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[1.]Srđan VASKOVIĆ, [2.]Petar GVERO,
[3.]Vlado MEDAKOVIĆ, [4.]Velid HALILOVIĆ

FEASIBILITY STUDY FOR REPLACEMENT HEATING SYSTEM ON NATURAL GAS WITH PELLET BOILERS AT PRIMARY SCHOOL "ST. SAVA" IN EAST SARAJEVO

[1,3.] University of East Sarajevo, Faculty of Mechanical Engineering East Sarajevo, BOSNIA & HERZEGOVINA
[2.] University of Banja Luka, Faculty of Mechanical Engineering Banja Luka, BOSNIA & HERZEGOVINA
[4.] University of Sarajevo, Faculty of Forestry Sarajevo, BOSNIA & HERZEGOVINA

ABSTRACT: This study describes the possibility of installation of pellet boilers for the production of thermal energy for heating in the primary school "Sveti Sava" in Lukavica. Existing heating system with natural gas turned out to be very expensive with high costs in terms of consumption of natural gas on annual level but also due to the high price of natural gas. Alternative possibility of heating premises within the school is seen in the installation of boilers that use wood pellets as an energy source. Above all, wood pellet represents an environmentally clean fuel in terms of CO_2 emissions, but also because of the availability of resource from nearby factories that produce pellets, it can be used as a domestic fuel. In this way, the story of sustainable community development is encouraged, as well as the flow of capital within the community is closed.
Keywords: Pellet, investment, economy, ecology, benefit, heat boiler

1. INTRODUCTION

Primary school "St. Sava" currently has two gas boilers with the power of Q_1=260kW and Q_2=100kW. The boiler with more power is used for heating the area intended for classrooms, offices, toilets, while the boiler with less power is used for heating the gym. The approximate surface area of the school that is heated is A_1=2682.2 m^2 and the area of the gym is A_2=420 m^2. Thus, the total approximate area that is heated is about A=3100m^2. The purpose of this study is to show that the alternative installation of wood pellet boilers and production of heating energy in this way will provide significant savings in comparison to heating system with natural gas. Figure 1 shows: (a) Primary school „St. Sava" Picture and (b) Gym.

a) b)

Figure 1. (a) Primary school „St. Sava"Picture and (b) Gym

2. BUSINESS IDEA

2.1. General

In the primary school "Sveti Sava" it is planned for gas boilers to be replaced with new pellet boilers. The plan is to provide a boiler with capacity of 300kW for the main school building, which is related to classrooms and office space area of 2682.2 m^2, due to the tendency to expand the space. For the building that refers to the gym with a surface of 420m^2 (because of the height

of the hall of more than 10m) it is necessary to provide a boiler with capacity of 100kW. Expectations related to the replacement of fossil fuels (natural gas) with bio-fuels (pellets), refer to the reduction of dependence on fossil fuels from suppliers, reduction in the fuel costs, as well as reducing of noxious emissions of carbon dioxide CO_2. All of these benefits associated together, give this school a positive image of raising awareness to the human environment. Particular emphasis is on the fact that the school is concerned as educational institution which would provide an example to students and everyone else about the possibility of using renewable energy sources and protection of the environment by using of clean ecological fuel.

2.2. Fuel

With the help of lignin contained in the wood, by increasing of pressure and temperature during the pressing process, it is excreted in the outer layers and thus leads to formation of wood bark that protects the briquette and pellet from mechanical damage and moisture. The diameter of pellet is usually about 8 mm, and its length is about 10-30mm. The moisture content in wood pellet is very low, about 7-10%. The rest of the ash after combustion of pellet is very low, about 0.5%. The density of pellet is about 650-700 kg/m^3. The calorific value of pellet is from 4.7 to 5 kWh/kg (16.9 to 18MJ/kg). A high quality pellet with no admixtures of bark usually has a calorific value of 5kWh. The energy content of the bulk cubic meter of pellet is about 3000-3300kWh/m^3. One tone of pellets takes up about 1,5m^3 of the storage [1].

2.3. Customers

The primary school "St. Sava" is the ultimate beneficiary of heat produced with the help of the new built-in pellet boiler. This business plan helps the school management to look into the benefits and investment feasibility of this project of alternative installation of pellet boilers.

2.4. Benefit for school and environment

Existing boilers that operate using natural gas have a total installed capacity of approximately 360kW.

Boiler No. 1 with capacity of Q_n =260kW has gas consumption at maximum load of:

$$q_1 = 3600 \cdot \frac{Q_n}{\eta_k \cdot H_d} = 29,8 \frac{m^3}{h} \quad (1)$$

The actual consumption of gas due to the correction of the heating value is:

$$q_{1s} = 31,4 \frac{m^3}{h} \quad (2)$$

Boiler No. 2 with capacity of Q_n =100kW has gas consumption at maximum load of:

$$q_2 = 3600 \cdot \frac{Q_n}{\eta_k \cdot H_d} = 12,5 \frac{m^3}{h} \quad (3)$$

The actual consumption of Boiler No.2 due to the correction of the flow is:

$$q_{2s} = 13,2 \frac{m^3}{h} \quad (4)$$

where they are the following: η_k =0,88 the efficiency of gas boiler, H_d =35696kJ/m^3 lower heating value of natural gas, design value[2].

However, natural gas boilers fired with total power of P=360kW during the heating season have different levels of load and never operate at full load (during the stationary operation mode and during the entire heating season). The following table gives an overview of the monthly bills for gas during the last three years.

Table 1. Costs for gas consumed during the past three years, for heating of the school "St. Sava"[3]

Year 2011		Year 2012		Year 2013	
January	3.937,59 BAM	January	5.474,42 BAM	January	5.225,21 BAM
February	5.083,80 BAM	February	6.139,22 BAM	February	4.355,97 BAM
March	3.140,31 BAM	March	3.524,04 BAM	March	3.793,06 BAM
April	0,00 BAM	April	2.178,44 BAM	April	1.299,85 BAM
October	2.271,59 BAM	October	1.993,58 BAM	October	2.000,00 BAM
November	5.193,66 BAM	November	2.958,95 BAM	November	3.000,00 BAM
December	5.364,25 BAM	December	5.855,69 BAM	December	5.365,25 BAM
Total:	24.991,2 BAM	Total:	28.124,3 BAM	Total:	25.039,3 BAM
Average costs of gas during the last three heating seasons		26.052 BAM			

From the table 1 it is clear to notice that during the past three years the highest "peak" of bills for consumed gas occurred in February, in 2012. At the same time from this table it can be concluded that the biggest bills of gas are consumed in three critical winter months (December, January and February). The smallest bills for the consumed gas appeared in April. These seven months which were observed and given during the heating season, are relevant to the overall budget of consumed gas. The primary school "St. Sava" works in two shifts, so the daily work of boilers includes a minimum of 12 hours. For calculation of the average level of the load on the gas boiler, during the heating season, it can be taken the average bill for gas of 26052 BAM. The average monthly bill for gas during the period of 7 months is:

$$\frac{26052}{7} = 3722 BAM \tag{5}$$

The average consumption of gas (in marks) by an hour of work of boilers is:

$$\frac{3722}{23 \cdot 12} = 13{,}5 \frac{BAM}{h} \tag{6}$$

The average gas consumption is approximately:

$$\frac{13{,}5 \frac{BAM}{h}}{1 \frac{BAM}{m^3}} = 13{,}5 \frac{m^3}{h} \tag{7}$$

The average load of gas boilers during the heating season is:

$$Q_s = \frac{q_s \cdot \eta_k \cdot H_d}{3600} = \frac{13{,}5 \cdot 0{,}88 \cdot 35696}{3600} = 118 kW. \tag{8}$$

On the basis of calculating the average load of gas boilers, we are going to calculate the consumption of pellet during the aforementioned heating season. The average load of gas boilers is 120/360=0.3. We will start the calculation under the assumption of medium load of pellet boilers of 0.3 on the basis of loads of old boilers. Thus, the average load of the pellet boilers is 400 x 0.3 = 120 kW (it represents the summarized average load of both of the boilers) during the mentioned period of the production of thermal energy.

$$q_p = 3600 \cdot \frac{Q_s}{\eta_k \cdot H_{dp}} = 3600 \cdot \frac{120}{0{,}95 \cdot 17500 \frac{kJ}{kg}} = 26 \frac{kg}{h} \tag{9}$$

and where is H_{dp} -lower heating pellet's value If we consider the heating season of 7 months, 23 working days and 12 hours of work per day, we get the total consumption of pellet:

$$L_p = 7 \cdot 23 \cdot 12 \cdot 26 = 50232 \frac{kg}{godini} = 51 \frac{ton}{godini}. \tag{10}$$

If we know that the price of pellet is 250 BAM per one tone, and then we have that the cost price of pellet for the whole season is:

$$C_p = L_P \cdot 250 \frac{BAM}{ton} = 12750 BAM. \tag{11}$$

Table 2. Ratios of carbon dioxide emissions of different fuels[5]

Fuel	Emission in kg CO_2/GJ
Biomass	109,6
peat	106
Stone coal	101,2
Dark coal	97,09
Lignite	96,43
Diesel	77,4
Crude oil	74,1
kerosene	73,3
gasoline	71,5
Liquefied petroleum gas	63,1
natural gas	56,1

If you compare it with the bill for gas of 26.052 BAM, significant savings are evident, which are: U_1=13.302 BAM at the annual level. As for the reduction of emissions in terms of carbon dioxide CO_2 The emission of CO_2 is considered to be zero during the combustion of wood pellet. This all is applicable for sustainable forest management. The amount of carbon dioxide that is emitted during the combustion of pellets is approximately equal to the same amount of CO_2 incorporated into the structure of wood biomass during the process of photosynthesis. Total median value of the

gas consumed during the heating season is V=26.052 m^3 (of standard cubic meters at temperature of 15^0 C and pressure of 1.01 bar). The bottom heating value of Russian natural gas is 34 MJ/m^3, correction value of thermal power [4].

The following table illustrates the carbon dioxide emissions for certain fuels. The emission of CO_2 for natural gas per GJ of energy from the caloric power of gas is e_1 = 56.1 $kgCO_2/GJ$.

The quantity of carbon dioxide emitted expressed in kg during the heating season when natural gas is used as the energy source in the previously mentioned school is: CO_2 = 49,69 tons. It is evident that there is the reduction of harmful CO_2 emission into the atmosphere when using wood pellets as fuel.

There are three pellet plants at the radius of 30 km. In order to ensure the security of supply it is possible to enter into the contract on an annual basis with the manufacturers.

Two pellet boilers total power of 300 + 100 kW along with the calculated small silos for the storage of wood pellets for seven days. It practically means that it is necessary to store approximately 26 x 12 x 7 = 2.184 tons of pellet and regarding the fact that the tone of pellets takes about 1.5 m^3 it would mean that both boilers would need silos for seven days period of 2.184 x 1.5 = 3276 m^3 approximately 3.3 m^3. The first silo of 2.2 m^3 will be provided for the bigger boiler and the second one of 1.1m^3 for the smaller. The volume of a silo may vary depending on the manufacturer of the equipment and its technical solutions. For storage of the total fuel (pellets) required for heating during one heating season, it is necessary to provide 0.026 x 12 x 23 x 7 x 1.5 = 75 m^3 or approximately the volume space of 6 x 6.5 x 2 = 78 m^2.

3. THE SITUATION ON THE MARKET WITH PELLETS AND OTHER ENERGY SOURCES

The market of pellets and bioenergy sources are still at the phase of development. There are no significant consumers of these sources of energy near above-mentioned school. The pellet plant Eu-pal d.o.o., is at a distance of approximately 30 km.

The construction of gas pipeline "South Stream" will not significantly affect the reduction of gas prices primarily because its customers will be the ultimate beneficiaries of this system. On the other hand, reserves of fossil fuels are very limited and a significant increase in prices of fossil fuel are to be expected in the future time.

4. FINANCIAL INDICATORS OF INVESTMENT

The following table 3 of calculations indicates the justification of investing in the replacement of pellet boilers in the above mentioned facility.

The investment expenses, table 4, refer to the costs of boilers and installation of system as well as the construction of the pellet storage. Data and boiler prices are taken over from the official web site of the manufacturer [6].

Table 3. The justification of investing in the replacement of pellet boilers in the above mentioned facility

EXPENSES	BAM
Expenses in fuel (old system)	26.052.00
Expenses of pellet purchasing on the annual basis (in the summer period)	12.750.00
Expenses of transport, operating and maintenance expenses	3.000.00
Total cost of pellet heating system	15.750.00
Annual savings in regard to previous system which uses natural gas	10.302.00

Table 4. The investment expenses [6]

INVESTMENT EXPENSES	In BAM taxes included
Boiler No.1 of power 300 kW with outlet fan	23.166,00
Boiler No.2 of power 100 kW with outlet fan	11.848,59
Additional equipment for both boilers: 1. Wireless thermostat – programmer (with 7 days schedule) 2. Telephone and modem (boiler on and off by telephone, landline connection needed) 3. Boiler managing by GSM control 4. Ash outlet container with engine 5. Big boiler silo of 100 KW and more	2x(210+220+400+170+1.500) = 5.000.00 BAM
Pellet storage construction, installation, preparation of a study and other costs	15.000 BAM
Lectures on Green package and promo material for workshops held by experts and teachers	3.000 BAM
TOTAL VALUE OF INVESTMENT	about 58.000.00 BAM
INVESTMENT RETURN FOR ITS OWN FUNDING	58.000/10.302 = 5.6 year
In case of donation, the boiler would bring the estimated annual savings of 10302 BAM in the first year of exploitation.	
The working life of boiler is up to 15 to 20 years.	

5. CONCLUSION

This example could also be a good promoter of using wooden biomass as a renewable energy source, but at the same time, it represents a unique educational example to raise awareness on environmental protection. On financial side, we have in this example with relatively short payback period of investment. Therefore, the best way is to start with the promotion of renewable energy sources from pupils in primary schools and enable them to raise awareness and personal knowledge of this form of pure energy on the example of their own school.

Limited knowledge about the pellet as energy source could be a disadvantage in the process of pellet supply.

It is necessary to find a secure supplier who would provide pellet of high quality without bark and high heating capacity as defined by the calculations.

Due to the small capacity of pellet boilers and small demand during heating season, the school could not possibly be the significant system which would cause any great demand for this fuel.

However, in the near future we should expect greater demand for pellet as a fuel. We must also keep in mind that the cost of fossil fuel is very variable and its growth is to be expected.

On the other hand, the existing gas boilers will remain operative and thus ensure that the school has the possibility of alternative gas heating. This is certainly an additional safety factor for the existing facility in case of any significant turbulence in the prices and supply of pellets.

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