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Case study
Studija slučaja

EFFICIENCY AND MANAGEMENT OF GAS BOILERS IN PUBLIC BUILDINGS IN VOJVODINA

STEPEN EFIKASNOSTI I UPRAVLJANJE GASNIM KOTLOVIMA U JAVNIM ZGRADAMA U VOJVODINI

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ABSTRACT

This paper presents a case study of gas boilers at 14 locations in Autonomous Province of Vojvodina, Republic of Serbia. AP Vojvodina is mainly gasified, i.e. 38 out of 45 municipalities have possibility to use gas. Therefore, a lot of public buildings, such as schools, kindergartens, municipality objects, are heated using natural gas. The aim of this paper is to get a better insight and manners of management of gas boilers in AP Vojvodina. Here are presented results of measuring boilers efficiencies and other parameters and some conclusions are stated. General conclusion is that the gas boilers are poorly managed. The boilers are mostly conventional type; often are oversized; there is a lack of automatic control of boiler according to the outside air temperature; manual control of boilers prevailes; lack of knowledge and failure of measuring instruments lead to significant energy losses. For the most of the investigated gas boilers NO_x and CO concentrations are higher than prescribed by regulation.

Key words: *gas boilers, boiler efficiency rate, gas boiler management.*

REZIME

Iako je gasifikacija Srbije započeta pre više od 30 godina, postoje velike razlike između nivoa gasifikacije različitih regiona u zemlji. Dok je severna Srbija (AP Vojvodina) skoro u potpunosti gasifikovana, dotle su zapadna i centralna Srbija gasifikovane samo delimično, a gasifikacija juga Srbije jedva da je počela. Danas, većina toplana koristi, pre svega, prirodni gas. U radu je predstavljena studija slučaja gasnih kotlova na 14 lokacija u Autonomnoj Pokrajini Vojvodini, Republika Srbija. Zbog dobre gasifikovanosti veliki broj javnih objekata, kao što su škole, obdaništa, zgrade opština zagrevaju se korišćenjem prirodnog gasa. Cilj ovog rada je da se dobije bolji uvid u načine upravljanja gasnim kotlovima u AP Vojvodini. Prikazani su rezultati merenja efikasnosti kotlova i drugi parametri, kao i zaključci izvedeni iz merenja i analiziranja rada kotlova. Opšti zaključak je da su gasnim kotlovima loše upravlja. Stari konvencionalni kotlovi su najbrojniji, često su predimenzionisani, nedostaje im automatske regulacija u skladu sa spoljnom temperaturom vazduha. Ručna kontrola kotlova, nedostatak znanja i neispravnost mernih instrumenata dovodi do značajnih gubitaka energije. Za većinu ispitivanih gasnih kotlova emisija NOx i CO veća je od zakonom propisanih.

Ključne reči: *gasni kotao, stepen efikasnosti kotla, upravljanje gasnim kotlovima.*

INTRODUCTION

Although gasification of Serbia started more than 30 years ago, there are large disparities between gasification levels of different regions of the country. While Northern Serbia (AP Vojvodina) is almost fully gasified, Western and Central Serbia are only partly gasified and the gasification of Southern Serbia has barely begun. Today, most heating power plants are primarily disbursing natural gas *(Brkić, 2008)*.

Usage of natural gas in AP Vojvodina is prevalent in 38 out of 45 municipalities, and the tendency is to gasify the other 7 municipalities. Vojvodina is partly supplied with natural gas from its own resources, and lack (75 % of its natural gas requirements) is compensated by importing gas from the Russian Federation via Hungary (*Energy Balance of AP Vojvodina/Plan for 2011./Part of Energy Balance of Republic of Serbia, Autonomous Province of Vojvodina, Provincial Secretariat for energy and Mineral Resources, 2010*). Distribution pipeline system managed by public enterprise "Srbijagas" includes medium pressure gas pipelines from 4 to 16 bar, with a length of 650 kilometers and low-pressure pipelines up to 4 bar, with length of about 3,000 km. It is a large system with significant potential for energy savings and emission reduction. The increase of energy efficiency and reduction of carbon monoxide (CO) and nitrogen oxides (NO_x) emision is global trend in the development and adjustment of gas boilers and gas burning plants. Increased energy efficiency of gas furnaces and plants is result of mainly technical solutions of water vapor condensation and flue gases regulation parameters. A mathematical model of condensing economizer by which is condensed water vapor of natural gas combustion products in district heating system was developed (*Vnukov and Rozanova, 2013*). Condensing economizer saves up to 8 % of the consumed gas. A new strategy for regulation of the gas boiler was proposed (*Yamaev, 2012*), which is reflected in the simultaneous regulation of gas-air side by means of impedance change and change of blower motor voltage frequency at the exhaust side of the boiler. Experimentally was confirmed the reduction of energy consumption of blowers of 38 %.

The presence of a hazardous CO in flue gases is an indicator of incomplete combustion. Decrease in concentrations of CO in flue gases achieved beside the well-known practice such as by adjusting system parameters (increasing amount of air supplied to the combustion chamber) or by substituting the gas burner, can be realized (if possible) by change of the system geometry. Experimentally was determined that from the stand point of CO emission, straight exhaust section of pipeline is preferable to the one with elbow (*Leem et al., 2008*) and a shorter section of exhaust pipe is more suitable than long one.

Emission of nitrogen oxides rises with increasing amount of air supplied to the combustion chamber, hence by controlling the excess air ratio we can control the production of nitrogen oxides (*Baubekov, 2008*). Authors (*Vnukov et al.,2007*) showed that, in the case of the boiler of 300 MW the optimal operating conditions can be achieved by controlling the emission of carbon monoxide CO in the exhaust gas.

Burner designed with two zones of the mixture of oxygen and gas, outer with a higher concentration of oxygen and inner with a lower concentration of oxygen was proved to significantly reduce the concentration of nitrogen oxides (*Baubekov 2008)*. It was managed to reduce the emission of nitrogen oxides in the range of 70 to 120 mg/Nm^3 by development of two-channel burner nozzle *(Osintsev, 2010)*. Through one channel a mixture of air and gas is fed with air-fuel equivalence ratio of 0.4 to 0.7, while through the second channel the air is fed so that the total air-fuel equivalence ratio is 1.07 to 1.1. He also found that with increase in the combustion chamber length, from the burner to the place of maximum flame temperature, the production of nitrogen oxides decreases. *Arablu and Poursaeidi (2011)* located the optimal point on the wall of the boiler to place injectors to feed air and gas using the CFD simulations, and thereby reduced NO production by 70 %, without increasing the amount of CO emitted.

A number of authors managed to reduce NOx emission in boiler flue gasses experimentally by decreasing the flue gas temperature below the dew point, by conversion of nitric oxide by oxidation to nitrogen dioxide and by absorption of nitrogen oxide by condensed water vapor from flue gas (*Kormilitsyn and Ezhovb, 2013*), by mixing natural gas with coke gas and blast-furnace gas (*Kazankin and Zakurin, 2012*) or by inserting reagent into flue gas (*Zhong and Fu, 1996*), (*Smyshlyaev et al., 2008*). Similarly, it was showed by CFD modeling (*Maloney et al., 2007*) that the combined combustion of coal and gas (gas is burned above the bed where is burned coal) leads also to reduction of nitrogen oxides emission. Using SCADA systems (*Bugarski et al., 2015*) in boiler burner control is a part of the conversion of a manually operated boiler towards a fully automated boiler.

Nomenclature:

A - surface area [m^2]
C - concentration [mg/m^3]
M - molar mass [g/mol]
NO_{2Add} - nitrogen dioxide addition factor [-]
O_{2ref} - referent content of oxygen in flue gas [%]
O_{2m} - content of oxygen in flue gas [%].
p - absolute pressure in chimney [kPa]
Q - power [kW]
qA - heat loss through chimney [-]
t - temperature [^{o}C]
T - absolute temperature in chimney [K]
V_0=22.4 dm^3/mol - molar volume

Greek symbols:
α - excess air ratio [-]
η - efficiency rate [-]
φ - relative humidity of air [-]

Subscripts:
Add - addition factor
b - boiler
g - gas
in - inlet
m - mass
n - normal conditions; nominal
ou - outlet
r - real conditions; room
ref - referent conditions
v - volume
w - water

MATERIAL AND MEHTOD

Regulative in Serbia

In line with the global trend of increase energy efficiency and reduction of the concentration of CO and NO_x in the flue gas, the Serbian Government adopted the *Decree on threshold limit values of air pollutants*.

The field of natural gas application in Serbia is also covered with following regulations:

- Rulebook on technical standards for the design, construction, operation and maintenance of gas boilers (*SFRJ Official Gazette 10/90 and 52/90*)
- Law on Air Protection, Republic of Serbia (*Official Gazette 36/2009 and 10/2013*)
- The Law on Environmental Protection (*Republic of Serbia Official Gazette 135/2004 and amendments to the Law no. 36/2009*).

In previously mentioned Decree on limit values of pollutants in the air are listed reference methods for pollutants emission measuring. The other methods can be used as well, if their equivalence can be proved. Measurement of pollutant emissions with gas analyzer with electrochemical cells is a generally accepted measurement method. According to Decree should be used standard ISO/IEC 17025 (General requirements for the competence of testing and calibration laboratories). Standard defines the period of calibration and testing of devices used for measuring of the emission of air pollutants, as well as the requirements to be fulfilled by the laboratory for testing and calibration of devices. The gas analyzer was calibrated in an accredited laboratory immediately before use.

The Decree on threshold limit values of air pollutants defines the number of annual measurements, describes the measuring point and provides the measurement plan. The Regulation defines the mathematical models according to which are calculated measured values of pollutants to the values which can be compared with the limits set out in the regulation.

Measurements

Experimental measurements were done at 14 locations in AP Vojvodina. Following objects were taken into account: kindergartens, schools, health care, municipality building and public enterprise. The aim of the experiment was to get an insight in gas boiler conditions. Therefore, measuring provided following data: water flow rate, concentration of oxygen, carbon monoxide, carbon dioxide, nitrogen monoxide, nitrogen oxides, hydrogen concentration in the flue gas, flue gas temperature, air temperature in the boiler room, air temperature at the inlet to the boiler, excess air, the efficiency rate of the boiler, water temperature on the pressure side of the boiler, water temperature in return pipe to the boiler; heat loss through the chimney, heat generated by the boiler delivered to the heating system, outdoor conditions - air temperature, barometric pressure and relative humidity.

To measure the temperature of the water in return and discharge pipes of gas boilers were used the infrared thermometer manufacturers "PCE", model 888 (*Fig. 1*). Infrared thermometer is a device for a contactless measurement of the fluid temperature.

For the measurement of atmospheric conditions was used air temperature, pressure and humidity measuring device manufactured by "PCE" model "THB38" (*Fig. 2*).

The water flow rate was measured with nondestructive ultrasonic flow meter manufactured by "Krohne" model "610U" (*Fig. 3*). The measuring device is very comfortable to work with since it measures the volumetric flow of liquid without deterioration of pipe walls.

To analyze the composition of flue gas a gas analyzer manufactured by "Testo" model 335 was used, shown in the *Fig. 4*.

Fig. 1. Contactless thermometer

Fig. 2. Measuring device

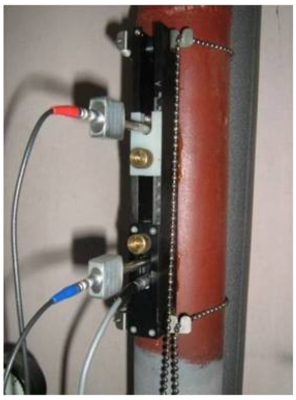

Fig. 3. Ultrasonic flow meter

Fig. 4. Gas analyzer

Used gas analyzer measures concentrations of pollutants in dry flue gas (water vapor is condensed in the unit), which is consistent with the maximum threshold limit values of air pollutants in flue gas as defined by Decree also given for dry flue gas. In order to compare the measured values of CO and NO_x in the flue gas with the maximum threshold limit values of air pollutants defined by Decree, it is necessary to recalculate measured properties. Conversion of the measured properties from ppm to mg/Nm^3 is carried out according to the following equation (*Decree*):

$$C_m = C_v \cdot \frac{M}{V_0}, \tag{1}$$

where are:

C_m - mass concentration [mg/m^3];

C_v - measured volumetric concentration [ppm];

M - molar mass [g/mol];

$V_0 = 22,4\ \text{dm}^3/\text{mol}$ - molar volume (at 273.15 K and 101325 Pa) [g/mol].

The Decree defines that total nitrogen oxides NO_x are determined based on measured concentrations of nitrogen monoxide NO and nitrogen dioxide NO_2 according to formula:

$$\text{NO}_x = \text{NO}_2 + \left[\text{NO} \cdot \left(\frac{M_{\text{NO2}}}{M_{\text{NO}}}\right)\right], \tag{2}$$

where are:

M_{NO2} - molar mass of NO_2 [g/mol] and

M_{NO} - molar mass of NO [g/mol],

what is equivalent to formula according which the gas analyzer calculates total nitrogen oxides:

$$\text{NO}_x = \text{NO} + \left(\text{NO}_{2\text{Add}} \cdot \text{NO}\right) = \text{NO} + \text{NO}_2, \tag{3}$$

where is NO_{2Add} – nitrogen dioxide addition factor [-].

The mass concentrations calculated to normal conditions is done according to equation (*Decree*):

$$C_{mn} = C_{mr} \cdot \frac{101,3}{p} \cdot \frac{T}{273,15}, \tag{4}$$

where are:

C_{mn} - mass concentration under normal conditions [mg/nm^3];

C_{mm} - mass concentration under real conditions [mg/nm^3];

p - absolute pressure in chimney [kPa] and

T - absolute temperature in chimney [K].

Recalculation of the mass concentrations to referent oxygen content in flue gases is carried out according to the following equation (*Decree*):

$$C_{ref} = \frac{21 - O_{2ref}}{21 - O_{2izm}} \cdot C_{mm}, \tag{5}$$

where are:

C_{ref} - mass concentration reduced to referent oxygen concentration [mg/nm^3];

C_{mr} - mass concentration under real conditions in chimney [mg/nm^3];

O_{2ref} - referent content of oxygen in flue gas [%]

O_{2m} - content of oxygen in flue gas [%].

Maximum thresholds limits of pollutants in flue gas from gas combustion refer to the volume fraction of oxygen in the flue gas of 3 % (*Decree*).

RESULTS AND DISCUSSION

The results of case study of gas boilers at 14 locations in the AP Vojvodina are shown in the *Table 5*. It shows that the installed capacity of gas boilers in most cases is higher than the thermal power consumption. These are oversized gas boilers, usually originally intended for supplying several buildings. In some facilities are implemented measures to reduce energy consumption (mainly insulation of facade and replacement of windows with more energy efficient), which has also contributed to the increase in the difference between installed capacity and thermal power consumption. In some cases, thermal power consumption could not be determined due to lack of information on the water flow rate. The reason for this is that some boiler operators did not allow the insulation to be removed from the pipes to measure the volumetric flow rate with nondestructive ultrasonic flow meter.

Most boilers do not have solenoid three-way valves and temperature regulation according to outside air temperature. Hence, the boiler operators are forced to manually regulate the water temperature at the outlet. In buildings without wall insulation and old windows and doors, the boiler operators use a long flame in the boiler in order to compensate heat losses. In some boiler rooms thermometers to measure the temperature of the water on the pressure and return pipe side are missing or broken. Most gas boilers are regular ones with lower efficiency rates compared to condensing boilers. The poor regulation, malfunctioning and missing measuring instruments, insufficient knowledge of boiler operators and the old conventional boilers are reflected to the basic parameters of the boiler: excess air ratio, efficiency rate, heat loss through the chimney etc., *Table 5*.

Most boilers do not have solenoid three-way valves and temperature regulation according to outside air temperature. In this way, the boiler operators are forced to manually regulate the water temperature at the outlet.

Table 5. The results of case study of gas boilers at 14 locations

	Kindergarten “Včelka” Bački Petrovac	Kindergarten “Včelka” Bački Petrovac	Kindergarten “Včelka” Bački Petrovac	Primary school “Svetozar Miletić“Vrbas	Kindergarten “Radosno detinjstvo PU Novi Sad”	“Radosno detinjstvo PU Novi Sad" Kindergarten	“Radosno detinjstvo PU Novi Sad" kindergarten	Primary school “Jožef Atila”Novi Sad	Primary school “Jožef Atila” Novi Sad	Health care in Žabalj	Primary school “Mvodiiloš Crnjanski” Žabalj	Primary school “Đura Jakšić” Čurug	Municipality building in Žabalj	Public enterprise “Srbijagas” Novi Sad
Q_n [kW]	46.4	3 x 48	32	65	300	250	85	850	850	400	700	600	700	1047
Q [kW]	25.3	44.8	2.84	27.2	89.5	87.4	83.9	-	-	-	-	-	-	-
t_{vul} [°C]	43	41	23	33	42	44	52	50	50	-	-	-	-	-
t_{viz} [°C]	54	46	25	59	49	56	69	73	73	-	-	35	50	50
O_2 [%]	5.25	15.2	16.9	6.02	3.35	8.84	15.3	10.7	11.9	3.37	4.87	4.03	3.97	5.51
CO [ppm]	68	30	15	138	2	252	2	25	70	2	1	516	1	1
CO_2 [%]	8.91	3.28	2.31	8.85	10	6.87	3.28	5.8	5.12	9.99	9.15	9.62	9.67	8.83
NO [ppm]	14	21	12	1	61	18	33	39	25	55	50	57	54	52
NOx [ppm]	15	21	13	1	65	19	35	41	26	58	52	59	57	55
H_2 [ppm]	18	19	3	189	1	13	1	1	2	2	0	337	3	1
t_{gou} [°C]	62.6	73.9	88.3	44.7	190.9	190	92.9	202	177.9	216.5	184.1	80.3	219.6	158.2
t_r [°C]	24.2	17.2	17.1	27.2	23.1	20.9	22.6	23.7	25	21.5	22.7	22.1	21	23.7
t_{gin} [°C]	24.6	18	34.2	27.2	23.1	20.9	22.6	23.7	5	21.5	22.7	22.1	21	23.7
α [-]	1.3	3.48	4.71	1.3	1.17	1.66	3.44	1.97	2.2	1.17	1.28	1.21	1.2	1.31
η_k [-]	98.1	93.2	87.9	102.5	92.9	89.3	91.3	86.9	87.5	91	91.9	87.9	90.6	93.2
Type	B	A	A	B	B	A	A	A	A	A	A	A	A	A
qA [-]	1.9		12.1		7.1	10.7	8.7	13.1	12.5	9	8.1	12.1	9.4	6.8
A [m^2]	1200		760	1150	1950	1000	400	7107			3491	2770	1400	-

In buildings without wall insulation and old windows and doors, the boiler operators use a long flame in the boiler in order to compensate heat losses. In some boiler rooms thermometers to measure the temperature of the water on the pressure and return pipe side are missing or broken. Most gas boilers are regular ones with lower efficiency rates compared to condensing boilers. The poor regulation, malfunctioning and missing measuring instruments, insufficient knowledge of boiler operators and the old conventional boilers are reflected to the basic parameters of the boiler: excess air ratio, efficiency rate, heat loss through the chimney etc., *Table 5*. Based on the presence of CO and H_2 in flue gases it can be concluded that in a number of gas boilers incomplete combustion occurs. Confirmation of that is that the concentrations of CO_2 are far from the theoretical values and excess air ratio α is far from optimal values.

According to the Rulebook on technical standards for the design, construction, operation and maintenance of gas boiler, every year before the heating season, the gas firebox installation have to be tested. There is no doubt that many boilers have not been tested or boiler operation parameters adjustment is done poorly during the test. Some gas boilers are not provided with connections for gas analyzer probe, and it is necessary to drill the hole in the flue pipe and insulation. The lack of openings for measuring the concentration of combustion products is a sign that the boiler either has not been tested or has been improperly tested. Gas boilers (*Table 5*), according to Decree, belong to a group of small plants for natural gas combustion where thermal power is not greater than 10 MW_{th}. For a group of small gas combustion plants, the maximum concentration of CO is 100 mg/Nm^3 (for thermal power plants up to 400 kW). The maximum allowable concentration of NO_x is also 100 mg/Nm^3 (water temperature in boiler lower than 110 °C and the gauge is less than 0.05 MPa).

Table 6. Measured values of CO and NO_x

Object	CO_{ref} [mg/nm^3]	NO_{xref} [mg/nm^3]
Kindergarten “Včelka” Bački Petrovac	119.4	43.2
Kindergarten “Včelka” Bački Petrovac	147.9	170
Kindergarten “Včelka” Bački Petrovac	108.9	155.1
Primary school “Svetozar Miletić“ Vrbas	241.2	2.8
Kindergarten “Radosno detinjstvo PU Novi Sad"	4.3	231.2
Kindergarten “Radosno detinjstvo PU Novi Sad"	790.9	97.9
Kindergarten “Radosno detinjstvo PU Novi Sad"	10.5	304.2
Primary school “Jožef Atila”Novi Sad	95	255.9
Primary school “Jožef Atila” Novi Sad	285.9	174.4
Health care in Žabalj	4.6	218
Primary school “Miloš Crnjanski” Žabalj	2.3	199.5
Primary school “Djura Jakšić” Čurug	885.5	166.3
Municipality building in Žabalj	2.4	223.2
Public enterprise “Srbijagas” Novi Sad	2.3	207.2

In order to compare the measured concentrations of CO and NO_x in flue gas with the threshold limit values of pollutants defined by Decree, the recalculation (equations (1) to (5)) of the measured parameters was done and results were presented in *Table 5*. Recalculated parameters of the measured concentrations of CO and NO_x in the flue gas are given in *Table 6*. They are recalculated to the same conditions as parameters defined by Decree.

According to the parameters shown in *Table 6* it can be observed that in most gas boilers that were the subject of investigation, concentrations of CO and NO_x exceeded the threshold limit values prescribed by Decree. Measured values of the concentration of NO_x are below the threshold limit value in only three gas boilers. However, what is more dangerous is the presence of high concentrations of CO in the flue gases. The measured concentration of CO of gas boiler in kindergarten "Radosno detinjstvo PU Novi Sad" is eight times higher than threshold limit value, while the concentration of CO in a gas boiler in elementary school "Djura Jaksic" from Curug is nine times higher. Taking into account that presence of CO can cause death, the situation is more than alarming.

The state of controlled boilers is as follows:

- Most boiler rooms do not have three-way solenoid control valve and temperature control according to outside air temperature. In this way, the boiler operators are forced to manually regulate the water temperature at the outlet.
- In buildings where no energy efficiency measures are applied (insulation and replaced windows), the boiler operators use a long flame on the burner in order to compensate for the heat losses of the object. This reduces the efficiency of the boiler;
- In most cases, the boiler operators do not have enough knowledge and experience to mange gas boilers (bad boiler management reflects on the basic parameters of the boiler: the coefficient of excess air, efficiency, heat loss through the chimney, etc..)
- Most controlled boilers are energy less efficient conventional gas boilers (compared to condensing boilers);
- Older boilers have high levels of carbon monoxide CO in flue gases;
- Older types and poorly adjusted burners high levels of nitrogen oxides NO_2 in flue gasses;
- Some of the gas boilers do not have connections for gas analyzer probes;
- In buildings with applied energy efficiency measures (insulation of walls and roof, replaced windows, etc.) gas boilers are oversized;
- In some gas boiler thermometers to measure the temperature of water discharge and recovery are missing or corrupted;
- Burner adjustment is done only according to pressure and not by gas flow.
- The absence of mandatory annual testing of gas boilers.

Proposed measures to improve the state of boilers are:

- Installation of three-way solenoid control valve and temperature control according to outside air temperature;
- Implementation of energy efficiency measures in buildings;
- Education of boiler operators in order to improve their management and achieve better parameters of gas boilers;
- Replacing less energy efficient conventional gas boilers with energy efficient condensing gas boilers;
- Replacement of existing burners and installation of modern ones (or previously mentioned measure) and adjustment of the parameters of gas boilers in order to reduce the

concentration of carbon monoxide CO and nitrogen oxides NO_2 in the flue gases;

- The flue pipes should all have connections for gas analyzer probes to enable quick and easy measuring of the composition of the combustion products and according to them to set the parameters of the boiler;
- Prior to boiler replacement should be measured all heat losses of the building in order to avoid over or sub sizing of boiler;
- Missing or broken thermometers on discharge and return pipes should be replaced;
- Boiler burner has to be adjusted according to pressure and to the flow of gas.

Authors of this paper are of the oppinion that together with proposed measures more attention should be aimed on usage of renewable energy sources, especialy solar energy in heating systems using gas boilers since Republic of Serbia has significant solar potential (*Milićević et al., 2015*).

CONCLUSION

The investigated gas boilers are poorly managed. Old conventional boilers, oversized boilers, the lack of automatic control of boiler according to the outside air temperature, manual control of boilers, lack of knowledge and failure of measuring instruments lead to significant energy losses. The absence of mandatory annual testing of gas boilers and poor adjustment during testing also leads also to a loss of energy, but also to air pollution due to excess emission of substances with concentrations higher than the threshold limit value. For the most of the investigated gas boilers NO_x concentration and CO concentration are higher than prescribed by regulation. Presence of carbon monoxide in concentrations higher than prescribed is extremely dangerous. This is a wake-up call.

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