00-05: Properties of firewood…

Firewood consists mainly of stem wood either from conifer trees or from deciduous trees, with or without bark.

The Baltic countries are in the latitudes of the Taiga – the northern coniferous belt – while northern continual Europe belongs to the temperate broadleaf zone. Most parts of northern Europe will exhibit mixed forests and typically firewood of both kinds is used.

The heating value for stem wood from conifer trees in northern Europe – mainly pine and spruce – is typically about 20 MJ/kg_{DAF} (Dry, Ash-Free) substance while the heating value for broadleaf trees is about 5 % lower, around 19 MJ/kg.

To recalculate MJ/kg into kWh/kg, divide by 3.6. Hence 20 MJ/kg is equal to 5.56 kWh/kg and to produce a thermal power of 5.56 kW you will have to combust 1 kg of dry coniferous wood per hour.

In the stem wood, the ash content is low, generally less than 1 % by weight while – if bark is present or the firewood has been stored directly on the ground and is dirty – the actual ash content may be significantly higher.

The actual heat content of firewood (ΔH) – as of any fuel – can be calculated if the heating value for the dry, ash-free substance (ΔH_{DAF}), the fraction of ash in the dry substance ($f_{ASH,DRY}$) and the moisture content (f_{WATER}) are known.

The general equation is

$$\Delta H = \Delta H_{DAF} \cdot (1 - f_{ASH,DRY}) \cdot (1 - f_{WATER}) - f_{WATER} \cdot 2.45 \quad MJ/kg$$

As an example, let's calculate the energy content in birch (ΔH_{DAF}=19.1 MJ/kg) with an ash content in the dry substance of 1.5 % ($f_{ASH,DRY}$=0.015) and water content 35 % (f_{WATER}=0.35):

$$\Delta H = 19.1 \cdot (1 - 0.015) \cdot (1 - 0.35) - 0.35 \cdot 2.45 =$$

$$=19.1 \cdot 0.985 \cdot 0.65 - 0.35 \cdot 2.45 = 12.229 - 0.858 = 11.371 \text{ MJ/kg (3.16 kWh/kg)}$$

Now compare this to the same case but with water content 20 %:

$$\Delta H = 19.1 \cdot (1 - 0.015) \cdot (1 - 0.20) - 0.20 \cdot 2.45 =$$

$$=19.1 \cdot 0.985 \cdot 0.80 - 0.20 \cdot 2.45 = 15.051 - 0.490 = 14.561 \text{ MJ/kg, (4.05 kWh/kg)}$$ i.e. 28 % more.

Hence, the water content is crucial for the total energy content in the firewood and the handling system must provide for an efficient drying of the fuel.

During the combustion process, the first thing is that the fuel is dried. This drying takes energy from the heat in the fireplace and hence cools down the flames. Since chemical reactions are very sensitive to temperature, such a cooling will slow down the combustion process.

As indicated in chapter 00-01, approximately half the energy is released from combustible gases while half the energy is released from the glowing char. Too moist a fuel, as well as too low a thermal load in the fireplace or an improper fireplace design may hence cool down the flames so that the combustion of the gases is delayed and that unburned gases escape from the fireplace. This is the cause of air pollution as well as of low total efficiency.