Shallow Geothermal Heat Exchangers: Sustainable Low-Cost Season Extension for Community Farmers

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PROJECT OVERVIEW

This project uses **on-farm research** and **community outreach** to increase adoption of a low-cost, sustainable technology that improves farmers' season extension capacity, improving their profitability and strengthening local food systems.

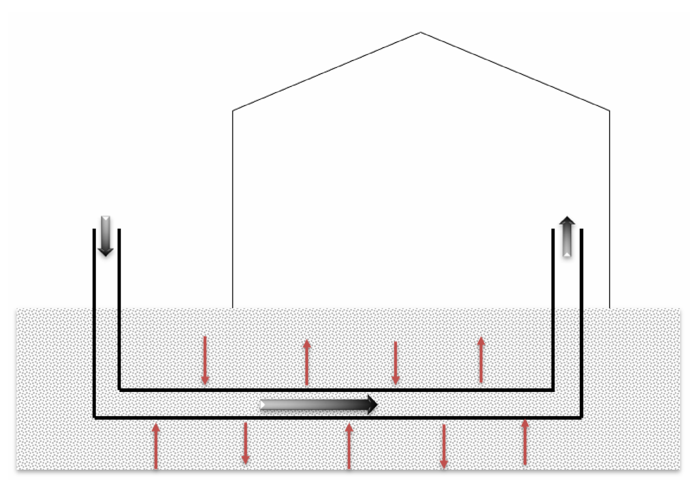
Background and Current Practices:

- Only **2** Farmer's Markets around Columbus, OH operate weekly through the winter [1].
- OSU's Sustainability Target to source **40%** of food from local or sustainable sources by 2050 [2].
- Growing produce in high tunnels and greenhouses allows **year-round availability** of fresh, local food.
- Current heating practices rely on natural gas or propane heaters, which are costly and increase **environmental impacts** of local foods.

Shallow Geothermal Resources

- Shallow geothermal energy reserves in the soil occur due to natural insulation
- Earth-to-air heat exchange systems (EAHX) move air through underground tubes and allow for heat transfer to/from the soil (Fig. 1)
- Geothermal systems installed at 3-6 ft depth can be built on-farm with common farm equipment

Figure 1: Earth-to-Air Heat Exchange



Using a fan, air is circulated through underground pipes which are in contact with soil. Heat is transferred from the soil to the pipes and from the pipes to the air. Engineering design is used to find the appropriately sized fan to move air through the pipes based on the pipes' roughness, size, and overall length. A large enough surface area between the air and pipes is needed to facilitate effective heat transfer, but more air flow, surface area, and friction necessitate a larger, more expensive fan.

Research Questions

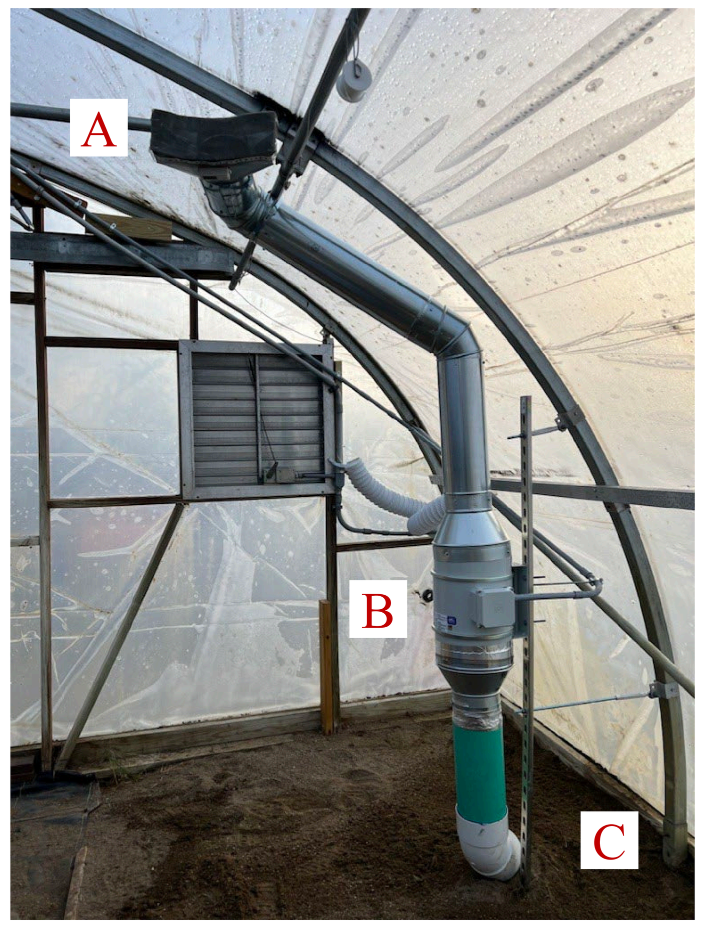
1. Can Earth-to-Air Heat Exchange (EAHX) systems provide heating and cooling while minimizing dependance on fossil fuels?
2. Is this an affordable option for farmers to expand their production season?

ENGAGEMENT WITH COMMUNITY PARTNERS

Collaborative, On-Farm Research

- Original partner farmers [Graham & Tonni Oberly] proposed research topic: finding feasibility and cost of retrofitting an EAHX to an existing production high tunnel at Oaks and Sprouts Limited.
- Oberly's collaborated in installation, monitoring, and outreach activities (Fig 2).

Figure 2: EAHX Components in High Tunnel



EAHX Components inside greenhouse. (A) 6" ductwork to conduct air tempered by EAHX towards high tunnel circulation fans. (B) In-line fan secured to high tunnel support beams. The system's only active, energy-using component. (C) EAHX system is buried before it goes outside to increase insulation of components

Needed Research for Decision-Making Tool

After completion of first system installation, we wanted to answer research questions to expand the applicability of a design and decision-making tool.

Sought community partners for further research, and found partners with:

- South Side Family Farms, Minister Aaron Hodges
- Franklinton Farms, Becca Brown
- Ohio Ecological Food and Farm Association
- OSU Franklin County Extension, Dr. Timothy McDermott

Research and Partnership Timeline

2021 — 2022 — 2023 — 2024

2021

- Conceived project, co-wrote grant applications with partners at Oaks and Sprouts Limited

2022

- Built pilot EAHX system at Oaks and Sprouts & monitored benefits and operational costs

2023

- Pursued funding for outreach & research to refine design tool
- Connected with more community partners

Ongoing Activities

- 2023: Install two more EAHX systems on community partners' farms and monitor heating and cooling compared to control high tunnels
- 2024: Launch user-friendly design tool for farmers considering EAHX systems on their farms
- 2023 & 2024: Host farm tours and design tool workshops

BENEFITS TO FIELD & PARTNERS

Near term: Building up Partner's Infrastructure

- Through research project, partners have season extension infrastructure expanded
- Partners now have on-site weather stations, which aid in farm management

Medium term: Decision-Making Tool

- Installation practices and design guidelines for simpler EAHX systems with on-farm equipment
- Quantification of EAHX heating and cooling capabilities
- Estimation of EAHX costs and benefits under different scenarios

Long term: Broader Outreach

- Building a scientifically-rigorous and easy to use design and decision-making tool for other farmers with high tunnels
- Hosting farm field days and workshops to demonstrate EAHX systems in use and application of design tool

Fig 3: Results from first season pilot EAHX system

Cost	Heating	Cooling
Installation accomplished under $2,000 with team of 2 and non-specialty equipment	Equivalent heat of 5.5 gallons of propane delivered in first two weeks of Fall 2023	Cooling equivalent up to 1/4 ton air conditioner unit in Summer 2023

Notes: Installation cost does not include additional expenditures for research and monitoring equipment. Heating calculated based on recorded heat differential delivered by EAHX, with adjustment factors for BTU/gallon propane and assumed propane heater efficiency of 78% (3).

CONCLUSIONS

On our way to answering research questions to build a design tool for extending farmers' adoption of an affordable, low-carbon tool for season extension, we are:

- Installing three operational EAHX systems on partners' farms, adding to their season extension capabilities
- Generating practical knowledge on system installation with on-farm resources and labor
- Learning from farmers what questions they have and how we can make a design tool user-friendly

BIBLIOGRAPHY

1. USDA Local Food Directories. Farmers Markets in Columbus, Ohio
2. Ohio State University. 2015. Sustainability Institute at the Ohio State University
3. University of Wisconsin- Madison Division of Extension. Heating Your Greenhouse.

ACKNOWLEDGEMENTS

Paul C. and Edna H. Warner Grant for Sustainable Agriculture, OSU CFAES
Ohio State Energy Partners Grant Program
USDA NCR-SARE Graduate Student Grant Award
NSF Traineeship for Data-Driven Sustainable Energy

NSF   OAKS & SPROUTS