Reducing Natural Gas / Propane use for Greenhouse Space Heating

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Natural gas and propane prices have been increasing over the past few years due to increasing demand and the continued instability in oil producing areas of the world. In October 2004 natural gas prices climbed to an all time high of $9.00 per mmBtu on the NYMEX commodity exchange for natural gas delivered to the Henry Hub in Louisiana before retreating to the $7.00 range in December 2004. Prices for 2004 were 149% higher than 5 years ago and 80% higher than 2 years ago. The Future prices for 2005 are trending down from current levels to $6.40 to $6.50 per mmBtu until November 2005 when prices are forecasted to rise to about $7.30 for the 2005-2006 heating season. Propane prices have also taken a dramatic jump with wholesale prices reaching record levels at $0.97 per gallon in October 2004, 64% above October 2003 prices and 115% higher than the average price for October 1999, five years earlier. Energy costs are the second largest cost for greenhouse owner behind labor costs, with greenhouse heating consuming 70 - 80% of the total energy budget. The long-term natural gas price forecast predicts prices to decline only about 5% as new wells come on line. Current propane prices for 2005 to 2007 are forecasted to be 15% above the 2004 price levels. Political instability and high demand will continue to affect future prices for both natural gas and propane. More information on what drives propane prices can be found at http://tonto.eia.doe.gov/FTPROOT/other/Propane_Prices_Pub.pdf.

The following are some things that can be done to reduce the impact of higher energy costs before this winter.

Heat Loss

IR and Anti-condensation Treated films

A double polyethylene covered greenhouse reduces infiltration losses but will allow infrared radiation to transmit out of the greenhouse unless it's using an IR treated film on the inside can reduce infrared radiation loss. Condensation on the inside of a poly covered greenhouse can reduce thermal radiation loss by up to 50%, however condensation also reduces light levels at the plant and the amount of solar radiation entering the greenhouse. Dripping condensation can also lead to plant quality issues so it is important to keep greenhouse covers free of condensation. The IR / anti-condensation treated films cost about $0.015 per square foot more than untreated films but reduce energy use by 15 to 20%. In Wisconsin, the payback on the incremental cost for purchasing IR / anti-condensation treated films should only be less than one heating season.

Insulated Side walls

Greenhouses that use bench systems can insulate the side walls, end walls and perimeter with 1" or 2" foam insulation board. Insulation should be dug in 12" to 24" (preferred) deep and can be extend up to the plant height. The foam should have a protective cover such as aluminum foil to protect the foam from UV deterioration and to reduce fire hazards. Spray-on foams on framed walls also provides excellent insulation but also needs to be protected. If foam is placed on the inside of the greenhouse, a reflective coating towards the inside will reflect direct solar radiation back to the crop canopy aiding in plant growth. Two inches of foam insulation around the knee wall of a 28-foot by 100-foot greenhouse will save about 400 gallons of fuel oil, 610 gallons of propane or 558 Therms of natural gas per year.

Night Curtains

Research indicates that 80% of the energy to heat a single-glazed greenhouse is required at night so reducing heat loss at night can pay dividends. A movable insulted curtain can reduce the heat loss by up to 70% when the curtain is closed. There are several types of blanket materials available with different advantages and disadvantages. Porous blankets save about 20% when closed but can be used for shading in the summer and allow water to drain through it. Non-porous aluminized materials provide the most savings; up to 70% when closed. Installation costs ($2001) can range from about $1.10 to $3.35 depending on the size of greenhouse, blanket material and type of track / drive system used.

Infiltration Losses

Infiltration is air movement into and out of a greenhouse through cracks and small openings in the shell of the building. New construction greenhouses can range from 0.5 to 1.5 air exchanges per hour while old construction glass glazed greenhouses can range from 1 to 4 air exchanges per hour. Wind velocity has a direct effect on the infiltration rate.

Weather Stripping
Weather strip, replace gaskets and caulk joints around doors and other opening in the greenhouse shell. Pay particular attention where the greenhouse cover or glazing attaches to the foundation, side walls and end walls and seals around vents. A 1/8 inch wide crack around a 36 inch wide door will allow 500 cubic feet per minute of air to infiltrate and require 25,000 Btu's per hour of additional heating.

Glass Houses
Glass greenhouses inherently have more infiltration because of the larger number of joints. Covering glass greenhouses with a single or double layer of poly film reduces infiltration and heat loss. The cover can be installed permanently or just during the winter months. Reducing infiltration can lead to increased humidity levels and a rapid depletion of carbon dioxide. Mechanical ventilation may be needed to control humidity and can be used to replace the carbon dioxide. If additional carbon dioxide is needed, it can supplied by purchasing compressed carbon dioxide or using a special natural gas or propane burner to enrich the air. The light levels will be reduced by 18% because of the poly films which needs to be taken into accounted in an economic analysis. A double poly cover can reduce heat losses by up to 50%.

Wind Breaks
In open, windy areas, wind breaks in the path of the prevailing winter wind will aid in reducing infiltration losses. A temporary wind break can be made from a 10 to 12 foot high snow fence placed 40-60 feet away from the greenhouse to protect the typical 11-14 foot high greenhouse. A more permanent wind break would be 4 or 5 rows of deciduous and evergreen trees planted 4 to 6 mature tree heights up wind of the greenhouse. A mix of tree species is best to guard against losing the entire windbreak from disease or insects. Fertilization and irrigation can accelerate tree growth to provide benefits in about 5 years.

Heating Systems

Thermostats
Clean thermostats regularly. A dirty thermostat will not accurately sense temperature. Calibrate thermostats annually. If purchasing a new thermostat or controller use electronic models with 1ºF differentials.

Furnace Checkup
Have Furnaces and unit heaters serviced and tested yearly. Replace older inefficient furnaces. A 2% increase in efficiency will save about 125 gallons of fuel oil, 190 gallons of propane or 174 Therms of natural gas per year for a 28-foot by 100-foot greenhouse. This savings would more than pay for the inspection and tune up for your heating systems for the coming winter.

Gas Burners - Flame should burn as blue as possible; yellow flame indicates insufficient air. Check gas supply line pressures, check all fittings for leaks.

Oil Burners - Replace the nozzle with one that meets the furnace manufacturer's specifications. Change oil filters twice per year. Check pump output pressure, typically between 100 -120 psi; low pressure causes incomplete combustion. Check spark jump between igniter contacts; new 14,000-volt electronic igniters are recommended. Clean igniter contacts and ignition sensors. At temperature below 20°F oil viscosity increases, water droplets freeze and paraffin precipitates out. Moving the oil storage tank inside, adding fuel treatments and raising pump pressures can reduce problems.

Chimneys - Should be air tight, same diameter as the furnace connection, at least 8 foot high and at least 2 foot above the greenhouse peak. A chimney cap will reduce back-drafts and keep rain out.

Central Heating Systems
Insulate pipes and air ducts in headhouses and boilers rooms. Many headhouses are over heated because of poor insulation of heating pipes running through to the greenhouse. Insulation is simple to install and usually has paybacks of less than two years. Each un-insulated linear foot of a 2-inch heating supply pipe will loose about $4 worth of heat this winter.[3]

Have the heating system serviced regularly. This includes soot removal inside the firebox, changing fuel filters, cleaning nozzles, checking valves and controls, checking and aligning belts, lubricating bearings and testing combustion efficiency. Soot can build up in fire tubes due to incomplete combustion of fuel caused by improper air to fuel ratios or plugged nozzles. An 1/8" of soot deposit can increase fuel consumption by 10% or more.

Bottom Heating
Moving heating pipes and air distributions systems from overhead to under bench, on-floor or in-floor can save 20-25% in heating costs and results in faster plant growth. One study reported a 7% average yield increase from greenhouse tomato production, thought occurred largely due to a 7ºF higher root medium temperature. A heating pipe under the gutters will still be needed on gutter connected greenhouses to aid in melting snow.

Alternate Fuels
If a central heating system is used, it may be easier to take advantage of alternate fuels such as wood or other bio-mass. Before investing in alternate fuel, make sure you are considering all costs (labor, maintenance, ash removal and ash disposal) and check with state environmental regulatory agency about permits and ash disposal requirements.

Waste Heat / Cogeneration
Cogeneration opportunities using waste heat are limited to sites adjacent to power plants or industrial sites. The waste heat source must be able to dependably supply 90º - 100ºF water. A radiant floor system is ideal for this system. Depending on the purchase agreement, energy costs can be reduced substantially.

Cogeneration may also be accomplished by powering an electrical generator with an internal combustion engine. The electricity not used for greenhouse operations is sold to the utility while recovering the waste heat from the engine cooling system and exhaust system for heating the greenhouse. The method can result in an overall efficiency of about 75%; 25% for the conversion of electricity and 50% for the use of waste heat. The disadvantage of such a system is the initial cost and maintenance and the need to have a backup heating system.

Considerations for New Greenhouses

Roof slopes
Gothic or peaked roofs with slopes of 6 in12 pitch (6 inches of rise for every 12 inches of horizontal) will allow condensation to run off, reducing reduction in light levels caused by condensation on the glazing.

Side wall height
Adding a foot or two to the sidewall heights to a greenhouse increases heat loss by only about 5% but gives room for hanging basket and may allow room for night curtains to be used.

Gutter connected greenhouses
Six 30 foot by 100 foot individual greenhouses with 10 foot sidewalls has 37% more surface area than a gutter connected greenhouse covering the same growing area. If individual growing rooms are needed, poly wall dividers can be installed between bays so there are different heating zones. It is also easier to take advantage of a centralized heating system with a gutter connected greenhouses.

Site Location
Chose a sheltered site to reduce wind induced infiltration heat losses as long as it doesn't reduce lighting levels.

Natural Ventilation
Greenhouses with roof vents or opening roofs and side wall vents can take advantage of thermal buoyancy for cooling. The air temperature at crop level should be no more than 5ºF above the ambient air temperature in a well designed system. Each vent should be 15-20% of the floor area and the sidewall vents should be equal in area to the ridge vent. Some ventilation fans may be need even in a greenhouse that can be naturally ventilated when only a little cooling is needed or the cold outside air could cause plant damage.

Space Utilization

Increasing the amount of plants that can be grown in your greenhouse will reduce your production costs per plant. This usually means reducing aisles or using tiers or racks to increase plant density.

Peninsular Bench Layout
A traditional straight row bench system utilizes 60 to 70% of the floor area for plant production while a peninsular bench layout provides over 75% of the floor area for growing; refer to reference 1 page 46.

Movable Bench System
Movable growing systems can increase plant production area to over 90%. There are two types of movable systems: moving benches and transport trays. Both provide high space efficiency and can increase labor efficiency and reduce energy use per plant. The disadvantage associated with movable benches is the limited space for maneuvering. This can to overcome by using a narrow portable belt conveyor or an overhead trolley to move plants into or out of the growing area.

Rack Growing Systems
The use of growing racks can double the growing space and create conditions similar to a forest canopy. This is useful when many different plants are being grown that have different light requirements.

Central Control System
A computerized control system coupled with a weather station can control the different operating parameters required for normal greenhouse operation as well as anticipate changes such as increased wind speeds or rain may dictate the need to close vents or low solar levels during cold weather may dictate closing thermal blankets and turning on supplemental lighting. These systems can also alert personnel to equipment failures or operating parameter that is outside control limits by an audible alarm, light or telephone. These control systems save energy due to smaller differential ranges on sensors, having safe guards that the fans and the heating system aren't running at the same time and anticipating changes that reduce energy input and increase plant growth.

Reference:

1) Bartok Jr, J.W., Energy Conservation for Commercial Greenhouses, NRAES, Ithaca, NY, 2001.

2) Aldrich, R.A, J.W. Bartok Jr, Greenhouse Engineering, NRAES-33, NRAES, Ithaca, NY, 1994.

3) Bartok Jr, J.W., "Grower 101: Heating Systems - Maintenance Pays", Greenhouse Product News, September 2003, Vol 13, No. 9, Pg 56-59.

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