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ENERGY EFFICIENCY IN MECHANICAL ENGINEERING FACULTY BUILDING SARAJEVO

Nijaz Delalic
Faculty of Mechanical Engineering, Sarajevo
Vilsonovo setaliste 9, BA-71000 Sarajevo

Fahrudin Kulić
USAID-3E
Gajev trg 2/II, BA-71000 Sarajevo

Ejub Džaferovic
Faculty of Mechanical Engineering, Sarajevo
Vilsonovo setaliste 9, BA-71000 Sarajevo

ABSTRACT
A large number of schools in B&H is similar to the method of construction, building form, size and type of window, and type of material of which were built. Specific energy consumption of these buildings were in range of 150 to 250 kWh/m2/year. Due to the large specific energy needs of these facilities have high costs of energy supply. In this paper, the results have an energy audit and verification of the measures for the Mechanical Engineering Faculty building Sarajevo. Calculated the actual energy needs and proposed measures to increase of energy efficiency. Each of the measures of energy efficiency has been evaluate. There are three main goals of the project:

1. *To reduce heat loss through the building envelope*
2. *To increase the efficiency of energy transformation of natural gas in the boiler house*
3. *To conduct monitoring of parameters necessary to establish an efficient and effective energy management*

Keywords: energy efficiency, school building, monitoring ,

1. INTRODUCTION
The MEF owns 2 buildings, one built in 1960 and the other in the late 1980s. This pilot project represents continuation of past activities in the area of energy efficiency at the MEF. There are three main goals of the project:

1. To reduce heat loss through the building envelope
2. To increase the efficiency of energy transformation of natural gas in the boiler house
3. To conduct monitoring of parameters necessary to establish an efficient and effective energy management

Technical Analysis and Conceptual Engineering Design performed by USAID 3E show that the heating systems for the west and east building should be separated and a new boiler for the west building installed. The systems will be connected manually when needed, as in the case of gas supply disruption or if the east building needs exceed the capabilities of two remaining boilers. It was also shown that significant energy savings can be achieved by replacing the windows, since they are 50 years old, poorly maintained and in bad condition and by thermally insulating the façade. The project also included a system for Monitoring energy consumption and Verification of energy savings (M&V system), which will serve for introducing energy management. This system in conjunction with UNDP developed EMIS.

The project devised in such a way has been supported by UNDP (Bosnia and Herzegovina). UNDP has financed insulation of the building envelope and replacement of windows and USAID 3E has

financed the replacement of the boiler and accompanying equipment in the boiler house and installation of the M&V system. The project started in fall 2010 with the installation of the M&V system and it was completed in December 2011.

2. BUILDING DESCRIPTION

Basic parameters of the Building are given in Table 1.

Table 1. Basic parameters of the Mechanical engineering faculty building

Type of building:	School (University)
Year of construction:	1960
Number of occupants:	
Permanent	350
Temporary	500
Occupancy schedule:	8 am - 4 pm (Monday to Friday) 8 am - 12 pm (Saturday) Closed - Sunday
Net floor area (basement and 6 floors)	5819 m^2
Net heating area	4119

3. ENERGY AND WATER CONSUMPTION

Natural gas, electricity and water consumptions were 515.345 kWh, 153.327 kWh and 2352 m^3 in 2011, respectively. The costs for these consumptions are presented in the figure 1. The average outside temperature in Sarajevo is presented too.

Specific energy consumption is as follows (in year 2011):

Natural gas: 125,1 kWh/m^2 (control measurements showed that heating was insufficient)

Electricity: 26,3 kWh/m^2

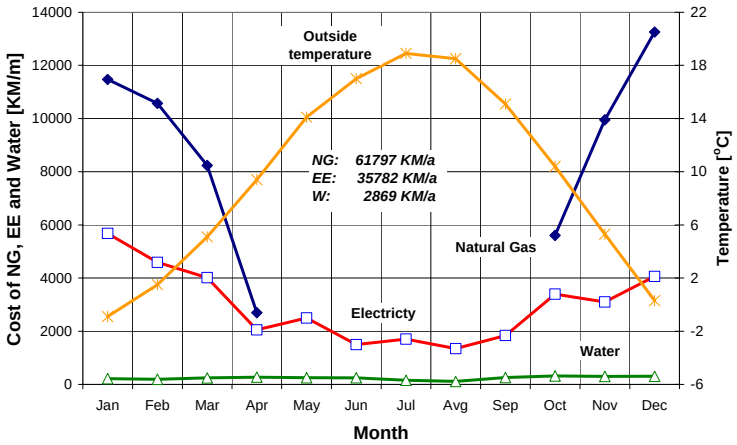

Figure 1. Base line of Monthly Energy and Water Costs

4. PROJECTS PROPOSED AND IMPLEMENTED

The following Energy Conservation Opportunities (ECOs) are recognized in the case of Mechanical Engineering Faculty:

4.1 EEM#1: Energy Management

Expected Annual Energy Savings 6.310 KM, Investment 27.730 KM and Simple Payback Period 4.4 Years

EEM#1-1: Installation of basic measurement system and development and introduction of energy management procedures

Installation of basic equipment for measuring energy indicators (consumption of natural gas, thermal energy and temperatures). Usual procedure for monitoring & verification implies the establishment of

energy balance for the building and determination of its efficiency, as well as the efficiency of energy transformations. For that purpose, the system of measurement and remote reading has been installed. These measurements mark the beginnings for the introduction of energy management at the MEF.
EEM#1-2: Installation of radiator thermostatic valves
Since the load is frequently changed in rooms because of a different number of occupants in the room, thermostatic valves will accomplish necessary regulation of temperature in the room. Otherwise, flow and return temperature of water is controlled automatically in the boiler house according to the outside temperature.

4.2 EEM#2: Building Envelope Retrofit, figure 2. and 3.
Expected Annual Energy Savings 309.206 kWh, Expected Annual Energy Savings 37.105 KM, Investment 410.000 KM, and Simple Payback Period 11 Years.
EEM#2-1: Replacement of windows
The replacement of windows is done immediately before the placement of insulation. Windows are removed from the outside. Treatment of the surface for the insertion of windows is done from the scaffold. Windows are made in the factory. New windows are installed form the scaffold.
EEM#2-2: Building envelope insulation
The price includes the construction of the scaffold, preparation of wall surfaces for the placement of insulation, placement of insulation, protective layer and painting of the façade, dismantling of the scaffold and removal from the site.

Figure 2. View on the west MEF building before

Figure 3.View on the west MEF building after

4.3 EEM#3: Partial Reconstruction of Boiler House (20% efficiency improvements) figure 4. and 5.
Expected Annual Energy Savings 103.069 kWh, Expected Annual Energy Savings 12.368 KM, Investment 96.220 KM, and Simple Payback Period 7,8 Years.
The boiler no 3 was dismantled and condensing boiler was installed. After dismantling, the wide area around the boiler was arranged. Preparations were made for mounting the new boiler, the connection to natural gas and electricity was then prepared. Instead of the existing chimney, the new chimney was placed and connected with the boiler. Underground flow-return pipeline was constructed of pre-insulated pipes and connected to the existing distribution pipes in the west MEF building. This pipeline was connected directly to the boiler. Circulating pump, three-way valve and expansion vessel were installed in the boiler house.

Figure 4.View on the old boiler

Figure 5.View on the new condensing boiler

6. MONITORING & VERIFICATION

The remote system, as shown in Figure 6., for monitoring energy consumption and fuels at the Mechanical Engineering Faculty in Sarajevo consists of measuring circuits for:

1. Total natural gas consumption
2. Water consumption (three independent water meters)
3. Inside air temperature (eight measuring points)
4. Outside air temperature (one measuring point)
5. Electrical energy consumption (six measuring pints)
6. Heat energy consumption (for radiator system of the west building , for radiator system of the east building and for air heating of the east building)

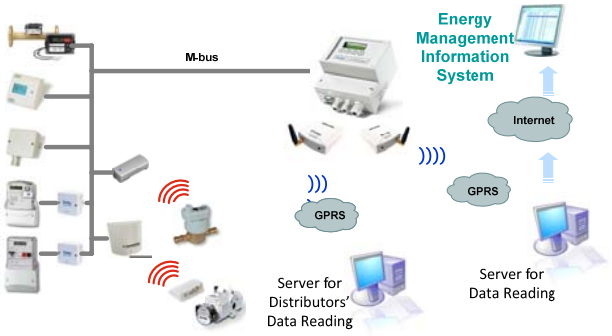

Figure 6. M&V System at the MEF in Sarajevo

6. CONCLUSIONS

Building and heating system performance improvements and first results are:

- Insulation of the building envelope and replacement of windows was finished at the beginning of December 2011.
- New condensing boiler was put in operation in December 2011.
- M&V system is in operation whole year 2011
- Installation of new boiler, insulation of the building envelope and replacement of windows has reduced heating energy consumption by some 40%. Natural gas consumption for period from Dec 13, 2011 to Jan 12, 2012 is presented in the figure 7. Electricity consumption is presented in figure 8. Expected energy (natural gas –NG) savings for season is 206.138 kWh
- Environmental impact: Expected reduction of CO_2 emission for season is $\Delta CO_2(NG)=0.19\times206.138=39.166$ kgCO_2/a

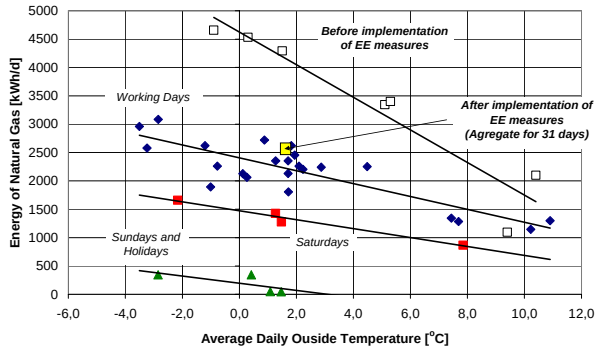

Figure 7. Natural gas consumption

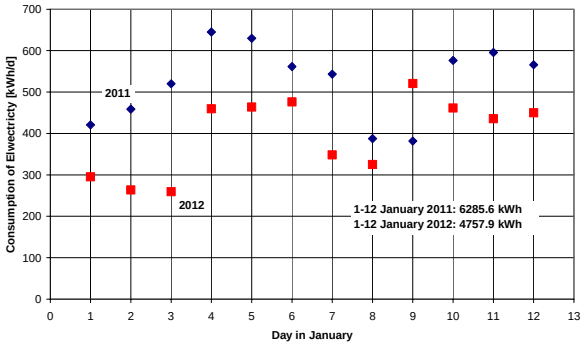

Figure 8. Electricity consumption

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