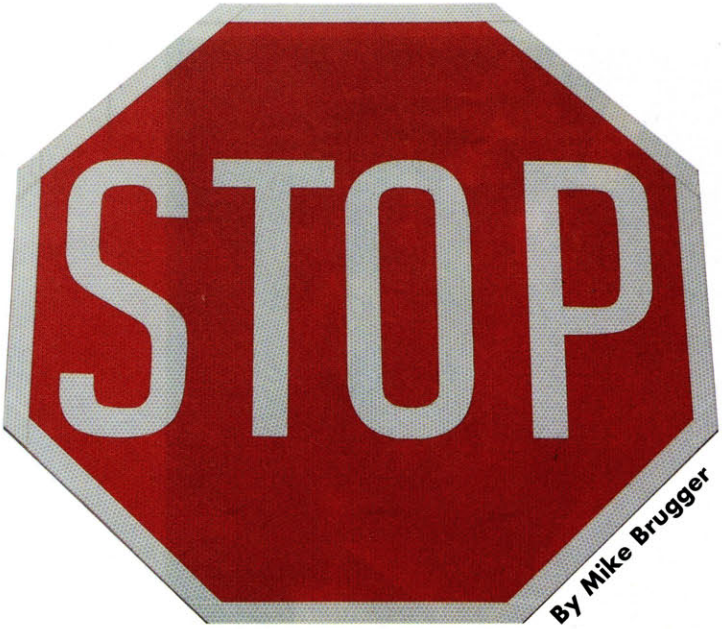


the invisible energy loss

By Mike Brugger

Take the time now to review your energy uses and prepare for the winter.

Many of the major decisions that impact energy use are best made at the time of construction, including greenhouse coverings, heater efficiency, supplemental lighting and energy blankets. For existing greenhouse operators, a review of your facilities can identify opportunities to reduce hidden energy uses and the associated costs.

Proper temperature and humidity sensor calibration and greenhouse location are important even when using an environmental control computer system.

Take time to review your energy uses and prepare for this coming winter. Why should you do this now? Higher energy costs along with low interest rates also mean more savings at less total cost, which can make changes more feasible.

Where energy is lost, what can be done to reduce the losses and the priority for making changes will vary from operation to operation. A review will identify several things that could save you money. The benefits of some of these are very obvious while others may appear to be good money savers at first glance, but may not be so good over the life of the greenhouses. Therefore, after identifying the opportunities; use a reasonable approach to prioritize the changes based on economics and feasibility of making the changes.

New vs. existing structures

When planning new structures, pay close attention to the energy savings that can be easily incorporated into a greenhouse, especially ones that will be difficult or less reasonable to add later. Major decisions that impact energy use include glazing material, motor efficiency, fan efficiency, heating system design, heating equipment efficiency, energy curtains (thermal blankets), water system design, light systems and wall insulation. Evaluate the alternatives and consider their impact on energy use, plant growth and plant quality.

For an existing greenhouse, changes that have major energy savings may be more difficult to incorporate. While energy blankets provide a significant reduction in energy losses, they are often difficult and more expensive to install in existing houses. While the savings from a more efficient fan would not justify replacing a good fan, the more efficient fan can be used to replace a bad fan.

Potential energy savings

Glazing material has the most potential for energy savings. A double-layer covering reduces heat loss over a single-layer covering. Infrared polyethylene films will provide savings over non-IR films by blocking the long wave radiation back to the cold night sky. The savings will be greater on a clear night than on a cloudy night when the clouds provide a warmer surface that is receiving the radiation.

Insulating the side walls up to bench height can provide a good return on investment, even though the total savings in annual heating bills will be small. Energy blankets reduce heat loss by providing an additional insulation layer.

Selecting energy-efficient ventilation equipment will reduce energy costs and can provide a good return on investment. Keeping fans and louvers clean so they will provide maximum airflow provides more efficient energy use.

Environmental controls

Greenhouse environmental controls should maintain the desired environmental conditions without using excessive energy and should effectively use energy to reduce other costs, such as pesticide applications. Accurate measurement of the plant environment is required to obtain the best performance with the least costs.

Greenhouse controls that are not accurately measuring the temperature can result in increased energy losses. For example, a 1-acre greenhouse with 16-foot side walls has a wall and roof surface area of 57,000 square feet. For each 1°F increase in greenhouse temperature above the required temperature, a glass-covered greenhouse loses 62,600 Btu per hour and a double-layer polyethylene film-covered greenhouse loses 39,800 Btu per hour.

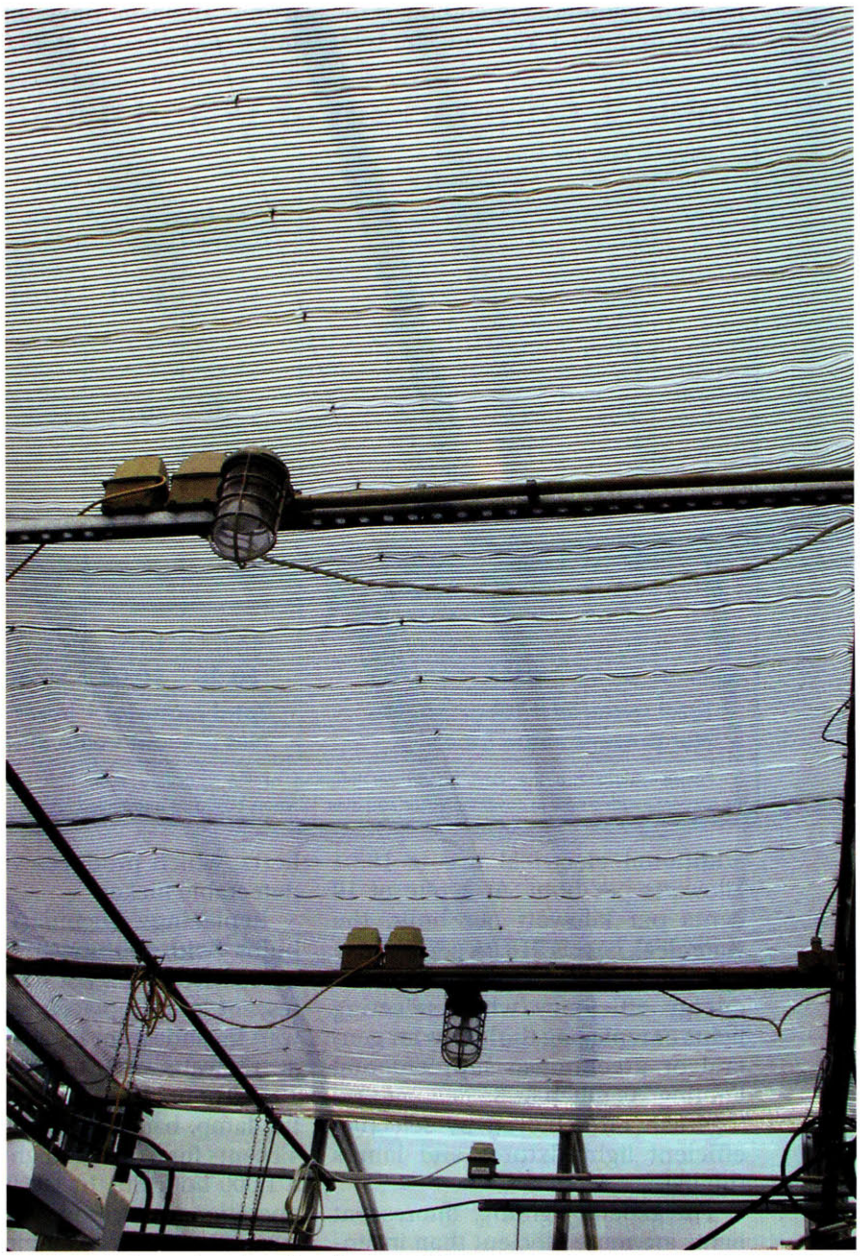
This greenhouse has a volume of 871,200 cubic feet. For each 1°F increase above the required, the infiltration heat loss is 8,000 Btu per hour with one air change every two hours. The total heat loss per degree increase in temperature is 70,000 Btu per hour for the glass greenhouse and 47,800 Btu per hour for the double-poly-covered greenhouse. For a 12-hour heating period, the daily extra energy required for just 1°F increase in temperature is 840,000 Btu for the glass greenhouse and 573,600 Btu for the double-poly house.

Reducing energy costs

• **Properly calibrate sensors.** To reduce energy costs, be sure that the sensors are properly calibrated. One approach is to place a calibrated thermometer beside the sensor and compare readings. An ice bath consisting of a mixture of ice and water provides a 32°F reference. With electronic sensors, check calibration at several points. A sensor with non-linear output can be accurate at one temperature and off at other temperatures.

Locate temperature sensors so they provide a representative reading of the greenhouse temperature. A sensor located in an unusually cool area will overheat the rest of the greenhouse.

Using a good thermometer, do a temperature survey at many points throughout the production area. If there are significant variations, look for causes and means to reduce them. Variations can be caused by many fac-



Energy curtains reduce heat loss by providing an additional insulation layer.

tors, including unplanned openings in the covering and the variability of the heating system. Consider installing horizontal-airflow fans to even out the temperatures.

• **Consider motor efficiency.** Motor efficiencies affect electrical use. When purchasing equipment or replacement motors, look at motor efficiency. A more efficient motor uses less energy and has an associated savings in energy costs.

• **Eliminate water leaks.** Overlooking small water leaks or excessive irrigation can add up. Leaks include the pumping cost if you have your own well or increased cost for purchasing water. For example, consider a water leak that causes a 1 horsepower pump to run an additional 30 minutes per day. This results in 182.4 hours of additional operation. If the pump requires 1 kilowatt, the total additional electrical use is 182.4 kilowatts per hour. At a rate of 10 cents per kilowatt per hour, the water leak cost is $18.24 per year.

• **Select efficient lighting.** Consider energy efficiency when selecting lights or replacing the lamps for general or greenhouse supplemental lighting. As much as 65 percent savings can be achieved by selecting efficient light fixtures and lamps (bulbs).

For general lighting, fluorescent lights are more efficient than incandescent lights.

Energy is used both in the lamp and the ballast. Lights with the same bulb wattage can use different levels of total energy. Lamps with electronic ballasts use less energy.

T-8 lamps with electronic ballasts are one of the more energy efficient. T-8 lamps are rated at 32 watts versus the 40 watt rating of the T-12 lamps.

Fluorescent lamps require a ballast to start the flow of electricity through the gas to create the light and control the flow of electricity once the lamp is started. In the past, electromagnetic design was used. The lamps operated at 60 hertz and had several drawbacks, including noise, light flicker, heat generation and PCB contamination. Today, electronic ballasts are an alternative. In addition, electronic ballasts have no audible noise and operate at 20,000-25,000 hertz, which produces virtually no detectable flicker.

Replacing incandescent light bulbs with compact fluorescent bulbs saves energy. A compact fluorescent lamp replacement for a 60-watt incandescent light bulb is rated at 13 watts at 710 lumens and a 10,000 hour life. The cost is $19.53 for the lamp, ballast and holder versus 49 cents for a 60-watt light bulb with a 1,000 hour life. In 10,000 hours of operation, the compact fluorescent costs $19.53 for the lamp and uses 130 kilowatts per hour The incandescent lamp costs $4.90 (10 lamps at 49 cents each) and uses 600 kilowatts per hour. At 10 cents per kilowatt per hour energy costs, the total cost for 10,000 hours is $32.53 for the compact fluorescent lamp and $64.90 for the incandescent lamp.

In large spaces, consider high-intensity discharge (HID) lamps, which are even more efficient. Common HID lamps are mercury, metal halide and low-pressure sodium.

Because mercury lamps are the least efficient (50 lumens per watt) and greatly reduce light output over the life, they are not recommended. Metal halide lamps are more efficient and provide a fuller light spectrum. They are used where light color is important.

Low-pressure sodium lamps are the most efficient, have the longest life and maintain their light output better than any other lamp; but produce a distinct yellow color. They are used for greenhouse supplemental lighting and space or outside lighting when the color spectrum of the lamp is not critical.

Because HID lamps require some time to come up to full lighting, consider installing some incandescent or fluorescent lamps in spaces with HID lamps. Use incandescent or fluorescent lamps when passing through the space or full lighting is not required.

Determining the economics

Before determining what changes should be made, each option needs to be fully evaluated. Growers should work with an accountant to complete an appropriate analysis for their specific operations.

Many times the expression "It will pay for itself in X years" is used (X is the number of years required for the savings in operating costs to equal the initial purchase price). This approach is acceptable when comparing options that accomplish the same task without any affect on other inputs or outputs. Either option should result in the same product quality, same growing period, same inputs, etc. When other inputs or outputs are affected by the decision, other methods of economic analysis that account for the other impacts need to be used.

An example is selecting between fan A and fan B. Both move the same amount of air, but one moves 22 cubic feet per minute per watt while the other moves 18 cfm per watt of electricity. If both move 10,000 cfm,

Table 1. Comparison of 1- and 4-year film

Inflation rate 4% Interest rate 6%

	1-year film			4-year film		
Year	Investment $/sq. ft.			Investment $/sq. ft.		
	Material	Labor	Future for material and labor	Material	Labor	Future for material and labor
0	$0.03	$0.01	$0.042	$0.07	$0.01	$0.08
1	$0.03	$0.01	$0.044			
2	$0.03	$0.01	$0.046			
3	$0.03	$0.01	$0.047			
4	$0.03	$0.01	$0.049	$0.07	$0.01	$0.09
5	$0.03	$0.01	$0.051			
6	$0.03	$0.01	$0.053			
7	$0.03	$0.01	$0.055			
8	$0.03	$0.01	$0.058	$0.07	$0.01	$0.11
9	$0.03	$0.01	$0.060			
10	$0.03	$0.01	$0.062			
11	$0.03	$0.01	$0.065			
12	$0.03	$0.01	$0.067	$0.07	$0.01	$ 0.11
Subtotal	**$0.42**	**$0.13**	**$0.70**	**$0.28**	**$0.04**	**$0.40**
Total material + labor $0.546				**Total material + labor $0.324**		
Net present value $0.46				**Net present value $0.34**		

Future values are the cost based on inflation at the specified rate. Net present value is the amount needed now to cover the entire cost over 12 years based on a specified rate of inflation.

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then fan A uses 454 watts or 0.454 kilowatts while fan B requires 555 watts or 0.555 kilowatts. It is projected that these fans will be running half the year or a total of 1,752 hours. The electricity uses for the two fans are:

Fan A: 0.454 kilowatts x 1,752 hours = 765 kilowatts per hour

Fan B: 0.555 kilowatts x 1,752 hours = 972 kilowatts per hour

The savings from using fan A is 207 kilowatts per hour per year. Assuming electricity costs 10 cents per kilowatt per hour, the annual savings is $20.70. Fan A costs $75 more than fan B. Therefore, the pay back period is $75/$20.70 per year = 3.6 years.

Another approach is to look at the return on investment. Investing $75 for the more efficient fan saves you $20.70 per year for each fan. This is a rate of return on the investment of 27.6 percent. The rate of return is the same as investing the money and receiving interest at that rate.

Evaluating costs

Other options require an initial investment and then different future investments over the planned life. Some do not have any

Insulating the north and side walls to bench height can save energy. Even though the savings is a small percentage of the total heating load, there is a good return on the investment.

difference in operating cost so there is no annual savings and, therefore, no years for the savings to pay back the costs. In these cases, an evaluation should look at which option costs the less over the useful life — the life of the longest-lasting option or a specified period that will clearly reflect the differences.

An example is plastic films with different useful lives and the same thermal and radiant energy-transmission characteristics. With plastic films of the same radiant energy-transmission properties, all other inputs and outputs will be the same. Looking at the costs of each system over a specified reasonable life that provides for several periods of additional investment provides a more complete story.

Table 1 on Page 58 shows the annual investment for labor and material in current dollars and the total for material and labor in inflated dollars for each year for 1- and 4-year films. Over 12 years, $0.70 per square foot will be spent on the 1-year film while $0.40 will be spent for the 4-year film. Based on the rate of inflation, the net present value, which is the amount of money that needs to be set aside now, can be calculated using appropriate tables. For 1-year film, $0.46 needs to be set aside while the 4-year film requires $0.34.

Considering new IR films requires additional analysis to account for the energy savings associated with the reduced radiant heat loss. The value of energy savings needs to be added into the analysis.

Consider all costs, options

Some options to consider include different initial costs. An example is comparing a glass-covered greenhouse to a double-poly film-covered greenhouse. Structural costs for a glass house are different from a poly-covered house. Also, there will be a difference in annual operating costs. These factors need to be considered in the analysis.

Others options have an impact on the productivity of the greenhouse. For example, root-zone heating can decrease a crop's production time. These benefits need to be included in the analysis.

Often low-cost, simple options are not considered because the savings is small in comparison to the total operating costs. An example is insulating the side walls of a greenhouse. The reduction in heat loss when compared to the total heating loss does not justify the investment. However, the investment in insulation is cost-effective and can have a high return on investment.

In addition to the economic analysis, look at how an option may be added later. If funds are tight, investing in a higher-return component that can be easily added later may be delayed while including a lower-return component that is difficult to add later.

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