Open Access Journal

**Journal of Power Technologies 91 (4) (2011) 165–170**

journal homepage:papers.itc.pw.edu.pl

# Co-firing of waste in power industry – analysis of legal conditions in Poland☆

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**Abstract**

The paper presents problems concerning three key and inter-related areas of national economic life: power industry, environmental protection and waste management. The formal and legal requirements incumbent on waste incinerating installations and co-incinerating installations are set out. This paper highlights the possible benefits and risks that result from the co-combustion of non-hazardous waste (alternative fuel) in power boilers intended for burning coal.

*Keywords:* waste co-firing, power plants, renewable energy, biomass, emission limits

## 1. Introduction

The volume and structure of waste produced in Poland is comparable to the situation in other countries of EU. The principal way of treating waste is landfill. This treatment extends to a broad spectrum of industrial waste as well. Landfill has various negative impacts on the environment. In response to EU targets the National Waste Management Plan 2014 (current government policy) sets out the policy objective of reducing the volume of household waste dumped in landfill over the next few years – mostly through incineration.

Currently, a few large municipal waste incinerating plants are being constructed, but they will not be able to solve the problem on their own and it could be years before adequate numbers become operational. Consequently, many contractors and municipal councils are contemplating alternative solutions. One is waste disposal in power plant boilers: public grid power plants and electricity autoproducers. Besides the technical problems, there are also additional formal and legal problems. In the main they concern emissions levels, obligatory measurements of process parameters in plant and their operating conditions. In the case of waste that contains biodegradable fractions, there is also the possibility to getting green certificates for the electricity and heat generated..

Waste management in the EU is, next to environmental protection and the power industry, one of the top priorities shaping the future direction of development. The member states are bound by restrictive laws in that field. The most important directly related EU legislation are 2 Directives: The Waste Framework Directive (2008/98/EC) and the Waste Incineration Directive (2000/76/EC). Many other EU Directives or regulations indirectly affect

☆Paper presented at the 10$^{th}$ International Conference on Research & Development in Power Engineering 2011, Warsaw, Poland

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waste management. The Industrial Emissions Directive (2010/75/EC) was adopted in 2010 and will in time completely replace Directive 2000/76/EC.

Following EU accession in 2004 successive Polish governments have substantially changed national legislation on environmental protection and waste management to adjust it to Community law [1–7]. In late 2010, the Polish parliament accepted the document entitled: The national plan of waste management 2014 (KPGO2014) [8], in which the main action plan directions are determined as follows:

- reduce waste production,
- increase recycling combined with selective collection and sorting of waste;
- reduce the volume of waste sent to landfill through biological, thermal or chemical treatment with special consideration given to the process of energy recovery.

Thermal treatment, as one of the major ways of waste disposal, can be achieved in both waste incineration plants and power plant boilers. The interest of public power plants (power stations, district heating plants and heat generating plants) in waste combustion and co-combustion in boilers results from the possibility of producing energy from renewable sources (biomass waste qualified as fuel) and receiving in return profitable green certificates. Unfortunately, this has led not simply to just burning wood waste from forestry, but large amounts of good quality timber that could be used better elsewhere in the economy.

Currently, the amount of non-fuel, non-biomass waste being incinerated in the power sector is relatively small, due to environmental protection requirements and the need to meet additional operating conditions. Recent legislative changes [9] mean that part of the energy generated from municipal waste incineration (max. 42%) can be classified as renewable energy. Accordingly, power stations have developed an interest in waste co-firing [10, 11].

The factor that is set to radically change waste management in Poland is a landfill waste regulation that will enter into force on January 1, 2013. Certain groups of waste will be banned from landfill dumping: waste (including sewage sludge and unsorted municipal waste) with a calorific value of dry mass higher than 6 MJ/kg [1]. Alternative approaches are particularly appealing in light of the legislative restrictions on $CO_2$ emission limits for the power industry for the period 2008–12 [2, 3] and the fact that biomass waste creates no $CO_2$ emissions.

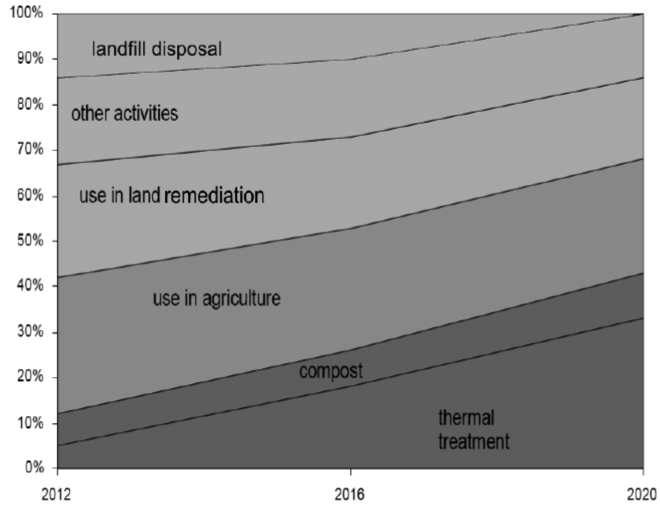


Figure 1: The outlook until 2020 for neutralization and recovery of sludge derived from municipal sewage treatment plants [8]

Some 12 million metric tons of municipal waste are produced annually in Poland. Organized garbage collection garners around 10 million tons. The majority is sent to landfills. The estimated amount of biodegradable fractions in deposited waste is 4 million tons (over one half of the weight of mixed municipal waste). According to [8], in 2020 over 14.2 million tons of waste will be produced, of which about 7.5 million tons will be biodegradable. Under the new regulation [1] only 1.5 million tons of waste can be dumped. This means that around 6 million tons of biodegradable waste will need different treatment methods, including incineration. Fig. 1 shows a vision for the evolution of municipal waste management in the period to 2020. It sets out planned incineration rates of around 30% of waste (4.3 million tons). Currently, there is only one incinerating plant in the country with a capacity of around 40,000 tons per year. There are a few similar facilities under construction, but the total capacity (around 1.5 million tons) will be insufficient for the thermal treatment of the anticipated waste flow.

Currently in Poland the public power plants coincinerate biomass waste coming from forestry, agriculture and energy crops - mostly to generate green energy. From the facts and forecasts presented herein, it seems that power plant boilers might act as a tool for disposal and/or recovery of municipal waste.

## 2. The legal aspects

The formal and legal aspects concerning the varying technologies for waste incineration and co-incineration are contained in three fundamental legislative acts (Acts of Parliament and secondary legislation and regulations): Environmental Law, Act on Waste, Act on Energy Law. According to the definitions set forth in the above legislation, we can divide waste into 3 groups for power industry needs:

1. biomass waste qualified as fuel (e.g. from agriculture and forestry)
2. non-fuel biomass waste (e.g. sewage sludge)
3. waste that is not biomass or fuel (e.g. waste plastics, unsorted municipal waste).

The rules on processing the particular substances, the technical requirements that the thermal treatment facility must fulfill and the possibility of recovering energy, depend on qualifying the incinerated substances in one of the listed groups. Strict rules and requirements refer especially to waste from groups 2 and 3 [12, 13].

### *2.1. Technical requirements concerning the combustion process*

Fulfilling operating requirements concerning the combustion process and the essential features of boiler installation are very important technical issues requiring individual treatment due to legal regulations [4]. Fig. 2 illustrates those requirements schematically in terms of: process parameters, process equipment and required measurements.

Research demonstrates clearly that fulfilling the process requirements in boilers is not a straightforward task and requires independent analysis on a case-by-case basis [10]. The particular condition of, for example, maintaining the flue gas at a specific temperature for 2 seconds can be difficult to achieve, especially with low-emission combustion with reduced temperatures in the combustion chamber and the aggravating factor of fluidized bed boilers [14]. Similarly, load changes can lower the temperature of flue gas or shorten the residence time at a specific temperature.

### *2.2. Measurement requirements concerning emission levels*

While it is easy to fulfill the requirements for the equipment and measurement devices for typical power plants, it is harder to fulfill the requirements concerning emissions levels as these can lead to problematic obstructions to waste incinerating (co-incinerating) in the power sector. Table 1 illustrates the measurement requirements for fossil fuel combustion and waste incineration plants. It can be seen that waste co-incineration with coal is treated in the same way as single waste incineration.

In the case of waste incineration – the thermal power of the plant aside – the following must be measured: the content of hydrochloric and hydrofluoric substances, organic carbon (TOC) and heavy metals in the exhaust gas. The measurements in themselves are not burdensome (especially for larger plants) but they are used to check if emission levels are complied with.

The permissible emission limits for particular substances in exhaust gases (emission standards) for waste incinerating plants are significantly stricter than those for fuel incinerating installations. Adapting a power plant for waste incineration means a step-up in emission standards. The general rule for estimating the emission level of $SO_2$, $NO_x$ and fly ash consists in calculating the weighted mean from the standards for conventional fuel and waste adequately to their contribution in exhaust gases [6].

For the co-combustion of various fuels, the weighted mean is estimated by the thermal power of fuels feeding the boiler, e.g. in the case of co-combustion of hard coal biomass (willow) the mean emission level is estimated as follows:

$$C_{HC+BIO} = \frac{C_{HC} \cdot \dot{Q}_{HC} + C_{BIO} \cdot \dot{Q}_{BIO}}{\dot{Q}_{HC} + \dot{Q}_{BIO}} \qquad (1)$$

where $C_{HC+BIO}$ – estimated mean emission level; $C_{HC}$, $C_{BIO}$ – emission levels for hard coal and

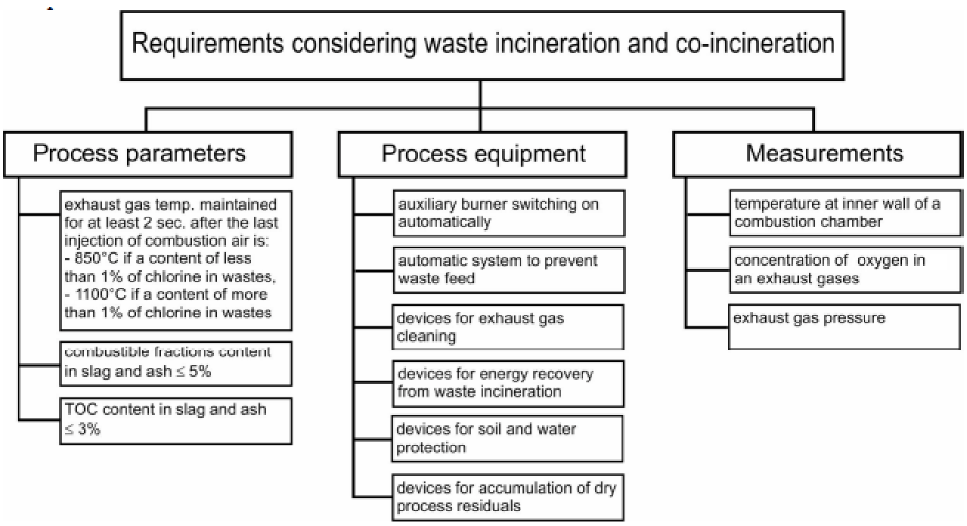


Figure 2: Requirements considering waste incineration and co-incineration [4]

Table 1: Measurement requirements for emissions [5]

<table>
<tr><th rowspan="2">parameter (exhaust gas)</th><th rowspan="2">unit</th><th colspan="2">Installation for fuel combustion with thermal power</th><th rowspan="2">Installation for waste incineration or waste co-incineration</th></tr>
<tr><th><100 MW</th><th>>100 MW</th></tr>
<tr><td>Fly ash total<br>$SO_2$<br>$NO_x$<br>CO<br>$O_2$</td><td>$mg/m^3$</td><td rowspan="2">discontinuous measurements (at least 2 per year)</td><td rowspan="2">continuous measurements</td><td rowspan="3">continuous measurements</td></tr>
<tr><td>Flow speed<br>Static pressure<br>Flue gas humidity<br>Flue gas temperature</td><td>m/s<br>Pa<br>% vol.<br>K</td></tr>
<tr><td>HCl<br>HF<br>TOC<br>Heavy metals</td><td>$mg/m^3$</td><td></td><td></td></tr>
<tr><td>Dioxins and furans</td><td>$ng/m^3$</td><td></td><td></td><td>discontinuous measurements</td></tr>
</table>

biomass, estimated in accordance with regulation [6] (appendices 1–4); $\dot{Q}_{HC}$, $\dot{Q}_{BIO}$ – assumed or measured thermal power from hard coal and biomass combustion.

For fuel co-combustion with waste, the weighted mean is estimated by the volume of exhaust gas resulting from fuel combustion and waste incineration, e.g. while co-combusting hard coal and dry sewage sludge (waste), and shall be calculated as follows:

$$C_{HC+WST} = \frac{C_{HCproc} \cdot V_{HC} + C_{WST} \cdot V_{WST}}{V_{HC} + V_{WST}} \qquad (2)$$

where: $C_{HC+WST}$ – estimated mean emission level; $C_{HCproc}$, $C_{WST}$ – emission levels f estimated in accordance with regulation [6] for hard coal (appendix 6) and waste (appendix 5); $V_{HC}$, $V_{WST}$ – assumed or measured exhaust gas volumes from coal and waste combustion.

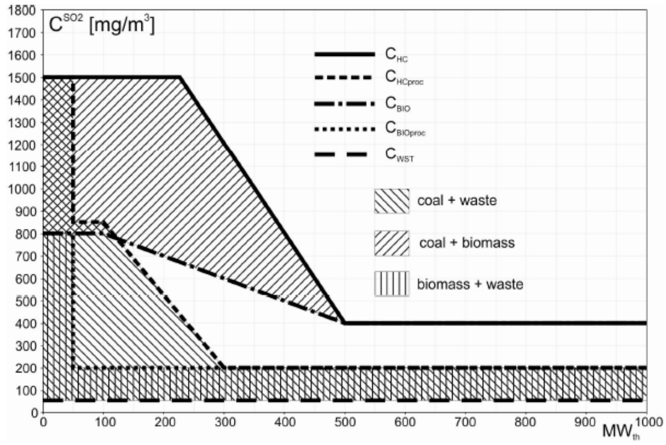


Figure 3: Total emission limit values for $SO_2$ dependent on the thermal power of the installation and considered cases of coal co-combustion with biomass and waste. Values determined for existing sources brought into service before March 29, 1990 [6]

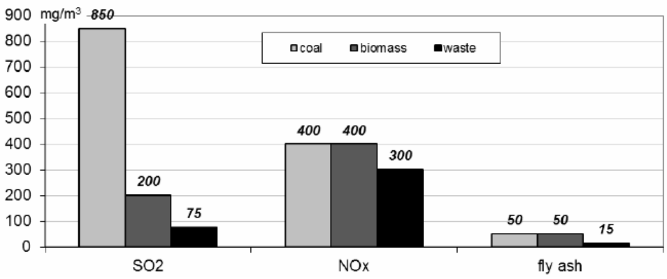


Figure 4: Comparison of emission standards for plants with thermal power of 50–100 MW

The tightening up of standards that occurs when adding biomass to the coal results from a lower value of $C_{BIO}$ than is the case with $C_{HC}$ – especially in older and smaller installations. The stricter standards applicable when adding waste (not qualified as biomass) result from the very low value of $C_{WST}$ and that the $C_{HCproc}$ is usually different (lower) than $C_{HC}$ in the case of incinerating coal alone (as determined in appendix 6 of the regulation).

Fig. 3 illustrates changes in $SO_2$ emission levels, which depend on the thermal power of the installation in the various cases: combustion of only hard coal, biomass or waste (single lines) and the co-combustion of those substances at the same time. In the last case the emission levels depend – according to equations (1) and (2) – on the amounts of fuel and waste feeding the boiler, so the range of variability of the standard values is represented by the shadowed area.

Fig. 4 illustrates examples of the emission limits for an installation with thermal power of 50-100 MW which incinerates coal, biomass and waste. Standard restrictions are observable especially for sulfur dioxide and fly ash.

## 3. Conclusions

The Polish government's waste management action plan assumes an intensification of the waste treatment processes, including an increasing reliance on incineration. The existing and planned infrastructure in the form of incineration plants seems to be insufficient in light of the 2020 targets. Hence, a pragmatic approach is to use power plant boilers for the purpose of waste disposal; indeed it is a necessity. Moreover, the added incentive of possibly qualifying part of the energy recovered from waste as renewable energy will certainly increase the interest of public power stations in waste co-incineration.

Waste co-incineration in the power plant boiler can cause certain changes in the incineration process that impact negatively on the operation of the installation and the technical and economic parameters. Hence, a detailed evaluation of those changes must be performed on a case-by-case basis before taking any decision to adapt the installation.

A formal and legal analysis of an investment resulting in the extension of existing installations or the building of new ones can lead to the following conclusions:

- incineration of municipal waste or sewage sludge may cause a significant increase (even doubling) in $SO_2$ $NO_x$ and fly ash emission levels compared to fossil fuels and the necessity to comply with emission standards for additional substances. In the case of qualifying biomass waste as fuel, the added restrictions imposed by the different standards are slight (a few percent if at all);

- additional requirements must be fulfilled for the process of incineration in a power boiler – which is not always easy to achieve (e.g. with waste groups 2 and 3 the required residence time for the exhaust gas to remain at a specific temperature).

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