IMPACT OF WOOD SOURCES ON POPs EMISSIONS OF BIOMASS COGENERATION UNITS

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Introduction

Practically half of the EU's renewable energy currently comes from wood biomass[1] and the use of this source of fuel is no more limited to countries with big forest activities. Indeed in Belgium, like other European countries, several cogeneration plants using wood as source of energy have been built up, mainly due to green-energy subsidies.

Most of these plants use relatively clean raw material coming from wood processing industries. Other plants use wood wastes coming from construction and demolition activities or municipal recycling centres. This alternative source of wood is interesting in terms of cost, but contains plastic and paint which results in a risk of POPs and other pollutants emissions when burning.

This paper presents the results of a comparative campaign performed in six different wood cogeneration installations. Half used "clean wood" and the other ones wood containing various materials (plastic, paint, metal …) which can generate various pollutants during the burning process.

Major gases, POPs, PAH, heavy metals, HCl / HF emissions are reported and discussed in this paper. The purpose of the campaigns was to estimate the impact of wood and wood wastes cogeneration on total Belgian POPs emissions and to highlight the need of specific recommendation in terms of abatement technique for plants using potentially contaminated wood.

Materials and methods

Selected industrial installations

Electricity/heat cogeneration installations can achieve energy efficiency levels of around 80-90 %, compared to 40-50% for classical boilers. Indeed, unlike traditional power plants where exhaust gases are directly evacuated by the chimney, the gases produced by cogeneration are first cooled before being evacuated by the stack, releasing their energy into a hot water circuit. Heat is generally used in another process by example for drying wood used in the production of pellets in some of the studied plants.

All the selected plants show similar characteristics in terms of process. The oven capacities are between 15 and 40 MW. The abatement principle is similar and limited to a bag house filter.

3 plants burn "clean wood" coming from wood processing industries whereas the 3 other ones use "polluted wood" coming from municipal recycling centres. No specific analysis has been performed on the raw materials, but according to literature[2] the level of chlorine can be expected to be close to 0.1%.

To allow a better comparison between plants and avoid difference due to dilution ratio, all data present in this paper have been recalculated at 11% oxygen on dry gases.

Procedure followed for the sampling of the pollutants

The reference methods followed for sampling and analysing all pollutants are listed in table 1. Number of samples per stack and minimal sampling time are also specified.

Pollutants	Norms of reference	Nbr. tests / stack	Sampling time
NOx	NBN EN 14792	6	min 3h
CO	EN 15058	6	min 3h
SO_2	EPA 6C	6	min 3h
PCDD/F	EN 1948-1	3	min 6h
DL PCB	EN 1948-4	3	min 6h
PAH	ISO 11338-1	3	min 6h
Heavy metals	EN 14385	3	min 3h
HCl	EN 1911	3	min 1h
HF	ISO 15713	3	min 1h

Table 1: Sampling procedures

Results and discussion

Results obtained for the different campaigns are summarized in table 2. All data have been aggregated depending on the source of fuel ("clean wood" or "contaminated wood") used by the plant in a way to highlight differences.

Pollutants	Units	All plants	Clean wood	Contaminated wood
NOx	mg NO_2/Nm³	200	188	213
CO	mg/Nm³	92	48	135
SO2	mg/Nm³	24	28	20
PCDD/F	I-TEQ ng/Nm³	0.006 - 0.015	0.004 - 0.018	0.007 - 0.011
DL PCB	WHO-TEQ ng/Nm³	0.0006 - 0.0012	0.0007 - 0.0015	0.0006 - 0.0008
PAH	µg/Nm³	0.0006 - 0.0018	0.0001 - 0.0019	0.0012 - 0.0017
As	µg/Nm³	0.6	0.8	0.4
Cd	µg/Nm³	0.3	0.5	0.1
Hg	µg/Nm³	0.6	0.1	1.0
Pb	µg/Nm³	5.8	5.3	6.3
Cr	µg/Nm³	0.8	0.7	0.8
Ni	µg/Nm³	1.3	1.9	0.7
Cu	µg/Nm³	1.4	2.0	0.9
Mn	µg/Nm³	24	46	1.6
Tl	µg/Nm³	0.5	0.5	0.5
Be	µg/Nm³	0.1	0.1	0.1
Co	µg/Nm³	0.2	0.2	0.3
Se	µg/Nm³	0.6	0.4	0.8
Te	µg/Nm³	0.9	0.7	1.0
Sb	µg/Nm³	0.5	0.4	0.5
V	µg/Nm³	0.4	0.3	0.5
Zn	µg/Nm³	47	76	17
Sn	µg/Nm³	0.9	0.7	1.2
HCl	mg/Nm³	6.7	8.5	4.9
HF	mg/Nm³	0.05	0.08	0.02

Table 2: Measured pollutants concentrations from wood cogeneration boilers

No difference is observed for SO_2 and NOx emissions between both types of fuel. As expected SO_2 concentration is quite low. Wood is indeed known as a source of energy with very low sulphur contain and is typically used in metallurgy for this characteristic. NOx emissions are more important than expected and are around values observed for plants using coal as source of energy. Nevertheless, the amount of nitrogen in wood is highly variable and NOx can also be generated by the combustion process in various ways depending on operation conditions (temperature, available oxygen, residence time and turbulence, moisture content, ...).

Emissions of CO are more important for plants using “contaminated wood”, but only one of them shows a very high value compared to plants using “clean wood”. This particular plant also shows the lowest level of NOx. For all plants a link is observed between NOx and CO emissions. NOx is indeed reduced when the amount of O_2 available to react with the nitrogen decreases, but more CO is then produced.

We can thus not take any conclusion on impact of “contaminated wood” on emissions of CO and NOx as the obtained results are more related to plant operation conditions than fuel branded. Results confirm the measurement of CO and NOx remains recommended for such installations.

No difference in POPs emissions between plants using “clean wood” and “contaminated wood” has been highlighted during this study. Deep interpretation is difficult at this level of concentration due to measurement uncertainty[3] and important variability in the wood composition used by the different plants. All plants remain nevertheless far below the emission limit value of 0.1 I-TEQ ng/Nm³.

We have noticed that emissions are on average higher than the value observed in Belgian municipal waste incinerators, but the studied wood cogeneration plants have really basic abatement technique (only a bag house filter) compared to municipal waste incinerators (deNOx, deSOx, ESP, bag house filter, active coal capture, …).

Emissions level of cogeneration plant using wood or wood wastes is estimated around 0.02 I-TEQ ng/Nm³. This value is close to results found in literature[4].

Mn, Zn and Pb represent the main emissions of heavy metals. Once again no impact of using “contaminated wood” is highlighted. These pollutants are present in wood and level of emissions measured is close to the values found in a large scale study focused on clean wood burning[5].

Same conclusion can be drawn for HAP. Variability is quite high from plant to plant and we also observe big variation from one day to the next. Once again the low concentrations present do not help data interpretation.

There is more or less no HF emissions detected.

Wood naturally contains chlorine, but we expected to find higher HCl emissions for plants using “contaminated wood”. This statement was not observed during this measurements campaign. Furthermore, the plant showing the higher HCl concentration was a plant using “clean wood” and for which the lower level of dioxins has been measured. The explanation could come from a slightly higher temperature in the oven of this plant which is favourable to the HCl formation.

Conclusions

No difference in emissions between plants using “clean wood” and “contaminated wood” has been highlighted during this study.

POPs emissions of cogeneration plants using wood or wood wastes are estimated around 0.02 I-TEQ ng/Nm³. The impact of the sector in Belgium on total emitted dioxins is thus limited and no specific action is recommended for this type of installation.

CO, NOx, Mn, Zn, Pb and HCl are other main pollutants found in the emissions. Most of them come from wood and once again no impact of using “contaminated wood” is highlighted.

In conclusion, cogeneration is a good method for recycling wood wastes from construction and demolition activities or municipal recycling centres. Based on the obtained result, the impact on environment is negligible and this solution is interesting for saving place in landfills and producing green energy at low cost.

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