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# Ten Ways To Heat Your House

Now that the winter heating season has started, it's a great time to evaluate your production practices and think of ways to heat more sustainably next winter.

Improving your greenhouse's fuel efficiency is a great way to become more sustainable. It reduces the environmental impact of your business by reducing fuel usage and your carbon footprint. Improving fuel efficiency is also good for your bottom line; many improvements in the sustainability of your greenhouse heating system will save money by lowering fuel costs.

Over the past few years, the creativity of growers and Extension professionals in their approaches to save fuel has inspired us. Here are 10 creative ideas for improving the sustainability of greenhouse heating:

**1. Change your fuel source.** The cost of traditional fuel has fluctuated, and in some cases, doubled over the past 10 years. Some growers have decided to switch to some very unusual fuel sources rather than wait for the next increase in fuel prices. At Laughing Stock Farm in Freeport, Maine, Ralph and Lisa Turner are refining waste cooking oil from local restaurants to heat their greenhouses. The restaurants provide this oil at no cost since they would normally pay to have it removed and disposed. This creative fuel source saves money for the Turners and the local restaurants. It also reduces the amount of waste oil going to waste facilities. Other alternate fuel sources include wood chips and waste corn.

**2. Grow bedding plants in high tunnels.** For cool crops or later spring sales, consider growing without heat in a temporary structure. A high tunnel, or unheated polyethylene covered greenhouse, only costs \$1.00 to 2.00 per sq. ft. to build. High tunnels provide shelter from wind and rain and somewhat warmer temperatures than outdoors. However, high tunnels are not a perfect solution; night temperatures are often the same temperature as outdoors and occasionally cooler. High tunnels excel on cool sunny days when they trap heat for much warmer day temperatures than outdoors. The temperature averaged across the day and night is important for driving plant development. Therefore, high tunnels help plants grow faster than outdoors, although, slower than in a heated greenhouse.

In a high tunnel at Cornell University (Ithaca, New York) the average air temperature from April 1 to May 15, 2008, was 58F (14C); outdoor average temperature was 53F (11C). We looked at the finish time of five bedding plant species transplanted into 4-in. pots on April 1 (Table 1). Compared to our heated greenhouse (average temperature 65°F [18C]), there was only a slight delay in flowering in the high tunnel. >>>

	High Tunnel Flower Date	Greenhouse Flower Date
Marigold Safari Orange	May 1	April 26
Pansy Delta Formula Mix	May 10	May 9
Petunia Dreams Midnight	May 4	April 29
Snapdragon Montego Mix	May 11	May 4
Zinnia Dreamland Mix	May 6	April 30

Table 1. Average flower date of bedding plants transplanted April 1 and grown in a high tunnel or heated greenhouse.

# Heating Solutions

**3. Add root-zone heat.** One of the problems in using a high tunnel is the risk involved—one night of hard frost could destroy your crop. The other difficulty is that because you can't control the indoor temperature, your crop may finish later than your market window. If you're using a high tunnel, a low-tech (read: low-cost) heating solution may be right for you. A household gas or electric hot water heater provides root-zone heat. Huguenot Street Farm in New Paltz, New York, successfully uses an electric hot water heater to start vegetable transplants in mid-March in their 1,500 sq. ft. high tunnel (pictured right).

Their heating costs for the spring season are \$125.00. Ron and Kate Khosla offered some tips: place foam insulation board on wooden benches, then place rubber tubing on top. This keeps heat at the root zone. They re-wired their 80-gal. heater so both heat elements operate at the same time, providing more heating power during cold nights. Reemay fabric provides a secondary cover to further trap heat on cool nights. Finally, the Khoslas note that only 500 sq. ft. of their tunnel is heated bench space. The rest of the floor space is used for hardening off transplants before they go outside.

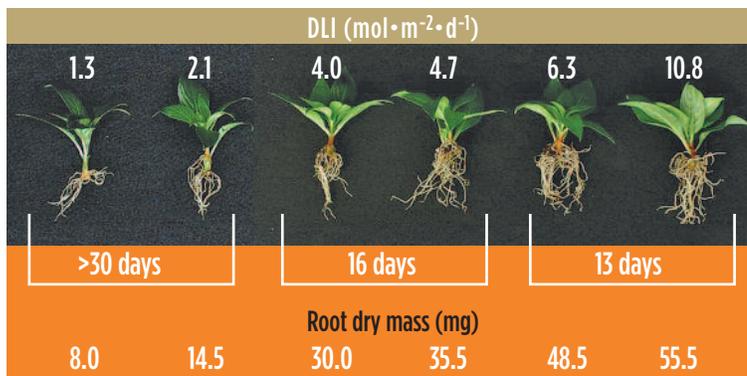


An electric water heater and rubber tubing is used to provide root-zone heat to this high tunnel. Hoops used for the Reemay fabric providing secondary cover are visible in the background.

**4. Know the photoperiod requirement of your crops.** Many bedding plants have a photoperiodic flowering response; long (LD) or short days (SD) promote flowering. When scheduling crops, take the time to identify if the crop has a photoperiod response so you can increase the accuracy of your production schedule and thus reduce timing and increase fuel efficiency.

If you want to sell your plants in color, knowing how to induce flowering will help you get your crop ready for your target sales date. If you're growing plants under a non-inductive photoperiod, you'll increase production time just waiting for them to flower! Let's say you want Crop "B" in flower for Memorial Day Weekend sales, Week 22. It's a SD plant that flowers about five weeks after the start of SD. To get plants flowering by the target sales date, you'd want to start SD around Week 17.

## New Guinea impatiens 'Harmony White' cuttings after 16 days of propagation



For example, as propagation DLI increased from 1 to 11 mol·(m<sup>-2</sup>·d<sup>-1</sup>), time to produce a liner of New Guinea impatiens Harmony White decreased from greater than 30 days to approximately 13 days (picture above, left). In this scenario, a grower who uses supplemental lighting during propagation would save on 17-plus days of heating! >>>

**5. Know the power of supplemental lighting.** Daily light integral (DLI) is an important environmental variable that should be measured in every greenhouse. It refers to the cumulative number of light particles or photons received each day in a particular area expressed as moles of light (mol) per square meter per day (or mol·m<sup>-2</sup>·d<sup>-1</sup>).

DLI can influence root and shoot growth of seedlings and cuttings, finished plant quality, and most importantly, timing (energy savings). Research conducted at Michigan State University and Purdue University has indicated that as DLI during propagation of unrooted cuttings and seedlings increases, rooting, biomass accumulation and quality generally increases, while propagation time and subsequent time to flower generally decreases.

# Heating Solutions

**6. Virtual Grower.** The USDA has developed a program that allows growers to estimate fuel heating and electricity costs for supplemental light, and predict the growth of certain crops. The best part of this powerful software is that it's free! Once you've downloaded and installed the program you can "build" a virtual greenhouse specifying the dimensions, covering type, heat source and fuel source. You can then program the temperatures used on your crops throughout the year. Virtual Grower will then calculate fuel costs.

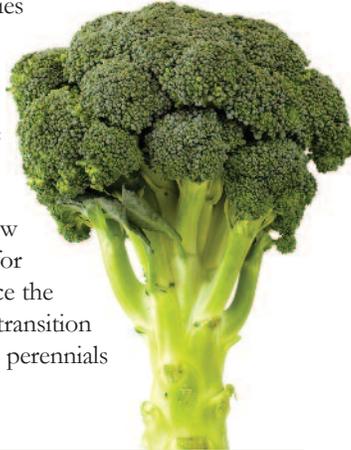
Virtual Grower is very flexible, so take some time to get to know it and see what you can save by making changes to your greenhouses and production.

Download Virtual Grower at

<http://www.ars.usda.gov/research/docs.htm?docid=11449>.

**7. Grow cold-tolerant crops.** Many greenhouse-grown crops are heat-tolerant, like annual vinca (70F/65F [21C/18C] day/night), pentas (72F/62F [22C/16C] day/night), New Guinea impatiens (68F/65F [20C/18C] day/night), and basil (75F/65F [23C/18C] day/night). If you grow in the coldest regions of the country, consider minimizing the number of heat-loving plants you grow, and focus on choosing cold-tolerant crops. For example, broccoli or ornamental cabbage and kale (55F/50F [12C/10C] day/night), pansies (65F/60F [18C/15C] day/night), and osteospermum (55F/45F [12C/7C] day/night) could be grown at much lower temperature set points.

This change may allow you to reduce the greenhouse temperature set point and save fuel. Some growers have started creatively using this concept during the coldest winter months. Everlasting Farms in Bangor, Maine, grew lettuce, kale, bok choy and other cold-loving vegetables for the local food market this winter. During the spring, once the outdoor temperatures begin to warm up, it's cheaper to transition into growing bedding plants, specialty annuals and other perennials that require warmer temperatures.



**8. Store excess heat in water tanks.** This process can be expensive, complicated and high-tech, but can also be very simple and easy. In sophisticated systems, the primary boiler used for greenhouse heating actively heats water continuously. This type of set-up avoids running a boiler at maximum capacity (low efficiency) when heat is needed the most, but instead requires a boiler to be run at optimum efficiency, 24 hours a day. In this scenario, the boiler is over-producing heat during the day but under-producing heat at night. The excess heat during the day is stored in a large (in the order of tens of thousands of gallons, depending on your greenhouse size) holding tank. Heat is then extracted from the tank during portions of the night when the boiler is under-producing heat. Running a boiler constantly offers fuel efficiency over cycling it on and off over the course of a day.

A low-tech method built on the same principle of storing heat in water can also be utilized. Think about how areas near large bodies of water have more moderated temperatures than those areas farther inland; the water in the ocean or lake acts as a buffer. Storing large amounts of water in the greenhouse near your crops can do the same thing. In an operation in New Hampshire, the grower has filled all unused space under the benches with 50-gal. drums filled with water. This water heats up due to solar gain during the day and acts as the buffer during cooler nights.

**9. Insulate the perimeter of your greenhouse.** This has one of the shortest paybacks on investment (potentially less than one year according to John Bartok). If you are constructing a new structure, consider adding a 1- to 2-in. rigid foam insulation below grade, 18 in. to 24 in. deep, around the perimeter. At a depth of 24 in., the costs should be around just over \$1.00 per linear foot. Although more difficult, you could also add this perimeter insulation below grade to existing houses. If you're dealing with existing structures and the thought of digging an 18- to 24-in. trench around the perimeter of your greenhouse sounds less than exciting, think about other places you can insulate easily. The glazing materials we use are excellent at transmitting light, but also lose heat easily. Often, there is a considerable amount of greenhouse glazing that provides little to no benefit to light transmittance. Think about the 2 ft. to 3 ft. below your benches; adding a layer of insulation in these areas translates into substantial savings.



Insulation of the greenhouse perimeter saves heat.

**10. Use a larger plug size.** While larger-sized plugs are more expensive per plant, they produce a finished crop more quickly. At Cornell, we transplanted Petunia Wave Purple plants into hanging baskets on April 8. Plants came from 144-, 288-, or 512-cell plug trays. On May 27, containers with 144- or 288-cell plants were considered marketable (having 15 to 20 flowers each), while baskets with 512-cell plants averaged only one flower. In general, consider larger plugs if this allows you to delay heating a greenhouse for two weeks. If a space will already be heated, then you might as well use it and transplant smaller plugs earlier.

Heating sustainably can involve changing a small aspect of your greenhouse or production schedule, or making a larger investment. Hopefully, these ideas will give you some creative heating solutions to integrate into your business in order to reduce heating costs. **GT**



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