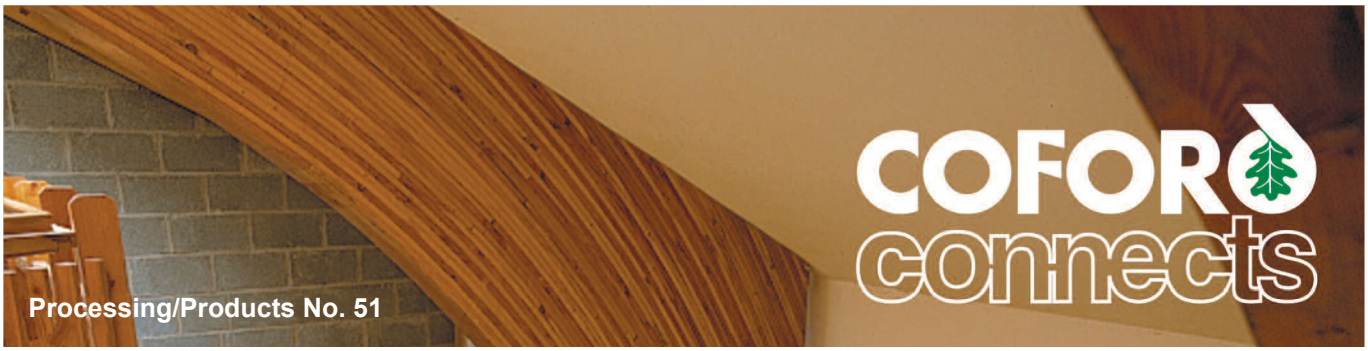

Fine dust is a health problem in modern society caused by traffic, but also from using biomass as a fuel incorrectly. The easy ways to reduce fine dust emissions are:

- ***Use dry fuel, i.e. firewood with a moisture content below 20%.***
- ***Use the top down method to light the fire.***
- ***Do not use paper to start the fire.***
- ***Do not overload the appliance with fuel.***
- ***Clean your chimney regularly.***
- ***Fit the chimney to the appliance.***
- ***Replace old fireplaces and stoves with modern ones fulfilling the Ecodesign criteria.***

COFORD
Department of Agriculture, Food and the Marine, Agriculture House, Kildare Street, Dublin 2, Ireland.
Email: fsd@agriculture.gov.ie
http://www.coford.ie

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An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine

Easy ways to reduce the emission of fine dust from existing stoves and boilers when burning firewood

Pieter D. Kofman and Eugene Hendrick

Background

Fine dust, also called particulate matter, is a problem in modern society. It originates from many sources such as road transport – mainly from tyre wear and also soot from diesel vehicle exhaust fumes. Combustion of solid fuels like peat, wood and coal also contribute, as do poorly serviced gas and oil boilers.

In the utilisation of solid biofuels, the generation of fine dust cannot be avoided, but with simple measures, the severity of the problem can be greatly reduced. This COFORD Connect Note describes methods to reduce the emission of fine dust from the burning of firewood.

It is well known that open fireplaces and older stoves emit a lot of fine dust when burning firewood and are quite inefficient in heating the house. However, more modern appliances can also emit particulate matter if not fired and maintained properly. The best stoves and boilers for residential wood use are those designed and approved under the Ecodesign Directive (2,3).

Most of the measures outlined in this note relate to the user and the fuel, but of course, the appliance is also very important. The most effective way to reduce fine dust emissions is to replace existing fireplaces and older stoves with modern Ecodesign appliances.

User measures to reduce fine dust emissions

During several stages in the burning of fuel, fine dust particles are emitted. Most emissions tend to occur during start-up and when adding fuel.

So, one has to look at user behaviour before and during start-up and when feeding fuel to the fire.

Before starting a fire

Before the heating season begins the chimney should be cleaned and checked. Birds may have built their nest at the chimney opening or objects may have become dislodged and have fallen into the chimney. At the same time, the chimney can be swept for any build-up of soot or ashes.

Before one lays the fire it is also good practice to clear out the ashes from the previous fire. If possible, ash is best disposed of on lawns or around flowers and shrubs as a source of potassium. It is best avoided as a fertiliser on vegetables because wood ash contains small amounts of heavy metals that will accumulate in the food.

Starting the fire

The traditional way of laying a fire, where one builds a kind of pyramid of kindling, along with liberal use of paper, adding larger logs on top, leads to emissions during start-up. The logs are cold and will absorb a lot of the heat from the kindling as it burns. This will lead to the chimney not being heated rapidly enough, and too slow a build-up of the draught that is necessary to create turbulence and the combustion of the volatiles being released from the wood as it heats. The result is that unburned gases and particles are emitted during start-up because they are not properly combusted.

A better way to lay the fire is the so-called top-down method, where one lays a few larger pieces of firewood on the bottom (preferably on some iron bars). On that foundation, one builds the pyramid of kindling, which is lighted by a single small fire starter block or bag (Figure 1). Paper should not be used as a fire starter as it will create a large amount of very fine dust, which easily is sucked up in the chimney and emitted. Paper is best recycled, not burned.

The pyramid starts to burn and will heat the chimney, creating the draught that is needed for the bigger logs to burn properly. The fire slowly burns down into the bigger logs and the temperature builds up. The iron bars or grate under the fuel will help air to come to the burning process and improve the draught. In this way, a lot of emissions during start-up are prevented.

Figure 1: Lighting a fire from the top-down.

Modern wood-burning appliances have controls to optimise the amount of air going into the burning chamber. Some even have automatic controls that reduce the amount of air after the initial full opening to help the starting combustion. Ecodesign boilers and stoves also use secondary air, which is inserted above the fire, and there adds to the combustion of the burning volatiles above the wood.

Unfortunately, most older appliances do not have these features. That is why one has to allow more air to come into the burning chamber on start-up or when one adds fuel to the burning chamber.

Adding extra fuel

After some time, it may be needed to add extra fuel to the fire. This should in principle be done when the flames have disappeared and only embers are still glowing. Often when one opens the stove when there are still visible flames, smoke will escape into the room. Smoke consists to a certain degree of unburned carbon compounds, which are unhealthy to inhale.

When adding extra fuel, push the embers together, add some kindling and then the bigger logs. Leave the door of the stove ajar for a short period with a good upward draught drawing in the air to the stove until the fire catches and then close the door. If one closes the door immediately, the wood may start to smoulder and emit a lot of smoke and unburned carbon compounds.

Choosing the right fuel

The foremost issue with woodfuel is the moisture content. It has been proven without any doubt that the use of wet fuel will create large amounts of fine dust and particulates, so it is imperative that only firewood with a moisture content (based on total weight) of 20% or lower is burned. However, firewood that is too dry (below 10% - sourced from say joinery works) can also create problems as the combustion process will be too rapid to burn all carbon compounds with the available air.

Not only will wet wood create a lot of smoke and fine dust, but also the amount of useful heat will be greatly reduced, so burning wet wood is uneconomical. Even though wet wood will last longer in the firebox this only means that more moisture has to be driven off before the wood reaches the temperature needed to burn properly. The energy required to drive off the moisture goes up the chimney as steam.

As well as the moisture content, the size of the logs is important. Logs that are too big take too long to heat up and reach the temperature needed for combustion. They will instead begin to smoulder, releasing smoke and compounds that will exit the chimney unburned. Again, they may last longer, but as with wet fuel this is a false economy. Valuable energy goes up the chimney instead of into the building. Small logs, on the other

hand, burn too fast and this leads to problems outlined earlier.

The answer is to use logs that are between 7 and 9 cm in diameter. Smaller logs can be used as kindling during starting of the fire. Large logs should be split to the required size. A simple way to check the size of the logs is shown in Figure 2, which is based on EN ISO 17225-5 (4). A similar template can easily be made at home from a piece of plywood or cardboard. Any piece of firewood that fits through the 10 cm hole and not through the 6 cm has the right size as firewood.

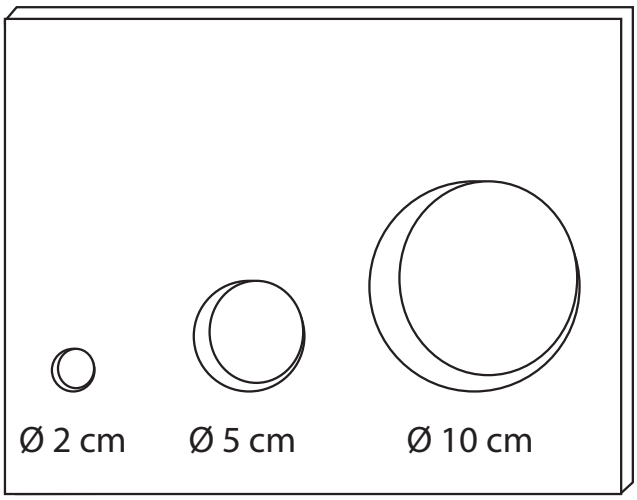

Figure 2: Template to measure size of firewood logs.

When one buys firewood from a Wood Fuel Quality Assurance (WFQA) approved source (www.wfqa.org), then the above problems should be minimized. The scheme checks the fuel at the supplier to see if they comply with the EN ISO standard 17225 part 5 - graded firewood (4). The requirements outlined are taken from that standard.

Another mistake that can be made is to overload the stove with fuel. If there is too much fuel in the burning chamber, there is not sufficient air and the wood will start to smoulder, emitting large amounts of smoke and fine dust. In the manual of the stove or boiler, the manufacturer has described how much fuel can be loaded in the burning chamber at any given time. That amount should not be exceeded.

Equipment

In this section, we are looking at the appliances to convert the fuel into heat: stoves and boilers. Equally important is the chimney, which leads the flue gasses out of the appliance and into the open.

Appliances

Often stoves and boilers are designed for multiple fuels, but these should not be used for burning woodfuels. Different solid fuels burn in different ways. Multi-fuel stoves should be avoided.

When buying a new stove or boiler, one should buy one that has been designed and tested and approved according to the Ecodesign Directive (2,3). In these appliances, the balance between air and fuel has been optimized, so that there is no superfluous air streaming through the installation to carry fine dust out of the chimney. Ecodesign appliances must also have an efficiency of over 80%, so they are more economical in use, as they will burn less fuel than other older boilers or stoves for the same heat output. These appliances carry the Ecodesign label as shown in Figure 3. Always look for the label when buying a wood-fuelled stove or boiler.

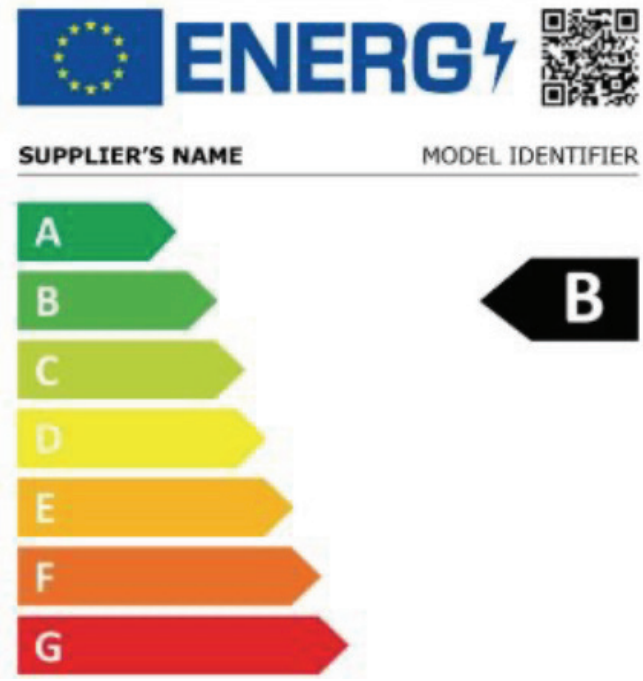

Figure 3: Eco-design label indicating the efficiency.

Along with the correct fuel, the design of the stove or boiler is key to reducing fine dust emissions. Ecodesign appliances result in excellent combustion, as the temperature in the firebox and the oxygen supply are optimised. A plentiful supply of secondary air and a baffle plate cause the flue gases to swirl and mix intensely leading to excellent combustion. An added advantage of the baffle plate is that heat is reflected onto the fuel, raising the temperature in the firebox.

Some very advanced stoves and boilers can be equipped with a catalyser, which will further reduce unwanted emissions. It is also possible to have a filter in the flue gas stream to filter out the fine dust, but this kind of equipment is more common in large installations, with high fuel loads.

Chimney

Almost as important as the stove/boiler is the chimney. The chimney should fit the appliance in length, diameter and straightness. A heating engineer, plumber or chimney sweep should be able to provide appropriate advice.
It is important to know what the chimney is constructed from, how well it is insulated and what the diameter is.
In the past chimneys were of stone, brick or block construction, from the 1930s with a manufactured (as a result of kiln firing, sometimes glazed) clay flue lining. In more recent years ceramic (kiln-fired and glazed) and stainless-steel flue liners have become commonplace.

Chimneys made from blocks (occasionally brick) usually have a square opening. These can take up a lot of moisture and are difficult to heat up and dry at the beginning of the heating season. Figure 4 shows a bad example of the inside of an old brick chimney, which is unsuitable for a modern appliance. Since the 1930s clay flue liners have been used, set in mortar in the chimney cavity. The material is porous and can absorb moisture from the flue gasses. Over time they tend to degrade and erode, losing much of their function.

Figure 4: Inside of an old brick chimney unsuitable for modern appliances.

Stainless steel piping is round both inside and out and is well insulated between the inner and outer pipe. Often the section of the chimney in the room to be heated is not insulated, to allow heat to be transferred to the room, see Figure 5.

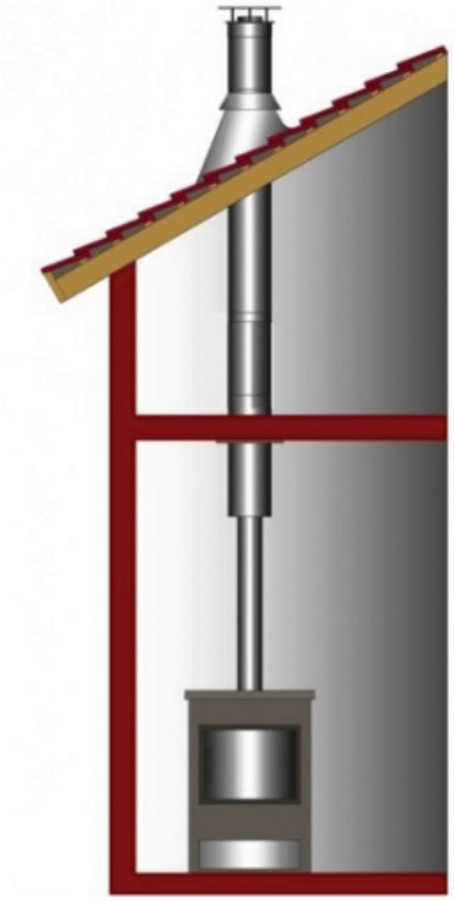

Figure 5: Steel pipe chimney. Note the lower part is not insulated.

Traditional chimneys, including clay flue pipelining, often have a large diameter which is not suited for modern stoves or boilers. It is usually possible to insert a (flexible) steel pipe inside the chimney to reduce flue diameter.
Ceramic and steel flues can be adapted in diameter to the requirements of the stove/boiler when they are installed at the same time as the appliance.

Further reading

1. Hendrick E, Kofman PD. 2021. Wood as a Fuel: Volume V *Woodfuel conversion and sustainable use*. Wood Fuel Book Partnership, Dublin.
2. Commission Regulation (EU) 2015/1185 of 24 April 2015, Implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for solid fuel local space heaters.
3. Commission Regulation (EU) 2015/1189 of 28 April 2015, implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for solid fuel boilers.
4. EN ISO 17225-5 Solid biofuels — Fuel specifications and classes — Part 5: Graded firewood.