11. Residual Products

Straw typically contains 3-5% ash. Part of the ash is taken out in the bottom of the boiler and is called bottom ash while the remainder is whirled round in the boiler with the combustion air and further out in a flue gas cleaning system. This part of the ash is called fly ash. In the flue gas cleaning system, the major part of the fly ash is separated, while the remainder is released through the chimney in the form of particle emission. Flue gas cleaning systems are described in more detail under Sections 7 and 8.

The collected bottom ash and fly ash from the straw-fired boiler are considered residual products and should pursuant to the (Danish) Environmental Act be disposed of in a safe way. Disposal may include recycling or storage.

	Limit values in force 01.10.1996 - 30.06.2000		Limit values in force 01.07.2000	
Heavy metals	mg per kg dry matter	mg per kg total phosphorus	mg per kg dry matter	mg per kg total phosphorus
Cadmium	0.8	200	0.4	100
Mercury	0.8	200	0.8	200
Lead	120	10,000	120	10,000
Nickel	30	2,500	30	2,500
Chromium	100		100	
Zinc	4,000		4,000	
Copper	1,000		1,000	

Table 11: Limit values for heavy metals, e.g., in ash for agricultural applications, see Executive Order No. 823 of September 16, 1996.

Ash

Recycling for Agricultural Applications.

Straw ash contains nutrients, primarily potassium and other soil amelioration matter like magnesium, phosphorus, and calcium and can therefore be applied in agriculture as fertiliser. Agricultural application of ash requires permission from the county. Applications submitted to the County are considered, thereby having regard to the Department of the Environment and Energy Executive Order No. 823 of September 16, 1996 on residual products for agricultural applications. This means, e.g., that the content of heavy metals in the ash should not exceed the limit values stated in the Executive Order. The Danish Environmental Protection Agency may however grant an exemption. It is optional whether the content of heavy metals in the ash is calculated on the basis of the dry matter content of the ash or its phosphorus content.

At the beginning of 1998, an investment is being carried out so as to clarify whether or not heavy metals can be concentrated in some smaller ash fractions by a separation of the ash flow from the grate, cyclone and filter sections. Thereby some fractions of the ash will get a lower heavy metal content, primarily of cadmium. In addition, the distribution of the ash nutrients among the ash fractions will be investigated. The Danish Environmental Protection Agency is preparing an Executive Order that, e.g., includes ash from straw and wood for agricultural applications.

Recycling for Cement and Concrete Applications

In Denmark, applications for a large proportion of the residual products (fly ash from coal) from the energy production have been found in the cement and concrete industry. The requirements applying to fly ash in concrete are set out in /ref. 23/. Straw ash will result in a too high content of alkali metals (potassium and sodium) and chloride in cement. Alkali metals constitute a problem because they can react to flint stone particles in the gravel aggregate with which the cement is mixed during concrete manufacturing. Thereby combinations can be formed that absorb water from the surroundings. This results in volume expansions, formation of cracks, and problems with the freezing and thawing properties. A high chloride content is problematic because it may result in corrosion of the reinforcement bars.

Slagging and Condensing

Usually, straw has a serious slagging tendency, i.e., a concretion or fusion of the ash. This may occur, e.g., locally on the grate in case of grate firing or in the combustion chamber where the temperatures are so high that the ash fuses wholly or partly. The hard, vitreous slag may be very difficult to remove. The slagging tendency of straw is due to its relatively high content of potassium that causes straw (bottom) ash to start fusing already at temperatures about 800-900°C (see Section 2). The slagging tendency may vary, though, depending on the type of straw and the growing conditions. A great proportion of the potassium content of straw is removed (washed out) by rain if the straw is left in the field after being harvested. The problems of slagging and condensing are therefore very much reduced when using straw that has been washed out in the field /ref. 33/.

Together with advisers, the power companies have carried out successful experiments on straw being subjected to a more controlled washing process. In the subsequent energy application of the washed straw, the energy utilisation can be controlled so that the increased water content of the washed straw does not give rise to any considerable energy loss.

During the combustion of straw, part of the potassium content of straw is liberated along with the major proportion of chlorine and sulphur to the flue gas. When cooling the flue gas later on, greyish depositing results whose thickness is currently increased, thereby reducing the heat transfer in the heating surfaces. The depositing may be so serious that frequent cleaning of the heating surfaces being required. In addition, submicrons (particles of diameter less than 1/1000 mm) are produced consisting of potassium chloride and potassium sulphate that are carried with the flue gas to the particle filter. Boiler design (superheater positioning, distance between the tubes etc.) may however prevent some of these nuisances.