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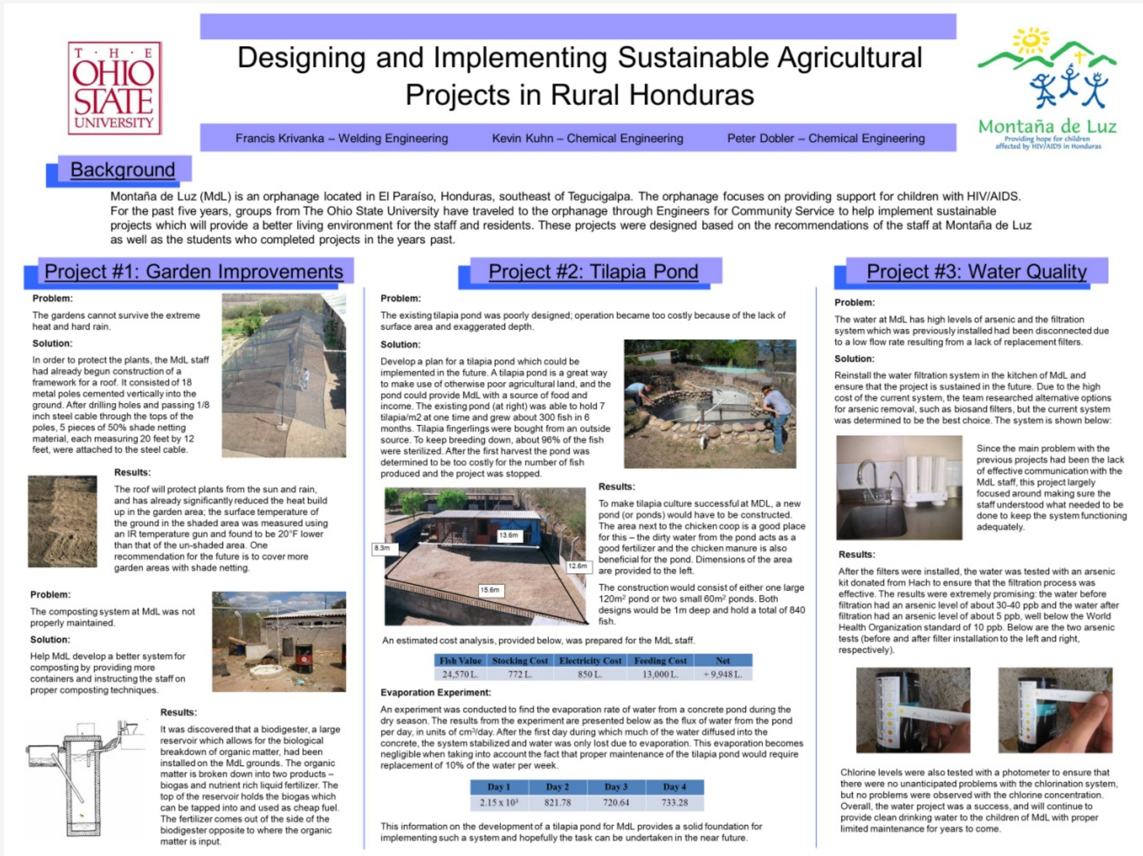

Designing and Implementing Sustainable Agricultural Projects in Rural Honduras

Francis Krivanka – Welding Engineering   Kevin Kuhn – Chemical Engineering   Peter Dobler – Chemical Engineering

Montaña de Luz
Providing hope for children affected by HIV/AIDS in Honduras

Background

Montaña de Luz (MdL) is an orphanage located in El Paraíso, Honduras, southeast of Tegucigalpa. The orphanage focuses on providing support for children with HIV/AIDS. For the past five years, groups from The Ohio State University have traveled to the orphanage through Engineers for Community Service to help implement sustainable projects which will provide a better living environment for the staff and residents. These projects were designed based on the recommendations of the staff at Montaña de Luz as well as the students who completed projects in the years past.

Project #1: Garden Improvements

Problem:

The gardens cannot survive the extreme heat and hard rain.

Solution:

In order to protect the plants, the MdL staff had already begun construction of a framework for a roof. It consisted of 18 metal poles cemented vertically into the ground. After drilling holes and passing 1/8 inch steel cable through the tops of the poles, 5 pieces of 50% shade netting material, each measuring 20 feet by 12 feet, were attached to the steel cable.

Results:

The roof will protect plants from the sun and rain, and has already significantly reduced the heat build up in the garden area; the surface temperature of the ground in the shaded area was measured using an IR temperature gun and found to be 20°F lower than that of the un-shaded area. One recommendation for the future is to cover more garden areas with shade netting.

Problem:

The composting system at MdL was not properly maintained.

Solution:

Help MdL develop a better system for composting by providing more containers and instructing the staff on proper composting techniques.

Results:

It was discovered that a biodigester, a large reservoir which allows for the biological breakdown of organic matter, had been installed on the MdL grounds. The organic matter is broken down into two products – biogas and nutrient rich liquid fertilizer. The top of the reservoir holds the biogas which can be tapped into and used as cheap fuel. The fertilizer comes out of the side of the biodigester opposite to where the organic matter is input.

Project #2: Tilapia Pond

Problem:

The existing tilapia pond was poorly designed; operation became too costly because of the lack of surface area and exaggerated depth.

Solution:

Develop a plan for a tilapia pond which could be implemented in the future. A tilapia pond is a great way to make use of otherwise poor agricultural land, and the pond could provide MdL with a source of food and income. The existing pond (at right) was able to hold 7 tilapia/m2 at one time and grew about 300 fish in 6 months. Tilapia fingerlings were bought from an outside source. To keep breeding down, about 96% of the fish were sterilized. After the first harvest the pond was determined to be too costly for the number of fish produced and the project was stopped.

8.3m
13.6m
12.6m
15.6m

Results:

To make tilapia culture successful at MDL, a new pond (or ponds) would have to be constructed. The area next to the chicken coop is a good place for this – the dirty water from the pond acts as a good fertilizer and the chicken manure is also beneficial for the pond. Dimensions of the area are provided to the left.

The construction would consist of either one large $120m^2$ pond or two small $60m^2$ ponds. Both designs would be 1m deep and hold a total of 840 fish.

An estimated cost analysis, provided below, was prepared for the MdL staff.

Fish Value	Stocking Cost	Electricity Cost	Feeding Cost	Net
24,570 L.	772 L.	850 L.	13,000 L.	+ 9,948 L.

Evaporation Experiment:

An experiment was conducted to find the evaporation rate of water from a concrete pond during the dry season. The results from the experiment are presented below as the flux of water from the pond per day, in units of cm^3/day. After the first day during which much of the water diffused into the concrete, the system stabilized and water was only lost due to evaporation. This evaporation becomes negligible when taking into account the fact that proper maintenance of the tilapia pond would require replacement of 10% of the water per week.

Day 1	Day 2	Day 3	Day 4
2.15×10^3	821.78	720.64	733.28

This information on the development of a tilapia pond for MdL provides a solid foundation for implementing such a system and hopefully the task can be undertaken in the near future.

Project #3: Water Quality

Problem:

The water at MdL has high levels of arsenic and the filtration system which was previously installed had been disconnected due to a low flow rate resulting from a lack of replacement filters.

Solution:

Reinstall the water filtration system in the kitchen of MdL and ensure that the project is sustained in the future. Due to the high cost of the current system, the team researched alternative options for arsenic removal, such as biosand filters, but the current system was determined to be the best choice. The system is shown below:

Since the main problem with the previous projects had been the lack of effective communication with the MdL staff, this project largely focused around making sure the staff understood what needed to be done to keep the system functioning adequately.

Results:

After the filters were installed, the water was tested with an arsenic kit donated from Hach to ensure that the filtration process was effective. The results were extremely promising: the water before filtration had an arsenic level of about 30-40 ppb and the water after filtration had an arsenic level of about 5 ppb, well below the World Health Organization standard of 10 ppb. Below are the two arsenic tests (before and after filter installation to the left and right, respectively).

Chlorine levels were also tested with a photometer to ensure that there were no unanticipated problems with the chlorination system, but no problems were observed with the chlorine concentration. Overall, the water project was a success, and will continue to provide clean drinking water to the children of MdL with proper limited maintenance for years to come.

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Honduran Aquaponics Systems for Sustainability

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Background

In developing countries, such as Honduras, a lack of money causes negative consequences for those living in poor areas. In particular, individuals living in poverty-stricken areas can struggle to earn enough money to purchase food for oneself or one's family. Without food, the hunger of the affected individuals will lead to unfavorable side effects for their physical health and their capacity to educate themselves. One potential solution to this problem could be found through the use of aquaponics systems.

Aquaponics systems have the following features:

- A combination of plant beds and fish tanks in such a way that water is circulated between the fish tanks and plant beds
- The plants use the fish waste products as nutrients and return filtered water to the fish
- Water can be moved by means of an electric pump powered by solar energy
- An aquaponics system provides a sustainable food source for a community

Our objectives were:

1. To modify a larger existing system so that it can be powered by solar panels rather than the unreliable Honduran grid power
2. To expand a smaller existing systems so that it will be able to support more fish
3. To establish a chemical testing routine for both systems

Objective 1 – Solar Power Design

Figure 1. Existing larger aquaponics system consisting of Three fish ponds and three grow beds. Water is circulated with Two 120VAC 80W submersible water pumps.

Objective 1 (continued)

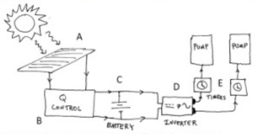

Figure 2. Solar power system installed for the larger larger aquaponics system. (A) Nine 50W M75 ARCO Solar Inc. solar panels; (B) One 450W 12VDC Sunforce charge controller; (C) Two 105Ah deep cell batteries wired in parallel; (D) One 12VDC to 120VAC 60Hz Whistler Pro inverter; (E) Two duty cycle timers. Components were sized to operate the water circulating pumps at a 50% duty cycle on a 24h basis (rather than 100% duty cycle used previously).

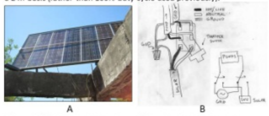

Figure 3. (A) Solar panels, in place; (B) Detail of wiring showing transfer switch installation. The system can operate from both solar or grid energy.

Summary – Objective 1

- Total cost of system $500.41. The largest cost was for the deep cell batteries ($285.71).
- Running the system at 50% duty cycle (rather than 100%), we estimate that the system will break even at 8 years, using the present cost for grid power in Honduras.

Objective 2 – System Expansion

Figure 4. Smaller existing system consisting of one fish tank and two grow beds. This system is solar powered with a manual backup pump.

Objective 2 (continued)

The Issue

- This solar-powered aquaponics system was built last year
- Over the past year, the owner observed that the plant life was thriving but the fish were dying prematurely

The Solution

- Increase grow bed:fish tank volume ratio to 2:1, in order to increase filtering capacity by plants and, as a result, return cleaner water to the fish

Figure 5. View of the modified smaller aquaponics system. The lower plant bed has been increased in size in order to achieve the 2:1 volume ratio between plant bed and fish tank.

Summary – Objective 2

- The new plant bed was built from available materials and, therefore, there was no associated cost.
- The solution was experimental and temporary. If successful, it will be improved in the future by the owner.

Objective 3 – Chemical Testing

Table 1. List of important chemical parameters associated with the water in an aquaponics system and their ideal ranges.

Chemical or Indicator	Safe Range	Units
Temperature	70 – 85 (20-30)	°F (°C)
pH	7-7.5	
Ammonia	< 0.02	Ppm NH_3/NH_4
Nitrate	< 25	ppm
Nitrite	< 1	ppm
Oxygen	6-7	mg/L

Summary – Objective 3

- Three easy-to-use test kits were purchased at $58.75 total
- Because the kits use test-strip technology, this supply of testing materals will last several years, at a once-a-month usage rate.

Objective 3 (continued)

Table 2. Data recorded at the larger system (A, B and C ponds) and the smaller system (school). Note the low pH at the small system.

Pond	Date & Time	Nitrate (ppm)	Nitrite (ppm)	Ammonia (ppm)	pH	Oxygen (ppm)
B	Sun 9:10 AM	0	0	-	-	5
B	Sun 7:30 PM	-	-	0	7.4	-
A	Sun 7:40 PM	0-5	0	0	-	7
C	Sun 7:45 PM	0-5	0	-	-	5
A	Mon7:20 AM	-	-	0	7	7
B	Mon 7:30 AM	-	-	-	-	4
C	Mon 7:30 AM	-	-	0	-	5
School	Wed 8:45 AM	5	0	0	6.6	9
A	Wed 4:45 PM	0	0	-	-	10
C	Wed 5:00 PM	0	0	0	-	8
B	Wed 5:15 PM	0	0	0	-	8

Discussion

- The solar electrical system proved to be able to produce energy to power the larger aquaponics system
- The reduction of pump activity from 100% duty cycle to 50% duty cycle, halved the energy consumption but, in turn, doubled the break even time for cost (to 8 years).
- The expanded tank needs further data collection to determine the effectiveness of the changes
- The water testing provides a useful tool to determine the health of the water

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- This service-learning mission (OSU ENG692) was limited to one week in-country implementation time
- Additional time is necessary to evaluate the true effectiveness of our work.

Conclusion

The improvements to these existing systems offers valuable information to the Honduran people about aquaponics systems. The details used in this project can be explored and replicated by the local people so that they can benefit from the sustainable food supply offered by aquaponics.

Acknowledgements

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Planning for Sustainable Development in Honduras Through a Local Business

Chelsea Johnson

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Abstract

Montaña de Luz (MdL) is an orphanage located in rural Honduras. The residents of the village travel nearly an hour by bus every week to buy basic food necessities. Furthermore, with almost 20 American volunteer groups visiting every year, there is a potential of a steady stream of revenue that is currently not being utilized. MdL wants to establish a store to meet these needs. The children of MdL can gain real-world job experience at the store and earn money through craft items they sell there. Using a projector, educational films can be shown at the store, free of charge, as entertainment for the community. Information on current market prices for food was gathered in Honduras to ensure that the store can break-even in profit. The goal is not to create a profit, and it must be ensured that the store will not compete with local *Pulperías* (snack shops). Sustainability is a key issue.

Background

- 8 m by 10 m building was built with a grant on a 20 m by 20 m plot of land in the village of Nueva Esperanza.
- MdL maintainss an orchard of 50+ banana and papaya trees, complete with an irrigation system.
- The garden grows a variety of vegetables.
- MdL also raises pigs as well as chickens, both for meat and eggs.

Objectives

- Identify the intentions of the store
- Help create a business plan
- Investigate current market prices for produce
- Teach the children business concepts and craft-making techniques

Establishing current market prices

Current market prices were researched to compare the cost of growing food to buying it. These prices will also serve as a basis for pricing food in the store. MdL spends $638 per week on food items.

Table 1. List of food prices gathered in Tegucigalpa on 3/27/09. Highlighted items are items currently being grown at MdL. All other items listed would be feasible for MdL to grow.

Product	Price ($)	Unit
Avocado	0.05	each
Bananas	0.32	per 10
Bell Pepper	0.11	per 5
Broccoli	0.53	each
Cabbage	0.32	per pound
Cauliflower	0.8	per pound
Carrot	0.37	per pound
Chicken	3.72	per pound
Cilantro	0.16	per pound
Cucumbers	0.37	per pound
Eggs	3.72	per 30
Green Beans	0.53	per pound
Lemons	1.06	per 25
Lettuce	0.53	per pound
Mangos	0.53	per pound
Onion	0.53	per pound
Pineapple	1.33	for 1
Potatoes	0.37	per pound
Radish	0.16	per 7
Strawberries	1.86	per pound
Sweet Potato	0.27	for 2
Tomato	3.19	per box

Instruction on making crafts

- The children already enjoy making crafts
- They previously made crafts of low quality and lack confidence in the ability to make high-quality items
- We taught the children how to work with wire and beads to create simple and beautiful patterns
- Materials purchased from the United States will be approximately $20 for 50 bracelets
- Bracelets can be sold for $1-$5 each
- Much of the jewelry supplies is acquired by donation
- Additionally, we taught them fundamental business concepts

Objectives of the store

- Provide produce and meat to the Honduran customer at an affordable price
- Provide a place for the children living at MdL to gain work experience
- Provide a creative outlet for the children
- Show fun and educational films to the community
- Break even in profit
- Not compete with local businesses

Table 2. Estimates of annual electricity and employee costs of the store. Prices calculated March 2009.

Item	Cost per year ($USD)
Storage freezer	383
One employee	2600
Coffee maker	60
3 CFL lights	36
VCR	18
Total	3097

Sustainability

- The garden can help alleviate food expenses if MdL can maximize production
- The store can be sustainable once it can break even in expenses
- Leaving craft supplies and jewelry-making instructional books at MdL
- Documenting this project (and others) in a "wiki" format for anyone to access
- Having students travel to Honduras annually to update projects previously implemented
- Staying in contact with MdL staff

Future Recommendations

- Better assess the needs of the Honduran customer, possibly through surveys
- Maximize the productivity of the garden and orchard so that demand can be met
- Consider hiring an additional gardener
- Address the electricity needs of the store
- Install a diesel-generator for the store's freezer, in preparation for frequent power outages
- Replacing several opaque roofing panels with translucent panels to provide natural lighting
- Involve the children as a way for gaining work experience

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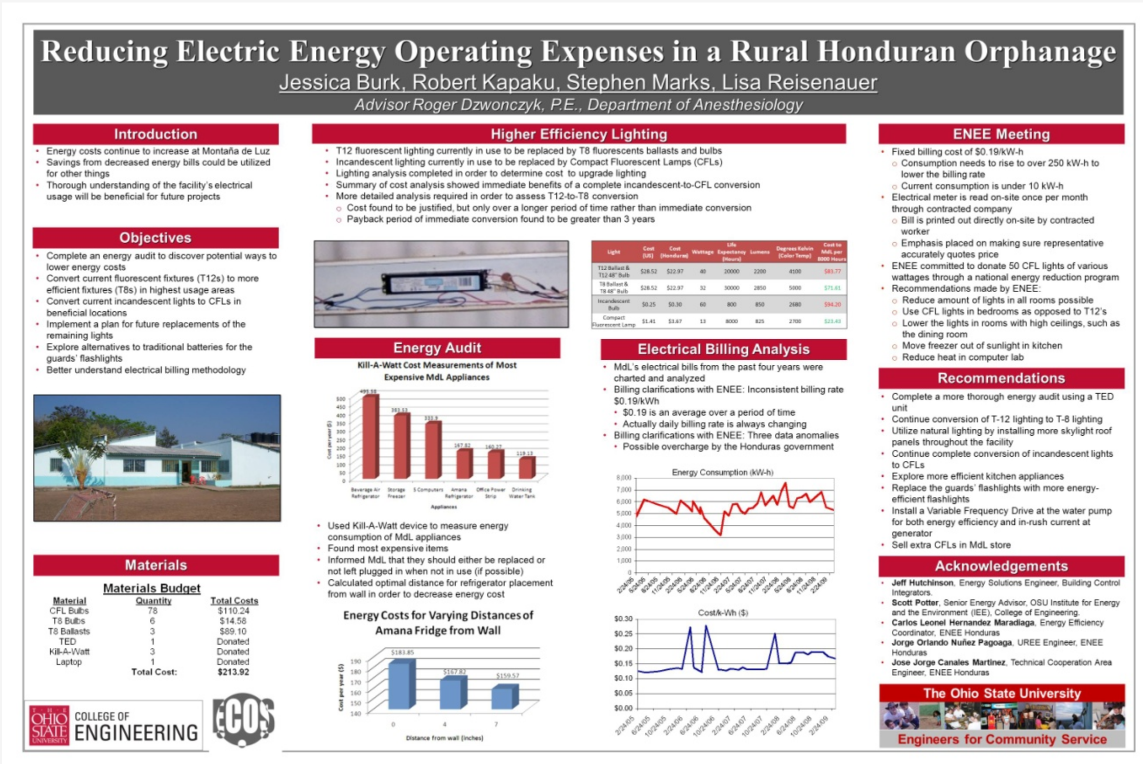

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Developing Appropriate Technology for Honduras in a Service Learning Program

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Abstract

Developing appropriate technology for third world end users is the challenge for a group of The Ohio State University (OSU) students. By partnering with stakeholders in Honduras and technical advisors, the student team designed a sustainable and affordable self-contained family-sized aquaponics system. They implemented and tested the system during the 2011 spring break immersion trip.

OSU students, interested in helping to alleviate global poverty, collaborate- in order to effectively design appropriate technology for people in developing countries. Students participate in an elective engineering design program that addresses developing appropriate technology for third-world end users. Understanding the various constraints when designing products is one of the most difficult challenges in this process. The service engineering program includes a quarter-long class, followed by a weeklong immersion trip to Honduras. Course content addresses a variety of applicable humanitarian engineering topics ranging from the anthropology of end users, to the technical aspects of design. Traveling to Honduras allows students to implement and test their product ideas. By partnering with technical experts and in-country stakeholders , students gain a detailed understanding of what is appropriate for the particular region. Thinking like anthropologists first and designers second helps students better understand the "voice of the end user" in order to maximize the chance of success.

Honduran stakeholders requested a family-sized self-contained aquaponics system, to provide a supplemental food source of fish and vegetables. After researching existing designs and communicating with Honduran stakeholders, a preliminary aquaponics system was designed and developed. The system's limiting factor was the water pump that recirculates the water from the fish tank to the grow bed. Since grid power is unreliable in areas of Honduras, a rechargeable solar powered system was selected as the primary power source, along with an emergency manual backup pumping system. Students incorporated commercially available components available in Honduras to increase the sustainability.

The initial model contained components procured in both the US and Honduras. As part of the development process, the students identified Honduran sources for all components of the system in order to achieve true sustainability.

Project Objective

Design and construct an aquaponics model demonstration system

Design Constraints

- Able to provide a supplemental food source (fish and vegetables) for a typical Honduran family of five (2 adults and 3 children)
- Primary power must be independent of Honduran electric power grid
- Must have backup pumping system in case of primary power or pump failures
- Target Capital Cost – US$400 (2011)
- Should be built with locally (Honduran) available equivalent parts and supplies

Design and Implementation

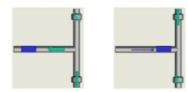
Solar Primary Pump Constraints

- Duty cycle – 25%
- Estimated Minimum Daily Sunlight – 8 hrs
- Length of Time on Battery Only – 3 days

Specifications

- Water Pump – 360 gal/hr marine bilge pump
- Solar Panels – 45 W
- Timer – Repeat cycle time w/ adjustable controls
- Battery – 36 Ahr deep-cell marine battery

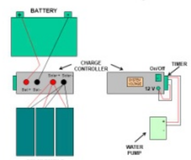
Manual Backup Pump



Piston pulls water from lower check valve, upper check valve is closed

Piston push water through upper check valve, lower check valve is closed

Schematic of Electrical System



Production Cost of Aquaponics System

Part	Source	Costs USD	Supplier	Estimated price in Choluteca Honduras (USD)
Solar panel kit	purchased in US	$196	Harbor Freight	$300*
Fish tank	purchased in Honduras	$20	Honduran local market	$20
Pump timer	purchased in US	$64	www.backwoodssolar.com	$50
Deep cycle battery	acquired in Honduras (used)	$0	WGM garage	$75
DC pump	purchased in US	$24	www.backwoodssolar.com	$25
Grow bed	acquired in Honduras (used)	$0	WGM garage	$20
Gravel	aquired in Honduras	$0	Honduran local river	$0
Manual pump & fittings	purchased in Honduras	$15	Honduran hardware store	$15
Wood supports	acquired in Honduras (used)	$0	WGM garage	$15
Total Cost:		$319		$520

* includes extra lighting hardware and

a. b. c.

Figure 1. (a and b) Grow beds. Water pumps from the fish tank to the top grow bed and then siphons to the lower grow bed. Each grow bed siphon controls plant root exposure to the water and nutrients. In this implementation, the grow beds are made from split plastic storage barrels. The fish tank is a plastic tank located under the upper grow bed and protected from direct sun light. (c) Solar panel array w/ storage battery. The control electronics are located in a protective box under the panels.

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Discussion

- The current system has been functioning properly
- The system is scalable – can be sized for multifamily application
- The system is modifiable
  - There are many locally available options for grow beds and fish tanks
  - The system can be powered by other alternative/renewable energy sources including wind
- System will be used as a model to teach local residents about aquaponics as a viable food source
- Future research: trade off s include grid vs. solar vs. wind power, time of year to market, profitability per year, durability/lifespan, sustainability

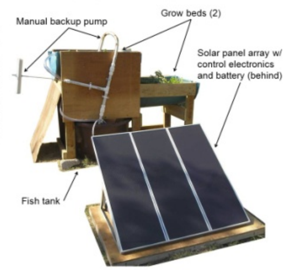

Figure 2. Overall view of aquaponics system

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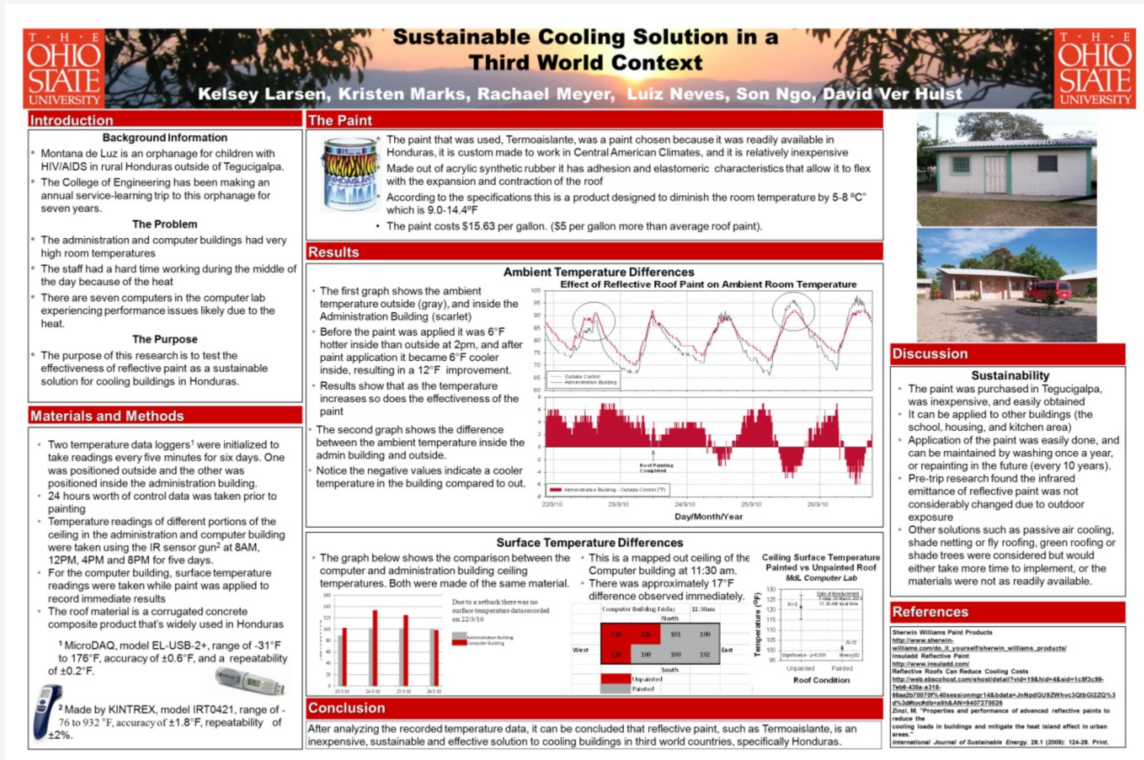

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