Flower & Nursery Report

for commercial growers

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CONTENTS

GREENHOUSE ENERGY NOTES—5: ENERGY CONSERVATION IDEAS

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Ideas and actions that have helped reduce energy use in California greenhouses are shown in the sketches that follow. Only a limited number of these will be appropriate for your particular greenhouse and conditions.

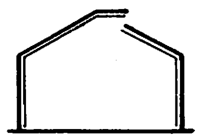
If you are looking to alternate energy forms, such as solar, wind, geothermal, photovoltaics, waste heat, etc., remember that most of the ideas below are aimed at conserving energy, which is a necessary step to make alternate energy economical.

To reduce loss of energy once its generation and distribution to the greenhouse has been made as efficient as possible, look at the greenhouse structure itself to see where energy is lost. Values in the table below indicate where heat is lost in a typical large, unmodified, California greenhouse range of glass, fiberglass or single-layer polyethylene.

Heat Losses in Typical California Greenhouse Range

Area	Percent of Heat Loss
Walls	9%
Gable ends	2%
Roof	68%
Infiltration	21%

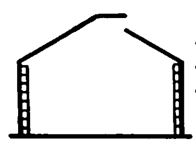
Note the high percentage of heat that can be lost through a greenhouse roof. Reduction of this loss is done primarily through materials selection and insulation in a manner that will not reduce light to a harmful level. Infiltration (air leakage) is the next big cause of energy loss, and some methods for reducing unwanted air leakage are indicated below.



Inner Lining
- Poly, air cell, etc.
- Permanent
- Good under glass
- Watch light under fiberglass

Save 40-50%

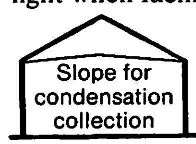
An inner lining of light-transmitting material, such as clear polyethylene, insulates a greenhouse wall or roof by providing a stagnant air layer between the materials—and perfectly stagnant air with an R value of 4.9 per inch of thickness is an excellent insulator. Additionally, such a layer will "tighten" the greenhouse and reduce unwanted air infiltration. This is one of the most cost-effective methods of reducing energy loss. If your plants have a high light requirement, try this in a small section of your greenhouse to test its effects on plant growth and quality. If polyethylene film is used, 6-mil is recommended because it is mechanically stronger than thinner materials and should last at least 4 years.



Wall Insulation
- Permanent
- Clear poly and airspace
- Air cell
- Rigid board insulation (Thermax, etc.) on north and east

Save 5-10%

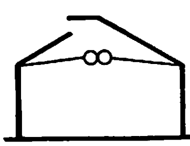
Wall insulation can be made with an inner layer of light-transmitting material enclosing a dead air space, but some growers have successfully made permanent installations on the north wall, and sometimes on the east wall, with rigid insulation boards, generally ¾" or 1" thick of rigid foam materials. In metal-frame greenhouses, these boards can often be cut for a pressure fitting to reduce installation labor. A board with a reflective surface will add light when facing the sun.



Permanent Sub-roof
- Clear poly-6 mil
- If: heat is below no ridge vent light is ok

Save 20-30%

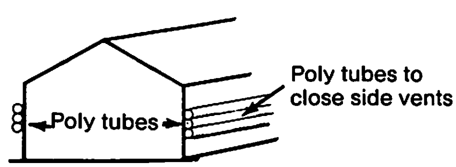
A permanent sub-roof of a light-trans-mitting material, such as clear polyethylene, is a very cost-effective method of insulating some greenhouses. Generally, this is easier to use in wood-frame greenhouses than in those with metal frames. Also, the greenhouse should not have a ridge vent, and any heating must be below the sub-roof. This provides a stagnant insulating air layer between the roof and the sub-roof, reduces the heated volume, and reduces infiltration losses. Although it is an effective energy conservation measure, it does reduce light which might reduce its value for some plants.



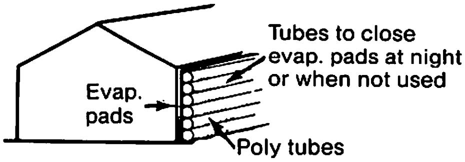
Permanent Sub-roof with poly tubes
- If: Ridge ventilation heat is below light is ok

Save 20-30%

A permanent sub-roof can be combined with inflatable **poly tubes** when ridge vents are used with daytime ventilation. Other comments apply as in the paragraph above.

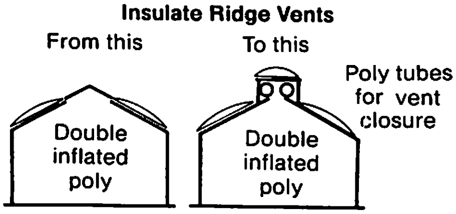


Polyethylene tubes can be used effectively to close greenhouse sidewalls. Many greenhouses in warmer areas need drop sidewalls or removable planels for sidewalls either for loading and unloading the greenhouse or for ventilation. Heat loss through such closures at night can be excessive. Inflatable polyethylene tubes provide excellent night insulation when they are inflated to fill an open sidewall space. They can be deflated when a sidewall opening is needed for ventilation or for handling products.



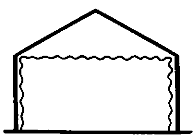
Polyethylene tubes can also be used to reduce air flow and heat loss through evaporative pads where these are used for greenhouse cooling. When these pads are not in use, inflate a series of poly tubes to close off and insulate the pad area. The tubes are equally effective outside or inside the greenhouse but should last much longer if located inside and not exposed to sunlight.

Insulate Ridge Vents



Best suited for wood frames

To insulate ridge vents the system shown above has worked well but has limited application. A wood framework can sometimes be constructed to replace an existing ridge vent (easiest in a wood-frame greenhouse) so as to support one or more inflatable poly tubes that can be deflated when ventilation is required.



Night heat curtain

- If: Heat is below eve reduction in night heat loss
- Polytubes 38%
- Clear 4 mil poly 40%
- Foylon 55%
- Tyvek 57%

Save 40-50%

Night heat curtains or thermal blankets have reduced night fuel use in greenhouses as much as 60 percent in some East Coast greenhouses. There have been several recent installations in California greenhouses, and early results from a test in one San Mateo County glasshouse indicates probable night fuel savings of 48 percent or more.

Blanket materials are pulled gutter to gutter, truss to truss, or gutter to ridge (least effective) each evening and withdrawn in the morning, either automatically or manually. They operate much as photoperiod blankets and, as a matter of fact, photoperiod blankets make effective thermal blankets and should be used if you now have them in your greenhouse.

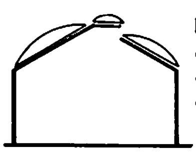
Thermal blankets reduce the greenhouse space to be heated at night, form an insulating dead air space between the blanket and the greenhouse walls and roof, and reduce some of the thermal (low-temperature) radiation loss of heat from plants and soil that moves through some greenhouse cover materials, particularly polyethylene.

Blankets are made of many types of materials and supported by tracks, cable, wires or combinations of all three. Blankets should seal tightly at the edges to reduce air movement and air infiltration.

There is no one best material for blankets, but they should be thin and fold compactly when stored for the least possible reduction of sunlight. Opaque materials with a reflective lower suface generally conserve the most energy. Porous fabric blankets allow moisture movement through them so that condensation "bulges" (from condensate collection on the supper side) are eliminated. Some California growers feel that greenhouse humidity problems might be less with porous blankets. Some growers prefer clear polyethylene blankets because they can remain pulled longer in the morning and allow light into the greenhouse. An excellent combination would be a two-layer blanket with a porous fabric layer below and an opaque material above.

Because of tension created by support wires or cables, some growers have found it necessary to reinforce some greenhouse structural members that tended to buckle.

You should consider thermal blankets as an effective enegy conservation measure, but you should check with a grower who has made such an installation to benefit from his experiences.



Double Inflated Poly

- By itself
- Over glass (watch light)
- 6 mil top—4 mil under

Save 25-40%

Double inflated poly is commonly used to cover California greenhouses because of its relatively low cost, good light transmission, and its inherent energy savings compared with a glass or fiberglass shell. Double poly replacing glass or a single layer of poly should reduce night energy use 38 to 40 percent; it will reduce energy use about 30 percent if it replaces fiberglass. Light will probably be about 10 percent less under double poly than under glass or single poly. The light transmission of new fiberglass and a new double polyroof will be about the same, except that light under fiberglass is more diffused, which may be an advantage for some crops. We usually mean polyethylene when we speak of "poly" but also available are good commercial non-polyethylene films of polyvinyl and polyester compositions.

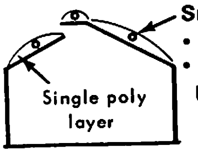
A 6-mil film is recommended for the top layer of a double poly cover with a 4-mil film for the bottom layer. This combination should easily last two or three seasons. On the other hand, some growers prefer to replace the film each year if they have crops with a high light requirement because light transmission of polyethylene film decreases with age.

Polyethylene film transmits about the same amount of sunlight as glass or fiberglass but reacts differently to low-temperature radiation (radiation from plants, soil and other objects in the greenhouse). While glass and fiberglass will transmit only a small amount of this low-temperature radiation (3 to 8 percent), and effectively keeps this source of heat within the greenhouse, polyethylene film will allow much of it to escape to the atmosphere outside the greenhouse. A single layer of polyethylene film transmits about 80 percent of low-temperature radiation and a double air inflated layer transmits about 63 percent). This is one reason that thermal blankets are more energy effective in a poly house, and also the reason that overhead steam pipes should be particularly lowered in a poly-covered house.

Remember too, that part of the energy advantage of a double poly house is the "tightening effect" and consequent reduction of infiltration heat loss. This same effect can increase greenhouse humidity, which can present potential problems.

Double air inflated poly is added to some existing glass houses in colder areas of the country, with reported energy reductions of 56 percent. This is also accompanied by a reduction of light of 14 percent or more. It is doubtful that this is appropriate for our milder California climates. A single-layer addition of polyethylene film over an existing glasshouse can be used beneficially in many California areas.

Add Single Layer of Poly
If light under double layer is unacceptable



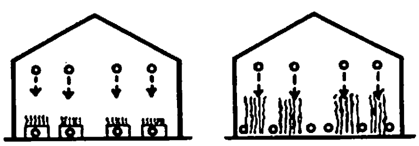
Small inflated poly tubes to:
- Tighten poly
- Form insulating air space

Use for roofs or endwalls over glass or fiberglass
Save 25-35%

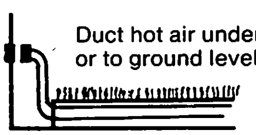
A single layer of poly over glass or fiberglass has been successfully used in California for added energy conservation. A double-layer inflated poly addition over glass or fiberglass is used in some colder regions of the country but probably is not so appropriate for our milder California conditions. On the other hand, a single-layer addition of poly under or over a glass or fiberglass roof does fit in with most California conditions and should reduce night energy usage 25 to 35 percent.

Where it is difficult to add a poly layer under a roof, add a single layer on top supported by a small non-perforated tube. The inflated tube will tighten the sheet and form an insulating air space between the new poly and the existing roof. One grower used a 30-inch tube and ½-inch pressure that resulted in a 15-inch separation between poly and glass. This worked well and withstood strong winds but the grower feels that an 18-inch tube will be better for his next installation.

Lower Heat Source

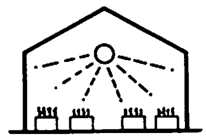


Under benches—or—near ground level



Duct hot air under benches or to ground level

You should **lower the heat source** in your greenhouse range where possible. In many older installations steam or hot water lines, perforated poly tubes, or warm air discharge from unit heaters are often above plant level—this is convenient because they thus do not obstruct the work area of the greenhouse. There are many reasons now why all of these heat sources should be brought down near ground level: (1) the heat source is brought nearer plant level where it is more useful; (2) less heat is wasted to the upper ridge area of the greenhouse; (3) it is necessary for the installation of thermal blankets or permanent clear poly subroofs (recommended for energy conservation); (4) there is increasing experimental evidence that heating the root zone or soil area might be beneficial for some crops and permit reduced greenhouse air temperatures and result in less energy requirements for heating; and (5) it should be recognized, with the increasing use of polyethylene films with their high rates of transmission loss for low-temperature thermal radiation, that steam pipes, for example, can transmit as much as one-half of their heat by radiation and much more of this will be lost through the poly roof if the steam pipes are at a high level in the greenhouse.



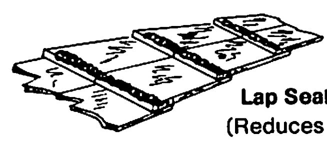
Infrared Heat
Saves 10-30%

Infrared heating systems, now available commercially, consist of a number of burners (natural gas or propane) that heat connecting steel pipes to high temperatures. The entire system is suspended from the greenhouse roof. Specially-designed metal reflectors over the pipes direct heat downward and warm plants and soil directly by radiation.

Infrared heating is reported to use less energy because: (1) the burner design, with an associated vacuum system, provides a higher combustion efficiency (about 90 percent) than most boilers or unit heaters, and (2) air temperature requirements for plants are less (how much less is not really known yet).

Several California growers are experimenting with infrared heating. After two months of tests, one grower reported a fuel savings of 50 percent with infrared heating of cuttings (short plants on benches). Another grower has reported a fuel saving of 20 percent when heating roses by infrared. This heating system is under test in a cucumber greenhouse but it is too early to tell how it is working.

Theoretically, infrared heating should be an effective energy-saving system, particularly for low-growing plants. Its use for tall plants such as roses needs some study.



Lap Seal for Glass
(Reduces infiltration)
Saves 5-40%

Sealant for glass laps is intended to reduce infiltration heat losses in glass greenhouses. "Lapseal," a product of Young Energy Systems, Rochester, N.Y. is one such product. The extent of energy savings depends on the condition of the house and the windiness of the location.

Sealants are generally applied commercially after dirt and moisture are first blown from between glass laps. A clear silicone-based sealant is injected to fill the glass lap space. It is nonhardening and will maintain a seal during glass expansion and contraction, and it prevents glass slippage.

A glass lap sealant is useful where high-light crops are grown under glass and where there might be a concern with any reduction of light that might be caused by adding a layer of polyethylene to a glasshouse to reduce air leakage.

Lower minimum night temperatures will reduce nighttime fuel consumption in California greenhouses about 3½ percent for each degree F the minimum temperature requirement is reduced. Certainly, there is no point in lowering temperatures if your cropping time is increased, or if yield and quality are reduced, but you should be aware of the importance of maintaining temperatures no higher than you need. You should check your thermostats and controls frequently to see that they give you a proper temperature.

Considerable research is under way related to "split-night" temperatures as a means of reducing energy requirements. This is a concept of growing plants under normal night temperatures for part of the night and under lower temperatures the rest of the night. The results of such a concept have been mixed. One Santa Clara County chrysanthemum grower maintains 60°F until 11 p.m. and then reduces the temperature to 53°F with no apparent loss in production or quality.

Increasing bench space, or growing space, within the greenhouse will reduce energy use per unit of plant produced. Movable benches allow most of the aisle space to be used for growing. Many of the current bench arrangements use only 60 to 70 percent of useable space—movable benches can increase this to 85 or 90 percent or more, and reduce the required energy per plant unit by 25 percent or more. Commercial movable bench systems are available but several California growers are making their own, especially as they replace older benches. The benches sit on a long 1½ to 2-inch diameter pipe that rolls on cross supports. One pipe is the full length of each bench and shorter pieces support the bench at the cross supports. The bench moves laterally by rolling the long pipe so that an aisle can be created between any two benches.

When there is enough light, many growers hang crops, using overhead space by growing hanging baskets over aisles and benches. This can reduce per plant energy use as much as 20 percent.

Some growers also grow crops under benches, reducing per plant energy use by 10 percent. One foliage plant grower in southern California gets five crops per year on top of the bench and two per year under the bench.

Maximize the use of heated greenhouse area where possible.

Aerated steam has been reported to reduce soil sterilization energy use by 30 percent. Where growers must treat media in their production operation there are advantages in using aerated steam, where steam is mixed with exhaust air from a blower and then moved through the media. The temperature of the media cannot be higher than the aerated steam, usually kept below 160°F. Pasteurizing a soil mix at 160°F for 30 minutes requires about 30 percent less fuel costs than treating with steam only, at 212°F.

Most weed seeds are inactivated when exposed to 160°F for 30 minutes and most pathogens of greenhouse plants are eliminated by treatment at 140°F for 30 minutes. There can be an over-kill of soil microflora with use of line steam at 212°F and this can lead to the proliferation of unwanted pathogens in treated soil.

Treating with aerated steam can be done by a batch or continuous flow method.

T. E. Bond is Area Energy Advisor—Greenhouses, Cooperative Extension, Salinas. *The author wishes to thank James F. Thompson, Agricultural Engineer, Cooperative Extension, Davis, and Ray F. Hasek, Horticultural Specialist, Cooperative Extension, Davis, for assistance with this publication.*