DESIGN OF A SUSTAINABLE GREENHOUSE

Jacob Hickman, Nikki Ghanfilli, Scott Gilrein, Chao Li

Department of Biological and Agricultural Engineering

THE PROBLEM

Creating a sustainable greenhouse is something that could revolutionize the way that food is produced. Greenhouses are able to provide a productive environment for plant growth through all of the seasons of a year, but doing this requires massive amounts of energy. The energy is often provided through the burning of fossil fuels which contribute carbon-dioxide and other pollutants into the atmosphere.

Our client is Val Eylands, the owner of Ozark All Seasons. His business produces lettuce through the use of aquaponics systems and it currently relies on a mixture of wood and propane burning, and electrical power to keep the greenhouse running at optimal conditions. The client is currently planning to renovate his existing greenhouses to make them more environmentally friendly and efficient.

THE PROJECT

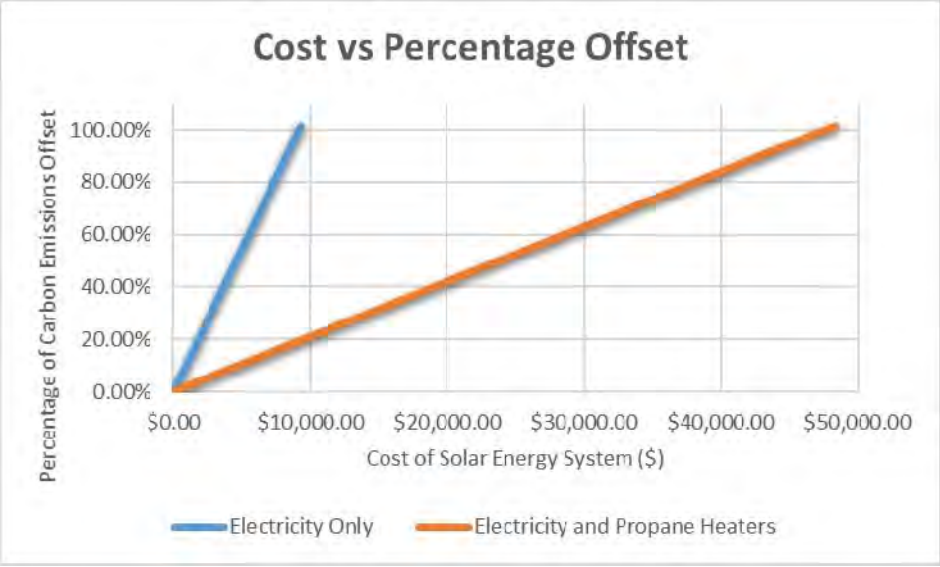
The first step to completing the project was to determine the overall goals of the client. The client wishes to bring the carbon footprint of his business down, with a long term goal being zero carbon footprint. They also wish to grow lettuce faster and more efficiently by increasing water temperatures during the winter

Once the goals were determined, the project team began to generate and evaluate solutions for the client's problems. Different methods of energy production were studied to determine if they could replace current fuel sources with environmentally friendly sources. The flow of water in the system was determined to size a heater that could provide an effective amount of warm water to the plants. Energy flow through the greenhouse's walls were also modeled to show the client the savings that different renovations could provide.

WATER HEATING

The design recommendation is to use a 182,000 btu/hr propane heater to warm the water and build a solar panel array that can offset both the propane usage and electrical energy used by the greenhouse's systems. It is most optimal to set the heater to a target temperature of 100 F. When the heated water is combined with the tank water flow, the temperature will drop to 68.7 F. This is an increase of 13.7 F over ambient temperatures.

Water Mixing	NRCP 982 LP	NRCP 982 LP	NRCP 982 LP	NRCP 982 LP	NRCP 982 LP
System Flow Rate (m^3/min)	0.097	0.097	0.097	0.097	0.097
Heated Water Flow Rate (gal/min)	3.800	7.000	7.800	8.700	5.800
Heated Water Flow Rate (m^3/min)	0.014	0.026	0.030	0.033	0.022
Heated Water Mass Flow Rate (kg/min)	14.356	26.445	29.467	32.867	21.911
Heated Water Temperature (F)	145.000	105.000	100.000	95.000	115.000
Unheated Water Flow Rate (m^3/min)	0.083	0.070	0.067	0.064	0.075
Unheated Water Mass Flow Rate (kg/min)	82.382	70.293	67.271	63.871	74.827
Unheated Water Temperature (F)	55.000	55.000	55.000	55.000	55.000
Combined Water Temperature (F)	68.356	68.668	68.707	68.590	68.590



SOLAR ENERGY

A solar panel array that offsets the carbon emissions due to electricity use by the greenhouse can be built at a cost of $9,376 after a tax credit. This system would provide 58.2 kWh of energy per day and all energy produced would be eligible for net metering benefits. Electricity produced past this point can only be used to offset carbon emissions. To offset both sources of emissions, electricity and propane, the system would cost approximately $47,870.

SUSTAINABILITY

This project is a small part of the effort to make humanity's food supply sustainable for years to come. As populations grow, more and more food will need to be produced on less land. Showcasing the benefits of making a greenhouse carbon-neutral will make them an even more attractive alternative to traditional agriculture. Further advances in greenhouse technologies will allow 24/7 growth of food in places where food was previously impossible to grow. The food that is produced by these methods will also avoid contributing carbon to the atmosphere, eliminating one source of pollution that threatens the long-term ability for us to live on our planet.

This project allowed for members of the project team to test their ability to design systems with heavy constraints. The team members will be able to take these skills into the industry for future projects, where sustainability has become a major issue. The project may also inspire others to evaluate their own impacts and what they can do to lessen them.

This poster was prepared in partial fulfillment of SUST 4103 Sustainability Capstone