Photo courtesy of Gunflint District - U.S. Forest Service

Heating With Wood

Using wood to heat your Northern Minnesota home

This fact sheet is written to help homeowners in Cook County, Minnesota evaluate options on the use of wood for home heating. If you are thinking about upgrading or purchasing a new wood burning appliance, there are many factors to consider.

Introduction

An estimated 500 households in Cook County already use wood for home heating – about 18% of homes in the county, according to recent U.S. Census data.

Interest in the use of wood, either as the sole source or a supplement to heating, has increased in recent years. Rising heating fuel costs and concern about dependence on foreign oil and carbon emissions are driving this interest.

Advances in wood burning technology

Wood burning technology has improved dramatically over the last 25 years making wood safer, more efficient and more convenient to use. Improvements include:

- New firebox designs capable of burning wood more completely, cleanly, and at higher efficiencies;
- Pellet stoves that are capable of providing at least 24 hours of unattended heating;
- New types of glass doors that can withstand and transfer heat while providing a clear view;
- Reliable installation safety standards that provide clear guidelines for safe installation and certification requirements for installers and inspectors (CMHC 2008);
- Outdoor wood furnaces that burn 90% cleaner than unqualified units (EPA 2008).

Choosing an appliance

If you are thinking about using wood for home heating, there are many factors to consider. One place to start is understanding the different types of appliances.

Wood burning appliances that can be used for home heating include:

- **Conventional Fireplaces**
- **Advanced Technology Fireplaces**
- **Outdoor Wood Boilers**
- **EPA-Certified Stoves and Inserts**
- **Residential Pellet Stoves, Furnaces and Boilers**
- **Masonry Heaters**

When looking for an appliance, it is important to look for new designs that are less polluting and more energy efficient than past models.

Today's EPA-certified wood stoves emit 70 percent less particle pollution and are approximately 50 percent more efficient than wood stoves manufactured before 1990 (EPA 2009).

Table 1. Residential Wood Appliance Efficiencies and Emissions

WOOD APPLIANCE	EFFICIENCY	PARTICLE EMISSION (g/hr)	CO_2 EMISSION (lb/MMBtu)
Conventional Fireplace1	-10 to 10%	50	2,157.0
Advanced Technology Fireplace3	50 to 70%	>1 to 5	
Outdoor Wood Boiler (prior to 2007)1	28 to 55%	55 to 143	359.5
Outdoor Wood Boiler (EPA Phase I)1	30 to 60%	15	
Outdoor Wood Boiler (EPA Phase II)2	50 to 90%	<1 to 6.5	
Fireplace Insert1	35 to 50%	0.94 to 3.9 g/kg	507.5
Airtight Stove1	40 to 50%	10 to 20	479.3
EPA-Certified Stove and Insert1	60 to 80%	2.5 to 7.5	317.2
Residential Pellet Stove1	75 to 90%	<1 to 2	296.6
Masonry Heater4	85 to 90%		

Sources: 1_Manomet (2010), 2_EPA (2008), 3_OEE (2009), 4_Energybible (2010)

Conventional Fireplaces

Commonly constructed of stone or brick and built into the structure of the house, these fireplaces do not incorporate any emission reduction technologies and are the most inefficient of all the home wood heating sources. Conventional fireplaces have been rated to have efficiencies in the -10% to +10% range (Manomet 2010). This inefficiency is caused by an inability to convert fuel into useful heat and the large air demands being drawn from the heated home and moved directly up the chimney. Additionally, conventional fireplaces create significantly more indoor and outdoor pollutants than more efficient methods of wood heating.

Today, conventional fireplaces are mainly used as a supplemental heating source or for viewing enjoyment rather than as a primary heat source. As a supplemental heat source, conventional fireplace can benefit from older technology implements such as glass doors, heat convection tubes, and contoured masonry fireboxes. Newer technologies - such as pellet and cordwood inserts discussed below - can significantly increase the useful heat of fireplaces and reduce emissions. For fireplaces used for aesthetic purposes, wax fire logs may be used. The heat content of wax logs is much higher than that of wood, moisture content is much lower, and particle emissions are about 68% lower than cordwood (OMNI 2009).

Advanced Technology Fireplaces

Sometimes called factory-built or zero-clearance fireplaces, advanced technology fireplaces make use of the same technologies used in advanced stoves and are also EPA-certified for low smoke emissions. Unlike conventional fireplaces, these fireplaces can be used for efficient home heating. Some of these fireplaces have a central heating capability through ducts to distribute heat to other parts of the house (Woodheat 2009).

Advanced technology units have better heat exchange properties than conventional fireplaces, increasing their energy efficiency to 50-70%. These fireplaces use two separate paths of preheated combustion air. One source of air is fed directly to the burning wood, while the second is aimed immediately above the main fire to capture and ignite the incomplete combustion products that would otherwise be released into the chimney. As a result of their enhanced features, advanced technology fireplaces have about the same air requirement as a high efficiency gas or oil furnace (OEE 2009).

Fireplace Inserts

If you have a conventional fireplace and would like to convert it to a more effective heating system, you may want to consider a fireplace insert. A fireplace insert is similar in function and performance to a wood burning stove inserted in the existing fireplace. Installation codes require that a stainless steel liner be installed from the flue collar to the top of the chimney. The average cost of a wood burning insert is around $1,200 to $2,200 (Clark 2010).

Outdoor Boilers and Central Heating Furnaces

Source: boiler-review.com 2011

Wood-fueled central heating systems tend to be implemented when a wood stove isn't sufficient and fuel is readily available. There have been substantial design changes in recent years that have greatly improved efficiency and reduced emissions. In 2007 the EPA launched a voluntary program to make hydronic heaters 70% cleaner. In 2009, phase 2 of the program went into effect making new hydronic heaters 90% cleaner than unqualified earlier models.

Outdoor Boilers

Outdoor boilers have a water jacket that surrounds the boiler's firebox, similar to the hydronic system. Heat is transferred from the fire to the water, and then pumped through insulated pipes to the building. The hot water then passes through a heat exchanger, or into a variety of heat emitters, and can be designed to provide hot water as well. Outdoor boilers usually have to be refueled on a daily basis.

Outdoor units can be used to heat large or multiple buildings while indoor units heat smaller areas. The following descriptions include several sizes and types of larger wood burning units:

Forced Hot-Air Systems

For buildings with existing forced air ductwork, a wood-fired furnace can be installed. These furnaces usually have a firebox, a chamber where combustion occurs, and optional hot-water coils controlled with a thermostat. This type of system burns wood to heat the air in a heat exchanger that is then distributed to the living spaces through the ductwork. Such equipment does not have a heat storage capacity, requiring it to be refueled regularly to maintain a consistent and comfortable temperature. The average price for a 100,000 Btu/hr hot-air furnace begins around $2,000-$3,000 (including installation).

Hydronic Systems

Hydronic systems are systems that use water to carry and circulate heat. They can burn wood, pellets, or coal to produce hot water that is used to heat buildings. They consist of a firebox with heavy cast-iron doors surrounded by a water jacket. The heated water is circulated through the building using a system of pipes that emit heat. The water jacket protects the firebox from overheating, a feature not available with hot-air furnaces. Hydronic heaters fueled by wood, pellets, and other biomass cost between $8,000 and $18,000 depending on the size of the unit. The cleaner units can cost as much as 15% more because of the improvements in technology (EPA 2008).

Combination

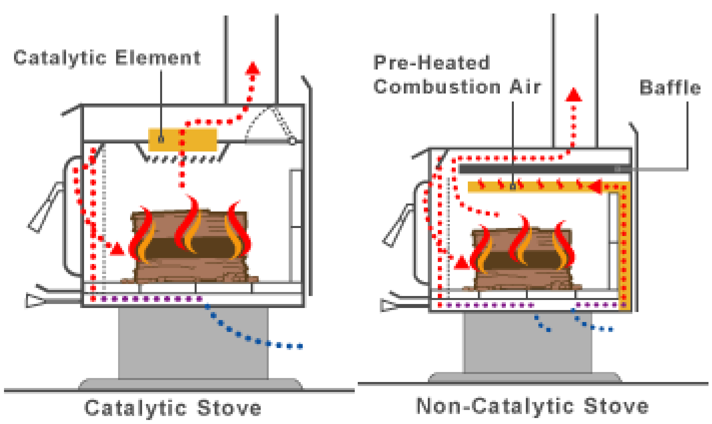
Combination systems allow wood to be used with fuels such as oil or gas, which can then be used as a backup when using wood is not possible. Such systems may also be equipped with an electric backup heating coil. Presently there are wood/gas, wood/oil and wood/electric heating combination furnaces on the market. One disadvantage is that combination systems tend to be almost twice as expensive as single-fuel systems.

Wood Stoves

A wood stove is the most common, flexible and inexpensive space heating option. Costs tend to run from around $700 to $3000 uninstalled (Pence 2010). Today's wood stoves come in a variety of materials such as porcelain, soapstone, and cast iron. A wood stove can be located almost anywhere there is enough space and a chimney can be properly routed. Ideally, a wood stove should be installed where the family spends most of its time and with the flue pipe running straight up from the stove flue collar into the chimney (CMHC 2008).

There are big differences in efficiency, performance, and safety between the newer technology stoves and conventional stoves (older cast iron box stoves, parlor stoves, Franklin fireplaces and the so called "airtights" of the 1970-80's (Woodheat 2009). Today's stoves produce less smoke (thus less creosote which reduces the risk of a chimney fire), minimal ash, and increased efficiencies that require less firewood. While older, uncertified stoves release 15-30 grams of smoke per hour, new EPA-certified stoves produce only 2-7g/hr. Be sure to look for the certification label on the back of the appliance. The most up-to-date listing for EPA-certified stoves can be found at: http://www.epa.gov/oecaerth/resources/publications/monitoring/caa/woodstoves/certifiedwood.pdf

Two types of EPA-certified wood stoves are available depending on the type of combustion system used: catalytic and non-catalytic.



Source: EPA Burnwise 2011

Catalytic Wood Stoves

In wood stoves with catalytic combustion, exhaust is passed through a coated ceramic honeycomb inside the stove where the smoke, gases and particles ignite and burn. This honeycomb structure is coated with a noble metal such as palladium, which interacts with unburned volatile organic compounds, particulate matter and carbon monoxide in the exhaust gases and lowers their combustion temperature.

Catalytic stoves have a lever-operated catalyst bypass damper, which is opened for starting and reloading, then closed when the fire has become hot enough for the catalyst to work. Once the optimum temperature is reached, the damper is closed to direct all exhaust through the catalyst structure. The catalytic honeycomb degrades over time and must be replaced. The catalyst can last more than six seasons if the stove is used properly. If the stove is over-fired, garbage is burned, and regular cleaning and maintenance are not done, the catalyst may break down in as little as two years. Garbage should never be burned in a wood stove or fireplace! Catalytic stoves are capable of producing long, even heat output.

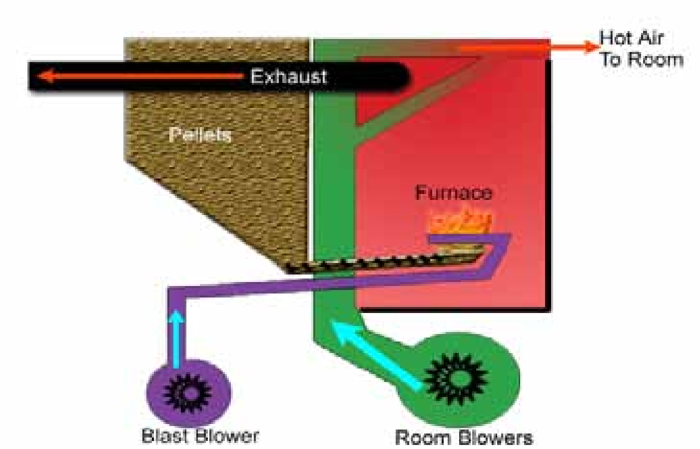
Non-catalytic Wood Stoves

Non-catalytic stoves do not use a catalyst, but have three other internal characteristics that create an environment for complete combustion. These are the firebox insulation, a large baffle (to produce a longer, hotter gas flow path), and pre-heated combustion air introduced through small holes above the fuel in the firebox. Like the catalyst in catalytic stoves, the baffle and some other internal parts of a non-catalytic stove need replacement periodically as they deteriorate from the high heat of efficient combustion.

Although most stoves on the market are non-catalytic due to their ease of use, some of the most popular high-end stoves use catalytic combustion. Because they are slightly more complicated to operate, and the best of them do perform exceptionally, catalytic stoves are suited to people who like technology and are prepared to operate the stove properly so it continues to perform at peak efficiency (EPA 2011).

You can purchase a retrofit kit to convert a non-catalytic stove to a catalytic. These kits are usually installed in the flue collar and involve adding a catalytic damper. Installation of a heat sensor on the stove body or stove pipe is recommended. These kits may not be appropriate for all types of stoves; review manufacturer's instructions carefully (DOE 2011).

Pellet Stoves



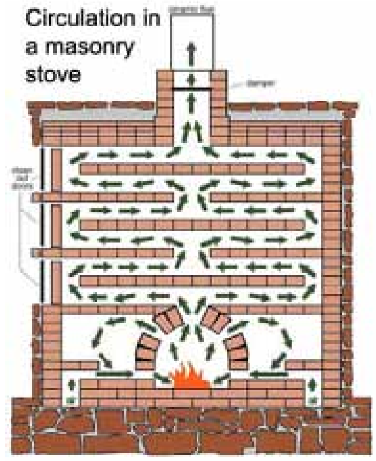
Source: Halstead, J. 2011

As the name suggests, pellet stoves use low moisture, high density pellets made from compacted sawdust, wood chips, bark and other organic materials as their fuel source. Pellet stoves require electricity to run (some units have battery back-up systems) and they are more complicated than wood stoves as they have three motorized systems. An auger moves the fuel from the storage hopper to the combustion chamber. An exhaust fan forces the exhaust gases into the venting system and draws in combustion air. Finally, a circulating fan forces air through the heat exchanger and into the room (CMHC 2008).

Pellet appliances have a hopper that holds the pellets until they are needed for burning. Most hoppers hold enough fuel to last a day or more under normal conditions. The amount of pellets that are fed by the auger into the combustion chamber determines the heat output. More advanced models are controlled by a thermostat to govern the pellet feed rate. The exhaust gases can be vented directly through a small flue pipe in a side wall or upwards through the roof, making placement of the stove flexible (DOE 2011).

Pellet burning appliances (inserts, furnaces, and boilers are also available) have very high efficiency ratings of 75-90%. Additionally, due to the near-complete combustion of the pellets, emissions can be as low as less than 1 g/hr of particulate matter. The pellets are packaged in 40lb bags which are ready to burn and can be purchased in advance and stored for the entire heating season. A typical homeowner uses 3 to 6 tons of pellets per heating season. As of March 2011, the average price of pellets was $225/ton for northern Minnesota, according to www.woodpelletsprice.com. Bulk storage and delivery with accompanying lower prices are becoming more prevalent as the pellet market grows.

Masonry Heaters



Source: The Energy Bible as cited in www.newadventure.ca

Masonry heaters are large wood stoves made of brick or stone. Due to the large amount of masonry material and the fire-resistant material lining the firebox, this type of heater is able to handle very high temperatures. The wood is burned very hot for a short time. The heat energy is transferred to the bricks or stones where it slowly dissipates as latent heat for up to 24 hours after the fire dies down.

The hot exhaust gases are routed through a series of combustion chambers or baffles built into the fireplace. The baffles prevent the heat from dispersing from the combustion chamber and cause the temperatures to rise to 1200-2000˚F. These high temperatures allow the exhaust gases to ignite thus achieving efficiencies of 85-90%. Masonry heaters tend to be very large and heavy, and reinforcement is likely to be needed when retrofitting in an existing home (Energybible 2010). Additionally, due to the amount of labor and materials required to build and install a masonry heater, these heating systems tend to be relatively expensive ranging from $10,000-$20,000 (Woodheat 2009).

ADDITIONAL CONSIDERATIONS WHEN PURCHASING OR USING A WOOD BURNING APPLIANCE

Local Wood Burning Regulations

Air quality regulations in some communities influence and restrict how people can burn wood. Some restrict burning when air quality is poor, some restrict the installation of wood burning appliances in new construction or at the time of sale. Be sure to check your local ordinances (HBPA 2011).

Placement

Choosing the right location for your appliance will be one of the most important decisions you make. Fireplaces, stoves and inserts are space heaters and chiefly intended to heat a space directly. Put the appliance in the area where you spend most of your time (Woodheat 2009).

Sizing

The best guide to heating capacity is related to the size of the firebox, not the size of the stove. A stove too small for the space will have to be loaded frequently and may deteriorate from being fired constantly at full output. A stove too large will overheat the space or produce smoky, particle-laden fires from being operated too low. Due to their higher efficiency, advanced combustion stoves will often have a smaller firebox (DOE 2011).

Installation

The Northwest Hearth, Patio and Barbeque Association recommends that all stoves, fireplaces, and inserts be installed by a hearth specialist. The technician you work with should be familiar with your model. This experience can save you time, money, and frustration in the long run. Plus, it gives you confidence your stove is installed properly and safely.

Make-Up Air

To burn wood efficiently, sufficient amounts of air are needed. Make-up air refers to ventilation that provides for fresh combustion air. In newer homes or very tightly-sealed homes, it is important to provide make-up air to ensure the wood burning appliance operates properly. Make-up air can be provided through an outside air duct or a properly adjusted Heat Recovery Ventilator (HRV). If you think you might have a make-air concern with a current wood-burning appliance, you can test for the problem before making major investments by opening an outside door or window near where the stove is installed. If make-up air is a problem, the stove will burn better with a door or window slightly ajar than it will with the outside doors and windows closed.

Operation and Maintenance

Be sure to familiarize yourself with the manufacturers instructions on proper and safe operation of your appliance. This can significantly increase the longevity of your investment and the effectiveness of your heating. Smoke rising through your chimney may condense and build up a substance known as creosote. This volatile substance can ignite and burn in the chimney, risking the safety of your home and family. Chimneys and vents can also become obstructed. Inspect your chimney regularly and clean as necessary.

Best Woods for Burning and Seasoned Wood

On average, a home in northern Minnesota may require 4 to 6 cords of wood for home heating each year.

The fuel value of wood varies by the type of wood and depends on its density and moisture content. Any wood will burn, but the denser (heavier) woods, if properly dried, will deliver more heat (Btu) per cord. Getting wood to a seasoned state (generally, anything below 25% moisture) depends on several factors. You can season most species of wood to 25% moisture content over the summer months.

Species

Moisture content, weight, and available heat energy will vary from species to species (See Table 2).

Time of year the tree was felled

Deciduous trees have heavy sap flow during spring and summer months—moisture content will be at its highest at these times. It's best to cut trees for heating in the winter.

Length of pieces

Wood dries fastest through the end grain but if the pieces are long, it will take more time for the moisture in the center to work its way out the ends. Cut wood to a length that will fit your appliance and facilitate quicker drying.

Split firewood

The fastest route for moisture is through the end grain, the second fastest is through the face of a split. If you want seasoned wood as quickly as possible, you need to split it.

Stacking

In order to speed the drying process, it's best if wood can be stacked off the ground, preferably in the sun, and where wind can blow through the pile.

Amount

The amount of wood you need to heat your home will depend upon the tree species you use, the type of appliance you have, the size of the space and other factors.

Table 2. Tree Species and Heat Energy Content

SPECIES	POUNDS AIR-DRIED[1]	MILLION BTU AVAILABLE[2]
Ash	3,370	23.6
Aspen (Poplar)	2,295	14.7
Balsam Fir	2,236	14.3
Birch	3,179	20.3
Maple (silver)	2,970	20.8
Maple (sugar)	3,577	25.0
Oak (red)	3,609	25.3
Oak (white)	3,863	27.0
Pine	2,713	19.0

[1] Approximate weight of standard cord (occupying 128 cubic feet of space and containing 80 cubic feet of solid wood), dried to 20% moisture content

[2] Potential available heat from standard cord with 100% unit efficiency. Heat at 20% moisture content.

Sources: Slusher (1995) and http://firewoodresource.com/firewood-btu-ratings/

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Cook County Local Energy Project
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US Department of Energy
www.energysavers.gov

Wood Heat Organization, Inc.
www.woodheat.org

Table 3. Summary of Wood Home Heating Appliance Considerations

	CONVENTIONAL FIREPLACE	ADVANCED FIREPLACE	OUTDOOR WOOD BOILER	EPA CERT STOVE (catalytic)	EPA CERT STOVE (non-cat)	PELLET STOVE	MASONRY
EFFICIENCY	-10 TO 10%	50 to 70%	50 to 90%	60 to 80%	60 to 80%	75 to 90%	85-90%
FIRE ENJOYMENT	x	x		x	x	x	x
ELECTRICITY NEEDED			x			x	
MECHANICAL PARTS		x	x	x	x	x	
FREQUENT REFILLING	x	x	x	x	x		
HOT SURFACES		x	x	x	x	x	
NEEDS CHIMNEY	x	x	x	x	x		x
WOOD STORAGE	x	x	x	x	x		x
24+ HR OPERATION POSSIBLE						x	x
EVEN HEAT			x	x		x	x
COST	$1,000 - 2,000	$1,500 - 2,500	$6,000 - 12,000	$700 - $3,000	$700 - $3,000	$1,500 - 3,500	$10,000 - 20,000

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