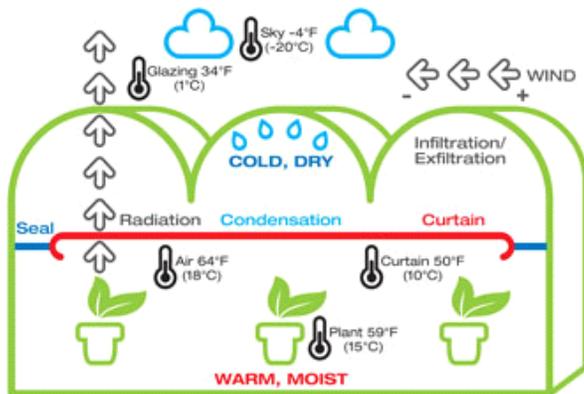


Energy: 'Tis the Season for Savings

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Any fan of HBO's "Game of Thrones" knows that the motto of House Stark, the family who rules the North region, is, "Winter is coming." The threat is as chilling as it sounds. The first cool days of autumn always remind me to look into the update of the Department of Energy's Outlook report for an indication of fuel prices and expenditures, which consider anticipated weather for the upcoming season.

Energy expenses are among the highest expenses for greenhouse operators and become a top concern as our days begin to shorten. With technological advances in drilling in shale, natural gas supply will be in abundance, which will keep the prices relatively low. Although newer demands, such as the use of natural gas to offset coal for the generation of electrical power, will continue, it's expected that natural gas prices will be low for some years to come.

If you have the ability to lock in prices for an extended period, it's probably a great idea to do so. With spot prices for natural gas around \$3.00 per million BTU for the commodity, they're less than half the price of just a few winters back. Growers in

some regions aren't fortunate enough to have access to a natural gas pipeline. For comparison's sake, propane prices are around \$13.00 per million BTU, and No. 2 heating oil is around \$24.00. (Keep in mind that equipment and distribution efficiencies should be noted when comparing fuel prices.)

Still, prices for natural gas should be relatively stable for some years to come, so investments in gaining access to natural gas should receive some attention.

Likewise, energy efficiency efforts, including the consideration of heat retention curtains, should be a top priority for growers who are heating with propane or oil.

Greenhouse curtain function

The utility of the greenhouse energy curtain for retaining heat during the night is well documented by the agricultural engineering community in not only the U.S. and Canada, but also in Europe and Asia. Heat is transferred from the greenhouse to the atmosphere via several modes. Important modes include radiation, infiltration and condensation. Radiation is the transfer of heat from the crop to the sky, and its rate is dictated by the temperature difference between the two objects.

A clear sky is 18 to 45F (10 to 25C)—lower than the outside ground temperature. In the southeastern U.S., if a typical spring night is characterized by a clear sky and a 41F (5C) ground temperature, the sky temperature could be in the neighborhood of -4F (-20C). If we assume a greenhouse set point temperature of 68F (20C), the temperature difference can be 72F (40C). This large temperature difference makes radiative heat loss the most significant mode of heat loss.

More than 70% of heat transmission is through the greenhouse cover, while 5% to 20% is due to infiltration/exfiltration heat loss (see drawing above depicting radiative barrier and attic creation). The greenhouse curtain is designed to be an opaque heat transfer barrier to slow the radiation heat loss. It creates an attic that reduces the infiltration effect.

When greenhouse vents don't seal tightly, wind creates a pressure that draws heated air out of the greenhouse. With the creation of an attic, the wind displaces unheated air rather than heated air. Heated air also carries moisture.

The heat that moves water from the leaf surfaces in the air becomes latent heat. Latent heat is lost not only with infiltration/exfiltration, but from the greenhouse cover when water vapor condenses on the underside of the roof. This is an under-appreciated mode of heat loss. Latent heat released via condensation on the roof increases heat transfer by about 10%.

With the majority of the surface area of the heated greenhouse being the roof, the heat transfer barrier makes a tremendous impact on nighttime heating requirements as these three important modes of heat loss are disrupted.

While usual savings in the heat requirements attributed to energy curtains have been reported in the neighborhood of 50%, savings of as much as 90% have been observed by the use of a highly insulated, reflective night curtain in a greenhouse with a thermally massive floor. For most

operations that are growing a spring crop, an annual savings in the range of 25% to 40% is readily attainable. Realizing the potential savings is dependent upon the curtain selection, hours of use and the quality of installation. The attic must be sealed off well from the growing zone.

The investment and important resources

Return on investment for a greenhouse energy curtain depends on growing season, target plant temperature, location, heating equipment and available fuel. Most systems pay back in less than three years, but some installations are recovered in less than one year.

The USDA has a very user-friendly energy use calculator called Virtual Grower 3.0. This calculator can be used to enter one's greenhouse zone geometry, crop-heating schedule and heating system details. The program uses historical weather data for your region to estimate the required heat input. This information, coupled with an estimate of annual savings, is sufficient to provide valuable investment decision guidance.

Although the economic performance is very attractive, governments and utilities are currently encouraging investments in energy saving technologies. The most widely available program is the USDA Rural Energy for America Program (REAP) Grants and Loan Guarantees. Contact your local office of Rural Development (www.rurdev.usda.gov/recd_map.html) for assistance in filing an application.

The U.S. Department of Energy's Energy Efficiency & Renewable Energy office, in conjunction with the North Carolina Solar Center and the Interstate Renewable Energy Council, has created a continually updated database of federal and state incentives for renewables and energy efficiency (www.dsireusa.org). When searching your state, see opportunities for energy efficiency and agricultural equipment.

The opening strategy is related to both light and temperature

The main effects of closing a curtain are: The reduced light transmission into the greenhouse and, thus, loss of photosynthesis; and increased insulation and the associated gain from fuel conservation. The best time to cover and uncover the curtain is when these two effects are equal. That is, the economic gain from your addition of biomass is equivalent to the cost to heat the space.

Whereas this can be estimated and managed based on a combination of time and temperature, the best technique is to establish solar radiation intensity thresholds. I. Seginer and L.D. Albright demonstrated that for their conditions in upstate New York, along with some assumptions they made in balancing of the photosynthesis and heat loss functions, the best level for the whole year on a year-round crop was about 33 watts (W) per m².

Researchers studying tomatoes in the Netherlands (J.A. Dieleman and F.L.K. Kempkes, 2006) considered the curtain-triggering thresholds of 5 and 50 W/m² and found that the higher threshold reduced energy consumption by 3.5% at a cost of only 0.34% of radiation.

With such a small cost associated with the light loss, it makes it easy to delay the uncovering in the morning and make more thermally productive conditions for the crop by not dropping cold attic air. The higher threshold allows more time for the sun to heat the attic air closer to the growing zone temperature. This, of course, leads us to the real value of having a moveable thermal barrier between the crop and the glazing—to make a more productive climate for the crop. But that's a different story ... winter is coming. **GT**

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