

CHECKLIST

ENERGY CONSERVATION FOR GREENHOUSES AND FIELD NURSERIES

Increasing energy costs make conservation and efficient use of facilities an important part of today's greenhouse operation. New greenhouse designs, better glazing, improved heating and ventilating equipment and new management systems should be included when upgrading or adding on. With typical annual energy usage being 75% for heating, 15% for electricity, and 10% for vehicles, efforts and resources should be put where the greatest savings can be realized.

Reduce Air Leaks

- ✓ Keep doors closed - use door closer or springs.
- ✓ Weatherstrip doors, vents, and fan openings. For example, a 48-inch fan louver that fails to close properly leaving 1-inch gaps, allows 23,000 Btu/hr of heat to escape, costing \$0.35 if you are burning \$1.50 fuel oil.
- ✓ Lubricate louvers frequently so that they close tightly. A partially open louver may allow several air changes per hour. Additional fuel is needed to heat this air. Shut off some fans during the winter and cover openings with insulation or plastic to reduce infiltration of air.
- ✓ Repair broken glass or holes in the plastic covering.

Double Covering

- ✓ Line sidewalls and endwalls of greenhouse inside with poly or bubble wrap to achieve the thermopane effect. Install double wall polycarbonate structured sheets to get insulation effect and reduce recovering labor.
- ✓ Use poly with an infrared inhibitor on the inner layer for 15% savings. Payback is two to three months.
- ✓ Add a single or double layer of plastic over older glasshouses to reduce infiltration and heat loss by 50%.

Energy Conserving Blanket

- ✓ Install a thermal blanket for 20 to 50% savings. Cost is \$1.00 to \$2.50 per square foot. Payback is one to two years. Tight closures should be maintained where curtains meet sidewalls, framing or gutters. Use a U-shaped trap to prevent heat from escaping overhead. Heat and water lines should be insulated or located below the blanket.

Foundation and Sidewall Insulation

- ✓ Insulate the foundation. Place 1- to 2-inch polyurethane or polystyrene board to 18 inches below ground to reduce heat loss. This can increase the soil temperature near the sidewall as much as 10 °F during the winter.
- ✓ Insulate the kneewall or sidewall to bench height. Use 1- to 2-inch insulation board. Applying 2 inches of foam insulation to a 3-foot-high kneewall on a 28-foot by 100-foot greenhouse will save about 400 gallons of fuel oil per year.
- ✓ Insulate behind sidewall heat pipes. Use aluminum faced building paper or insulation board behind to radiant heat back into the growing area. Leave air space next to wall to prevent frost damage to the wall.

Site Location

- ✓ Locate new greenhouses in sheltered areas to reduce wind-induced heat loss, if this does not reduce light.
- ✓ Install windbreaks on the north and northwest sides of the greenhouse. The windbreak

can be a double row of conifer trees or plastic snow fence.

Space Utilization

- ✓ Increase space utilization to 80 to 90% with peninsular or movable benches.
- ✓ Install multi-level racks for crops that don't require high light levels.
- ✓ Grow a crop of hanging baskets on overhead rails or truss-mounted conveyor system.
- ✓ A roll-out bench system can double growing space. Plants are moved outside during the day.

Efficient Heating System

- ✓ Installation of floor or under-bench heat will allow air temperature to be set 5 to 10 °F lower.
- ✓ Yearly maintenance - Check boiler, burner and backup systems to make sure they are operating at peak efficiency. Have furnaces cleaned and adjusted and an efficiency test run before heating season. A 2% increase in efficiency for a 30-foot by 150-foot greenhouse will save about 200 gallons of fuel oil.
- ✓ Clean heating pipes and other radiation surfaces frequently.
- ✓ Check accuracy of thermostats - correcting a reading that is 2 °F high will save \$100 to \$200.
- ✓ Install electronic thermostats or controllers with a 1 °F accuracy. Potential yearly savings of 500 gallons of fuel oil in a 30 foot by 100 foot greenhouse when changing from a mechanical to electronic thermostat or controller.
- ✓ Aspirate thermostats or sensors for more uniform temperature control. Differential between on and off can be reduced as much as 6 °F.
- ✓ Install horizontal air flow (HAF) fans to get more uniform temperature in the growing area.
- ✓ Insulate distribution pipes in areas where heat is not required.
- ✓ Check and repair leaks in valves, steam traps, and pipes.

Efficient Cooling System

- ✓ Build a new greenhouse with open-roof design to eliminate the need for fans.
- ✓ Install roll-up or guillotine sides to reduce the need for fan ventilation.
- ✓ Use shading to reduce the need for mechanical cooling.
- ✓ Install evaporative cooling to get better temperature control during the summer.
- ✓ Select fans that meet AMCA standards and have a Ventilation Efficiency Ratio greater than 15.
- ✓ Use the largest diameter fan with the smallest motor that meets ventilation requirements.
- ✓ Keep doors closed when fans are operating. Locate intake louvers to give uniform cooling.

Conserve Electricity

- ✓ Have wiring system inspected for overloading, corroded parts, and faulty insulation.
- ✓ Replace 3 hp or larger motors with high efficiency ones to reduce electric consumption by 2 to 5%.
- ✓ Check for proper belt tension and alignment.
- ✓ Replace incandescent bulbs with low wattage fluorescent or HID bulbs. Save two-thirds on electricity.
- ✓ Install motion detectors to control security lights so they are not on all the time.

Trucks and Tractors

- ✓ Regularly scheduled tune-ups can save 10% on fuel usage. Keep tires properly inflated.

- ✓ Avoid lengthy idling. Idling can consume 15 to 20% of the fuel used.
- ✓ Run equipment in the proper gear for the load.

Water Systems

- ✓ Locate hot water tanks as close as possible to the largest and most frequent use. Insulate pipes.
- ✓ Heat water to the lowest temperature needed; usually 120 °F is adequate.
- ✓ Use pipe size large enough to supply necessary water at minimum friction loss.
- ✓ Eliminate water leaks. A dripping faucet at 60 drops per minute will waste 113 gallons per month.

Management

- ✓ Lower night temperature. Fuel consumption is reduced 3% for each 1 °F night temperature is lowered.
- ✓ Delay starting the greenhouse by a week or more. Build a germination/growth chamber to start seedlings.
- ✓ Keep growing areas full at all times.

Additional information can be found in **Energy Conservation for Commercial Greenhouses** - NRAES-3, 100 pages, \$20.00 available from the Department of Natural Resources Mgt. & Engr., 1376 Storrs Rd., University of Connecticut, Storrs, CT 06269-4087. Make check payable to UConn. Price includes postage and handling.

Energy Conservation in the Field

- ✓ Practice good nutrient management.
- ✓ Consider used oil as equipment fuel.
- ✓ Keep equipment maintained.
- ✓ Provide operator training.
- ✓ Keep irrigation engines serviced and well-tuned.
- ✓ Consider the cost of different fuels in terms of energy value.

Energy Conservation in the Field

Consider Used Oil as Equipment Fuel

Waste engine oil and hydraulic oil also can be filtered (5 micron filter or smaller) and burned in a diesel solution in tractors and in other equipment. A good starting point is 90% diesel and 10% oil, although up to 100% oil use is possible with good filtration and preheating. Be sure to check with the engine manufacturer before burning waste oil in engines under warranty. With vegetable oil prices low (20 cents or less per pound) and diesel prices high, soybean or cotton seed oil blends with diesel fuel may be economical.

Practice Efficiency

Good equipment maintenance and operator training go hand in hand toward saving energy. A faster, more efficient job saves fuel. Clean or replace air filters, and use appropriate equipment ballast to keep wheels from slipping and using more fuel. Keep tires properly inflated.

Save Energy on Irrigation

Keep irrigation engines serviced and well-tuned. Make sure electric motors, switches, and control panels are clean and free of dirt, insects, or bird nests. Check connections to ensure they are tight, and lubricate moving parts that require it. Use an irrigation scheduling method to time irrigations for more efficient fuel and water use. Start irrigation before soils are completely dry.

Other Energy Management Tips

Compare Fuel Efficiency

Consider the cost of different fuels in terms of energy value.

To determine the cost and value of a fuel, first consider the number of British Thermal Units (Btu) produced by the fuel (Table 5). To determine the Btu value per dollar, divide the fuel's Btu per unit by the unit price.

Table 5. Approximate heating value of common fuels

Fuel type	Heating value	
Natural Gas	1,030 Btu/cu ft	100,000 Btu/therm
Propane	2,500 Btu/cu ft	92,500 Btu/gal
Methane	1,000 Btu/cu ft	
Landfill gas	500 Btu/cu ft	
Butane	3,200 Btu/cu ft	130,000 Btu/gal
Methanol		57,000 Btu/gal
Ethanol		76,000 Btu/gal
Fuel Oil		
Kerosene	135,000 Btu/gal	
#2	138,500 Btu/gal	
#4	145,000 Btu/gal	
#6	153,000 Btu/gal	
1 Barrel of oil	42 gal	
Waste oil	125,000 Btu/gal	
Biodiesel - Waste vegetable oil	120,000 Btu/gal	
Gasoline	125,000 Btu/gal	
Wood		
Softwood	2-3,000 lb/cord*	10-15,000,000 Btu/cord
Hardwood	4-5,000 lb/cord	18-24,000,000 Btu/cord
Sawdust - green	10-13 lb/cu ft	8-10,000,000 Btu/ton
Sawdust - kiln dry	8-10 lb/cu ft	14-18,000,000 Btu/ton
Chips - 45% moisture	10-30 lb/cu ft	7,600,000 Btu/ton
Hogged	10-30 lb/cu ft	16-20,000,000 Btu/ton
Bark	10-20 lb/cu ft	9-10,500,000 Btu/ton
Wood pellets - 10% moisture	40-50 lb/cu ft	16,000,000 Btu/ton
Hard Coal (anthracite)	13,000 Btu/lb	26,000,000 Btu/ton
Soft Coal (bituminous)	12,000 Btu/lb	24,000,000 Btu/ton
Rubber - pelletized	16,000 Btu/lb	32-34,000,000 Btu/ton
Plastic	18-20,000 Btu/lb	
Corn - shelled	7,800-8,500 Btu/lb	15-17,000,000 Btu/ton
cobs	8,000-8,300 Btu/lb	16-17,000,000 Btu/ton
Electricity	3412 Btu/kilowatt hour	

