Fact Sheet: Maine Greenhouse & Covered Agriculture Program

Topic:
APPLICATIONS FOR PHASE CHANGE MATERIALS IN HIGH TUNNELS, LOW TUNNELS AND GREENHOUSES

December 2020

IN THIS ISSUE:

- PHASE CHANGE MATERIAL DESIGN AND TESTING FOR WINTER FARM APPLICATIONS
- CASE STUDIES  Little River Flower Farm  Waldoboro Business Park  BUXTON, Maine  WALDOBORO, Maine
- DESIGN CONCEPTS  Insolcorp  BIDDEFORD, Maine  & ALBEMARE, North Carolina
What is Phase Change Material?

Phase Change Material (PCM) is a salt hydrate that releases heat at it changes from a liquid to a solid. It works much like an standard ice pack, but in reverse. It often comes in a roll like giant ketchup packets or ice a large rolls of ice paks and it's increasingly common to see it in addition to insulation in the ceilings and/or walls of a building envelope. It adds value to the energy used for heating by absorbing heat when its warm and then releasing it when is gets cooler. Once it absorbs heat it will slowly release it while changing phases, and as it does so it helps maintain a steadier indoor temperature which can result in less overall heating energy is needed from your heat source.

This [wikipedia article](https://en.wikipedia.org/wiki/Phase_change_material) discusses PCM is much greater detail and lists available products.

How is it used in farming?

Through still in early testing for greenhouse and covered ag systems it's not hard to see how a giant reverse ice pack that absorbs heat when your indoor temp climbs to 65, and releases heat when it drops under 65 could be useful. Among the target uses currently being considered is to heat to winter greenhouse or insulated high tunnel above freezing: PCM set to 42 degree phase change in a low tunnel with crop blakets do the work of retaining and slow releasing daytime heat well after the sun is gone. However the uses are potentially vast and trails are only in early stages.

When heat is precious and the amount of heat you use justifies the cost of install, that translates to savings and a reasonable payback period for your budget/and operation. When used in combination with a heater and us design for a target temperature phase change and installed properly, it can reduce the amount of work a fossil fuel, pellet, wood, or solar heater has to do everyday. This can translate to savings in overall fuel cost.
Trials and Demonstrations on Maine Farms

Different styles of PCM behave differently; a popular use is to seal a building envelope with it. If properly installed and set to an appropriate temperature PCM can be used to line potato storage buildings, utility buildings, barns and greenhouse endwalls to add value and savings to heating.

Real time graphing tools, like this Intellergy data graph demonstrate the energy and heating impact of new infrastructure tools. Night-time spikes show the LP gas heater at work. During the day sunlight is captured inside the ducts and solar plenums, the and the fossil fuel heater is not needed.

Overview of PCM Manufacturer Insolcorp

Insolcorp, a business that formerly operated out of Biddeford and now is located in Albemarle, North Carolina, manufactures a number of inorganic salt based PCM products that change phase in a range of temperatures between 0 and 160 degrees F. PCM that is factory set between 65 to 84 degrees F is the most common for agriculture applications to date. Each PCM product has a fixed phase change temperature when it is shipped form the factory.

Bio-based (organic) phase change materials are also available on the market. These are typically derived from plant based parrafins, waxes, oils or alcohols. Unlike inorganic salt based PCM products, bio-based PCM's can be very flammable and should not be installed in building envelopes or greenhouses without proper confirmation of safety.

Experimental farmers looking to test an idea for application of phase change material will find a PCM industry eager to prove the value of their products in new applications. The next two pages show preliminary trial the impact of PCM in a raised bed trial and a air duct design concept that show potential for breakthrough for high tunnel and greenhouse cold crop heating.
In this research trial, we measured soil temperatures in two adjacent raised beds, one treated with phase change material and one without. Our hypothesis was that phase change would provide slow release heat between firings of the greenhouse’s hydronic radiant heating system, thereby maintaining a steadier constant temperature. PEX circulation tubes deliver 150-170 degree heat from the hydronic boiler deep under the raised beds which radiates and disperses up through the root-zone and into the air above. The walls of the beds are built with polycarbonate panelling, and the PCM is set on the inside wall.

This raised bed system is unique for soil based growers; if the beds were not raised the ground and adjacent paths would provide the same heat retention function. However, this operator’s design provided a good opportunity to test PCM in a commercial greenhouse.

**Study Design**

At a cost of 3.00/square foot for PCM, we set out to see if it’s cost effective to install and whether it would provide any savings in heating fuel use or any benefit to plants that lead to a higher quality yield.

Soil temperature probes were placed in the center of two adjacent beds. One bed had walls that were lined with PCM and the other did not. Soil probes collected temperature at 1 inch depth (blue line below) and another at 12 inches (green). Ambient air probes recorded the air temps (yellow).

![Study site: Sensor array soil probes in raised beds](image)

### Analysis

The data suggests that the phase change performed as anticipated in terms of steadier heat; the soil heat probes tracked together throughout the year. However, phase change treated beds are consistently equal or a few degrees warmer between cycles radiant heat circulation from the boiler in winter and cooler between day time high temps in the summer. Controls for these studies were not effective enough to make determination about yeild or crop quality. The greenhouse had a number of unanticipated variables, but could be refined to provide a clear dollar value return on investment and analysis of phase change and its effect on soil biology, heat retention et cetera.

### Conclusion

The concept worked, but other variables in the production made any conclusion about the exact amount of savings impossible to measure precisely. We’re recommending more inventive uses for phase change.
Additional Uses for Phase Change Materials:

**Design Concept for Wall Panel with Integrated PCM**

Phase Change Materials are impacting the way we think about heating. PCM, paneling such as the products available from Insolcorp, absorb heat in daytime and release it at night turning a well designed solar wall into a passive heater. In this application, traditional insulation is required between PCM panels and outer wall to be sure heat ends up inside your greenhouse, not lost outside.

**Design Concept for Greenhouse Phase Change Material Air Duct Heater**

This application for PCM uses a duct system with a phase change air heater that concentrates its thermal energy on air passing through the duct. With this duct you get an endless boost in air temperature that can passively raise temperatures by storing heat energy produced during the day for slow release at night.

For many winter vegetable farms operating in high tunnels with proper seals and insulation, this design is among the most promising for low carbon fuel/fossil fuel free winter greens.

Trial designs are currently underway in commercial greenhouses. If your farm, business or research station has an application for duct phase duct heaters, consider joining our “Maine Greenhouse Heat Storage Working Group” and volunteering as a demonstration site for on farm trials.

*Design concept and sketches courtesy of Mick Dunn, Insolcorp LLC*
**Additional Resources:**

Looking for help budgeting for new tools and infrastructure? Check out ME SAS’ draft editable Enterprise Greenhouse Budget Planning Tool. Use the tool to plug in and calculate cost, depreciation, estimated payback and even carbon emissions for whole farm accounting. This draft of the tool comes pre-loaded with a model budget.

For more info on solar greenhouse technologies see National Center for Appropriate Technology “Solar Greenhouses” Fact Sheet. For info specific to Maine see UMAINE Cooperative Extension Season Extension Bulletin and the Sustainable Year Round Agriculture Program Final report.

Recycle agriculture plastics! UMaine Cooperative Extension's Agricultural Plastics Recycling Program

**Produced by:**
The AGRICULTURE INFRASTRUCTURE AND AND GREENHOUSE PROGRAM; a project of the Maine Sustainable Agriculture Society.

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