5.0 Project Milestones

5.1 Senior Design 1

Number	Milestone	Completion Week
1	Initial Product Documentation (Divide and Conquer 1.0)	4
2	Search for potential sponsor	4
3	Meet with advisor to confirm project idea	5
4	Research systems and create initial designs	5
5	Revised Product Documentation (Divide and Conquer 2.0)	6
6	Confirm design of power management system	6
7	Create PCB initial design	6
8	Update system designs (software, water retrieval, nutrient delivery)	7
9	Prototype spectrophotometer	8
10	Prototype nutrient delivery and pump system (software and hardware)	9
11	Finalize PCB design	10
12	Purchase components and PCB	10

13	Finalize 60 Page Draft	11
14	Finalize 100 Page Draft	13
15	Complete Final Report	16

5.2 Senior Design 2

Number	Milestone	Completion Week
1	Construct housing and hydroponic bed	1
2	Begin Integration	2
3	Complete nutrient selection software and interface	3
4	Complete integration	4
5	Begin Testing	6
6	Complete Testing	8
7	Deliver Product	9