INCREASE OF THE ENERGY EFFICIENCY OF ROOF TOP BOILER PLANTS AND INSTALLATION OF CONDENSING BOILERS

SUMMARY:

KJKP Toplane Sarajevo is the largest district heating system in Bosnia and Herzegovina. A significant part of total thermal capacity (44,8 MW) has been attributed to the roof top boiler plants. The state of boiler plants was relatively satisfying regarding the safety of production and distribution of thermal heat, but extremely negative with regards to the efficiency and the content of pollution in flue gases. The contents of CO and NOx in all boiler plants were far above the limited values defined by regulation, while the efficiency coefficients were extremely low.

The project named "Increase of the energy efficiency of roof top boiler plants and installation of condensing boilers" was a part of Development program of KJKP Toplane Sarajevo for the period 2006 – 2013. This project was one the most important projects in the area of environment protection and increase of energy efficiency in Canton Sarajevo.
The project was realized in two phases. During the heating seasons 2005/2006 and 2006/2007 the Pilot project was carried out.

By the replacement of existing boilers with new condensing boilers in two boiler plants (together with a large spectrum of system improvements), extremely advantageous results have been achieved. Real gas consumption saving (due to use of condensing boilers) was on the level of approximately 18 to 20 %. Pollution content in flue gases for condensing boilers in both boiler plants was significantly lower than limited values defined by law. The quoted gas consumption savings made it possible to pay back expenses in a period of 5 to 6 years.

All the results from this Pilot project were a clear basis for further activities on second phase. The Main project has assumed the reconstruction of 82 boiler plants during the period 2007-2012.

Project goals:

- Reduction of total energy consumption
- Reduction of harmful flue gas emission
- Improvement of environment quality
- Improvement of heating quality and living comfort

Project effects after completion of the whole Project:

- Total gas consumption saving is on the level of ca 20 %. That means approximately 1,4 million Sm^3/year of natural gas
- Emission of NOx is reduced ca 9 times (from 15.665 t/year to 1.700 t/year)
- Emission of CO is reduced ca 50 times (from 8.645 t/year to 180 t/year)
- Emission of CO_2 is reduced ca 14 % (from 10.756 t/year to 9.251 t/year)
- System energy efficiency coefficients are very high and that ranged from 95%-101%.

1. BASIC INFORMATION

1.1. General part

Cantonal Public Utility Company KJKP Toplane - Sarajevo is the largest district heating system in Bosnia and Herzegovina.

The district heating system is very specific. It consists of a large number of bigger and smaller area boiler plants with independent distribution networks. There are different types of systems: hot water or warm water, depending on size of facilities, with thermal capacities of particular boiler plants ranging from 600 kW to 56 MW.

Within Toplane's system, there is no cogeneration system for combined heat and electricity production.

Total number of individual boiler-plants	138
Medium and large-scale boiler plants	47
Roof top boiler plants	91
Installed capacity	503 MW
Engaged capacity	323 MW
Distributive network	82 km
Heating substations	146
Number of heated flats	50.194
Number of heated building	1.492
Number of heated business premises	2.471
Main fuel	Natural gas
Alternative fuel	Light and heavy fuel oil

Table no. 1: Basic data KJKP Toplane - Sarajevo

Picture No. 1: Existing boilers in a typical boiler plant

1.2. Roof top boiler plants

A significant part of total thermal capacity (44,8 MW) can be attributed to the roof top boiler plants, which have been built in Sarajevo since 1983, and serve to heat a single building or part of a building. They are located on the buildings' roof tops exclusively and in some cases they served for preparation of domestic hot water. During the war, the whole distribution network was destroyed, which was the main reason why after the war the inhabitants have turned to use electricity for that purpose.

Average installed capacities ranged between 300 and 1.000 kW, with the biggest part between 500 and 600 kW. These boiler plants were equipped with atmospheric burners, with gradual regulation achieved by including or excluding certain number of cells, depending on outdoor temperature.

The state of boiler plants was relatively satisfying regarding the safety of production and distribution of thermal heat, but extremely negative with regards to the efficiency and the content of pollution in exhaust gases. The contents of CO and NOx in all boiler plants were far above the limited values defined by regulation, while the efficiency coefficients are extremely low (from 74% to 81%).

1.3. The Project planning

The whole Project named “Increase of the energy efficiency of roof top boiler plants and installation of condensing boilers” planned to be realized in two phases:
I phase: Pilot project implemented in two typical boiler houses.
II phase optionally: If the benefits of Pilot project were as expected, reconstruction of all roof top boiler houses in a period of ca 6 years (according to the company financial capabilities)

2. PILOT PROJECT

2.1. Introduction

Pilot project was realized in two relatively smaller boiler plants. The Pilot Project was completed during the seasons 2005/2006 and 2006/2007.

2.2. Selection of boiler plants in Pilot project

Boiler plants H2D and H4 are located in area the Breka - area unit Centar. Before reconstruction in both boiler plants, cast iron cells with 75 kW nominal heat capacity grouped into batteries with larger capacity (''Hydrotherm – Multiblock'' 300 kW each) were installed. The reconstruction included replacement of existing batteries with new condensing boilers (two types of two different producers).

Boiler plant H4: Type Vitocrossal 300, CM3, product of Viessmann, thermal capacity 2x130 kW, made of Inox, with Matrix radiant burner and modulated regulation

(Picture No. 2)

Boiler plant H2D: Type H2D–WTC60-A, product of Weishaupt, thermal capacity 4x60 kW, made of Alumimium, with separate burner and modulated regulation

(Picture No. 3)

Boiler Plant	System parameters	Installed capacity kW	Engaged capacity kW	Number of heated flats	Heating surface m^2	
					Flats	Business premises
H2D	90/70 °C	240	249	35	2.455	0
H4	90/70 °C	260	245	40	2.860	209

Table No. 2: Basic data on "pilot" boiler plants:

Because of specific working conditions with condensing facilities a complete or partial reconstruction of existing boiler plants' segments has been done:

- Replacement of open expansion system with a closed one
- Introduction of pump system with frequency regulation
- Accommodation of system for exhaust gases
- Installation of a new automatic water supply system
- Installation of condensate drainage system through neutralization vessels
- Installation of hydraulic switch (bypass) in boiler plant H2D
- Introduction of remote control and monitoring system.

2.3. Working parameters analysis

Some of basic indicators have been elaborated within the analysis:

- Burning process
- Hydraulic system
- Energy consumption
- Chemical water treatment and condensate drain
- Automatic pressurizing system and water supply set points
- Internal house installation

Parameters monitoring was done in a following way:

Parameters	Season 2005/2006	Season 2006/2007
Gas	Daily	Daily
Heat energy	Daily	Mountly
Burning proces	Weekly	As other systems

Table No. 3: Parameters

Analyses were done in a following way:

Season 2005/2006	Season 2006/2007
Weekly	Half a season

Table No. 4: Analyses

2.3. 1. Burning process

Regular burning process monitoring of all boilers and burners in Toplane was carried out periodically, minimum two times per season. For the purpose of this project, during the first year, measurement and analysis was carried out every week (pollution content in flue gases: NOx, CO, CO_2, flue gases temperatures, efficiency coefficient, gas flow depending on capacity level during measurement itself, etc).

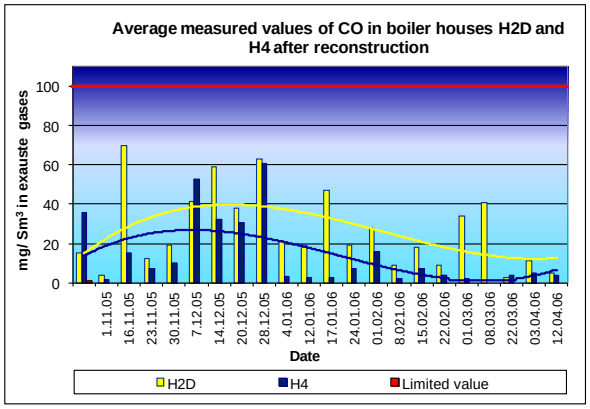


Chart No. 1

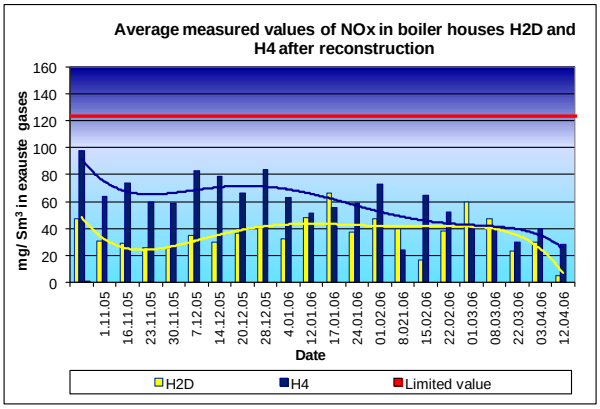


Chart No.2

Conclusions (charts No.1 – No.4):

1. Pollution content in flue gases for condensing boilers in both boiler plants was much lower than in old facilities
2. Pollution content in flue gases for condensing boilers in both boiler plants was significantly lower than the limited values defined by law
3. Content of CO in flue gases in boiler plant H2D was higher than in boiler plant H4
4. Content of NOx in boiler plant H2D was lower than in boiler plant H4
5. Amount of CO_2 in both boiler plants was lower than in the old facilities

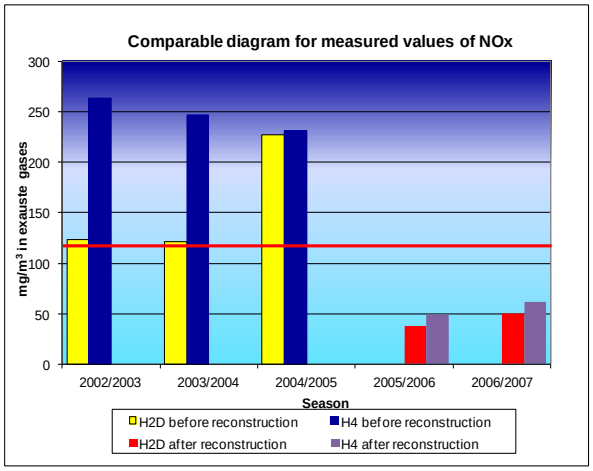


Chart No. 3

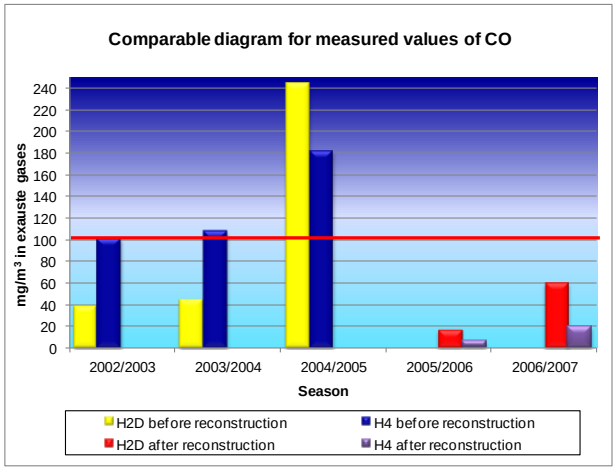


Chart No. 4

2.3.2. Energy consumption

The results of monitoring the operation in boiler plants with respect to the gas consumption, produced thermal energy and efficiency coefficients, are shown in the table No. 5 and the charts 5 to 8.

Roof top boiler plants	Boiler plant capacity	Period	Average temperature		Degree days		Gas consumption				Energy		Efficiency	Average efficiency coefficient
							Real consumption	Real consumption	Based on degree days	Gas saving	Based on gas consumption	Based on heat meters		
	(kW)		°C				Sm³			%	MWh	MWh	η %	η %
			Season				Season				Season			
NOV. 2005 - APRIL 2006			*4.May*	*5.June*	*4.May*	*5.June*	*4.May*	*5.June*			*5.June*			
H2D	249	01.11.2005 - 23.04.2006	2,5	2,8	3.090	2.983	46.398	35.630	36.909	20	329,9	309,7	*93,9*	94,7
H4	245						51.690	41.009	42.481	18	379,7	362,5	*95,5*	
SEASON 2006/2007			*4.May*	*6.July*	*4.May*	*6.July*	*4.May*	*6.July*			*6.July*			
H2D	249	11.10.2006 - 23.04.2007	3,6	6,2	3.400	2.870	46.311	31.805	37.678	19	300,9	296,6	*98,6*	100,4
H4	245						51.601	31.291	37.069	28	296	302,5	*102,2*	

Table No. 5: Energy data

Conclusions (charts No.5 – No.8):

1. Real gas consumption for the new condensing boilers in both boiler plants was remarkably lower than for the old atmospheric boilers (when using the same climate conditions based on “degree days”). Reductions in gas consumption during whole heating seasons were significant, and they ranged up to 28 percent.

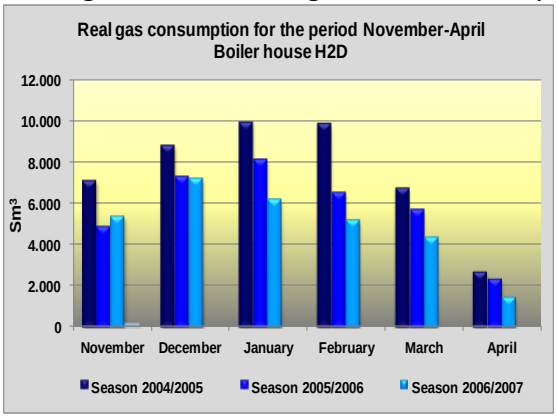


Chart No.5

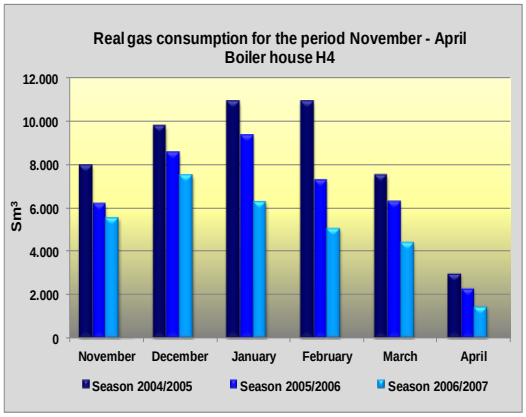


Chart No.6

2. System efficiency coefficient during the observed period had very high values, and it ranged from 94 to 102 %.
3. System efficiency coefficient for the season 2006/2007 had the highest values: 98,6 % for boiler plant H2D and 102,2 % for boiler plant H4.

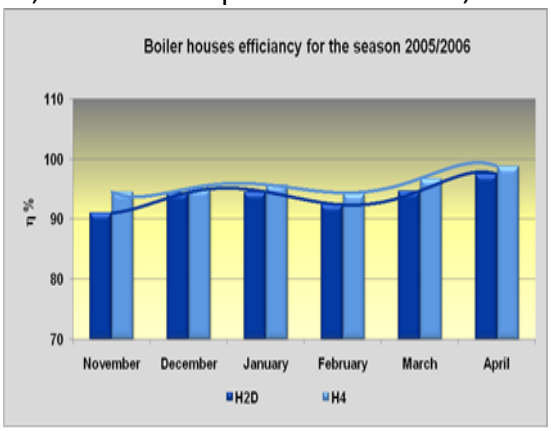


Chart No. 7

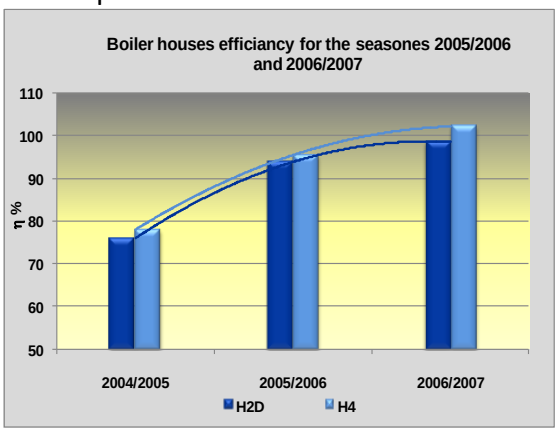


Chart No.8

This increase of efficiency could be explained by the fact that condensing effects were the most important during low water temperatures, i.e. during high outside temperatures. The relevant season was much warmer than the average one, which led to much lower supply and return water temperatures, i.e. bigger condensing effects.

2.3. 3. Hydraulic system

Both facilities demand pumps with frequency regulation. Weishaupt boilers also require use of hydraulic switch (bypass), so the system is more sensitive on water flow changes.

Real state of thermostatic valves built in radiators has not been checked. With respect to the age of buildings and its installations, we presumed that a high number of valves were not in function.

Large water losses in internal installations have emerged during putting facilities in operation, especially during morning start of boiler plant. In order to avoid this problem, an

automatic water supply system was installed. In this way, the problem of pressure reduction and keeping minimal boiler pressure needed for start and operation has been solved.

2.3.4. Chemical water treatment and condensate drain

In accordance to technical norms, also ISO 14001 standards, the necessary equipment for water treatment (Water softener) and condensate drain (Neutralization dish) were installed. Experience so far has shown the following:

- Condensate quality (pH value 6.5 – 9) for both system were within the approved limits
- Measured pH values of water in the systems were sometimes above 9 (8.2 – 9.5). That higher value could be attributed to the spontaneous emergence of alkaline products from present Na conjunctions in softened water.
- Recommended pH values for Weishaupt units (made of Al) were 6.5 – 8.5
- pH values of neutralized condensate (6.5 – 9) and water pH values in boiler plant H4 (8.2 – 9.5) were within the limited values recommended by the supplier

2.3.5. Main effects achieved through the Pilot Project

- Pollution content in flue gases: NOx and CO was much lower than in old facilities and significantly lower than limited values defined by law.
- Average real gas consumption saving (due to use of condensing boilers) was on the level of approximately 18 up to 20 %. That fact was used as a basis for further assessment. The quoted gas consumption savings made it possible to pay back expenses in a period of 5 to 6 years.
- With regards to significantly lower gas consumption, the amount of flue gases emitted to the atmosphere was significantly lower, and also lower CO_2 amount.
- System efficiency coefficients for both roof top boiler plants were significantly higher (from 74% to 94,7% in one boiler roof top plant and from 81% to 100,4% in another one).

3. MAIN PROJECT

The results achieved during carrying out the Pilot project have been the basis for further activities on reconstruction of all roof top boiler plants. That project had assumed the reconstruction of all **82** boiler plants. The Main project was financed by Canton Sarajevo government and KJKP Toplane - Sarajevo.

3.1 Project realization

The main Project was realized in the period 2007- 2012 step by step. Condensing boilers, type Vitocrossal 200, CM2, product of Viessmann made of Inox with Matrix radiant burner were installed in all boiler plants. All the essential parameters were monitored on a regular basis and the analysis too.

Some of measurement results are shown in the following table:

Ord. Num.	Boiler Plant	Boiler plant capacity	CO_2		CO		NOx		Boiler efficiency %		Season 2012/2013			
			%		mg/Sm^3		mg/Sm^3				Delivered heat energy	Gas consumption	Energy content of gas	System efficiency
		kW	before	after	before	after	before	after	before	after	MWh	Sm^3	MWh	%
2007. year		**6.820**												
1	A2 Bjelave	735	7,7	8,7	129,0	5,3	239,7	30,5	79,2	98,2	878,2	96.337	911,8	96,3
2	A4-5 M. Dvor	855	7,7	8,6	263,5	5,8	254,0	34,0	79,5	101,0	910,5	96.217	910,7	100,0
3	S40 Hadžići	260	8,1	8,6	46,5	4,3	210,0	27,8	77,6	99,2	250,8	27.047	256,0	98,0
4	BVI/3 Dobrinja II	570	8,0	8,9	59,5	4,3	187,0	35,5	80,8	98,9	602,1	65.293	618,0	97,4
5	BV/3 Dobrinja II	450	7,9	8,5	79,8	5,5	216,0	30,5	78,3	103,0	380,8	39.884	377,5	100,9
6	ABIV/2 Dobrinja II	675	7,9	8,3	150,3	3,5	234,1	29,0	79,8	101,5	460,9	49.299	466,6	98,8
7	ABVI/1 Dobrinja II	450	7,6	8,3	40,0	3,3	201,8	39,0	77,5	98,4	340,1	37.199	352,1	96,6
8	AII/1 Dobrinja II	450	8,4	8,9	21,0	2,5	207,9	30,5	77,2	98,6	488,3	53.025	501,9	97,3
9	BV/8 Dobrinja II	340	7,8	8,5	87,0	2,8	235,6	21,3	77,2	98,5	258,2	28.465	269,4	95,8
10	ABIII/4 Dobrinja II	675	7,9	8,4	69,5	4,5	204,5	21,3	79,5	101,0	485,7	51.225	484,8	100,2
11	BIV/3 Dobrinja II	340	8,0	8,3	82,0	5,5	221,3	28,0	77,6	101,2	234,0	24.698	233,8	100,1
12	ABVI/4 Dobrinja II	450	7,4	8,3	53,8	1,8	208,5	34,5	79,6	101,5	473,0	49.341	467,0	101,3
13	AIII/2 Dobrinja II	570	7,9	8,4	12,0	2,0	180,0	37,8	73,0	99,2	464,2	49.961	472,9	98,2
2008. year		**10.490**												
1	MIII/3 Mojmilo	570	7,7	8,2	166,8	2,1	262,3	28,9	73,0	100,2	587,4	62.374	590,4	99,5
2	AII/1 M.Dvor	570	8,0	8,9	17,7	3,9	288,0	36,0	80,4	98,6	648,5	70.112	663,6	97,7
3	AIII/4 M.Dvor	450	7,9	8,4	156,4	1,8	271,0	29,9	70,2	98,3	524,7	56.668	536,4	97,8
4	JAT	570	7,8	8,6	173,0	2,9	242,6	33,6	74,1	98,5	590,9	64.606	611,5	96,6
5	Trampina	855	7,9	8,4	221,6	2,5	258,5	29,4	80,4	99,8	854,8	90.580	857,3	99,7
6	S1D Breka	450	7,8	8,6	141,2	3,4	228,8	28,0	51,9	98,4	470,2	51.542	487,8	96,4
7	AIII/5 Dobrinja II	570	7,7	8,5	60,4	3,9	197,0	30,4	79,0	98,8	457,5	49.413	467,7	97,8
8	MII/1 Mojmilo	570	7,8	8,4	166,6	1,4	280,2	30,8	79,5	98,8	538,4	58.371	552,5	97,5
9	MIV/5 Mojmilo	570	7,8	8,4	200,3	2,7	262,6	26,8	78,5	96,3	556,0	61.265	579,9	95,9
10	MV/5 Mojmilo	450	7,9	8,5	194,6	1,8	263,4	38,4	79,0	99,2	465,9	49.906	472,4	98,6
11	A-1 Hadžići	570	7,8	8,6	146,7	3,6	252,1	29,3	78,2	98,2	554,9	59.861	566,6	97,9
12	SP-104 Hadžići	855	7,9	8,7	175,5	3,5	111,0	37,1	79,8	98,5	950,5	102.322	968,5	98,1
13	BV/6 Dobrinja II	450	7,9	8,4	79,2	3,2	159,2	28,7	80,0	98,8	393,0	42.495	402,2	97,7
14	AII/3 Dobrinja II	340	8,1	8,7	42,3	1,5	203,7	22,1	76,0	98,7	300,0	32.560	308,2	97,4
15	BV/1 Dobrinja II	340	8,1	8,5	90,5	2,6	202,5	22,5	79,0	99,2	273,5	29.188	276,3	99,0
16	AI/3 Dobrinja II	450	7,9	8,2	103,0	1,9	177,7	26,2	78,5	99,5	390,4	41.982	397,4	98,2
17	AI/6 Dobrinja II	450	8,0	8,9	97,0	2,4	193,2	27,2	75,9	97,8	410,1	45.156	427,4	96,0
18	ABII/2 Dobrinja II	510	8,0	8,5	31,5	2,7	245,2	26,7	68,0	99,5	459,2	49.377	467,4	98,2
19	ABII/4 Dobrinja II	450	7,9	8,4	67,3	2,4	241,0	28,2	93,2	99,0	403,3	43.131	408,2	98,8
20	ABV/3 Dobrinja II	450	7,8	8,4	144,1	2,0	239,0	20,8	81,6	97,3	442,1	48.399	458,1	96,5
2009. year		**8.010**												
1	ABIII/2 Dobrinja II	510	7,9	8,4	328,0	3,3	221,0	28,0	88,5	98,7	417,3	45.180	427,6	97,6
2	CI/2 Dobrinja II	260	7,9	8,3	31,0	1,3	250,0	29,5	89,0	99,2	249,9	26.851	254,1	98,3
3	AI/4 M. Dvor	510	8,0	8,4	39,0	3,8	194,0	29,8	86,3	99,2	493,1	53.088	502,5	98,1
4	O-1 Jukićeva	450	7,9	8,5	103,0	6,3	287,0	38,8	86,8	97,5	345,9	37.594	355,8	97,2
5	O-2 Jukićeva	450	7,0	8,4	93,0	6,8	286,0	33,8	88,2	99,4	380,1	40.850	386,6	98,3
6	HI/1 (H1D) Breka	300	8,1	8,7	68,0	2,3	202,0	33,3	89,1	97,6	250,2	27.661	261,8	95,6
7	SII/1 (S2D) Breka	450	8,0	8,5	180,0	8,3	215,0	29,3	87,5	97,3	416,9	46.052	435,9	95,6
8	BIV/5 Dobrinja II	450	8,1	8,5	76,0	2,8	303,0	33,3	86,0	98,5	386,4	41.733	395,0	97,8
9	BIV/1 Dobrinja II	260	8,0	8,5	278,0	1,3	272,0	29,5	85,9	98,5	129,9	14.057	133,0	97,6
10	ABV/4 Dobrinja II	340	7,9	8,4	65,0	0,8	251,0	19,0	86,4	97,6	324,4	36.099	341,7	94,9
11	MVIII/3 Mojmilo	855	7,8	8,4	99,0	7,5	249,0	30,0	82,7	98,9	870,1	93.578	885,7	98,2

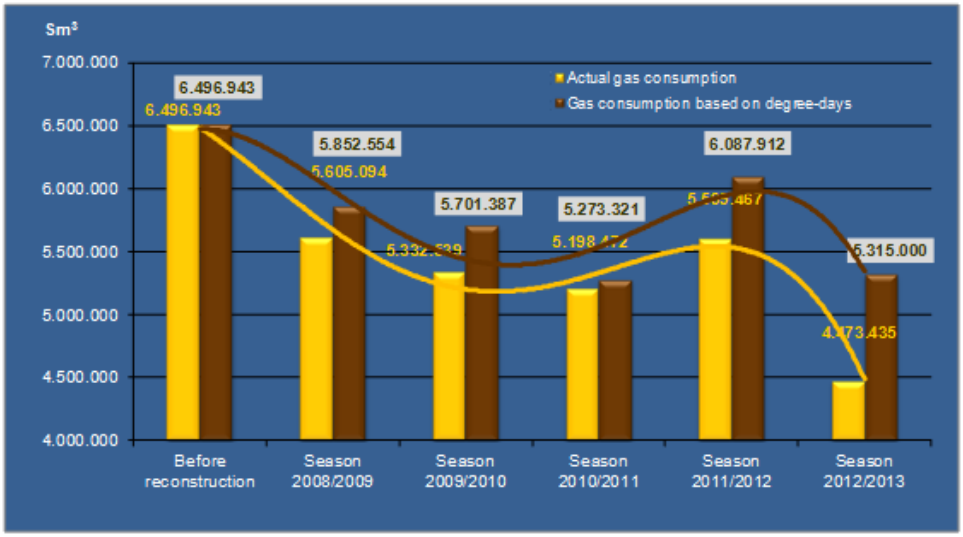
Ord. Num.	Boiler Plant	Boiler plant capacity	CO_2		CO		NOx		Boiler efficiency %		Season 2012/2013			
			%		mg/Sm^3		mg/Sm^3				Delivered heat energy	Gas consumption	Energy content of gas	System efficiency
		kW	before	after	before	after	before	after	before	after	MWh	Sm^3	MWh	%
12	MVII/2 Mojmilo	855	8,0	8,4	64,0	6,8	262,0	33,0	86,4	103,0	1.072,8	110.321	1.044,2	102,7
13	MV/8 Mojmilo	450	7,7	8,3	103,0	3,0	284,0	30,8	84,4	98,5	489,2	52.672	498,5	98,1
14	MV/3 Mojmilo	395	8,0	8,5	126,0	4,8	282,0	29,3	86,6	101,8	402,8	42.137	398,8	101,0
15	S1L Breka	570	8,1	8,6	134,0	9,3	209,0	29,0	88,1	101,0	376,4	39.662	375,4	100,3
16	MVI/2 Mojmilo	395	7,9	8,4	97,0	3,3	281,0	34,5	86,7	97,5	427,6	46.648	441,5	96,8
17	H1-L Breka	510	7,9	8,8	194,0	2,5	252,0	30,5	88,6	97,5	411,5	44.971	425,7	96,7
2010. year		**7.790**												
1	BI/2 Dobrinja II	450	8,0	8,4	58,7	7,0	107,7	34,0	88,0	98,8	404,6	43.579	412,5	98,1
2	BCI/2 Dobrinja II	570	7,9	8,3	85,3	9,0	152,4	32,5	87,0	97,0	488,6	53.679	508,1	96,2
3	AI/8 Dobrinja II	260	7,8	8,2	21,3	6,0	89,9	33,0	86,0	98,3	159,2	17.306	163,8	97,2
4	ABI/3 Dobrinja II	510	8,0	8,7	79,0	9,0	163,5	25,5	88,0	98,0	458,7	49.903	472,3	97,1
5	BII/2 Dobrinja II	450	7,9	8,4	36,9	8,0	99,5	33,2	84,0	99,0	375,8	40.258	381,0	98,6
6	MI/3 Mojmilo	570	8,0	8,5	91,3	14,0	261,0	39,0	89,0	99,5	546,3	58.420	552,9	98,8
7	MIX/2 Mojmilo	510	7,9	8,4	117,4	6,8	180,4	28,0	88,0	98,0	499,0	54.166	512,7	97,3
8	H-1 Hadžići	450	8,0	8,6	62,5	7,8	294,0	31,0	87,0	98,8	455,0	49.285	466,5	97,5
9	H-2 Hadžići	855	8,1	8,5	43,2	12,8	219,9	32,0	87,0	98,0	654,9	71.322	675,1	97,0
10	H-3 Hadžići	570	8,0	8,6	53,1	10,7	201,6	35,0	88,0	99,7	664,6	71.016	672,2	98,9
11	MIV/2 Mojmilo	510	7,9	8,4	90,4	13,0	217,9	35,0	88,0	98,0	442,7	48.517	459,2	96,4
12	O3 Jukićeva	450	8,0	8,5	38,1	6,3	241,0	27,0	89,0	98,8	404,4	43.457	411,3	98,3
13	AIII/I M. Dvor	675	8,0	8,4	10,0	11,0	251,3	29,0	88,0	98,0	555,8	61.094	578,3	96,1
14	H3 Breka	510	7,9	8,7	94,0	10,5	227,5	26,5	87,0	98,0	536,1	58.339	552,2	97,1
15	BII/5 Dobrinja II	450	8,0	8,5	52,4	7,8	161,5	36,0	86,0	99,0	305,8	32.948	311,9	98,1
2011. year		**4.825**												
1	AI/1 Dobrinja	260	8,1	8,6	58,7	0,8	107,7	28,8	88,0	98,5	143,8	15.492	146,6	98,1
2	BIV/7 Dobrinja	260	8,2	8,7	85,3	0,0	152,4	31,5	87,0	98,0	128,3	14.084	133,3	96,2
3	BIV (B4) Breka	855	8,0	8,6	36,9	6,5	99,5	39,0	84,0	99,0	869,0	95.006	899,2	96,6
4	SIII/2 (S3) Breka	675	8,1	8,7	52,4	3,8	161,5	32,8	89,0	99,0	746,8	79.845	755,7	98,8
5	BIII/6 (B3L) Breka	450	8,0	8,5	94,0	4,0	227,5	36,8	88,0	99,0	331,7	36.146	342,1	97,0
6	AI/1 M.Dvor	570	7,9	8,4	90,4	4,5	217,9	28,0	86,0	99,2	613,1	65.778	622,6	98,5
7	SII/7 (S2L) Breka	450	7,8	8,5	38,1	4,3	241,0	33,3	88,0	99,0	448,6	48.202	456,2	98,3
8	HII/2 (H2L) Breka	395	7,9	8,4	10,0	3,5	251,3	34,5	87,0	99,0	291,2	31.251	295,8	98,4
9	BIII/3 Dobrinja	570	8,1	8,6	21,3	3,8	227,5	36,8	86,0	99,4	537,6	57.511	544,3	98,8
10	BI/5 Dobrinja	340	8,0	8,6	79,0	1,3	163,5	56,5	88,0	98,0	255,5	27.592	261,2	97,8
2012. year		**3.790**												
1	MX/2 Mojmilo	675	8,1	8,6	75,0	4,3	138,0	42,8	91,0	98,0	656,2	70.988	671,9	97,7
2	SIV (S4) Breka	735	8,0	8,5	70,0	4,2	180,0	39,2	87,0	98,0	722,2	79.274	750,3	96,2
3	SV (S5) Breka	450	7,9	8,5	60,0	3,8	150,0	47,0	89,0	100,2	494,8	52.784	499,6	99,0
4	BIII/2 (B3D) Breka	450	7,8	8,5	70,0	5,0	185,0	42,8	86,0	98,0	415,3	45.623	431,8	96,2
5	A2-IV M.Dvor	570	7,9	8,4	50,0	7,0	230,0	44,0	88,0	99,0	544,7	59.320	561,5	97,0
6	CII/2 Dobrinja	340	8,0	8,6	108,0	5,5	300,0	43,3	91,0	98,0	303,6	33.018	312,5	97,1
7	CIII/5 Dobrinja	570	8,1	8,6	100,0	8,5	298,0	44,8	89,0	98,8	430,8	46.498	440,1	97,9

Table No. 6: Measurement results

3.2 Project effects

Exploitation experiences during the period of realization of Main Project are outstanding. Pollution metering results, efficiency coefficients, gas consumption savings, etc. follows all the basic trends achieved through the completion of Pilot project:

- **Pollution content** % NOx and CO in flue gases are much lower than in old facilities and significantly lower than limited values defined by law (NOx: from ca 240 mg/Sm^3 to ca 30 mg/Sm^3, CO: from ca 120 mg/Sm^3 to ca 6 mg/Sm^3).
- **Greenhouse gas emission reduction and other emission reduction**: The amount of flue gases emitted to the atmosphere (with regards to the significantly lower gas consumption) is significantly lower:
  - Emission of NOx is reduced ca 9 times (from 15.665 t/year before reconstruction to 1.700 t/year after reconstruction)
  - Emission of CO is reduced ca 50 times (from 8.645 t/year before reconstruction to 180 t/year after reconstruction)
  - Emission of CO_2 is reduced ca 14 % (from 10.756 t/year before reconstruction to 9.251 t/year after reconstruction).
- **System energy efficiency** coefficient has very high values, and it ranges from 95 to 101 %.
- **Total gas consumption savings** in all rooftop boiler plants due to use of condensing boilers were on the level of ca 20 % (ca 1,4 million Sm^3 of natural gas).



CONCLUSION:

This Project is one of the most important projects in area of environmental protection and increase of energy efficiency in Canton Sarajevo. Modernization of roof top boiler plants and installation of condensing boilers is remarquably useful, self-sustainable and very profitable project.

The quoted gas consumption savings made it possible to pay back expenses in a period of **5** to **6** years.