LAKOTA Greenhouse Transition Document For Fall 2018

Purdue Team Members:

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Brief Description of the Project:

The Lakota EPICS team is a partnership between three universities (Oglala Lakota College, South Dakota School of Mines, and Purdue University) with the goal of designing and building an innovative multipurpose learning center and greenhouse for the Lakota people of the Pine Ridge Reservation. This project offers a challenging experience, working together to create a self-sustaining facility that will help to promote the cultural traditions of the Lakota people.

Our project involves a variety of exciting subtopics that involve expertise from different disciplines:

- Designing a Solar Powered Energy System for the greenhouse
- Designing an irrigation system for the plants in the greenhouse
- Computer design using software programs to model both structures
- Creating a system of sensors requiring electrical and computer knowledge
- Matlab coding to model energy consumption
- Designing a center that will strengthen the Lakota Nation's culture
- Communicating directly with the Lakota people and learn more about their culture
- Using Construction techniques to properly design two developed structures

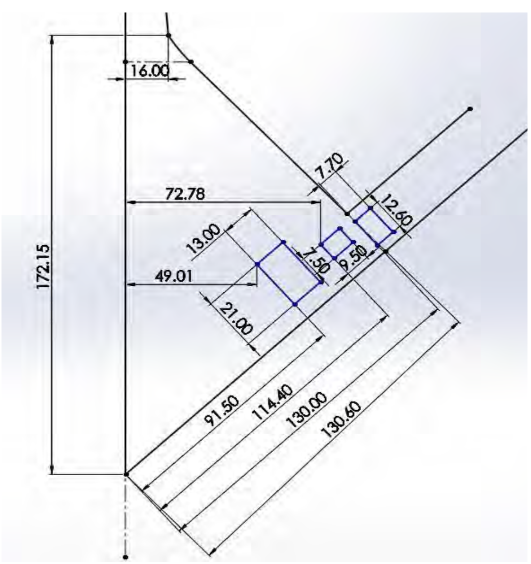
1 Table of Contents

2 Cultural Importance of the Greenhouse

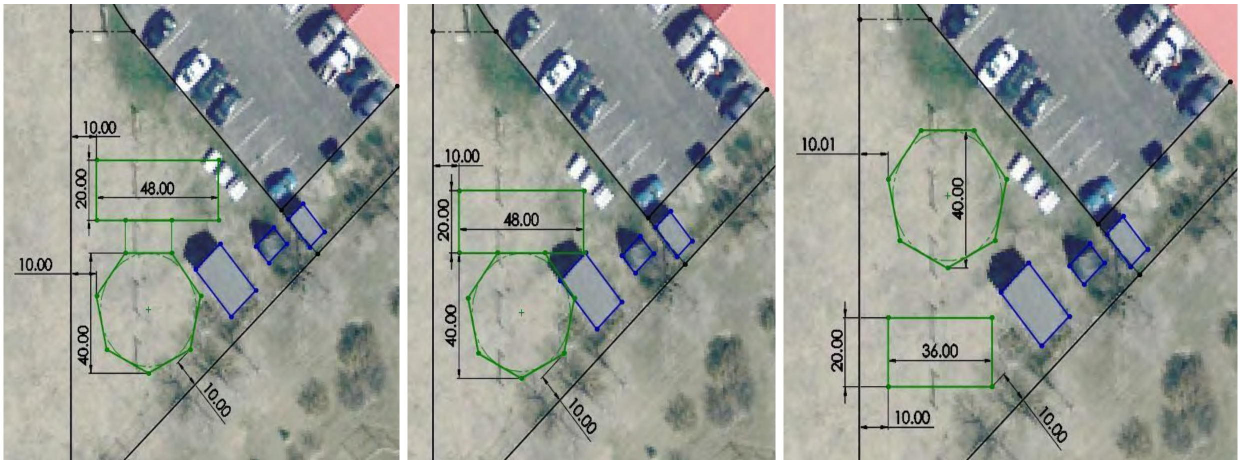
From our South Dakota trip we gained a better understanding to what OLC wanted from this greenhouse. After hearing OLC discuss their culture and the greenhouses important they stated that rather than focussing on the actual food production aspect they wanted the greenhouse to be more of a learning classroom environment where they could teach the children of their community about the Lakota ways (things like traditions foods that they grew). However, the Food Sovereignty initiative in Pine Ridge is still being addressed by this facility. Instead of growing as many plants as possible this greenhouse will be an educational precedent for the development of agricultural knowledge and future facilities. The greenhouse is being designed internally to accommodate a wide range of cultural plants that are still being narrowed down and determined.

3 Description of Location

This is a birds eye view of the OLC Campus in Rapid City South Dakota. The black line represents the property line. The greenhouse/learning center will be built in the triangular area in the bottom left of the property.



This picture shows a blown up view of the triangular space in the bottom left of the top image with its dimensions. The blue boxes are sheds that are currently on the property. They can be removed at a later date if more space is required for the greenhouse/learning center.



These are footprints created by Samuel at SDSMT that show possible orientations for the greenhouse structure (rectangle) and the learning center (7 sided)

4 Where the Project Currently Stands

We are currently in the conceptual design and nearing detailed design. We have completed all the rudimentary research and will now continue on with the specifics of the project. We have done research on the insulation, solar panels, energy consumption and several other topics. We have also created an algorithm that calculates the wattage and energy duration with respect to the part of year and time.

5 Suggestions for Fall 2018

5a Communication and Lab Meetings

This semester PIGS has helped to inform our project partners and advisors as to what we have been working on during the week as well as inform us as to what our project partners have been working on. Since the bee-box team at Purdue has been dissolved this semester, we have not heard from Bo or anyone else about the the progress on the bee box progress since mid-semester design review. Instead the calls with OLC and SDSMT have been focused solely on the greenhouse, allowing us to make much more progress. Friday lab meetings are usually occupied mainly by the joint call with our partners and this allows us to stay in touch with all aspects of the the greenhouse.

5b What Needs to be Done to Complete the Project

- Finalizing brainstorming process and converge these ideas into one
- Final design for the greenhouse (locked in place) with final list of specifications
    - Should be approved by OLC and SDSMT partners
- List of materials needed to construct this design

- After the design for the greenhouse has been completed, or at some other determined time, begin working on the learning center portion of the project as well

5c First Four Weeks of Next Semester

The first four weeks of the semester are important to determine what the goal of this project is and to determine where the new team can pick up from last semester. The following is a proposal of what could be done in the first four weeks of the next semester.

Week 1: establish contact with partners and find out what OLC and SDSMT have completed over the summer, (there have been discussions in lab that there will be work done over the summer on site by students taking summer courses or maybe through a summer program) make introductions so everyone is aware of whose on the team between all the schools, and establish a way to communicate between the team and all project partners quickly.

Week 2: analyze previous work up to the lab meeting on friday and then, with a knowledge of what this project is and where we currently are, develop team roles, this semester our team roles were almost non-existent, and in order to maximize team efficiency they should be developed quickly.

Week 3: after team members have an understanding of the project, the team can begin to analyze what needs to be researched and develop their knowledge in specific aspects of the greenhouse.

Week 4: the previous weeks research will help team members come up with conceptual designs to present to the project partners on Friday so that the the project can potentially move out of the conceptual design phase, If one general design is chosen, the team will be able to dynamically switch between detailed design and specification development in order to narrow down the scope of the project and make progress.

6 South Dakota Trip

4 teams members visited South Dakota in the beginning of November 2017 and met up with our partners at OLC and Mines at OLC's rapid city campus. There meetings were held to talk about Lakota culture as well as the future direction for the greenhouse. On top of that the group visited OLC's research campus on the reservation to see what kinds of topics their students study. The Thunder Valley site on the reservation was also visited. There the group got to learn about the development of a new community being built for the Lakota people as a place to live and be self sufficient. That is where the group saw an under construction geothermal greenhouse as well as a chicken pen and eco friendly houses.

Thunder Valley meeting site (Informational Video)
Ecosystem of Opportunity: A Short Thunder Valley CDC Documentary

Geothermal Greenhouse

- 16 tubes 8ft in the ground pull heat from the ground into the greenhouse
- Survived hail and 70 mph winds that didn't even damage the structure

- Polycarbonate sheeting covers the top of the greenhouse
- Possibly grow dwarf citrus trees
- Corrugated tubes help cool the system with a fan
- Based on Russ Finch Greenhouse in the snow: http://www.npr.org/sections/thesalt/2016/02/11/466050766/citrus-in-the-snow-geothermal-greenhouses-grow-local-produce-in-winter


Yellow lines are ground level

Questions Answered:

- We should be working on an overall concept for the greenhouse
- Work on possible fundraising/determining how much money we have available to us
- What plants they want us to grow
    - Tomatoes, lettuce, shrubs, local medicinal herbs, and other local plants
- They seem to want to be using polycarbonate
- Figure out what OLC wants to do with the space within the greenhouse
- Look into the application of Plant Tower Growing

8 Solar Panels

Types of solar panels:

Monocrystalline:

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

Polycrystalline:
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

Types of Batteries:

Sealed lead acid battery-
[illegible]

Flood lead acid battery-
[illegible]
[illegible]
[illegible]

Lithium ion battery-
[illegible]

Types of Inverters:

String inverters-
[illegible]
[illegible]
[illegible]
[illegible]

Micro inverters-
[illegible]
[illegible]
[illegible]

Placement of Solar Panels:

Ground-

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

Roof-

[illegible]
[illegible]

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9 Energy Usage Algorithm

An algorithm has been developed in MATLAB that receives user inputs (wattage of general lighting, wattage of grow lights, wattage of ventilation system, wattage of irrigation system, square footage of solar panels, angle of panels from horizontal, efficiency of panels) and returns several printed outputs as well as several graphical outputs that can be used to determine how much electrical energy the greenhouse would consume/generate every day over the course of the year, as well as a cumulative measurement for the yearly electrical energy consumption/generation. The algorithm is available for download on the Freedcamp website that we have been using to coordinate efforts as a team, and Nick Demsher can answer any questions about the algorithm if troubleshooting is necessary. If there is a computer science/computer engineering major involved in the Fall of 2018, some work could be done on the algorithm. For example, the algorithm in its current iteration is written as one long script. I would recommend breaking the script up into several functions controlled from a main function, partially from an aesthetic perspective, but also as a means to debug any misbehaving components of the algorithm. It could also be helpful to re-do certain lines of code and re-comment them to make the algorithm easier to understand for those who would be using the algorithm but do not have much coding experience. One more suggested alteration would be to allow for user-inputs to be scanned in at the beginning of execution rather than hard-coded as constants prior to execution. Again, if any of this has been worded poorly or there is any other form of confusion regarding this algorithm, Nick Demsher is available to help.

10 Work on Insulation

The climate of the environment around the greenhouse can be very harsh in the summer and especially the winter, in order to protect the growth of the plants and reduce the cost of temperature regulating systems the greenhouse should be well insulated.
To tackle this issue, there was research last semester on insulation techniques and types. The two main products that were researched last semester was Insulated Concrete Forms and Closed Cell Spray Foam.

Spray Foam:
After looking into spray foams, we learned that there were two different types that others can be categorized into, open cell and closed cell. Closed cell is more expensive and chemically intense but it has more protection against the elements and has a higher insulation factor. It seems like it will most likely be the one to choose for this greenhouse project because of how little of it we might use.

- Closed cell foam
  - has a density of about 2 lb. per cubic foot and an R-value of 6 to 6.5 per inch
  - Keeps air and moisture out, good performance during severe weather
  - More expensive and environmentally unfriendly
- Open cell foam
  - has a density of about 0.5 lb. per cubic foot and an R-value of 3.5 or 3.6 per inch.
  - less environmentally harmful choice (however both are not considered as environmentally friendly)
  - Struggles with moisture

Insulated Concrete Forms (ICF’s):

- ICF’s- Insulated Concrete Forms
  - A layer of concrete sandwiched between two layers of foam insulation, usually EPS (expanded polystyrene), these two panels are connected to each other with plastic connectors or steel ties that hold the foam layers in place. The space in the middle is filled with concrete.
  - Oswald’s Vineyard- used ICF’s then covered with EIFS (exterior insulation finishing system)

(Oswald Vineyard used ICF knee-walls)

11 Heating

11a Overview

This section summarizes possible methods for heating the greenhouse. More details are available in the project work folder on Freedcamp.

Research done by Samuel Ryckman at Mines.

11b Heat Loss

Assuming that

- the greenhouse is 40’x80’,
- uses materials similar to the ones listed in this document,
- has an outside temperature of -15°F,
- Has an inside temperature regulated at 50°F,

the heat lost during a day would be:

Q = 195 kWh/day

If we were to add a thermal blanket over the transparent portion of the greenhouse, this would reduce to:

$$Q = 102 \text{ kWh/day}$$

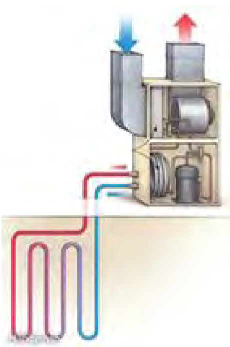
11c Heating Options

Electric Heater

Converts electricity directly to heat.

- + Electric to heat conversion is 100% efficient.
- + These heaters are cheap compared to other options.
- - Unfortunately, they use a lot of electricity.

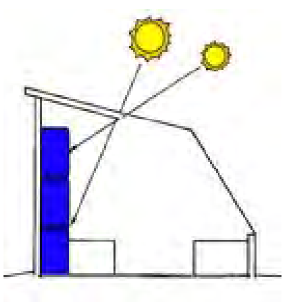
Geothermal Heat Pump



Transfers heat from the ground to the building or vice versa.

- + Efficiency (ratio of electricity input to heat output) is greater than 100% (360% avg).
- + Can be used for cooling as well as heating.
- - Expensive compared to other options.
- - Even though it is more efficient, it still uses electricity.

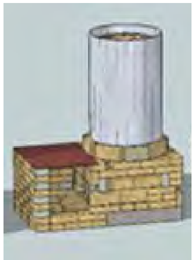
Thermal Mass



Stores excess heat and releases it when temperature is lower.

- + Requires no electricity.
- + Relatively cheap.
- - Takes a large amount of space.
- - The amount of heat produced would depend on the amount of sun received.

Rocket Mass Heater

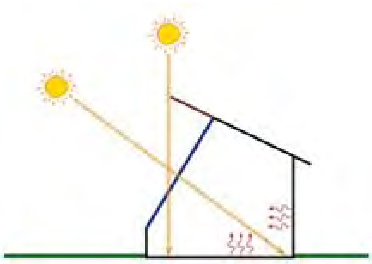


Extremely efficient method of burning fuel, storing the heat, and releasing it as needed.

- + Requires no electricity.
- + More efficient than wood burning stoves and maintains heat after burn is completed.
- + Relatively Cheap
- - Would have to manually operate.

Solar Heating

Typical method of heating a greenhouse. Sunlight enters, and the heat is trapped inside.



- + Requires no electricity.
- + Also provides light for plants.
- - Materials for transparent roofs are expensive.
- - Large amounts of heat would be lost through material.

11d Summary

The below table summarizes the details for each of the heating options.

Type of Heating	Approximate Cost	Average Heat Produced (Watts)	Max Heat Produced Per Day (kWh/day)	Average Power Needed (Watts)
Electric Heater	$113	5,600	134	5,600
Geothermal	$8,000	5,860	141	1,670
Thermal Mass	$730	3,510	84.3	0
Rocket Mass Heater	$700	727	17.4	0
Solar Heating	$3,240	3,510	84.3	0