FAMU-FSU College of Engineering

Department of Electrical and Computer Engineering

System-Level Design Review

EEL4911C – ECE Senior Design Project I

SOLAR SAUSAGE PROJECT 'B'

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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 type of cooling system to keep the PV panels at a safe temperature, and a process to pasteurize the water. 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 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 pasteurization process will be achieved by heating the water to a certain temperature for a decided amount of time in the second solar sausage.

The purpose of this Solar Sausage project long term will be to provide electricity to a desired load and to prove that clean drinking water is a product. 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, about 100 Watts, 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.

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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, in the long run this device will be available 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. 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 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 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 100 Watt load for this project, a scaled up version will be able to support a small village.

The intended user of the solar sausage will be 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

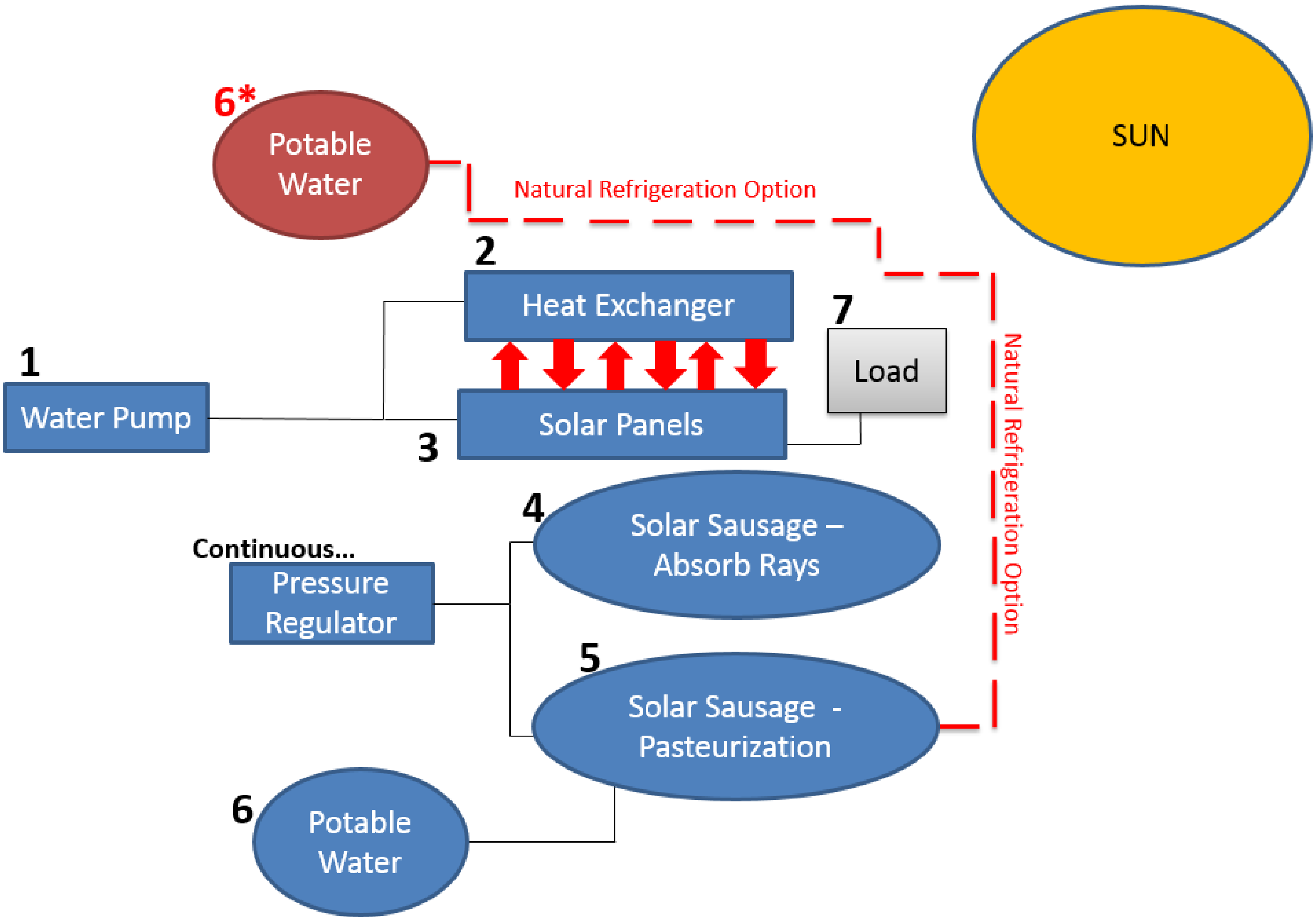
1.6 Expected End Product and Other Deliverables

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 of about 100 Watts. A scaled up version of the design teams project should in theory be able to support a larger load, for example a small village. The end product will be delivered April 2015.

2. System Design

2.1 Overview of the System

The below block diagram illustrates the design teams current plan for the Solar Sausage System. The anticipated end product of this system will provide sufficient power to support a load of about 100 Watts **(location 7),** this load will be connected to **position (3)** of the flow chart. When the load is receiving enough power, the design team will be able to conclude that the system is working in regards to the power output. The second function that this system will need to achieve will be the production of potable drinking water. This process will occur throughout the system. The water will need to be heated to a certain temperature via the heat exchanger **(position 2)** and the process must be completed in the second solar sausage **(position 5)**. The water will exit the system at an extremely high temperature, using this method. An additional process will be added to cool the water once it has been pasteurized to make it safe to drink. An option that the design team has come up with would be to use a natural refrigeration cycle to cool down the potable water produced. This process is highlighted in red in the following diagram. Using this method, the water that is made potable will return to the heat exchanger portion of the system **(position 2)** using an exact replication of that system. With the hot water running next to the incoming cool water, the potable water will be cooled fast enough to avoid bacteria build up and allow drinkability. A bonus to this method is the fact that when the hot water passes the cool water is also heating up the cool water, this will allow that water to be at a hotter temperature when the pasteurization process begins, allowing the water to be made potable more quickly.



2.2 Major Components of the System

2.2.1 Pump

The water pump to be used has the sole purpose of regulating water flow. The heating of the water further ahead in the system will create pressure, the pump will need to overcome this pressure.

2.2.2 Heat Exchanger

This component will serve two purposes: the heat exchanger will be used to cool the PV panels to keep them in working condition, along with cooling the panels the water running through the heat exchanger will be heated and the pasteurization process will begin.

2.2.3 Solar Panel (Power Output)

The purpose of the solar panels are to attract the sunlight which will be used to make the cheap electricity. The optimum power output of one PV panel is 100 Watts, the design team has decided to use a 10” portable fan as the load. This will prove that the system is working, and the load provided is a make sense power output for this project. This output can be increased by using multiple solar panels, if the load desired is for a small village our design can be scaled.

2.2.4 Pressure Regulator

The pressure regulator will be used to make sure that the two chambers of the Solar Sausage are maintained at the required levels. This is a very vital part of the system, if the pressure is off in either chamber it greatly effects the efficiency of the solar sausage design.

2.2.5 Pasteurization Process

This sub-system will produce the potable water for the consumer. The pasteurization section of the Solar Sausage will use the water that is pumped through the heat exchanger to cool the PV panel; once this water is heated to the required temperature the water is considered potable. This water will be extremely hot when exiting the system, and will need to be cooled fast enough as to not let bacteria form.

2.2.6 Natural Refrigeration Cycle

This process is an option for cooling the potable water produced during the pasteurization process. The water will be pumped back to the area of the system where the water is cooling the PV panels and beginning its heating for pasteurization; here the already potable water, which is extremely hot, will be pumped through an exact duplicate of the heat exchanger directly on top of the PV panels, the water will be running beside the incoming cool water and a natural refrigeration will occur. The hot water will cool to a temperature that is safe to drink, and the cool water on its way to be pasteurized will receive a bump in temperature allowing for pasteurization to be reached more quickly.

2.3 Design of Major Components

2.3.1 Load

The selected load that will be used in the demonstration of this project will be an O2Cool, small ten inch fan. This fan operates on 12V and about 0.6 A. From the equation:

$$P = VI$$

Equation 3.1

In the equation represented above one can see that the Power absorbed by this fan will be 7.2 Watts.

Fig. 3.1 Picture from O2Cool's displaying the fan that will be used in the demonstration

This component cannot exceed the max power output from the solar panels. If the max power output is exceeded then it will cause the fan not to turn on, or not to function at its peak performance.

2.3.2 Solar Panels

The solar panel is the main component of this whole project, it provides the electricity for the entire system. The graph below represents the real model inside the solar panel. The dotted line indicate the non-ideal model, it included the shunt resistance and series resistance. Many things can influence the I-V curve, such as insolation, temperature, and shade. The material of Solar Panel is a Polycrystalline; which is a dark blue and not uniform in distribution.

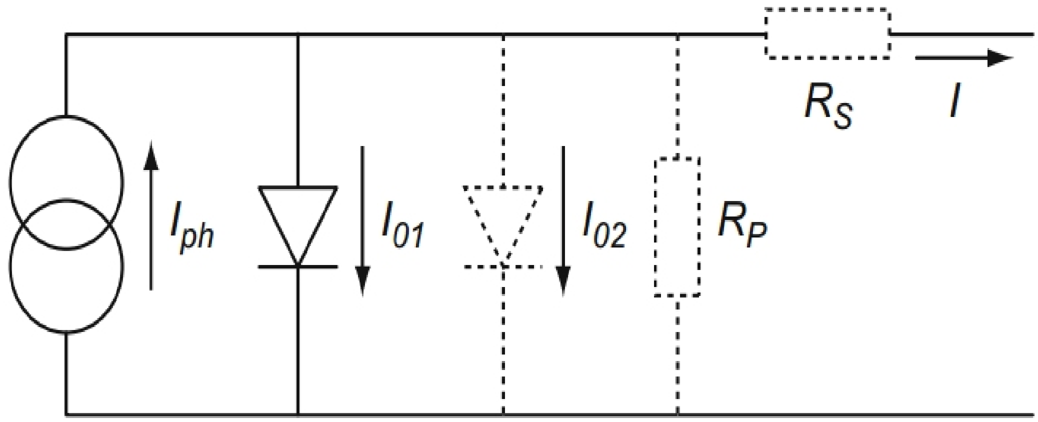
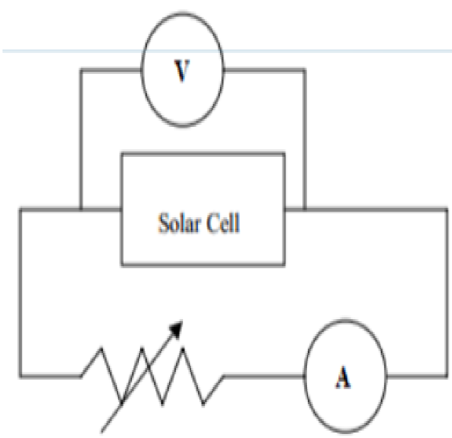


Fig 3.2 The model of the circuitry inside solar panels

Preliminary Testing of Solar Panel:

- Test Equipment:

  Solar cell, Protractor, Light source, Power source, Ammeter, Voltmeter
- Set the circuit as in the diagram above (Ammeter is in series, Voltmeter parallel)
- Measure the Short Circuit Current (by having maximum resistance) and Open Circuit Voltage (by disconnect ting the variable resistor



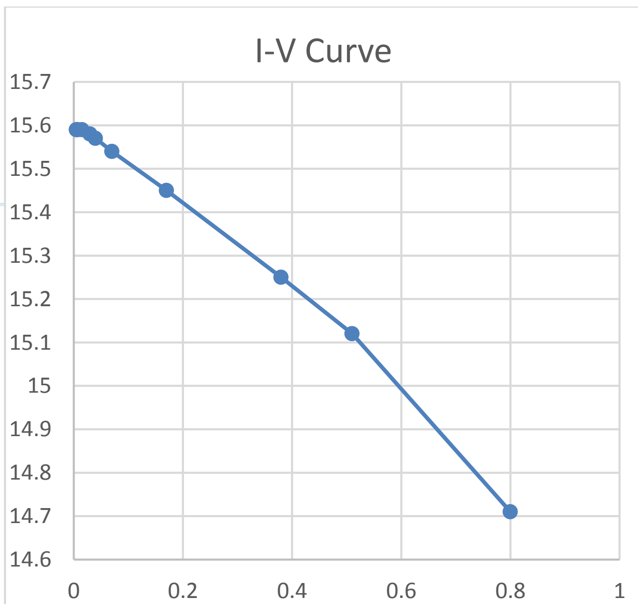


Fig 3.3 i-v charerstic curve from Preliminary Solar panel testing

2.3.3 Solar Tracking

The sun tracking mechanism will be a derivative of how a weight bench works. There will be locking positions that will set the angle of elevation for the specified angles in Table 3.1. Figure 3.1 will give an excellent visual of how the solar panels should be angled in order to

Month	Angle of elevation (θ)
January	65°
February	17°
March	81°
April	83°
May	97°
June	104°
July	97°
August	89°
September	81°
October	73°
November	65°
December	58°

Table 3.1 Information from the GoGreenSolar.com solar panel tilt calculator.

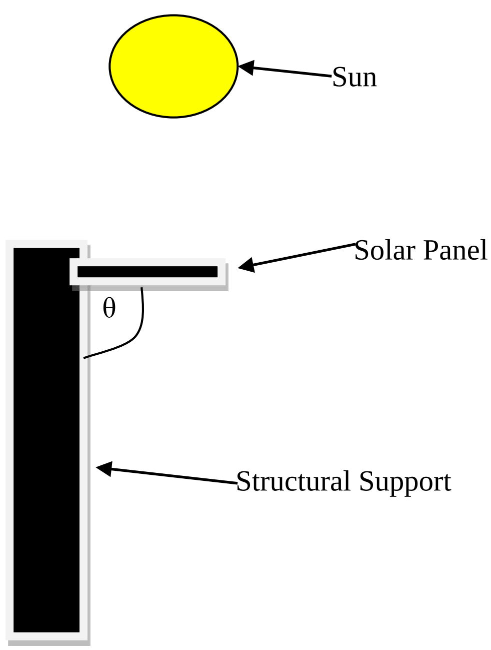


Figure 3.4 Visual of how the different angles are measured

This system will use a solid piece of metal which will be inserted into a slot that will lock in the correct angle value. As one can observe, from table 3.1, there will only need to be 7 different locking positions. This can be attained because the following months have the same angle value: January and November, February and October, March and September, April and August, May and July. The only two remaining months, June and December, are outliers on opposite ends of the spectrum which will each have its own locking position.

2.3.4 Charge Regulator

In the solar energy system, the charge regulator is very important. The importance of charge regulator appears in the following aspect; firstly, it can limit the rate at which electric current is added to or drawn from the batteries. In addition, it helps prevent the battery from being overcharged. If the battery is overcharged, it will cause the battery's life to decrease very quickly; in this way, it will damage the battery. The charge regulator selected should have the Maximum Power Point Tracking (MPPT) function. With the MPPT function, we can optimize the performance and the capacity of the solar panel; such that, we can make full use of the limited energy that can be harvested from the solar panel.

Fig 3.5 Genasun MPPT Charge Controller 10.5A, 12V GV-10-Pb-12V

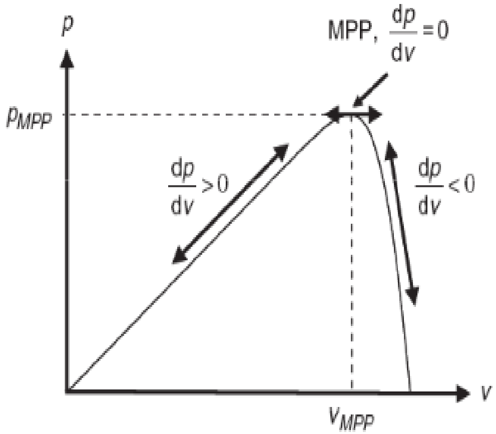
This charge regulator has the High-Speed MPPT, the peak efficiency can reach around 98.3%.Inside the regulator, it has advanced electronic protections, without appreciable incurring losses. There are six ports which represent the "+","-" poles of the solar panel, battery and load (electric fan).Connect the wire with the terminal correctly.

Function:

- Always keep the battery on fill voltage condition.
- Prevent the battery from over-charging.

- Prevent the battery from over-discharging.
- Prevent the battery from reverse charging to solar panels during nights.
- Reverse Polarity Protection for Battery
- Reverse Polarity Protection for Solar Panels
- When the battery voltage is low, the controller will automatically cut off the load from the system. If the voltage of battery is back to normal and the load will restart working.
- Thunder protection
- According to the battery voltage grade, the controller can automatically set charge-off voltage, the load-off voltage, the load- restore voltage. (The parameter is default under 25℃ condition, locked by the CPU procedure, cannot adjust.)
- The controller will automatically compensate the temperature of the charging voltage according to the changes of ambient temperature.

MPPT principle



$$\frac{dp}{dv}=\frac{d(vi)}{dv}=i+v\frac{di}{dv} \qquad \frac{i}{v}+\frac{di}{dv}=0$$

$$di \approx \Delta i = i(z)-i(z-1)$$

$$dv \approx \Delta v = v(z)-v(z-1)$$

Fig 3.6 MPPT p-v slope

This MPPT technology is based on the p-v slope(as seen in figure 3.6), when the slope is positive, the operation point on the left of the maximun power point. When the slope is negative, the operation point is on the right of the maximun power point. The operation point does not reach the maximun power point until the slope is zero.

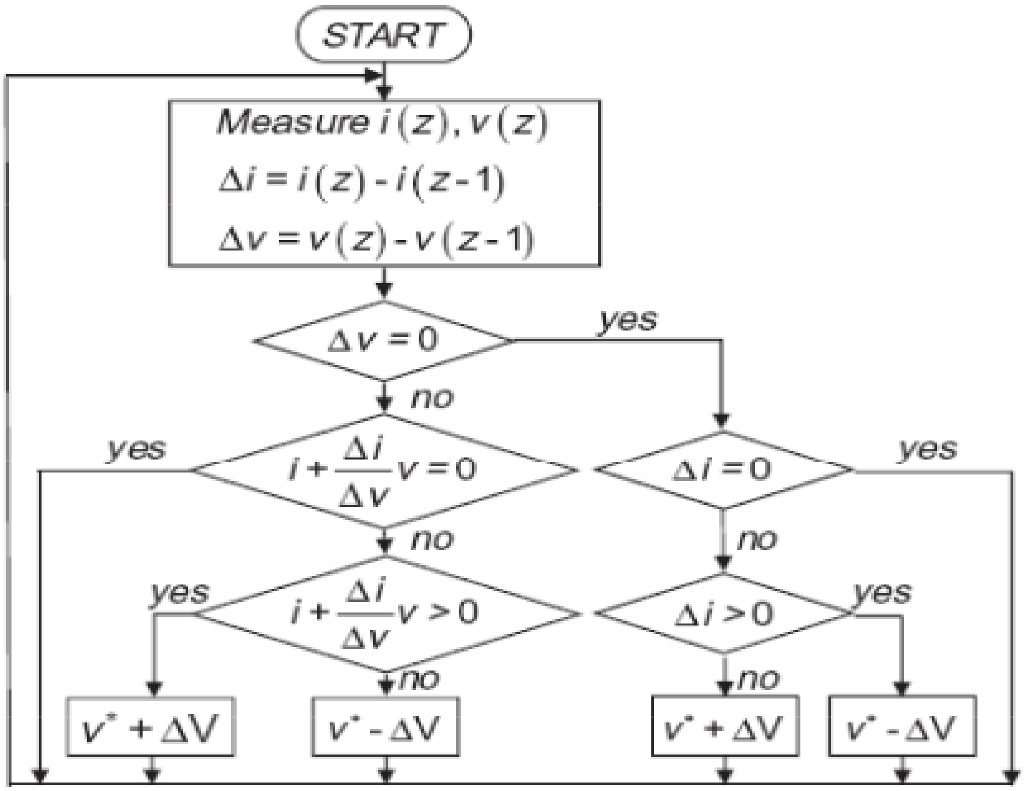


Fig 3.7 Flow chart of the MPPT information

Genasun MPPT Charge Controller 10.5A, 12V GV-10-Pb-12V	
Operating Temp. Range	-40°C - 85°C
Electrical Efficiency	96% - 98%
Night Consumption	0.9mA
Connection	4-position terminal block for 12-30AWG wire
Weight	0.41 lbs (6.5 oz., 185g)
Dimensions	5.5 x 2.5 x 1.2" (14 x 6.5 x 3.1 cm)

Table 3.2 Specs of the Genasun Charge Controller

2.3.5 Energy Storage Device (Battery)

Energy storage will be executed by connecting the charge regulator to a battery. Battery energy storage is a traditional method used to store energy, especially in the solar power system. The purpose for an energy storage device is to make sure that, even during extreme weather conditions, the energy that has been stored can be easily accessible. The Republic of Panama frequently has inclement weather, and if there is an overcast, the sun will no longer be able to excite the solar panels to generate electricity; moreover, the output power of solar panel is not a constant value (it change throughout the day). And also, the temperature, isolation, shaded of other objects will influence the solar panel, too. There are other objectives that can hinder the solar panels from attaining ideal sunlight on a sunny day such as: temperature, isolation, shading from other objects, etc. A relatively stable power supply is extremely important to the success of this project; therefore, choosing an applicable battery is very important.

Fig 3.8 Picture showing the fully integrated electrical components

Fig 3.9 Battery: Exide EP1229W 12V 7Ah Sealed Lead Acid Battery   AJC-D7S-A-1-159072

This kind of lead acid battery is commonly used with power supply system. The battery will be integrated just like in figure 3.8. In this way, we get the whole solar power system.

Exide EP1229W 12V 7Ah Sealed Lead Acid Battery AJC-D7S-A-1-159072	
Voltage	12 Volt
Capacity	7Ah (7000mAh)
Chemistry	Sealed Lead Acid (AGM)
Length	5.9 inches
Width	2.6 inches
Height	3.7 inches
Terminal	Copper

Table 3.3 Specs of the Exide Battery

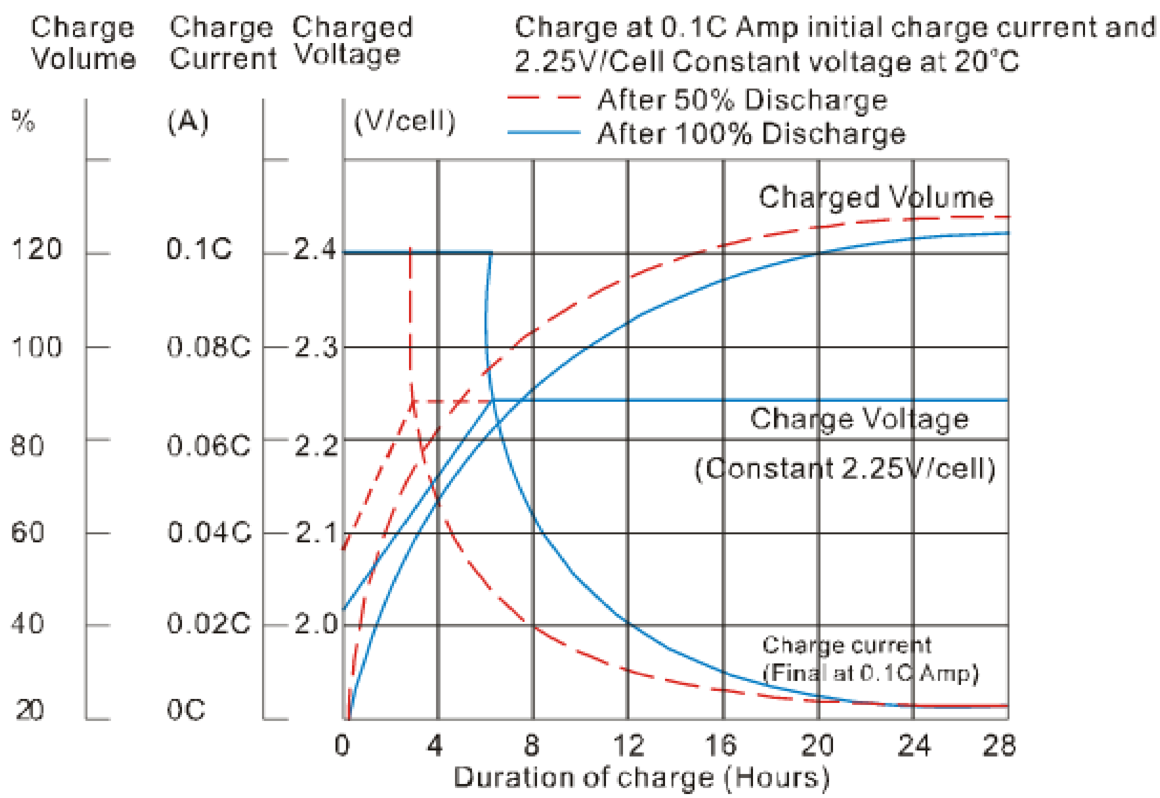


Fig 3.10 Charging Specs of the Exide Battery

Source: Exide Edge AGM Company

2.3.6 Pasteurization

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 the water, it will be drawn directly once the water is released from the pasteurization process and a thermometer will be inserted to ensure the temperature.

2.3.7

2.3.7 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.

Deciding on a Heat Exchanger

There were three different designs for the PV Panel heat exchanger. To determine which design to use it was important we compared all of the specifications of each design using a decision matrix. From discussing the important factors, it was determined that the decision matrix be comprised of five different factors: These factors include the weight of the design, the ease of manufacturing, the ease of maintenance, the cost of the design and efficiency. After creating a design matrix, seen in Figure 1, that incorporates all of the major concerns, we were able to decide on a design.

2.3.8 Pressure Regulator

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. The team will be using the current pressure regulators to regulate the pressure inside the solar sausage. This system of pressure regulators come with two manometers that will monitor the pressure inside the solar sausage. If the solar sausage has a deficiency in pressure, more compressed air is supplied to the solar sausage. The reverse will be done if the solar sausage is over pressurized. The pressure regulators are made from PVC piping and have valves that monitor the flow of air in and out of the solar sausage. The team decided to use the current design because it is very efficient in doing its job and because of budgets constraints this seemed to be the best option for the team.

Weighted Decision Matrix - Which Heat Exchanger?

Date last saved: Nov-11 2014

Decision Factors		Morgan's Design	Brian's Design	James' Design
Criteria	Wt.	1	2	3
Weight	2.0	0	0	0
Ease of Manufacturing	2.0	-1	-1	1
Ease of Maintenance	1.0	1	0	1
Cost	2.0	1	1	0
Efficiency	1.0	2	2	1
Weighted Scores		3.0	2.0	4.0

Which Heat Exchanger Design Should We Use?

Criteria	Definition
Weight	How heavy is the design
Ease of Manufacturing	How easily the design can be manufactured with common manufacturing techniques
Ease of Maintenance	How easily the design can be maintained
Cost	Up-front costs and ongoing costs (e.g. payment to developer)
Efficiency	How efficiently and effectively the design transfers heat to the water

Instructions: Select and insert a score of **-5 to +5** for each criteria. The score will be multiplied by the weight to arrive at the total weighted score.
ın for **status quo** (i.e. no change) and score the options against the status quo.

Figure 1 – Decision matrix used to select the heat exchanger design

Design three, the looped design that can be seen in Figure 2a was chosen primarily due to easier manufacturing. With the other designs, it was going to be a challenge to create 10 feet long holes through a solid piece of aluminum. In the looped design, 6 inch holes are drilled throughout the side of the solid piece of aluminum which can be seen in Figure 2b. After the holes have been made, one inch by 6 inch tubes of copper will be inserted into these holes. After the copper tubes have been placed, they will all be connected using copper elbows. After cost and material analysis it has been determined that using a solid piece of aluminum and using copper for the tubing will have a relatively large cost. Price searching for the best deal on aluminum and copper will be an important task for our team to allow for this design to be monetarily feasible.

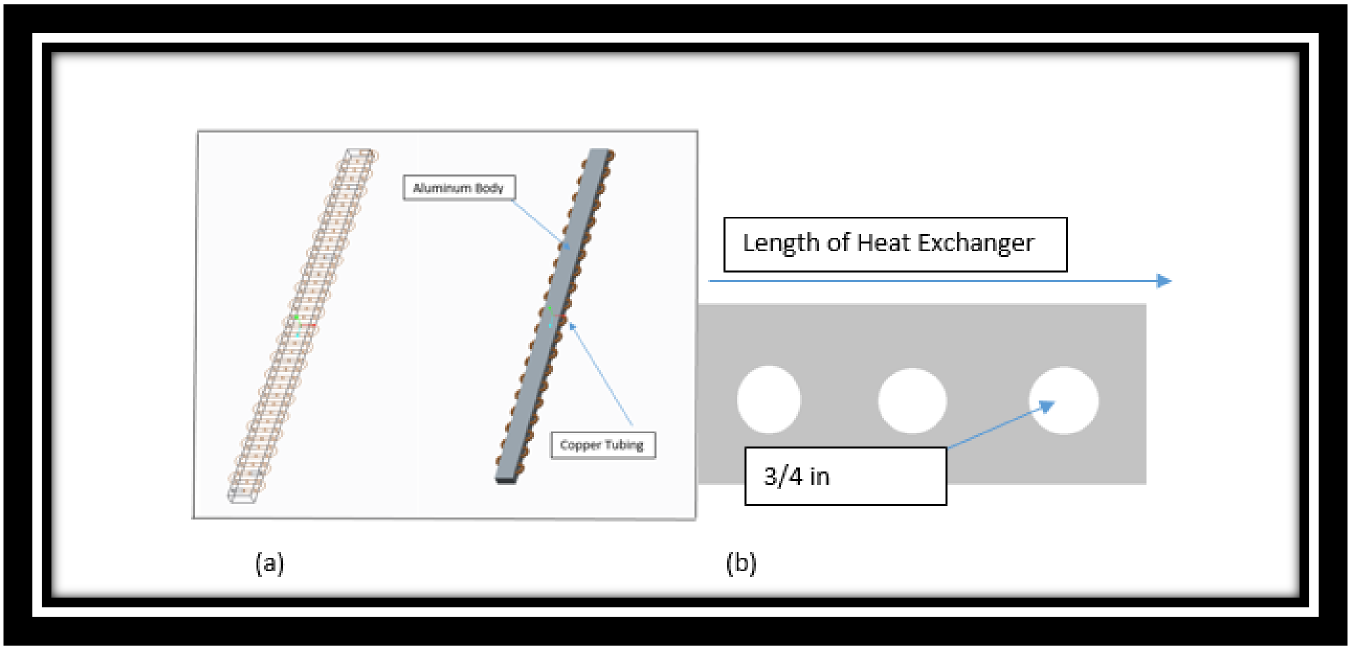


Figure 2: (a) Looped flow design and (b) up close look along the length of the Heat Exchanger

Cost Analysis

This design may be more expensive than the other two designs since it may need multiple copper elbows. From analyzing the cost of this design it is estimated that there will be about 40 copper loops in the heat exchanger that will require a bit less than 60ft of copper tubing. Assessing the price of copper tubing, it was chosen that ¾in copper tubing would be the used. This would bring the price of copper needed to about $100. From sources found on the web, it has been determined that aluminum 6061 can be bought at a price of about $1 a pound. From analyzing the weight and dimensions of the aluminum needed, about 400lb is required. Although, not all of the aluminum will be utilized since we will be drilling about 40, ¾in holes, which brings the weight amount down to 300lb. Since it will be possible to sell back the unused aluminum, it brings the cost of aluminum to approximately $300. This means the total cost of the materials needed for this heat exchanger design to $400.

4. Risk Assessment

The overall risk assessment analyzes the overall functionality of the system design. Pertaining to the sola sausage we have to factor in the electrical components and water which an important factor in the risk of electrocution. 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:

- Technical Risks
  - Electrocution – exposure of the solar panel without following
    - Probability:
      - Low
    - Consequences: Severe or Catastrophic
      - Injury or death
    - Strategy:
      - To make sure there are no exposed wires throughout the system and that every component meets IEEE standards
  - Battery Life
    - Probability:
      - Low
    - Consequences
      - Moderate
    - Strategy:
      - To refine the use of our energy storage techniques.

- Schedule Risks
  - Optimistic Scheduling
    - Probability: Moderate
      - At the beginning of the project the design team was carefully warned by Dr. Frank that the projects will have hiccups and bumps along the way. The anticipation of something failing or going wrong was taken into consideration; however, with that being said,

no one can predict the future and there is always the probability of some unforeseen extenuating circumstance that could arise.

    - Consequences: Severe
        - The consequences of optimistic scheduling have the potential to be catastrophic. This could cause a huge amount of time to be consumed on the realistic circumstance. This would delay the entire project and could cause an extreme delay in progress. If delayed long enough it could cause the design team to not be able to graduate.
    - Strategy
        - The group has designed a flexible schedule that has lighter workloads in some weeks than others. If there is an obstacle that presents itself to be great, then the group can simply push other dates back to fill the easier weeks with tasks.
- Change of Delivery Date
    - Probability: Low
        - The delivery date is set in stone. The conclusion of the semester is already known; therefore, the final product has to be submitted before that date. Moving it up may be proposed; however, the schedule has been set to have the project completed a couple of weeks prior to the conclusion of the semester anyway. This can be compensated by the risk listed above.
    - Consequences: High
        - If the delivery date is changed then the consequences then the consequences could play out to be relatively high. This would cause a rift in the entire schedule if the date is moved too far back.
    - Strategy
        - The delivery date has been set according the conclusion of the spring 2015 academic semester. This date has been set by Florida A&M University and Florida State University. These dates will not change.
- Excessive Scheduling of events
    - Probability: High
        - This project has already been declared as extremely difficult, and major aspects of the project have been cut out due to the difficulty. All of the foreseen aspects of this project have already been proven difficult; therefore, excessively scheduling events is easy to do. All the members of the project have ideas that go into the scheduling, and certain people get weighed down with extreme amounts of work that is not possible to complete.
    - Consequences: Moderate
        - The consequence of this would be a loss of time that could be spent on doing more relevant and attainable things. This could be compensated by the lack of optimism in the schedule already; however, some things could take too much time.
    - Strategy

      - The group has designed a flexible schedule that has lighter workloads in some weeks than others. If there is an obstacle that presents itself to be great, then the group can simply push other dates back to fill the easier weeks with tasks.
- Omissions
  - Probability: Low
    - This risk has a very low probability of coming true. Dr. Frank ensured that each team went through and made sure their schedule would compensate for things like the risks mentioned above. The plan was carefully thought out and discussed amongst the entire group.
  - Consequences: Low
    - This risk would have low impact on the overall schedule, because like mentioned above we have scheduled time for any setbacks.
  - Strategy
    - Conversing with Dr. Ian Winger helped clear up any omissions. Winger helped clarify what he expects, and what he wants improved. He informed the group of things that would be a waste of time, and things that the group was forgetting and should consider.
- Delay in tasks
  - Probability: Moderate
    - Majority of the components used on the Solar Sausage are custom made; therefore, the group will have to go through him to recreate the things needed to complete the project. There is very little room for error with some of these things, so some tasks can be delayed.
  - Consequences: Low
    - Consequences could prolong the completion but not by much if any at all. For example, the solar panels are custom designed solar panels in which need to be recreated. If some unforeseen complication happens then it would cause an extra day or two to be needed to complete the task.
  - Strategy
    - Dr. Winger will be assisting the team in building all of the necessary components. This will help keep the team on track and ensure that everything is being built the correct way.
- Project is more complex than anticipated
  - Probability: High
    - Complications has already been made aware to the group. Quite a bit of the complications have been cut from the project; however, some complications have not been, and the schedule may need to be altered a little to compensate for these complications.
  - Consequences: Moderate
    - Since some of these complications have been cut and others have been revealed to the group the extra time gained from cutting

certain parts out of the project can be used to work harder on the more complex parts.

- Strategy
  - Working closely with Dr. Edrington and Dr. Ordonez will help discover any major complications that would extend outside the scope of the project, or anything that may require more time.

- Budget Risks
  - Insufficient Funding
    - Probability: Low
      - The probability is low because most of our materials are being donated directly from Dr. Winger. He informed the group that they will have more than enough materials to run all types of testing, and prototyping.
    - Consequences: High
      - Although the probability of insufficient funding is low the consequences are high. If the sponsor decides not to come out of pocket with any more money, then the project will die. Thus causing all other risks to come true and the project will not be completed and the team will not graduate.
    - Strategy
      - To assist in overspending all purchases will be discussed by the entire team; once an agreement is reached, the team will take the purchase to Dr. Winger and ensure that it is necessary for the project. Also a business student will be added to the team in the spring semester to Summary of Risk Status

5. 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

6. 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

7. Conclusion

This document shows the updates that the design team has decided upon for the Solar Sausage system. The team has considered and implemented many of the thoughts shared to them via the faculty advisors. The system produced will prove to be more reasonable and efficient than the initial design created at the beginning of the project. This report will verify that the Solar Sausage team is moving forward with the design process at an acceptable speed, at this rate the project will be able to be completed during the year long deadline. This project is great for society as a whole, producing cheap electricity and potable water; the design team is looking for the most efficient way to complete this design project while keeping it simple.

8. References

1. "Solar Panel Tilt Calculator." *What's the optimal angle for my solar panel. Web. 13 Nov. 2014.* <http://www.gogreensolar.com/pages/solar-panel-tilt-calculator>
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