Real measurement of selected biomass boilers in households

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Introduction

This article presents the results of field measurements of five boilers with thermal power output 20-30 kW (three wood gasification GW and two wood pellets automatic AP). The measurements were conducted during routine daily use. Our research aimed at the determination of real parameters in field measurements of five biomass boilers with heat output 20-30 kW (three wood gasification and two wood pellets automatic boilers). All measured boilers met the Ecodesign requirements during the certification. The measurements were conducted during routine daily use. Obtained results were compared to declare emission classification (according to EN 303-5:2012).

Materials and methods

There are three gasification wood boilers (GW) and two wood pellet boilers (AP) discussed in this study. Nominal thermal output of measured devices was in the range from 20 to 30 kW.

Temperature of flue gas, chimney draught, oxygen and CO content in flue gas were measured continually. A gravimetric one-time TSP measurement was conducted. Thermal efficiency of devices was determined indirectly. A fuel analysis was performed. Thermal output was calculated from measured water flow and a temperature difference. CO and TSP concentrations (Table 1) and thermal efficiency (Table 2) were compared with EN 303-5.

Table 1. Limit values of CO and TSP for emission classes.

Parameter	Emission classification	Boiler category	
		Manual	Automatic
		Biomass	Biomass
CO [$mg.m^{-3}$]	1	25,000	15,000
	2	8,000	5,000
	3	5,000	3,000
	4	1,200	1,000
	5	700	500
TSP [$mg.m^{-3}$]	1	200	200
	2	180	180
	3	150	150
	4	75	60
	5	60	40

Table 2. Limit values of thermal efficiency for emission classes.

Parameter	Classification	Nominal thermal output [kW]			
		15	20	25	30
Thermal efficiency [%]	1	54.1	54.8	55.4	55.9
	2	64.1	64.8	65.4	65.9
	3	74.1	74.8	75.4	75.9
	4	82.4	82.6	82.8	83.0
	5	88.2	88.3	88.4	88.5

Results and discussion

The real parameters of biomass boilers are worse than in the testing boiler laboratory. None of the measured boilers reached the labelled (certified) values. Wood pellet boilers were better than wood gasification boilers.

Gasification boilers achieved the best parameters when operated at nominal output. Therefore, they are not certified at reduced output but must be operated in a system with storage tanks.

Although all measured gasification boilers had discharged (cold) storage tanks, they were not operated at nominal output and therefore the quality of combustion was very poor. Incorrect setting of the control elements switched off the flue gas fan.

Pellet boilers can be operated from 30-100% of output without significant deterioration of operating parameters (reduced output is also measured during certification, the requirements on Ecodesign give a large importance to value of 85%), which was also confirmed in our measurements.

The effect of reduced output on higher production of pollutants is significantly greater in gasification boilers than in pellet boilers.

The pellet boiler (4AP) burned well and was the one to meet the emission requirements for the 5th class in real operation. However, it did not meet the efficiency requirements due to non-performed maintenance (cleaning of the heat exchanger surfaces). After their cleaning, all measured requirements were met.

Table 3. Measured data and corresponding emission classification.

Boiler	CO		TSP		Efficiency		Thermal output		Boiler class	
	$mg.m^{-3}$	Class	$mg.m^{-3}$	Class	%	Class	Measured	Nominal	Certified	Measured
1GW	449	5	35	5	84.9	4	16.8	22	5	4
2GW	3,347	3	69	4	77.7	3	15.7	30	5	3
3GW	21,643	1	558	–	76.7	3	10.9	25	5	1
1AP	62	5	31	5	83.8	4	12.4	20	5	4
2AP	191	5	63	3	85.0	4	17.5	30	5	3

Conclusions

The effect of reduced output on higher production of pollutants is significantly greater in gasification boilers than in pellet boilers. For quality combustion, gasification biomass boilers must be operated at the nominal output. The installation of storage tanks does not guarantee that the boiler will be operated at nominal output. The difference between label values was significantly smaller for pellet boilers than for gasification boilers. Even such expensive and modern combustion devices cannot be operated without regular maintenance – cleaning of heat exchanger surfaces (higher chimney loss). Results lead to conclusion that there are four factors impacting generated pollution (boiler construction, operator awareness, quality of fuel, boiler maintenance). If one factor is omitted, generated pollution immediately or progressively increased.

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