

Engineering Architecture Preliminary Engineering Technical Memorandum

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1.0 Abstract

This report outlines the design aspects that have been decided based on research conducted throughout the Fall 2015 semester by the architecture team. The decided design is a quonset shape, a half cylinder, that has dimensions approximately 30'x100'. A prefabricated greenhouse will be bought and used as the bones, however if needed, modifications will be made to improve efficiency and design. The walls of the structure will be triple-wall polycarbonate as the increase in the polycarbonate walls will increase the energy efficiency. The placement and orientation of the structure will be determined in the Spring 2016 semester based on analysis of the terrain of the site. The structure will be made sturdy enough to withstand winds of 103 mph for up to 3 minutes. Based on this, the four main factors that will be the focus on the design include orientation, insulation, glass, and mass.

2.0 Objective

REAP strives to help individuals who have had long-term unemployment in civil society including veterans, former inmates, and homeless individuals. Food security is also a huge issue in today's world. This project seeks to provide employment for individuals who will work in greenhouse as well as provide a source of fresh food for local families, directly corresponding to REAP's mission.

The objective of the architecture team for this first phase of the project is to decide the design of the greenhouse and who it will be purchased from (the greenhouse will be prefabricated). A preliminary cost estimate for the construction of the greenhouse will be completed and the various building codes that will be required for construction will be addressed.

3.0 Research

It is recommended that a Quonset-style greenhouse be used for this project. The main advantage of the Quonset greenhouse is that its design allows for the most solar radiation to be absorbed compared to other greenhouses (1). This is useful in areas where temperatures get low and plants don't thrive as well. The website Farmtek.com has a variety of different styles of prefabricated greenhouses for sale. One in particular has almost the exact measurements that were specified by the community partner. It is a 30' x 96' greenhouse with added height. This will be helpful for the tower-style aeroponics system in which the crops will be grown on tall towers as opposed to rows. It is suggested that this be the greenhouse that is used (2).

4.0 Data Collection

In November 2015, the EPICS team did a site visit to the Navajo Nation in Winslow, AZ. From this visit, many questions regarding the land and greenhouse structure were answered. Surveying equipment was brought up to collect data about coordinates of geographical features and other obstacles that will affect the location and orientation of the greenhouse. This data will be analyzed using 3D modeling software in the coming semester. Image 1 below shows an overview of where the greenhouse will be placed. It can be seen that there is a natural incline in the terrain and power lines running through the center of the area. These will be taken into consideration when deciding the

location. It is planned to use the natural incline to aid in water disbursement and rain collection for the greenhouse.



Image 1: Overview of site

Information gathered from Joe Castion, a solar greenhouse design professional the team met during the site visit, has been taken into consideration when deciding many details of the construction and design of the greenhouse.

Orientation, insulation, glass, and mass are the four concerns the team should be focused on in the design.

1- Orientation

To obtain maximum sun exposure during all seasons, the greenhouse will be oriented with the long edge running east to west. Based on research, the greenhouse should have a minimum of 6 hours of sun absorption in the day for best results. If it is determined from analysis of the terrain that it is not possible to orient the greenhouse this way, the next best option will be to collect light during the morning to aid in photosynthesis all day. (3) Exact geographical coordinates of the site and angles of the sun when it is at a maximum and minimum in the sky throughout the year will be used in determining optimum orientation. This will be completed in the coming semester when the terrain is analyzed and a location determined.

2- Insulation

During the site visit, Joe Castion suggested using triple wall polycarbonate as the walls of the greenhouse. In a polycarbonate, the polymer units are linked through carbonate groups, which include molding materials. This forms a rigid, plastic material that is a common material for greenhouse walls (4). When increasing the layers of the polycarbonate material, the energy efficiency increases due to the number of surfaces heat must travel between before escaping. This prevents the interior from getting cold and aids in photosynthesis in the plants. A limiting factor that will prevent

the team from using triple wall polycarbonate is the cost; increasing the walls, increases the cost. Details on the cost will be in the cost estimate below.

3- Glass

Glass will not be used in the design of the greenhouse as triple-wall polycarbonate will be used instead. This material was suggested by an engineer that has experience with greenhouses specifically.

4- Mass

The overall mass of the greenhouse must be sturdy enough to withstand 103 mph winds for up to 3 minutes. Because of this, solar panels being placed on the roof will not be done. In choosing the material, the triple-wall polycarbonate will provide strength and rigidity against high winds and other weather challenges. Due to the training aspect of this initial greenhouse, any additional pieces must be light enough to be taken down and rebuilt in a respectable time frame.

Security for the greenhouse will need to be protected against humans and animals (i.e. rodents). This means all doors and windows will need to have locks and wire mesh will be implemented in the design to prevent any creatures from entering. There is no specific height designated in the design, however a 30' x 100' requirement is planned.

As this greenhouse will be constructed on land that is owned by the Navajo Nation, building permits mandated by the government will not be needed. This will reduce the cost of the architecture greatly.

5.0 Cost Estimate

Description	Quantity	Cost
Series 500 Extra-Tall Greenhouse - 30'W x 96'L Double Layer w/Drop-Down Sides	1	\$10,195.00
Polycarbonate panels	54	\$9,688.68
Total cost		\$19,883.68

6.0 Conclusions

The objective of this project in the past semester has been to decide the design of the structure, the materials, details that will need to be implemented to make it secure, and become familiar with the terrain to prepare for next semester. Overall, a quonset style has been decided as it will be structurally sound and provide optimum sun exposure for the crops. The walls will be made out of

triple-wall polycarbonate as it will provide the best energy efficiency as it will stay well insulated as heat will not leave the interior. The orientation and exact placement of the greenhouse will be decided based on analysis of the data collected when the land was surveyed. This analysis will be completed in the Spring of 2016 using 3D modeling technology. Research will be conducted to determine sun angles throughout the year for when the sun is at a minimum and maximum in the sky. If it is determined that the terrain will not accommodate an orientation for maximum sun intake, the roof of the structure may be adjusted. For the design aspects, the community partner has suggested shelving units within the structure along the walls for storage and placement of more crops. Doors will be placed on the ends of the structure for easy access. The doors will be equipped with locks for security and the perimeter along the exterior of the structure will have wire mesh to prevent animals from entering and destroying/eating the produce. The entire structure must be disassembled and reconstructed within a reasonable time frame for the use of training. This means the design needs to be simple yet effective.

7.0 References

- (1) Simplified Building. Quonset Style Greenhouse Plans. <http://www.simplifiedbuilding.com/projects/greenhouse-frame/> (accessed Dec 19, 2015)
- (2) FarmTek. Series 500 Extra-Tall Greenhouses - 30'W. http://www.farmtek.com/farm/supplies/prod1;ft_greenhouses-ft_professional_greenhouses-ft_500_series_extra_tall_greenhouse;pg_50030gh.html (accessed Dec 20, 2015)
- (3) Garden & Greenhouse. The Sunny Side of Life- Placement of a Greenhouse. <http://gardenandgreenhouse.net/index.php/past-issues-mainmenu-18/13-2007-gg/may-2007/60-the-sunny-side-of-life> (accessed Dec 20, 2015)
- (4) Mother Earth News. Choosing a Greenhouse. <http://www.motherearthnews.com/organic-gardening/choosing-a-greenhouse-zmaz03fmzgoe.aspx> (accessed Dec 20, 2015)