Energy Savings of Evaporative Cooler Vent Covers at Orchard Park

Carrie Ng, Omar Samara, Caitlin Walker

ABT 212 - Zero Net Energy, Spring 2018

Introduction

Many of the greenhouses at Orchard Park are outdated and lack vent covers. The ***absence of vent covers allows heated air to escape the greenhouse at night***, which severely lowers the heating and energy efficiencies of the facility.

The managers have received a $2 million grant for design adjustments and construction. Our team has partnered with them to investigate the ***economic feasibility*** of installing vent covers in order to better inform their spending.

Objectives

- Reduce energy usage and increase heating efficiency by preventing heated air from escaping via cooler vents
- Support both UC Davis research mission and Sustainable 2nd Century initiative
- Inform grant spending for greenhouse upgrades

Methodology

Following a literature review, data was collected and analyzed for 2 structurally comparable greenhouses: one with a vent cover (GH607), and one without (GH608). A month's worth of ***temperature and hot water heating data*** was salvaged and used with infrared images in an attempt to estimate the difference in energy use between the two.

Ultimately, this data was deemed incomparable for further analysis.

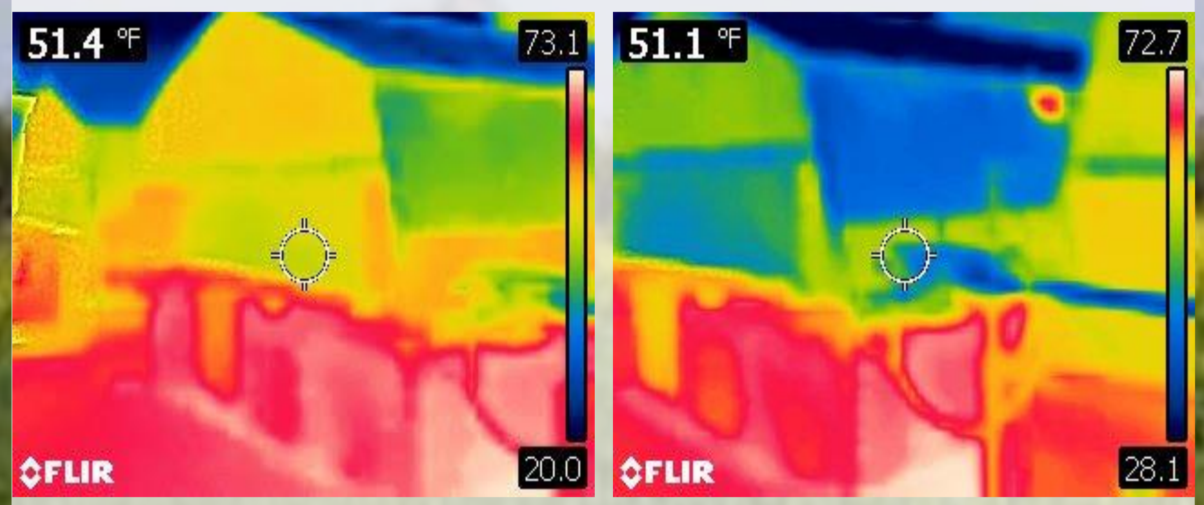


Fig. 1 - IR Images taken on 5/23/2018 at 10 PM

As a result, a heat loss equation was used to calculate the ***theoretical energy savings***. Using the energy savings, a simple payback period was calculated using a contractor quote and a rough estimation of installation and labor costs for the overall project.

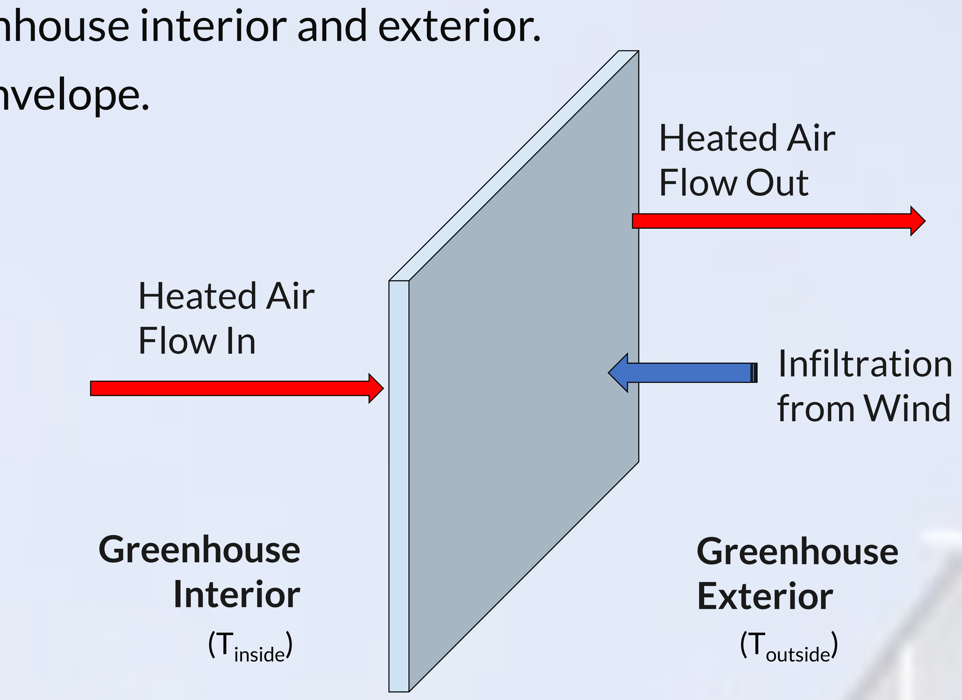
Theoretical Airflow Model

Using an constant internal temperature of 25°C and meteorological data for Davis[1], an empirical equation[2] for calculating airflow through the vent was used to model the system. There are two main contributors to the loss of conditioned air:

1.) ***Stack effects*** - driven by temperature difference between the greenhouse interior and exterior.

2.) ***Wind driven infiltration*** - driven by exterior wind through gaps in envelope.

$$Q_{ventilation} = \frac{A_L}{1000}\sqrt{C_s \Delta T + C_w U^2}$$



$Q_{ventilation}$ = air leakage flow rate [m³/sec]; A_L = effective vent area [in²]; U = wind velocity [m/s];
ΔT = interior/exterior temp difference [F]; C_S = stack coefficient, 0.000145[3]; C_W = wind coefficient, 0.000032[3]

The theoretical flow rate was used to estimate the ***heat losses***[4] of the open system (no vent cover), and combined with UCD utility rates[5] of 80% efficiency to calculate ***potential energy savings*** per greenhouse.

$$Q_{ventilation\ loss} = C_P \times \rho_{air} \times Q_{ventilation} \times (\mathrm{T_{inside}} - \mathrm{T_{outside}})$$

$Q_{ventilation\ loss}$ = heat loss via ventilation [Btu/sec]; C_P = specific heat of air [in²]; p_{air} = density of air [m/s]; $Q_{ventilation}$ = air leakage flow rate [m³/sec]

Results

Monthly & Annual Energy Savings:

Using the heat equation, estimated monthly savings vary from $72 to $233 depending on monthly heating necessities. The ***total annual savings estimate is $1,585***.

The amount of savings depends heavily on average wind speeds and night-time exterior temperatures, which are both included in the theoretical model.

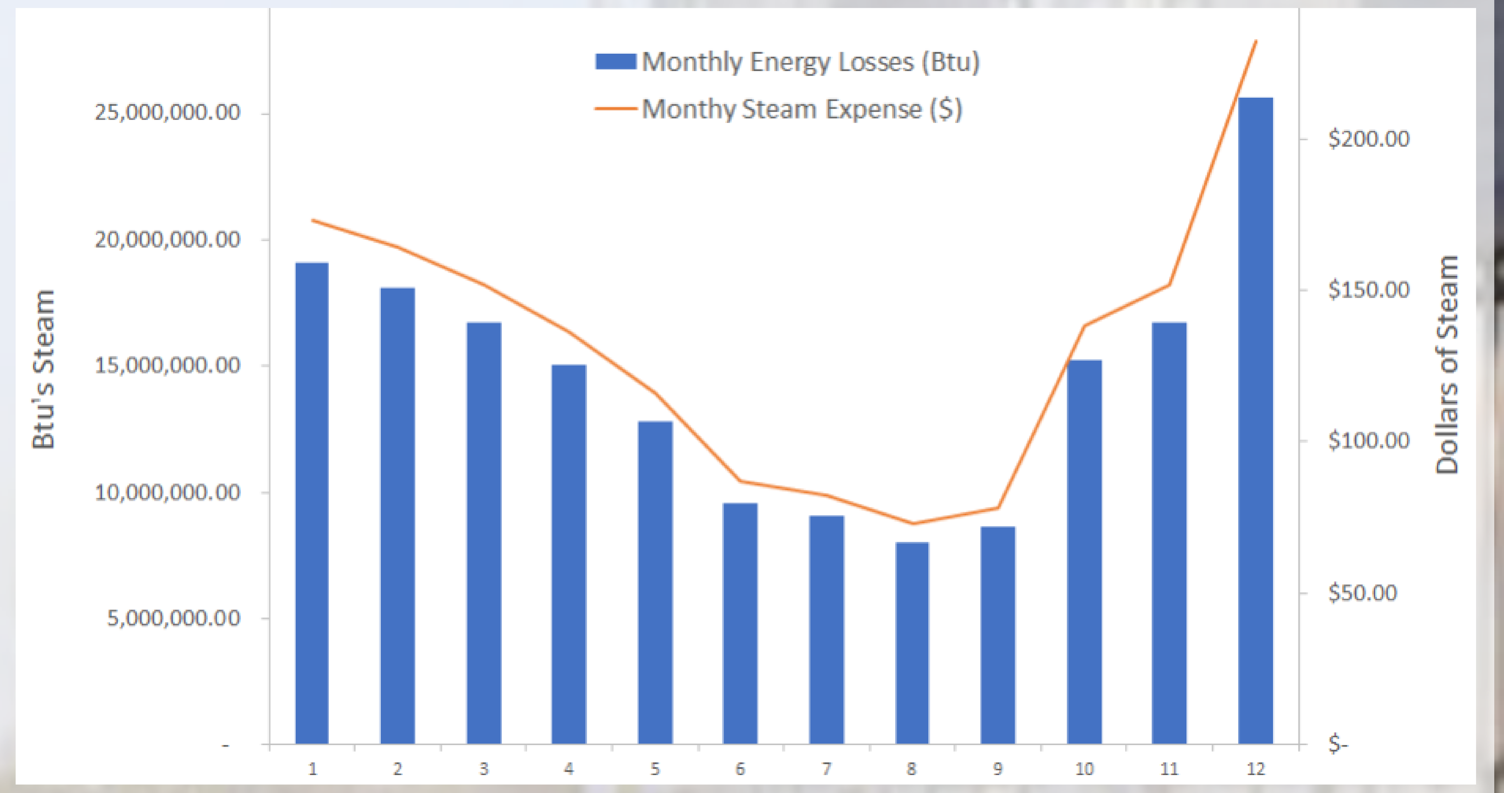


Fig. 2 - Annual Heat Usage with Seasonal Variations

Table 1 - Projected Savings Over Project Lifetime

69 Greenhouses				
Project Years	Energy Savings	Project Cost	Total Savings	Rate of Return
1	$109,355	$233,220	-$123,865	-53%
2	$218,710	$233,220	-$14,510	-6%
3	$328,065	$233,220	$94,845	41%
5	$546,775	$233,220	$313,555	134%
7	$765,485	$233,220	$532,265	228%
9	$984,196	$233,220	$750,976	322%
10	$1,093,551	$233,220	$860,331	369%

Projected Savings for Payback Period:

Installation and labor costs were estimated to be 30% of the vent cover cost, resulting in a price tag of ***$3,380 per vent cover***.

A breakeven point is reached after ***2 years*** of vent cover use.

This analysis assumes that energy rates do not change and if they increase, energy savings will proportionally increase.

Summary of Deliverables

Annual Energy Savings*

$1,585

Installation Cost*

$3,380

Payback Period

2.1 years

*per greenhouse

Conclusions

There is potential for over $1 million in energy savings with a 369% rate of return over a 10 year lifetime for 69 greenhouses. Saving potential and feasibility of installation depends on lifetime of project, therefore:

We recommend the installation of vent covers on any greenhouses with a 3+ year lifespan.

Acknowledgements

We would like to thank Dr. Kurt Kornbluth, Lisa Slaughter, and Josh Morejohn for their advice, humor, and support this quarter.

We would also like to thank Chris Durand, Garry Pearson, and Ronald Lane for showing us the facilities and sharing their knowledge.

Contact Info

Carrie Ng - cryng@ucdavis.edu
Omar Samara - oasamara@ucdavis.edu
Caitlin Walker - cswalker@ucdavis.edu

References

1. CIMIS Database (https://cimis.water.ca.gov/WSNReportCriteria.aspx)
2. ECI 125 Lecture Slides, c/o Dr. David Vernon
3. ASHRAE Handbook of Fundamentals, 2017 ed.
4. Jaga Heating Products, Ltd., "Useful Calculations" (https://www.jaga.co.uk/assets/downloads/docs/UsefulCalculations.pdf)
5. UC Davis Facilities, "Utility Rates" (https://facilities.ucdavis.edu/utility-rates)