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FIGURE 1. The start of a new broiler flock.
Photo courtesy of University of Arkansas Broiler Research Farm.

Poultry barn heating with wood energy

Scott Sanford

Wood is a renewable energy source and an abundant resource in the upper Midwest. Using wood byproducts for energy creates markets for a low value product, reduces fossil fuel use and related pollution. Wood combustion technology has improved greatly in the past 10 years resulting in higher thermal efficiency with low air emissions.

Making the case for wood energy

Wood has many direct and indirect advantages for the producer and the local community. Either a wood furnace or boiler will supply heated air to the barn without adding moisture. Direct vented gas heaters are typically used in poultry barns adding 0.8 gallons of water per gallon of propane burned along with the products of combustion into the building. This increases the humidity level in the barn. Wood heating, on the other hand, results in dryer litter and better air quality because the water vapor and combustion gases are not discharged into the building. Lower humidity in the barn keeps the litter dryer which results in less ammonia being produced and lower ventilation rates required which means less heating demand. Today's wood pellet and chip burning appliances are designed to operate automatically with only weekly maintenance to remove ash, clean the heat exchanger, and ensure there is adequate fuel in storage.

Wood pricing has been stable for many years with only small increases to cover inflation (figure 2) versus the volatile price spikes that Liquid Petroleum (LP) gas and other petroleum fuel has experienced over the last 10–15 years. There are several advantages to using wood to heat poultry production buildings. As a renewable energy source, wood is almost carbon neutral with only a small amount of fossil fuel used for harvesting and transportation. Wood is sourced locally or at least regionally which means more of your energy expenditures stay in the local community versus 80% of it leaving immediately if fossil fuel is used. Replacing LP gas purchases with wood fuel to heat poultry houses and other buildings provides jobs to harvest, process, and transport wood fuels which increases local economic activity.

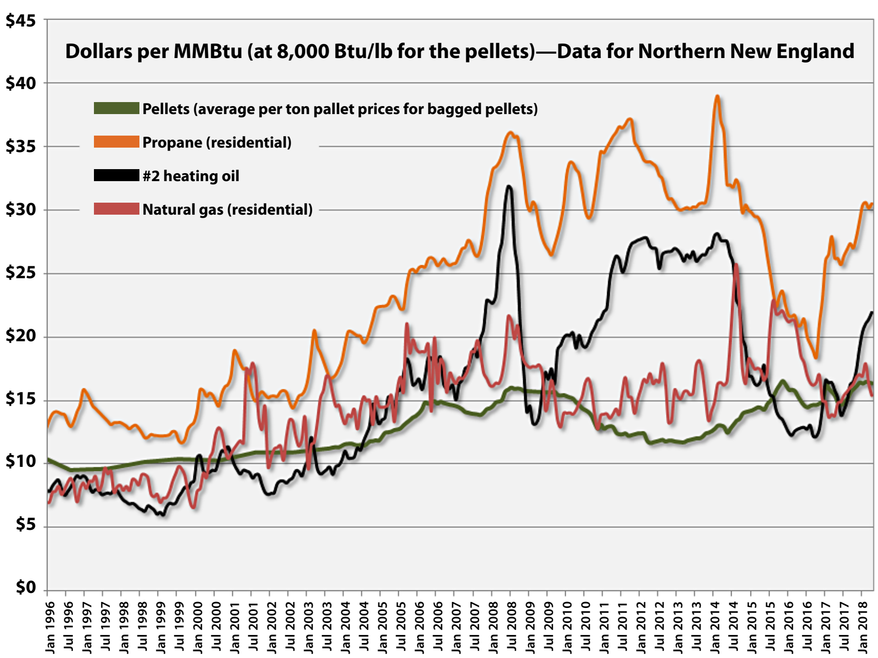

FIGURE 2. Cost per million Btu, 1996–2018. Figure and analysis by FutureMetrics LLC. Source: EIA, regional sources, FutureMetrics' pellet price database, July 2018.

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Types of wood fuels

Wood fuels come in several forms. Traditional cord wood or cut and split logs is the standard but this type of fuel doesn't work well for most operations because of the labor required for refueling. Wood chips or wood pellets are the best option for poultry producers because the wood fuel can be automatically metered into the firebox as heating is required. Wood pellets have uniform characteristics, can be stored in a grain bin, and handled with typical grain handling equipment. The pellets are typically ¼-inch in diameter and 1–1½-inch long (figure 3), dried to a moisture content of less than 8%, and contain an ash content of less than 2%. They can be purchased in 40-pound bags or in bulk, and delivered either in truck loads or flexible intermediate bulk containers (FIBCs) sometimes called bulk bags.

Wood chips are less expensive than wood pellets, but more costly equipment is required to meter the chips into the firebox. Wood chips can come from a variety of sources. Whole trees, tops and branches are typically high in moisture, about 50%, and come from logging operations, urban forests or tree service companies. Green mill residue is typically made up of bark and chips (figures 4 and 5) from slab wood and sawdust from sawmill operations. These residues are usually greater than 20% moisture and can be stored in piles outside. Dry mill residue is sawdust and trimming from the manufacturing of wood products and is made from kiln-dried lumber with moisture less than 10%. It will have the highest energy content but is also in demand for other products such as wood pellets and animal bedding. If you are thinking about using wood chips, make sure there is ample supply locally and understand who may be competing for them before you invest in the combustion equipment.

FIGURE 5. Load of green wood chips.
Photo courtesy of USDOE NREL.

Which to choose—pellets or chips? If you have one or two barns, then wood pellets will likely be more economical. Wood pellets will be more expensive but the combustion equipment will cost less. If your heating needs are greater than 2–3 million Btu/hr, then wood chips may be more cost effective if there is an ample local supply. It is important to look at the total annual cost, including maintenance costs, and not just the fuel cost alone when making a decision on which fuel type to use.

Wood combustion equipment

Pellet and wood chip combustion appliances are designed to run automatically without daily maintenance, and they have many safety features to prevent them from causing a fire. When considering using wood energy the first decision to make is whether to use a furnace or boiler. If you have a single barn, a furnace may be a more economical option. If you have multiple barns, then a boiler allows the heating system and fuel storage to be located centrally and pump hot water to each barn. Both furnaces and boilers are available that burn wood pellets or wood chips. A wood chip feed system will be more expensive than a wood pellet system, but wood chips are generally lower in cost per unit of heat generated.

FIGURE 3. Wood pellets.

FIGURE 4. Wood chips.

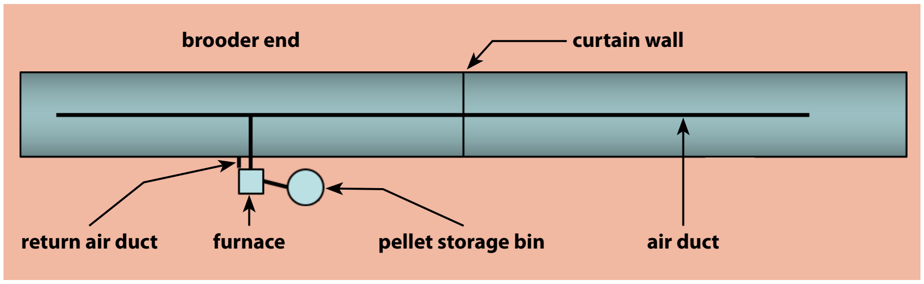

FIGURE 6A. Furnace located at one end of barn.

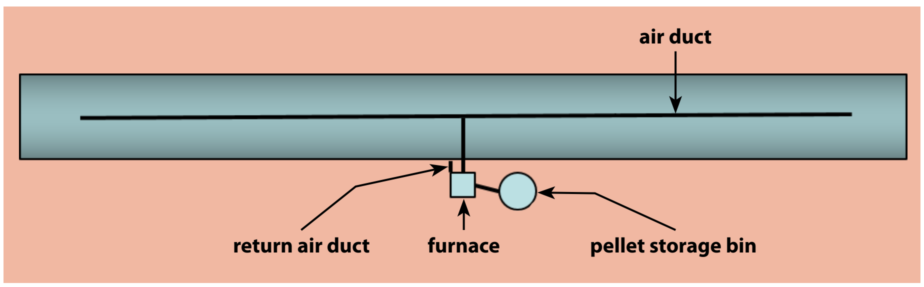

FIGURE 6B. Furnace located at center of barn.

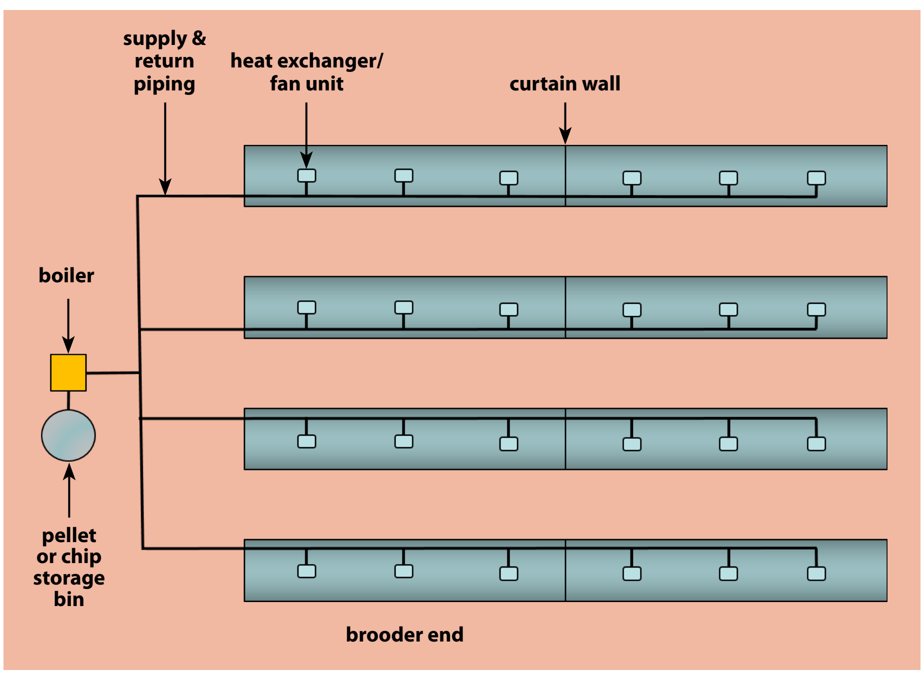

FIGURE 7. Central boiler system and fuel storage.

Furnace location

At the start of a new flock, if you restrict the chicks to one end of the barn and open up the space as they grow, locating the furnace in the center of the end (figure 6A) where the new flock will be located will work best. If a new flock has the run of the barn, then locating the furnace in the center of the barn (figure 6B) works best. Metal ductwork must run from the furnace to the center of the barn. From that point the ducts can be either metal or plastic. Warm air from the furnace is distributed through holes in the sides of the ducts sending the warm air towards the outside walls. Dampers in the ducts control how much of the barn length is heated.

Boiler setup

The boiler and fuel storage should be located centrally to the complex of buildings (figure 7) with ample access for fuel delivery. The typical water temperature of 180°F from the boiler is delivered to the barns through insulated underground pipes. The pipes run the length of each barn to heat exchangers with fans (figure 8) spaced every 60–80 feet along the center of each barn. The heat exchangers are hung by cables from the ceiling so they can be raised out of the way for barn cleaning. The fans will distribute the warm air radially about 40–60 feet from the heat exchanger.

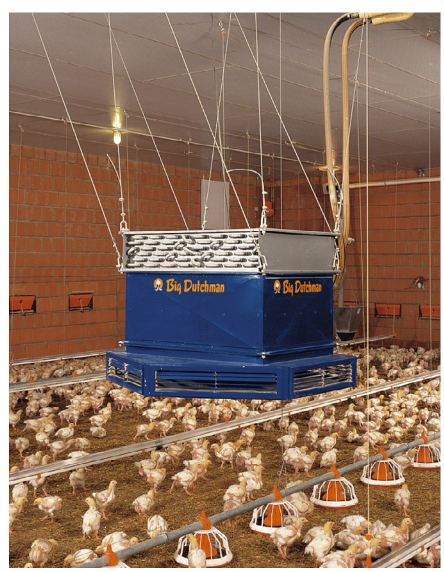

FIGURE 8. Hot water heat exchanger and fan.
Photo courtesy of Big Dutchman, Inc.

Limitations of wood energy

Wood burning systems can't be turned on and off rapidly like LP gas heaters, so in the spring and fall of the year when temperatures may be cool overnight and then warm up quickly during the day, a wood system won't run efficiently. Wood systems work best if they can burn at a steady rate. If a boiler is used, a thermal storage tank can be used to store heat when it is not needed in the barn. This levels the peaks and valleys of the demand curve and allows for more efficient combustion. A furnace system may operate with a greater temperature differential (high to low temperature) due to the slower respond with burning wood versus LP gas.

Some parts for wood combustion appliances are not "off-the-shelf" parts compared to typical heating systems. This should be discussed with your equipment supplier to make sure critical parts are stocked and an emergency phone number is maintained to get service in the event of a breakdown. Another option is to maintain your current heating system for backup in case of a breakdown. This is an added cost but reduces risk until you have confidence in operating the wood heating system. If you maintain the gas heaters, using them for the late spring and early fall heating may be more cost effective than using wood and will provide some run time to ensure they are working.

Maintenance

Wood combustion systems will require a minimum of 1–2 hours of labor per month for maintenance to clean heat exchanges, remove ash, etc. A case study in Minnesota found that the poultry producer spent an average of 8.5 hours per flock (approximately 8 weeks) for maintenance. Most systems are automated and can be set up to alert a person via a phone call or text message if there is a problem or the appliance needs some maintenance.

Examples of poultry barns with wood heating

Viking Company

This is a broiler operation in Albany, MN, with two identical barns. One barn was used as a control and the other was converted to use a wood chip furnace. The study period was 22 months for 6 flocks. Fuel savings for wood energy was $8,029 per year compared to LP gas with prices that fluctuated from $1.00 to $1.30 per gallon. The investment was $130,000 with a cost recovery of 16.2 years based solely on fuel savings. However, the grower had higher daily gains and lower costs per pound compared to the control barn which resulted in an additional $2,095 cost savings per income per flock. When added to the fuel savings, the capital cost recovery drops to 6.3 years. A link to the report for the project can be found in the reference section.

Turkey farm in Buffalo, MO

In 2008 a 500,000 Btu/hr pellet furnace was added to a 55-foot-wide by 550-foot-long barn that used propane heaters (house 1) and was compared to a second identical barn (house 2) with only propane heaters. During an 18-week grow-out period, the propane heaters (house 2) used 8,174 gallons at a cost of $1.74/gallon totaling $14,223. During the same period, the wood pellets and propane (house 1) used 2,149 gallons of propane and 41 tons of wood pellets at $145/ton. The total fuel cost for house 1 was $9,684 for a total savings of $4,539.

Figure 9 is an example of a wood pellet/chip furnace setup to heat a poultry barn. In northern climates, the furnace would be housed in a building to protect it from the weather.

FIGURE 9. Wood pellet/chip furnace heating a poultry barn.
Photo courtesy of Even Temp Biomass.

Estimating wood heating cost

The best way to estimate the cost advantage of wood fuel is to compare wood to your historical fuel use of the current fuel. If you are going to maintain the existing LP gas heaters and use them in the late spring and early fall when minimal supplemental heat is needed, then you should estimate replacing 80–90% of the LP gas. To estimate the cost you will need to know the following:

1. Type and amount of fuel currently being used.
2. Thermal efficiency of the current heating appliance/system.
3. Type of fuel and the energy value of the wood fuel.
4. Thermal efficiency of the wood heating appliance/system.
5. Estimate of the amount of the current fuel that will be replaced.

The amount of fuel used historically should be available from your fuel supplier. If your barns share a common fuel tank with other barns, consider estimating the fuel cost for all the barns (or part of barns) that are heated to see if it is economical to change before trying to separate out the usage of each barn. If the buildings have similar construction, house the same types of flocks, at the same time, then the energy usage could be split based on the square footage of space for each barn.

Thermal efficiency of current heaters

Most poultry barns use direct vented heaters. These units require some air exchange into the barn when the heaters are running to provide ample oxygen level for combustion. This air needs to be heated which reduces the overall efficiency versus the use of a vented heater that doesn't require air exchange or uses an air intake for combustion air. This reduces the efficiency for direct vented unit heaters to about 90%. If the minimum ventilation rate for the barn is higher than the minimum ventilation rate recommended by the direct vent heater manufacturer, then the reduction in efficiency can be ignored (in which case use 98% efficiency).

Table 1 and the fuel cost comparison worksheet (back page) can help calculate fuel cost savings.

TABLE 1. Typical energy content of fuels.

Fuel type	Unit of sale	Energy content (Btu/unit)	Thermal efficiency range
Natural gas	therm	100,000 Btu/therm	80–94%
LP gas (propane)	gallon	91,600 Btu/gallon	80–94%
Wood pellets	pound	8,000–8,200 Btu/pound	80–92%
	ton	16,000,000 Btu/ton	
Heating oil	gallon	138,000 Btu/gallon	70–85%
Wood chips	pound	3,800 (50%)–6,200 (25%)* Btu/pound	70–85%

* (% moisture)

Appendix

Energy efficiency first

Before switching to wood energy, one should invest in energy efficiency first. This may involve adding insulation to walls and ceilings, converting the barn to a totally-enclosed, tunnel-ventilated building with no side wall curtains, reducing unplanned infiltration (foundation still, around doors, other openings), performing routine maintenance on heating equipment, replacing inefficient heaters, installing a climate control system, adjusting air inlets to promote proper air mixing and reducing over ventilation. Litter management can have an effect on barn energy use. If the litter is damp, then there will be higher ammonia production, which will require higher ventilation rates. Energy efficiency items will usually provide a faster payback and can reduce the cost of a future wood appliances then simply switching fuel sources.

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Fuel cost comparison worksheet

Type of heating fuel currently being used ______________________

1. Cost per unit of current fuel **$** ____________ / ____________ (use same units shown in table 1)
2. Energy content of fuel (consult table 1) ____________ **Btu**
3. Amount of fuel used per year (same units as in table 1) ____________ / ____________ **units**
4. Percentage of the current fuel that will be replaced ____________ **%**
5. Multiply lines 2, 3, and 4 ____________ **Btu**
6. Efficiency of heating appliance
   - a. Output Btu (from label on heating unit) ____________ **Btu**
   - b. Input Btu (from label on heating unit) ____________ **Btu**
   - c. Divide line a by line b, then multiply by 100 ____________ **%**

   or
   - d. If you have a direct-vent heater, use 90%. ____________ **%**
7. Usable heat (multiply the results of line 5 by line 6c or 6d ____________ **Btu**
8. Fuel cost per year (multiply lines 1 & 3) **$** ____________ **Btu**

Potential new fuel type for comparison ______________________

9. Cost per unit of "new" fuel **$** ____________ / ____________ (use same units shown in table 1)
10. Energy content of "new" fuel (consult table 1) ____________ **Btu**
11. What is the efficiency of the proposed new appliance? ____________ **%**
    - a. For a standard wood pellet furnace or boiler, use 82%.
    - b. For a high efficiency wood pellet furnace, use 90%.
    - c. For a wood chip boiler or furnace, use 80%.
12. Annual energy input (divide line 7 by 11) ____________ **Btu**
13. Amount of new fuel estimated per year (divide line 12 by line 10) ____________ / ____________ **units**
14. New fuel cost per year (multiply line 13 by line 9) **$** ____________
15. Annual fuel cost saving/loss (subtract line 8 from line 14) **$** ____________
16. Cost/investment of new fuel appliance **$** ____________
17. State/federal incentives (incentives can be found at **http://programs.dsireusa.org**) **$** ____________
18. Net investment (subtract line 17 from line 16) **$** ____________
19. Approximate time for payback (divide line 18 by line 15) ____________ **years**

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For more information on using wood for heating visit www.wisconsinwoodenergy.org.

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