Guidebook

Effective and environmentally friendly firing of firewood

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This guidebook is for firewood users and gives practical advices for firing firewood in firing units in order to achieve efficient combustion and low emissions. These advices include the latest research results on the field.

This guidebook is a result of the EU-project Quality Wood, carried out in cooperation with the following project partners:

- **VTT** - Technical Research Centre of Finland
- **SINTEF Energy Research**, Norway
- **ADEME** - The French Environment and Energy Management Agency, France
- **A.E.A** - Austrian Energy Agency, Austria
- **CENER** - Renewable Energy National Centre, Spain
- **ApE** - Energy Restructuring Agency Ltd, Slovenia
- **CIS-Madera** - Centro de Inovación y Servicios Tecnológicos de la Madera de Galicia, Spain

Quality Wood project – EIE/06/178/SI2.444403

How firewood burn

We can separate the burning of the firewood into three stages.

Stage 1 – Vaporizing of water

When firewood is heated, the water contained in the log is transported to the log surface. The water on the log surface will be heated by the nearby flames and then gradually be transformed into water vapour. This heat, which is needed to vaporize the water is lost and reduces the temperature, resisting in poor combustion and heat output.

Use dry firewood containing less than 20% of moisture.

Stage 2 – Vaporizing and burning of gases from the firewood

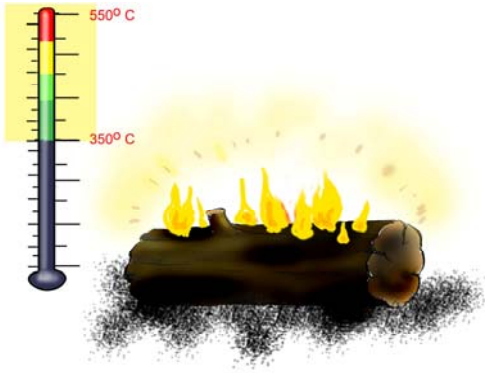
If we continue to heat the wood after all the water is gone, the wood mass itself will start to vaporize into a fumes containing hundreds of different volatile organic gases. If the temperature is too low, the mixture of the supplied air and these gaseous fumes will result in poor combustion, creating unburned compounds such as creosote, particles and unburned gases. These are unhealthy substances for both for the environment and for people. If such gases are allowed to escape from the firewood without being burned, a lot of potent heating energy is just going up the chimney.

Make sure that the firewood is supplied with enough air so that the firewood starts burning as soon as possible.

Stage 3 – Burning the charcoal

If the fumes from the vaporized wood and the air are mixed properly, nearby flames will ignite and start burning at temperatures around 350 ^{o}C. When most of the wood mass has vaporized, only a small part remains, which is called the charcoal rest. The charcoal will need temperatures of approximately 550 ^{o}C to burn. Combustion, taking place mainly on the surface of the charcoal rest, requiring much less air to burn.

You can reduce the secondary air when the firewood has turned to charcoal.



Consider your firewood

The quality of the firewood you can purchase may vary. Check to ensure:

- has the firewood been produced in accordance with any standards? If so, the manufacturer is probably serious about his quality requirements
- can you see any fungi, decay or mould? Good quality firewood does not have this

- cracked ends that radiate from the centre indicate that the firewood is well dried
- the firewood is light in weight. This indicates low moisture content, which is good
- knock two logs together. Wet firewood makes a dull “thud-like” sound while dry firewood makes a “cracking” sound like a bat hitting a baseball
- no green should be visible under the bark. If so, the firewood is too moist

Firewood from softwood and hardwood

The density of the firewood is important for the combustion and especially during the ignition period.

Softwood

Typical softwoods are pine and spruce. Softwood generally has a low density and is easier to ignite than hardwood. Softwood normally burns faster and needs more secondary air to burn the gases. Softwood is ideal for kindling and starting a fire in a cold stove or fireplace. Pine and spruce easily create creosote due to their high sap content.

Hardwood

Typical hardwoods are birch, beech and oak. Hardwood generally has a high density and is more difficult to ignite than firewood from softwood. You can put more energy per volume into the combustion chamber with hardwood and the burning normally lasts longer than with softwood. The need for secondary air is normally lower than with softwood.

Do not burn anything other than firewood of good quality

Burning anything other than firewood in your stove, fireplace or boiler can create large amounts of unhealthy toxic smoke. If the equipment has a catalyst, it will no longer work as intended.

Do not burn:

- garbage
- waste
- rubber
- plastic
- painted or treated wood
- plywood
- coloured paper
- glossy paper
- paint or solvent
- oil
- coal or charcoal

The firewood and particle emissions

The quality and the size of your firewood are important factors in obtaining low particle emissions, depending on how the burning is done. Research on many specific topics, related to wood burning, has shown that:

- moisture and size are the most important factors
- moisture is a major factor for high emission
- with a high burning rates the particle emissions can easily increase 10 times with a high moisture content (above 20 %)

- with a low burning rate the particle emissions can easily increase to 30 times with a high moisture content (above 20 %)
- large pieces of firewood give high emissions with a low air supply in cold stoves
- small wet firewood give lower emissions than large wet firewood
- even good quality firewood can give too many emissions when firing with a reduced air supply
- firewood should be adapted to certain stove conditions or the stove should be used according to the properties of the firewood
- an ignition briquette with a high energy content is excellent for igniting firewood. Igniting the wood from the top will also considerably reduce the particle emissions in the start-up phase
- small dry wood should be used for heating up the stove with a sufficient ignition period (at least 10 minutes) to ensure low emissions
- only dry (> 10% moisture) firewood is recommended for use in ignition together with an ignition briquette that contains a high energy content
- sufficient ignition (at least 10 min) period before gently reducing the air supply to the stove
- fuel with high moisture (> 20% moisture) should be split into smaller pieces (2 – 5 cm) if firing at a low burning rates

Ignition briquettes with high energy content

Gases from the firewood need heat and air to burn. When firing from the top the gases from the firewood below will enter the flames and ignite on their way up. Without flames on the top of the firewood the gases go unburned up to the chimney and form particles. Recent tests have shown:

- up to a six time reduction in particle emissions for heavy stoves and tile stoves
- up to a two times reduction in particle emissions for small stoves

Ignite the firewood from the top

Particle emissions contain energy that can heat your house if burned.

Particle emissions are bad for the environment and people, and waste of money.

Advice for good firewood combustion

Open fireplaces

Open fireplaces are not good heaters. They can take 250 – 350 m^3 of air from your room, which has to be replaced with cold air from the outside that cool down the room.

- control the air flow with a damper, but make sure that all smoke enters the chimney and not the room
- remember to close the damper when the fire has burned out
- do not leave an open fire overnight

Closed stoves and fireplaces

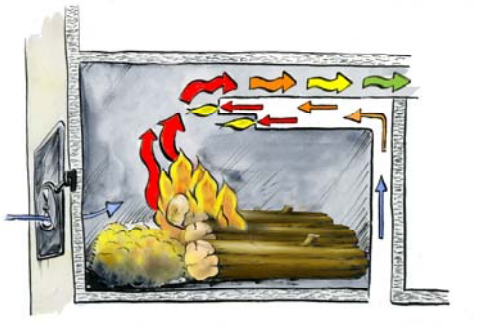
If there is no disagreement with the user manual you will obtain good heating and reduced particle emissions if you:

- ignite the cold stove or fireplace from the top of the firewood
- use an ignition briquette with a high energy content and small pieces of wood for igniting the firewood
- start with all air inlets to the stove or fireplace open
- when the firewood is burning well, start to close the air from the bottom of the firewood (if your stove or fireplace is equipped with an air supply from the bottom)
- lower the heat by reducing the airflow in the front (normally for older stoves or fireplaces) or reducing airflow from the top of the glass in the door (normally for new stoves or fireplaces) until obtaining the desired heat output
- do not choke the fire by closing the damper(s) too much (low airflow results in poor combustion)

Closed stoves with deep combustion chamber

Stoves with deep combustion chambers normally have the air inlet somewhere in the front of the stove near the door, or in the door itself. If there is no disagreement with the user manual you should check that:

- if the stove is cold, ignite the firewood with a ignition briquette placed directly behind the combustion chamber door
- when the stove is cold, open all air inlets to the stove
- after the stove has become hot, reduce the airflow from the front of the door to reduce the heat output
- enough air must be continually supplied so that the flames are not choked
- when the firewood has burned out and only pieces of glowing charcoal remain, move the charcoal to the front of the combustion chamber (near the door). For the best possible burnout, new firewood should be loaded behind the burning charcoal



Heat retaining stoves

Most of the heat retaining stoves in use today have a fixed grate were primary air flows. Secondary air is introduced through inlets above the window, though modern stoves have different methods of air introduction. Recent research has shown that most of the emissions form when new firewood is added to the grate. In modern heat retaining stoves most of the combustion air in this phase is introduced as secondary air into the fumes from the vaporizing firewood. It is very important to follow the manufacturer's instructions if you have a modern heat retaining stove. If there is no disagreement with the user manual you should:

- ignite the first batch of firewood from the top
- add only a reasonable amount of firewood at each loading
- use a total of about 1 kg of wood per 100 kg of stove weight
- use only dry wood (15 - 20 % moisture)
- hard wood gives lower emissions
- do not try to reduce the heat output, because heat is stored into the mass of the stove
- do not burn waste in the stove
- make sure combustion is complete before you close the flue gas dampers
- add the firewood gradually and start firing with smaller logs; when loading more firewood, use larger logs

Sauna stoves

Heating instructions for sauna stoves are quite similar to those of heat retaining stoves. Sauna stoves heat at first with a high burning rate to heat the sauna room quickly. When the temperature in the sauna room is high enough (70 - 100 ^{o}C), the burning rate can be reduced by adding larger logs and smaller batches of firewood. Hardwood is better than softwood in this heating phase because it does not burn as quickly.

In conventional sauna stoves, combustion air is only controlled by drawing out the ash pan and introducing the combustion air through the grate. Normally most of the combustion air is introduced as primary air, which results in very high emissions. The ash pan is also used to control the draught. If the draught is too high, metal parts of the sauna stove will start to glow. This dramatically shortens the lifetime of a sauna stove.

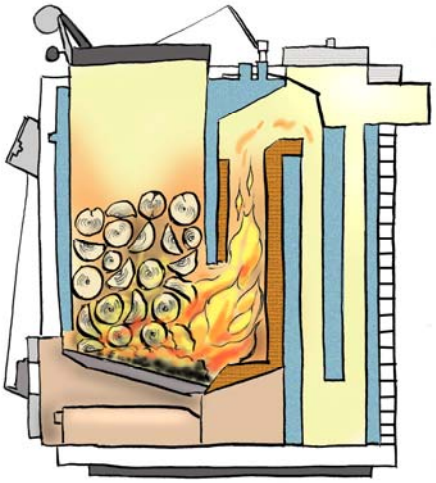
New models of sauna stoves are, however, coming to the market. Combustion air is introduced more or less using the same principles used in modern heat retaining stoves. Less primary air and more secondary air are needed. It is very important to follow the user instructions when you buy this type of modern sauna stove.

Over-fire boilers
Over-fire boilers are simple and easy-to-use. However, emissions are quite high because a large amount of firewood, at same time, is burned in the boiler. Some ways to lower the emissions are to:

- use high quality wood logs
- use moderate fuel batches
- control the draught

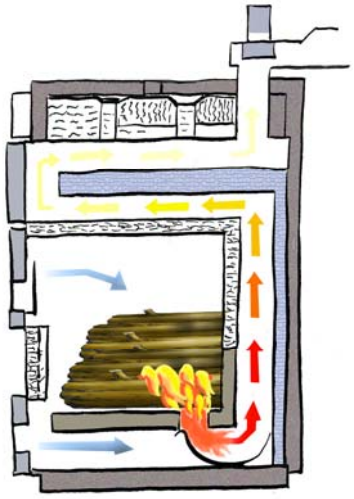
The principle of an over-fire boiler

Under-fire boilers
Under-fire boilers use the continuous combustion principle, because only the lower part of the firewood mass is burning. For emission control use the same instructions as for over-fire boilers.



The principle of an under-fire boiler

Down-draught boilers
Down-draught wood log boilers are the only type of boiler in existence today that can be sold in the countries where emissions limits are very strict. They are basically downdraught gasifiers with a secondary burning chamber for pyrolysis gases.



The principle of a down-draught boiler

The emission control rules for this type of boilers are similar to those of other boilers. They usually have lambda-control for the combustion process, which results in more precise control and eliminates the effect of the user. Research has shown that firewood can have a slightly higher moisture content in down-draught boilers.

How much heat can you expect to your room from the energy in the firewood?

Antique stoves	20 – 40%
Open fireplaces*	10 – 15%
Fireplace with insert – old technology	35 – 50%
Fireplaces with insert – new technology	60 – 80%
Airtight stoves – old technology	35 – 50%
Airtight stoves – new technology	60 – 85%
Tile and Soap stone stoves	75 – 85%
Sauna stoves	50 - 65%
Boilers – old technology	60 - 75%
Boilers – new technology	80 - 90%

* *Open fireplaces can empty your room of hot air if you forget to close the damper after finishing the burning, which gives negative heat support to the room.*

Note:
If there is information in this guidebook that does not fit with information in the user manual of your firing equipment you **should** not follow the information given in this guidebook, but do follow the information given in the user manual.

More information: http://www.eufirewood.info
http://www.biohousing.eu.com