UNIT HEATER EFFICIENCY

by **CHRIS GUNTERMANN**

How efficient can a unit heater be once it's installed and running? An expert runs a thermodynamic analysis to show where efficiency losses can occur

Heating costs are *the* hot topic for growers. With ever-increasing fuel costs, everyone wants to gain every percentage point of efficiency possible. But before you consider making a change to your current heating system, I recommend you consider all the links that will change in your other growing or control practices. It's easy to focus in on the benefit of one change but ignore the potential hidden costs that might come with that change.

Ventless heaters are one example. There are many brands of ventless heaters, and they all can do a good job heating your greenhouse, either as primary or supplemental heat. My company sells and installs both ventless and vented types.

One attraction of ventless heaters is their promise of 99.9% efficiency. They may deliver that under perfect conditions. But in real-world greenhouse settings that number will usually be lower due to various factors. But let's do some thermodynamic analysis to show what I mean.

Combustion byproducts

One feature of ventless heaters is that they introduce *all* of the products of combustion into the greenhouse. Burn a hydrocarbon and, in a perfect world, you get HEAT + CO_2 and H_2O (water vapor). However, in our imperfect world you can also get some NO_x (nitrous oxides, i.e., smog) and CO (carbon monoxide). Manufacturers take great care to instruct heater installers on how to manage for these byproducts.

Also in the real world, natural gas and propane can contain impurities such as other hydrocarbons, sulphur, water, nitrogen, carbon dioxide and even PCBs. These impurities may also produce combustion byproducts. Very little is published about the effects of such byproducts on the growth and flowering of plants. Energy transporters must meet varying government regulations for allowable impurities; so check the makeup of your natural gas and propane.

Changes in the greenhouse atmosphere can also cause unexpected changes. Remember that ambient air is only 21% oxygen to begin with, and large heaters can deplete up to 1.4% per hour.[1] Reduced levels of oxygen can increase the unwanted combustion byproducts and can also affect the physiological efficiency of photosynthesis and respiration (plants, and especially roots, do use oxygen.)

Combustion oxygen

Ventless heaters require a good supply of oxygen for complete combustion. Manufacturers recommend louvers or tubes to introduce outside oxygen to the heaters. However, air won't naturally flow in toward the heater if you don't allow some air out of the greenhouse, so manufacturers also recommend using exhaust fans. Now, if air must be exhausted out in order to ▶

1 Based upon the cubic volume of a 30 ft. x 100 ft. Quonset-style greenhouse.

supply oxygen to the heater, then that air is taking some of your heat with it.

How many BTUs are being exhausted? The rule of thumb is that 1 cubic foot of air holds 0.02 BTU per degree.[2] A typical ventless heater requires 250 cfm per 100,000 BTUs.[3] If your exhausted air is 30 degrees higher than the outside temperature, then 30 degrees x 250 cfm x 60 min./hr. x 0.02 reveals that 9,000 BTUs of your 100,000 BTUs are going outside.

Now your ventless heater's 99.9% efficiency has dropped to 90.9% efficiency. That's only 1.5% better than the stack loss of a typical power-vented heater, which loses 10,530 BTU when it's exhausting the typical 27 cfm/100,000 BTU at a stack temperature difference of 325 degrees (325 degrees x 27 cfm x 60 min./hr. x .02 = 10,530 BTU/hr.).

Water vapor

Water vapor is a product of combustion. For every 100,000 BTUs burned, you'll get about 1 gal. of water vapor (or 1 gal. of condensate) inside your greenhouse.

That water vapor carries a lot of heat. When the vapor turns back into water, it releases about 8,087 BTUs.[4] Those BTUs will transfer quite rapidly to the cool things in your greenhouse, such as steel and glazing, leaving condensation behind.

With the loss of 9,000 BTUs through letting in fresh combustion air and the additional 8,087 BTUs from water vapor condensing, our 99.9% efficiency is down to 82.9%.

Plus, now you have gallons of cold water to deal with. It reduces light transmission and can encourage algae growth on the glazing.

Also, before the water vapor condenses or is vented, it hangs in your greenhouse air as relative humidity. In some parts of the country, you might welcome the higher humidity, but here in the Northwest we generally fight the negative effects of high humidity. Why? Not only because of the problem with dripping condensation but also for its effect on plants. Remember, if your plants are transpiring (evaporating) water, then the leaf will generally be cooler than the surrounding air. Hence, it's a cool target for condensation and maybe disease. If your plants aren't transpiring because of high humidity, then they're also not transporting nutrients.

Part of your whole system

Your overall greenhouse energy strategy should take into account a careful analysis of your temperature requirements, your condensate removal options, your crop's tolerances (how closely you need to control temperatures), your fuel cost, the percentage of fuel cost versus crop value and your banker's and your risk tolerance.

Ventless heaters can and should be part of your heating strategy. As with any heating system, it's critical that you understand how they work, where their efficiencies come from and where you can lose efficiency. And it's extra critical that heaters be installed according to manufacturer's requirements for outside air supply.

While you're looking at ventless heaters, take a comparison look at the newer high-efficiency unit heaters that combine power venting, combustion air separation and electronic ignition. Also look for the newest in high-efficiency vented heaters that are entering the marketplace. These offer up to 90.6% energy efficiency even after calculating ventilation requirements.

Of course, the best way to reduce heat loss is by installing heat-retention blanket systems. This should come long before you sweat a few percent savings from a new heater. If you're still using thermostats, you should definitely consider the newer computerized control systems that can reduce heat cost by a reported 10 to 20%.[5] And finally, don't forget to look into lower-risk alternative production investments, such as labor-saving devices.

In summary

- High-combustion efficiency is good.
- CO_2 generation is good (up to a point).
- Installation simplicity is good.
- Low equipment cost is good.
- Exhaust byproducts may be bad.
- Heated air must be exhausted from the greenhouse in order to draw in fresh oxygen.
- Condensation and high relative humidity are generally to be avoided.
- Plants don't like low oxygen levels.
- People don't like low oxygen levels, high CO_2 levels or carbon monoxide.
- Diseases benefit from high humidity.
- Algae and liverwort love to grow on wet surfaces.
- Seasonal efficiency (AFUE[6]) differences between vented and ventless heaters can be lower than the touted 10 to 20%.
- An integrated approach to energy utilization offers the lowest risk and highest reward. ■

Chris Guntermann, a sales representative with Horticulture Services Inc., Sumner, Washington, has been active in the horticultural trades for 37 years. He earned a bachelors degree in horticulture from Colorado State University after switching majors from engineering. He has 19 years experience marketing greenhouses and environmental equipment to the Northwest horticultural industry. His company sells and installs all types of heaters, including ventless.

2 The published specific heat of air at STP.
3 From the L.B. White Heater owner's manual requiring 300 cfm for a 120,000 BTU size.
4 Based upon the heat of vaporization of water of 2,260 kj/kg.
5 *Energy Conservation Opportunities for Greenhouse Structures*, September 2003, Minnesota Department of Commerce Energy Office.
6 AFUE is a standardized measure of Annual Fuel Use Efficiency, a.k.a. seasonal efficiency.