


# Publications From the SL Program



**THE OHIO STATE UNIVERSITY**

## 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

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### Background

Montaña de Luz (MdL) is an orphanage located in El Paraiso, 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/m<sup>2</sup> 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.

**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<sup>2</sup> pond or two small 60m<sup>2</sup> 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	13,060 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<sup>3</sup>/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 x 10 <sup>4</sup>	821.76	729.64	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.

**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).

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.

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.

College of Engineering  
Office of International Affairs



## Model Home Design Through Sustainable Engineering in Choloteca, Honduras

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 Advisor: Roger Dzwonczyk, The Ohio State University Columbus, OH




### Introduction

- This is the second year a team from OSU has been working in in Choloteca, Honduras (an impoverished community located in the southwestern corner of the country.) Living conditions are poor and locals are looking for new ideas for more "livable" homes.
- Past achievements**
  - Initial assessment of community
  - Established contact with community members
  - Surveyed "typical" house
- Partnership with local missionaries**
  - Established partnership with Larry and Angie Overholt, former OSU graduates and members of World Gospel Mission, who have worked in Choloteca for over 25 years



### Goals and Objectives

- Investigate alternative building currently used in the Third World methods based on priorities stated in the initial assessment report
- Conduct first-hand assessment in the community
- Speak with locals about living conditions
- Speak with missionaries about living conditions
- Establish design priorities based on findings
- Investigate alternate building methods on component parts
- Propose component projects for future groups
- Relay findings to missionaries and gather feedback

### Component Projects

- Structure
  - Roof
  - Bricks
- Rain Water Collection
  - Filtration
  - Storage
- Latrine
  - VIP Style
- Stove
  - Low/No Smoke
  - Temperature Control
  - Alternate Fuel
- Alternative Cooling
  - Reflective Paint
  - Height of Floor
  - Ventilation
- Gardens
  - Roof-Top
  - Vertical

### Acknowledgments

- Larry and Angie Overholt of World Gospel Missions
- Residents of Choloteca, Honduras
- Dr. Job Ebenezer, Technology for the Poor
- Roger Dzwonczyk, The Ohio State University Department of Anesthesiology and Team Advisor
- Greg Bixler, P.E. and Team Advisor
- Dr. John Merrill, The Ohio State University Department of Engineering and Team Advisor

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### Design Priorities

- Protection from elements**
  - Resist heavy rain
  - Resist heavy wind
  - Protect against fire
  - Earthquake resistance
- Best Practices**
  - Conserve resources
  - Remain sustainable and affordable
  - Comply with local construction practices

### Recommendations

- Coursework**
  - Senior design program
  - Multidisciplinary focus
  - Year-long independent study
  - Investigate grants
- Project**
  - More teams on site
  - More involvement from locals







The Ohio State University

Engineers for Community Service



## 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:

- To modify a larger existing system so that it can be powered by solar panels rather than the unreliable Honduran grid power
- To expand a smaller existing system so that it will be able to support more fish
- 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)

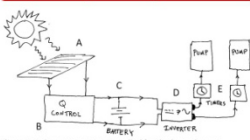


Figure 2. Solar power system installed for the larger aquaponics system. (A) Nine 50W M75 ARCO Solar Inc. solar panels; (B) One 450W 12VDC Sunforce charge controller; (C) Two 120VAC 80W submersible water pumps; (D) One 12VDC to 120VAC 60Hz Whistler Pro inverter; (E) Two duty cycle timers. Components were sized to operate the water circulating pumps at a 50% duty cycle on a 24h basis (rather than 100% duty cycle used previously).

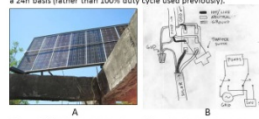


Figure 3. (A) Solar panels in place; (B) Detail of wiring showing transfer switch installation. The system can operate from both solar or grid energy.

#### 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 <sub>3</sub> /NH <sub>4</sub>
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 materials 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	0	7.4	5
B	Sun 7:30 PM	0	0	0	7	7
A	Sun 7:40 PM	0.5	0	0	7	7
C	Sun 7:45 PM	0.5	0	0	7	5
A	Mon 7:30 AM	0	0	0	7	7
B	Mon 7:30 AM	0	0	0	7	4
C	Mon 7:30 AM	0	0	0	7	5
School	Wed 8:45 AM	5	0	0	6.6	5
A	Wed 4:45 PM	0	0	0	10	10
C	Wed 5:00 PM	0	0	0	8	8
B	Wed 5:15 PM	0	0	0	8	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

- 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

Roger Drzewonczyk, Miriam Simon, Dr. John Merrill, World Gospel Mission, OSU Office of International Affairs, Larry & Angie Overholt

### References

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## Introduction

### Background Information.

- Students from OSU College of Engineering have conducted service-learning missions in Honduras since 2005, applying technology to improve people's lives. This year they served in Choluteca.
- Choluteca is an urban city in southern Honduras with a population of about 100,000 people.
- Aquaponics can provide a supplemental food source (fish and vegetables) for Hondurans.

### Overall Objective

Create an inexpensive (<\$500), sustainable and replicable aquaponics system for a typical single-family Honduran household.

### Specific Objective of this Project

- Design and build the water pump component for the aquaponics system.

### Pump Design Criteria

- Low capital investment
- Off-grid design – Honduran electricity is unreliable and expensive
- Low operating cost
- Reliable – The system should include a primary and backup pumping mechanism

### Aquaponics System Components

- Fish tank – 250g volume
  - + 1 ft<sup>3</sup> water/full grown fish
  - + 25-30 fish in the tank at any given time
- Plant tank - About 100g (ideal) filled with gravel/clay to form grow bed for vegetables.

### Recommended Pump Requirements

- Pump must circulate 30% of the water per cycle.
- Pump duty cycle – 25%.

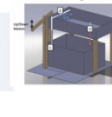
## The Pumps

### Manual Backup Pump

Original Design – Prototype built in the US



Modified Design – Built in Honduras



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



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

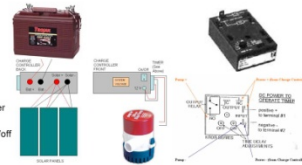
### Solar Primary Pump

Estimated Values

- Daily time running – 6h
- Minimum sunlight – 8h
- Time without sun (running on batteries) – 3d

### System Specifications

- Solar panels – 45 Watt solar panel kit with charge controller
- Water pump – 360g/h marine bilge pump
- Timer mechanism – Repeat cycle timer with adjustable on/off controls
- Battery – >36Ah deep cell marine battery



## Results

### A working system built in country with locally available materials including fish and plants

Bill of Materials			
Part	Price	Source	Pricing for Honduras
Water Pump/Kit	\$150	Harbor Freight	100%
Plant Tank	\$20	Local Materials	20
Plant Tank	\$20	www.bonsaiwarehouse.com	100%
Deep Light Reflector	\$20	Local Materials	100%
Deep Light Reflector	\$20	www.bonsaiwarehouse.com	100%
Grow Bed	\$10	Local Materials - Sump	20
Gravel	\$10	Local Materials - Collected at River	0
Water Pump/Kit	\$150	Local Materials - Harbor Freight	100
Plant Tank	\$20	Local Materials - Sump	20
<b>Total Cost</b>	<b>\$500</b>		<b>\$500</b>



# Planning for Sustainable Development in Honduras Through a Local Business

Chelsea Johnson

Advisor: Roger Dzwonczyk, P.E., Department of Anesthesiology

## 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 maintains 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 21
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
<b>Total</b>	<b>3097</b>



## 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

## Acknowledgements

- Roger Dzwonczyk
- Dario Rubio
- Dr. John Merrill
- Erin Galloway
- Vicki Rush

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# Reducing Electric Energy Operating Expenses in a Rural Honduran Orphanage

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Advisor Roger Dzwonczyk, P.E., Department of Anesthesiology

## Introduction

- Energy costs continue to increase at Montaña de Luz
- Savings from decreased energy bills could be utilized for other things
- Thorough understanding of the facility's electrical usage will be beneficial for future projects

## Objectives

- Complete an energy audit to discover potential ways to lower energy costs
- Convert current fluorescent fixtures (T12s) to more efficient fixtures (T8s) in highest usage areas
- Convert current incandescent lights to CFLs in beneficial locations
- Implement a plan for future replacements of the remaining lights
- Explore alternatives to traditional batteries for the guards' flashlights
- Better understand electrical billing methodology



## Materials

Material	Quantity	Total Costs
CFL Bulbs	75	\$110.24
T8 Bulbs	6	\$14.56
T8 Ballasts	3	\$89.10
TED	1	Donated
Kil-A-Watt	3	Donated
Laptop	1	Donated
Total Cost:		\$213.92



## Higher Efficiency Lighting

- T12 fluorescent lighting currently in use to be replaced by T8 fluorescent ballasts and bulbs
- Incandescent lighting currently in use to be replaced by Compact Fluorescent Lamps (CFLs)
- Lighting analysis completed in order to determine cost to upgrade lighting
- Summary of cost analysis showed immediate benefits of a complete incandescent-to-CFL conversion
- More detailed analysis required in order to assess T12-to-T8 conversion
  - Cost found to be justified, but only over a longer period of time rather than immediate conversion
  - Payback period of immediate conversion found to be greater than 3 years



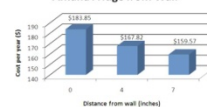
## Energy Audit

Kil-A-Watt Cost Measurements of Most Expensive MDL Appliances



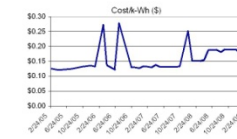
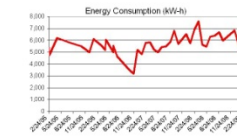
- Used Kill-A-Watt device to measure energy consumption of MDL appliances
- Found most expensive items
- Informed MDL that they should either be replaced or not left plugged in when not in use (if possible)
- Calculated optimal distance for refrigerator placement from wall in order to decrease energy cost

Energy Costs for Varying Distances of Amana Fridge from Wall



## Electrical Billing Analysis

- MDL's electrical bills from the past four years were charted and analyzed
- Billing clarifications with ENEE: Inconsistent billing rate \$0.19/kWh
- \$0.19 is an average over a period of time
- Actually daily billing rate is always changing
- Billing clarifications with ENEE: Three data anomalies
  - Possible overcharge by the Honduras government



## ENEE Meeting

- Fixed billing cost of \$0.19/kWh
  - Consumption needs to rise to over 250 kWh to lower the billing rate
  - Current consumption is under 10 kWh
- Electrical meter is read on-site once per month through contracted company
- Bill is printed out directly on-site by contracted worker
- Emphasis placed on making sure representative accurately quotes price
- ENEE committed to donate 50 CFL lights of various wattages through a national energy reduction program
- Recommendations made by ENEE:
  - Reduce amount of lights in all rooms possible
  - Use CFL lights in bedrooms as opposed to T12's
  - Lower the lights in rooms with high ceilings, such as the dining room
  - Move freezer out of sunlight in kitchen
  - Reduce heat in computer lab

## Recommendations

- Complete a more thorough energy audit using a TED unit
- Continue conversion of T-12 lighting to T-8 lighting
- Utilize natural lighting by installing more skylight roof panels throughout the facility
- Continue complete conversion of incandescent lights to CFLs
- Explore more efficient kitchen appliances
- Replace the guards' flashlights with more energy-efficient flashlights
- Install a Variable Frequency Drive at the water pump for both energy efficiency and in-rush current at generator
- Sell extra CFLs in MDL store

## Acknowledgements

- Jeff Hutchinson, Energy Solutions Engineer, Building Control Integration
- Scott Potter, Senior Energy Advisor, OSU Institute for Energy and the Environment (IEE), College of Engineering
- Carlos Leonel Hernandez Marañón, Energy Efficiency Coordinator, ENEE Honduras
- Jorge Orlando Núñez Páezaga, UREE Engineer, ENEE Honduras
- Jose Jorge Canales Martinez, Technical Cooperation Area Engineer, ENEE Honduras

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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

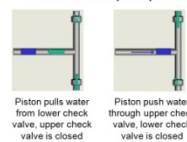
#### Solar Primary Pump Constraints

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

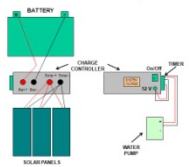
#### Specifications

- 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



#### Schematic of Electrical System



#### Production Cost of Aquaponics System

Part	Source	Costs USD	Supplier	Estimated price in Choloma Honduras (USD)
Solar panel kit	purchased in US	\$136	Hudson Freight	\$200*
Pump timer	purchased in Honduras	\$20	Honduran local market	\$20
DC pump	purchased in US	\$14	www.basewoodsolar.com	\$15
Deep cycle battery	acquired in Honduras (used)	\$1	Walmart garage	\$25
Grow bed	purchased in Honduras (used)	\$1	Walmart garage	\$25
Grow bed	acquired in Honduras	\$1	Honduran local market	\$1
Manual pump & timer	purchased in Honduras	\$10	Honduran hardware store	\$15
Wood supports	acquired in Honduras (used)	\$1	Walmart garage	\$15
<b>Total Cost</b>		<b>\$183</b>		<b>\$200</b>

\* See below notes lighting hardware and



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.



### 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 a include grid vs. solar vs. wind power, time of year to market, profitability per year, durability/lifespan, sustainability

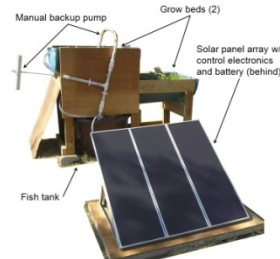


Figure 2. Overall view of aquaponics system

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- Acknowledgements: G. Bixler, R. Dzwonczyk, K. Froman, M. Jewitt, J. Merrill, S. Ngo, R. Nims, L. Overholt, A. Peterson, D. Pitt, M. Simon, M. Wolfe

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