Stoves, Furnaces & Fireplaces

Part Two In A Series
On Wood As A Fuel Source
INTRODUCTION

As the costs of all types of fossil fuels increase, more and more attention is being focused upon the role that wood may play in the heating of homes. Many people want to learn more about how to prepare firewood, how to choose and operate a wood heater, and the possible problems related to home heating with wood.

Wood has advantages as a fuel because it is in plentiful supply in many areas and it can be an economical heat source, as well as a renewable resource. However, because the cutting and hauling of wood is hard work, and the wood must dry for at least 6 months before use, wood as a fuel may not be convenient for everyone. Wood fires also require attention, and stove pipes and chimneys need cleaning to remove soot and creosote.

Stoves, furnaces, and fireplaces are the three possible choices when deciding on the type of wood burning installation for your home. The following information should be helpful in deciding which unit is best for you based upon efficiency and how it will be used.

WOOD BURNING STOVES

Before purchasing a stove, first decide how it will be used. Will it be for
1. emergencies such as power outages?
2. supplemental heat to the main furnace or to heat one or two rooms?
3. total heating of the entire house?
4. conversation and occasional use?

Consider the total cost of installing a stove. Remember you may need to buy stove pipe, floor and wall protection and a chimney. A complete installation can cost several thousand dollars which will take many years to pay back. Often this money is better spent on insulating and weather tightening the house before switching fuels.

There are thousands of manufacturers of woodburning stoves throughout the world. Appearance, style, finish, construction, materials, and weight are some of the characteristics which need to be evaluated. Durability of welding, sharpness of cabinet or stove edges which may scratch or cut people, and ability to burn wood efficiently for maximum heat are other factors to consider. Some persons are concerned with creosoting of the stove pipe and chimney from slow burning airtight stoves while others want stoves which will burn wood for a long time and with little attention.

Materials of Construction

Sheet metal stoves of relatively thin gauge have been used for many years for heating. They are relatively inexpensive but have a shorter life than plate steel or cast iron stoves. They will quickly heat a room, but they also cool rapidly when the fire dies down. If occasional quick heating is needed, such as for a cabin, a garage, or emergency use thin walled stoves are appropriate.

Good draft control is very important to control the rate of heating. Thin wall stoves should never be heated red hot as they tend to warp and burn through. Examine these stoves frequently for thin spots.

Plate steel stoves made from steel $\frac{1}{8}$ inch or thicker are also available. These welded stoves hold heat longer. Many of these stoves are lined with firebrick to protect the metal and to provide more even heat.

Cast iron stoves warm up more slowly and retain heat longer than sheet metal stoves. However, if other design and operating practices
are equal, the same amount of heat will be delivered to the room. Cast iron holds up well under heat, has a long life, spreads the heat away from hot spots in the fire, and generally does not warp. It cracks easily if dropped. Used cast iron stoves should be thoroughly inspected by persons knowledgeable in their construction to determine if there are any cracked, broken, or missing parts, or areas that are warped or thin.

**Stove Types**

Most wood stoves transfer heat to the room by radiating heat from the hot surface of the stove. Radiant heaters produce heat that is most intense at close proximity and diminishes rapidly with distance from the stove. Surfaces in direct line with the stove will be heated.

The combination type stove is similar to the Franklin stove in its use. It can be operated as an open fireplace or a closed stove. Most of these are manufactured of cast iron and are large enough to heat one or two rooms. Some of the stoves are built with airtight doors and good draft control.

A box stove is just what the name indicates, a box. It can have either a square or rectangular cross-section and is most often supported on legs. The wood is placed on a bed of sand or ashes as the stove does not usually have a grate. These stoves are available in many sizes, in airtight construction and with baffles or warming boxes to increase their efficiency. In the larger sizes, the fire box will take firewood in 24 inch lengths.

The parlor stove was designed to heat a single room. It usually has a double steel wall or jacket around it which gives a lower surface temperature than a single wall stove. It is often available with a thermostat that regulates the drafts and thereby the temperature in the room.

The pot belly stove is most often associated with railroad stations and country houses. It is usually made of cast iron and often has ornate designs and trim. The small diameter firebox requires that wood be cut in short lengths. The added height allows better burning of the volatile gases.

Kitchen stoves: A range can be used for cooking as well as heating. Of course, a range warms the kitchen whenever it is used, which can be uncomfortable in summer. Most ranges are of cast iron construction and will burn either wood or coal. When wood is burned, the pieces need to be short and split fairly small.

Circulating Stoves: These stoves are constructed with a metal box spaced about one inch from the wall of the firebox. Vents in the top and bottom of the outer box allow natural air currents to carry the heat away from the stove. The outer surface of a circulating stove is not as hot as a radiant stove and thus can be installed closer to combustible material than radiant stoves. This also makes the circulating stove a wise choice if small children are involved. Circulating stoves are better suited to heating a large room than radiant stoves.
Types of Stoves

- Kitchen Stove
- Parlor Stove
- Box Stove
- Circulating Stove
- Pot Belly Stove
- Air-tight Stoves
- Double Chamber
Efficiency

The stove characteristic that usually receives the most attention is efficiency. Efficiency is the percentage or fraction of chemical energy available from the wood that heats the room. Efficiency depends on:

1. the wood used
2. the skill of the operator
3. the design of the stove and chimney.

Wood varies in size, density and moisture content; it is not a simple, uniform fuel like natural gas, propane or fuel oil. Gas and oil burners uniformly mix fuel with oxygen, while various size chunks of wood are periodically dumped into a firebox. Over the years many stove designs have been developed to overcome the difficulties inherent in wood-fueled combustion.

Gas and oil can be burned at fairly high efficiencies because the burner always operates at full output, but the fuel can easily be started and stopped. Wood-fueled heaters operate most efficiently when they are burning at nearly full capacity. In Spring and Fall it is difficult to operate wood stoves at full output to create high enough temperatures for good combustion and heat transfer without overheating the room. Because the stove is normally operated at reduced draft in order to achieve a comfortable room temperature, or in order to hold the fire overnight, the efficiency of the stove is sacrificed. Thus, stove efficiency may not be the most important factor in selecting a stove.

Combustion Efficiency

When burning wood, combustion of the volatiles can supply a majority of heat from the burning process. Fireplaces, which are about 10 percent efficient, do not retain the gases long enough to burn them completely. To burn these gases a long flame path, heated above 1100 degrees F, is required.

Much greater efficiencies can be achieved by burning wood in a stove. The walls and top of a simple box stove can be heated sufficiently to aid in burning the volatile gases. Some stoves have a baffle built into the firebox. The baffle, heated by the fire, creates a long flame path which is necessary to efficiently burn the volatile gases. Stoves with no baffle are called updraft or diagonal draft stoves. Baffles can create a downdraft, a crosscraft or an S draft.

The single most important factor in stove efficiency is the control of airflow to the fire. The

Draft Configurations

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<th>Up</th>
<th>Diagonal</th>
<th>Cross</th>
<th>Bypass Damper</th>
<th>Double Chamber</th>
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Baffles heated by the fire create a long flame path necessary to efficiently burn volatile gases.
Airtight stove is best in this regard because air can be controlled very well using tight fitting adjustable draft openings, operated either manually or with a thermostat. A box stove offers little control of the air supply because air leaks around doors and at joints. When the air supply is controlled to the stove, the wood will burn more efficiently and less cool air from outside will be drawn into the house for combustion.

### Combustion Efficiency of Typical Heating Units

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<th>STYLE</th>
<th>EFFICIENCY</th>
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<tr>
<td>Standard Fireplace</td>
<td>up to 10%</td>
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<tr>
<td>Fireplace with metal liners or tube grates</td>
<td>up to 20%</td>
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<tr>
<td>Simple Updraft Stove, Franklin stove</td>
<td>up to 30%</td>
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<tr>
<td>Airtight Stoves</td>
<td>up to 45-60%</td>
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<tr>
<td>Wood Furnace (Burning maple at 20% moisture content)</td>
<td>up to 50-60%</td>
</tr>
<tr>
<td>Gas or Oil fired Furnace</td>
<td>up to 65-80%</td>
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### Heat Transfer Efficiency

The ability of a stove to transfer the heat to the surroundings is important to overall efficiency. The surfaces of the stove must be warmed to radiate heat. Updraft stoves typically burn hotter than downdraft stoves; downdraft and S draft stoves, on the other hand, usually are larger to accommodate a baffle, so they have more surface to radiate heat. Fire brick lining in the fire box retains a hotter fire and provides protection for the stove walls, but it reduces the radiation from that part of the stove.

### Draft Control

A comfortable room temperature is most easily maintained by controlling the rate that the fire consumes the wood in the stove. The loose fitting doors on a Franklin stove provide some control of the fire. However, much better control is achieved if the stove door seals the opening and the air flow into the stove is controlled by an adjustable vent. Stoves constructed in this manner are called airtight stoves. On some stoves, this air inlet is controlled by a thermostat.

The primary air supply may not be adequate or in the correct position to support the combustion of the volatile gases, so some stoves have an additional air vent to introduce secondary air above the flame. The amount of secondary air admitted is critical for efficient operation. If too little air is admitted, incomplete combustion will result. If too much air is admitted, the gases will be cooled, affecting combustion and heat transfer.

If you have been operating an air-tight stove at reduced draft for a period of time, do not immediately open the door. Open the air inlets and wait 20 to 30 seconds before opening the door. As the wood in the stove is burning with a low air supply, air rushing in through an open door could cause flames to shoot out through the opening. A further precaution would be to stand to the side of the door.

### Stove Heating Capacity

Many manufacturers rate their stoves by either the number of cubic feet or the number of rooms the stove will heat. Any capacity rating must be used cautiously. In colder areas or poorly insulated houses, less area will be heated. In addition, heat movement into more than one room of the house may be very poor. Unless the rooms are very open, attempting to heat more than one room with a stove may result in uneven temperatures and cold drafts along the floor.

Many people purchase a stove that is too large for the room in which it is installed. If the stove is operating efficiently, the room is overheated. It is difficult to maintain a small fire in a large stove. One option would be to try to move the heat into other rooms of the house.

While the concepts of heat flow are well established, the design recommendations for moving heat from a wood stove through the house have not been well documented. Warm air will rise to a room above if a path is provided for the cool air to return to the stove. The return path could be registers close to the outside walls, or an open stairway.
A furnace blower will provide forced convection and the size of both the hot air and cold air return registers can be smaller than the registers used for natural convection. The normal furnace fan is designed to move large amounts of hot air as the furnace is running intermittently. A wood stove is a gentler, continuous heat source. The rpm of the fan can be reduced by one half to provide a quieter continuous operation.

If a fan must be purchased, the typical specifications would be a centrifugal (squirrel cage) fan with a fractional horsepower motor for semi-continuous duty. The fan should circulate about one complete air change in the house each 30 minutes. A 300 to 500 cfm fan would be adequate for most homes.

A fan is usually necessary to move the warm air from room to room when the rooms are on the same level of the home as the stove.

Another effective way to move heat to other parts of the house is to install hot water coils in the stove and pump the hot water to baseboard radiators. The water coils will normally be kept at a temperature that is less than the boiling point of water. Creosote will form on these coils but creosote is less of a problem on coils inside the stove than coils inside the stove pipe. A pressure relief valve should always be installed in the water line. Such valves are part of all conventional water heaters and boilers.

With some installations, the hot water may flow through the pipes by natural convection. However, the pipes must be carefully designed so that air traps are avoided. A thermostatically controlled pump provides positive circulation and may be more effective than natural convection systems.

**FURNACES**

Woodstoves are good for heating small, open houses or one or two rooms. But most houses are designed for central heating with a furnace. Wood burning furnaces are large enough to heat an entire house. Some are made to fit a hot air duct system, others a hot water system. If you have a good wood supply and don’t mind the hard work of cutting, splitting, stacking and feeding the wood, a furnace may be a good investment.

A stove becomes a furnace if a sheet metal jacket or box is placed around the stove to allow air to circulate around the stove. The heated air is then distributed through ducts and eventually returns back to the furnace for reheating. A good wood or multi-fuel furnace with a conventional heat circulating system provides even heat distribution throughout the house and offers the convenience of remote temperature control.

Because of the large fuel capacity and controlled burning, most furnaces require stoking no more often than once every 10 hours and sometimes as little as once every 24 hours. Some of these units have a storage magazine like a hopper, which holds a large charge of wood and feeds it slowly into the combustion zone. Others have extremely large fireboxes that permit the stoking of large quantities of large chunks of wood (as large as 13 inches in diameter and 3 feet long).
Though burning large chunks is not as efficient as burning small sticks, the saving in cost of fuel preparation is great.

All furnaces are thermostatically controlled. When the thermostat is not calling for heat, the primary air supply is very low so the fire will continue with a very low heat output. When heat is demanded by the thermostat, the primary and secondary air supplies are opened. The fire will burn at a high rate, with near complete combustion. On some furnaces, primary and secondary air is supplied by a blower. The hot gases of combustion then pass through a heat exchanger to heat the air or water used to heat the house. Usually another blower forces air from the house through the exchanger. This type of furnace can be quite efficient.

In addition to cutting the wood and stoking the fire, a wood furnace requires more maintenance than a gas or oil burning one. Ashes must be removed and the chimney must be cleaned periodically. The boiler or heat exchanger may need cleaning to remove any deposits. Before purchasing a wood burning furnace, you should first talk to someone who already has one to learn more about how well they operate.

It is desirable to keep your house warm when you are not at home to avoid frozen water pipes. Many wood burning furnaces come equipped, or can be equipped, with thermostatically controlled oil burners. The oil furnace automatically comes on when the wood fire dies down.

FIREPLACES

A masonry fireplace supplies radiant energy to bring quick comfort to a cold room. However, it is not a very efficient heater. The volatile gases, containing the highest percentage of the heat value of the wood, are drawn up the chimney unburned and wasted to the outside air. In addition, air that supports combustion in the fireplace is drawn from the room, and must be replaced by cold outside air. The heat radiated to the room may be less than the heat that is contained in the air that is drawn up the chimney. Additional heat can be lost if the flue damper is left open after the fire dies out.

In open hearth fireplaces, most of the heat escapes up the chimney

Only 10% of the potential heat available goes to the room

A furnace's thermostat, if located away from the fireplace, should be turned down when using the fire for heat so that the combustion air is not warmed by the furnace. A thermostat located near the fire will be "fooled" into thinking the whole area controlled by that thermostat is warm.

Fireplace Construction and Improving Efficiency

"Zero clearance" prefabricated metal fireplaces are available that can be installed close to the walls. Other metal freestanding fireplaces must be placed out in the room at least 36 inches away from combustible walls. These metal fireplaces have about the same efficiency as masonry fireplaces, but they warm up faster. Of course, they cool rapidly once the fire dies down.
Metal Freestanding Fireplaces

At the time of construction, a metal liner can be installed in a masonry fireplace. This unit circulating air from the room behind the metal fire box and out into the room either along the edge or above the fireplace mantle. A fan can be placed in the duct in some of these units. A liner can double the heat that reaches the room from a conventional fireplace.

Hollow Tubes

Tight fitting glass doors on the fireplace greatly reduce the radiation that reaches the room. However, the doors reduce the amount of warm air from the room that is lost up the chimney. Probably the most heat will be gained if the doors are opened during the hotter stages of the fire and closed as the fire dies out. The greatest saving occurs when the closed doors control the loss of heat overnight. A tight fitting metal door or sheet of asbestos could also be used.

Modified fireplaces heat more efficiently than ordinary fireplaces.

Tubes or hollow grates are available that can be placed in the fireplace to provide additional heat by air circulation. Some of these units rely on natural airflow, others use a fan. One advertisement for a hollow tube device indicates a 5,000 to 10,000 Btu per hour heat gain. If electricity costs 5¢ per KWH, this amount of heat can be produced electrically for 7¢ to 15¢ per hour. If the unit is very expensive, many fires are needed to recover this investment.
Replacing Fireplaces with Wood Stoves

Several stoves have been developed to increase the efficiency of the fireplace. Some controlled draft wood stoves are built to fit inside existing fireplaces. Others are designed to sit in front of the fireplace with a piece of sheet metal to cover the fireplace opening. These installations eliminate the need for another chimney.

If the stove is designed to fit inside the fireplace, the manufacturer's instructions for installation should be followed.

Stoves That Fit Into Existing Fireplaces

There are several ways to insert the stovepipe into the chimney for stoves that sit in front of the fireplace. One way is to remove or wire open the damper and insert the stove pipe through a snug fitting metal sheet placed in the damper opening. A non-combustible material can be used to create a seal at the connection. Be sure the stove pipe can be easily removed for cleaning.

If the stove is too tall for the stove pipe to be inserted directly into the fireplace, or if you want to obtain heat from the stove pipe, the connection can be made above the fireplace.

In some instances creosote may run down toward the fireplace into the sealing material or past the damper and accumulate in the original fireplace opening. Check frequently for creosote accumulation. The material used to create the seal the fireplace may need to be replaced periodically.

Adapted by Kathy Collier, Extension Assistant and Larry W. Turner, Extension Agricultural Engineer, University of Kentucky, from the publication, "Burning Wood," by the Northeast Regional Agricultural Engineering Service, Cornell University, Ithaca, New York, 14853.