IPRO 323
Low-Cost Water Pump Design/Testing to Serve Rural Villages
Project Plan

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Sponsor: US Environmental Protection Agency, National Collegiate Inventors & Innovators Alliance (NCIIA) and Stuart Grants

Team: Brian Albee
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1. Objective

The objective of IRPO 323 is to find and optimize a system to deliver drinkable water to communities that do not have easy access to water. Mainly in locating a water source accessible to the region based on geographical limitations. From there, creation of a system to draw out the water in order to meet the demands of the people based on their lifestyle. The system has to be easy to maintain, fulfill the water requirement, and is cost effective in the life of the design. However, in order to fully understand the system and its limitations a test model will be used. In order to accomplish this project in a timely manner each individual will have to learn, develop, and apply interpersonal skills, research methods, and coordination. The set objectives, therefore, are:

- Evaluate water sources and water demands of the target community
- Design a system for this community
- Research products and costs for system components
- Create a test model to better understand the system components

2. Background

a. Sponsors

The project was started when Professor Khalili was attempting to apply water filtration techniques to a region of Monterrey, Mexico. When the professor realized that access to drinking water was difficult. It was necessary with the assistance of grants and the mentioned sponsors the basis for the IPRO began. The Monterrey Institute of Technology has spent a year devising a solution for this problem in similar conditions that the IPRO will be facing. They have sent information regarding the methodology and resources used in determining needs.

b. User Problems

The community selected currently has difficulty in obtaining a reliable amount of drinkable water due to the current reliance upon wind mills. The problems are that the wells for these wind generators are not deep enough to draw upon a reliable ground water source and the wind streams in Mexico are not uniform enough resulting in damage to the high maintenance wind mills.

c. Technological Implications

There has been much technology developed in both the US and all over world with addressing water needs ranging from manual labor sources such as the hand pump, horse pump, and other physical task oriented methods for retrieving water. Modern technology plays a role in the form of gas and diesel engines to pump water. With the desire to decrease in reliance on oil, technology has gotten “greener” in relying upon renewable energy sources in extracting water. Pump technology has been well developed in different aspects of manufacturing, agriculture, and other industrial applications that it is possible to find multiple products that can achieve a specific need. Well construction will be relied upon to gain access to the water source.

d. Historical Success and Failures

Previous attempts to solve the water crisis have been done in the form of wind turbine technology. This technology relied upon wind movement to create enough electricity or generate enough mechanical motion to power the well pumps to extract water. However, due to the rapid change of wind directions in Mexico the turbines have sustained consistent damage making repairs costly and frequent.

e. Cultural and Scientific Issues

The location of the project site is Mexico, creating both a language and possible cultural barriers that will have to be considered in designing the system. Government policies will have to be observed under regulations of ground water access.

f. Costs of the Problem

Without a consistent source of drinking water, communities lacking such a commodity come to a standstill without the ability to raise livestock, agriculture, or daily necessities. This forces an import of water, which is a costly expenditure over a long duration of time upon the citizens.

g. Details of a Proposed Implementation

Through research and consultation a list of possible solutions will be considered. The best solution will then be tested in the form of a scaled down test model to understand the machinations of the key components. The assembly of a full scale prototype, the documentation of the assembly, and possibly the implementation of the project in Mexico will be within the scope of the IPRO. The sister university of the Monterrey Institute of Technology has already performed a similar analysis for another community in Monterrey. Thusly a review was done as an introduction of the topic to the IPRO board as attached.

h. Attached Documents

<Attached documents from the Monterrey Institute of Technology and the IPRO proposal>

3. Methodology / Brainstorm / Work Breakdown Structure

a. Problems

The first set of problems consists of physical constraints and needs of the target users. Specifically, the source of drinkable water, water demands, extraction of the water, and how to power this extraction of water.

b. Solving the Problem

The information needed for the source of water and the water demands are to be taken by consulting both the Monterrey Institute of Technology faculty, students, and the resident expert on the IPRO team. Geographical limitations will help in selecting the possible water sources with consultation with the above. Questions pertaining to lifestyle, activities, and location will help in determining the appropriate amount of water required.

The method of extraction of water will be considered among different types of technologies available while satisfying easy maintenance, fulfills water requirements, and is cost effective over the expected lifetime. The powering of the method will also be determined by similar criterions used for the water extraction.

c. Testing of Solutions

The source of water will be tested by consulting the available government documents pertaining to the availability of water. The water demands will be tested by comparing the water demands of the user community to similar communities across the world to determine if it is within reason. The types of technology will be evaluated by research and consulting with various specialists in culmination of testing of the technology to see of the feasibility in meeting the objectives.

d. Documentation of Solutions

Recording the government documentations used will help for future references in the case of change and for accountability. Water demands will be taken from research and consultation and compared for reference to world organizations such as the UN. The test models of the technology will be documented through brainstorming diagrams, schematics, and experimental data.

e. Analyzing Solutions

Analyzing the information regarding the availability of water will be done through consultants who have spent time in Mexico. Analysis of water demands will be considered by the pumping sub team in order to the select the technology required. Determination of the usefulness of the solution will be based on the performance of the technology to bench mark tests established by the sub teams compared to the data provided by vendors and the vast amount of data provided on similar products.

f. IPRO Deliverable Generation

The IPRO deliverables will consist of the test model with applicable data from testing. The available data used in selection of the components for the full scale model based upon success of the testing. The documentation used from other sources in order to determine the requirements of water and consumption.

4. Expected Results
    a. Expected Results of Activities
        - Obtaining the required information with regard to the water sources available and the option required in accessing the water both physically and politically.
        - The water demands will be well established based upon estimates of similar communities in the region and around the world.

- Successful building of a test model in order to test the viability of key components of the model with regard to the ability of meeting physical or electrical demands.

b. Research / Testing Expectations

Data pertaining to the water source will be based on lexicon of the professional field dealing with the source ranging from ground water to surface flowing water. Evaluation of the water consumption model will be done in a liter per day and gallons per day in order to understand the differences in water requirements across the world. The data will be recorded in both a graphical and tabulated representation showing data of flow rates for the water extraction method. Electrical values will be documented for the device that will power the water extraction.

c. Potential Products

Through research, the ideal site for water source extraction should be determined along with estimates regarding the water demands tailored to the community. The data from the test model will aid in determining the reliability of data given by the manufacturer. Also the test model will help in understanding the variables that control the outputs to the various key components.

The output of the tasks will be raw data of products against a benchmark test. The end output will be a system that will meet the water consumption demands of the community while meeting the required objectives.

d. Potential Outputs

A test model will be constructed for the key components of the system, while the construction and ordering of the required components of a full scale model will be made as a physical deliverable.

e. Working Deliverables

The creation of the test model will satisfy the learning criterion of the IPRO institution. The completion of the full scale model will satisfy the needs of the target community and complete the objective of the IPRO.

f. Sponsor Expectations

The water source type along with the predicted water value helps determine the type of technologies required. The data and observations from the test model will help predict the values expected for selecting a full scale model. A full scale model can then be taken and implemented into the project site fulfilling both the necessities of a community while providing an ample learning experience to the IPRO team.

g. Integration into Solution Framework

The data and experience taken from the creation of the design system will help in creating a team of individuals versed in system design. While the output data of the test model will aid in determining the reliability of values when selecting the full scale components.

5. Project Budget

Item	Estimated Cost
Test Systems (Pumps)	$500
Test Systems (Solar Panels)	$200
Test Systems (Storage)	$80
Test Systems (Pipe)	$30
Test Systems (Other)	$150
Full Scale System (Pumps)	$2000
Full Scale System (Panels)	$1000
Full Scale System (Storage)	$1200
Full Scale System (Pipe)	$200
Full Scale System (Other)	$1000
Transportation	Varies on Plan
Well Construction	$5000
Total	$11360

6. Schedule of Tasks and Milestone Tasks
   <Attached Gantt Chart>

7. Individual Team Member Assignments

Subteam: Piping
Subteam Leader: Not Applicable
Subgroup Members: Brian, Bill
Task: Designing the piping materials, stability, and requirements for the test model and for the full scale model.
Individual Responsibilities:

Name: William E. Pajak "Bill"
Major: Aerospace Engineering (Fourth Year)
Skills and Strengths: Family plumbing background
Bill: Calculating the equation necessary to determine the piping options, purchasing piping and materials.

Name: Brian Albee
Major: Chemistry (Second Year)
Skills and Strengths: Family construction background

Brian: Adapting the model design to the piping needs and also purchasing piping and necessary materials. Both of us will be participating in the construction of the test design as well as working on the piping needs and construction design of the Mexico model.

Subteam: Pump and Control System
Subteam Leader: Joshua Sullivan
Subteam Members: Katty Davis, Erick Leong, Joshua Sullivan
Task:

- Design and calculation of a) pump functional requirements and b) corresponding control system requirements.
- Selection of product(s) in market that satisfies functional requirements above.
- Documentation of system dynamics for other groups to use in design. (e.g. flow rate and outlet size for pipe system and water storage groups; power requirements for solar group).
- Coordination with other groups over specification of test system measurements.

Individual Responsibilities:
The group as whole coordinates synergistically with all team responsibilities and there are not, nor do there seem to need to be, task specific delegations per team member.

Name: Katty Davis
Major: Master of Environmental Engineering
Skills and Strengths: Assisting the IPRO as a graduate student with a Mexico background.

Name: Erick Leong
Major: Mechanical Engineering
Skills and Strengths: Interested in the project with aspirations of joining Engineers without Borders.

Name: Joshua Sullivan
Major: Mechanical Engineering
Skills and Strengths: I have previous work experience with machine design and manufacturing. I was in a prior IPRO focused on the design of a gravity fed water distribution system for Pignon, Haiti. My interest related to both these IPROs has to do with wanting to apply my limited engineering skill to help people who have far less resources and knowledge but the same worth of life.

Subteam: Solar Panels
Subteam Leader: Not Applicable
Subteam Members: Juacinta, Ellen, Ryan
Task:

- Select a small scale solar panel

- Create a test system to monitor the voltage potentials and variations here in Chicago
- Use all available information to select the optimal solar panels for the most efficien performance in Mexico

Individual Responsibilities:

Name: Jaucinta Burt
Major / Background Education: Electrical Engineering
Skills and Strengths in IPRO: Building and testing electric circuits, and working well with others. I have an interest in helping others especially when it comes to important things such as obtaining water. Also, I am interesting in seeing how solar power can be implemented.
Jaucinta: Researching the solar panels, test system, and connection to be used, decide on what is more proficient and should be used, and assembling and testing the efficiency of the panels.

Name: Ellen Rohde
Major: Mechanical Engineering (3rd year)
Skills and Strengths:
General mechanical engineering
-Thermodynamics
-Statics
-Currently in fluids and dynamic
Ellen: To select/create the test system for the Chicago test panel as well as look into the specific models to purchase

Name: Ryan Yarzak
Major / Background Education: Biomedical Engineering
Skills / Strengths / Academic Interest in IPRO: Experience in Uganda
Ryan: Help design the test system and figure out what is necessary to take to Mexico

Subteam: Water Storage

Subteam Leader: Nicole Galbraith

Subteam Members: Nicole Galbraith, Jinting Liu, Leon Chan

Task: Initially finding a tank to use as water reservoir with pump sitting inside and water flow returning to tank. For the initial testing, the water storage group will also be in charge of the water temperature regulation. Once the Mexico objective in is queue, the group will focus on a water storage tank to hold water for use when the pump is in the resting phase. All three members researched initial water storage and will research further pressurized water tanks for Mexico use.

Individual Responsibilities:

Name: Nicole Galbraith

Major: Aerospace/experience with Auto-CAD and fluid dynamics

Skills and Strengths: Strong background in fluids and Bernoulli's equations/part of SWE and AIAA/strong aptitude in computer systems.

Nicole: In charge of temperature regulation for the testing set-up.

Name: Jinting Liu
Major: Master of Environmental Management in Stuart, IIT
Background Education:
Bachelor of Environmental Engineering in Nankai University, China
Bachelor of Business Administration in Tianjin University, China
Skills and Strengths:
I have participated in a similar program in my college so I am more familiar with this program. And interdisciplinary background and some research experiences can help me contribute more on the project. And I am also good at doing research and paperwork.
Jinting: In charge of filling and emptying the water storage tank for testing.

Name: Leon Chan
Major: Civil Engineering / experience in CAD and surveying
Skills and Strength: 3 weeks of work experience with a general contractor / part of ASCE
Leon: In charge of the stability of the test tank for testing.

8. Designation of Roles
   Meeting Minutes – Erick
   Timesheets – Erick
   Weekly Task List - Erick
   iGroups Management – Erick