3. Annual Energy Crops

Biomass that is grown for the purpose of energy production contrary to, e.g., straw that is a residual product/by-product from cereal production is called *energy crops*. Annual energy crops may be cereal grain or rape alone or cereal grain/rape and straw harvested together, e.g., by swathing. Perennial energy crops may be willow, elephant grass, and reed canary grass.

photo: jørgen hinge

Triticale left in swaths without having been combined. The swath is too wide for the big baler and should be raked before baling. The raking results in grain losses. The stiff, unthreshed triticale stalks are difficult to bale into big bales. The picture is from the test at Djursland.

Burning of cereal grain in boiler plants larger than 250 kW is prohibited. This appears from the Danish Energy Agency Follow Directions in connection with the Heat Supply Act of June 13, 1990. The prohibition is laid down in a letter of September 13, 1990/ref. 24/ that has been circulated to all municipalities, and it says in the letter that it is not allowed to either wholly or partly burn fish oil, surplus butter, cereal grain etc. The prohibition may be rooted in ethical considerations in respect of burning food in a starving world.

The provisions do not apply to plants below 250 kW. This means that a farmer with own farm-scale boiler may legally burn cereal grain or rape. However, it must be a crop deriving from the ordinary agricultural production. If the crop has been grown on fallow land, then according to the EU Directions, it must not be used for own heating purposes, nor be "traded" with the neighbour if he is a grain grower, too.

Cereal Grain and Rape for Small Boilers

It is difficult to estimate how much cereal grain and rape small boilers consume. Rape can only be used as co-firing in small amounts together with, e.g., cereal grain or wood pellets, e.g. because the boiler firing system is adapted to fuel with less energy content (the lower calorific value of rape is approx. 24 MJ/kg at approx. 10% water). Usually pure rape firing results in so much energy being fed that the boiler bottom "is covered with" oil, resulting in danger of fire and malfunction. About ten boilers for cereal grain firing have been type approved by the Test Laboratory for small Biofuel Boilers (see Section 5). Then the boilers can be state-subsidised and they are of a good standard in terms of the combustion of cereal grain. Certain other boilers may also be suitable for burning cereal grain, but the efficiency and emission through the chimney has not been documented, and it cannot be recommended to burn cereal grain in a boiler that is not designed to it.

Full-scale Tests on Cereal Grain Burning

During the period from 1995-97, full-scale tests on the burning of cereal grain were carried out at 5 locations, i.e., Bornholm, Lolland, Langeland, Djursland, and Haunstrup near Herning. The individual heating and CHP plants had filed applications to the Danish Energy Agency for an exemp-

Plant	MW_{heat}	$MW_{elec.}$	Plant type	Fuels	Tonnes
Holeby	3.1	0	D. H./grate	Wheat and triticale in big bales	394
Tullebølle	1.6	0	D. H./whole bales	Triticale in big bales	169
Lohals	1.4	0	D. H./sliced bales	Triticale in big bales	51
Haunstrup	0.5	0	D. H./stoker	Rye grains	222
Rudkøbing	7	2.3	Steam/grate	Triticale in big bales	380
Studstrup 1	0	150	Steam/pulverised fuel	Triticale in big bales	1100
Grenå	60	18.6	Steam/fluidized bed	Triticale in big bales	2000
Bornholm	35	16	Steam/spreader stoker	Wheat grains	781

Table 2: Survey of plants carrying out combustion tests in 1995-96. D. H. = District Heating.

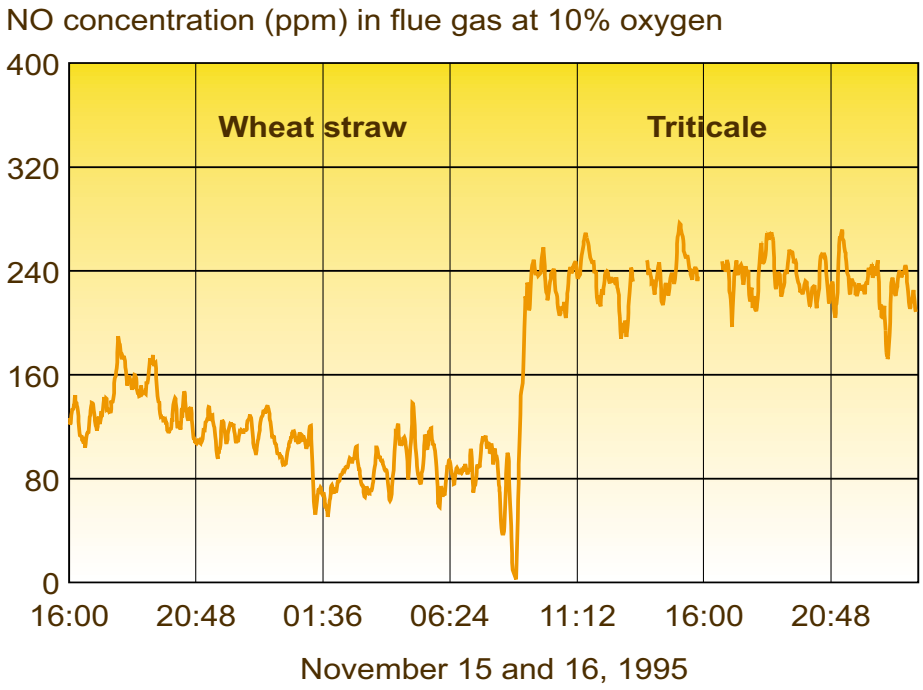

Figure 8: At Holeby Halmvarmeværk (straw-fired heating plant), a heavy increase in the NO emission is seen by firing with cereal grain. At the same time, a halving of the CO emission was measured.

tion from the prohibition of burning cereal grain, and EU-approved crop delivery contracts for the supply of cereal crops from fallow land areas were concluded between the farmers and the plants. During the growing and harvesting period, large-scale registration of the application of fertilisers, pesticides and insecticides, harvesting technique (swath forming mower), baling into big bales and storage on the farm was made. Unthreshed grains and straw were used except for Bornholm and Haunstrup.

Table 2 shows the plants that carried out combustion tests during 1995-96.

During the heating season of 1996-97, the plants Holeby, Haunstrup, Studstrup 1, Grenaa, and Østkraft (Bornholm) participated.

In summary, it can be concluded that the tests demonstrated:

- that rye and triticale are better than wheat due to reduced grain losses and reduced requirement for the application of fertilisers, pesticides and insecticides.
- Particularly in dry seasons, the straw is suitable for swathing, but the stiff straw/stalks may be difficult to bale into homogeneous big bales. In wet crop years, there is a great risk of sprouting of the crop left in swaths.
- The heating plants had problems in lifting the heavy energy grain bales (600-700 kg).
- Emissions and efficiencies are more or less the same for energy grain (cereal grain and straw) as for wheat straw. However, a marked rise in the NO emission could be seen at few of the plants, since the protein content of the grain during burning releases nitrogen (N) /ref. 7, 8, 36, and 37/.

Energy Crop Programme 1997-2000

In 1997, a large demonstration programme was implemented concerning the production and use of energy crops. It is a 4-year programme and shall pave the way for a large-scale consumption of energy crops after the year 2005. In Energy 21, it is estimated that the consumption of energy crops rises from 0 tonnes in 2005 to almost 3 million tonnes in 2030 (see Figure 2). The purpose of the project is to develop and demonstrate an optimal operating economy and an environmentally sound production of energy crops. The greatest importance has been attached to the use of rye, triticale and afforestation. Of other fuels that form part of the programme can be mentioned willow, elephant grass, reed canary grass, and hemp.

The programme includes subsidiary programmes consisting of:

- Establishing and growing
- Harvesting, storage, and transport
- Importance of choice of species
- Fuel characterising and combustion tests
- Impact on the aquatic environment
- Flora and fauna conditions
- Landscape visualising
- Carbon balance of the earth
- Financial analyses

The programme is carried through by seven research institutions and one electrical power producer /ref. 38/.