
THE SANCTUARY'S SOLAR FOOD DEHYDRATOR

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1 Problem Formulation

1.1 Introduction

The purpose of problem formulation is to give context to the project. The background gives information on the client. Problem identification explicitly states the problem the client is having. The objective states the mission of the project. The black box model provides the scope of the project.

1.2 Background

Team BALM are engineering students at Humboldt State University in Introduction to Design Course. Team BALM includes Lynn Brown, Brayden Leach, Andrew Rushing and Marissa Woolsey. The client for the project is the Sanctuary.

The Sanctuary is a non-Profit corporation located in Arcata, California. The mission of the Sanctuary is to inspire creative growth through arts. The Sanctuary provides art facilities for the Arcata Community and the general public. The art facilities include a general shop, a garden, a library, a kitchen, and workshop spaces for textiles, ceramics, jewelry, music, printmaking and bike repair. The sanctuary is focused on restoration, recycling and repurposing materials as well as inspiring waste-diversion and prevention.

Waste-diversion and prevention is modeled in different ways at the Sanctuary. One way the Sanctuary diverts waste is the compost system located on the property. The system reduces the amount of food waste sent to landfills and provides nutrients used in the garden. Another way the Sanctuary diverts waste is through an agreement with local farms. Food with imperfections or unable to be sold is donated to the Sanctuary by the local farms. The food donated is usually thrown away by the farms but this opportunity reduces the waste in the community while feeding the community. The food donations come in large quantities at one time. The produce is available for all who visit the Sanctuary. The food is used in the kitchen at the sanctuary. When there is not enough demand for the donations before they go bad, the Sanctuary creates alternative ways to preserve the food. The means of food preservation occurs through canning and dehydrating at the Sanctuary.

The Sanctuary utilizes food dehydrators to preserve excess food. The two current dehydrators on site, run on electricity and both are stored in the indoor workshop space. One of the current food dehydrators is large and produces a lot of noise when in use. Due to the size and weight of the food dehydrator it is not easily transported by the Sanctuary Staff.



Figure 1-1 The Sanctuary's Electric Food Dehydrator

1.3 Problem Identification

The Sanctuary is in need of an alternative solution for dehydrating food. The current dehydrator uses too much energy. The space in the Sanctuary workshops are dynamic as well as limited, the two dehydrators onsite both use a significant amount of this space.

1.4 Objective

The objective of this project is to find and create a food dehydration system that reflects upon the Sanctuary's mission on waste-diversion and recycling. The food dehydration must use solar energy, and be portable.

1.5 Black Box Model

The black box model depicts the world before the project and the world after. The model clarifies what the problem is by defining the state of the world as it is and how the world is affected by the unspecified solution. The scope of the project is defined by the client, the Sanctuary. The Sanctuary uses a food dehydrator that runs on a lot of energy and is not easily transported. The black box represents the project. After the project the Sanctuary would have a

solar food dehydrator that is portable.

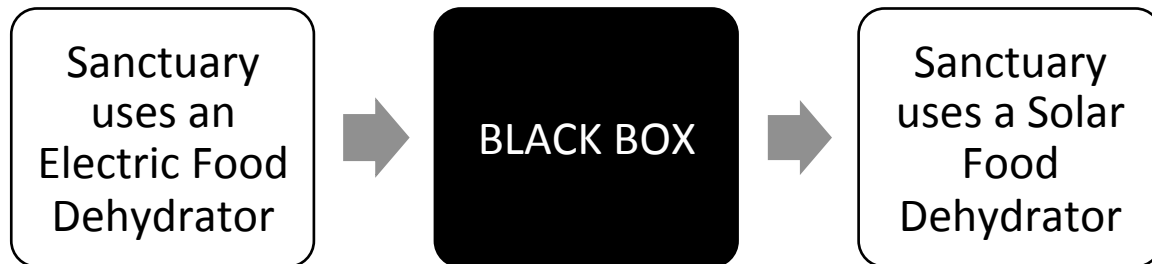


Figure 1-2 Black Box Model

2 Problem Analysis and Literature Review

Phase two of the design process is gathering information. The problem analysis and literature review compiles the relevant information and research for building a solar food dehydrator and what is desired by the Sanctuary.

2.1 Introduction to Problem Analysis

The problem analysis section covers the specifications required from the client, the Sanctuary, as well as considerations necessary to identify pertinent information related to the location, the client and solar food dehydrators. The following section will also layout the criteria, constraints, usage of the project, and the production volume.

2.1.1 Specifications

The specifications listed are based off of concerns conveyed by Solomon Lowenstein III and Mark Dubrow, the client representatives for the Sanctuary. The food dehydrator must rely on solar radiation for heat. A main specification expressed by the client is that the food dehydrator must be mobile. Mobility is made possible through a detachment system that allows the client to easily transport the dehydrator. To accommodate a large design within a small space when it is unideal to use the dehydrator, it should have dynamic components. The dehydrator must be able to dehydrate food effectively. The materials used should be scavenged or recycled. The food dehydrator must also be sufficiently weather-resistant while also working with the weather, such as the sun, to dehydrate the food in a timely matter. The new food dehydration area must surpass the current dehydration area of fifteen square feet.

2.1.2 Criteria and Constraints

The criteria described below are parameters that will determine whether the product is successful. The separate criterion defines aspects of the problem's solution. The constraints are to give dimension to criteria.

Table 1 Criteria List

Criteria	Constraint
Durability	Must withstand environment for a season
Insect Proofing	Must deter insects from entering the food compartment.
Ease of Use	Must be able to be operated with less than a fifteen-minute training for an adult.
Aesthetics	Exceed the look of Bayside Food Dehydrator, must look like it belongs to the Sanctuary
Safety	Must be food safe and not endanger users
Effectiveness	Must reach temperature ranges
Adaptability	Must have the ability to be used in different environments
Replicability	Must be easily recreated
Use of Recycled Materials	More than half of the materials used should be reused, repurposed or recycled
Cost	Use the least amount of money
Mobility	Must be easily transported

2.1.3 Considerations

Considerations include the spatial restrictions for the project, the amount of food going into the dehydrator, the pest and insect intrusions, and the weather fluctuations of Arcata, California. A measurement of thirty square feet for the dehydrating area capacity was expressed as ideal by the client. The location allotted in the Sanctuary for the food dehydrator is in the middle of the garden, it is an uncovered area that will be open to elements. The client expressed interest in a detachable unit that is easily transported throughout rugged terrain. An expressed interest is in car food dehydrators. The food dehydrator should be aesthetically pleasing, so much so that it can appeal to individuals looking to make their own. As well as looking professional it should also look as if it belongs to the Sanctuary with similar style of colors and artistic workspace. The Sanctuary is an artistic workspace within the garden, the surrounding buildings on property are vibrant colors that stand out in the neighborhood. The production volume of the dehydrator, not

the project but the design, is based off of the amount of food the Sanctuary receives throughout the seasons. This can fluctuate based on donations, food produced and demand for the food available at the Sanctuary.

2.1.3.1 Usage of food dehydrator

Members of the Sanctuary will use the food dehydrator depending on the food collections during harvest season. The produce available at the Sanctuary is either sourced on site or from a local food pantry that is no longer fresh enough to be offered through their facility. The purpose for the food dehydrator is to create an alternative and immediate solution to an influx of food available at the Sanctuary when demand for the produce is low. The primary seasons of use for the dehydrator are summer through fall. During the offseason, alternative uses for the food dehydrator include as a seed starting compartment with the use of the catchment of the dehydrator.

2.1.3.2 Production Volume

One food dehydrator will be produced for the project. The client has described plans of expansion for the food dehydrator. Plans and directions for recreating the Sanctuary's solar food dehydrator.

2.2 Introduction to Literature Review

The literature review is research on relevant topics to the project. This section will provide an appropriate background on pertinent information related to the Sanctuary and solar food dehydrators. Starting with a brief introduction of Thermodynamic and Chemical laws relevant to solar food dehydration are defined. The location of the Sanctuary is used to contextualize climate. Related materials and essential components of solar food dehydrators are located in this section.

2.2.1 Physics and Chemistry

The following section describes Physics and Chemistry concepts, laws and applications. This a brief introduction to give background for Food Dehydration.

2.2.1.1 Energy

Thermodynamics is the study of energy and the transformation of energy from one form to another form. Mechanical work done is a force that moves an object any distance. Potential Energy is the stored energy in an object based on its position. Kinetic Energy is known as the energy an object has in motion based on its mass and the magnitude of velocity at any time while in motion. (Gilbert, et al., 2015)

$$KE = \frac{1}{2}mu^2$$

Equation 2.2.1.1-1 Kinetic Energy

Thermal Energy is kinetic energy on a subatomic level. The random motion of atoms, ions and molecules, are examples of Thermal Energy. The law of conservation of energy states that energy is not created nor destroyed, rather converted from one form to another. (Gilbert et al. 2015)

Other forms of energy, in addition to what is described above, are mechanical, chemical, electrical, and thermal. Energy balances are similar to the conservation of matter because it is able to be balanced. For an open system, the net change in energy is the difference in energy of mass entering system and energy of mass leaving system plus or minus the energy flow into or out of the system. For many systems, the change in energy is dependent on time. (Davis, et al., 2009)

2.2.1.2 System and Surroundings

To interpret thermodynamics, define system and surroundings. Isolate part of the universe to be studied as the system, and the surroundings to be everything else, sets parameters to isolate what is being observed by the system. Three types of systems in thermodynamics define the interactions with surroundings: closed, isolated and open systems. Closed systems exchange energy with surroundings but not matter. Isolated systems do not exchange energy or matter. Open systems exchange energy and matter. (Gilbert et al. 2015)

2.2.1.3 Laws of Thermodynamics

The first law of thermodynamics is defined as the change in energy by a system must equal the change in energy by the surroundings. (Gilbert et al. 2015) Reiterate the law of conservation of energy defined in the Energy section, cannot be created or destroyed without nuclear reaction. Energy simply changes form. Enthalpy, also known as a system's heat content, is a thermodynamic property of a material that depends on temperature, pressure and the volume and internal energy of the material. It is thermal energy, with kilojoules as units. The flow of energy is the product of volume (in cubic meters or liters), and pressure (in kilopascals or atmospheres). (Davis, et al., 2009) Enthalpy is the product of pressure and volume added to the internal energy of a system. Enthalpy change is the change in heat of a process, heat absorbed in an endothermic or heat expelled from an exothermic at a constant pressure. (Gilbert, et al., 2015) With a constant pressure the energy to change the temperature of a substance-with a mass of 1 gram-1 degree Celsius higher is defined as specific heat. (Gilbert, et al., 2015)

The second law of thermodynamics is dependent on entropy. Entropy is defined as the measurement of the dispersion, or distribution of energy at a specific temperature in a system. The second law of thermodynamics is defined as the principle of total entropy increases in any spontaneous process. In a system, entropy is based on temperature. At higher temperatures particles have greater motion, and the entropic measurement would be higher. Alternatively, at lower temperatures particles' kinetic energy decrease and the entropic measurement would be lower. (Gilbert, et al., 2015)

The Third law of thermodynamics is as follows and is based on absolute entropy at zero. When motion within a particle is absent there is no kinetic energy. In a perfect crystalline structure, the absolute entropy is zero at zero kelvin. (Gilbert, et al., 2015)

2.2.1.4 Processes

Exothermic and endothermic processes define whether a system is releasing energy to surroundings, exothermic, or absorbing energy from the surroundings, endothermic. (Gilbert et al. 2015)

2.2.1.5 Gas Laws

The following laws are fundamental to the changing states from liquid to gaseous state. Evaporation is the key process of food dehydration. Utilizing the ideal gas law and Dalton's law identifies the importance of change in temperature.

The ideal gas law defines the relationship of temperature, pressure and volume of gases. Pressure has units of atmospheres (atm), it is denoted as P. Temperature has units of kelvin (K), it is denoted as T. Volume has units of liters (L), it is denoted as V. The number of moles has units in moles and is denoted as n. The ideal gas law constant is denoted as R and is always $0.082057 \left(\frac{L \cdot atm}{mol \cdot K} \right)$ with the given units. Described mathematically:

$$PV = nRT$$

Equation 2.2.1.5-1 Ideal Gas Law

Standard temperature and pressure is 273.15 K and 1 atm. At STP one mole of any gas the volume is 22.4 Liters. (Chemistry, Gilbert et al. 2015)

John Dalton is credited for finding the total pressure from a mixture of gasses is equivalent to the sum of each type of pressure from individual gases. Described mathematically:

$$P_t = P_1 + P_2 + \dots + P_n$$

Equation 2.2.1.5-2 Dalton's Partial Pressures

Isolating pressure in the ideal gas law, refer to Equation 2.2.1.5-3 Ideal Gas Law with Dalton's Partial Pressures the product of: number of moles, ideal gas law constant, temperature and the reciprocal of volume. Temperature, volume and the constant are defined by the same closed system so, these values are the same for each gas. This means the number of moles is the only differing component of the system. Described mathematically:

$$P_t = (n_1 + n_2 + n_3 + \dots) \frac{RT}{V}$$

Equation 2.2.1.5-3 Ideal Gas Law with Dalton's Partial Pressures

(Davis, et al., 2009)

2.2.2 Heat

As described in the section of Gas Laws on Equation 2.2.1.5-3 Ideal Gas Law with Dalton's Partial Pressures, heat or temperature is directly related to gases. The three types of heat are crucial components in varying degrees to a food dehydrator. Food dehydrators use all three types; conduction, convection and radiation.

2.2.2.1 Conduction

Conduction is the transfer of heat through a material where there is a difference in temperature between objects through molecular diffusion, the process of objects dispersed molecules to reach an even distribution of heat. The expression for calculating energy flow by conductive heat is provided by Fourier's law. The rate of change in enthalpy has units of kilojoules per second, which is equivalent to kilowatts ($\frac{kJ}{s}$ or kW) and is represented by the derivative $\frac{dH}{dt}$. Surface area is in meters squared (m^2) and is denoted as A. The change in temperature with respect to distance is represented as the following $\frac{dT}{dx}$, the units associated are kelvin over meters (K/m). Thermal conductivity has all of the units stated above ($\frac{kJ}{s \cdot m \cdot K}$ or $\frac{kW}{m \cdot K}$) and is represented with h_{tc} . Described mathematically:

$$\frac{dH}{dt} = -h_{tc} A \frac{dT}{dx}$$

Equation 2.2.2.1-1 Fourier's Law: Conductive Heat

(Davis, et al., 2009)

Thermal bridging is conductive heat transfer. Thermal bridges are discontinuities in any thermal barrier. If the discontinuity is made of highly conductive material it makes the bridge more pronounce. The resulting problem is that energy is lost from the thermal barrier. (Totten, et al., 2008) In relation to a food dehydrator the heat must stay inside the solar dehydrator, the thermal barrier, and potential thermal bridges like metal screws can cause heat to be lost. Metal screws are highly conductive so it can transfer heat from inside the dehydrator system to the surroundings if exposed to both.

2.2.2.2 Convection

Forced convective heat transfer is the transfer of thermal energy through a large fluid motion. Fluid motion can be liquid flow or wind blowing. The parameters are as such, that the heat transfer is between a solid and a fluid. Convective heat transfer is the difference in temperature of the fluid T_f and the solid T_s both in kelvin (K). The convective heat transfer coefficient is denoted as h_c and has units of kilojoules over the product of kelvin, meters squared and seconds. Surface area is in meters squared and as previously stated, in 1.5.1 Conduction, is denoted as A. The following equation is convective heat transfer. (Davis, et al., 2009)

$$\frac{dH}{dt} = h_c A (T_f - T_s)$$

Equation 2.2.2.2-1 Convective Heat Transfer

Air used as a transfer fluid is convection. Solar collectors can be designed to collect heat with air and transfer it through the system. (ASHRAE, 1978)

2.2.2.3 Radiation

Radiant energy is transported by electromagnetic radiation, unlike convection and conduction does not require a medium, such as a fluid in convection or material in conduction, for heat transfer. The radiative heat transfer involves both, absorption of radiant energy by an object and the radiation being emitted from that object. The energy is denoted by E and are differentiated by their subscripts. The change in heat or enthalpy for Radiative heat is as follows:

$$\frac{dH}{dt} = E_{absorped} - E_{emitted}$$

Equation 2.2.2.3-1 Radiative Heat Transfer

Blackbody radiation is the maximum amount of radiation that an object can emit at a given temperature. (Davis and Masten 2009)

The greenhouse effect is used to describe the radiant heat transfer from the sun to earth. The sun emits solar radiation that enters the earth's atmosphere. Those rays are either absorbed by the earth or reflected off the surface back out of the atmosphere. The incoming rays are short sun rays the rays reflected off the surface that released from the atmosphere are long rays. The short rays become trapped in the atmosphere heating the earth's surface. This known as the greenhouse effect and is what keeps the earth warm enough to sustain life. (Davis and Masten 2009)

2.2.2.4 Relationships of Heat Transfer

Heating and cooling is addressed in relationship to building structures. Heating and cooling are simplified terms for heat transfer while thermal storage is the rate of heat transfer related to time. A Sunspace is defined as a room that provides heat to the rest of the building. Although the heat coming in is Solar Radiation, see 1.5.3 Radiation, the heat transfer from the sunspace to the rest of the building is through convection. It is to be noted that an exposed area such as a sunspace has temperature swings dependent on the sun exposure in the day; an increase in temperature as high as 95 degrees Fahrenheit and in the night, a decrease as low as 45 degrees Fahrenheit. (Brown, et al., 2001)

2.2.3 Solar Food Dehydrator Design

The following section defines the basic components of solar food dehydrators. It also gives different designs researched. Due to the broad scope of kinds of solar food dehydrator and time constraints there are a limited number of design types researched.

2.2.3.1 Solar Food Dehydration

In order to preserve food, drying or dehydrating food can be used to store food for use at a later date. Removing water, or moisture from food prevents bacteria, yeast and mold from growing and spoiling food. Drying slows naturally occurring substances, enzymes, from ripening the food. Sun drying is recommended for fruits due to a high sugar and acid content. Vegetables are

low in sugar and acid so they are at a higher risk for food spoiling. Meats are susceptible to microbial growth in heat and humidity because of the protein content, making meat not safe for temperature variance.

(Harrison, et al., 2010)

2.2.4 Effectiveness

Food dehydration is dependent on temperature, air flow, humidity and density of food. The variables are dependent on one another to effectively remove water from food. The minimum temperature needed is 86° Fahrenheit with higher temperatures being better.

Ventilation promotes convection through the system. As the temperature rises in the air, the warm air rises through the food dehydrator. In order to remove the moisture from the surrounding area near the food the air flow must transfer vapor away from the system. Humidity is water vapor in the air. If the humidity is high, it is harder to remove water from fruit. The ideal humidity is below 60% for sun drying.

(Harrison, et al., 2010)

2.2.4.1 Solar Food Dehydrator Examples

The following solar food dehydrators were researched for the project. The primary focus on a design was based on a passive airflow dehydrator.

2.2.4.1.1 Guatemala Solar Food Dehydrator

The Guatemala Solar Food Dehydrator was created by Michigan State University Engineering Undergraduate Students for citizens of Panyebar Guatemala. This design is an updraft solar dehydrator with adjustable ventilation holes. This project test updraft and downdraft solar dehydrators.

(Chi, et al., 2009)

2.2.4.1.2 Scanlin Solar Food Dehydrator

Dennis M Scanlin, the Professor of Sustainable Technology at Appalachian State University published the guide manual “Build a Solar Dehydrator”. The guide includes an overview of the research conducted over a 15-year period on comparing different designs and their effectiveness. (Scanlin)

2.2.4.1.3 Bayside Park Farm Solar Dehydrator

A solar food dehydrator was implemented at Bayside Park Farm in 2009 by a group in the Appropriate Technology class at Humboldt State University. The solar food dehydrator was decommissioned after reaching a temperature that cooked the outside without dehydrating the inner section of the food. (Ichien, et al., 2009)

2.2.5 Client Criteria

The client conveyed a main focus of having a food dehydrator that is very simple, low tech and that works well. If the project is completed early we can expand on that. If possible, make another food storage unit. Aesthetics: this project should be an example that someone else would want to recreate. Replicable: create a direction guide with pictures. Scavenged Materials: use materials on Sanctuary property or in the neighboring areas. Portability: this is not a permanent structure; the food dehydrator should be movable by one person. Detachable Unit: want to use the food dehydrator at river. Dehydrating square footage: would like to have it be more than 15 ft^2 , how much their current one holds an ideal area would be around 30 ft^2 and something that would be too much would be 50 ft^2 . Scanlin design is an example pointed out by the client representatives, see 2.2.4.1.2 Scanlin Solar Food Dehydrator. Difficulty: must be easy to use by the community members that visit the sanctuary. Durability: must not fall apart and needs to withstand the Arcata weather. Size: no longer than 12 ft., height not expressed.

2.2.6 Ergonomics

Ergonomics is the study of human capability in relationship to work demand. The Occupational Safety and Health Administration, OSHA, of The United States Department of Labor states that lifting more than 50 pounds will increase the risk of injury. This is verified by the Center of Disease Control and Prevention. (Waters, et al., 1994) OSHA categorizes inadequate handholds as a potential hazard when moving loads. One possible solution stated is to utilize proper handholds to reduce the risk of injury. Handholds should be large enough to accommodate an above average hand size and should not dig into fingers and palms. In transfers, pushing should be utilized over pulling. Pulling carries greater risk of strain and injury, while pushing allows individuals to use large muscle groups to apply force to load. (OSHA, 2015)

2.2.7 Climate

Climate is broken into categories to relate it in context. Structures exposed to climate are affected in different aspects. Temperature, wind, humidity, and rain are the categories that assist in defining Climate as they are defined by subcategories.

2.2.7.1 Arcata

The Sanctuary is located in the City of Arcata. The location of the sanctuary is 40.8729 N, 124.0878 W. The Recommended seasons for food dehydration are between July 21 to September 21 and March 21 to May 21. (Scanlin)

The Table of solar time is sourced from (ASHRAE, 1978)

2.2.8 Solar

Solar Radiation is the primary source of heat for solar food dehydrators. Radiation is described in Radiation 2.2.2.3 of the Literature Review.

2.2.9 Materials

The materials used throughout the design of the solar food dehydrator are listed. The Alternative Solutions and Final Design refer to materials that are used to describe the design. Not all of the materials listed are used in the final project.

2.2.9.1 Glazing

Solar Food Dehydrators with a solar collection component use glazing to let in solar radiation trapping the infrared rays to heat the system. R-value is the resistance of a material to heat flow. A window with a high R-value has greater resistance to heat flow. Table 2 Properties of Glazing shows properties of glazing used on greenhouses. (Marshall, 2006)

Table 2 Properties of Glazing (Marshall, 2006)

The Properties of Various Glazing Materials						
Material	Life Span in years	Maintenance	Structural Value	Insulation R-Value	Degradation	Light Transmission (approximate)
Glass (Single Pane)	Indefinite	Low	Strong	2-8	Low	90%
Polycarbonate (6mil double-wall)	10-15	Low to Moderate	Medium	3-6	Low to Medium	80%
Acrylic (double-wall)	8-12	Low to Moderate	Medium	2-6	Low to Medium	85%
Fiberglass (single-wall)	8-12	Moderate	Light	1-4	Medium	90%
Polyethylene sheeting (single layer)	12	Moderate to High	Light	1-3	Medium to High	85%
PVC Sheeting (single layer)	3-5	Moderate	Light	1-2	Medium to High	85%

2.2.9.1.1 Polycarbonate

Polycarbonate is used as glazing for greenhouses and solar dehydrators. The maintenance of Polycarbonate can be found in double or triple walls. Double walls save 30% more heat than single wall panels and allow 85% of the available light. The R-value for double wall polycarbonate is 1.6 and for triple wall is 2.1. Polycarbonate has a greater impact resistance than glass, making it less like to break if struck by an object. (Marshall, 2006)

2.2.9.1.2 Glass

Typical R-Values for single pane windows are 2 or 3, double pane 4 to 6 and triple pane window may be as high as 8 or 9. (Marshall, 2006)

2.2.9.2 Wood

Wood materials are used for solar food dehydrator structure as well as the trays that will go inside. For the dehydrator's trays, almost any wood found may be used. Do not use green wood, pine, cedar, oak or redwood for these woods warp stain the food or cause off-flavors in the food. (Harrison, et al., 2010)

2.2.9.3 Insulation

Department of Engineering To seal holes in the solar dehydrator silicon based insulation is used. Silicon based insulation is food safe and resistant to heat.

2.2.9.4 Food Screens

The screens that will come into contact with the food must be food safe. Avoid galvanized metal cloth that is coated with cadmium or zinc because these materials can oxidize and leave residues that are harmful to humans if consumed. Copper is not ideal for use because it increases oxidation and destroys vitamin C. Lastly Aluminum should be avoided as it tends to discolor and corrode. The screen materials recommended by the University of Georgia Cooperative Extension Service in the publication Preserving Food: Drying Fruits and Vegetables are stainless steel, Teflon coated fiberglass or plastic. (Harrison, et al., 2010)

3 Alternative Solutions

3.1 Introduction

The following section identifies the nine designs proposed as solutions to the Sanctuary's need for a solar food dehydrator. The brainstorming included in this section is the process team BALM used to find different alternatives to pursue.

3.2 Brainstorming

The brainstorming session was all of the members of Team BALM collaborating on different ways to approach designing a solar food dehydrator. The process focused on designs based off of what was researched on the subject of food dehydrators. Parameters set to guide the session included a positive attitude, a safe environment, inclusion of all ideas presented. Brayden Leach facilitated the meeting in a new location to promote creativity. Different from previous meetings, each group member had an active and equal amount of time to provide input. Within a given time period an unstructured brainstorm session presented as many solutions possible with most consideration on innovation. The following period focused on the ideas presented that were practical for the group and client.

3.3 Alternative Solutions

The alternative solutions are based on research in the Literature Review, Client Criteria, group brainstorming and observations found at the Client location, The Sanctuary. There are nine designs for solar food dehydrators that meet various requirements.

3.3.1 The L Design

The L design is the design by Dennis Scanlin in *How to build a Solar Dehydrator*. Refer to the Literature Review section titled Scanlin Solar Dehydrator for more information on the guide.

The two components of this design are the food compartment and the collector. The collector box is where heat from solar radiation is collected and ventilated throughout the system. This hollow box is open on the end for intake ventilation. The opening lets air flow through as the temperature of the heated collector rises and vents upward through the food compartment. Inside the collector there is dark layered mesh that fits the collector attachment; this helps retain heat to move with the air flow to the foods. The front attachment also has an aluminum foil lining that will reflect solar rays while retaining infrared rays to heat the collector.

The food compartment stores food that is to be dehydrated. The food compartment, which makes up the top half of the design, contains a plywood outer structure, metal food trays, a plywood roof, mesh and a food access door. The metal trays are a source of heat and provide sanitary placement for the food that is drying; the metal used is food safe. The plywood roofing will be necessary protection from the various weather occurrences such as heavy rain and to the possibility of hail. The mesh would act as a barrier inside the drying chamber; the barriers purpose is to deter bugs/birds from entering the food storage. The stand holds the collector and food compartment together. To easily transport the dehydrator there is a wheel located on the long front attachment; this allows the device to be moved in a similar fashion to a wheelbarrow. The food storage frame structure and door will be painted plywood, by painting the wood the design will reduce warping of the wood and unnecessary air leaks. On the front side of the food storage, the side that is opposite of the door, will have a reflective sheet. The reflective sheet will bounce the sun's rays onto the collector box to heat the mesh.

The structure is made of plywood, which is an easily accessible material and known to work well in food dehydrators. Figure 3-1 The L design represents a side view of the whole dehydrator and two separate pictures of the top and bottom halves of the figure.

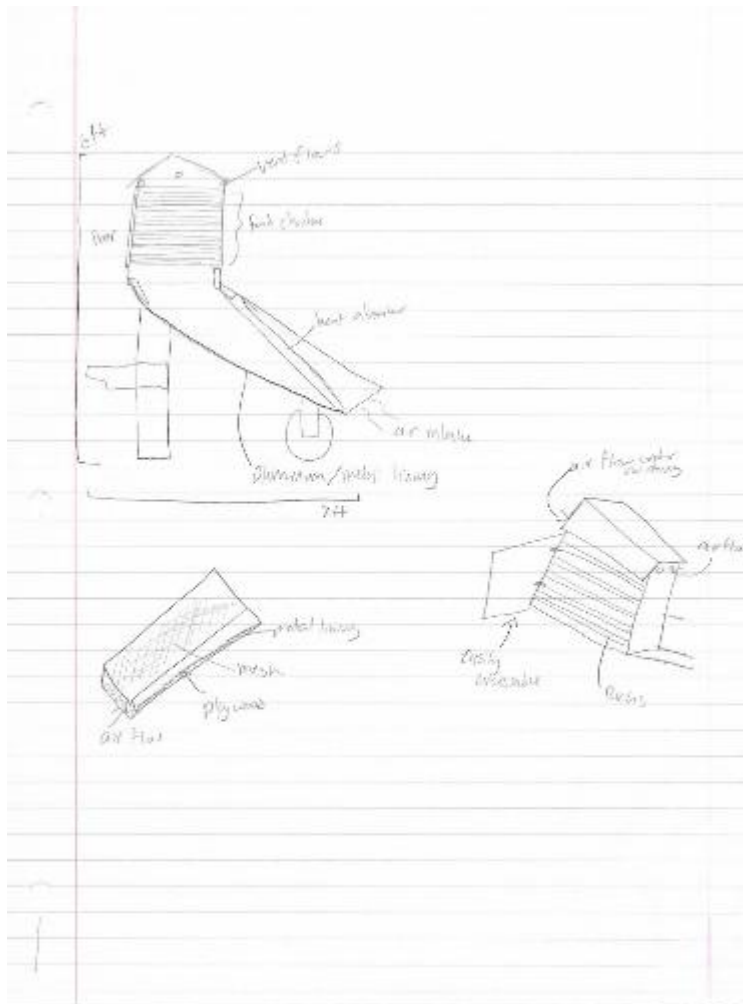


Figure 3-1 The L design

3.3.2 The Trapezoidal Turner

The trapezoidal turner is a design for quick and simple airflow to dehydrate food. The structure will be made predominantly of plywood, glass, mesh barriers and hinges. The top structure, the food dehydrator box, will detach from the table-like structure and become transportable with handles on the side of the box. In the figure below the front and side view show the main components of the design. Airflow will be accessible through the east and west side through the front side's collector box, and out the back through a smaller air flow channel. Airflow will also be accessible through the north and south sides through small air holes. The east and west sides collector systems, that act as air vents, will be detachable to allow easy transportation. The front air vent will also sub as a heat collector box with a heat collecting mesh inside. The slanted side of the box will be the access door to the racks as well as the glass wall. The insulation of choice, that will be the least environmentally impactful and cause no food contamination, is a cotton based insulation. The table that the trapezoidal dehydrator sits on will also have a lazy Susan so that it can be turned easy to follow the sun. This design is modeled after a typical trapezoidal

dehydrator that does not feature any external extremities.

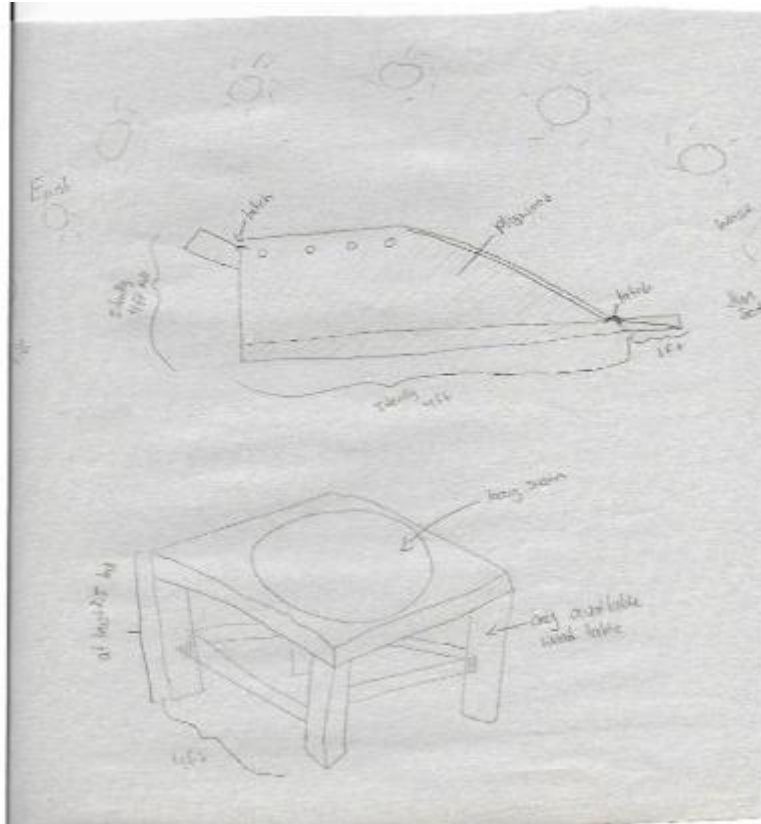


Figure 3-2 Side View of Trapezoidal Turner

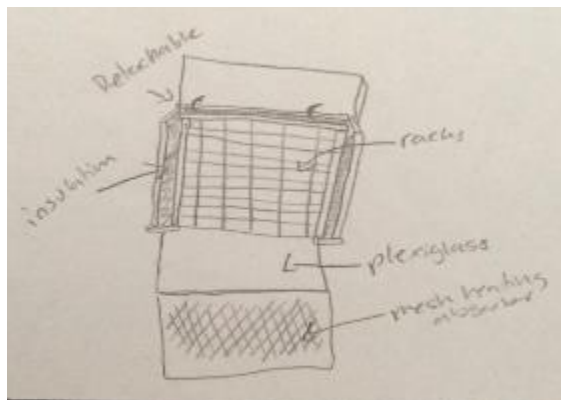


Figure 3-3 Trapezoidal Turner Front View

3.3.3 Cube-O-Matic

The Cube-O-Matic design uses a wood frame and glass for the parts inside the frame arranged in a cube type shape to help get as much heat as possible into the unit. The wood frame would be most effective if made out of a dense wood. The frame would set the food storage two feet off the ground. This design has an intake at the top of the unit and an air exhaust toward the bottom to create good air circulation. On top of the intake component would be a solar powered fan to assist in air ventilation. Constructing this design would be quite easy to put together due to its simplicity. The construction would include measuring and cutting the wooden frame to proper dimensions and guides for the glass. The glass would slide into the guides in the wooden frame. The top of the frame would be the entry point for user with a hinged opening with a latching component. Attach latch and hinges to wood frame, cut ventilation holes in glass and a larger hole for the fan. Attach latch and hinges to wood frame, cut ventilation holes in glass and a larger hole for the fan.

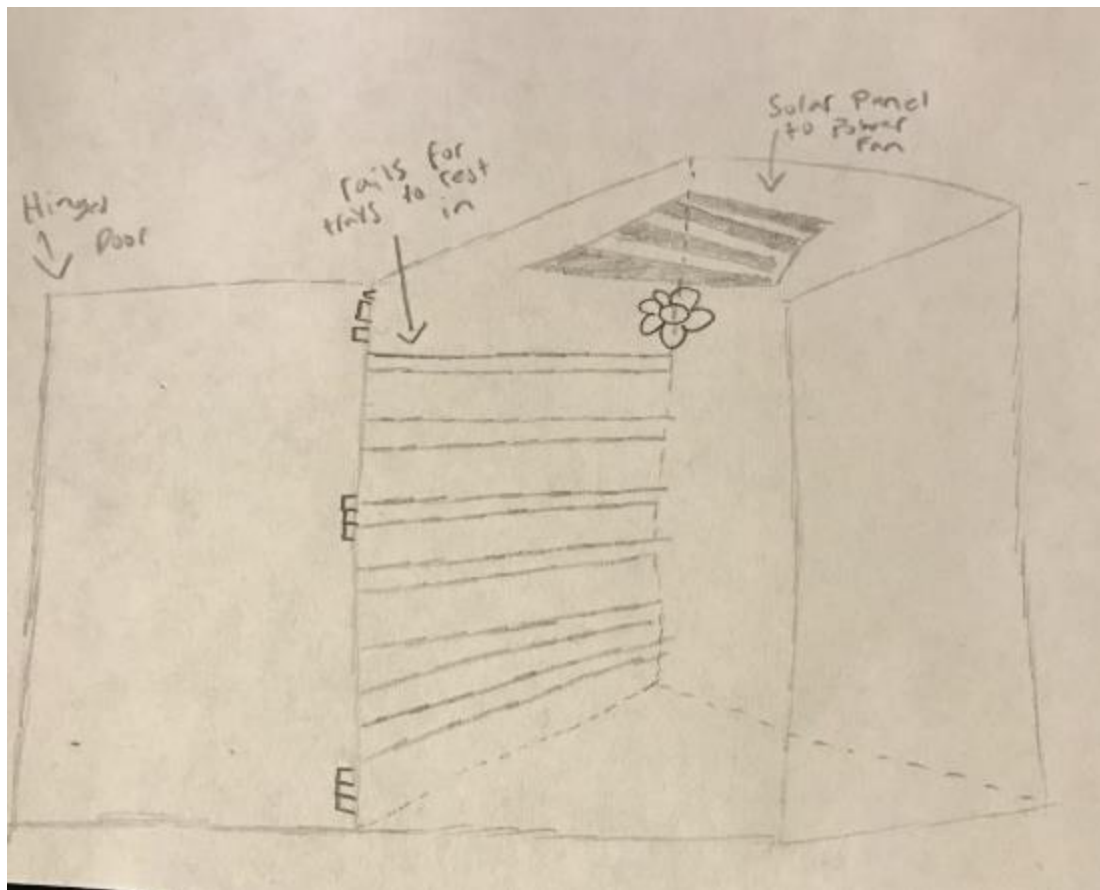


Figure 3-4 Cube-o-matic Design

3.3.4 Technical Powerhouse

This solution is by far one of the most technically incorporated. The unit is made mostly out of polyethylene and dark dense painted wood. On one side lies a polyethylene and wood framed

box with a solar powered fan placed such that it assists in the intake of air. That air would then pass through a heat collector chamber that lies in the middle of the unit, and on the far side would be a container for the food trays. The food container has the benefit of hot air being forced directly to it by use of the fan. The construction would be difficult as this design requires a lot of carefully calculated cuts, attachments in corners to keep a tight seal, and due to the materials being more difficult to work with.

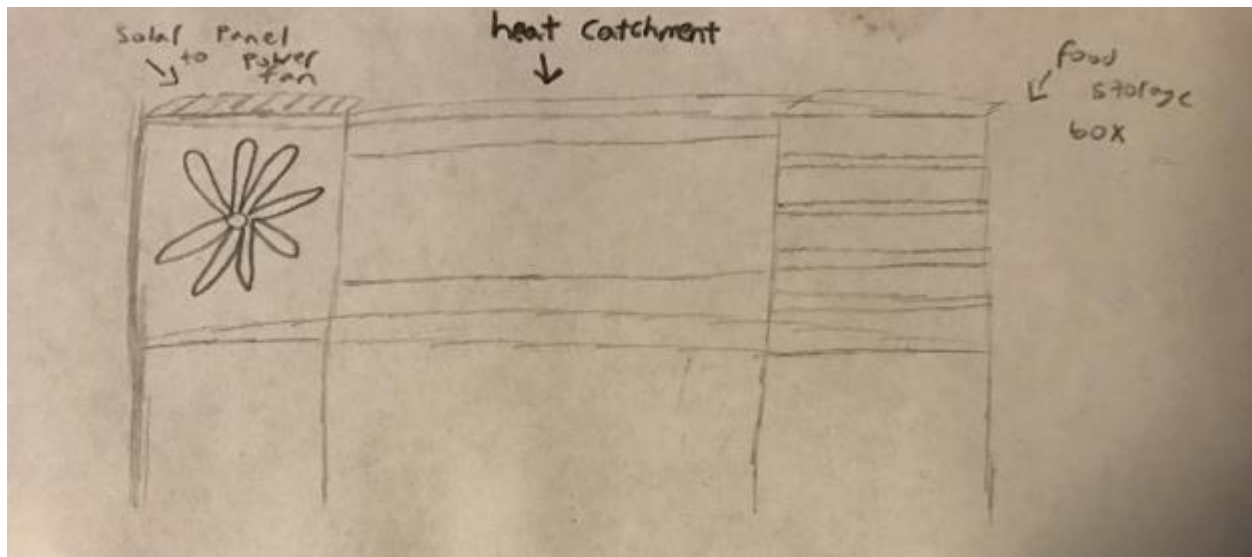


Figure 3-5 Industrial Powerhouse

3.3.5 Vehicle dehydrator

Instead of having a food dehydrator that is in the garden the vehicle dehydrator could be set in the cars surrounding the sanctuary. It is scaled down much smaller to accommodate its position on a car's dashboard. The box would be approximately eighteen inches long, twelve inches wide with a sloping top that is a maximum of ten inches. The backside of the dehydrator, that would be closest to a passenger in the car, would have a hinged door similar to a bread box. This would be convenient for the user when inputting food for dehydration. The sides of the contraption that would mirror one another would have three ventilation holes that are an inch in diameter. To deter insects, the holes would be covered with mesh. To meet the requirement for drying surface area there would be multiple dehydrators in each car that is usually parked outside the sanctuary. This design is one expressed by the client as an alternative to a single large food dehydrator. The sloping side as well as the ventilated sides would be made of transparent material that allows solar radiation to enter into the vehicle through the windshield or the rear window and pass through the dehydrator to create the desired effect. The door and the base could be made out of an opaque material that absorbs heat. A viable option would be plywood for ease of building and abundance of it to be scavenged.



Figure 3-6 Vehicle Dehydrator

3.3.6 Food Dehydrator To-Go

The client proposed a couple desires, one was to have a food dehydrator that is mobile enough to take to the entire unit or a small component, inland where it is significantly warmer. The purpose of this design is to accommodate this desire to take a component to one of the many rivers in the surrounding area of the sanctuary.

The L design is the design by Dennis Scanlin in *How to build a Solar Dehydrator*. Refer to the Literature Review section titled Scanlin Solar Dehydrator for more information on the guide.

The two components of this design are the food compartment and the collector. The collector box is where heat from solar radiation is collected and ventilated throughout the system. This hollow box is open on the end for intake ventilation. The opening lets air flow through as the temperature of the heated collector rises and vents upward through the food compartment. Inside the collector there is dark layered mesh that fits the collector attachment; this helps retain heat to move with the air flow to the foods. The front attachment also has an aluminum foil lining that will reflect solar rays while retaining infrared rays to heat the collector.

The food compartment stores food that is to be dehydrated. The food compartment, which makes up the top half of the design, contains a plywood outer structure, metal food trays, a plywood roof, mesh and a food access door. The metal trays are a source of heat and provide sanitary placement for the food that is drying; the metal used is food safe. The plywood roofing will be necessary protection from the various weather occurrences such as heavy rain and to the

possibility of hail. The mesh would act as a barrier inside the drying chamber; the barriers purpose is to deter bugs and birds from entering the food storage. The stand holds the collector and food compartment together. To easily transport the dehydrator there is a wheel located on the long front attachment; this allows the device to be moved in a similar fashion to a wheelbarrow. The food storage frame structure and door will be painted plywood, by painting the wood the design will reduce warping of the wood and unnecessary air leaks. On the front side of the food storage, the side that is opposite of the door, will have a reflective sheet. The reflective sheet will bounce the sun's rays onto the collector box to heat the mesh.

This To-Go dehydrator is meant to work with a large solar collector seamlessly for when it is at the Sanctuary in Arcata. To have a detachable component that can be used on a weekend camping trip is where this design branches off.

The Sanctuary Dehydrator will be mobile and should have a weight distribution that favors a low center of gravity. The wheels and base will act as a dolly to move throughout the Sanctuary grounds with ease.

The food compartment would have a smaller collector that slides into the larger one while on its base. In addition to a detachable food compartment the collector would be also be detachable in order to store it if not in use.

When detaching the food compartment the distribution of weight would shift from the center of the stand to collector. Designing the collector as detachable would mean that it must come off before the food compartment. Considering campgrounds uneven terrain, the To-Go component would have a smaller stand that is lightweight and adjustable to accommodate this. This design would have two handles on each side and would not exceed a weight that two adults could comfortably carry for a mile.



Figure 3-7 Dehydrator To-Go

3.3.7 Seed Starting Collector

The Seed Starting Collector is an iteration of the L Design. The L design is the design by Dennis Scanlin in *How to build a Solar Dehydrator*. Refer to the Literature Review section titled Scanlin Solar Dehydrator for more information on the guide.

The two components of this design are the food compartment and the collector. The collector box is where heat from solar radiation is collected and ventilated throughout the system. This hollow box is open on the end for intake ventilation. The opening lets air flow through as the temperature of the heated collector rises and vents upward through the food compartment. Inside the collector there is dark layered mesh that fits the collector attachment; this helps retain heat to move with the air flow to the foods. The front attachment also has an aluminum foil lining that will reflect solar rays while retaining infrared rays to heat the collector.

The food compartment stores food that is to be dehydrated. The food compartment, which makes up the top half of the design, contains a plywood outer structure, metal food trays, a plywood roof, mesh and a food access door. The metal trays are a source of heat and provide

sanitary placement for the food that is drying; the metal used is food safe. The plywood roofing will be necessary protection from the various weather occurrences such as heavy rain and to the possibility of hail. The mesh would act as a barrier inside the drying chamber; the barriers purpose is to deter bugs and birds from entering the food storage. The stand holds the collector and food compartment together. To easily transport the dehydrator there is a wheel located on the long front attachment; this allows the device to be moved in a similar fashion to a wheelbarrow. The food storage frame structure and door will be painted plywood, by painting the wood the design will reduce warping of the wood and unnecessary air leaks. On the front side of the food storage, the side that is opposite of the door, will have a reflective sheet. The reflective sheet will bounce the sun's rays onto the collector box to heat the mesh.

In the spring the food dehydrator it is not ideal to use due to Arcata's Climate. In order to utilize the space more effectively, it could double as a seed starting planter in the collector. With the collector that is install shelving to keep pots stationary on the incline and also keep the entire component well ventilated. In order to make the collector accessible to place the planters the top would be hinged.



Figure 3-8 Seed Starting Collector Design

3.3.8 The Vortex Dryer

The Vortex Dryer is a solar food dehydrator which uses a clear vertical glass cylinder that is sealed to dehydrate food. Running vertically through the center of the cylinder is a double-tube, such that the outer tube chamber is about 1.5 inches' diameter, and the inner tube chamber is about 0.75 inches' diameter. The outer tube chamber is filled with water and sealed. The top seal can expand and contract to prevent too much pressure from built up from heating of the water. The inside chamber of this double-tube is hollow to allow air to flow through, providing more surface area for the air to contact the warmed thermal mass of water sealed within. The outside layer of the double-tube is a thin steel layer, which is painted black for absorbing heat. Lining of the inside circumference of the main clear cylinder is a highly reflective coating. The flat donut shape horizontal food-grade mesh "discs" are evenly spaced within the main glass chamber, and provide platforms for sliced fruit or herbs to lay on. The bottom and top of the device is sealed, except for a specially designed air-circulation path to keep air flowing. Inside the circulatory path is a reusable desiccant bag which removes moisture from the flowing air.

The top sealed part of the main glass chamber is a slightly inverted dome-funnel-shaped. Lining inside the top dome-funnel part are short upward angled ridges which direct the rising air within the device to begin rotating like a vortex. The air rotates faster as it reaches the top of the chamber because the volume of air is squeezed into a smaller rotational circumference. At the end of the funnel is a perpendicularly attached flexible tube, horizontally tangent to the circumference of the small part of the dome-funnel, which then directs air flow diagonally to a bottom inlet on the device. The tube has the same diameter as the inner double-tube. This air-flow tube is arranged such that air which is moving clockwise towards the top of the device gets routed to induce a flow of clockwise rotating air from the inlet at the bottom of the device. This keeps the air within the entire device rotating in a consistent direction.

Affixed to, or nearby, but not shading over the device, is a small photovoltaic panel. The panel provides solar-electric conversion to run a tiny electric fan via very small electric wires. The fan is placed just prior to the bottom inlet for the air-flow tube, directing air towards the inlet. This aids in pulling air from the top of the device and keeping it moving.

Directly at the top outlet is a small bimetallic valve (a small U-piece of two different flat metals, attached or bonded to each other, expanding at slightly different rates) such that a small flap opens part way INTO the device. The flap is arranged and operated via the bimetallic valve to partly open when the temperature inside gets too high. The flap allows some of the outside air into the device to even out the temperature, giving it some "fresh air" in other words.

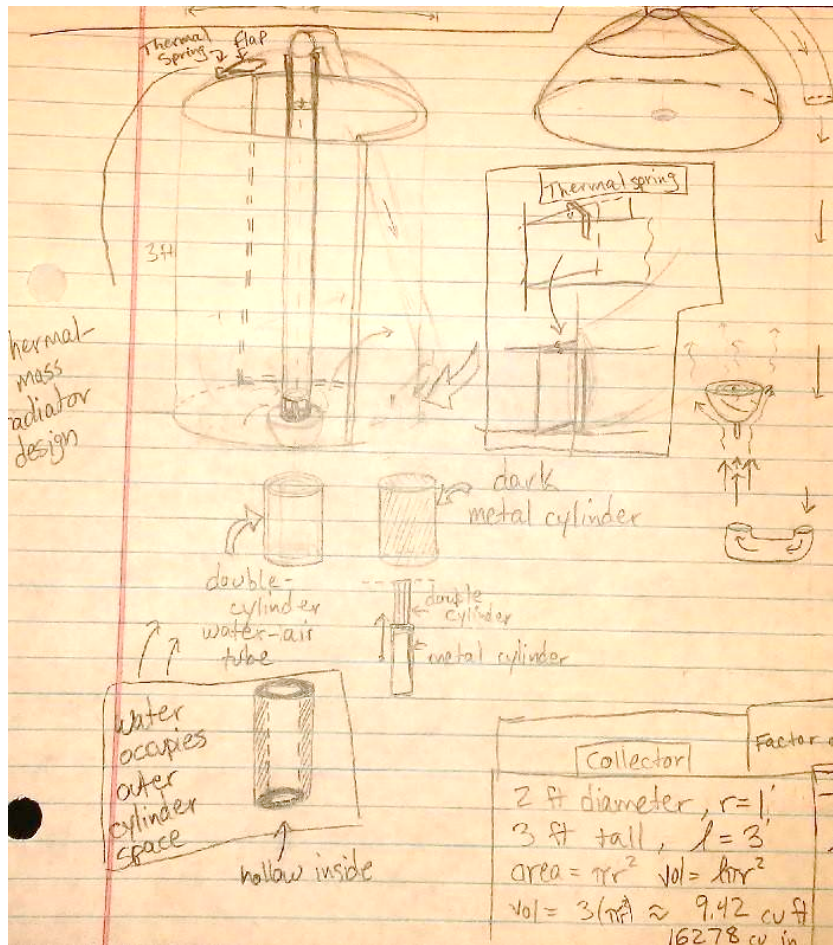


Figure 3-9 Vortex Dryer Design

3.3.9 Vac-u-matic

The Vac-u-matic is a sealed container with a vacuum pump attached. Within the container are platforms on which food is placed and heating elements raise the temperature of the food. The general form is shown in the figure below.

Heating is turned off and a vacuum is applied to the container as a result. The very warm water within the food will react and sublime changing from a liquid to a gas. Water boils at 100C, but that temperature is measured at sea level. The ideal gas law states that pressure and temperature are directly proportional. At higher elevation, the atmospheric pressure is lower than at sea level. When at high elevation, when the pressure is lower, sublimation occurs at a lower temperature. This is the reason why cookbooks have a high-elevation conversion included with some recipes. Food requires less time to cook due to boiling point of water is at a lower temperature than when cooking at sea level. The Vac-u-matic does not boil the water, but evaporates it due to pressure difference.

To any mobile dehydrator that can fit in their car or SUV would be a definite plus. They might be able to dehydrate their fruit right before going on camping trips right in their car, as well as

during their trip. Set up near a car, turn on the car while loading up, and run first the heating element 12V plug, then unplug that and plug in the vacuum-pump and run that.



Figure 3-10 Picture of Vac-u-matic Prototype

4 Decision Process

4.1 Introduction

The decision process outlines which of the designs proposed is chosen for the Sanctuary's solar food dehydrator. The criteria are stated in this section as reference to declare each criterion's importance. Using the Delphi Matrix Method, the team was able to come to a conclusion on picking a final design from the Alternative Solutions. The Delphi Method calculates the ideal solution based on how well an alternative solution meets each criterion.

4.2 Decision Process Involvement

The decision process is broken into consecutive components. Each component of the decision-making process includes client consideration, Professor Lonny Grafman input, and the deliberation between Team BALM, the design team. The different parts of the design process are as follows: Criteria design, criteria ranking, alternative solution ranking, Delphi matrix and final

decision. Group Deliberation took each of the individual conclusions to create a consensus among team members. Outside input are suggestions from the professor. The client consideration is sourced from meetings with Mark Dubrow and Solomon Lowenstein III.

4.3 Criteria Ranking

Listed below are the ratable criterion for each alternative solution that was used in the Delphi Chart:

- **Durability** – The Food Dehydrator must withstand Arcata Climate. Must withstand handling by multiple users, enduring transfers, rain, and sun exposure.
- **Insect Proofing** - The structure must prevent insects and rodents from reaching the food component.
- **Ease of Use** – The food dehydrator needs to be able to be used by an adult with instruction.
- **Aesthetics** - The design must look professional, and well built.
- **Safety** - The design must be able to be operated without the risk of injury.
- **Effectiveness** - The design must reach at least temperature of 86° Fahrenheit, higher being better consistently, drying food within 3-7 days
- **Adaptability** - The structure must be able to be detached and moved to new locations and still be operational.
- **Recycled Materials** - Half of the materials used in the design need to be sourced from donations; found in the local community, or be recycled to make something new.
- **Cost** - The project must be within the four-hundred-dollar budget using the least amount of money possible.
- **Replicability** - The design will be easily replicable, to encourage the community to dehydrate their extra food.
- **Portability** - The food dehydrator must be able to be moved by an adult without endangering them.

Each criterion, within the list of criteria, represents an important segment of the design. Every criterion is assigned a number of its level of importance to the project. The number ranking scales from zero to ten. The importance being greater with a high number and less important with a lower number.

Table 3 Criteria Ranking

Criteria	Ranking (0-10 High)
Durability	10
Safety	10
Recycled Materials	9
Insect Proofing	9
Effectiveness	9
Adaptability	8
Mobility	8
Ease of Use	7
Aesthetics	7
Cost	7

Replication Ability	6
---------------------	---

4.4 Solutions Ranking

The design solutions are described in detail within the Alternative Solutions Section. Every design is focused on a different aspect of the objective set in the Problem Analysis Section. Each solution meets the criteria listed in the previous section Criteria Ranking in unique ways. The alternative solution ranking asserts a score for each criterion. The number ranking scales from zero to fifty. The importance is greater with a high number and less important with a lower number. The following are the design solutions that ranked in the Delphi Matrix.

- The L Design
- The Trapezoidal Turner
- Cube-O-Matic
- Technical Powerhouse
- Vehicle Dehydrator
- Food Dehydrator To-Go
- Seed Starter
- The Vortex Dryer
- Vac-U-Matic

The Delphi Matrix is the calculation tool used to sum the scores of the alternative solutions for each criterion. The criteria weight is described in detail in the previous section titled Criteria Ranking. Each of the alternative solution is ranked by the criteria in the first column of each solution. The second column under the solution is the product of the criterion rank and alternative solution rank. The total at the bottom of the Delphi Matrix is the sum of the second column. The highest total determines the best ranked Alternative Solutions.

Table 4 Delphi Matrix

Criterion	Weight	Alternative Solutions											
		The L Design	Trapezoidal Turner	Cube-O-Matic	Technical Power house	Vehicle Dehydrator	Food Dehy. To-Go	Seed Starter	Vortex Dryer	Vac-U-Matic			
Durability	10	42	40	35	35	35	40	35	30	35			
		420	400	350	350	350	400	350	300	350			
Insect Proofing	9	40	40	35	30	30	45	35	45	40			
		360	360	315	270	270	405	315	405	360			
Ease of Use	7	40	45	35	25	40	40	35	30	30			
		280	315	245	175	280	280	245	210	210			
Aesthetics	7	40	40	25	25	30	35	35	25	25			
		280	280	175	175	210	245	245	175	175			
Safety	10	40	40	37	35	20	35	40	30	35			
		400	400	370	350	200	350	400	300	350			
Effectiveness	9	45	32	35	35	20	45	30	40	45			
		405	288	315	315	180	405	270	360	405			
Adaptability	8	30	35	30	10	30	45	45	15	10			
		240	280	240	80	240	360	360	120	80			
Recycled Materials	9	40	40	35	15	30	35	40	5	25			
		360	360	315	135	270	315	360	45	225			
Cost	7	35	40	25	10	35	35	35	5	30			
		245	280	175	70	245	245	245	35	210			
Replicability	6	40	40	30	15	35	35	30	10	35			
		240	240	180	90	210	210	180	60	210			
Mobility	8	25	45	30	5	45	45	20	40	40			
		200	360	240	40	360	360	160	320	320			
Total		3430	3563	2920	2050	2815	3575	3130	2330	2895			

The results of the Delphi Matrix have the top two solutions within 12 points of each other. The highest ranked solution is the L design and the second, the Trapezoidal Turner. The close result was determined with group deliberation.

4.5 Final Decision

After discussing the results, the final solution determined was Trapezoidal-Turner as the solution. The highest ranked criteria are safety, durability, and effectiveness. In the three highest-ranked criteria, the L design was ranked higher than the Trapezoidal-Turner because of the research that that is described in both the Alternative Solutions section as well as the literature review section. Aesthetics and replicability are ranked with less importance, and are ranked equally between the two designs. Mobility, which is in place of portability is the only criterion that is ranked significantly higher in favor of the Trapezoidal Turner, due its smaller design. Arguably, the Trapezoidal-Turner encapsulates the innovative spirit within the Sanctuary's creativity.

The team meeting on the

5 Final Design

5.1 Introduction

This section outlines the final solution of the Sanctuary's Solar Food Dehydrator. The solution is outlined below in the description of solution section, supported by a computer-generated design and plan of action. Included below are the total costs spent to implement the Solar Food Dehydrator and the estimate of costs for maintenance. Instructions for implementation include an outline to recreate this project, proper maintenance and directions of use.

5.2 Description of Solution

The Solar Food Dehydrator made for the Sanctuary is a trapezoidal food box with a detachable solar collector on a stand. The dimensions for the food box are, base 19"x 21.5", top 19" x 24" the height is 27". The side panels are identical to one another. The front of the box is a framed piece of polycarbonate attached on the angled end of side panels. The 4"x19" space below the frame is for the detachable solar collector. Figure 5-1 AutoCAD of Final Design is the computer-generated model of the project. The racking space available for dehydrating is an area of 41 ft^2 .

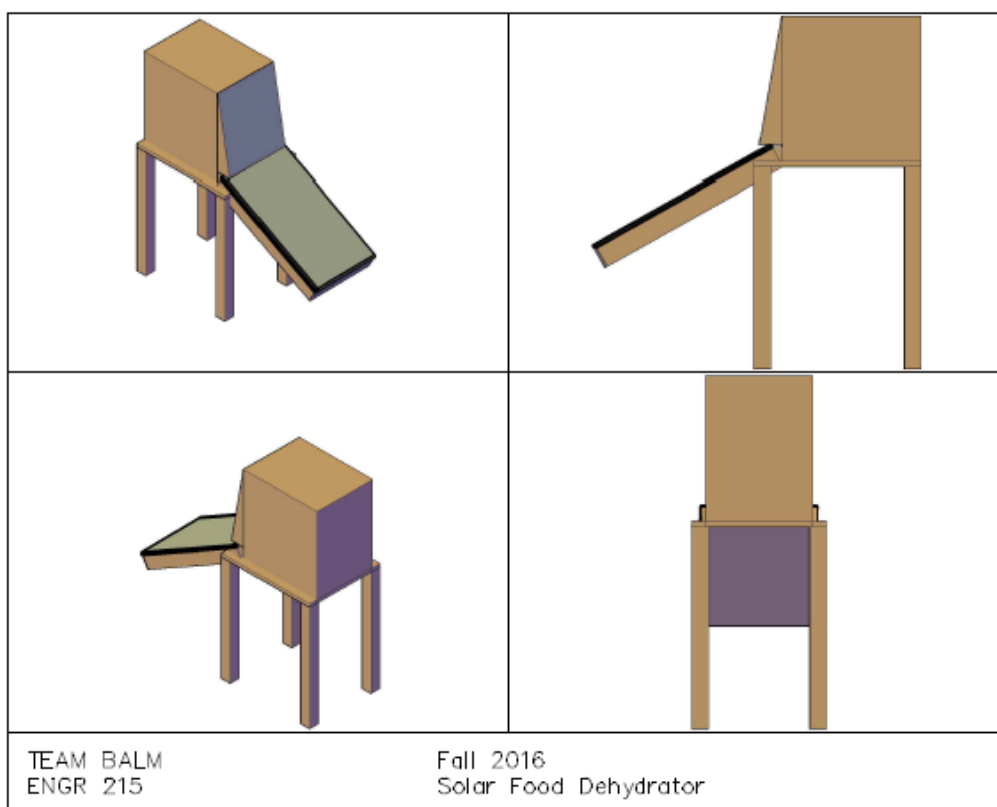


Figure 5-1 AutoCAD of Final Design

5.3 Prototype

Prototyping is a design tool that assists in creating a model of a design. For this project a scale model was designed to give to the Sanctuary reference to the design plans. Figure 5-2 Prototype Design depicts the first iteration of final design. The Trapezoidal Turner and the L design were both utilized to create a model with a solar collector. The prototype was critiqued so that the ventilation exhaust did not protrude in the back of the dehydrator.



Figure 5-2 Prototype Design

5.4 Costs

Cost is measured in two metrics: time and money. Time is reported in hours, money spent is reported as US Currency.

5.4.1 Monetary Cost

Tools used that were borrowed from the Sanctuary, Humboldt State University, Team BALM are denoted as donations. The Materials in Table 5 Materials List that are listed as \$0.00 are donations as well.

Table 5 Materials List

Materials	Quantity	Total Estimated Store Value per Material	Total Cost Spent per Material
Plywood 4',8',.3"	2	\$44.00	\$44.00
Assorted Wood Screws	150	\$16.00	\$0.00
Double pane Corrugated Polycarbonate (4',4')	1	\$54.00	\$0.00
Paint	1	\$8.50	\$8.50
Silicon Filler	1	\$8.00	\$8.00
Mesh Screen	1	\$21.00	\$0.00

Weatherproofing Roll .25",17'	1	\$5.00	\$0.00
Total		\$156.00	\$38.50

5.4.2 Time Cost

The time spent on the Sanctuary's Food Dehydrator is listed in this section. The time spent on research and construction make up the implementation hours. Maintenance hours are the recommended amount of time that is needed to keep the dehydrator functioning.

5.4.2.1 Implementation Hours

The hours included are the collective amount of time each group member of Team BALM invested in the project for implementation. The phases separated the time into categories. Phase one, Define the Problem, is documented in Section One: Problem Formulation. Phase Two, Gather Information, is split into two sections Problem Analysis and Literature Review. Phase Three, Generate Alternative Solutions, is located in Section 4 Alternative Solutions. Phase Four, Analyze and Select a Solution, is Section Five under in the Decision Process. Phase Five, Test and Implement the solution, is located in Section Final Design. The Implementation Hours table are the total amount spent on each phase and construction. The total number of hours invested in the overall project is 366.7 hours by the team members. The pie chart depicts the division of time spent. The time spent is shown in

Figure 5-3 Implementation Hours Pie Chart and in Table 6 Implementation Hours.

Table 6 Implementation Hours

Implementation Section	Hours
Build	103.1
Phase 1	37.3
Phase 2	107.3
Phase 3	39.9
Phase 4	32.8
Phase 5	46.5
Total	366.7

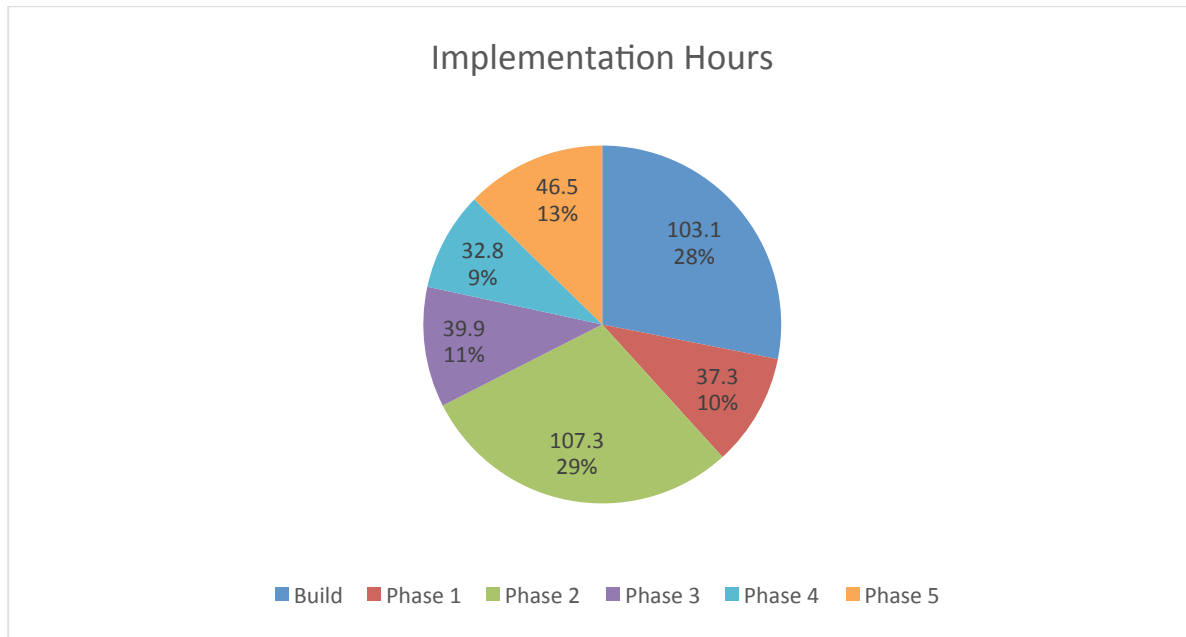


Figure 5-3 Implementation Hours Pie Chart

5.4.2.2 Maintenance Cost

The estimated time of maintenance includes cleaning the dehydrator racks, and wiping out the inside of the food box. This will take an estimated thirty minutes each week that food is placed into the dehydrating box. The other maintenance required will be to replace the weather-stripping throughout the box due to frequent use and outdoor exposure. The project is measured out to be used during farm harvesting seasons where the Sanctuary is given abundant food from local farms and growers.

5.5 Instructions for Implementation and Use of Model

The Instructions for implementation are directions to recreate this model.

The solar food dehydrator reaches temperatures safe for the following food. Refer to Index 1 for dehydration of food at specific temperatures and recommended length of dehydration. Use caution when using this appliance, check the temperature every hour between the hours of sunlight specific to the month in which the food dehydrator is in use. If the temperature exceeds the recommended ranges adjust ventilation by opening vents located on the sides and back of dehydrator. If the temperature is too low restrict ventilation enough to reach the recommended range, be sure to allow for enough ventilation for there to be circulation. Consider time of day, weather and season before attempting to dehydrate food.

1. First measure out the sides (28" tall x 19" wide (on top) x 21 ¼ "wide (bottom) x the slant lengths), back (22" wide x 28" tall), roof (22" wide x 19" long) and bottom (22.2" wide x 21.5" long) out in the wood
2. Second measure out the wood pieces for the heat collector 2 sides: 3.5"x 33" and bottom: 21" x 33"
3. Cut and measure out the Polycarbonate used on front panel (22" x 24 ¾") and heat collector (heat collector plastic 21" wide x 33" length)

4. Cut out framing for front piece (4 pieces 22" long on a 1x1) with .5" indents for the Polycarbonate should have the columns vertical to let in the maximum amount of sun.



Figure 5-4 Food Compartment Front Panel

5. Screw together pieces, and measure out where back piece will fit. Make sure that to seal any exposed screws inside the box



Figure 5-5 Solar Collector Guides

6. Measure out and input the tray holders (1 x 1 wood pieces with a length of 18.5") in the inside box they will be 1" apart with a space of 5.25" from the top of the box



Figure 5-6 Inside View of Solar Dehydrator

7. Screw on door, front piece and put together heat collector
8. Attach door appropriately: put a 19"x 1" x1" across the top and seal with weather stripping



Figure 5-7 Weather proofing and Door fitting

9. Build Trays using food safe screening
10. Make sure to have the heat collector and box sitting on a stand



Figure 5-8 Solar Collector attached to Food Box

11. Create 2"x2" holes on the back door for heat flow to escape
12. Apply wire mesh (or other bug barrier material) onto outside opening of heat collector and on back door vent holes



Figure 5-9 Implemented Mesh in Collector

13. Over 150 wood screws for this project
14. Use weather stripping wherever there is a hole (recommended areas: door framing, heat collector framing inside box)
15. Two side wood planks (attached to outer part of heat collector) 4" x 5" this will be used to secure the heat collector to the dehydrating box

5.6 Results

The Solar Food Dehydrator was not tested for efficiency. The food compartment is safe in terms of structure. The food box is reinforced so it will not capsize. The solar collector is painted black and is able to be attached.



Figure 5-10 Final Design Product

Appendix A

References

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Appendix B

Drying Times for Fruit

Drying Fruits					
Fruit	Preparation	Pretreatment			Drying Times (hours)
		Sulfur (hr.)	Steam (min.)	Syrup (min.)	Electric Dehydrator
Apples	Peel and core then slice into 1/8" thick	3/4	3-5	10	6-12
Apricots	Pit and halve or slice	2	3-4	10	24-36
Bananas	Avoid bruised or overripe bananas. Peel and slice .25" to .38"				8-10
Firm Berries (blueberries, cranberries, currants, gooseberries and huckleberries)	Wash and drain berries, plunge into boiling water for 15-30 seconds to "check" skins. Stop cooking by placing fruit in ice water				24-36
Soft Berries (Boysenberries, Straw berries)	Wash and drain				24-36
Cherries	Stem, wash, drain and pit fully ripe cherries			10 (if sour)	24-36
Citrus Peel	Peels of citrus. Thick skinned navel peel dries faster than thin skinned Valencia. Wash thoroughly. Remove out peel avoid bitter pith				8-12
Figs	Wash or clean whole fruit with damp cloth. Dip into boiling water for 30 seconds or more to check skins then plunge into ice water				6-12
Seedless Grapes	Leave whole. Dip into boiling water for 30 seconds or more to check				12-20

	skins then plunge into ice water.				
Grapes with seeds	Half and remove seeds				12-20
Nectarines and Peaches	When sulfuring, pit and halve. For steam and syrup blanching leave whole then pit and halve. Slice if desired	2-3 (halves) 1 (slice)	8	10	36-48
Pears	Cut in Half and core Peeling is preferred.	5 (halves) 2 (slices))	6 (halves)	10	24-36
Persimmons	Peel and slice using stainless steel knife				12-15
Pineapple	Wash peel and remove rough peel. Slice length wise and remove core.				24-36
Plums / Prunes	Leave whole or if sulfuring halves the fruit				24-36

Note Drying times for sun drying can range from 2 to 6 days depending on temperature and humidity. (Harrison, et al., 2010)