Fact Sheet
TILLAGE No. 5

Teagasc
Agriculture and Food Development Authority

Cereal Grains as a Boiler Fuel

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Oats and barley are currently valued at €160 per tonne each for conventional uses as a food, in malting, or as animal feed. Given these low prices and rising energy costs, it is not surprising that the value of grain for combustion is being reexamined.

This re-evaluation may provide a solution to an over-supplied feed grain market

Increased oil prices and falling feed grain prices make grain burning a much more realistic possibility than at any time in the past. However, the value and suitability of grain as a fuel, the market prospects for fuel grain, and the practical problems of its supply and use must first be addressed.

Heating value of grain

All cereal grains have similar heat values with oats coming first because of its high oil content. At 15% moisture all grains have heat values approximately less than half that of diesel fuel and similar to wood chips.
The energy density of grain is approximately one-third that of oil and three times higher than that of wood chips. Therefore, the storage of grain as a fuel supply should not present a major problem. Feeding into a storage bin and metering from there into the boiler is relatively easy; this would facilitate automatic operation of the boiler at high efficiency and with little supervision and low emissions.

Grain burning issues

Ash problems

The high potassium (K) content of grain (Table 2) leads to a low ash softening temperature. Grain ash softens at approximately 700°C (wheat) to 1,000°C (oats) compared to approximately 1,300°C for willow chips. This may cause slagging in the combustion chamber, i.e. the formation of lumps of congealed ash that may block the air supply and impede ash removal. The ash softening point could be increased by mixing quicklime with the grain. It must be remembered that these solutions increase capital or operating costs.
The high potassium content of wheat and barley, and the silicon content of oats, increases their ash content (2.7% wheat, 3% barley, 3.5% oats) above that of saw-log wood (0.5%) but not much more than willow (2%).

Emissions

CO emissions, with the exception of barley are lower than with wood, but are still high and may require flue-gas cleaning in the future. A more serious problem is the higher content of nitrogen in the grain, this leads to higher NOx-emissions compared to wood. Reduction of these emissions by selecting grain with low protein is unlikely to be practical, and in the future it may be necessary to install NOx flue-gas cleaning.
An unpleasant odour is sometimes mentioned as a problem with burning grain. However, this only occurs when the flame is restricted and the grain smoulders. This may be overcome by reducing low-load operation, by under-sizing the boiler and using calorifier tanks for heat storage.

Boilers for grain

Grain-burning boilers to-date are not as advanced as those for wood chips or pellets. However, many of the issues of burning grain have been resolved in recent years and good boilers are now on the market, especially in Denmark and Austria.

Many of these are also suitable for other biomass fuels such as wood pellets or wood chips, without substantial changes. It is also possible to convert many existing wood-burning boilers to suit grain.

A more complex combustion-air distribution system is required for grain than for wood chips, as the grain packs more tightly and restricts air movement. This should be remembered in attempting to convert boilers from other biomass to grain.

The higher chlorine content of grain (Table 2) has led to corrosion problems in the past. This has been largely overcome by the use of corrosion-resistant materials.

Given the concerns that come with grain combustion (more storage needed, more ash problems, more complex combustion control and more emission concerns), a grain-burning plant will cost more than a similar size oil or gas plan. This must be factored into final profitability calculations.

Grain vs oil

Based on cereal heat values and assuming an oil price of €0.60/litre (approximately €700/tonne). A farmhouse with an annual heating bill of €1,800 (3,000 litres) would make significant savings by converting to a grain boiler. Tests completed at the Danish test centres indicate the calorific value of grain equates 2.9 kg of grain to 1kg of oil. 858 kg of oil (1,000 litres specific gravity) is equal to 2,488 kg (2.5 tonnes) of cereal grain depending on boiler output. The required grain (oats) is 7.5 tonnes/annum at an opportunity cost to the farmer of €1,200 in comparison to 3,000 litres of oil costing €1,800 and rising.

To get a realistic estimate of the ex-farm value of the grain as fuel, deduct from this figure an allowance for the extra capital cost of installing or modifying a solid fuel boiler. Some extra grain storage and transport costs may also arise. Burning grain for fuel is a relatively new practice – so it is difficult to know how the boilers will perform over time. It is necessary to monitor the area around the burning head in the burner as this is the area most susceptible to corrosion.

Benekov Grain Boiler

Potential customers

- Use on merchant premises for grain drying and processing: Grain drying would take on average approximately 25kg of fuel grain/tonne of grain dried i.e. 2.5% of the crop. No extra grain storage or transport costs are incurred, but the cost of plant adaptation for a short working season is high, especially in premises with more than one drier. Plants where ration formulation involves cooking or toasting would have a more year-round demand and a better opportunity of being profitable.
- Supply to a local boiler: The best prospect for a profitable fuel use is likely to be in medium-sized boilers in the range from 100 KW to 1 MW. Small domestic-scale boilers are quite difficult to adapt and supply. Large multi-megawatt installations are likely to have favourable contracts for low-priced heavy oil, coal or gas. Intermediate sizes presently using gas, oil or kerosene are likely to provide the most profitable opportunities.

Substantial variations in the availability and price of grain should be expected over the life of a boiler. It would, therefore, make sense to establish a supply chain based on a number of alternative biomass fuels (e.g. wood chips or pellets) with the grain being substituted when prices are attractive.

Capital grants for biomass boilers (woodchip, pellet) are now available. However, capital grants for grain boilers are not yet available. Some boilers currently approved for burning woodchip or wood pellets can also burn grain. Further increases in oil and gas prices may result in grain as a fuel becoming more realistic.

Table 1: Approximate heat content and energy density of biomass fuel

Source: Andrew Keppel, Teagasc, Oak park

Fuel	Net heat value [MJ/kg]	MJ/kg*	Bulk density [kg/m3]	Energy density [GJ/m3]
	On DM basis	At normal moisture		
Wheat (grain)	17	14.1 (15% m.c.)	750	10.6 (15% m.c.)
Barley (grain)	17.5	14.5 (15% m.c.)	690	10.0 (15% m.c.)
Oats (grain)	18	14.9 (15 % m.c.)	560	8.3 (15% m.c.)
Willow chips	18.4	13.2 (25% m.c.)	195	2.6 (25% m.c.)
Oil	42	42 (0% m.c)	850	35.7

*MJ/kg = Megajoules/kg

Table 2: Comparison: grain versus wood

Source: Andrew Keppel, Teagasc, Oak park

	Chlorine	Nitrogen	Potassium
	%	%	%
Grain (wheat)	0.04	1.79	0.46
Willow chips	0.004	0.54	0.26

Further information:

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