

**CHECKLIST
ENERGY CONSERVATION**

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. Prices are at the time of publication.

Reduce Air Leaks

- ✓ **Keep doors closed** - use door closer or springs.
- ✓ **Weather-strip 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 \$0.53 if you are burning \$2.30 fuel oil (prices at time of publication).
- ✓ **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 or Curtain

- ✓ **Install a thermal blanket** for 20 to 50% savings. Cost is \$1.50 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.



Photo: Tina Smith, UMass Extension

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.
- ✓ **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.



Under-bench heat system

Photo: Tina Smith, UMass Extension

- ✓ **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 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.



Photo: Tina Smith, UMass Extension

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.
- ✓ **Use root zone heating.**

Energy Resources

Booklet: “Energy Conservation for Commercial Greenhouses” - NRAES-3, 100 pages, \$21.25 available from the Resource Center, Unit 4035, W.B. Young Building, Rm.2, Storrs, CT 06269-4035. Make check payable to UConn. Price includes postage and handling.

Fact Sheets: For details on energy use in greenhouses see the following **fact sheets** by *John Bartok* available from **University of Massachusetts**

Extension: <http://www.umass.edu/umext/floriculture/>

- Corn - A Home Grown Heat Source
- Insulation-Know How
- Natural Ventilation in Hoophouses
- Combat Higher Fuel Prices with Efficient Heating Systems
- High Tunnels - Low Cost Seasonal Growing Space



Corn Burning Furnace in Greenhouse
Photo: Tina Smith, UMass Extension

- Greenhouse Energy Conservation Checklist
- Fuels and Alternate Heat Sources for Commercial Greenhouses
- Horizontal Air Flow is Best for Greenhouse Air Circulation
- Mechanization and Labor Saving for the Small Grower
- Retractable Roof Greenhouses and Shadehouses
- Root Zone Heating Systems
- Selecting and Building a Commercial Greenhouse
- Selecting an Energy/Shade Screen System
- Selecting and Maintaining Thermostats
- Will the Zoning Commission Approve Your Greenhouse?
- Greenhouse Ventilation
- Greenhouse Facilities Master Plan
- Problems With Using Unvented Heaters in Greenhouses
- Geothermal Heat for Greenhouses
- Wood Heat for Greenhouses



Wood chips are being used as a source of fuel to heat greenhouses.

Massachusetts Department of Agriculture (MDAR) Energy Program

<http://www.mass.gov/agr/programs/energy/index.htm>

The MDAR Energy Program's primary function is to promote energy knowledge and awareness and to facilitate the implementation of energy related projects for our agri-businesses through energy efficiency, energy conservation, and renewable energy applications, as a means to reduce both energy costs and environmental pollution. Information on grants and funding are also available on this website.

Energy Broker/Consultant

Large energy users often hire a consultant or broker to assist in reducing and managing their electricity and natural gas, fuel oil and other energy expenses. The consultant analyzes business energy use and helps negotiate contracts and rates.

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 1). To determine the Btu value per dollar, divide the fuel's Btu per unit by the unit price. Example: #2 Fuel Oil $\text{BTU}/\$ = \frac{138,500 \text{ BTU/gal}}{\$2.50/\text{gal}} = 55,400 \text{ BTU/dollar}$

Table 1. 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 gallons		
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	

Prepared by: John W. Bartok, Jr., Agricultural Engineer
University of Connecticut, Storrs CT 06269-4087
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