FAMU-FSU College of Engineering

Department of Electrical and Computer Engineering

PROJECT PROPOSAL AND STATEMENT OF WORK

EEL4911C – ECE Senior Design Project I

SOLAR SAUSAGE PROJECT 'B'

Team Members:

- **Jimmy Smith, Jr**., electrical & computer engineering (jls11e@my.fsu.edu)
- **Aileen Ulm**, electrical engineering (amu10@my.fsu.edu)
- **Xiaoxiang Gao,** electrical engineering (xg14c@my.fsu.edu)
- **Jonathan Melton**, electrical engineering (jonathan1.melton@famu.edu)
- **Morgan Bublitz**, mechanical engineering (mrb09c@my.fsu.edu)
- **James Harrell**, mechanical engineering (jph12@my.fsu.edu)
- **Madanha Chibudu**, mechanical engineering (mbc07@my.fsu.edu)

Senior Design Project Instructor: **Dr. Michael Frank**

Technical Advisors: **Dr. Edrington and Dr. Ordonez**

October 16, 2014

Project Executive Summary

The Solar Sausage design project is a multi-department project to be completed in a year. The Solar Sausage project was initially started by a research team at The Florida State University, this team created the parabolic trough system used to create cheap electricity via solar panels. The student design team will take the current system, invented by Ian Winger and Sean Barton, and look for possible ways to fix inefficiencies and add any applications that will help to improve the overall output of the Solar Sausage system.

The end goal that the student-led design team will accomplish, is to create electricity via PV panels and provide a system that will be able to purify water. The design team must focus on three factors to keep the system working smoothly: the sensitivity of pressure levels within the two chambers of the sausage, a way to store the energy created during the day time for use at night, and a type of cooling system to keep the PV panels at a safe temperature. A pressure regulator will be present in the design in order to keep the separate chambers at their exact measurements respectfully. In this system, if the pressure is not exact, the output of the system alters drastically and will not perform as expected. The energy storage aspect of this project is very important, without a storage device all of the work that the system does during working hours will be lost when the sun goes down. The design team plans on using a series of batteries for storage, this will allow the loads being serviced during the day to keep up being active. The PV panels must be kept at such a temperature that they will not overheat, if the panels get too hot their functionality decreases. A design for a heat exchanger will be used to pull the heat from the PV panels into the water, this is the same water that will later be pasteurized and used as drinking water.

The purpose of this Solar Sausage project long term will be to provide electricity and clean drinking water to underdeveloped countries or villages. This specific project team will use the country of Panama as their design location when thinking about design ideas. The fact that this system will end up in an underdeveloped country means that the team will need to make sure that the upkeep and replacement of the Solar Sausage is simple and the parts easily accessible to the region. The Solar Sausage system can consist of as many separate sausages that the required load needs. The prototype made by the student-led team will have a minimal load connected to the system, 1-1.5 kW, in the long run it would be ideal if a string of solar sausages could support an entire village. The end-product of this year’s design team may not be advanced enough to support such large loads, however the prototype created will be a miniature version of a system that would be able to support an entire community.

Table of Contents

1. Introduction

1.1 Acknowledgements

The design team would like to thank Ian Winger for his commitment to the team. Dr. Winger has provided hours of support and advice in regards to his invention, giving the team opportunities to search for improvements on his original design. Dr. Winger has also provided the team with equipment to build their prototype. Along with Dr. Winger, the design teams technical advisors, Dr. Edrington and Dr. Ordonez have helped critique and perfect ideas presented by the Solar Sausage project team. With the continued support of these individuals, the design team will have the best chance to create an efficiently working prototype for their Senior Design Project.

1.2 Problem Statement

The purpose of this project is to design a complete and working prototype of a Solar Sausage. The end product will prove to produce a cheap and simple way to create electricity and potable drinking water for underdeveloped countries. There are a few main issues facing the group when it comes to the analysis and design of the Sausage. The team will first look at the inefficiencies in the current model in regards to pressure regulations. Having exact pressure levels in the top and bottom chambers of the Solar Sausage is of the upmost importance to the productivity of the system. Another problem in need of fixing is the fact that an energy storage device needs to be added to the Solar Sausage. Currently there is no way to store the energy made during the hours with the most sunlight, once the sun goes down this is lost using the current design. An efficient way of cooling the solar panels will need to be implemented as well. The panels can very easily overheat and without a cooling system the panels will go out of commission rather quickly

Referring to the issues stated above, the design team has plans in place to correct these problems. Since the pressure levels are the most important to keep regulated one choice would be to implement a microcontroller that can read and alter pressure readings according to design specs. This system, however, will end up in under developed countries and the use of complex devices may not make sense. Another answer to the pressure problem would be to create a purely mechanical pressure regulator system that has easy and cheap upkeep and can effectively keep the system at correct levels. The issue of energy storage has multiple solutions. The design team will use a type of battery that can harness the energy to be used at night, when the sunlight needed to operate the system is at its obvious lowest point. The cooling process for the solar panels will include a heat exchanger. This will be designed to pull the heat from the solar panels into the water. This is the water that will be used during the pasteurization process. At the end of the design process these solutions will, as a whole, create a more efficient Solar Sausage.

1.3 Operating Environment

The Solar Sausage performs at its best in hot, dry climates, making Florida a bit of a challenge to keep the system working at high efficiency. The design team will have to account for such weather conditions as humidity, pressure changes due to storms, and morning dew. Any of these changes to the environment can affect how the Sausage produces its output. The end product of this system will be designed to be able to operate in a country such as Panama, as FSU has a satellite campus there and the Engineers Without Borders chapter at the FAMU-FSU College of Engineering does work in this area. This region has close to the same weather conditions that affect Florida, making it easier to work through many possible issues in Tallahassee.

1.4 Intended Use(s) and Intended User(s)

The intended use(s) of the solar sausage is to provide electricity and potable water to impoverished countries. Water and electricity are necessities of life and the solar sausage will help in providing those necessities. Also, the solar sausage will support a 1-1.5 kW load for this project, a scaled up version will be able to support a small village.

The intended user(s) of the solar sausage are people who live in villages or other impoverished countries who are not equipped with the tools or equipment needed to provide an ample amount of drinkable water or electricity.

1.5 Assumptions and Limitations

Assumptions	Limitations
Components for the project will be inexpensive	$5,000 budget
Provide potable water	Scarce water sources
Project will be completed in two semesters	Unforeseen circumstances
Solar Sausage and Photovoltaic panel will both have a length of 10 feet.	Storing the Solar Sausage
Power output of 900 W/m^2	Ideal Sunlight
Water will be pasteurized from 65°C – 90°C.	Continuous water flow
Upper & Lower hemispheres will maintain a constant pressure	Morning dew
One axial rotation	Few moving parts to track the sun
Reflective material is convenient	The tension on both ends of the sausage

1.6 Expected End Product and Other Deliverables

The design team will produce an end product consisting of a two-sausage Solar Sausage system to their client, in this case their advisors. Once this prototype is designed, built, and delivered, the team will not be supplying any other deliverables after the completion of the project. The system being provided will consist of two solar sausages working together, creating electricity and cooling the PV panels in the first sausage and finishing the pasteurization process of the water in the second sausage. This end system will prove to support a load between 1 and 1.5 kW. A scaled up version of the design teams project should in theory be able to support a larger load, for example a small village.

2. Concept Generation & Proposed Design

2.1 Water Pump

The water pump required for this project would need to have the ability to pump water from a deep water source such as a well. An electric pump would be ideal so that it could be powered by the PV panels.

A high voltage and low current pump is desirable to limit the power consumption and increase the efficiency of the system. From researching potential water pumps online the ***Red Lion 24 GPM 1HP Cast Iron Shallow Well Jet Pump*** looks like it could accomplish the job required. The specifications for this motor can be found in table X.

Running Amps:	Unknown-Amps
Voltage	120/240-Volt
HP/CC:	1 HP
Gallons Per Minute:	24 GPM
Outlet Diameter:	1"
Weight:	42.5 Lbs. (19.28 kilograms)
Suction Head:	25 Feet

Table X: Specifications for *Red Lion 24 GPM 1HP Cast Iron Shallow Well Jet Pump*

This pump would be desirable for a shallow well but does not have the suction power for a deep well source. This water pump would be used if there was a shallow pond or lake. Since the pump is primarily made of cast iron it would be wise to keep the pump contained away from rain water and humidity to keep rust from accumulating. The current requirement is unknown, which is an important specification to know but it can be determined if the horsepower and voltage are known. The proper water pump depends on the application and the final decision on a water pump will involve a decision matrix and a concrete application of what type of water source will be used.

2.2 Heat Exchanger

The photovoltaic panel is going to utilize a heat exchanger system that cools down the surface temperature of the photovoltaic panel in order to increase the efficiency of the photovoltaic cells. The heat exchanger design uses the principal theories behind internal forced convection, where fluid in such applications is forced to flow by a fan or pump through a tube that is sufficiently long to accomplish the desired heat transfer.

The heat exchanger system is going to use an active cooling system that uses an electrical pump to propel water from a well to the photovoltaic panels. The pump will help with the circulation of the water out of the photovoltaic panel. As the water flows throughout the photovoltaic panel, the fluid will collect some heat from the photovoltaic cells. This process keeps the panels operating at their desired temperatures which range from 25°C to 50°C. The convective heat transfer rate of the heater exchanger system is going to be highest at the entrance region. As the fluid flows throughout the pipeline system the convective heat transfer rate will go down. The water flowing out from the heat exchanger comes out at a temperature of 50°C. This will prepare the water for the pasteurization process which will occur after the water flows out of the heat exchanger. The heat exchanger as an aluminum outer casing which makes it a good thermal conductor. The heat from the aluminum casing is going to be transferred to the copper pipes through a process of convection. The heat collected by the copper pipes is then transferred to the moving water inside the pipes through a process of conduction.

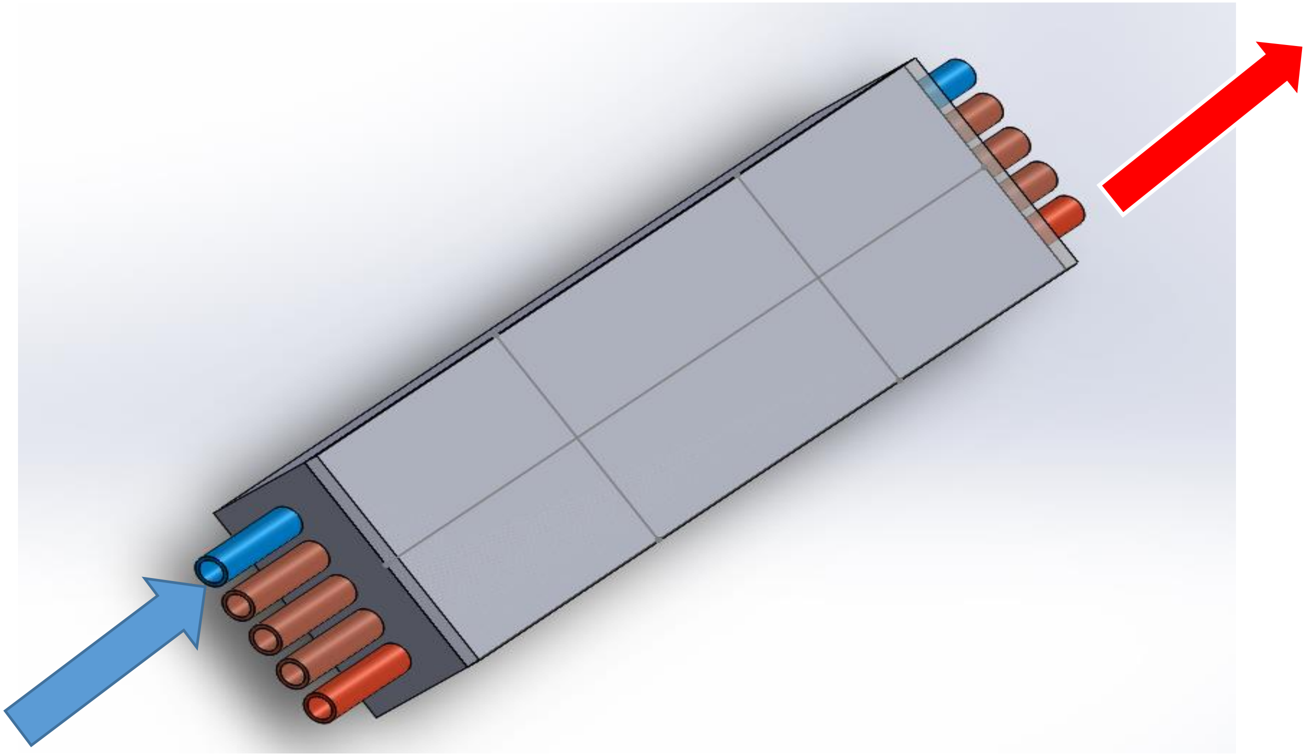


Figure X: Heat Exchanger Design X

The blue pipe shown in the picture above indicates the inlet flow of cold water from the reservoir or well and the red pipe shows the warm water flowing out of the heat exchanger.

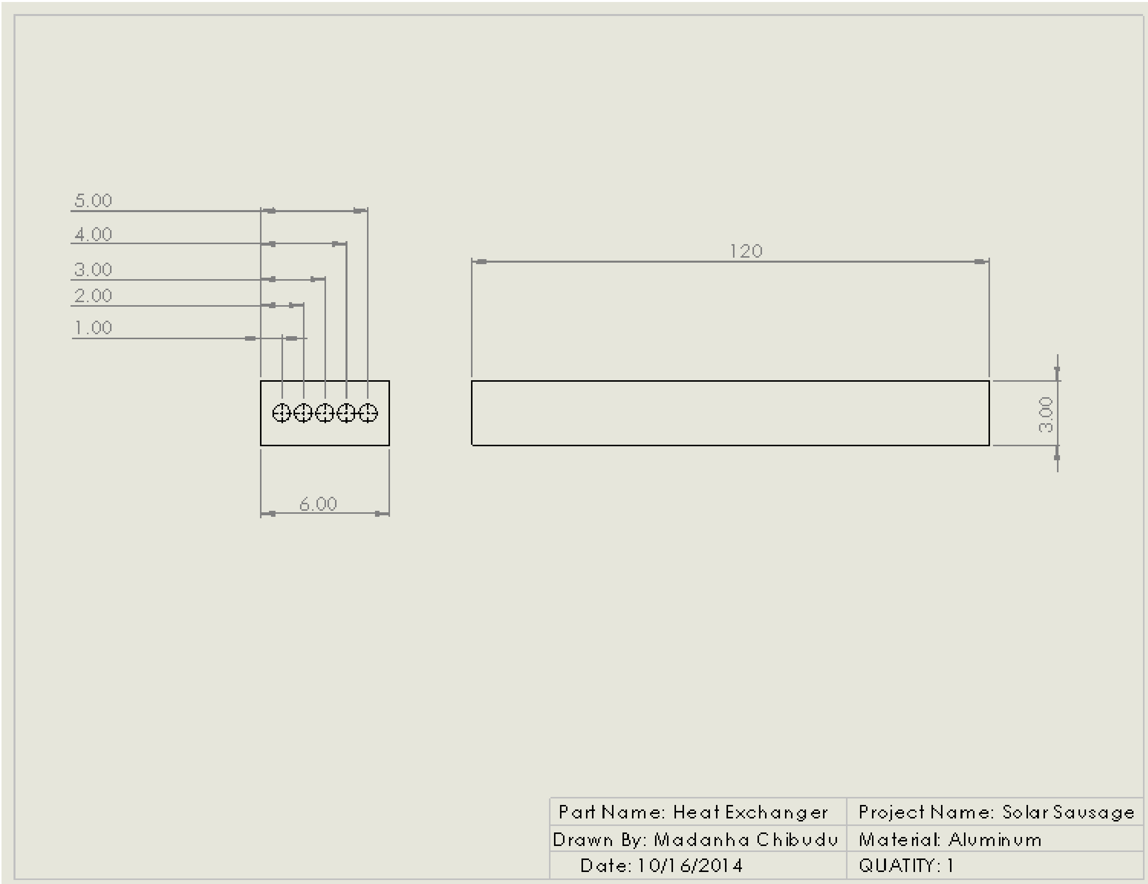


Figure X: 2D drawing of the heat exchanger outer casing

Advantages:

- Preheats the water for the pasteurization process, therefore shortening the pasteurization process.
- Keeps the panel cells working at their optimal temperature range.
- Copper pipes are easy to work with (machining).
- The material in constructing the heat exchanger is relative cheap.
- Copper has a high thermal conductivity rate, which increases the heat transfer between copper and its surrounding medium.
- Large pipe length that the water to flow out at higher temperatures.

Disadvantages:

- The design requires an electrical pump to assist the flow of water throughout the heat exchange.
- Large pipe length can also be a disadvantage because it can also heat up the photovoltaic cells.
- The photovoltaic panel can experience high temperatures which reduces the efficiency of the photovoltaic panel.

Bur Cam Jet Pump Option 2

This water pump is a centrifugal water pump which is well suited for the application of pumping water from well or surface water. This type uses a rotating impeller to draw water into the pump and pressurize the discharge flow. Its main function to pump water from shallow wells. The small size of this water pump makes it easy to install and it does not take up a lot of space.

The pump has a high mass flow rate of 13.6 gpm which decrease the time which the water is able to absorb the heat from the copper pipe. This decreases the heat transfer process that occurs between the copper and the water. At the same time this helps the photovoltaic cells to operate at temperatures that are slight above room temperature. This increases the efficiency of the photovoltaic panel.

Figure X: Bur-Cam 13gpm Jet pump

Specifications:

- Gallons Per Minute – 13.6 GPM
- Inlet Diameter - 1in
- Suction Head - 25ft
- Total Head Lift - 65ft
- Running Amps - 8.6 A at 120V or 4.3A at 240V
- Voltage - 120V or 240V
- Maximum PSI - 65
- Weight - 38lbs or 17.24kg
- Dimensions – 45.72cm x 27.97cm x 54.61cm

Advantages:

- High suction head.
- Small in size which makes it easy to install.
- The cost is moderately cheap.
- There is no water to air contact eliminating rust.
- Without waterlogging this pump eliminates the need for air volume controls.
- The high flow rate means that this pump can be applied to a water sink.
- The pump has a jet ejector that assist the impellers in raising the pressure to lift the water.

Disadvantages:

- High mass flow rate which reduced the time to preheat the water for the pasteurization.

Digital Pressure Gauge, 30 PSI MGA-9V Option 2

The digital pressure gauge will monitor the pressure inside the solar sausage. The pressure inside the solar sausage cannot go above or below 0.5psi. This makes it crucial for the solar sausage to have a pressure gauge. The MGA-9V digital pressure gage consists of a piezoresistive pressure sensing element, signal conditioning circuitry for temperature and calibration compensation. Piezoresistive pressure sensors are sensitive to changes in temperature.

Figure X: Media Gauge™ Model MGA-9V

Specifications:

- Dial Size: 2.5in
- Pressure Range: 0 – 30psi
- Connection Size: ¼ - 18 NPT W/22 MM Hex 316L stainless steel
- Connection location: Bottom
- Accuracy: +/- 1.0%
- Display: 4 Digit LCD
- Powered By: 9V battery
- Agency Compliance: ROHS
- Operating Temperature Range: -10°C to 60°C or 14F to 140F
- Storage Temperature: -20°C to 85°C

Advantages:

- Low price cost for a digital pressure.
- The pressure gauge has a high pressure range.
- The pressure gauge has a high level of accuracy.
- The pressure gauge is ideal for pressure controls.

Disadvantages:

- Requires someone who is well skilled in programming to a data acquisition software

2.3 Pressure Gauge and Three Channel Heat Exchanger

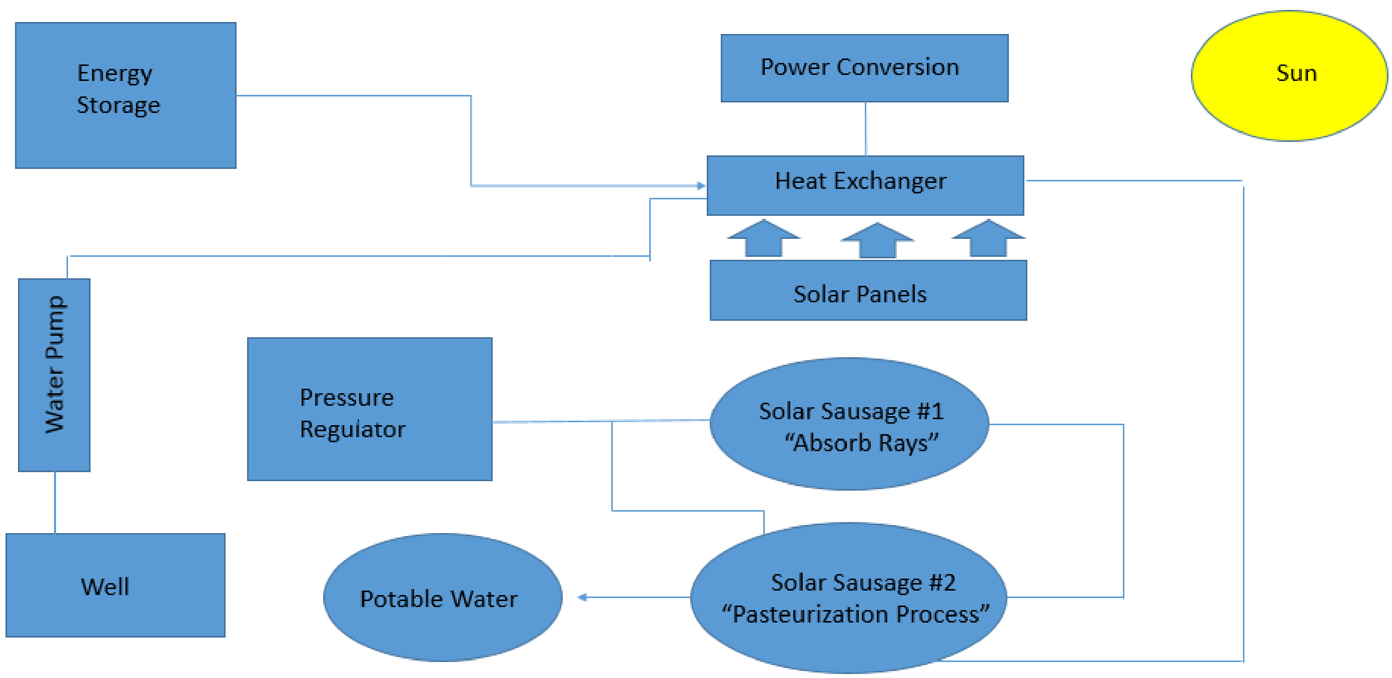
Pressure Gauge

The pressure gauge determined to be used in the design team's application thus far is the current design implemented with the previous solar sausages. Further research into a more cost effective solution is being done. One option being researched is a regulator that would be using a purely mechanical switch that integrates several spring loaded plungers. Each switch within the regulator would implement a different air filling setting. The mechanical switch would also have an overpressure valve that would release air if the pressure were to exceed the desired pressure. In order to test such a device it would be necessary to create an experiment using accurate pressure gauges to check the calibration and sensitivity of the new pressure regulator.

Three Channel Heat Exchanger

The three channel heat exchanger proposes an idea with having a limited number of cooling channels so the heat transfer into the water is efficient at absorbing the heat while also raising the initial temperature of the water flowing through the system before it enters the superheating section. The three channel heat exchanger has one inch holes drilled through a solid aluminum block that will be fastened to the back side of the photovoltaic panels. The water will flow from a single water pump and then divided through a simple manifold into the three channels and attached to the heat exchanger by use of threaded pipe fittings. The same manifold system will be used on the downstream side of the heat exchanger to recombine the water to be fed into the next stage of the system.

The material aluminum was chosen as it is cheap and light in comparison to the other material choices with nearly the same thermodynamic properties of which are desirable for this application. The shape of the holes were chosen to be a circle as it is the ideal shape of a cooling channel. The size of the cooling channel was determined through space constraints for three holes to be evenly distributed through the given area. The flow rate of the water through the system is still to be determined and will be decided during experimentation of the device to find the ideal mass flow rate to achieve the ideal amount of cooling of the photovoltaic panels versus the preheating temperature of the water.



***The above top-level diagram shows the design team's current overall plan for the Solar Sausage System*.**

3.1 Statement of Work (SOW)

The engineers assigned to this project are computer, electrical, and mechanical engineers. None of the team members have individual experience in environmental engineering topics; therefore, as a group all seven engineers will come together to tackle the pasteurization process. All of the electrical design work will be handled by the four electrical engineers; likewise, the mechanical engineers will handle all of the mechanical devices in the project. The electrical engineers will have an advisor, Dr. Chris S. Edrington, who will help answer any questions that may arise about the electrical aspects of the Solar Sausage. Similarly the mechanical engineers will have an advisor, Dr. Juan Carlos Ordonez, to go to with their questions as well. Questions about either aspect, electrical or mechanical, may be taken to one of the inventors, Dr. Ian Winger.

Jimmy Smith Jr., Project Manager, will be overseeing the entire progress of the project to make sure it remains within all specified constraints. The project manager has taken into account all of the milestone dates, and has composed a schedule, such that, all important deadlines will be met.

The remaining six engineers will be in charge of completing different aspects of this project. Xiaoxiang Gao, Jonathan Melton, and Aileen Ulm are the remaining electrical engineers, Morgan Bublitz, Madanha Chibudu, and James Harrell will be completing the mechanical parts of the project. A brief introduction of each team member can be found in section 6 of this report.

3.2 Design and Application

3.2.1 Objective

This task will ensure that each component of the solar sausage is working on an individual level prior to it being implemented into the overall final design. These various components will be tested on an individual, lower block, level to ensure they are functioning within the correct specifications so they will not cause the overall design any harm or malfunction.

3.2.2 Approach

3.2.2.1 Design and Implementation of Electrical Components

3.2.2.1.1 Objective

The design and implementation of the electrical components of the Solar Sausage will be used to harvest solar energy and convert this to useable electrical power. This power will be used to power any mechanical devices that need electricity to run, and it will supply AC power to the community.

3.2.2.*2* Subtask – Solar Panels

3.2.2.2.1 Objective

The Solar Panels are going to be used in order to harvest all of the energy needed for the Solar Sausage to be fully functional. These solar panels will be photovoltaic panels. This subtask is one of the most vital tasks so ensure the functionality of the overall project.

3.2.2.2.2 Approach

The solar panels will be placed on top or on the side of the Sausage for the optimal generation of power. Both locations will be researched before the group comes to a decision by majority rules to harvest the sun's rays. Solar panels will be linked together in series, parallel, or a combination in order to optimize the voltage obtained from the panels.

3.2.2.2.3 Test Plan

This test will be done without hooking up any other electrical components up to it to ensure that the proper output is achieved. First the output of a single panel will be obtained, then circuit designs will be drawn up to test which way is the optimal way of linking the solar panels together. The preliminary test will be done using Multisim. Once the panels are actually built and hooked in the desired pattern, a multimeter will be linked to the output ports of the PV panels and the voltage, current, and watt output will be tested using the multimeter.

3.2.2.2.4 Outcome

The outcome of this task will be that the solar panels will all be used in the best possible combination to ensure that no unnecessary panels will be used to achieve the same goal.

3.2.2.*3* Subtask – Inverter

3.2.2.3.1 Objective

The objective of this section is to make the power generated by the PV panels usable for the equipment to make the water for the people drinkable. Without useful power the PV panels would be nearly useless.

3.2.2.3.2 Approach

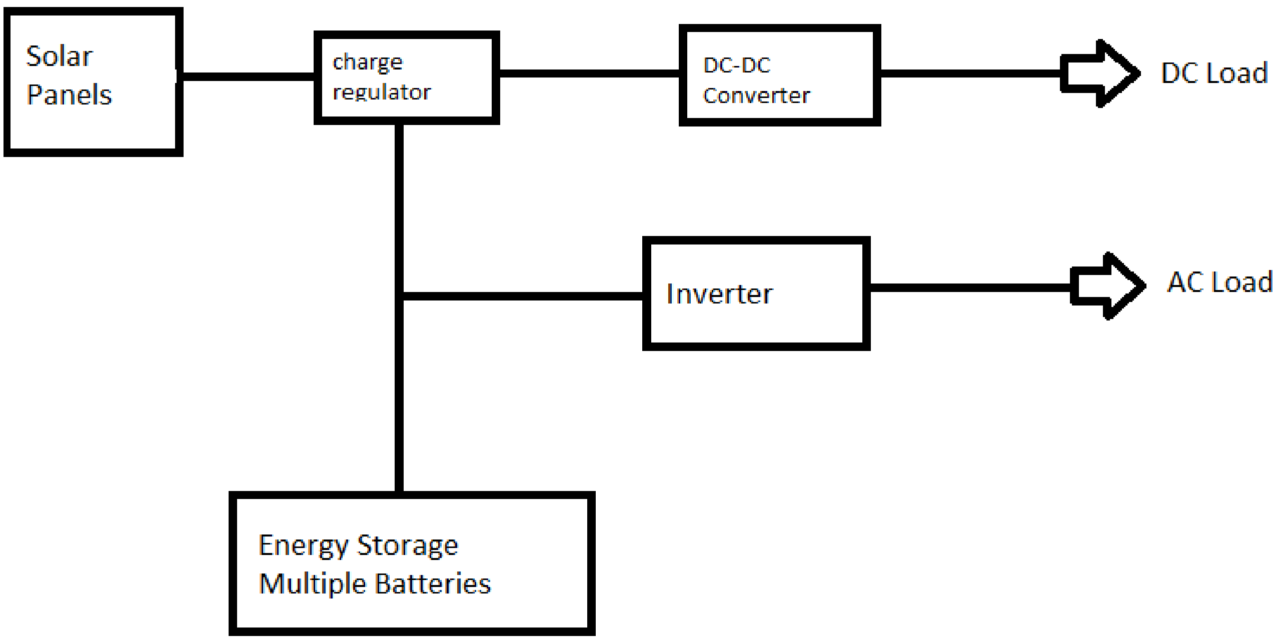
The approach of this task is to convert the power attained from the PV solar panels to useable AC power. This will include converting the power from DC to a frequency of 60 Hz AC. The Republic of Panama uses the same frequency and power outlets that are used in the United States. In fact, the entire North American Continent uses the same frequency and outlet size.

3.2.2.3.3 Test Plans

This subtask will need to be tested upon the completion of the testing of the solar panels. Once the solar panels have proven to be fully functional the design team can hook the panels up to the power inverter then take the same multimeter and link it to the output ports of the inverter and get readings from it. These outputs will have to be somewhere close to the desired output for the usage specifications. Once the desired output is reached, then a load will be connected to the inverter to ensure the desirable frequency, voltage, and current are attained.

3.2.2.3.4 Outcome

With the completion of this task the power generated will be converted into AC power which could be used in the mechanical devices of the Solar Sausage, and by the neighborhood it will be supplying power to.



3.2.2.4 Subtask - Energy Storage System

3.2.2.4.1 Objective

This subtask will collect solar energy, and then disperse the energy when the solar panels are not able to generate electricity. The primary time when the solar panels will not be generating electricity will be during the nighttime, and during an overcast. Once the energy is stored this system will be able to release the electricity as needed.

3.2.2.4.2 Approach

The design team is still researching two different ways of using this. The first way is a mechanical potential energy storage system. A quick overview of this is to pump the water up into a tower, and as the water is used it will fall down and turn a turbine to generate the electricity. The second way is to use a power electronic device such as an energy bidirectional flow converter. This device performs like a high efficiency battery.

3.2.2.4.3 Test Plans

Each system, described in 4.2.2.4.2 would have to be tested differently. In the mechanical potential energy storage system the testing would be relatively simple in testing only the electrical output of this system. The multimeter will be useful again in this test plan. In testing the bidirectional flow converter; the design team would just ensure the proper direction of the flow, then the multimeter can be used in this test as well to read results. If results are within the correct parameters then a load can be added to ensure proper power is being supplied by the system.

3.2.2.4.4 Outcome

The outcome of this task is to have energy available when the PV panels are not able to generate electricity.

3.2.2.5 Subtask – Step up Transformers

3.2.2.5.1 Objective

This subtask is to increase the voltage from the inverter to 120 volts, which is the most common. The Republic of Panama also uses the same standard for most of their electrical devices. This process will take the energy collected through the solar panels and make it available for the use of daily electronic devices in the Republic of Panama.

3.2.2.5.2 Approach

The approach to this subtask will use the common step up transformer to increase the voltage to the desired amount. This is attained by using the coupling inductance method.

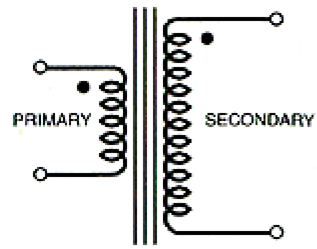


Fig 4.1 An image of a 12V to 120V step up transformer

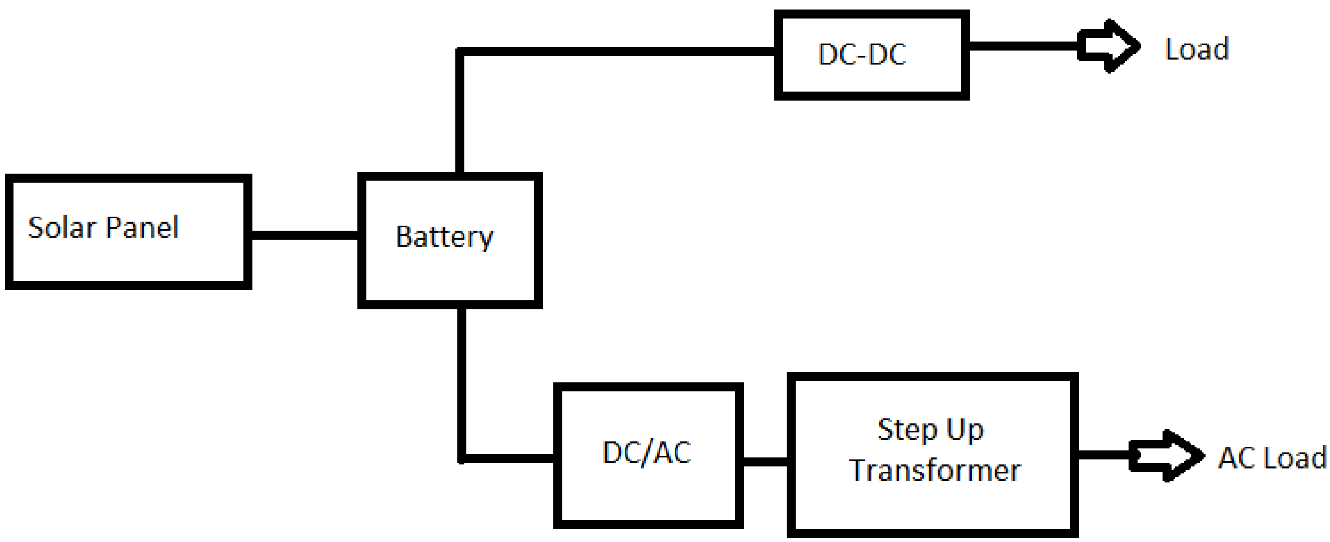
Figure 4.1 is a simplified version of how this transformation will be achieved.

3.2.2.5.3 Test Plan

The first test plan to ensure this task is working will be to simulate this in Multisim. Multisim is a tool the electrical engineers can use when simulating circuits and seeing how certain components will perform together. Once 120 V output is reached on Multisim; the design team will build the circuit and see how it performs with a multimeter.

3.2.2.5.4 Outcome

With the completion of this task the AC power will finally be useable by electronics. A coffee pot or a phone charger can now be plugged up and will work perfectly.



3.2.3 Design and Implementation of Mechanical Devices

3.2.3.1 Objective

There are various devices that are essential to the success of this project that deal with mechanical engineering topics. When these work in perfect harmony with the electrical components then the project will be complete. The mechanical engineers will make sure that every mechanical device is working to its fullest potential. Upon completion of this task all the mechanical components and devices will be working as intended.

3.2.3.2 Subtask Sun Tracking System

3.2.3.2.1 Objective

The sun tracking system will be used such that the devices that either absorb solar energy, or reflect the solar energy will be able to remain close to optimal position to absorbing the sun's rays. The sun produces parallel rays, and in order to optimize the absorption or reflection of the rays the devices need to be facing the sun as often as they can. If the devices are not facing the sun then there will be extreme loss due to the way the rays are received.

3.2.3.2.2 Approach

Since the Earth is constantly rotating around the Sun one can imagine that the degree at which the solar panels need to be angled is constantly changing. Although this is true to decrease the level of complexity of this system the angle will only need to be changed monthly. A small microcontroller can be used to have the panels rotate along with the sun hourly. A mechanical device will be implemented to rotate the angle needed during the different seasons. This device will be adjusted monthly. Two different approaches are in the process of being researched for this monthly tracking function.

The first device would be one that uses different locking positions on a semicircular frame. The panels will rest on a pin that will lock in the locking position on the frame. When it is time to change the angle for the different month's the maintenance worker could simply pull out the pin lift or lower the panels into the new position and lock it into its new location. Several months will overlap, such as: January and November, February and October, March and September, April and August, May and July. June and December are months with extremities, these months will require their own locking position; however, the other paired months can share a locking position. There will be seven locking positions total. This device will work like an adjustable flat bench in a gym.

The second device will use a crank connected to a series of gears which will adjust all of the solar panels at once. This device will have flags or indicators set on them to let the user know when to stop cranking for the specified month.

This device will be easier to use; however, it will also be harder to make and easier to malfunction. The exposure to air may also cause oxidation; in which, the gears will rust.

3.2.3.2.3 Test Plan

Testing either of the above mentioned mechanisms will be simple. Using some type of device to measure the angle at which each position is and comparing it to the nationally specified angles at which to have solar panels angled. Once each position has been confirmed as correct then the mechanism will be ready for use.

3.2.3.2.4 Outcome

Upon the completion of the sun tracking device the solar panels will be able to capture the optimal amount of sun for operating at peak performance.

3.2.3.3 Subtask Pressure Regulator

3.2.3.3.1 Objective

The pressure regulator will need to be used in order to maintain the difference in pressure inside the Solar Sausage. The Solar Sausage has a reflective film that separates the device into two pressure chambers, a high pressure chamber and a low pressure chamber. The chambers must differ by about 0.5 psi. The pressure regulator will make sure these pressures stays near this number.

3.2.3.3.2 Approach

There is already a pressure regulator in use by Ian Winger. This is the front runner in the two regulating devices the group is deciding on. The design team is also working on possibly having a digital regulator which would not be as complex as the current mechanical regulator.

3.2.3.3.3 Test Plan

The test plan for this device will be finalized when a device is agreed upon; however, both devices can use a similar test. A balloon will be connected to the high pressure valve; likewise, another balloon will be connected to the low pressure valve. The balloons will have different pressures, and after being connected to the regulator for a short span of time if the two balloons have a pressure difference within 0.5 psi then the pressure regulator will pass the test.

3.2.3.3.4 Outcome

Upon completion of this subtask the group will not have to worry about snapping the reflective film in the inside of the balloon due to extreme difference in pressures.

3.2.3.4 Subtask Structural System

3.2.3.4.1 Objective

The structural system will be what the sausage is actually stationed on. This system will be in place to keep the sausage up off of the ground and it will be able to rotate as needed. Without this system the sausage would sit on the ground and blow away with the wind.

3.2.3.4.2 Approach

The approach to this subtask will more than likely use the structural system that Winger already has in use. There are wooden posts used to support the system and all of the plumbing to the design as a whole.

3.2.3.4.3 Test Plan

The design that is already in use has already proven to be efficient; however, the test for this structure will be simply to just add weights which are slightly heavier than the sausage itself. If the system can support weights heavier than the Solar Sausage then it will have no problem supporting the sausage.

3.2.3.4.4 Outcome

The outcome of this subtask will be that the entire system will be supported off the ground, and will not be destroyed or carried away if slight weather changes come about.

3.2.3.5 Subtask Pump

3.2.3.5.1 Objective

The purpose of this stage is to select the most efficient pump to pump water from a deep well, shallow well or surface water. This subtask will attempt to find the required total dynamic head (TDH) to pump water to the heat exchanger. In order to determine the total dynamic head, certain details such as the drop pipe measurements, horizontal pipe measurements and vertical pipe measurements have to be determined first.

TDH = Static Height + Static Lift + Friction Loss

This also evaluates if a double suction, end suction, multistage or vertical turbine pump is ideal to pump the water.

3.2.3.5.2 Approach

In order to get the best efficiency of the pump, the following could be carried out:

- Measure the lengths of the drop pipe, horizontal pipe and the vertical pipe.
- Determine the frictional losses encountered from the piping system.
- Use Tyco Pump Selection App to find the efficiency of the water pump and the net positive suction head (NPSH) of the pump.
- Use pump selection app to identity which pump satisfies the required mass flow rate and also provided the maximum efficiency of the pump.
- For higher pressure or greater lifts, two or more impellers would speed the process of pumping water.
- Use a jet ejector to assist the impellers in raising pressures.

3.2.3.5.3 Test Plan

This stage will begin once the engineers decided on a pump to use and when that pump purchased to start doing the testing. The testing stage will also investigating the mass flow rates at which the pump has the best efficiency in pumping the water. Test engineers will also investigate the suction head of the pump at deep well, shallow well and at surface water levels. Test engineers will also test the pump to see how it works at different pipe sizing of the heat exchanger.

3.2.3.5.4 Outcome

The outcome of this task will ultimate decided which pump is best for the project. The results of this task will also help the test engineers to make changes to the pump, if any changes are needed to be done.

3.2.3.6 Subtask Cooling System

3.2.3.6.1 Objective

The focus of this system will be keep the solar panels down at an operable temperature. As one can safely assume, with the gathering of solar energy the solar panels will heat up relatively quickly. If the solar panels exceed temperatures of 50° C then they will not operate at maximum potential. This system's job is to ensure that this does not happen.

3.2.3.6.2 Approach

A variety of heat exchangers are being discussed for this process. All the different heat exchangers with the pros and cons to each were listed in section 2.2 of this report.

3.2.3.6.3 Test Plan

More research and testing is being constructed to select a heat exchanger. Each exchanger may be tested slightly differently; however, a final test to ensure it will be cooling the solar panels will be constructed. The chosen exchanger will be installed to a heating element of some sort. With this the heating element will try to get to the temperature that the solar panels will operate at without any cooling system. The exchangers will be engaged, and the temperature of the element will be recorded to ensure that it is less than 50°C.

3.2.3.6.4 Outcome

With the proper outcome of this subtask, the solar panels will always operate at an optimal temperature. With this the maximum power can be generated by the solar panels at all times.

3.3 Test Plan

Upon completion of the project there will need to be an ultimate test plan. Since the lower level block designs will have already been tested and approved, the only thing left to test will be the overall functionality of the Solar Sausage. There will be two parts to this ultimate test, and one of the two parts will be broken down into to smaller parts.

3.3.1 Electrical Component Integration

First the design team will test the electrical output of the Solar Sausage. This is the test that will be broken down into two smaller tests. The first test will be to test the DC power output. A simple DC radio will be connected and it will simply have a pass/fail criteria. If the radio turns on and sound is heard then the team will know that the DC output is useable.

The AC output will be connected to an oscilloscope to see max voltages, and to ensure that the max voltages of each harmonic do not vary outside of the accepted values. The criteria for this test will use THD, Total Harmonic Distortion, which states: Voltage must be within 3% and current must be within 5% of expected values.

Upon reaching approved harmonic distortion values, the team will then plug in one of the three following devices: toaster, cell phone charger, or a coffee pot. If the selected device works as it should then the test has been passed.

3.3.2 Mechanical Component Integration

With the integration of each mechanical component there is not a way to test to ensure each is running in harmony. The same test that were mentioned earlier for the mechanical devices can remain in place, and each can be monitored to ensure that nothing is obstructing each component from doing its job. One prototype will have multiple sensors hooked up to it to ensure that the heat exchanger, pump, pressure regulator, and sun tracker are all working. The final will not need all of these different sensors connected to it.

3.3.3 Water Purification Test

The water will be pumped from an underground water source; which means, the water will not need to be purified. Although the water does not need to be purified it will, however, need to be pasteurized. The pasteurization process is one that just raises the temperature of the water to kill off some microbes such as: worms, E. coli, Salmonella, Hepatitis A, etc. As one can safely assume killing these harmful bacteria is vital for the success of this project as a whole. Developing regions may not have a way of completing the pasteurization process themselves; therefore, the Solar Sausage will complete this process for them. Water can be considered pasteurized when it reaches a temperature of 65° C. The testing of this is still being considered by the entire team of engineers. A couple of ideas have been proposed.

The first idea is to have a sensor on the tube where the pasteurization process will be taking place, and a microprocessor will be programmed to open a valve and pump water out when the pasteurization temperature is reached. To test this the water will be drawn directly after the water is released from the pasteurization process and a thermometer will be inserted to ensure the temperature.

4. Risk Assessment

It would be unrealistic to think that the design team's project proposal can be completed without any possibility of risk. Many factors can risk the quality of the system's output. Risks can include the following:

- → Lack of understanding of client requirements or wants
- → Ignoring consequences that weather will put upon the project
- → Minor measurement mistakes while building the system may throw off the success of the Solar Sausage
- → Scheduling issues may cause the whole project to fail to meet the deadline
- → Designs may not hold up to certain specs given to the team by the client
- → The temperature may not be controlled at a level to keep all of the equipment safely cool
- → Undecided design routes for the overall project design
- → Pressure stability could not be reached
- → The water exiting the system may not be completely potable
- → Heat exchanger may not cool the PV panels enough
- → Energy storage device could fail at keeping the energy, leaving no use of the system at night
- → End deliverable system not completely successful in all aspects of what is expected of the project team

5. Qualifications and Responsibilities of Project Team

5.1 Qualifications

5.1.1 Jimmy Smith-

My name is Jimmy Smith, Jr. and I am a senior at Florida State University. I am a dual degree seeking student majoring in Computer & Electrical Engineering. I chose Computer & Electrical engineering because at a young age I was always fascinated with technology and how things worked. The classes that qualify me for this project is EEL 3111, EEL 3112, EEE 3300, EEL 4746, COP 3014, and COP 3330.

5.1.2 Aileen Ulm

My name is Aileen Ulm, I am a senior at Florida State University majoring in electrical engineering. For the past 4 years I have interned as an engineer at Skae Power Solutions in New York. During this time I have been involved in multiple projects for the company: the efficiency and workings of data centers, calculating a client's power usage, and understanding the process the company uses to bill power usage are among the main tasks that I have been trusted with. A main interest of the company is focusing on how we can help personal clients, or schools become more energy efficient. Helping these establishments become "Green" helps save a lot of money, while lowering the waste put out into the environment. At the college of engineering I have taken multiple classes to aid the design team with our future tasks in this Solar Sausage project such as: Fundamentals of Power Systems, fundamental thermodynamics, and multiple classes on circuitry. My experience with working as a team member on projects will allow me to transition into this project process very easily, collaborating with team members will come naturally.

5.1.3 Xiaoxiang Gao-

My name is Xiaoxiang Gao, I am an exchange student from Tianjin University of Technology, China. I have finished my previous three years in China, and I came to Florida State University to finish my senior year's study. My major is Electrical Engineering, my duty is to test all the electrical components, and make sure that all of these components can work in good condition, especially the solar energy aspect. I have finished many fundamental classes in Electrical Engineering, such as circuit analysis, automatic control theory, and so on. My solar energy background comes from taking the photovoltaic (EEL 4930) class.With the knowledge that I have learned in the class, I have the confidence to finish my job well. I am also learning Power Electronics (EEL 5317) and fundamentals of power systems (EEL 3216), which will very helpful to this project.

5.1.4 Jonathan Melton-

Jonathan Melton is a senior, electrical engineering major, at Florida Agricultural and Mechanical University (FAMU). He is also currently working at Florida A&M University Developmental Research School (FAMU DRS). Melton serves as a tutor and mentor to middle and high school aged students at FAMU DRS. In addition, Mr. Melton has a special area in power and circuit analysis. A little work experience was gained when Jonathan worked for Advanced Electrical solutions (AES). Advanced Electrical Solutions is a company based out of Ft. Lauderdale, Fl. Jonathan worked with a team of engineers to help make commercial buildings more energy efficient. In Tallahassee Jonathan helped with the Department of Corrections, the Holland building, the Carr building, and the Douglas building.

5.1.5 Morgan Bublitz-

My name is Morgan Bublitz and this is my senior year in Mechanical Engineering. Before Mechanical Engineering I studied Biology for several years. While I was in Biology I did worked in an undergraduate research lab studying meiofaunic organisms found in water. This type of microscopic work benefits me in this project by having the experience in sorting microorganisms from water and being able to identify the quality of water under a microscope. This skill will help our team in the future when we go to determine the final water quality delivered from our device. During my time as a Mechanical Engineering student I have been involved in several other research laboratories. These labs include the Center for Advanced Power Systems where I built a piping network to help validate the simulation of a flowing water system that included a heat exchanger and separate devices using the temperature controlled water. This experience will significantly benefit our team in the design and implementation of our experimental setup and obtaining well documented results. The other Mechanical Engineering research laboratory I have worked in is the Energy and Sustainability Laboratory, where I worked directly with a solar simulator and parabolic trough. The experience I gained working with a very similar technology will benefit my group significantly when it comes time to measuring the theoretical inputs from the sun and also running the testing phase on our prototypes.

5.1.6 James Harrell-

My name is James Harrell and I am a mechanical engineering major that has been assigned to the ECE lead project: Solar Sausage for electricity and potable water. I transferred to Florida State University in spring of 2012 as a pre-engineering major. I chose mechanical engineering as my major due to my interests in renewable energy research. The pursuit of a cost effective and renewable energy is of major importance to our society and has always been an intriguing topic of mine. I was able to gain a further understanding and interest on the subject after taking fluid classes such as thermal fluids one, thermal fluids two and thermal fluids lab here at the FSU-FAMU College of

Engineering. As a Graduate assistant at the Morcom Aquatics Center I have been asked to help understand and maintain the mechanical pumping system and geothermal systems that control the flow and generate heat for the pool water, respectively. Helping decrease the inefficiencies which lead monetary losses per year is a project that I have been working on this semester alongside school. I have also gained experience as a leader being an assistant manager at Morcom which has helped me understand how to work in a team effectively. The skills I have acquired at my current job and the applicable classes that I have taken on the subject of thermal flow give me an advantage while working as a team on the solar sausage for electricity and potable water project. I plan to keep gaining knowledge on the subject and attaining my master's degree in mechanical engineering here at the FSU-FAMU College of Engineering. I would be specializing in sustainable power generation.

5.1.7 Madanha Chibudu-

Brian Chibudu is a senior Mechanical Engineering student at the Florida State University. He is concentrating his studies in Thermal Fluids. He has already earned a Bachelor of Science degree in Statistics, also from FSU. Brian also holds certifications in SAS Programming and Data Analysis from FSU. Throughout the time he worked on his statistics and engineering degrees, Brian became proficient in the following software: ANSYS, AutoCAD, HVAC Solution, KYPipe, Pro-Engineer, Solidworks, and MatLab.

Brian's current experience in engineering includes his position as research assistant in the Experimental Aerodynamics Group at FSU, where he documents data and designs boundary layer rakes for the polysonic wind tunnel. Brian is also an intern at the Florida Center for Advanced Aero-Propulsion (FCAAP), where he creates 3D assemblies of test models for the polysonic tunnel. He also assists with the calibration of pressure transducers at the FCAAP.

Brian's other work experience includes tutoring mathematics and coaching track and field at American Heritage School. Brian was a student athlete in track and field at FSU, which brought him numerous honors and awards. Brian was also recognized for his academic performance in engineering by gaining membership in the Tau Beta PI Engineering Society. He is also a member of the Golden Key academic honor society and the Delta Epsilon Iota honor society. Brian also holds professional memberships in the American Institute of Aeronautics and Astronautics and in the American Society of Mechanical Engineers.

In addition to his academics and work, Brian has spent his time volunteering for the Sunrise Police Department and with Friends of Internationals.

5.2 Task Assignment Responsibilities

Team Member Legend:

A) Jimmy Smith
B) Aileen Ulm
C) Xiaoxiang Gao
D) Jonathan Melton
E) Morgan Bublitz
F) James Harrell
G) Madanha Chibudu

Task	Subtask	Title	Assignment	Skills and Knowledge
1		**Project Management**	**A**	Scheduling
2		**Power Analysis**	**B,C,D**	Power and Energy
	1	Total Output		
	2	Energy Storage		
	3	Peak hours		
	4	DC to AC Conversion		
3		**Pressure Regulator**	**E,F**	Mechanical System
	1	Calculate Psi for each chamber		
	2	Design device to read pressure		
	3	Test pressures		
	4	Maintain pressure		
4		**Heat Exchanger**	**F,G**	Thermodynamics
	1	Design model		
	2	Calculate temperature that solar panels need to be cooled to		
	3	Testing to make sure solar panels can operate efficiently		
5		**Water Pump**	**E,F,G**	Mechanical Sytem, Pump Analysis
		Decide on Location of water		
		Well		
		Surface Water		
		Pump water into system		
		Use water to cool down pv panels		
		Use same water for filtration		
6		**Filtration System**	**A-G**	Environmental, Pasteurization
	1	Pasteurization		
	2	Test Temperatures		
	3	Control speed of pasteurization		
	4	Test potability of water		
7		**Sun Tracking**	**A,B,C,D**	Programming, environmental
	1	Determine Placement of system		
	2	Track sun's movement in that area		
	3	Create design that will follow patterns in that region		
	4	Test movement of tracking system		

6. Schedule – Gantt Chart

Task Mode	Task Name	Duration	Start	Finish
	Milestone #1	7 days	Wed 9/10/14	Thu 9/18/14
	Milestone #2	13 days	Wed 10/1/14	Fri 10/17/14
	Milestone #3	11 days	Thu 10/30/14	Thu 11/13/14
	Build First Sausage	4 days	Tue 9/9/14	Fri 9/12/14
	Research and Design for System	148 days	Wed 10/1/14	Fri 4/24/15
	Heat Exchange Testing	**63 days**	**Mon 11/17/14**	**Wed 2/11/15**
?	Design model			
?	Calc. temp. to cool PV panels			
?	Testing: Make sure system cools effectively			
	Power Analysis	**36 days**	**Wed 11/26/14**	**Wed 1/14/15**
	Total output measurement	5 days	Wed 11/26/14	Tue 12/2/14
	Energy Storage	11 days	Tue 12/2/14	Tue 12/16/14
	Design DC-AC conversion	20 days	Thu 12/18/14	Wed 1/14/15
	Pressure Regulator Implementation	**40 days**	**Fri 11/28/14**	**Thu 1/22/15**
	Calculate psi for each chamber	3 days	Fri 11/28/14	Tue 12/2/14
	Design a device to read pressure	32 days	Tue 12/2/14	Wed 1/14/15
	Test system at calculated pressures	5 days	Wed 1/14/15	Tue 1/20/15
	Filter/ Pasteurization	**27 days**	**Mon 3/16/15**	**Tue 4/21/15**
?	Design process for pasteurization			
?	Test temperatures the process takes place			
?	Determine duration of pasteurization			
	Sun Tracking System	**51 days**	**Wed 1/7/15**	**Wed 3/18/15**
	Determine placement of system	4 days	Wed 1/7/15	Mon 1/12/15
	Track sun's movement in region	5 days	Mon 1/12/15	Fri 1/16/15
	Create design that will follow sun patterns	34 days	Fri 1/16/15	Wed 3/4/15
	Test movement of tracking system	11 days	Wed 3/4/15	Wed 3/18/15
	Water Pump	**18 days**	**Tue 3/10/15**	**Thu 4/2/15**
	Decide on location of water (well, surface, etc.)	2 days	Tue 3/10/15	Wed 3/11/15
	Design pump to effectively bring water to system	16 days	Thu 3/12/15	Thu 4/2/15

Yearly Gantt Chart- Visual

7. Budget Estimate

A. Personnel				
Engineer	**$/hour**	**hr/week**	**#weeks**	**Total Pay**
Jimmy Smith	30	12	32	$11,520.00
Aileen Ulm	30	12	32	$11,520.00
Xiaoxiang Gao	30	12	32	$11,520.00
Jonathan Melton	30	12	32	$11,520.00
Morgan Bublitz	30	12	32	$11,520.00
James Harrell	30	12	32	$11,520.00
Madanha Chibudu	30	12	32	$11,520.00
			Subtotal	**$80,640.00**
B. Fringe Benefits			29%	**$23,385.60**
C. Total Personnel				**$104,025.60**
D. Expense				
	Quantity	**Cost**		**Total**
Inverter	1	$160.00		$160.00
Charge Regulator	1	$80.00		$80.00
Fuse	2	$2.50		$5.00
Batteries	1	$200.00		$200.00
Water Pump	1	$300.00		$300.00
Jet pump	1	$220.00		$220.00
Pressure Gauge	1	$150.00		$150.00
			Expense Total	**$1,115.00**
			Total Direct Costs	**$105,140.60**
	Overhead Costs		**45% of Total Direct**	**$47,313.27**
			Total OCO	**$152,453.87**

8. Deliverables

The deliverables for this project will be produced to the end-user in April 2015. The deliverables for this project will include the physical Solar Sausages used for the system, along with each hardware device the design team implements. There will be no excess deliverables given to the end-user as there should be no need for the end-user to complete any part of the project. The outcome of this project will be an electricity and potable water generator, since this design will be located in underdeveloped countries the hardware used cannot be complicated. Although there are several separate systems within the overall project overview, when the final project is presented to the end user it will be given as one complete working system.

8.1 Hardware

The physical components as a whole are essential deliverables for this project. They represent how the design team has gone step by step to provide a smoothly working Solar Sausage system. The hardware will include all of the serviceable gear that is purchased for the project.

8.2 Electrical Components

The components that the design team buys for the electrical aspects of this project, power conversion, sun tracking etc, are important deliverables. These components will be documented in such a way that the end-user will be able to understand how they complement the system. Any components not used will be delivered to the end-user as well if need be.

8.3 Drawings

Compiling the design drawings for this system is another very vital deliverable. These drawings will allow the end-user to see section by section of the overall system. These drawings will be a simplistic view of the Solar Sausage, and will increase in complexity as the design process moves from stage to stage.

8.4 Reports

Another form of deliverables for the design team will include any and all reports, future and past. These reports will be able to show the end user, and advisors, that the thinking process of the design team has matured as each report is completed. The reports delivered will create a solid base plan for the overall system to be turned in. Included in these reports will be design reviews, block diagrams, analysis of advantages and disadvantages, and most importantly the needs and requirements of the client.

9. References

1. "Digital Pressure Gauge, 30 PSI MGA-9V." *SSI Digital Pressure Gauge,30 PSI MGA-9V*. N.p., n.d. Web. 16 Oct. 2014. <http://www.grainger.com/product>.
2. "Bur-Cam 503127S 13 GPM 1/2 HP Cast Iron Shallow Well Jet Pump W/ 6.6 Gal. Steel Tank." *Water Pumps Direct*. N.p., n.d. Web. 16 Oct. 2014. <http://www.waterpumpsdirect.com/Bur-Cam-503127S-Water-Pump>.
3. "Taco-Hvac." *Taco-Hvac*. N.p., n.d. Web. 17 Oct. 2014. <http://www.taco-hvac.com/>.
4. “More AC Power from Solar Panels”*MIT Technology Review*. Web. 16 Oct. 2014. < http://www.technologyreview.com/news/413504/more-ac-power-from-solar-panels/>.