PURDUE UNIVERSITY

CAPSTONE EXPERIENCE 2014

Hydroponics System Development

Agricultural & Biological ENGINEERING

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Problem Statement

The amount of fertile agricultural land available is directly proportional to population growth. Haiti is one developing nation currently struggling to feed its 10 million citizens, in part due to lack of arable land available to grow crops. The rocky, sloped terrain, as well as extensive urban growth limits agricultural practices severely. The Village of Hope Organization along with EEI, Inc. has presented the team with a need to develop a low-cost, modular hydroponics system to implement at the Village of Hope school center outside of Port-au-Prince, Haiti. The ultimate goal of this project is to provide a sustainable method of supplementing the schoolchildren's current diet of rice and beans with fruits and vegetables.

Deliverables include:

- A completed hydroponics design, including thermal and electrical inputs and outputs
- Demonstration prototype of hydroponics system
- Water and nutrient requirements for crops grown
- Crop output/growth rate capabilities for the designed unit
- Cost analysis of prototype and final design

Background

Hydroponics is a form of soil-less agronomic systems that use water as a medium for nutrient transport, which enables users to intensively grow crops in a variety of environments. Benefits include:

- Versatility – can be used in urban environments, indoors, or where soil is not suitable
- No runoff or nutrient waste – system is closed
- Decreased labor costs – no tilling, cultivating, or irrigating
- No crop limitations due to soil type or health

Design Process

Crop Selection and Nutrient Balance:

- Butter head lettuce
- Nitrogen, potassium, calcium, and phosphorous solution

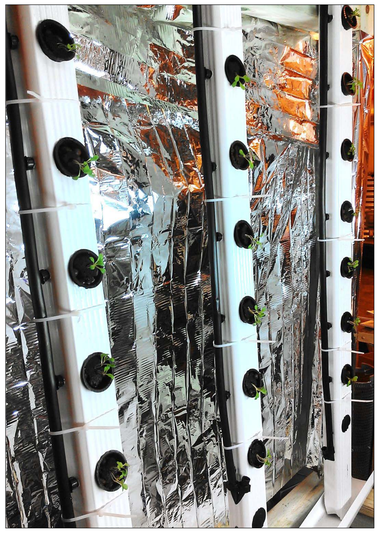
System Design Choices:

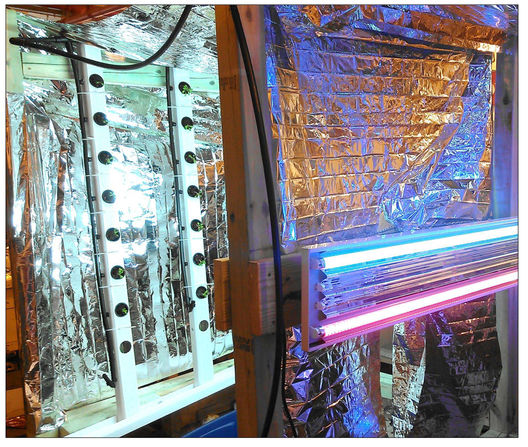
- Assembled within a standard 'high cube' shipping container, allowing for temperature and security control
- Vertical rows of plants maximizes space

Energy and Water Requirements:

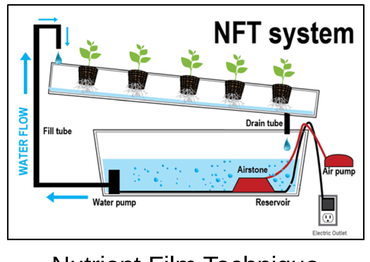
- LED lighting
- Pump
- Generator
- Reservoir tanks- 25 gallons each

Prototype Assembly



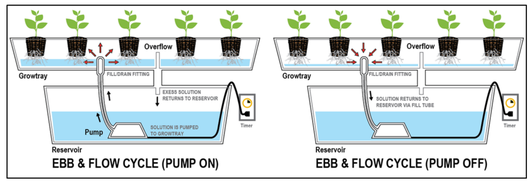


Alternative Solutions



Nutrient Film Technique

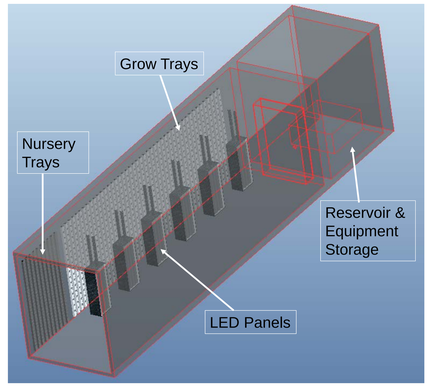
Deep Water Culture



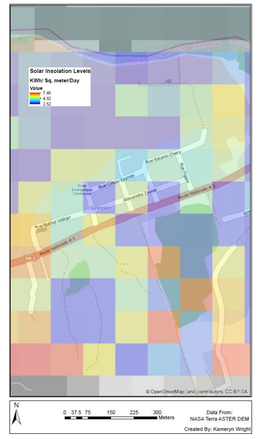
Ebb and Flow

Final Design

CREO Model of System Layout:



Incoming Solar Radiation:



Heat Transfer and Component Loading Analysis:

Convective Heat Transfer (kWh/day)		Solar Radiation (kWh/day)		Component Load Heat Generation (kWh/day)	
Summer	-148.79	With screen	268.56	LED Lighting	4.52
Winter	223.18	Without screen	895.20	Generator	66.81

Total Heat Rejection (kWh/day):

Season	With Screen	Without Screen
Summer	-488.68	-1115.32
Winter	-116.71	-743.35

Strategies for Heat Load Reduction:

- Misters within grow trays perform evaporative cooling on plant roots
- Sun screens reduce impact of solar radiation on container walls
- Active ventilation will circulate air within the system and keep indoor air temperature within an acceptable range for plant growth

Cost Analysis

Prototype Cost Breakdown		Projected Full System Cost	
Item	Cost	Item	Cost
Structural Materials	$288.00	Centrifugal Pump	$392.25
LED Lighting	$273.14	Honda Generator	$2,000.00
Growth Medium, Net Cups	$72.52	Nutrients, Seeds, Growth Medium	$477.20
Fluorescent Lighting	$65.33	Irrigation Tubing/Misters	$1710.94
Pump, Adapter	$74.94	Reservoir Tank	126.10
Seeds, Nutrients	$69.00	Structural Parts	$1,050.84
Irrigation Tubing/Misters	$150.00	LED Lighting	$1,638.84
TOTAL:	**$992.93**	**TOTAL:**	**$7396.17**

Project Impacts

- A sustainable solution to nutrition issues of the children at Village of Hope
- A secure, versatile, and potentially expandable unit that consistently grows fruits and vegetables locally
- An interactive example for teaching students about sustainable agriculture methods
- A driver for economic development within the community

Sponsors:
Bill Larson, Liaison, Village of Hope
George Benda, General Manager, EEI, Inc.

Technical Advisor:
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