Wood Heating for Poultry Housing

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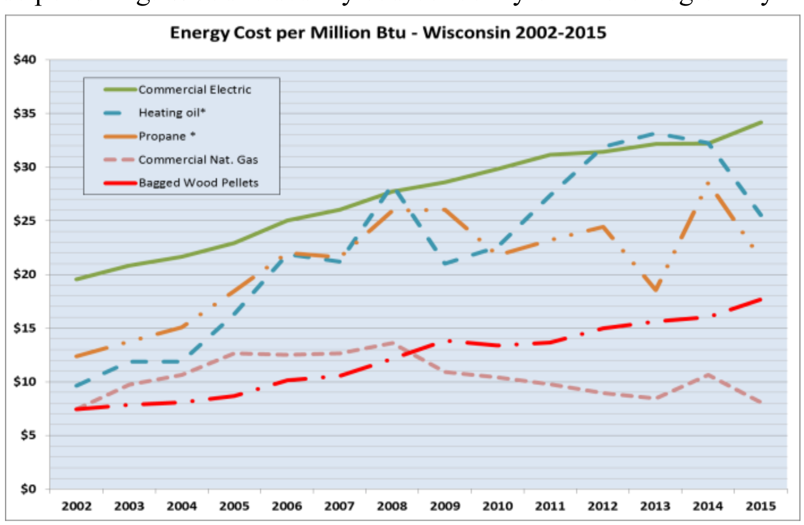
Wood energy has been used for centuries for heating but was replaced by cheaper more convenient fossil fuel sources in the early 1900's. But with the increase in global energy costs and tight margins in the poultry industry, wood heating is a possible alternative. However, before an alternate energy source is considered, energy efficiency measures should be evaluated due to the higher return on investment. This could include adding insulation to the ceiling, closing up sidewall curtains and insulating, reducing unplanned infiltration (drafts), installing more efficient gas heating units, properly maintaining heating equipment, checking inlet vents are working properly, reducing over ventilation and improving litter management to reduce ammonia levels.

Why wood energy and what are the advantages. Wood supplies a dry heat to the barn when compared to direct vent gas heaters that are typically used in the poultry barns. A direct vent heater discharges all the products of combustion into the barn air including about three-quarters of a gallon of water vapor. The water vapor will keep humidity level higher, increasing ammonia levels and can create conditions that lead to respiratory diseases. If properly ventilated according to manufacturer's recommendations, the ventilation heat loss will reduce the overall efficiency of direct-vent heaters to about 80%. The dry heat from wood dries out litter faster, reducing ammonia generation which allows lower ventilation rates and eliminates the risk of carbon monoxide poisoning. Wood is usually source locally or at least regionally which keeps the energy expenditures local, thus providing local economic growth. Wood is also considered a renewable resource and is nearly carbon neutral, which could be used as marketing advantage. Wood energy prices have been relatively stable over the last 15 years compared to the fluctuating fossil fuel market so your energy costs are more predictable, see figure. There is more maintenance required for wood combustion systems than gas-fired systems.



There are several types of wood fuels available. Cordwood is popular but labor intensive. Many people view cordwood as low cost especially if they have a wood lot. But it doesn't magically get from a standing tree to a split log without some labor and equipment. Typically a piece of wood will be handled 3 to 6 times to get it from the wood lot to the boiler. To burn properly, the moisture content should be below 20%. This is accomplished by air drying for 1 or 2 summers after being split to less than a 6 inches thickness so some planning is required. Cordwood cannot be automatically loaded into small boilers so labor will be required for re-fueling, possibly in the middle of the night. The unburned material left after combustion, ash, will need to be removed from the boiler frequently and disposed of.

Wood chips and wood by-products are plentiful in many areas and can be purchased at a relatively low cost for fuel. Green mill residue is the bark and sawdust from processing logs into lumber. It is high in moisture, usually greater than 20%, and is typically stored in piles outside. Dry mill residue comes from planning of kiln-dried lumber and furniture making. It has the advantage of low moisture (less than 10%) but is in high demand for animal bedding and fuel pellet manufacturing so the price is higher but also the energy content. Wood chips from whole trees, urban forest trimmings and logging residue (tops & limbs) can also be used for heat production but is typically high in moisture (~50%) so the net energy content is lower. Wood chips are handled in bulk which reduces labor costs. Handling can be done with dump trucks, loaders, augers and conveyor. If using green chips, they can be piled outside reducing storage costs otherwise a covered bunker may be necessary to maintain the net energy content.

The capital investment for wood chip boiler system is higher and due to the number of moving parts (augers and conveyors), the maintenance costs may also be higher than a pellet boiler or outdoor wood boiler. Chips are bulky so they are expensive to transport very far. They are supplied by the tractor trailer or dump truck load so adequate space is required to store chips. Typically storage is needed for 1.5 truckloads of chips so the supply is not interrupted. A wood chip system may have a hopper bin which is loaded several times a day with a bucket loader or a bin with a walking floor at the bottom to meter the chips onto a conveyor which transport the chips to the boiler. A typical wood chip boiler will be 75 to 80 percent efficient. Wood chip boilers are ideally suited for larger producers but new European technology may reduce the cost and size requirements. Many of the new system can use either chips or pellets which allow greater flexibility in sourcing fuel. Some of the European wood chip boilers are 85 to 89% efficient. The European technology uses electronic controls and sensors and can be monitored from a web application. The chip feed system uses a lower cost rotary head with springs attached to pull chips into a conveyor that feeds the boiler. Capacities range from 120,000 Btu/hr to 2 MMBtu/hr for small units and up to 60 MMBtu for large system. Handling and combustion equipment for wood chips is more expensive but due to the lower cost of the fuel, it may be very cost effective for larger operations. Before investing in a wood chip heating system one should evaluate current local and future supply and demand for wood chips.

Densification of bulky materials into pellets or cubes has many advantages. One of the main advantages is that it facilitates handling and reduces transportation costs. Wood pellets, increases the energy density and creates a uniform product that flows easily. Pellets can be made from many different by-products and low value materials – wood, crop residue, dedicated energy crops. Pellets can be handled with conventional grain handling equipment and need dry storage. Pellet combustion appliances automatically meter (stoke) the pellets into the fire box with an auger. The auger speed can be controlled based on the air temperature or the boiler water temperature. Wood pellets burn very efficiently with low smoke emissions with efficiencies typically range from 80% to greater than 90% for high efficiency units. The only disadvantage is that the pellet cost is higher per ton than cord wood or wood chips but the pellet burning appliance and fuel handling system are lower in cost. Wood pellets are sold in tons for bulk delivery or 40-50 pound bags. The maximum moisture is 8 to 10% and ash content less than 2% for most grades.

Typically wood pellets will have an energy content of about 8000 Btu/lb but that can vary depending on what they are made from. Wood pellet systems will likely be more cost effective for smaller producers.

A combustion appliance used for heating can be either a boiler or a furnace. A boiler heats a heat transfer fluid that is pumped through pipes to the location of use. The fluid can be water, glycol/water solution or steam. A furnace heats air that is blown through ducts to the needed location. A basic wood heating system will include a furnace or boiler, fuel storage, heat distribution system (ducts or piping), and a structure to house the equipment if needed. With a furnace, typically an air duct is run down the center of a poultry barn. It can be a fabric or sheet metal tube with holes in the sides to distribute the air down the length of the building. The furnace is typically set outside the barn in the center of the brooder end of the barn with a supply duct going through the wall to the air distribution duct running the length of the barn. A boiler system can be located centrally on the farm with piping running to convection unit heaters in each barn. A fan in the convection unit pulls air across the hot coils and distributes the heated air horizontally above the floor radially from the unit. The units are positioned about 3-4 feet above the floor. The distance between units will depend on the throw distance of the air. The air flow will create a mushroom shaped pattern within the barn. Some units have a tube that goes to the ceiling to prevent stratification of the air in the barn. The temperature variation within a building should be very low (within 3F) if the air distribution system is sized correctly.

Wood combustion works best when it is continuous, however, the demand for heating can be cyclical. One option to level the peaks and valleys of demand and allow the wood combustion to run longer without interruption is to use thermal storage in conjunction with boiler systems. Thermal storage is typically an insulated tank to storage the heated fluid. This acts as a buffer between fluctuating demand and the boiler capacity, smoothing the demand curve and reducing the number of turndown periods. Boilers with automated feed systems will require less thermal storage to reduce turndown periods than cordwood boilers. The capacity of the thermal storage will depend on the tank size and temperature differential above the distribution temperature. If the distribution temperature is 120ºF and the maximum temperature is 170ºF, there will be about 400 Btu of storage per gallon of water. The general recommendation for thermal storage sizing is 400 to 550 gallons per 100,000 Btu/hr of capacity for cordwood boilers, 100 gallons per 100,000 Btu/hr of capacity for wood chip boilers and 75 gallons per 100,000 Btu/hr of capacity for wood pellet boilers.

In order to compare different fuels, one needs to calculate the cost per 1,000,000 Btu delivered which takes into account the efficiency of the combustion appliance. The adjacent table is a comparison of different fuels based on current prices (Dec 2015) and typical boiler efficiencies. The cost per million Btu only includes fuel cost and does not include capital recovery, maintenance or labor for operating a boiler. Electricity is the most expensive heating source followed by an old style outdoor wood boiler and heating oil. Note that the low efficiency of the outdoor

Fuel Type Comparison (2015)

Fuel Type	Energy content (Btu / fuel unit)	Thermal Efficiency (2)	Unit cost USD (4)	units	Cost per 1,000,000 Btu
Natural Gas	100000/therm	80-94% (90%)	0.80	Therm	$8.89
Wood Chips	3780 (50%) - 6190 (25%) / lb	50 - 75% (70%)	50	ton (50%)	$9.45
Wood Pellets (High Eff)	15400000 per ton	70-85% (92%)	185	ton (bulk)	$13.06
High-Eff Corewood boiler	22,000,000 per cord (3)	81%	250	Cord	$14.03
Wood Pellets (bulk)	15400000 per ton	70-85% (82%)	185	ton (bulk)	$14.65
Wood Pellets (bags)			250	ton (by bag)	$19.80
Outdoor Wood Boiler EPA Phase 2 (1)	22,000,000 per cord (3)	63%	250	cord	$18.04
Propane (6)	91600	80-94% (90%)	1.50	gallon	$18.20
Heating Oil (#2)	138000	70-85% (75%)	2.50	gallon	$24.15
Outdoor Wood Boiler - Not EPA certified (5)	22,000,000 per cord (3)	40%	250	cord	$28.41
Electricity	3413 / kWh	98%	0.12	kWh	$35.16

1) Meets EPA Phase 2 emissions requirement
2) Values in () used for calculations;
3) 6500 Btu/pound (20% moisture);
4) Fuel costs in Madison, WI for 2013-2014 heating season delivered to point of use. Does not include any storage costs;
5) Typical Pre-2008 outdoor wood-fired boiler (Does not meet EPA Phase 2 requirement)
6) Customer leased tank

wood stove causes it to be more expensive than heating oil or propane. The least expensive heat source is natural gas and wood chips. Energy costs are a moving target and vary regionally so one should evaluate energy costs locally. The equation for calculating the cost per MMBtu is as follows:

= ($ per unit of fuel x 1,000,000 Btu) / (energy content (Btu) per unit of fuel x combustion efficiency)

Example: propane at $2.00 per gallon combusted in an appliance that is 80% efficient.

$ / MMBtu = ($2.00 / gallon x 1,000,000 Btu) / (91,600 Btu/gallon x 0.80) = $27.29 / MMBtu

The fuel savings must be high enough to cover the cost of combustion equipment, fuel storage, labor and maintenance.

Let's use an example to show how to evaluate a wood chip system: Brooder Barn in south central Wisconsin used 7900 gallons of propane in 2014. It is assumed that the gas heaters are 80% efficient and propane cost is $1.00 per gallon. It is proposed to use wood chip that can be delivered for $50 per ton with an energy content of 6000 Btu/lb. The wood chip furnace has an efficiency of 85%.

The energy use to heat the building is the (gallons of fuel used) x (the fuel energy content) x (the appliance efficiency). This is the energy that is discharged into the barn. Based on the example 7900 gal x 91600 Btu/gal x 0.80 = 578,912,000 Btu of delivered heat. To convert to wood chips we divide the previous result by the appliance efficiency, energy content of wood chips and the conversion factor from pounds to tons. 578,912,000 ÷ (0.85 x 6000 Btu/lb x 2000lb/ton) = 56.8 tons of wood chips. The cost of the wood chips is estimated at $2840 (56.8 tons x $50 per ton). The fuel cost savings over propane is $5060 per year. Based on conversations with several equipment suppliers the wood furnace, bin, air duct and installation will cost about $40,000. A quick analysis metric is simple payback which is the equipment cost divided by the savings. For this example: $40,000 / $5060 = 7.9 years. This analysis does not include the cost of a building to protect the furnace (if needed), maintenance and repair costs and the return on investment. It also doesn't include benefits such as energy savings from potentially lower ventilation rates due to less moisture in the air or non-energy benefits such as lower mortality and faster weight gain.

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