

# Comparison of dust emissions from an individual wood-fired boiler and dust emissions in the production of the same amount of heat in a combined heat and power plant

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**Abstract.** Comparison of dust emissions from an individual wood fired boiler (of various types) and of dust emissions during generation of the same amount of heat in a heat and power station were the aim of this work. For the purpose of the calculations the dust emissions from the heat and power station were assumed as the maximum permissible dust emissions, in line with the regulation of the Minister of Environment of 4 November 2014 on emission standards for certain types of installations, fuel combustion sources and waste incineration and co-incineration devices. The emissions of dusts for boilers were assumed based on available publications. For the purposes of the analysis, three boilers of 15 [kW] power were considered. Based on the obtained results it can be stated that the amounts of dust emitted by selected wood-fired boilers are not significantly different from the amount of dust emitted by a heat and power station for the same effect on the recipient's side. Heating boilers of powers lower than 15 [kW] exist and for some of them the dust emissions are even smaller than for the boilers discussed herewith. The discussed boilers have heating efficiency of 86 %. If their efficiency were to be higher, the concentration of the dust would have been lower. The solid fuel (wood) fired boilers considered in this work are not the best ones on the market with respect the dust emissions. The ongoing development of the fuel combustion technology allows expecting even further reduction of emissions of dusts.

## 1 Introduction

A high number of boilers of low power and low energy efficiency is operated in Poland. They are emitting high volumes of products of incomplete combustion. In order to limit the emission of solid combustion products and to increase the energy efficiency of boilers, the heat sources have to be properly designed and operated.

The main method for the generation of the primary energy is combustion of fuels. This process is however also one of the key sources of emissions to air. Even though the existing technologies in the power industry allow to meet the legal requirements on the emissions to air, there are still existing vast possibilities to further reduce the emissions of air pollutants by means of improved air protection technologies [1].

Comparison of dust emissions from an individual wood fired boiler (of various types) and of dust emissions during generation of the same amount of heat in a heat and power station were the aim of this work. As in reality the distance between a recipient and a heat and power station varies, the considerations assumed utilization of heat from a heating network and electric heating. Dust emissions of individual wood-fired boilers of 15 [kW] power in a single-family house were compared with dust emissions from a heat and power station during generation of the same amount of heat. An

analysis of the results and conclusions conclude the paper.

## 2 Legal requirements for dust emissions from heat and power stations

Legal requirements on dust emissions for heat and power stations have been established by the regulation of the Minister of Environment of 4 November 2014 [2]. It contains emission standards for sulphur dioxide, nitrogen oxides, carbon monoxide and dust. The requirements for dusts have been referenced in table 1.

**Table 1.** Emission standards for combustion of solid and liquid fuels, excluding gas engines.

Nominal heating power of the source in [MW]	Dust emission standards in [mg/m <sup>3</sup> ]		
	for 6% oxygen content in the off-gases	other solid fuels	for 15% oxygen content in the off-gases for gas turbines and 3% for the remaining sources
	biomass and peat	other solid fuels	liquid fuels
1	2	4	5

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$\geq 50$ and $\leq 100$	30	30	30
$\geq 100$ and $\leq 300$	20	25	25
$> 300$	20	20	20

Reference: Regulation of the Minister of Environment of 4 November 2014 on emission standards for certain types of installations, fuel combustion sources and waste incineration and co-incineration devices. (Official Journal, position 1546 of 7 November 2014), p. 22. [2]

### 3 Emissions of air pollutants from small-scale boilers manufactured in Poland

Table 2 presents, based on literature references, results of measurements of concentrations of pollutants produced during combustion of fuels in various heating boilers manufactured in Poland. All of the boilers (except for one, which was then omitted in further considerations) have heating efficiency exceeding 85%. The tests were conducted in accredited laboratories and the results were provided in the technical documentation and sales folders.

**Table 2.** Comparison of pollutant concentrations produced by various boilers [3].

Boiler type	Power [kW]	Fuel	Dust Concentration at 10% O <sub>2</sub> [mg/m <sup>3</sup> ]
FUWI chips fired	15	woodchips	46
FUWI/Bio-P	29	woodchips	21
FUWI chips fired	30	woodchips	32
Cichewicz /Futura Picus	14 ÷60	woodchips	90
HEF/Eko-Plus "U" Pellets	18 ÷50	woodchips	55
SAS/ Agro-Eco	15 ÷100	woodchips	50÷75
Termo-Tech/Biomaster	10 ÷100	woodchips	80
MCI Sp. z.o.o./ R-Eco Pellet	24,6	woodchips	25
Koterm/ KWMP 4	31 ÷60	woodchips	20÷60
Defro Duo/ Defro Duo	15 ÷42	woodchips	45÷70
Zębiec/KP	15 ÷60	woodchips	90
Elekromet/ Eko-PE	20 ÷35	woodchips	45÷80
Elekromet/ Eko-PE	20	woodchips	45
Hiton/Hiton-25	15 ÷25	woodchips	145
Elekromet/ Eko-PE	35	woodchips	80
Sigma Dual - chips	20 ÷25	woodchips	-
Sigma Dual - wood	20	wood	-

Cichewicz/ FB25	20	sawdust briquettes	485
Buderus KP	18 ÷38	wood logs	150
Hiton/ Moderator	20	oats	560
Moderator/Smok	60	biomass briquettes	495

Reference: Marek Juszcak, Low power, biomass-fired source of heat: energy-environmental efficiency for selected fuels, published by Poznan University of Technology, Poznan 2016, p. 44. [3]

### 4 Comparative calculations of dust emissions for a boiler of 15 [kW] power fired with beech chips and for a heat and power station

For the purposes of the analysis, three boilers of 15 [kW] power were considered: woodchips-fired FUWI, Termo-Tech/Biomaster and Hiton/Hiton-25, of efficiency 86%. Stoichiometric calculations assuming the net calorific value of the woodchips  $W_d = 14836$  [kJ/kg], indicated that the required feed of woodchips is 4,23 [kg/h] and the stream of off-gases is 31,46 [m<sup>3</sup>/h].

The power of the comparative heat and power station was assumed as 100 [MW]. The efficiency of heat generation was assumed as 85 %, of heat distribution as 86,7 %, of electricity generation as 38 %, and of distribution of electricity as 92,7 %. Based on stoichiometric calculations, with the assumed net calorific value of bituminous coal  $W_d = 21000$  [kJ/kg], the required feed of the coal was:

For heating with district heating - 3,49 [kg/h] and stream of off-gases 33,61 [m<sup>3</sup>/h].

For electric heating – 7,30 [kg/h] and stream of off-gases 70.30 [m<sup>3</sup>/h].

The resulting stream of off-gases carries the amount of dusts equalling the standards listed in table 1 for heat and power stations, i.e. 30 [mg/m<sup>3</sup>] and for small-sized boilers equalling the one from table 2 - i.e. 46, 80 and 145 [mg/m<sup>3</sup>] for each boiler type respectively. The results have been elaborated in table 3.

### 5 Analysis of results and conclusions

For the purpose of the calculations the dust emissions from the heat and power station were assumed as the maximum permissible dust emissions, in line with the regulation of the Minister of Environment of 4 November 2014 on emission standards for certain types of installations, fuel combustion sources and waste incineration and co-incineration devices. In reality, this emission might be lower, meaning the calculated amount of dust emissions from the heat and power station might be lower. The emissions of dusts for boilers were assumed based on the publication of Marek Juszcak [3].

Based on the obtained results it can be stated that **the amounts of dust emitted by selected wood-fired boilers are not significantly different from the**

**amount of dust emitted by a heat and power station** for the same effect on the recipient's side. In addition, the FUWI boiler generates a significantly smaller amount of dust in comparison to the heat and power station when the building is heated using electric heating.

Heating boilers of powers lower than 15 [kW] exist and for some of them the dust emissions are even smaller than for the boilers discussed herewith. One of them is boiler Futura Pellets of heating power equal 5,4 [kW] which generates 6 [mg/m<sup>3</sup>] of dust.

**Table 1.** Compilation of results.

Selected boilers				
Boiler type	Power [kW]	Fuel	Dust concentration at 10% O <sub>2</sub> [mg/m <sup>3</sup> ]	Amount of dust generated over the course of one hour [g/h]
FUWI woodchips fired	15	Woodchips	46	1,447
Temo-Tech/Biomaster	15	Woodchips	80	2,517
Hilton/Hilton-25 Energy	15	Woodchips	145	4,562
	Power [MW]	Fuel	Dust concentration at 10% O <sub>2</sub> [mg/m <sup>3</sup> ]	Amount of dust generated over the course of one hour [g/h]
Heat and power station (heat)	100	Bituminous coal	30	1,008
Heat and power station (electricity)	100	Bituminous coal	30	2,109

Reference: Own calculations.

The discussed boilers have heating efficiency of 86 %. If their efficiency were to be higher, the concentration of the dust would have been lower. An example here is boiler Pellets Unit ETA of 15 [kW] heating power and heating efficiency 93,5 % which emits 19 [mg/m<sup>3</sup>] of dust.

The solid fuel (wood) fired boilers considered in this work, as one can conclude from the previous paragraph, are not the best ones on the market with respect the dust emissions. The ongoing development of the fuel combustion technology allows expecting even further reduction of emissions of dusts.

Coupling of a single-family house to a heat distribution network generates costs - for the construction of the district heating substation and the fee for the hook-up. Part (or even the entirety) of these costs can be covered by the utilities company. It is dependent however on its policy.

When a given building is to be heated using electric heating, it must be powered with three-phase electric power and the wiring inside the building has to be adapted as well. These operations also generate costs.

For a small boiler, all data is taken from materials from the bibliography; there is no description of the sensors there. For the boiler of the combined heat and power plant, the maximum permissible dust emission values were adopted for the calculations (measurement data were not used). Dust emitted from small boilers propagates at low altitude - a maximum of a dozen or so meters. Dust emitted from the chimney of the heat and power plant propagates at the height of several dozen meters.

## References

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2. Rozporządzenia Ministra Środowiska z dnia 4 listopada 2014 r. w sprawie standardów emisji dla niektórych rodzajów instalacji, źródeł spalania paliw oraz urządzeń spalania lub współspalania odpadów, Dziennik. Ustaw, poz. 1546 z dnia 7 listopada 2014r.
3. M. Juszczak, *Źródło ciepła małej mocy zasilane biomasą: efektywność energetyczno-ekologiczna dla wybranych paliw* (1<sup>th</sup> edition, Wydawnictwo Politechniki Poznańskiej, Poznań, 2016)