# Solar Autoclave for Rural Areas

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Team 6

# Needs Assessment

Document

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## INTRODUCTION

An autoclave is a device used to sterilize medical equipment. While there are many sterilization techniques available, the preferred method is steam sterilization. In this process, water is pressurized to raise its boiling point. When this occurs, steam will be created at a temperature higher than $100^{o}$C. In fact, in order to fully eliminate all prions and bacteria associated with disease, saturated steam needs to be at least $121^{o}$C when in contact with the equipment being sterilized. Currently, many advanced designs are being used in western countries. These designs are usually powered with electricity and use computers to monitor the internal temperatures and pressures. Unfortunately, many developing areas around the world do not have the technology available to operate these types of autoclaves. As a result, nurses and doctors at remote health clinics in these rural areas are continually challenged with the decision to operate with unsanitary equipment, risking the spread of infection, or to not operate at all. A solar autoclave provides an alternative solution to this problem. Using only solar radiation, a solar autoclave can provide remote health clinics with an inexpensive, efficient way to sterilize medical equipment.

## NEEDS IDENTIFICATION

Many developing areas around the world have limited availability to sterilized medical equipment. Currently, several countries in rural areas cannot properly sterilize what limited medical equipment is available. This results in medical treatment or surgery with unsafe equipment, risking the chance of infection and possibly the life of the patient. Sometimes, no treatment is done at all.

## PROBLEM STATEMENT

### Goal

i. Overall Goal Statement – To create a solar autoclave that can be easily used at remote clinics in rural areas.

ii. Overall Scope of Goal - The project will be aimed for several regions across the globe in need of sterile medical equipment, with ample amounts of sunlight to power the solar autoclave.

## Objectives

The three main objectives for this project include:

- To provide remote clinics in rural areas with the means to sterilize medical equipment.
- To create a flexible design from location to location.
  - A solar autoclave can be implemented in any region with enough sunlight available. This design will be able to me modified using the resources and materials locally available.
- The individual parts can be repaired or replaced from local, readily available materials.

Below is a table of the objectives listed along with the basis for measurement for each.

**Table 1** – Table of Objectives

| Objective | Basis for Measurement | Units |
|---|---|---|
| Provide remote health clinics with the means to sterilize medical equipment | Temperature & Pressure | °C & bar |
| Create a flexible design from location to location | N/A | N/A |
| Parts can be repaired / replaced with local, readily available materials | Cost | $ |

## Constraints

There are not many constraints for this project. The most important one is to sterilize the medical equipment. This constraint can be broken up into two categories: temperature and pressure. These two sub constraints include:

- Temperature of steam must reach and hold $121^{o}$C for at least 15 minutes.
- Pressure must reach and hold 2.05 bar for at least 15 minutes.

Using these objectives and constraints, a criteria tree was created. This can be seen in Figure 1 below.

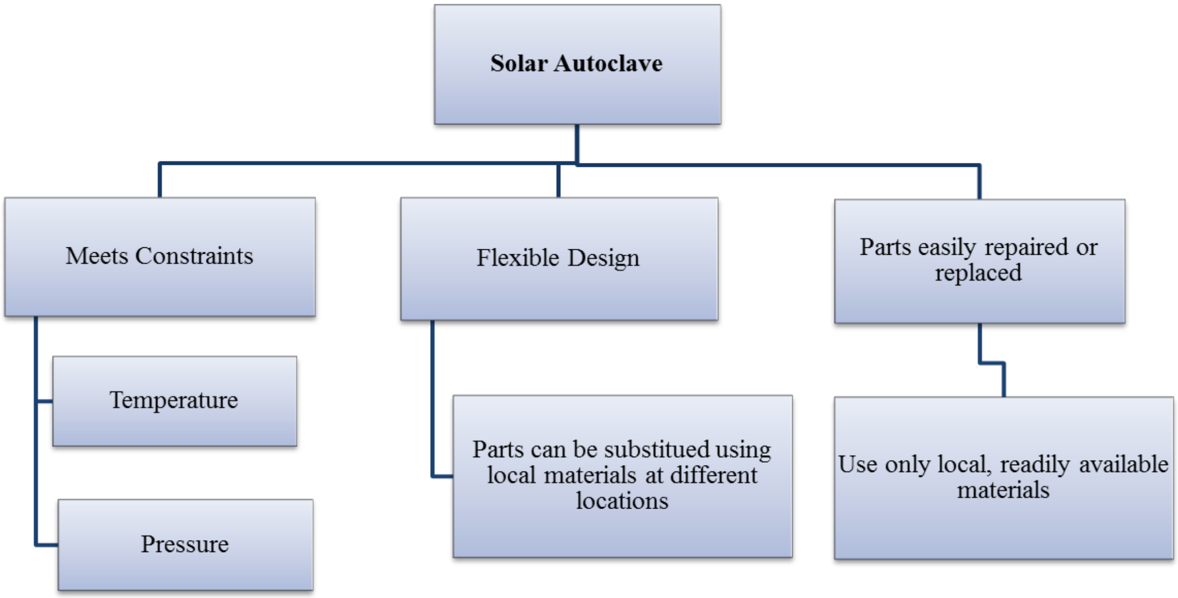


**Figure 1** – Criteria Tree

Our design consists of five major steps. These steps describe the autoclave process, and can be seen in the functional diagram below.

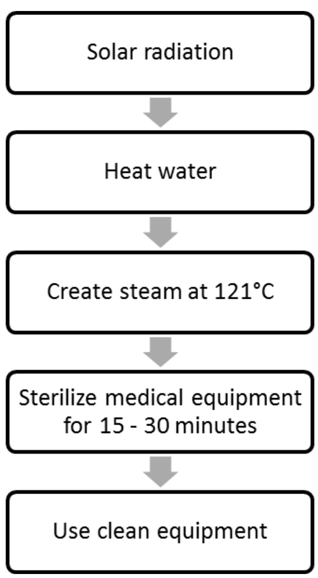


**Figure 2** – Functional Diagram

Additional engineering requirements were developed for the solar autoclave. The following house of quality displays these requirements, and shows how each requirement affects the others.

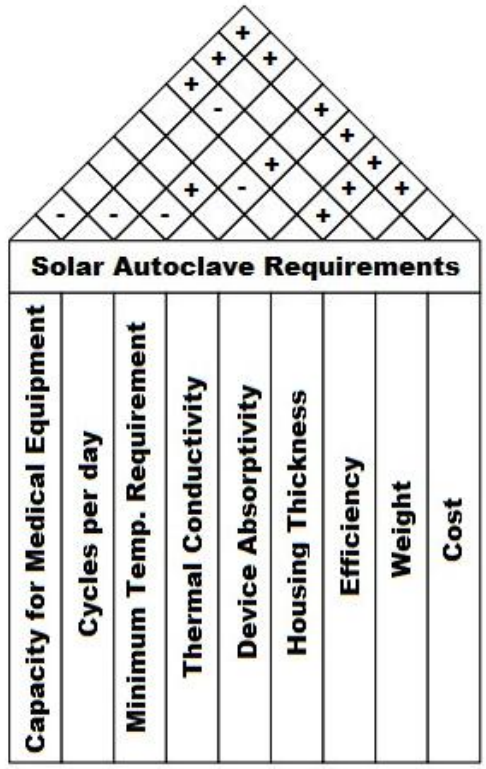


**Figure 3** – House of Quality

This house of quality shows how each engineering requirement relates to one another. Plus signs indicate a direct correlation, while minus signs show that the two requirements are not directly related. For example, housing thickness and cost are directly related. As the housing thickness is increased, the cost will be as well.

In addition to developing engineering requirements, our team had to determine the corresponding customer requirements. Both sets of requirements were related to one another, and can be seen in the quality function deployment below.

| Customer Requirements | Engineering Requirements | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Capacity for Medical Equipment | Cycles per Day | Minimum Temperature Requirement | Thermal Conductivity | Device Absorptivity | Housing Thickness | Efficiency | Pressure | Cost |
| Easy to use | X | X | | | | | | | |
| Portable | X | | | | | | | | |
| Readily Available Materials | | | | X | X | | X | | X |
| Use Energy as efficiency as Possible | | X | | X | X | | X | | |
| Durable | | | | | | X | | | X |
| Achieve the Required Internal Eviornment | | | X | | | | | X | |
| Safe | | | X | | | | | X | |
| Inexpensive | X | | | | | X | | | X |
| Units | $cm^3$ | min | °C | $W \cdot m^{-1} \cdot K^{-1}$ | $W \cdot m^2$ | mm | % | bar | $ |
| Engineering Targets | | | 121 | | | | | 2.05 | |

**Figure 4** – Quality Function Deployment

This diagram shows the correlation between customer and engineering requirements for the solar autoclave. Each ‘X’ means the two requirements are related to each other in some way. For example, a customer requirement of being safe to use is directly related to the minimum temperature and pressure required to sterilize the medical equipment. Too much pressure can cause a catastrophic failure, shooting out large amounts of dangerous, saturated steam.

Finally, our timeline for this semester was created, showing the different tasks needed to be accomplished. This timeline can be seen in the gantt chart below.

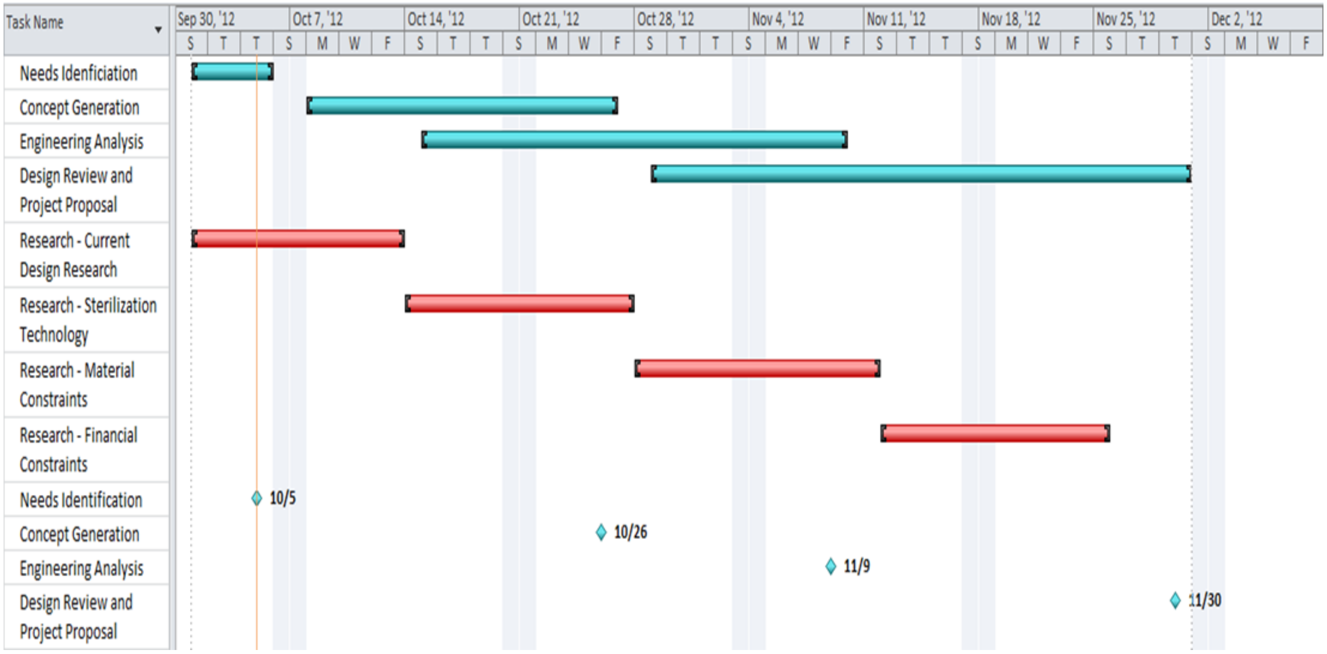


**Figure 5** – Gantt chart for semester

This timeline includes continuing research throughout the semester, as well as concept generation and selection to help achieve a final design.

### Test Environment

The test environment that would be best for the solar autoclave would have to be a rural, sunny area. This device will be used at remote health clinics in rural areas around the world, so a similar environment that would allow us to test our final design would be ideal. Since Flagstaff is not far from desert, somewhere isolated near Phoenix would be suitable. This area has substantial sunlight, and can simulate a rural area.

### Summary

Unsterile medical equipment is a great concern in remote areas around the world. Many patients cannot be properly operated on, leading to the spread of infection, diseases, and sometimes death. The solar autoclave is an important and unique project. It has the ability to help people in developing areas by providing the means to properly sterilize medical equipment. For this to happen, the constraints previously listed will have to be met. Our team is excited to take on this challenge, and will work hard to ensure that the solar autoclave design we create will meet and exceed our goals and expectations.

## REFERENCES

[1]. Centers for Disease Control and Prevention. Web. 1 October 2012. URL: http://www.cdc.gov/

[2]. World Health Organization. Web. 1 October 2012. URL: http://www.who.int/en/