Conceptual Design

Introduction

The purpose of this document is to identify problems that will need to be solved by the design of the greenhouse, in conjunction with the identified design criteria and target specifications. Another goal is to gather many potential solutions to specific problems, and allow each individual group member to present ideas. In the future, these proposed solutions will be chosen, combined, altered, etc. by the group and incorporated into the final design. Essentially, the problem has been broken down into many smaller problems that can be addressed more easily, and every group member has been offered a chance to propose their solutions.

Problem: Power Supply

Some way of providing electricity to the greenhouse will be necessary, as there will potentially be a need to power lights, a fan, a pump and/or a back up heating system. These devices will help to make the greenhouse more user-friendly, as well as keep the plants alive (by keeping the temperature fairly steady).

Solution (Essraa): Solar Panels

The electricity will be provided through solar panels installed on the top of the roof. The tilt of the solar panels will be 20 degrees plus that latitude of the area, which is 53.2 degrees celsius. Therefore, the tilt of the solar panel that will obtain the most amount of sun is geographical south, 73.2 degrees to the horizontal. This value may be too steep for the structure, therefore two solutions can be addressed. The first one is to create a separate structure that will handle that tilt. However, limitations in regards to cost may apply. The second possible solution is in the architecture of the roof. It is possible to increase the incline of the roof, however, not to the degree of 73 celsius because the height of the roof would be too large. Therefore, increasing the degree to be as close to that limit is the optimal solution.

Solution (Kyla): Windmill

An alternative power source to the solar panels would be a small-scale windmill to provide power to the greenhouse. This would provide the system with year round power which would be comparatively unaffected by the snow during the winter, and the client mentioned that there is already a functioning windmill within the community. This solution creates a significant additional cost in materials, as well as the need for one of our group members to learn the necessary skills to construct a functioning windmill that produces electricity.

Problem: Variations in Temperature

Temperature inside the structure must be restricted within a certain domain to ensure proper growth of vegetation.

Solution (Essraa): Heating/Cooling System Programmed Using an Arduino Board

A possible solution for this problem is to program an arduino board, similar to what we did in lab 2. The vegetation housed within the greenhouse will be unable to survive if the temperature reached below 4.4 degrees celsius, and if it is ever higher that 32.2 degrees celsius. However, since the geographical area tends to be cold for most of the year, the major concern is if the temperature drops too low to be safe. Therefore, a heating system is a necessity. Having a fan to circulate warm air within the greenhouse will provide a warmer environment for the plants placed in the lower half of the greenhouse, as warm air is less dense than cool air, which causes it to rise. In addition, a heater must be placed in the greenhouse so that it prevents temperatures from dropping too low.

Solution (Ena): Air Circulation

In order to successfully grow plants inside the greenhouse, all of the air inside the greenhouse must be at a reasonable temperature as per the plants' requirements. Since warmer air tends to rise, a fan could be used in order circulate the air that gets caught inside the rafters. The fan can be installed near the top of one end of the greenhouse pointing downwards in order to help bring the hot air back down towards the plants.
On the other hand, in the summer, it could be helpful to have a vent that enables some heat to escape. This could be as simple as having a window which opens. This window can be screened in order to prevent insects from entering. The window would ideally be placed near the top of the structure since this will let the hottest air out of the greenhouse and provide a circulation of the air as the cooler heat rises.Another solution would be to screen the door to the greenhouse.

Solution (Ece): Material Selection

Our greenhouse will be built with glass walls and a roof with solar panels on it. Clear plastic may be taken into consideration instead of glass for the roof, for the parts without the solar panels. Since the solar radiation passes through the glass structure, it can also trapped by dark soil. Dark soil absorbs almost all the rays where it increases the temperature in the pots and the ones that do not have a pot. In addition, the temperature of the materials are also affected in favor. The material that is going to be used, also acts as an insulator where it prevents the cold air and wind to harm the greenhouse. Plugging the leaks also works where the main principle is reducing the areas that could lose heat like doors, vents etc.
Energy curtains also reduce unwanted heat transfer to the roof where the curtains have to fit tightly to trap warm air in the growing space; otherwise, warm air will rise into the air and reduce its effectiveness.

Solution (Osama): Controlling Microclimates

Each greenhouse has its own microclimate, but within that could be a variety of different microclimates. For instance, cold air sinks if your greenhouse has two levels

and slopes. The lowest path will be a cold sink, and the outer edges of the space will be colder in the winter season, where they lose heat to the outside. By installing circulating fans, you can diminish this problem.

Problem: Snow Build Up

In the area where the greenhouse will be placed permanently, there is frequently a snow build up of several feet throughout the winter months (according to the client). This means there will need to be some system put in place to remove snow and/or minimize snow build up. If snow were to build up on the roof there it would compromise the structural integrity as well as block the plants from receiving sunlight.

Solution (Essraa): Steep Roof

The subsystem concerned with this issue is the architecture of the roof. The roof must be made to be as steep as possible, which will cause snow to slide off of the roof more easily. Furthermore, installing heat cables in the roof is a possible option that will help reduce snow buildup, however, budget restrictions apply.

An issue that is associated with snow buildup is water seeping into the greenhouse due to cracks and holes in the roof. These cracks will also encourage heat to escape the greenhouse, which is detrimental to the health of the vegetation stored within. Therefore a solution for this issue is to coat the roof with roof sealant materials. A challenge will be trying to find some roof sealant materials that are transparent, as we do not want any hindrance to sunlight seeping through the glass (or any other material composing the roof).

Problem: Rodents

According to the client, mice are an issue for the community. We must find a way to stop mice from entering the structure and eating the plants. Mice are able to enter structures by chewing through the foundation (in our case wood).

Solution (Kyla): Tin Mouse Barrier

A potential solution to this issue is to add a mouse barrier to the structure. A mouse barrier could be constructed close to the ground and made of a material that mice are unable to chew through, like many metals. I propose that a foot high sheet of tin be attached to the greenhouse base to act as a mouse barrier. Mice are also able to burrow underground, which is why typical mouse barriers are also dug a foot into the ground. To address this, we should also add a tin barrier to the underside of the floor of the greenhouse. A problem with this solution is it's cost, as there is a limited budget and the cost of tin would be a significant addition.

Solution (Kyla): Elevated Structure

A potential solution to this issue is to elevate the greenhouse so that mice are unable to chew through the base. The greenhouse could be built about a foot off the ground on stilts, so that mice are unable to chew through the foundation. One problem that this solution creates is that the space under the greenhouse would provide an optimal nesting place for other wild animals (according to the client, who said this has been an issue for other elevated structures within the community). Another problem that creates is a loss of structural integrity, due to the relative instability as compared to a structure built directly on the ground, and due to the potential of mice chewing through the wooden stilts and causing a collapse.

Solution (Kyla): No Gaps in the Structure Base

Although not a complete solution, as mice have the ability to chew through most soft materials and create their own holes, an effort should be made to ensure there are no gaps between building materials in the base of the structure. Mice are able to squeeze through even the smallest of holes, and considering our structure will be made up of a series of panels that are connected together, we should keep this in mind. Our connections between wall panels (as well as floor panels) should be sealed tightly to prevent the entry of mice.

Problem 2: Heat Loss from Greenhouse to Environment

Our goal is for the Greenhouse to retain as much heat as possible in order to support the plant life even during the extreme cold temperatures in the winter (as detailed by the client).

Solution (Ena): Insulated Walls and South Facing Windows

A possible solution for this problem is to build one of the walls of the greenhouse out of an insulating material such as wood instead of having a glass wall. Having an insulating material on the north side of the greenhouse may help keep an optimal temperature inside the greenhouse since the windows will be facing southward towards the sun. Having the windows face south will increase the amount of sunlight for the plants to absorb.

It is also possible to build a border that is a couple feet tall along the bottom of the greenhouse with insulating material instead of having a whole wall that is unable to provide sunlight to the plants. Since most of the plants will be hanging and above ground level, there will be no plants in the ground that could potentially be blocked from sunlight with the border. This border can be made of wood, concrete, bricks, among other materials. However, wood is the optimal material since the others are harder to transport.

Solution (Kyla): Installation of a Wooden Floor

Although a floor may not seem completely necessary for a greenhouse, it should be added as a method of preventing heat loss through the ground. A wooden floor would act as an insulator between the greenhouse and the earth. This will be an added cost,

and could prove to be difficult in terms of construction as it must be made up of portable sections that can easily attach together.

Solution (Kyla): Half-height Wooden Walls

A potential solution to this issue is to construct wooden walls that go halfway up our structure. This would provide better insulation from the outside air than typical greenhouse materials (glass panes, clear plastic sheets, plexiglass, etc.). This solution would also help to save material costs, as wood is less expensive than the clear greenhouse materials. A problem that this solution presents us with is that less sunlight will enter the greenhouse due to less clear material being used.

Solution (Kyla): Well Sealed Structure

Another way to minimize heat loss from the greenhouse into the environment is by making the entire structure as airtight as possible. This will prevent heat from escaping through cracks or holes. This solution may be difficult to implement, as our structure will be made up of panels that can be taken apart and put back together (creating many joints in the structure that will need to be sealed).

Problem 3: Portable Structure

The structure will need to be built then taken apart for transport and rebuilt at its permanent location. It must be possible to rebuild the structure within a few hours with only a few workers who may not be completely familiar with the design.

Solution (Kyla): Walls, Roof and Floor made up of Panels

One way to make the structure portable is to make the walls in interlocking 2ft by 6ft sections. This way, the structure can easily be taken apart for transport and put quickly back together. One problem this presents is a method of sealing the joints between panels so that there are no gaps which may create an area of heat loss of a place for mice to enter. This also means a suitable method of attaching panels will need to be found.

Problem 4: Water Tank is Supported

The structure must contain a water tank for storing captured rainwater, large enough to water the plants for an extended period (tank size to be determined by the hydroponics team). This water tank must be properly supported (especially if it is elevated) and stable, so that it does not create a safety hazard.

Solution (Kyla): Interior Support Beams

If the water tank is to be elevated (as the hydroponics team requested), a solution to supporting it is the installation of interior support beams. Wooden support beams could be built horizontally (below the roof, suspended between the walls along the width of the structure), and vertical support beams could be built at the center point of each of the horizontal beams to help support the weight. With this model, the water

tank could be stored in the roof section (similar to an attic but without a floor). This would have the added benefit of keeping the water warmer, as it is known that heat rises. Some problems that this solution presents are relating to portability and the blockage of sunlight, as well as cost. The support beams would need to be re-installed every time the structure is moved, and the water tank being placed within the structure up near the roof would block sunlight coming from the windows from reaching the plants. The additional materials required to construct the support structure would also lead to an elevated cost.

Solution (Kyla): Water Tank at Ground Level

An alternative to elevating the water tank is placing it on the ground. This would eliminate the need for additional interior structures to support its weight, but create the need for a pump so that the water can be made to flow through the hydroponic system. This solution would make the greenhouse much easier to build on site, and would allow the sunlight coming from the roof to reach the plants unhindered. This solution would require using some of the floor space for the water tank instead of plants, and would add the cost of a pump to the hydroponics budget.

Problem: Sturdy Structure

The structure of the greenhouse must be able to withstand all weather including the intense winter storms local to the area.

Solution (Ena): Weather-Proof Materials

First of all, the greenhouse must be built out of sturdy material in order for it to stay functional when there are strong winds or heavy snow. For this reason, the frame should be made a material such as metal or wood, specifically aluminium, cedar, or redwood. This is because aluminium does not rust and cedar as well as redwood do not rot easily. For the windows of the greenhouse, a solid material can be used such as polycarbonate instead of sheets of plastic. This will prevent the windows from tearing due to strong winds and will lessen the risk of a collapsed roof due to snow. In addition, it is not uncommon for people to build a windbreak such as a wooden wall near the greenhouse. Another option would be to place the greenhouse near the edge of the forest which can act as a barrier against winds.

Problem: Sufficient Sunlight

In order to support healthy vegetation within the greenhouse, it is important that enough sunlight is allowed into the structure.

Solution (Lemuel): Translucent Materials

The greenhouse, must be built to receive enough sunlight which is beneficial for plant growth and development of produce. Therefore, the use of translucent material like solexx xp panel, ground glass etc on the walls of the greenhouse should be encouraged because it allows the passage of sunlight into the greenhouse.

Solution (Lemuel): Orientation of the Structure

Placement of the greenhouse should be north due east and south due west because the plants in the greenhouse, will be entitled to more solar energy when the sun rises from the north and sets on the south, also, research shows that 20% the solar energy is being emitted by the sun from those coordinates even on a cloudy day. While the remaining 80% is when the sun is at its peak. The presence of sunlight will prevent malnutrition in plants and promote food production, which is the main purpose for greenhouses.

Problem: User-friendly

According to the client, many of the community members who will be interacting with the final product are inexperienced when it comes to managing a greenhouse. Thus, it should be easy to operate and maintain for even the most inexperienced of users.

Solution (Lemuel) :

The most important part of engineering is solving problems using ideas and the needed material and not creating more problems to clients or employers.
The greenhouse should be developed and designed in a way that the clients with low or no expertise would be able to operate the greenhouse. Also if the greenhouse is built to be complex, operation manuals should be provided to people who are not familiar with how the design of the greenhouse operates. Also, the engineers should be able to explain how the greenhouse operates, clearly and effectively. By doing this, the durability of the greenhouse is increased.

Solution (Ece): Easy Maintenance in Case of Damage

Local people of the place we are going to construct the house in do not have any experience with building or maintaining a greenhouse. The structure should not be complicated, instead it should satisfy the needs and should easily be built. Materials such as glass should be in a structure where you can all take them apart at the same time and build if necessary afterwards. The one thing that really should be taken into account is that the junction points of the glasses must be very resistant for carrying around. If a damage occurs, it can cause the glasses to lose their insulating functions.

Problem: Inhospitable Landscape

In the community where the greenhouse will be placed, there is a lack of produce for many months of the year due to the weather conditions and soil. The Community is in need of the greenhouse to be their sole provider of fresh crops throughout much of the year.

Solution (Ece):

Foods that can grow in that isolated area should be planted since they do not have a variety of food growing due to the weather conditions. The soil is not sufficient to plant lots of corps. Food with high nutrients should be planted. In addition tobacco is necessary for planting due to the cultural needs. However, despite the variety of the food, the amount should overcome feeding 50 people per greenhouse.

Conclusion

Throughout this document, a total of nine problems were outlined that our design must address. At least one solution was proposed for each problem, and for many problems there were multiple solutions proposed. During the remainder of the design process, we will be able to refer to these concise descriptions of problems and their corresponding proposed solutions. This will help us to finalize a design that addresses all the important problems and includes the input and creativity of every group member.