LAKOTA Spring Design Review

April 20th, 2018

SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY

EPICS

This work is the combined effort by the students from Purdue, SDSMT and OLC.

Partnering Universities

OGLALA LAKOTA COLLEGE

SOUTH DAKOTA
M
SCHOOL OF MINES & TECHNOLOGY

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Team Members: Purdue

Jonathan Damon
Project Manager
First Year Engineering

Shamya Dey
First Year
Engineering

Jacob Lundgren
First Year
Engineering

Nick Demsher
Electrical
Engineering
Junior

Alyssa Tamvakis
First Year
Engineering

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Team Members: SD School of Mines

Samuel Ryckman
2nd year
Mechanical Engineer
Computer Science

Erika Weeks
2nd year
Chemical Engineer

Caleb Ehrisman
1st year
Mechanical Engineer

Jason Phillips
Civil and Environmental Engineering

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Team Members: Oglala Lakota College

Amanda Ruiz
Project Manager
Earth Science
Lakota Botany
Senior

LaShell Bagola
Earth Science
Lakota Botany
Junior

Rick Gerlach
Lakota Studies
Junior

Madison Phelps
1st year Pre-Engineering
AA in Tribal Law
Junior

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Community Partner Information

Food Desert: An area where either a substantial number or share of residents has low access to a supermarket or large grocery store (USDA)

- 80% limited access to grocery stores
- 95% of food from off-reservation sources
- Food cost 10% higher

EPICS PURDUE

Social Context & The Trip to Pine Ridge

Thunder Valley 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

Thunder Valley Greenhouse, South Dakota

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Our Project OLC/Mines

- **Design and build a cultural education greenhouse that will be home to a diversity of traditional cultural plants used as food and medicines**

- **Design a learning center to serve as a cultural hub station to strengthen STEM education, Research, Lakota culture, Lakota Language, Science, IT and Engineering**

Stakeholders

Number	*Stakeholder*
1	Residents of the Oglala Sioux Tribe (Pine Ridge Reservation)
2	Students at Oglala Lakota College (Nine OLC Centers)
3	Members of the Lakota Nation located in Rapid City, South Dakota.

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User Needs

Number	*User need*	*Stakeholder*
1	Learning center 7 sided	The tribes that make up OLC.
2	Door facing east	The tribes that make up OLC.
3	Cultural plants (will be picked by them)	The tribes that make up OLC.
4	Seperate room for mushrooms	The tribes that make up OLC.
5	No cement floor	The tribes that make up OLC.
6	Try to make as energy efficient as possible	The tribes that make up OLC.
7	Try to involve the community as much as possible	The tribes that make up OLC.

Phase: Specification Development

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Specifications

Project	Greenhouse		
Number	*User need*	*Specification number*	*Specification*
1	Fit the cultural wants		
		1.1 1.2 1.3 1.4 1.5	7 sided learning center Door facing east Cultural plants (picked out by the Lakota people) Seperate room for mushrooms No cement floor

Specifications

Project	**Greenhouse**		
Number	*User need*	*Specification number*	*Specification*
2	Greenhouse specifications		
		2.1	20 by 48 ft
		2.2	As energy efficient as possible
		2.3	Use solar panels
		2.4	Do not use electricity for primary source of heating
		2.5	Have an irrigation system that conserves water
		2.6	Window roof

Specifications

Project	Greenhouse		
Number	*User need*	*Specification number*	*Specification*
3	Learning Center		
		3.1 3.2 3.3	7 sided Must have enough space for a classroom of people Door must be facing east

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Specifications

Project	**Greenhouse**		
Number	*User need*	*Specification number*	*Specification*
4	Both structures must withstand the weather		
		4.1	Large hail (1.50-1.75”) 70 mph winds 100+ f degree weather <0 f degree weather snow pile up

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Energy Usage (OLC/Mines)

Energy Needs

Item	Average While Running (Watts)	Energy Used Per Day (kWh/day)
Lights	340	2.04
Water Pump	200	0.2
Ventilation/cooling	1,490	17.9
Heating	0	0
	Total:	**20.1**

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Heating (OLC/Mines)

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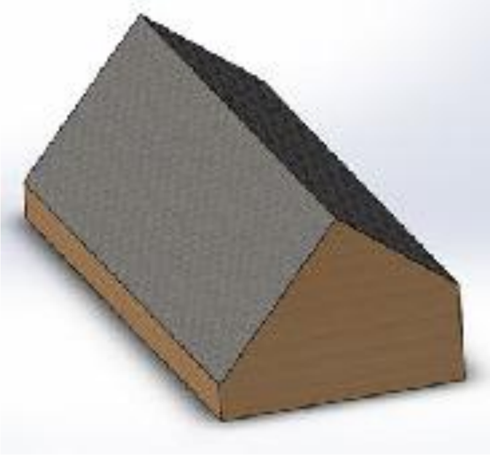
Heat Loss

Worst Case

- Loss through non-transparent: *57.9 kWh/day*
- Loss through transparent: *137 kWh/day*

Total heat lost = **195 kWh/day**



Thermal Blanket

- Loss through transparent: *44.0 kWh/day*

Total heat lost = **102 kWh/day**

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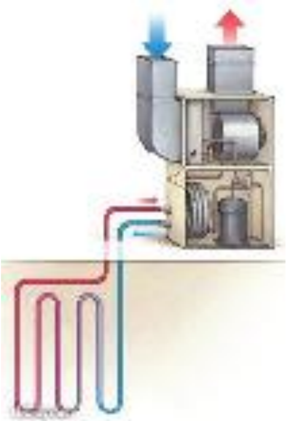
Different types of heating

Electric Heater

+ 100% efficient
+ Cheap
- Uses a lot of electricity



Geothermal Heat Pump

+ > 100% efficient (360% avg)
+ Can also be used for cooling
- Expensive
- Still uses electricity

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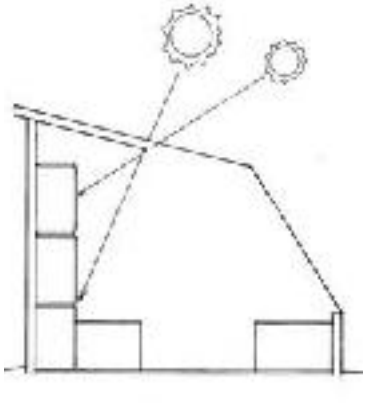
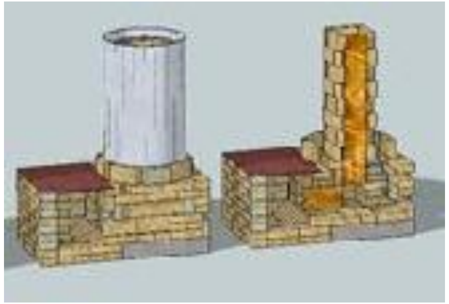
Different types of heating



Thermal Mass

+ Requires no electricity
+ Relatively Cheap
- Takes a large amount of space
- Limited Heat Production

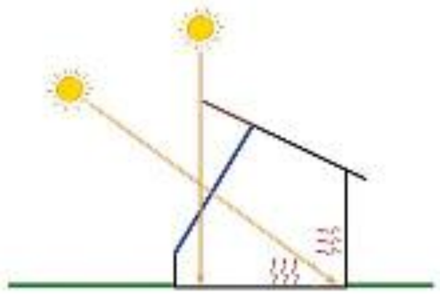


Rocket Mass Heater

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

EPICS

Different types of heating



Solar Heating

+ Requires no electricity
+ Also give light to plants
- Materials are expensive
- Large amounts of heat lost through material

Heating Summary

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

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Ventilation

JavaScript Greenhouse Exhaust Fan CFM Calculator		
Do This	**JavaScript Calculator**	**Example**
Measure the **height** of your greenhouse.	13	You measured a floor to ceiling height of 8 feet.
Determine the **width** of your greenhouse.	20	You measured the width at 8 feet
Find out the **length.**	48	You enjoy a medium sized greenhouse, measuring 16 feet long.
Multiply the height by the width by the length.	calculate	Your greenhouse measurements were 8'H, 8'W, and 16'L.
Look for this **minimum ventilation fan CFM rating** to keep your greenhouse healthy year round.	12480	8'H x 8'W x 16'L = 1024 cfm
This is the **optimum ventilation fan CFM rating** many growers use.	18720	8'H x 8'W x 16'L x 1.5 = 1536 cfm

https://www.greenhousecatalog.com/greenhouse-fan-calculator

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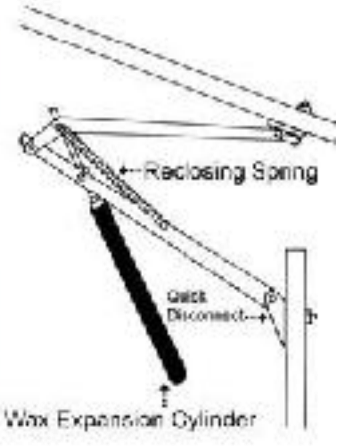
Erika Weeks

Ventilation

Natural Ventilation (Air Flow/wind):

- 20% of the area of the floor
    - 48x20=960 sq ft
    - 960x0.20= 192 sq ft of airflow



Beeswax window openers-> $52.00

30” shutter with motor -> $195.00

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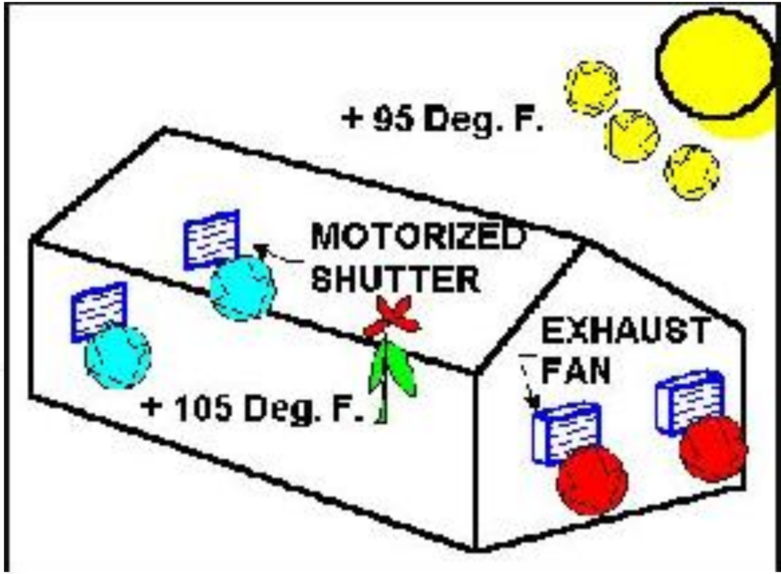
Ventilation

Package:

$890 { 1 30" fan
With
2 30" shutters }



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MATLAB Algorithm

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Net Energy Usage Algorithm

Algorithm receives user-input values for:

- Total Area of Solar Panels (square feet)
- Angle of Solar Panels from horizontal (degrees)
- Efficiency of Solar Panels (number between 0.00 and 1.00)
- Latitude of Installation (Rapid City, SD is at 44.076^0 N)
- Power Rating of Ventilation System (Watts)
- Power Rating of Irrigation System (Watts)
- Power Rating of Growing Lights (Watts)
- Power Rating of General Lights (Watts)

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Net Energy Usage Algorithm: Example Case

The following execution of the algorithm is based off the following user inputs:

- Total Area of Panels: 200 square feet
- Angle from Horizontal: 40.5^{o} (experimentally determined optimal angle)
- Panel Efficiency: 0.15 (typical solar panel efficiency rating)
- Latitude: 44.076^{o} N (Latitude of Rapid City, SD)
- Power Rating, Ventilation: 500 W
- Power Rating, Irrigation: 200 W
- Power Rating, Grow Lights: 10X9 W LED's = 90 W
- Power Rating, General Lights: 10X8.5 W LED's = 85 W

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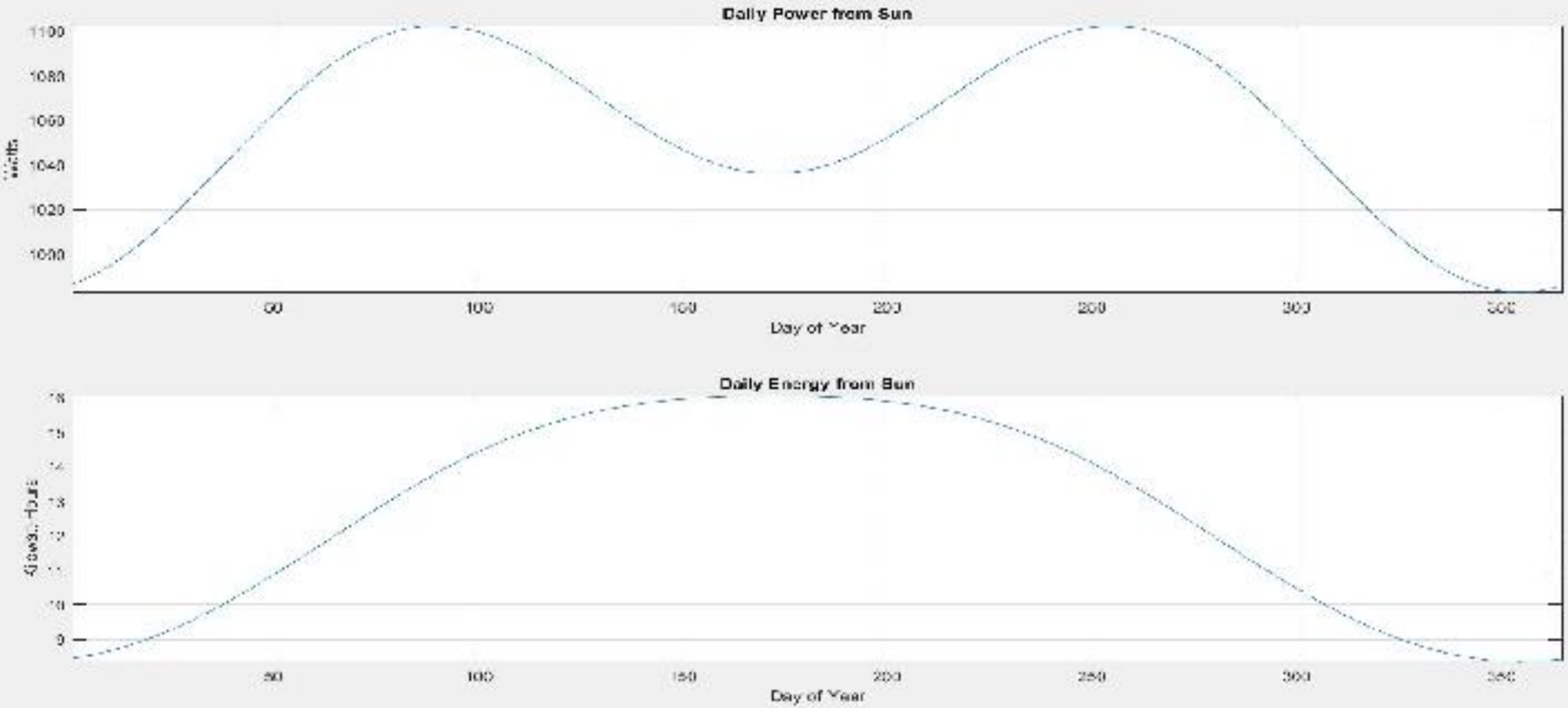
Print Output

```
Area of Panels: 200 square feet
Latitude: 44.076 N
Angle of Panels: 40.6 degrees from horizontal
Panel Efficiency: 15%
Average Daily Power Generated: 1.05468 kW
Average Daily Energy Generated: 12.703 kWh
Total Yearly Energy Generated: 4636.59 kWh
Total Yearly Energy Consumed:  6391.15 kWh
```

Graphical Output (1/3)



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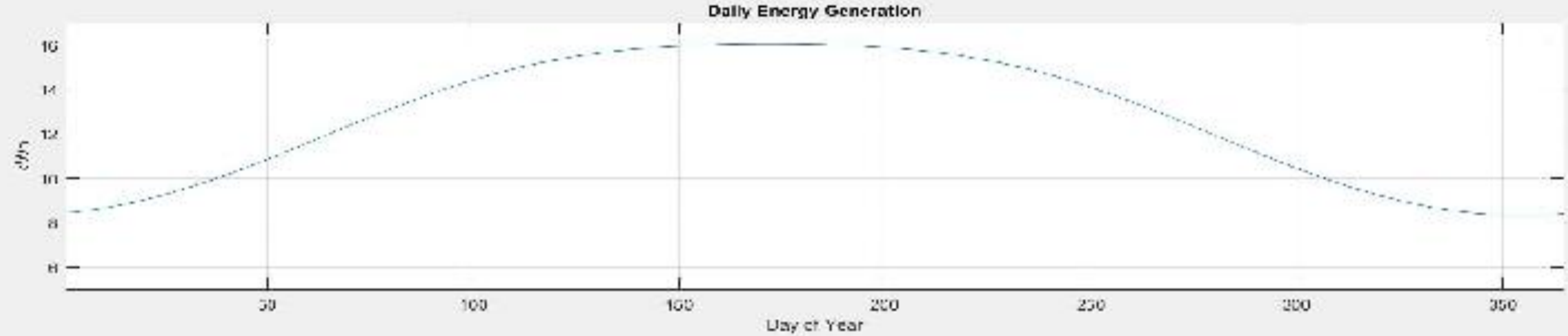
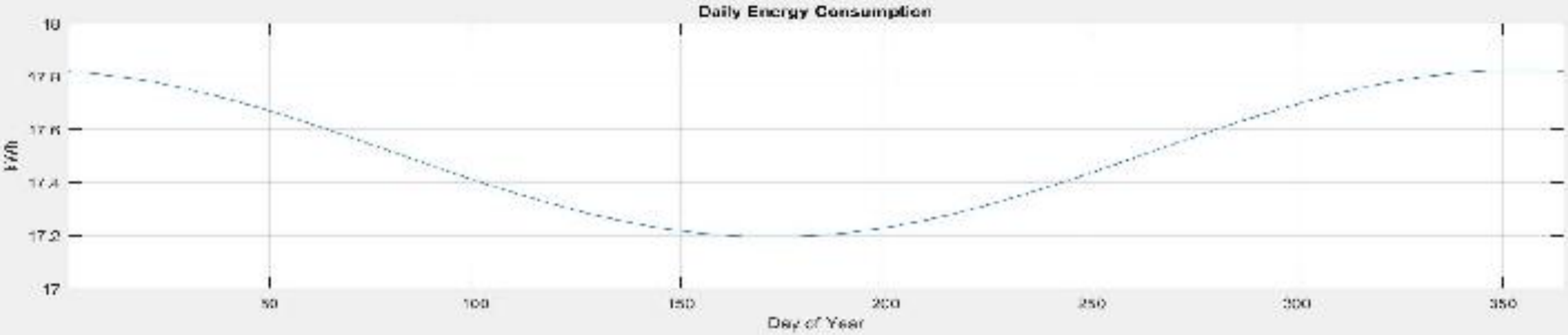
Graphical Output (2/3)





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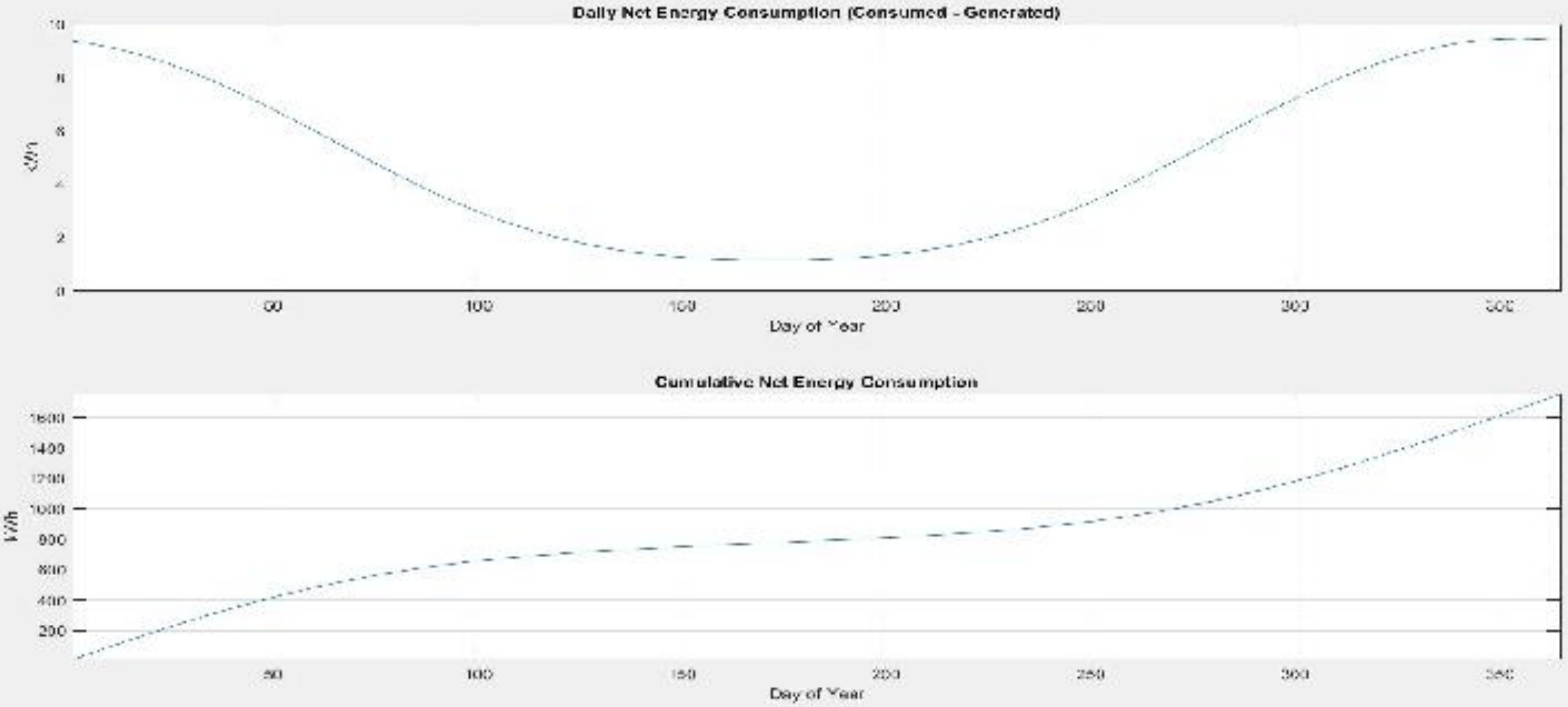
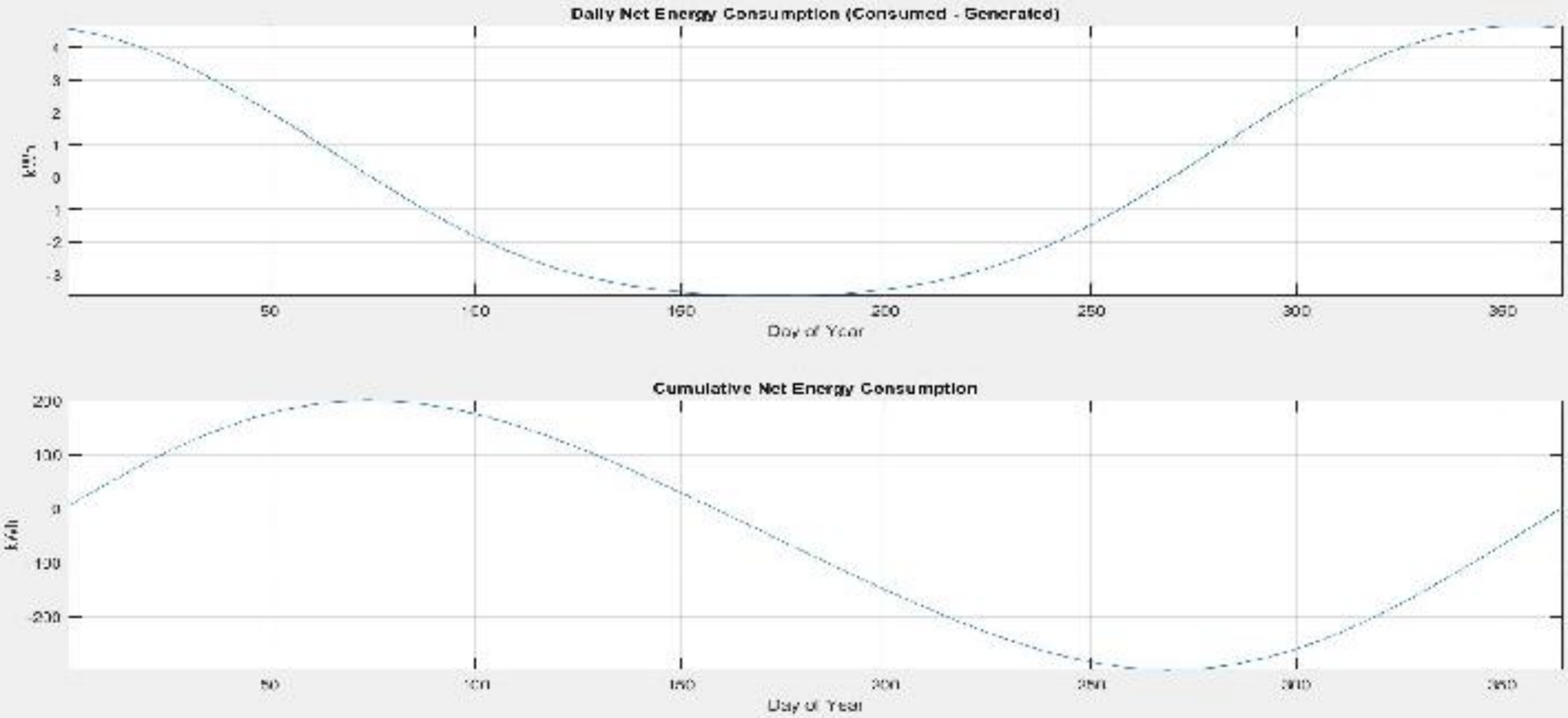
Graphical Output (3/3)



Graphical Output (3/3) (Sans Irrigation Pump)



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Roofing

Polycarbonate:

- \+ Durable (10+ years)
- \+ Lightweight
- \+ Environmentally friendly (recyclable)
- \+ UV resistant
- \- Reduced light transmission (~78%)
- \- Moderately expensive

Glass:

- \+ Extremely durable (30+ years)
- \+ Excellent light transmission (>90%)
- \- Expensive
- \- Heavy
- \- Poor thermal insulator

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Solar Panels

EPICS

Solar Panels: How much Sun

RESULTS

Print Results

19,166 kWh/Year*

System output may range from 18,652 to 19,434kWh per year near this location.
Click HERE for more information.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	3.81	1,291	139
February	4.71	1,422	153
March	5.25	1,711	184
April	5.48	1,671	180
May	5.78	1,787	193
June	6.14	1,786	193
July	6.35	1,858	200
August	6.38	1,854	200
September	5.81	1,690	182
October	5.33	1,665	179
November	3.95	1,257	135
December	3.66	1,173	126
Annual	5.21	19,165	$ 2,064

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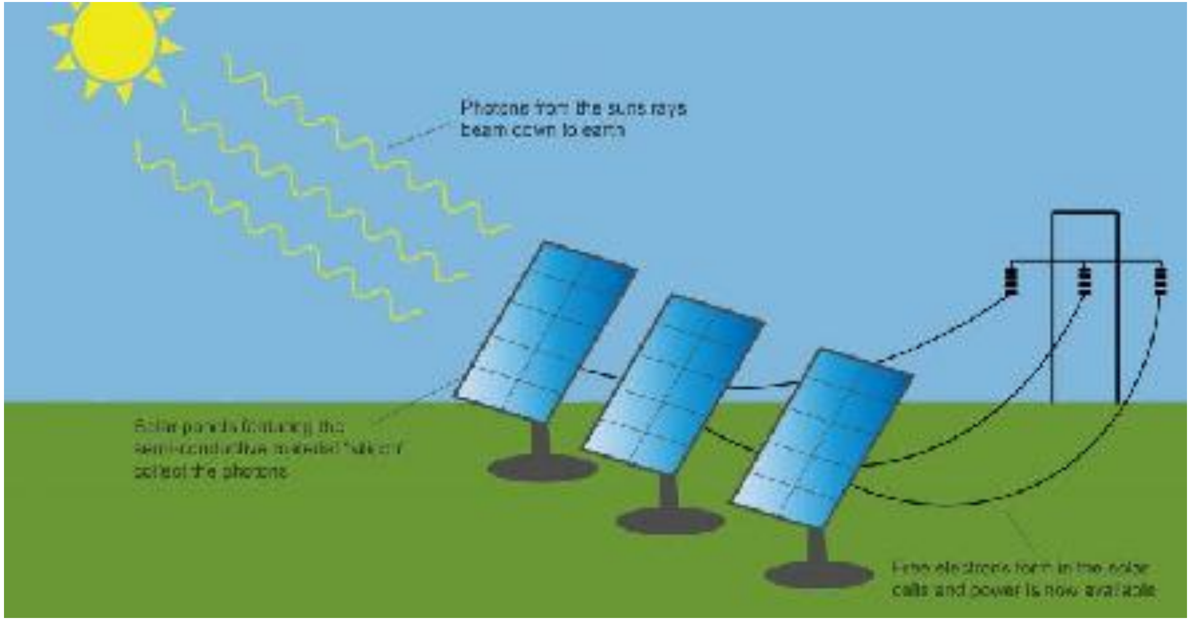
National Renewable Energy Lab (2018)

Solar Panels: How they work

1. The panels get sunlight
2. Inverters convert DC power to AC power
3. The current is then carried through the panels
4. Goes to grid or storage place



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Solar Panel: Types

Monocrystalline
-21.5% efficiency
-uses silicon ingots manufacturing (more expensive and creates waste)
-require little space
-do well in low lighting

Polycrystalline
-13%-16% efficiency
-made with silicon melting process (less waste/less expensive)
-Larger and take up more space
-Don't perform well in high heat or low lighting

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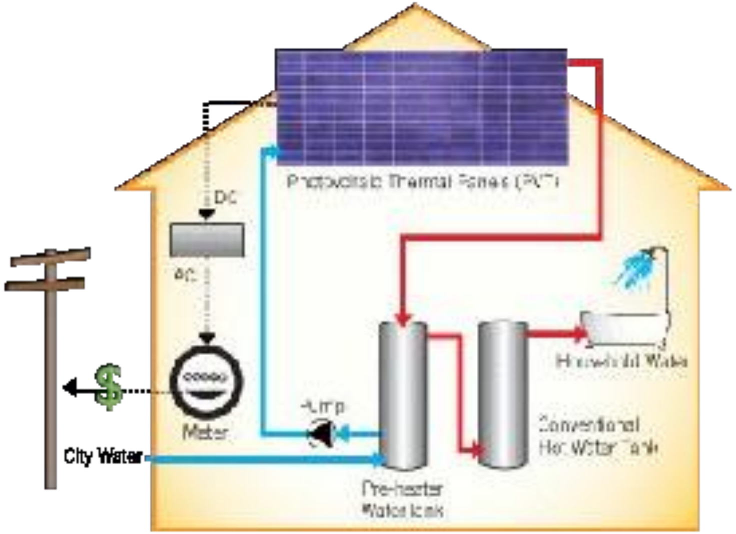
Solar Panels: Reneww House

- Jason Scheeman, Project Engineer Whirlpool
- Their goal is to take an average home and make it energy efficient therefore not perfect
- Use monocrystalline solar panels
- They sell energy back to the grid
- They have found the solar panels to be very durable some issues are
    - Over heating
        - Photovoltaic thermal system
    - Poor inverters



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Solar Panels: Professor William Hutzel

- Professor in Mechanical engineering Technology
- Series v. Parallel
- Net zero because they use the grid
- Inverters (Spring v. Micro)
- Match the solar panels to latitude (44 degrees)
- Moving solar panels increase max 10%
- Solar panels should be able to melt off snow
- Batteries are not that sustainable
    - Bidirectional meter

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Solar Panels: GenPro

- Tanner Jobgen, Distribution Sales Manager
- Have monocrystalline and polycrystalline
  - Range from 190 watts to 325 watts
- Have both types of inverters
- Recommends combination of parallel and series
- Gird most popular and cost effective
- Different types of batteries
  - Flood lead Acid
    - 7-10 years with maintenance
  - Sealed lead Acid
    - 6 years no maintenance
  - Lithium Ion
    - Work with the grid
- Weather not an issue (more vandallism)
- Moving solar panels not a good idea

GENPRO
ENERGY SOLUTIONS

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Solar Panel: Placement

Ground

- \+ Do not need to worry about space
- \+ Easy to clean off
- \+ More efficient
- \- More susceptible for people manipulating them
- \- Wiring would be on the ground
- \- More expensive

Roof

- \+ No one will touch them
- \- They cannot be manually cleared off
- \- They block some of the plant sunlight
- \- Add weight to roof

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Solar Panel: Summary

Conclusion:

- Types of solar panels
- Placement of solar panels
- Types of batteries
- Types of power

Future Plans:

- Decide types
- Decide placement
- Decide wiring
- Continue contact with Genpro

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Insulation

Insulation: Analysis

- Goal: reduce heat loss from greenhouse
- Limited surface area to install insulation because of transparency

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Insulation: Spray Foam

- Dynamic uses/application
- Closed Cell: Does not absorb moisture, vapor barrier, strong finish, long life
- Open Cell: Intended for for mild climates, not as dense R-3.5/inch, struggles with moisture

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Insulation: Spray Foam Continued

- Benchmark: ReNEWW House in West Lafayette uses a Honeywell closed spray foam and siding R-6.35/inch
- Other brands have up to R-7/inch
- Intended to be DIY

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Insulated Concrete

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Insulated Concrete

- ICF's (Insulated Concrete Forms)
  - Pre-assembled, no wood
  - 2 layers of foam with concrete poured in-between
  - Estimated R-12

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Oswald Vineyard

- Family made and run Greenhouse in Texas
- Insulated Concrete Forms
- Corrugated Polycarbonate panels
- Hoop House Design
- Withstood hailstorm with minor damages to polycarbonate

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Plants (OLC/Mines)

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Plants

Plants categorized by soil type

- Dry soil
  - Lead plant
  - Western sagewort
  - Fringed sagewort
  - Cudweed sagewort
  - Annual sunflower
- Moist soil
  - Yarrow
  - Oregon Grape
  - Wild bergamot
  - Wild Raspberry
  - Stinging nettle
- Rocky, sandy, loamy soil
  - Chokecherry
- Well drained soil
  - Hawthorn
  - Echinacea
  - Annual sunflower
  - Basil
  - Rosemary
  - Thyme
- Rich soil
  - Corn
  - Beans
  - Squash
- Almost any/any soil
  - Catnip
  - Wild rose
  - Dandelion

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Irrigation (OLC/Mines)

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Irrigation

- Drip Irrigation System
  - Water is delivered to plants directly to the roots, through a system of pipes and nozzles embedded in each pot or growing tray/bed
  - Ability to start small and add more “taps” as needed
  - Use water sensors to detect soil needs
  - Very efficient, little to no water gets wasted and nothing gets wet except for the plants
  - Relatively easy to install
  - Cost is usually about $25-$50 for a kit.
    - $23.99 for 50 ft kit found on amazon

Considering hydroponic system experimentally and for educational purpose

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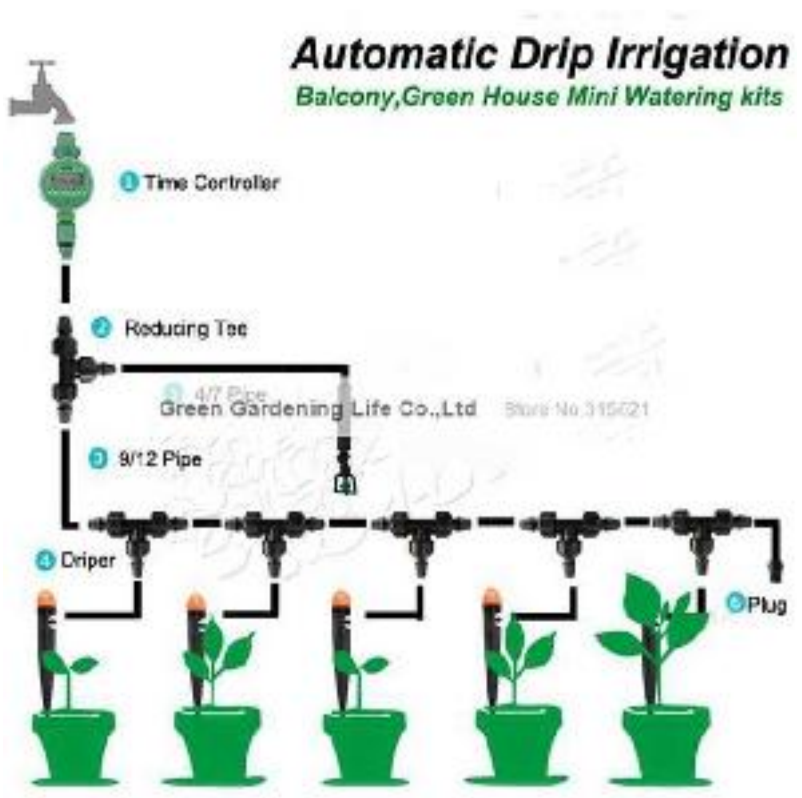
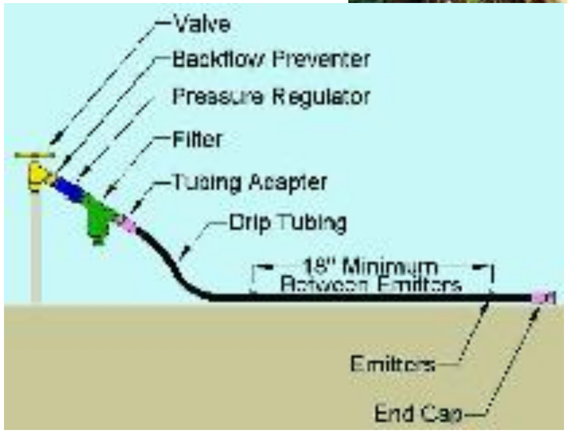
Drip irrigation system





Designs (OLC/Mines)

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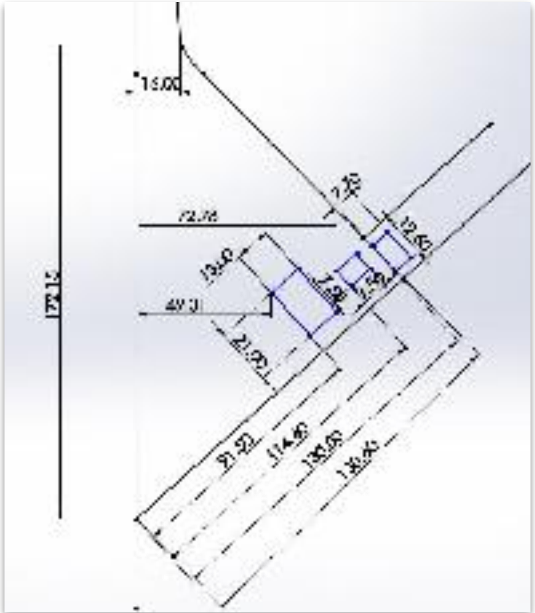
Land Plat: Greenhouse Location



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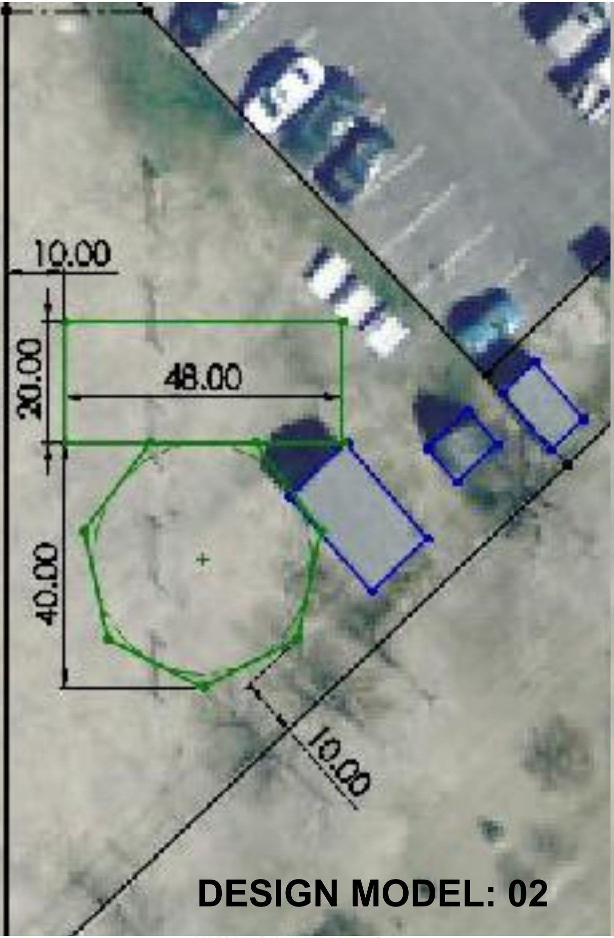
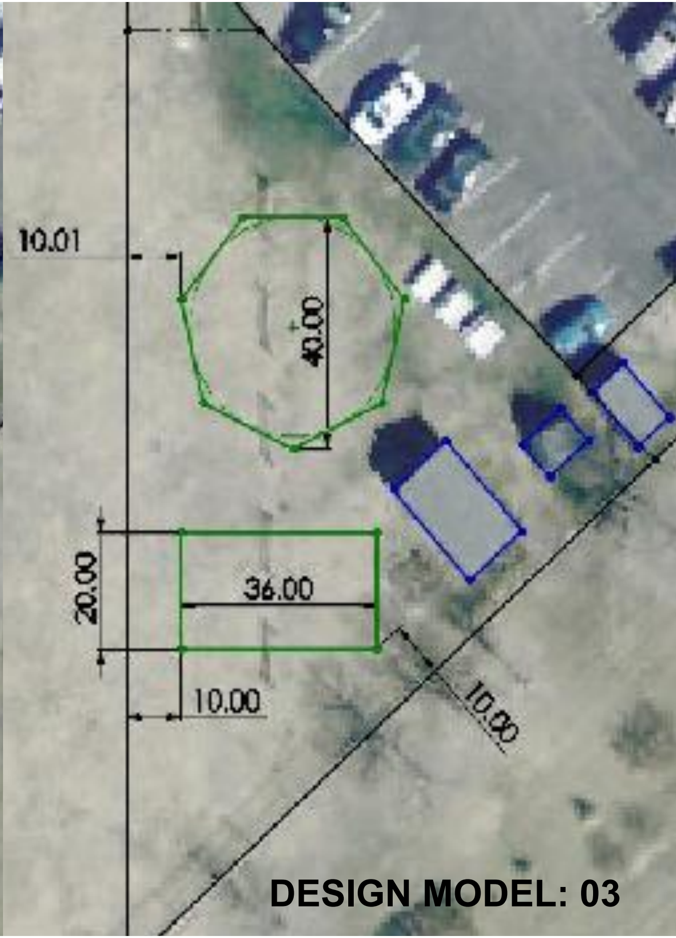
Conceptual Design Models

DESIGN MODEL: 01



DESIGN MODEL: 02



DESIGN MODEL: 03

Next Semester Goals

Transition fully into Conceptual Design

- Insulation- Compare numbers between products and types
- Solar Panels
  - Create multiple possible decisions on type and placement
- Matlab code
- Looking at Funding

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Questions?

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