ENERGY EFFICIENCY IN PUBLIC AND RESIDENTIAL SECTORS

-Projects Development and Implementation-

Sarajevo

Spring 2014

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PREFACE

The Enterprise Energy Efficiency (3E) Project began in May 2010. The Project was financed by the United States Agency for International Development (USAID). The anticipated duration of the Project was three years. This document is the summary of results achieved during the course of work on the Project; it is intended as a guideline for those who would like to engage in the field of energy efficiency in Bosnia and Herzegovina (B&H).

The USAID Enterprise Energy Efficiency (3E) program was primarily focused on the energy efficiency of buildings, the centerpiece of which was the development of a number of pilot projects (PPs), accompanied by other activities involving capacity building and raising public awareness among end users.

At the very beginning, the project was primarily oriented towards public buildings, but in cooperation with partners, the activities were extended to residential buildings and public street lighting.

Technical solutions that have been demonstrated within this project are commercial and well-adapted to end users. 3E hasattempted to avoid offering highly advanced technical solutions that would be expensive,and, more importantly, difficult to understand and replicate in some environments. The uniqueness of this project is that it has brought together several donors and increased the value of the project; it has successfully motivated local governments; and, by means of a versatile and extensive campaign, it has contributed to the promotion of energy efficiency in B&H. It should be particularly noted that 3Eis one of the rare projects in the region that has managed pilot projects from their inception to implementation: this means that 3E was able to install and implement a Monitoring and Verification (M&V) procedurein the majority of pilot projects. Thispractice of including M&Vin projects introduced a special tool that leads to the continuous and sustainable improvement of energy efficiency.

This document will explain the approach in the development and implementation of energy efficiency pilot projects in BiHand energy management.

We believe that the practical examples presented will be used for better understanding of this multidisciplinary field and in particular, of the current opportunities to apply energy efficiency measures to reduce energy consumption.

We hope that this document will also reach the national and regional energy policymakers, and that the practical solutions offered demonstrate practical solutions that can be the basis of governmental policies.

Sarajevo,
May 2014

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1. DESCRIPTION OF ENERGY EFFICIENCY PROJECTS

At first glance, the concepts of energy efficiency are easy to understand; however, their implementation in practice has proved to be a very demanding. The complexity of the problem arises from the need to connect people, procedures and technology in order to achieve a consistent and lasting upgrade of energy efficiency and provide visible effects on the improvement of the environment. Such an approach has been used in the implementation of this project.

The universal time and spatial process of the implementation of energy efficiency projects is shown in Figure 1. Four sequential phases and their individual activities are shown: the scope of each activity depends not only on the complexity of proposed and analyzed energy efficiency measures, but also on available data.

In the first phase of 'Project selection', a list of project candidates can be made in several ways (public announcement, direct contact of private or public companies with known activities [e.g, schools, hospitals], clients of banks that intend to provide a service package in the energy efficiency area). In this stage, it is necessary to perform project screening, collect data and make site visits. Sometimes it is not necessary to visit the site, if available documentation about possible projects has been well-prepared. This is typical engineering work that requires significant experience.

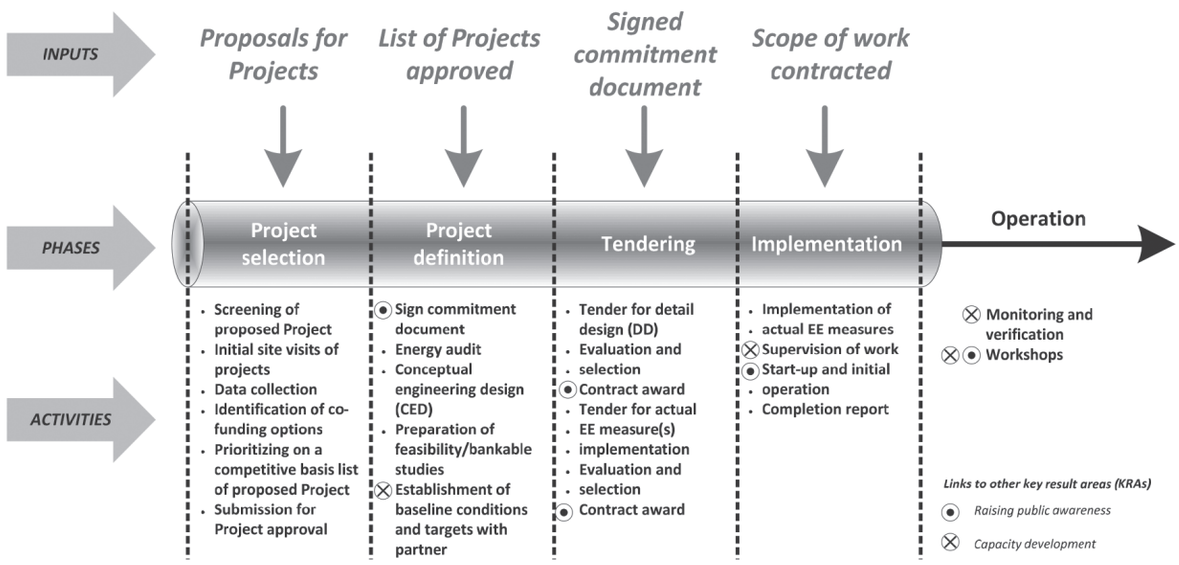

Figure 1: Project Development Pipeline

After a very rough estimate of potential energy savings and investments, it is necessary to identify funding options. If there are several potential projects within the same facility, sub-projects should be placed in a logical order, so that the effects of one sub-project do not interfere with other ones. For example, if it is anticipated that windows will be replaced andinsulation installed on a building and a boiler will be replaced at the same time, then there are no doubts that windows should be replaced and insulation installed before the boiler replacement, because the new boiler will certainly be of lower capacity than the old one.

The first phase should be completed with a report submitted for approval to the responsible party.

After projects have been selected, the second phase of Project Definition follows (Fig. 1). This phase starts with signing a commitment document in which stakeholders take over part of the obligations related to project implementation. The scope of works in this phase depends, of course, on the complexity and the value of the project, but also on available data collected in the previous phase. The basic steps of this phase are (Figure 1):

- Energy audit;
- Conceptual engineering design (CED);
- Feasibility/bankable study;
- Establishment of baseline conditions and targets.

The concept and contents of the energy audit are given in Attachment 1. The final part of the energy audit is the Conceptual Engineering Design[1] (CED). On the basis of the conducted energy audit and delivered CED, it is logical to prepare a feasibility study, or an analysis and evaluation of a proposed project, to determine if it (1) is technically feasible, (2) is viable within the estimated cost, and (3) will be profitable. Feasibility studies are almost always conducted where large sums are at stake. A project or proposal that has sufficient collateral, adequate future cash flow and a high probability of success that is acceptable to institutional lenders for financing is called bankable.

At the end of this phase of project implementation, conditions are created for the establishment of baseline energy consumption and targets for energy efficiency improvement.

This phase, as well as other phases of the energy efficiency project,forms an integral part of capacity development. As people's, institutional, and a society's capacities change over time, the results achieved at the end of this phase of the project should be used for capacity development. Capacity development is a process of change and hence, it is about managing transformations.

Since the EE market in B&H has been and still is immature, full attention is devoted particularly to these capacity building segmentof project implementation.

In the third phase of Tendering, the project is entering into the technical stage when its concept has to be completely defined. Again, depending on the project's scope and complexity, this stage can be divided into several parts, but for all of them it is typical that they contain the process of tendering, the aim of which is procurement, or a process of buying goods, works or services. Procurement is often carried out by the process of tendering rather than buying products directly from a seller.

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[1] *The conceptual engineering design aims to identify the machinery, equipment, supplies and facilities necessary to implement a project.A conceptual engineering study should logically consider the issues, concerns and goals that may be raised by an engineering request. It evaluates possible technical solutions and clearly reports findings and recommendations. It is intended to provide a comparative basis for decision-making regarding further actions without expenditure of exhaustive engineering efforts. Further preliminary engineering (e.g., equipment layouts, geological studies, testing and inspections) may then be suggested for the recommended conceptual solution prior to full project funding commitment and detailed engineering design.*

In this phase, the design has a very important role, requiringa very distinct critical attitude and active communication among team members. The team consists of a group of individuals, who are responsible not only for certain elements of the project, but also for the final outcome of the design. The whole team is required to have broad knowledge of the problem and extensive practical experience, as well as a variety of good and modern information. In addition to basic technical requirements that the project should fulfill and are related to the efficiency and effectiveness of the system,design preparation should also take care of the following aspects:

a. **Environment protection.** At the end of the design process, it is compulsory to make an environmental impact analysis for the operation of the designedbuilding energy systemsand to compare obtained results with legal regulations. Modern equipmentisenergy efficient and emits low levels of pollutants; however, it is more expensive and increasesthe total investment.

b. **Safety and reliability.** Personal safety comes first. Even at an early stage of design, it is important to set safety conditions, as they may help designers to opt for some alternatives. For this purpose, a good knowledge of legislation is necessary. In addition to personal safety, it is also important to satisfy the requirements of materials, safety equipment and especially of the environment. The design team is required to predict events in the operation of the building energy systems that can lead to failures or damages. The analysis of potential failures of critical elements of building energy systems can be simulated on computers and design solutions can be improved, or rigorous monitoring of the equipment can be prescribed in order to reduce the risk of failures or damages. Reliability is closely related to the availability and viability of the building energy systems. Reliability is the probability that the system will successfully perform its function under given conditions throughout its whole lifecycle. Since there are no absolutely reliable systems, it is necessary to seek systems that can be easily maintained during a minimum period of time and with minimum costs. Thus, reliability, availability and sustainability are very important components of the design, and they will also contribute to an increase in design costs. However, this is usually a worthwhile investment.

c. **Building energy systems,performance and associated costs.** Equipment installed in the majority of energy projects is based on commercial technologies, meaning that after performing often complex calculations, the selection of equipment follows. Designers most often obtain price information from equipment manufacturers or vendors:if designers have conducted good technical calculations based on reliable starting assumptions and if the manufacturers' data on performance and prices for their equipment are also reliable, thenthe cost estimate and actual costs for the installationof the equipmentand commissioning will vary roughly ± 5%.

The fourth project phase is implementation. It can be said that this is a completely engineering task, requiring not only good technical knowledge but also familiarity with regulations. The final report of this phase results in obtaining aoperationpermit for the installed equipment (e.g. boiler house).

In the implementation phase, engineers have the important role of ensuring that the interests of the investor are met and that the contractor is duly paid. The investor wants the best value for the money, and the contractor wants to secure a good profit.Although this dichotomy can involve an enormous range of complex and contentious issues, satisfying various interests often comes down to ensuring that the following "triangle of objectives" are met:

- **Cost:** Has the work been completed within the costs agreed in the contract?
- **Quality:** Has the work been carried out in accordance with what was specified?
- **Time:** Has the work been completed satisfactorily within the specified time?

After this phase, the project enters into the operational phase. Basically, energy efficiency projects offer an increase of the degree of efficiency of some energy transformation. This is achieved by changing the managing procedure in a building, by replacing parts or the whole of a technology, etc. No matter what the issue is and what kind of changes are going to be made, it is necessary to provide continuous monitoring of energy flows.

Measurement and Verification (M&V) is the procedure of performing continuous measurements of energy parameters for the purpose of evaluating effects achieved by applying measures for the increase of energy efficiency in an entire buildingor a part of it. Measures to increase energy efficiency are applied in order to achieve a reduction of energy and/or water consumption in a building and to reduce the cost of business operations and reduce environmental pollution.

Effects achieved are determined by comparing measured values of energy consumption before and after the application of one or more measures aimed at increasing energy efficiency. The activities under the M&V procedures are:

- Installation, calibration and maintenance of measuring devices;
- Data collection, processing and analyses;
- Development of calculation methods;
- Calculations with measured data, and
- Reporting to all relevant stakeholders and verification of reports by a third party, if necessary.

Measurements conducted within M&V should be distinguished from measurements related to conducting the process or measurements that are periodically performed during preliminary and detailed energy audits. After several years following the project commissioning and the implementation of the M&V, it is possible to determine a new baseline for energy management.

The project development pipeline presented here has been applied in all projects implemented under the USAID Project: Enterprise Energy Efficiency (3E).

Case studies for 15 of the 17 3E implemented projects are presented in this paper, which focuses on the energy efficient renovation of existing buildings. (The two projects not included in thispaper involved the construction of new buildings.)Each of these projects has its specificities and required special analyses and approaches.

2. CASE STUDIES

2.1 Mechanical Engineering Faculty, Sarajevo (Building Envelope and Heating System Reconstruction)

1. Introduction

The MEF owns two buildings, one built in 1960 and the other in the late 1980s.

This pilot project represents the continuation of past activities in the field 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 the parameters necessary to establish efficient and effective energy management.

Technical Analysis and Conceptual Engineering Design performed by USAID 3E showed that the heating systems for the west and east building should be separated and a new boiler for the west building installed. The systems could be connected manually when needed, as in the case of gas supply disruption or if the east building needs exceed the capabilities of the two remaining boilers. It was also shown that significant energy savings could be achieved by replacing the windows, since they were 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 to introduce energy management. This system was usedin conjunction with the UNDP-developed EMIS.

The project was supported by UNDP (Bosnia and Herzegovina). UNDP financed the insulation of the building envelope and replacement of windows, and USAID 3E 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 was completed in December 2011.

2. Building Description

Type of building:	School (University)
Year of construction:	1960
Number of occupants:	
Permanent	100
Temporary	150
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

Figure 1: Project Development Pipeline

3. Energy and Water Consumption

The consumption of natural gas, electricity, and water were 515345 kWh, 153327 kWh and 2352 m^3 in 2011, respectively. The costs for this consumption are presented in Figure 1, along with the average outside temperature in Sarajevo.

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

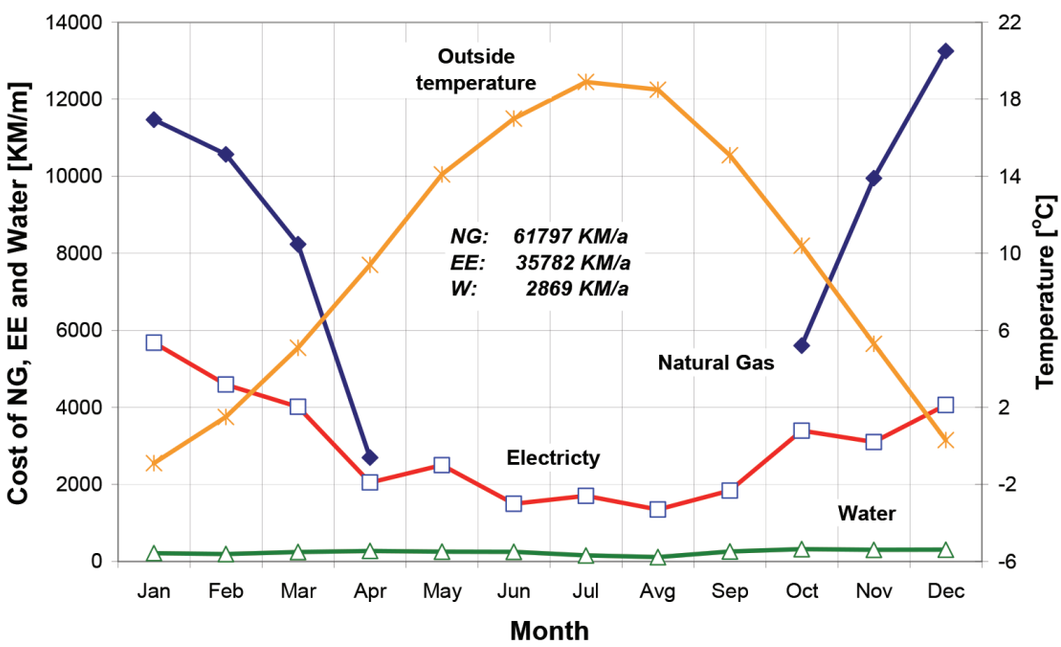

Figure 1. Baseline of Monthly Energy and Water Costs

4. Projects Proposed and Implemented

The following Energy Efficiency Measures (EEM)were recognized and proposed in the case of the Mechanical Engineering Faculty:

EEM#1: Energy Management

Expected Annual Energy Savings6,300 KM, Investment 26,000 KM and Simple Payback Period 4.1 Years

EEM#1-1: Installation of basic measurement system and development and introduction of energy management procedures
The basic equipment for measuring energy indicators (consumption of natural gas, thermal energy and temperatures) was installed. The usual procedure for monitoring & verification implies the establishment of an energy balance for the building and determination of its efficiency, as well as the efficiency of energy transformation. For that purpose, a system of measurement and remote reading was installed. These measurements marked the beginning of the introduction of energy management at the MEF.

EEM#1-2: Installation of radiator thermostatic valves
Since the load was frequently changed in rooms because of different numbers of occupants, thermostatic valves accomplished the necessary temperature regulation in a room. Otherwise, the flow and return temperature of water is controlled automatically in the boiler house according to the outside temperature.

EEM#2: Building Envelope Retrofit

Expected Annual Energy Savings 309,206 kWh, Expected Annual Energy Savings37,100 KM, Investment 428,500 KM, and Simple Payback Period 11.5 Years.

EEM#2-1: Replacement of windows
The replacement of windows was done immediately before the placement of insulation. The windows were removed from the outside, andtreatment of the surface for the insertion of windows was done from a scaffold. The windows were made in a factory, and new windows were installed from a scaffold.

EEM#2-2: Building envelope insulation
The price includeed the construction of the scaffold, preparation of wall surfaces for the placement of insulation, placement of insulation, a protective layer and painting of the façade, dismantling of the scaffold and removal from the site.

Photos of the MEF building before and after the envelop retrofit are presented in Figure 2 and 3, respectively.

Figure 2. View on the west MEF building before

Figure 3. View on the west MEF building after

EEM#3: Partial Reconstruction of Boiler House

Expected Annual Energy Savings 103,069 kWh, Expected Annual Energy Savings 12,400 KM, Investment 107,000 KM, and Simple Payback Period 8.6 Years.

Boiler no. 3 (Figure 4) was dismantled, and a condensing boiler (Figure 5) was installed, which is expected to result in an increase of energy efficiency of 20%. After dismantling, the wide area around the boiler was arranged. Preparations were made for mounting the new boiler,and the connection to natural gas and electricity was then prepared. Instead of the existing chimney, a new chimney was placed and connected with the boiler. An 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. A circulating pump, three-way valve and expansion vessel were installed in the boiler house.

Figure 4. View of the old boiler

Figure 5. View on the new condensing boiler

5. Environmental impact

Expected energy (natural gas-NG and electrical energy-EE) savings after implementation of all proposed ECMs are:

ΔNG:(309,206.0 × 1.2) = 371,047.2 kWh/a
ΔEE: 0.24 x 153327 kWh= 36,798 kWh
Total energy savings 371,047.2 + 36,798 =407,845 kWh/a

Reduction of CO_2 emission is (see attachment 3):
$\Delta CO_2(NG)=0.1836 \times \Delta NG = 68,124\ kgCO_2e/a$
$\Delta CO_2(EE)= 0.5246 \times \Delta EE = 19,304\ kgCO_2e/a$
Total CO_2 emission reduction is 68,124 + 19,304 =87,428 $kgCO_2e/a$

6. Monitoring & Verification

The remote system for monitoring energy consumption and fuels at the Mechanical Engineering Faculty in Sarajevo consists of measuring circuits for (Figure 6):

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 points);
6. Heat energy consumption (for the radiator system in the west building , for the radiator system in the east building and for air heating of the east building).

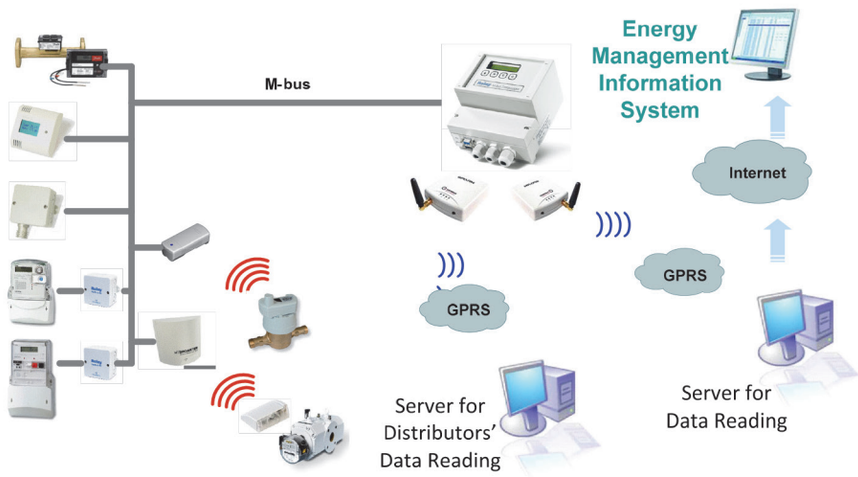

Figure 6. M&V System at the MEF in Sarajevo

7. Building and Heating System Performance Improvements and First Results

- Insulation of the building envelope and replacement of windows was completed in early December 2011.
- A new condensing boiler was put in operation in December 2011.
- An M&V system was in operation for the entirety of 2011.
- Installation of a new boiler, insulation of the building envelope and replacement of windows has reduced heating energy consumption by some 40%. Natural gas consumption for the period from Dec 13, 2011 to Jan 12, 2012 is presented in Figure 7.

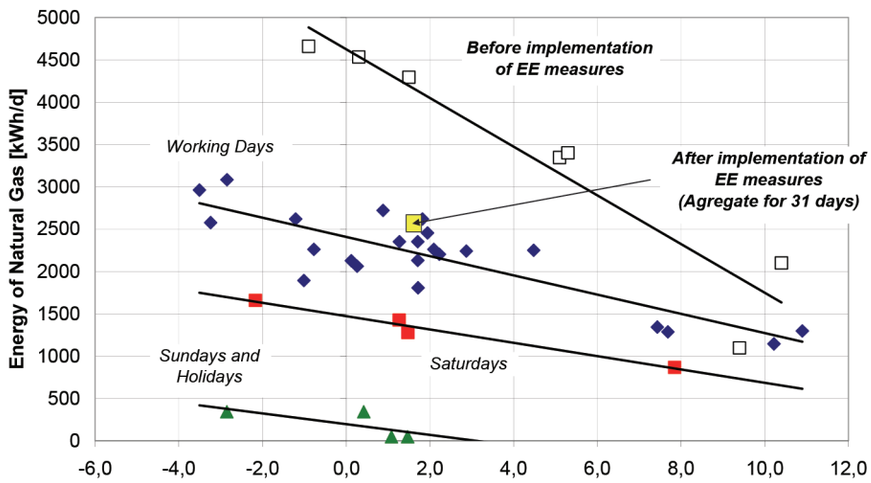

Figure 7. Energy Consumption versus Average Outside Temperature Before and After the EE Measures Implementation

- From category E, the building has moved into category C, according to the criteria for building certification.
- After a month of monitoring the average inside temperature of rooms in the building, the increase of temperature has been recorded from an insufficient 19 °C to a comfortable 21 °C.
- The medium efficiency degree of old boilers in the boiler house was around 73%. It is expected that the installed condensing boiler will reach a middle efficiency close to 100% (calculated according to the lower heating capacity).
- The installed M&V system enables the complete energy management of heating, electricity and water consumption. In 2012, the energy management system was put into operation.
- CO_2 emissions have been reduced by about 20 tonnes per year only through savings in the heating system.
- The measurement control conducted for 12 days in January 2011 and 2012 shows that electrical energy consumption fell by 24% in January 2012, in relation to the electric energy consumption in the same period in 2011. Electricity consumption in the mentioned periods is presented in Figure 8.

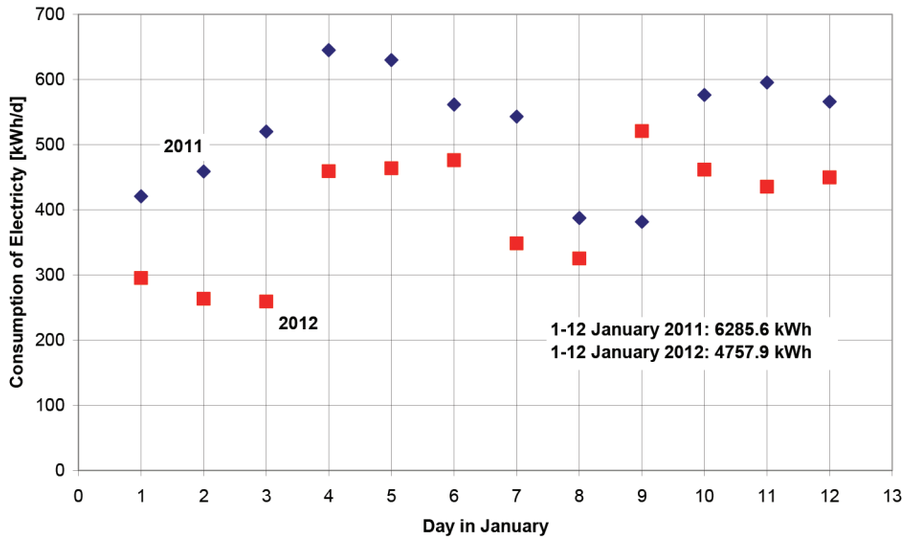

Figure 8. Electricity Consumption versus Day in January

8. Conclusions

- By applying proposed and implemented measures for an energy efficiency increase, annual aggregate savings of about 40% of heat energy were achieved.
- Electricity savingsare around 24%.
- It is very important to emphasize that comfort conditions are significantly improved, which was confirmed in many conversations with students and teaching staff. This is also proved by temperature measurements in several typical rooms within the M&V Program.
- Installation of condensing boilers is not a novelty in B&H, but it is an unjustifiably neglected measure. Installation of such a boiler at the Mechanical Engineering Faculty will certainly contribute to the education of students and the promotion of this highly efficient boiler.
- The establishment of a modern M&V system has created conditions for essential improvement of energy management; however, to achieve that, it has been necessary to establish and train theenergy management team headed by the energy manager.

2.2 High School, Mostar (Improvement of Regulation of Heating System)

1. Introduction

In November 2010, a preliminary energy audit of the High School in Mostar was done. Taking into account the implemented and ongoing energy efficiency projects in the High School, it was proposed to start with the implementation of three measures for increasing energy efficiency as part of the USAID 3E pilot project. These measures were:

EEM #1: Division of Heating Areas into Eight ZONES and Heating Management in Each

Explanation: The operating hours of the High School were very specific because the teaching process was carried out in two different regimes and there were many extracurricular activities in the evenings and during weekends. Such a versatile operating regime requires an adjustable heating system. Unfortunately, the existing heating system was centralized, meaning that the whole building had to be heated although there were activities in only one part.

EEM #2: Reconstruction of Heaters in the Gym

Explanation: In the gym, the radiators were mounted on the ceiling, which is technically incorrect. The way in which the heaters were mounted was also very problematic and could put students in danger.

EEM #3: Monitoring & Verification

Explanation: All USAID 3E projects involve preliminary energy audits, design, supervision and commissioning. Noticing that generally there is little energy management in the majority of buildings, the project anticipated the component of Monitoring & Verification (M&V) as a basis for energy management improvement.

Figure 1 shows the photograph of the facade of the High School in Mostar. This is, in fact, a very old building of much cultural importance (dating back to 1893). The total heating area is 2924 m2. The owner of the building is the City of Mostar.

Figure 1: Photograph of the Mostar High School

2. Basic Information

2.1 Building Description

Year of construction	1893
Year of last reconstruction	2009
Number of floors	Ground floor + 2 floors + basement + attic
Heating area	2924 m^2
External walls area	about 3000 m^2
Windows area	about 500 m^2
Number of students and staff	900
Operating hours	8:00 – 20:00 (Monday – Friday) 8:00 – 14:00 (Saturday)

2.2 Heating System

Type	Boiler room/dual piping/radiator
Fuel	Light fuel oil (LFO)

Boiler 1 – Capacity (kW)	315	T_1/T_2 (°C)	90/70	Year of production	2004
Boiler 1 – Capacity (kW)	315	T_1/T_2 (°C)	90/70	Year of production	2004

Distribution system (water)	Dual piping – Two verticals and, at each vertical, four horizontal pipes. Vertical capacity is V1 = 140 kW and V2 = 130 kW
Total capacity of radiators	270 kW
Pipe material	Steel
System balancing	Manual in two vertical pipes and ordinary valves on horizontal pipes
T_1/T_2 (°C)	90/70
Distribution system condition	Good

2.3 Weather Data for Mostar

City	Outside Design Temperature (°C)	Degree Day (DD)	Heating Period (Z) (Day/Year)	Average Outside Temperature in the Heating Period (°C)
Mostar	-6	1670	149	7.8

2.4 Layout Plan of the Building

Figure 2.1 shows a drawing of the layout plan of the High School and its main dimensions. Two vertical pipes of the heating system are also indicated. Each of them is connected by four horizontal pipes.

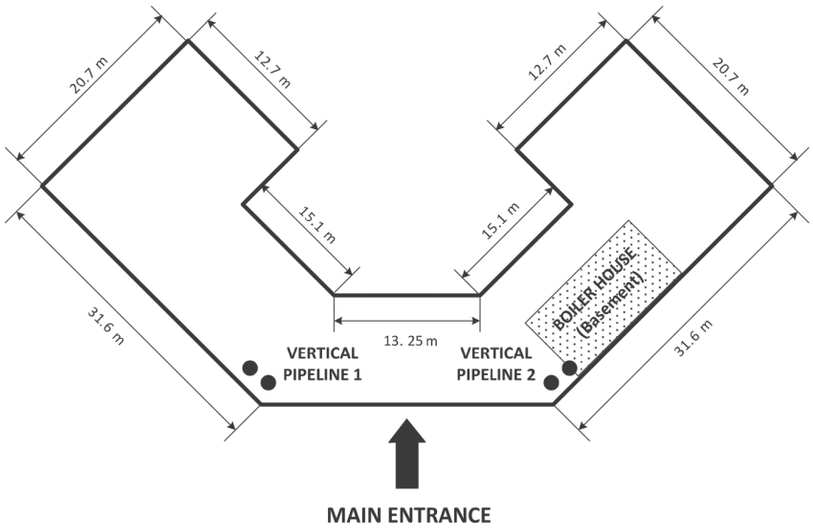

Figure 2: Layout Plan of the High School

3. Energy Carriers' Data

The High School is connected to the local electricity distribution network through a block transformer. There are two measuring points for electricity consumption.

There is no data regarding the composition of LFO,and none regarding sulfur content. The following data wasadopted from literature:

Low calorific value:	43.72 MJ/kg (40.65 MJ/l)
Density:	0.93 kg/l
During 2010, costs and consumption of energy and water were:	
- Electricity (per bills):	24,663 KM (with VAT) 82,515 kWh
- LFO (unit price: 1.6 KM/l):	33,600 KM (with VAT) about 21,000 l
- Water (price: 1.2 KM/m^3):	3,100 KM (with VAT) about 2580 m^3
TOTAL:	61,363 KM

Based on this data, it is possible to calculate that the average value of electricity is 0.2989 KM/kWh. The average price of LFO is estimated to 1.6 KM/l, and the price of water and sewerage is 1.2 KM/m^3. All prices include VAT.

4. Energy System

4.1 Heating System

- Number of boilers:	2
- Capacity of boilers:	315 + 315 = 630 [kW]
- Annual consumption of LFO:	21,000 [l/a] (in 2010-11)
- Assessed time of boiler operation:	
Heating season duration	*149 days or 21.3 weeks or 3576 hours*
Assessed interruption time due to holidays	*3.3 weeks*
Weekly operations of the heating system	*5 × (20 - 6) + (14 - 6) = 78 hours out of 68 (24 × 7)*
Total heating system operating time	*(21.3 – 3.3) × 78 = 1404 h/a*

The annual fuel consumption is:

EG = 21,000 l x 40.65 MJ/l x 1/3.6=237,125 kWh/a

The control calculation was performed for the fuel consumption based on installed heat capacity (130 and 140 kW) and weather data for Mostar. Thus, it was determined that heat energy consumption is:

$$Q_{TE} = (130 + 140) \times \frac{20 - 7.8}{20 - (-6)} \times 149 \times 12 = 226{,}526 \text{ kWh/a}$$

Specific heat energy consumption according to this calculation equals:

$$SPTE = \frac{226{,}526}{2924.17} = 77.5 \text{ kWh/m}^2 \text{ a}$$

Assessed fuel consumption is:

$$LFO = \frac{226{,}526}{40.65 \times 0.2778} = 20{,}060 \text{ l/a}$$

There is very good agreement here with the consumption obtained from the High School's Finance Department.

The drawing of the Boiler Room is given in Figure 3. The installed capacity of radiatorswas 270 kW in total, and it was obvious that one boiler was sufficient for heating requirements. The other boiler is a reserve.

Figures 4 to 6 show photographs of boilers, circular duplex pumps for both vertical pipes, and the return pipeline from the building and starting pipeline from the boilers.

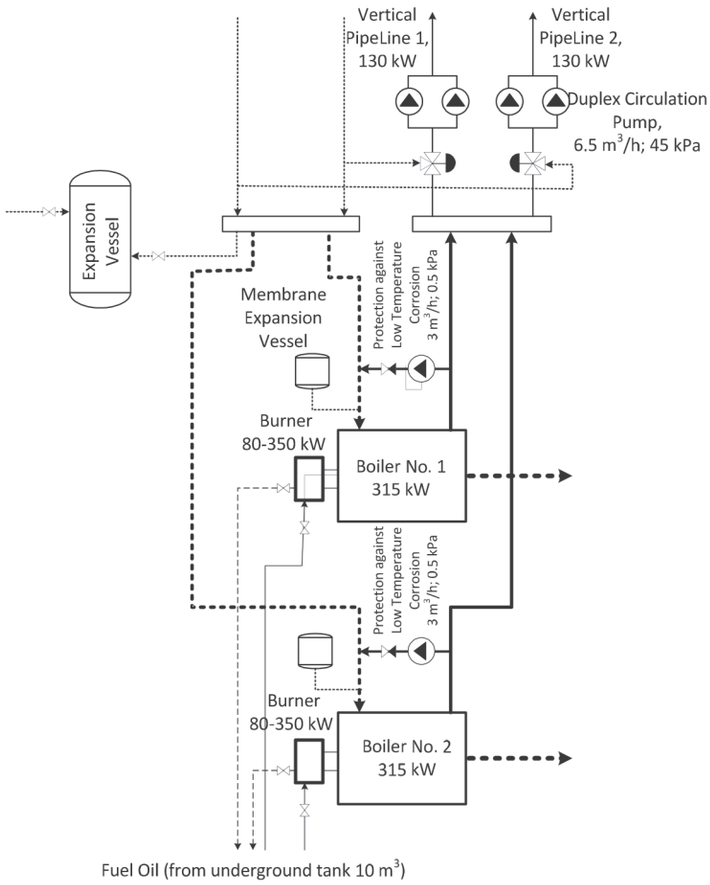

Figure 3: Drawing of the Boiler Room

Figure 4: Photograph of the Boiler Vertical Pipes

Figure 5: Circulation Duplex Pumps in Starting Vertical Pipes

Figure 6: Return Pipeline from the Building and Collector and Start/Return Boiler Piping

4.2 Heat Energy Consumption

Figure 7 shows a diagram of vertical and horizontal pipes. Operating activities in areas heated by the horizontal pipes (and therefore, by vertical pipes) were very different, which means that certain parts of the building were heated unnecessarily.

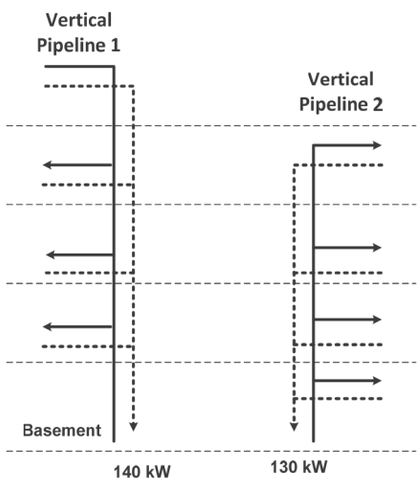

Figure 7: Diagram of Vertical and Horizontal Piping

5. Energy Consumption Indicators

The total heating surface of the High School is 2924 m^2. The total consumption of LFO energy is 21,000 liters or 237,125 kWh/a. The specific consumption of LFOwas:

- LFO: 81.1 kWh/(m^2 a)

The annual consumption of electricity is 82,515 kWh/a, and the specific consumption of electricity was:

- Electricity: 28.2 kWh/(m^2 a)

6. Analysis of Recommended Elegy Efficiency Measures (EEM)

6.1 EEM #1: Division of Heating Areas into Eight ZONES and Heating Management in Each

Because of different operating hours in eight operating units of the High School, it was necessary to provide the possibility for regulating heating in individual sections. The single boiler room was the starting point for two vertical pipes with approximately identical heating capacity. Four horizontal pipes were connected to each vertical pipe. For the purpose of avoiding freezing of one part of the installation and to reduce the effects of discomfort on the occasion of a longer interruption of heating and minimal disturbance to the hydraulic balance of the network, it was necessary to install three-way valves that would ensure minimum water flow in radiators of roughly 25%.

Analysis of the working schedule of certain Departments in the High School (regular and extracurricular activities) gave the rough assessment that 50% of the time it is necessary to heat the entire heated area. Itwas necessary to heat 66% of the area 30% of the time, and only 33% of the area 20% of the time. Thus, it was possible to estimate that potential energy savings were equal to:

$$EG_{MEE\#1} = 237{,}125 \times [0.5 \times 1 + 0.3 \times 0.66 + 0.2 \times 0.33] = 181{,}164 \text{ kWh/a}$$

Now, it was possible to estimate a savings of LFO at the annual level:

$$DEG_{MEE\#1} = \frac{(237{,}125 - 181{,}164) \times 3.6}{40.65} = 4956 \text{ l/a}$$

or an amount worth 7930 KM/a.

In summer 2011, the replacement of the windows was completed. The M&V system was put in operation in October 2012. In October and November, the operation of the heating system was under restriction because of an HFO shortage,so room comfort was under requirements. Because of the aforementioned irregularity in the heating system operation, measurements showed high energy savings. Following measurements, the energy savings in the 2012/2013 season was 7700 l/a, but the fuel oil consumption was very low in October and November 2012 because the school lacked funds to purchase fuel oil. Therefore, for further analysis the above-calculated value of 4956 liters will be used.

Figure 8 shows the diagram of reconstructed installations enabling the control of water flow in horizontal pipes. From the boiler room, selected horizontal pipes can be turned on and off in compliance with a previously prepared schedule. Horizontal pipes cannot be completely closed, but only up to some 25% of the nominal flow. In this way, emergency heating will be ensured, which will, after longer interruptions of heating, ensure a shorter time to reach full comfort in the working area. It will also preventpart of the installation from freezing, although such a possibility

is minimal, taking into consideration the mild climate. The three-way valve should ensure conditions for minimum impact on the hydraulic system; and, therefore, frequency regulation of the circulation pumps is not required. The three-way valve should contain a positioner. There will be only two positions: 1) Completely open branch A and completely closed branch B and 2) partially open branch A (about 25%) and partially closed branch B (about 75%).

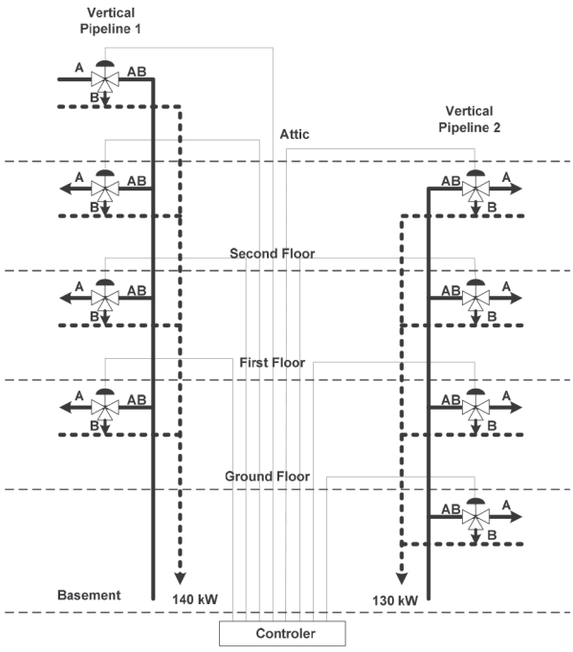

Figure 8: Diagram of Reconstructed Distribution Installation

Costs:

Purchase of valves	14,000 KM
Controller	3,000 KM
Assembly material (20% of equipment value)	1,500 KM
Assembly costs (50% of equipment value)	6,500 KM
Total Equipment and Assembly	**25,000 KM**
Design and Supervision (10% of equipment value)	2,000 KM
Other (10% of equipment value)	3,000 KM
TOTAL:	**30,000 KM**

6.2 EEM #2: Reconstruction of Heaters in the Gym

Radiators were mounted on the ceiling, whichis technically unacceptable. Radiators were removed and installed below the windows with robust protective masks. The total heat capacity of the radiators is 21.8 kW, according to design calculations.

It is not possible to expect large energy savings by applying this measure because of the low level of consumption of the relevant radiators in relation to the overall consumption. However, it is possible to say with certainty that ceiling heaters only served to consume energy, since their heating effect was minimal. This means that energy efficiency will be increased,as well as safety.

Costs:

Removal of existing heaters on the ceiling	500 KM
Purchase of new radiators (120 h × 21 KM/h)	2,000 KM
Assembly materials	500 KM
Purchase of massive masks	750 KM
Assembly of new radiators and masks below windows	750 KM
TOTAL:	**4,500 KM**

6.3 EEM #2: Installation of Monitoring & Verification System (Figure 9)

The remote system for monitoring energy consumption and fuels at the High School in Mostar consists of measuring circuits for:

1. Fuel oil consumption (two measuring points, one for each boiler);
2. Heat energy consumption (one measuring point);
3. Water consumption (one measuring point);
4. Electrical energy consumption (one measuring point);
5. Inside air temperature (seven measuring points, one in the gym);
6. Outside air temperature (one measuring point).

The Monitoring & Verification System cost 19,000 KM to install.

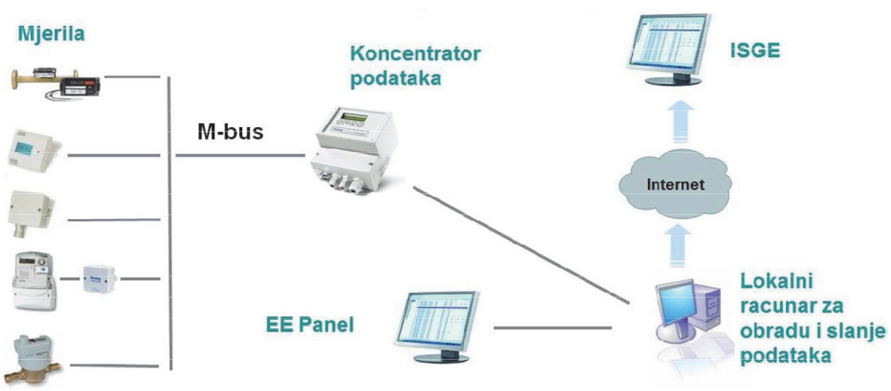

Figure 9. M&V System at the high school in Mostar

6.4 Summary of Recommended Measures

Energy Efficiency Measures (EEM)	Expected Annual Energy Savings [kWh]	Expected Annual Reduction of Costs [KM]	Investments [KM]	Simple Payback Period [Year]
EEM #1:Division of Heating Areas into Eight ZONES and Heating Management in Each.	55,961	7,930 KM	30,000 KM	3.8
EEM #2: Reconstruction of Heaters in the Gym	N/A	N/A	4,500 KM	
EEM #3: Monitoring and Verification			19,000	
TOTAL			53,500 KM	

7. Baseline of LFO Consumption During Heating Season

Necessary measurements:

- Temperature in six rooms was measured; and, based on these measurements, the average temperature in the building was determined;
- Outside temperature;
- Temperatures at the start and return of hot water flow in the heating system;
- Flow and consumption of LFO in each boiler separately.

Based on the above measurement during the preliminary and detail energy audit and based on necessary calculations concerning the effects of the recommended measures for the increase of energy efficiency, the target line of heating energy consumption was determined (Fig. 10).

Monthly consumption of LFO for average monthly outside temperatures was then inserted.

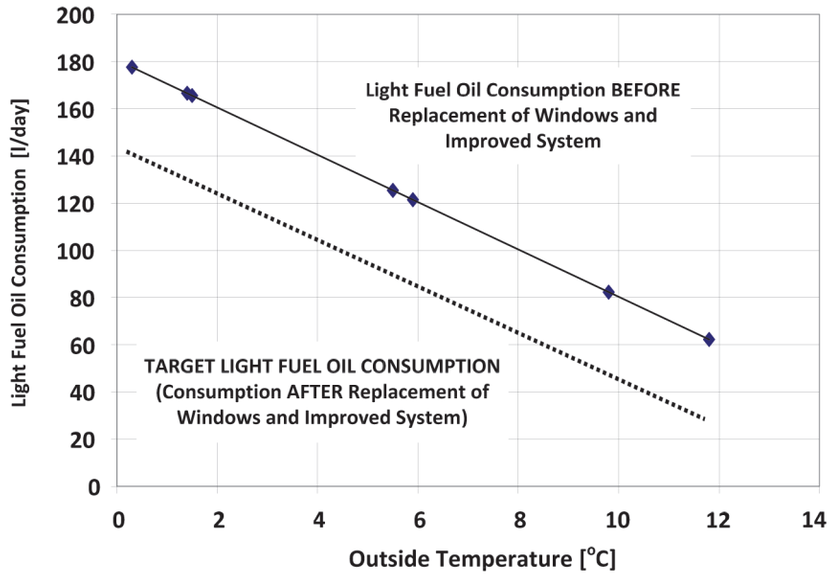

Figure 10: Target Line of LFO Consumption versus Average outlet Temperature

8. Environmental Impact Analysis

In case of the Mostar High School, the consumption ofLFOwas:

LFO: 21,000 l/a

Savings expected by EEM #1 application are:

ΔLFO: 55,961 kWh/a

Reduction of CO_2 is:

$$D\,CO_2(LFO) = 0.25 \times 55{,}961 = 13{,}990\ kgCO_2\ /\ a$$

9. Conclusion

- Prior to the implementation of this project (3 EEMs), the project of replacing the windows in the building of the High School Mostar was completed.
- By applying EEM #1, it was calculated that the estimated possibility for savingswas about 25%. The first results achieved by EEM #3: Monitoring & Verification indicates that the estimated savings were correct. Monitoring results were shown on a screen placed at the entrance into the High School, showing the educational effect of this project.
- The application of EEM #2 has moved the radiatorsthat had been placed on the ceiling of the gym. The reconstructed heating system in the gym resulted in satisfactory heating.

2.3 "Pazar" Primary School, Tuzla (Window Replacement and Heating System Reconstruction)

1. Introduction

In November 2010, there was a preliminary energy audit of the "Pazar" Primary School in Tuzla. Taking into consideration the already-implemented projects in the area of energy efficiency, it was proposed that three measures for improving energy efficiency in the school be implemented as a USAID 3E pilot project. These measures are:

EEM #1: Replacement of 2/3 of the School Windows

Explanation: One-third of the school's windows had already been replaced. Doubleglazed PVC windows with a vacuum between the glass panes had been installed. The school was built in 1937 in a standard building style at that time. The roof was insulated. This project anticipates the completion of the replacement of 2/3 of the windows with new PVC windows U-Value ≤ 1.4 W/(m^2 K). The ratio between window surface and outside walls is 385/1324 = 0.29.

EEM #2: Replacement of School Substation

Explanation: The school is connected to the district heating system. The existing substation was technologically obsolete and poorly maintained. Therefore, its replacement was recommended, as well as a transfer from payment according to square meter to payment per heat energy consumption.

EEM #3: Monitoring & Verification

Explanation: The school is a typical example of a system with variable loads due to the changeable number of children and time variable load in classrooms. For that reason, it was recommended that thermostatic valves be installed in order to enable local regulation of temperature in certain rooms.

Figure 1 shows the photo of front and back sides of the school building before project implementation.

Figure 1: Photo of Front and Back Sides of the Pazar Primary School in Tuzla before project implementation

2. Basic Information

a. Basic Characteristics of the Building

Heated area of the building A (m^2)	1597
Volume of heated area of the building V (m^3)	5572
Area of external walls (m^2)	1323
Window area (m^2)	385
Useful area of the building A_K(m^2)	1783
Type of heating	District heating

b. Heating System

Heating is connected to the district heating system. The installed power of the substation is about 150 kW. The temperature regime of the heating system was 90/70 °C (dual pipe system). A temporary heat meterwas installed to measure the consumption of heat energy in the entire building. Measurement data was used for an assessment of annual heat energy consumption.

Figure 2: Photo of the Substation (about 150 kW)

City	Outside Design Temperature (°C)	Degree Day	Heating Period (Day/Year)	Average Outside Temperature in Heating Period (°C)
Tuzla	-17	2881	201	4.7

Average monthly outside temperatures for Tuzla and surroundings are (Attachment 3):

Month	**°C**	**Month**	**°C**
January	-0.7	July	21.3
February	0.6	August	21.4
March	4.9	September	16.4
April	9.8	October	11.3
May	15.2	November	5.1
June	18.7	December	0.2

c. Tariff System

The Pazar Primary School in Tuzla is connected to the local distribution network through a block transformer.

The official heating season in Tuzla lasts for 201 days per year (in practice about 180 days/year). The municipal district heating system has a capacity of 220 MW. Hot water is generated in the Tuzla thermal power plant. The municipal utility company is in charge of operations and organization of the entire heating system.

The price of heating is 1.4 KM/m^2 + VAT = 1.64 KM/m^2. If the option for heat energy payment is by consumption, then the price is 61.8 KM/MWh + VAT = 72.31 KM/MWh.

d. Heating System

The subject matter of this project was the heating system and building envelope. Since there were neither continuous energy consumption measurements during the length of the heating season nor reliable estimates, the assessment of annual heat energy consumption was done on the basis of one month's measurements as shown in Table 1. Measurements were carried out in the school's substation in the period from 27 February to 25 March 2010. The average daily heat energy consumption during March 2010 was estimated at 1728.9 kWh.

	kWh/d
27/02/10	1273
28/02/10	1637
1/3/2010	1190
2/3/2010	1416
3/3/2010	1812
4/3/2010	2151
5/3/2010	2309
6/3/2010	2190
7/3/2010	2182
8/3/2010	2468
9/3/2010	2401
10/3/2010	2486
11/3/2010	2034
12/3/2010	2108
13/3/2010	2031
14/3/2010	1616
15/3/2010	1762
16/3/2010	1722
17/3/2010	1662
18/3/2010	1676
19/3/2010	1354
20/3/2010	1310
21/3/2010	1310
22/3/2010	1164
23/3/2010	1090
24/3/2010	1194
25/3/2010	1132
	1728.9

Table 1. Heat Energy Consumption Measurements

Based on these values, the average monthly temperature in the Tuzla region, and duration of the heating season (16 hours of daily heating), total consumption of heat energy is estimated at 343,178.7 kWh/a (Table 2). If this energy was paid for at the energy price, the total annual cost would be 24,815 KM/a. In the 2009/2010 season, heating was paid per square meter in the amount of 26,000 KM/a. It should be pointed out that heating operated continuously during the entire heating season (weekends and holidays), and that there were holidays and breaks in school operation that couldadd up to 40% of the total heating time.

	°C	d/m	Average Daily Consumption kWh/d	Monthly Consumption kWh/m
January	-0.7	31	2370.1	73472.1
February	0.6	28	2221.2	62194.2
March	4.9	31	1728.9	53595.6
April	9.8	15	1167.9	17517.9
May	15.2			
June	18.7			
July	21.3			
August	21.4			
September	16.4			
October	11.3	15	996.1	14941.7
November	5.1	30	1706.0	51179.7
December	0.2	31	2267.0	70277.6
TOTAL		**181.0 d/a**		**343,178.7 kWh/a**

Table 2: Calculation of Annual Heat Energy Consumption

e. Heat Energy Consumption

The total heated area of the school was 1597 m^2. The total consumed heat energy was 343,178.7kWh/a. Specific heat energy consumption is:

$$SPTE = \frac{373,178.7}{1597} = 233.7 \quad [kWh/m^2\ a$$

Assessment of Heating System Capacity

The total consumed energy in Table 2 was calculated for a heating season of 180 days, as this was its length duringthe 2009/2010 season. The system operated for about 16 hours daily. Thus, the average heating capacity was:

$$SG = \frac{343,178.7}{180 \times 16} = 119\ kW$$

This capacity does not imply that satisfactory room temperatures were always reached.

3. Analysis of Recommended Energy Efficiency Measures (EEM)

a. EEM #1: Replacement of 2/3 of windows in the school and insulation of walls and the roof (Due to a lack of resources, only the remaining windows have been replaced. The complete calculation is given in order to consider the effect of EEM#1 when completely implemented)

The calculation of heat losses before and after the installation of 10 cm thick expanded polystyrene (EPS) insulation and replacement of 2/3 of remaining windows showed that it is possible to reduce heat losses by 48%. Calculation details are given in Tables 3 and 4.

PAZAR, Tuzla					
Building type: Educational Institution / Business					
Basic Info					
Year of building:		**1937**			
Number of levels:		**1**			
Heated area: m^2		**1.597**			
Heated volume: m^3		**5.572**			
Net wall area: m^2		**1.324**	**77%**		
Total Windows and Doors		**385**	**23%**		
Permanent inhabitants/staff		**500**	Persons		
Temporary inhabitants/staff/visitors		**100**	Persons		
Average number of inhabitants		**250**	Persons during occupancy		
Envelope					
Roof:	Flat roof with 16 cm concrete + 5 cm thermal insulation + 8 cm concrete				
	Flat roof area: m^2	**877,00**			
	U-value of the flat roof is: $W/m^2°C$:	**0,78**		**684**	W/oC
Walls:	**Type #1**				
	External walls are made of **compact bricks** with two layer of plasters,				
	without thermal insulation. Wall thickness is 30 cm				
	Structure: 2 cm plaster + Brick 25 cm + 2,5 cm plaster				
	Average U-value is about: $W/m^2°C$:	**1,50**			
	Walls Area: m^2	**1324,0**		**1986**	W/oC
	Type #2				
	External walls are made of **Concrete** with two layer of plasters,				
	without thermal insulation. Wall thickness is 45 cm.				
	Structure: 2 cm plaster + Concrete 40 cm + 2,5 cm plaster				
	Average U-value is about: $W/m^2°C$:	**2,74**			
	Walls Area: m^2	**0,0**			
Windows:					
	In general, windows are in bad condition. External side is not maintained.				
	Mostwindows do not close properly. Infiltration losses remain high				
	Type of glass areas:				
	Wood windows, two frames with single pane in each frame: $W/m^2°C$:				
Windows:	Average U-value is about: $W/m^2°C$:	**3,40**			
	Total surface of windows: m^2	**257**			
Panels:	Average U-value is about: $W/m^2°C$:	**1,40**	Total Windows	**1052**	W/oC
	Total surface of windows: m^2	**128,33**	**385**	m2	
Doors:	Type of glass areas:				
	Aluminum doors with single pane U-value: $W/m^2°C$:				
	Average U-value is about: $W/m^2°C$:	**2,50**	Total Windows and Doors		
	Total surface of doors: m^2	**0**			
Basement:	Basement area is heated. Depth of basement floor below ground level is 1,7m.				
	Area: m2	U-value W/m2°C:			
	Floor slab	**877**	**0,86**		
	Basement slab	**0**	**0,86**		
	Walls	**0**	**3,47**		
		0	**2,74**		

Table 3: Calculation Details

BEFORE - Energy Consumption:		**kWh/yr**	**318.273**			
Consumption per square meter:		**kWh/yr.m2**	**199,3**			
Current Requirements						
Boiler Installed Capacity			**239**	**kW**	159	kW
Heating System Operations - AVERAGE			**16**	h/day	24	h/dan
Outside Design Temperature			**-17**	°C		
Inside Design Temperature			**20**	°C		
Average Outside Temperature [oC]			[kW]	h/monthly	[kWh]	m3
	Jan	-0,70	134	496	66.388	8.023
	Feb	0,60	125	448	56.198	6.792
	Mar	4,90	98	496	48.428	5.853
	Apr	9,80	66	304	20.050	2.423
	Oct	11,30	56	310	17.461	2.110
	Nov	5,10	96	480	46.245	5.589
	Dec	0,20	128	496	63.502	7.674
				3.030	**318.273**	38.465
Control:	Consumption per square meter:				**199**	kWh/yr.m2
		Natural gas consumption				
		2007 god	708.437	kWh		
		2008 god	643.644	kWh		
AFTER RECONSTRUCTION:						
				Reduction by:		
Energy Requirements:		kWh/year	148.527	**48%**		
Energy per m2/year		kWh/m2 year	93			
Energy Consumption:		kWh/year	166.218			
Consumption per square meter:		kWh/yrm2	104			
Future Requirements:						
Boiler Installed Capacity:			**143**	**kW**		
Heating System Operations - AVERAGE			**14**	h/day		
Outside Design Temperature			**-17**	°C		
Inside Design Temperature			**20**	°C		
Average Outside Temperature [oC]			[kW]	h/month	[kWh]	m3
	Jan	-0,70	80	434	34.671	4.190
	Feb	0,60	75	392	29.349	3.547
	Mar	4,90	58	434	25.291	3.057
	Apr	9,80	39	266	10.471	1.265
	Oct	11,30	34	272	9.119	1.102
	Nov	5,10	58	420	24.151	2.919
	Dec	0,20	76	434	33.163	4.008
				2.652	**166.216**	20.088
Control	Consumption per square meter:				**104**	kWh/yr.m2

Table 4: Calculation Details (Possible Savings)

On the basis of the measurements taken in the school and the calculation of consumption in the 2009/2010 season, the total heat energy consumption was estimated to be **343,178.7 kWh/a.** The energy consumption of 318.273 kWh/a shown in Table 3 was somewhat lower, but it was calculated according to average conditions given in design documentation and the estimates of the building construction properties. Given the calculation methodology, the agreement between the calculated value from Table 3 and the value based on measured consumption - 343,178.7 kWh/a is very good. Measured values were used.

Since total calculation of savingswas 48%, it was possible to estimate that the application of the above previously planned measure for energy efficiency increase EEM#1 will bring a reduction in consumption by 0.48 × 343178.7 = 164725.8 kWh/a. Monetary savings of 165 × 75.8 = 12,507 KM/a is possible. However, as the result of insufficient funds, only the replacement of remaining windows has been carried out. Based on Table 2, it is possible to calculate that the share of windows in total losses is about 30%; thus, the savings achieved can be estimated to about 0.30 × 164,725.8 = 49417.7 kWh/a (14.4%).

Measurements performed by using an M&V system showed the following energy consumption:

- Heating season 2011/12 253 MWh
- Heating season 2012/13 300 MWh

These consumption figures were higher than expected. However, the same M&V system registered that temperatures in the rooms and especially in the gym were much higher than expected 20 °C.

b. EEM #2: Replacement of the School's Substation

The main benefit of substation replacement was automatic heating system regulation, measurement of real heat energy consumption and the possibility of programming periods of heating system operation.

Total annual heat losses after implementation of EEM #1 will be $QEEM_{\#1}$ = 293,761 kW/a.

A heating season of 180 days is about 25.7 weeks, or 4317.6 hours. However, the district heating system operates on an average 16 h/day, which totals 2878.4 h/a.

Out of these 25.7 weeks, the school was open for about 21 weeks (the remaining time refers to holidays and weekends). During a week, the school was open for 12 hours per day × 5 days per week and 8 hours on Saturday. This is 68 hours per week or 1428 h/a. Currently (without programming the periods of operation), the heating system operates 2878.4 h/a, although it is necessary to operate only 49.6% of this time.

With the possibility of programming, the system would be operating under full capacity only some 50% of the time, while the remaining 50% it would operate with reduced capacity, maintaining room temperature at about 12 °C. Since the average temperature during the heating season in Tuzla is 4.7 °C, then the heating capacity in case of reduced temperature (emergency) would be:

$$\frac{N_{dez}}{N_{nom}} = \frac{12 - 4,7}{20 - 4,7} = 0,48$$

The average heating capacity in the current system of continuous operation (16 h/d) was:

$$N_{nom} = \frac{Q_{MEE\#1}}{2878,4} \text{ kW}$$

The total heating energy after the introduction of emergency heating would be:

$$Q_{MEE\#2} = 0,738 \times Q_{MEE\#1} = 0,738 \times 293761 = 216796 \text{ kWh/a}$$

That is, a savings of 26.2% could be achieved.

c. EEM #3: Monitoring & Verification

The remote system for monitoring energy consumption and fuels at the Pazar Primary School in Tuzla consists of measuring circuits for:

1. Heat energy consumption (one measuring point);
2. Water consumption (one measuring point);
3. Electrical energy consumption (one measuring point);
4. Inside air temperature (three measuring points, one in the gym);
5. Outside air temperature (one measuring point).

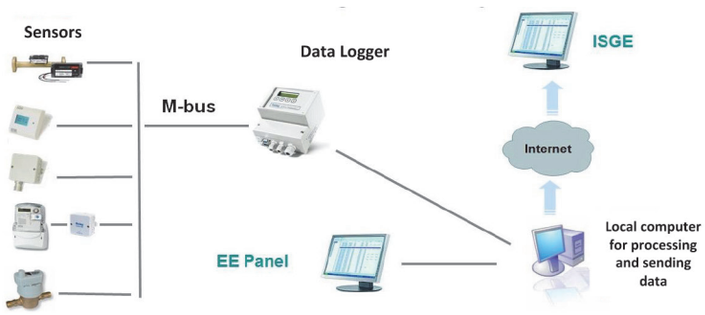

Figure 3. M&V System at the Pazar Primary School in Tuzla

4. Evaluation of Investment

Investment Assessment:

Replacement of 2/3 of windows	82,000 KM
Retrofit of heating system (control valves, Thermostatic valves, new radiators in gym)	35,000 KM
New substation and expansion system	44,000 KM
Monitoring & Verification System	9000 KM
TOTAL:	170,000 KM

5. Baseline Heat Energy Consumption

Necessary measurements:

- The temperature in selected rooms (two classroom and gym) was measured; based on these measurements, the average temperature in the building was determined;
- Outside temperature;
- Temperatures at the start and return of hot water flow in the municipal district heating system;
- Water flow;
- Consumption of heat energy taken from the municipal district heating system.

Based on the above measurements during the preliminary and detailed energy audit and based on necessary calculations concerning the effects of recommended measures for the increase of energy efficiency, the target line of heating energy consumption was determined (Fig. 4).

Monthly consumption of heat energy for average monthly outside temperatures were then inserted.

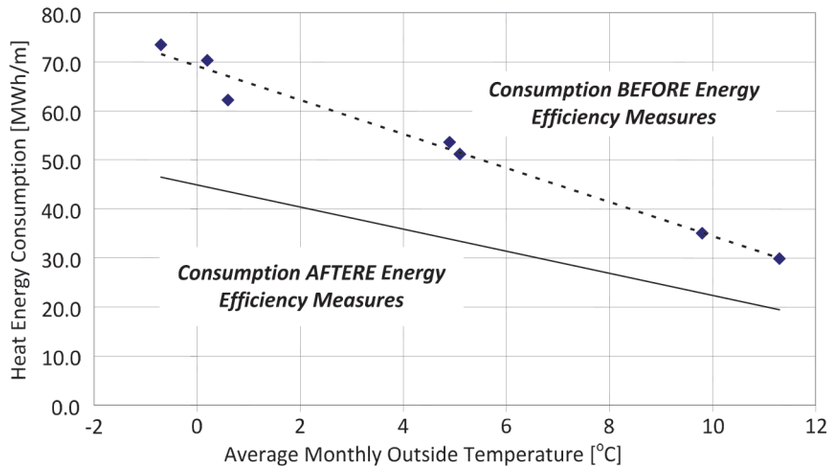

Figure 4. Target Line of Heat Consumption versus Average Outlet Temperature

6. Environmental Impact Analysis

In the case of the PazarPrimary School in Tuzla, the expected savings of heat energy were equal to:

ΔTE: 126.4 MWh/a

Coal in the thermal power plant is used for the production of heat energy. Avoiding the complexity of the energy transformation process in the thermal power plant, it could be assumed that the level of efficiency of complete energy transformation, transmission and distribution is 0.7, meaning that the coal energy required for the production of heat energy used in the school is 126.4 / 0.7 = 180.6 MWh/a. This will mean a savings of coal if the recommended measures were implemented. Adequate reduction of CO2 emissions is:

$$\Delta CO_2(\text{Coal}) = 0.3325 \cdot 180,600 = 60,050 \quad [\text{kgCO}_2 / \text{a}]$$

Here, 0.3325 $kgCO_2$/kWh is CO_2 ratio per kWh of coal energy (Attachment 3). This was the average value for medium quality coals.

7. Conclusion

- By applying EEM #1, it was calculated that the estimated possibility for savingswas about 14.4%. The first results obtained by applying EEM #3: Monitoring & Verification indicated that the estimated savings were accurate. It is especially necessary to point out that the monitoring results are displayed at the entrance to the primary school, showing the educational effect of this project.

- By applying EEM #2, it was possible to manage the use of heat energy according to the actual needs. The estimated savingsthat could be achieved by installing a modern heat substation was about 48% in relation to consumption after the application of EEM #1.

- Within EEM#1, it was planned to thermally insulatethe external walls and the roof. Unfortunately, due to alack of resources, this measure has not been implemented.

- In the project planning stage, it was proposed that thermostatic radiator valves be installed. Due to a lack of resources, this measure was not implemented. Since this measure does not require a large amount of money, its implementation has been proposed within the regular maintenance during the next year.

2.4 "LepaRadić" Kindergarten (Building Envelope, Heating System and Hot Water System Reconstruction in the kindergarten building)

Introduction

The LepaRadić kindergarten building in Gradiškamunicipality was built in 1973,with additional upgrading taking place in the period between 1975 and 1978. The building is owned by the Gradiška Municipality, and its purpose is to accommodate and care for preschool children. The building is used 10 hours/day, from 06:30 to 16:30. There are 28 employees and 156 children in this building.

The main problem in this building is the inadequate and uncomfortable temperature of approximately 19°C, while the standard temperature for such a type of buildings that provides comfort is 21°C – 24°C. A particularly inadequate temperature was measured in the room used by the youngest children. There were several factors affecting the low temperature in this building:

- Outdated and poor joinery;
- Insufficient thermal insulation of the building;
- A poor and inefficient heating system;
- Inadequate maintenance.

The Partners in this project were the Gradiška Municipality, UNDP and USAID. The cost of the project was 230,000 USD.

Works on the replacement of the old joinery were finished on 29 June 2011, the roof was placed on 14 August 2011 and the façade was completed on 21 August 2011. On 18 October 2011, the new pellet boiler was put into operation, and on 23 May 2012, solar collectors for domestic hot water preparation were put into operation.

1. Building Description and Energy Consumption (the situation as found)

• Heated area of the building	1277 m^2
• Type of heating system	Central
• Fuel	Wood
• Average monthly outside air temperature at the building's location in the coldest month	-0.6 °C
• Average monthly outside air temperature at the building's location in the hottest month	+20.6 °C
• Annual estimated heat demand for heating purposes with reference to climate data	237.7 [MWh/a]
• Annual heat demand for heating purposes per m^2 of heated area	186.1 [kWh/m^2 a]

Some details about the building are shown in Figures 1 and 2.

Figure 1. Old and new windows of the LepaRadić Kindergarten in Gradiška

Figure 2. Boiler Room in LepaRadić Kindergarten in Gradiška (before and after)

2. Description of Applied Measures for the Increase of Energy Efficiency

Applied measures for the increase of energy efficiency and their investment values are given in Table 1.

MEASURES FOR ENERGY EFFICIENCY INCREASE	Investment [KM][2]
Installation of thermal insulation on the external side of outside walls of the building and the ceiling (100 mm polystyrene);	63,000
Roof reconstruction	85,000
Replacement of windows and external doors	90,000
Replacement of the existing wood boiler with a new pellet one. Minor reconstruction of the heating distribution system.	35,000
Installation of solar collectors and accompanying equipment for domestic hot water preparation.	35,000
Monitoring & Verification (M&V) Program	12,000
TOTAL	**320,000**

Table 1: Applied Measures for the Increase of Energy Efficiency

The M&V Program includes the following systems:

1. Building heating
2. Electricity
3. Domestic cold water

The annual consumption of heat energy in the 2009/2010 season was 237,684 [kWh/a].

The new system for the preparation of domestic hot water uses solar collectors, hot water from the heating system when it is in operation and an electric heater incase the previous two systems are not sufficient for water heating. Until the construction of this system, the preparation of hot domestic water was done with classical electric heaters. There are no data and estimates of electricity consumption for the preparation of hot water.

In 2011, 47,920 kWh of electricity was consumed and its cost was KM 5216,10. The average unit price of electricity was 0.1088 KM/kWh.

In the same year, 1007 m^3 was consumed and its cost was KM 2562.4. The unit price of water was 2.54 KM/m^3.

[2] *1USD = 1.507848 KM*

The M&V program anticipated measurement of energy consumption for building heating, for the preparation of domestic hot water (solar, heat energy from the heating system and electricity for reheating), total consumption of electricity and total consumption of domestic cold water. Direct measurement of solar heating system participation was not performed because of a lack of funds. It should be done in the future.

3. Available Measurements and Data about Energy and Water Costs

Figure 3 shows monthly consumption of electricity from January 2011 to June 2012. Seasonal variations of consumption are understandable (shorter days during winter and lower occupancy of the building during summer). Generally, it can be said that the average consumption from July 2011 to June 2012 was less than that from July 2010 to June 2011. The pellet boiler installation and minor reconstruction of the heating system were done before the beginning of the heating season 2011/2012, which explains the reduced energy consumption.

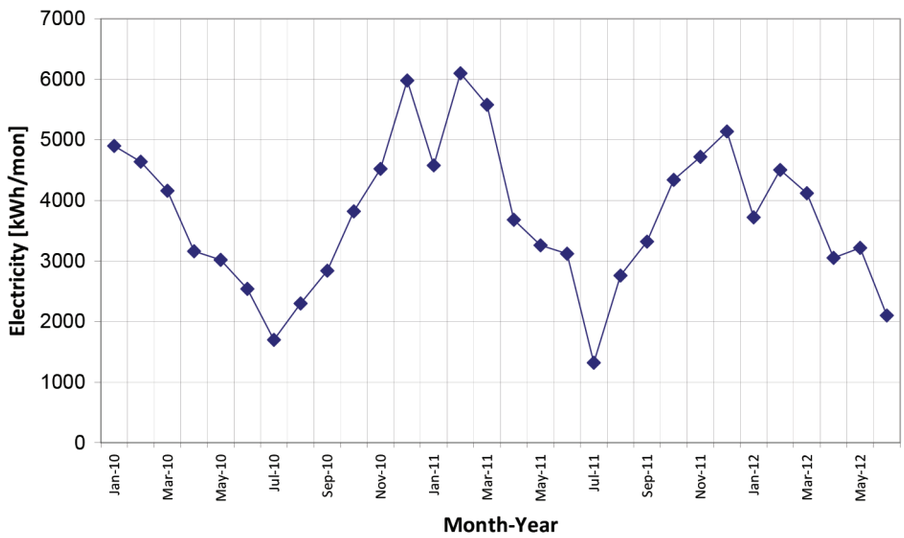

Figure 3. Monthly Electricity Consumption

The consumption of cold water is shown in Figure 4. The trend of increased cold water consumption is obvious as well as two peaks (August 2011 and June 2012). It is suggested that these deviations be considered.

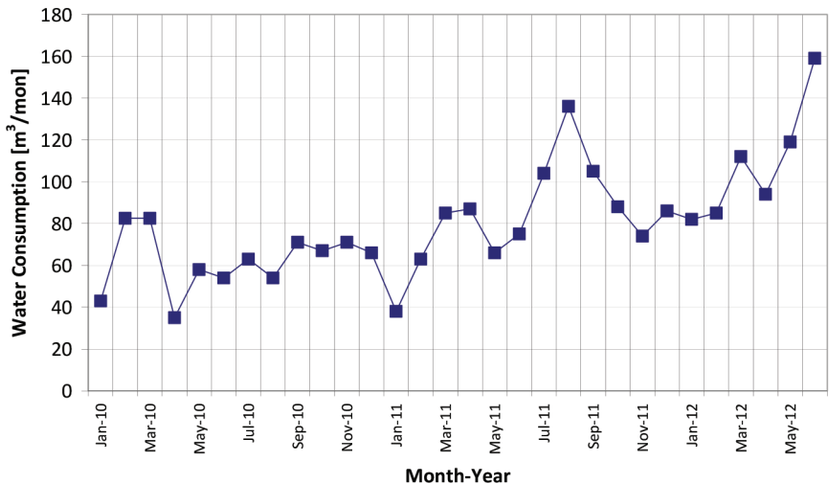

Figure 4. Monthly Consumption of Domestic Cold Water

The purchase of pellets in the heating season 2011/2012 was as follows:

27 October 2011	12 t
23 December 2011	6 t
6 February 2012	6 t
28 February 2012	6.93 t
24 April 2012	1 t

The total consumption of pellets was 31.93 tons. The energy value of this quantity of pellets is 172.07 MWh. The pellet producer is SAVA-ENSABIHd.o.oSrbac. The declared upper calorific value of these pellets is 19.4 MJ/kg=5.38 kwh/kg (http://www.ensabh.com/images/analiza.pdf).

The quantity of pellet consumption is dependent on the average monthly outside temperatures in Gradiška The dependence of pellet consumption (expressed in energy units based on declared calorific value of pellets) and average monthly outside temperature is shown in Figure 5.

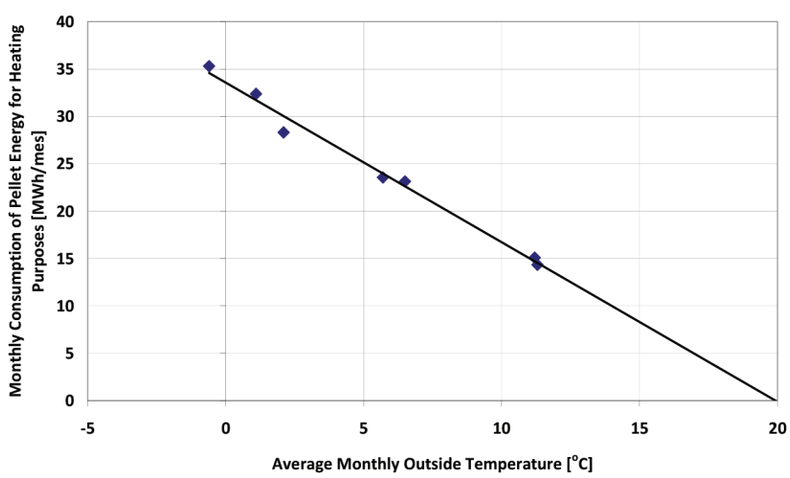

Figure 5. Dependence of Pellet Consumption on Outside Temperature

4. Defining Baseline for Energy and Water

Before the introduction of measures for the increase of energy efficiency, the consumption of heat energy for heating purposes was 237.7 MWh (the estimated energy value of wood for firing the boiler in the heating season 2010/2011). After the pellet boiler was been put into operation, but primarily due to the insulation of external walls and the replacement of windows and the outside door, annual heat energy consumption was reduced to 172.07 MWh. This means that the effect of the increase of energy efficiency of the heating system can be estimated to around 28% in relation to the situation before the introduction of the aforementioned measures. The increase of the consumption of heat energy because of the utilization of boiler water for the preparation of domestic hot water is some 4-5 MWh per year. There are no measured data regarding the effect achieved by solar collectors.

Figure 6 shows the desired monthly consumption of pellet heat energy. It is expected that all measurements will fall within the shaded portion.

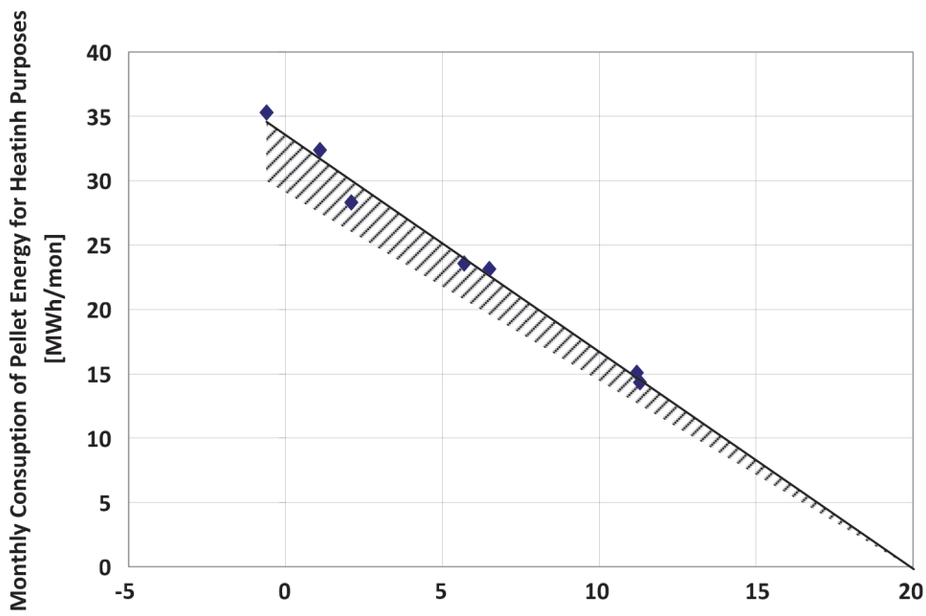

Figure 6. Baseline for the Heating System

Total annual consumption of cold water was 1657 m^3/year. Since there area total of 184 employees and children, water consumption per person was some 9 m^3/person/year.

The consumption of domestic hot water in kindergartens was around 15 l/person/day (personal use of water + kitchen + laundry). The total annual consumption of hot water can be estimated as follows:

$$W = 15\,\frac{\text{liter}}{\text{person}} \cdot 22\,\frac{\text{working day}}{\text{month}} \cdot 11\,\frac{\text{working month}}{\text{year}} \cdot 184\ \text{person} = 667{,}920\ \text{liter / year}$$

or 668 m^3/year.

The energy needed for reheating this water from 20 to 45 °C is:

$$Q_W = 667{,}920 \frac{kg}{year} \cdot 4.21 \frac{kJ}{kg\,^{o}C} \cdot (45-20)\,^{o}C \cdot \frac{1}{3{,}600} = 19{,}527\ kWh/year$$

This concerns electricity. The total annual consumption of electricity is 51,432 kWh/year. Some 38% of electricity is used for the preparation of domestic hot water.

The estimated opportunities to save 45% of this energy can be achieved by the use of solar collectors (30 m^2 is the gross area of solar collectors). The tanks for hot water are 2 m^3 (2 times of 1 m^3) in total capacity.

Figure 7 shows the expected monthly heat energy from solar collectors for the preparation of domestic hot water.

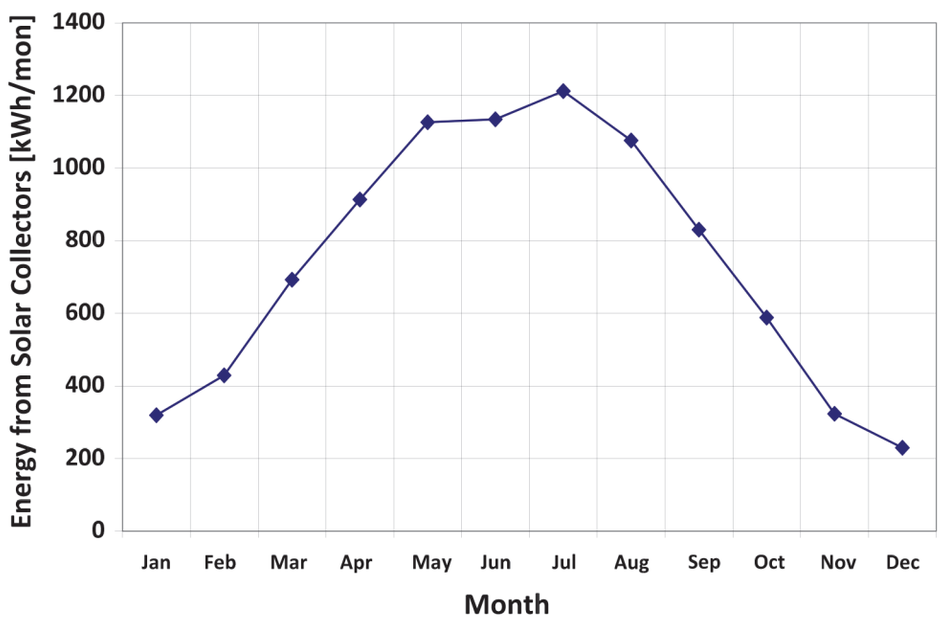

Figure 7. Expected Heat Energy from Solar Collectors for Domestic Hot Water Preparation

The M&V system should also include one heat meter that will measure this heat energy. Figure 8 shows the drawing of the collector and the heat meter.

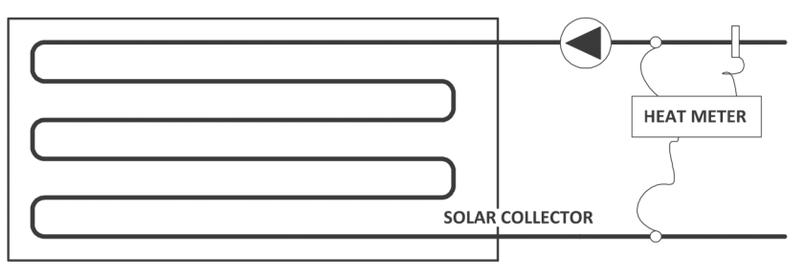

Figure 8. Drawing of the Heat meter for the Solar Collector

5. Conclusion

The consumption of heat energy before the replacement of windows, the entrance door and installation of insulation for the exterior walls was 238 MWh/a. After the improvement of thermal characteristics of the building envelope, the consumption of energy for heating purposes was reduced to 172 MWh/a, which is a decrease of 28%.

In addition to the obvious decrease of energy costs, it is necessary to emphasize the aesthetic improvements of the building, which are of high social importance. Since the comfort is now within standard limits, this will also be reflected in the health of children and employees.

The effect of the reduction of greenhouse gas emissions has not been achieved through improvements on the building envelope and heating system, since both wood, which was previously used for heating purposes, and pellets, which are now used for heating purposes, belong to renewable energy sources.

In addition, the utilization of solar collectors for the preparation of domestic hot water can achieve a reduction in heat energy consumption of $0.45 \times 0.38 \times 51{,}432 = 8795$ kWh/a (38% of the total consumption of electricity is used for the preparation of domestic hot water; it is expected that solar collectors can replace 45% of this consumption). The reduction of greenhouse gas emissions will be 0.43 $kgCO_2/kWh \times 8795$ kWh/a = 3782 $kgCO_2/a$.

In addition to the obviouslygreat energy savings achieved, recommendations for further improvements of the energy systems include: 1) replacement of classical valves on heating bodies with thermostatic valves, 2) installation of sensors to control lighting, and 3) better maintenance.

2.5 Energy Renovation of 20 Residential Houses in B&H

1. Introduction

This project included energy-efficient renovation of 20 houses (10 in the Sarajevo region and 10 in the Tuzla region).

EEM: Thermal Insulation of Facade

The project involved the delivery of insulating material (polystyrene, 10 cm thick) to selected and qualified homeowners. The project provided technical assistance to the homeowners for reconstruction in accordance with energy-efficiency standards. In addition to the material (polystyrene) provided by the project, homeowners invested their own funds for necessary additional materials and any needed workers. The main goals of the project were:

a. To reduce heat loss through the building envelope of the houses; and

b. To promote the need to improve energy properties of the building envelope as a basic prerequisite for increased energy efficiency in the building sector. The results achieved in this project confirm significant potential for the decrease of energy consumption and for the reduction of greenhouse gas emissions.

The photograph of one of twenty houses before and after insulation is shown in Figure 1. In this specific case, a 45% reduction of heat energy consumption was achieved.

Figure 1: Photo of One of the Houses Before and After Implementation of Proposed Energy Efficiency Measures

2. Basic Information

2.1 Residential houses and consumption

Number of residential houses	20
Average size of heated space per unit	200
Energy source and price	Wood 88KM/m^3
	Brown coal 184KM/t
Consumption of coal (t) in 2010/2011	221
Consumption of coal (t)in 2011/2012	111.7
Consumption of wood (m^3) in 2010/2011	23
Consumption of wood (m^3) in 2011/2012	30.5
Type of heating	Individual furnaces
Average co-financing percentage	80

Table 1: Applied Measures for the Increase of Energy Efficiency

- The energy consumption data for all houses in the 2010/2011 heating season were collected through application forms. Data was verified during field visits. Based on the collected data, the calculation of expected energy savings after insulation was conducted by applying specialized software licensed by energy consultants Ehrsam&Partners, Pratteln (Switzerland).
- The effective energy savings were established based on the quantity of consumed fuel in the 2011/2012 heating season. Apart from the quantity of fuel, indoor temperature records filled in by house owners in the 2011/2012 heating season were taken into account for the assessment of energy savings.
- The project comprised the Tuzla region (Tuzla town, Živinice, Gračanica, Lukavac[Federation of B&H]) and the Sarajevo region (Sarajevo town, Ilidža, Vogošća, Ilijaš[Federation of B&H]); and Pale, Eastern Ilidža (Republic of Srpska).

2.2 Weather Conditions in Tuzla and Sarajevo

City	Outside Design Temperature (°C)	Degree Day	Heating Period (Day/Year)	Average Outside Temperature in Heating Period (°C)
Tuzla	-17	2881	201	4.7
Sarajevo	-16	3007	211	4.4

Monitoring and Follow-up after EEM

- According to conducted calculations and energy balances, the expected energy savings (ex ante) were estimated to be 50%.
- The percentage of CO2 emissions reduction was estimated similarly, because none of the beneficiaries intended to change the fuel in the heating system.
- The projected energy saving potential (based on an individually calculated energy balance) and discussions with homeowners in the course of the project often encouraged the owners to take additional energy efficiency measures, such as replacement of windows, roof insulation or planning of future investments in energy efficiency measures for their houses.
- All homeowners pointed out that their houses were heated more quickly and that it took more time to cool down. They also stated that there were days when they did not have to turn on the heating at all. They claimed that quite often they had a problem with space overheating, because they had the habit of frequent and extensive heating. After insulation, their stoves were found to be oversized.
- The houses were screened with an infrared (IR) camera in January/February 2012. The common conclusion based on the IR recording was that the thermal insulation of walls on all buildings was properly completed, and that any large heat losses were caused by windows.

2. ExPost Data Collection

After the end of the heating season, relevant and available data were collected from all users who kept records of indoor temperatures and quantities of consumed fuel. Based on analysis of temperature lists, it can be concluded that the average in-house temperature ranged between 23 - 28°C, which means that the houses were continuously overheated after being insulated. Having in mind that an increase in temperature by 1° C results in a 4% increase in energy consumption, it is clear how much energy was unnecessarily wasted.

Figure 2 shows indoor temperatures in all ten houses.

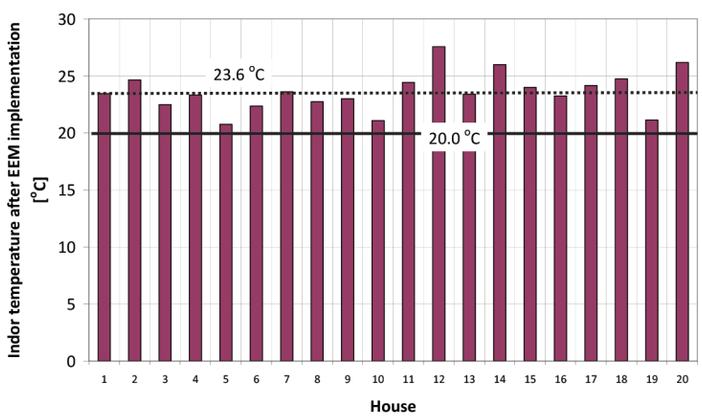

Figure 2: Indoor Temperature in Houses after Their Insulation

After analyzing data collected on the consumption of energy, it is evident that there are large variations in the percentage of fuel savings in different buildings. For example, in one house, fuel savings of 73% were achieved with an average indoor temperature of 23.3 oC, while in another house, fuel savings of only 23% were achieved with the average indoor temperature of 26.2 oC. This indicates large differences in heating system management and a lack of automated control.

3. Data Analysis

Energy consumption decreased on average by 45%:

- Average annual energy consumption in all houses before EEM: 305 kWh/m^2
- Average annual energy consumption in all housesafter EEM: 166 kWh/m^2

The table below shows the comparison of heat energy consumption in MJ/year for 20 buildings before and after EEM:

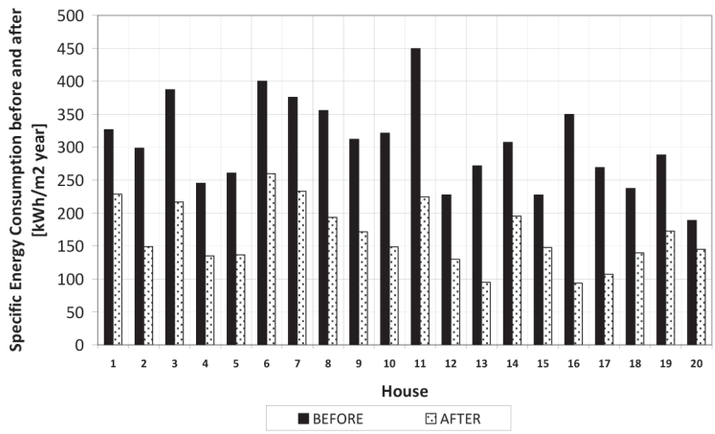

Figure 3: Specific Annual Energy Consumption of All Twenty Houses Before and After Energy Efficiency Measures Implementation

Although the renovation significantly reduced energy consumption per m^2 of heated space after comparing the results with European standards, it can be concluded that the specific energy consumption per m^2 remains high. It should be below 100 kWh/m^2 annually. The reasons for this high specific energy consumption could be as follows:

- Continued habit of frequent addition of coal to the furnace;
- Overheating of the living space (room temperature much above the standard of 20 ^{o}C);
- Large heat losses through windows and doors (due to low quality and condition);
- Improper ventilation (windows opened too often);
- Oversized furnace;
- Poor or improper combustion in furnaces;
- Heat losses in pipes and furnaces due to uninsulated boiler room and pipes;
- Poor central and local heating control system.

The CO_2 emissions were calculated based on the type and the quantity of consumed fuel for all buildings individually before and after rehabilitation (Figure 4). In the calculation, the guidelines of the Federal Ministry of Environment and Tourism of B&H were applied.

- Average CO_2 emissions per house BEFORE measures: **19.43 t** CO_2
- Average CO_2 emissions per house AFTER measures: **9.88 t** CO_2 (49.3% reduction)

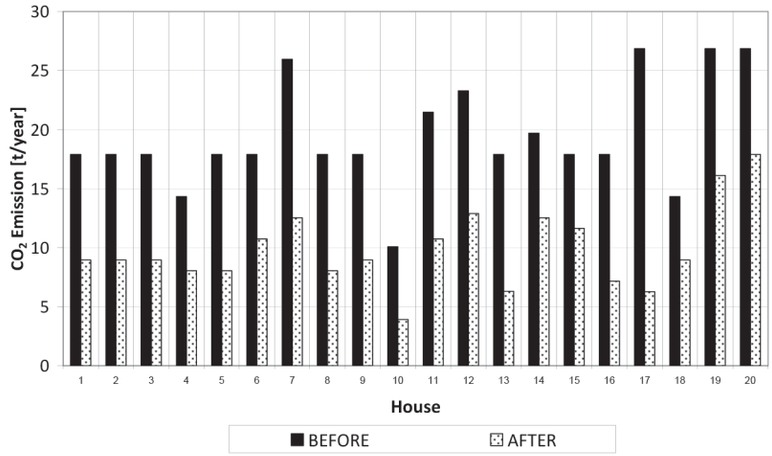

Figure 4: CO2 before and after Rehabilitation 20 Houses

By comparing results obtained here with results for buildings in the European Union (EU), it can be concluded that CO_2 emissions per m^2 of heated space in B&H are still high. Such high emissions are partially caused by the fact that coal is still often used as a heating fuel in B&H. Therefore, it is recommended that additional projects be developed that would include further insulation measures and the use of more environmentally friendly fuels and renewable energy sources in order to further reduce CO_2 emissions.

4. Conclusion

The energy efficient renovation of buildings can significantly reduce energy consumption and CO2 emissions. In addition to energy and financial savings, a great advantage emphasized by project beneficiaries is the improvement of living comfort, reduction of moisture condensing on external walls, and less frequent addition of fuel to the furnace.

The whole process of implementation was completed without major problems. All of the compulsory works were performed in accordance with set standards and on time. Individually agreed additional works were executed by all beneficiaries. Four homeowners insulated their roofs, four replaced old windows, and one implemented both of these additional measures.

The most important lesson learned during this project is that energy efficiency measures are very important, but the willingness of owners to take the maximum benefit out of these measures by properly managing the system for heating is also crucial. That is why it is necessary to simultaneously work on the promotion of energy efficiency and raising awareness and changing habits.

There are still thousands of thermally uninsulated family houses in Bosnia and Herzegovina. This type of reconstruction extends the life of buildings and further increases their value. The results of the project show that the owners will repay their investment on average in eight years while living in a much more comfortable home, which should encourage other homeowners to invest in insulating their houses.

2.6 "BrankoĆopić" Primary School, Prijedor (Window Replacement and Building Envelope Insulation)

1. Introduction

The USAID Project Energy Efficiency Economy (3E) in cooperation with UNDP, Prijedor Municipality and the Ministry of Education and Culture of the Republic of Srpska implemented a pilot project at BrankoĆopićPrimary School in Prijedor.

In August 2011, an energy audit of facilities was conducted, and the site visit report and pilot project proposal evaluation were prepared. All necessary measures for the increase of energy efficiency were taken into consideration in detail, and the following was proposed:

- Building envelope insulation;
- Replacement of windows;
- Overhaul of the heating system;
- Installation of heating substation (200 kW) with automatic control system;
- Establishing a Monitoring and Verification System.

Given the available financial resources, it was possible to realize the following measures:

1. Thermal insulation of external walls (insulation thickness of 10 cm) and the roof (15 cm) with polystyrene with a density of 16-18 kg/m^3. (Roof reconstruction as a renovation measure is needed because of roof deterioration.)
2. Replacement of all windows and the door of the main building (the gym is not included).

The project was completed in October 2012.

The school is connected to the district heating system; but due to local disagreements at the time of project implementation and afterward, a transfer was made to heating by means of the old boiler house on solid fuel (wood). Because of insufficientfinancial resources and theaforementioned disagreements, the reconstruction of the internal energy infrastructure was not the subject matter of the project.

Figure 1 shows the photo of the front side of the school building before and after the reconstruction.

[3]*The school gym was not included in the project because of insufficient resources.*

Figure 1. Photo of the school before and after the energy efficiency measures implementation

2. Basic Information

Basic Characteristics of the Building

BrankoĆopić Primary School, built in 1982, is located near the city center of Prijedor. The school is comprised of two buildings, the building where classrooms and offices are located, and the gym for sport and cultural activities. Approximately 920 pupils attend this school, and there are 85 employees. The school is owned by the City of Prijedor and funded by the RS Ministry of Education and Culture.

The school windows are the original windows from 1982, and have not been painted regularly; thus, they are in poor condition.

The building walls are 25 cm thick, and none of the walls, roof and the top ceiling slab are insulated. This creates a very large heat loss (much higher than allowed by the today's construction code).

Name of the building	Elementary School **Branko Ćopić**, Prijedor
Address	Rudnička 13, 79101 Prijedor
Year of construction	1982
Number of floors	Ground floor and first floor
Useful area of the building (m^2)	1988
Area of the gym (m^2)	591
Area of the attic (m^2)	870
Volume of heated area of the building (m^3)	6591
Area of external walls (m^2)	617
Area of windows (m^2)	534
Type of heating	The building is connected to the district heating system of the City of Prijedor. Alternatively, it can use its own boiler fired by wood or coal.
Estimate of heat energy consumption for heating (MWh). This estimate is made on the basis of available data from incomplete design documentation.	About 500MWh (196 kWh/m2 god)

Table 1. Basic Characteristics of the Building

Heating System

When the school was opened in 1982, the hot water supply for heating purposes was done from the coal and wood boiler house. Heat distribution was done by means of a radiator system. Later, the school was connected to the district heating system. The installed power of the substation is about 150 kW. The temperature regime of the heating system is 90/70 °C (dual pipe system).

As has already been mentioned, due to local disagreements, the school's management decided to terminate the contract with the local heating plant and start using again the existing boiler with coal and wood fuel.

2.3 Weather Conditions in Prijedor

Basic geographic and climate data for Prijedor are given in Table 2.

PRIJEDOR	Unit	Climate data location
Latitude	˚N	45,0
Longitude	˚E	16,7
Elevation	m	428
Heating design temperature	°C	-4,2
Cooling design temperature	°C	27,0
Earth temperature amplitude	°C	19,4

Table 2. Basic Geographic and Climate Data

Average monthly values of basic climate data for Prijedor are given in Table 3. The data is from the NASA Surface Meteorology and Solar Energy. The number of heating degree-days for Prijedor is equal to 2802. InTable 3, degree-days are calculated in accordance with the strict criteria for maintaining inside temperature without heating interruption and without taking into account the building heat inertia.

Month	Air temperature	Relative humidity	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days	Cooling degree-days
	°C	%	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	0,5	79,5%	1,31	96,9	2,9	-0,1	543	0
February	1,7	75,8%	2,10	96,8	3,1	1,3	457	0
March	5,8	70,1%	3,21	96,7	3,0	6,0	379	0
April	10,1	66,0%	4,06	96,4	3,0	10,7	238	2
May	15,4	61,3%	5,18	96,5	2,5	16,3	82	166
June	19,1	56,9%	5,87	96,6	2,5	20,3	0	272
July	21,8	51,5%	6,22	96,6	2,4	23,2	0	367
August	21,7	53,2%	5,30	96,6	2,5	22,7	0	361
September	16,6	62,4%	3,88	96,7	2,4	17,1	42	198
October	11,9	71,5%	2,36	96,9	2,7	11,9	189	59
November	5,9	80,1%	1,37	96,8	2,8	5,5	362	0
December	1,5	81,3%	1,08	96,9	3,0	0,9	510	0
Annual	11,0	67,4%	3,50	96,7	2,7	11,4	2.802	1.425
Measured at (m)					10,0	0,0		

Table 3. Average Monthly Values of Climate Data (RETScreen - http://www.retscreen.net/)

3. Basic Information about Energy Consumption

In the 2011/2012 season (some 180 days), approximately 160 cubic meters of wood were consumed. One cubic meter of firewood, when stacked in logs,contains approximately 0.7 $m^3$of solid wood. The wood density varies widely (0.4 – 0.8 m^3/kg) and depends on the type of wood. There is no reliable data about the type of wood used. The project of the building envelope reconstruction was completed in October 2012, and the above-mentioned consumption is a reference value for the calculation of effects achieved by reconstruction.

If the heat value of wood is around 5.5 GJ/cubic meter, then the total heat in the chemical energy of the fuel is equal to:

$$Q_{Wood} = 160\ \text{cubics} \times 5.5\ \text{GJ / cubic} = 880\ \text{GJ / a} \qquad (244.4\ \text{MWh / a})$$

It is not possible to determine the heat value without measurements. It is neither known what the type of wood concerned is nor its humidity or the way in which it has been cut in order to determine its actual mass. The value of 5.5 GJ/m^3 is an estimate based on experience.

The heated area is 2548 m2. The consumption of fuel energy per m2 of heated area of the building is equal to = $\frac{244400}{2548} = 95.9\ \text{kWh / (m}^2\ \text{a)}$

According to statements given by employees and pupils, it is possible to say that the quality of heating was substandard; that is, the temperatures were lower than the defined level (20 °C). There are no more reliable data and quantified evaluations of deviations of actual from desired heating.

After the reconstruction (replacement of windows and doors, insulation of walls and construction of a new insulated roof,although without reconstruction of the heating system and installation of thermostatic valves for fine regulation and monitoring), the consumption of firewood for heating purposes was reduced to about 110 cubic meters (2012/2013 heating season). This is a 31.2% reduction. The quality of wood and its humidity is again not known. There has been no survey regarding the subjective feeling of comfort. Therefore, without a properly conducted survey and only on the basis of sample discussions with employees and pupils, it is possible to conclude that the quality of heating has been improved and that the subjective feeling of comfort is significantly better than before the implementation of measures to increase theschool's energy efficiency.

4. Measures Applied for the Increase of Energy Efficiency

After numerous analyses and consideration of actual economic possibilities and technically realistic and logical measures, the following was done:

Thermal Insulation of External Walls and the Roof

Thermal insulation has been placed on the façade, consisting of thermal insulation panels made of expanded polystyrene. Thermal insulation panels are overlapping, 10 cm thick and have a heat conduction coefficient of 0.04 W/m K. The total area of the façade that has been insulated is about 620 m^2.

The warranty period for the façade durability excluding paint is 10 years.

Since the old roof was structurally unstable, it was necessary to reconstruct the roof and builda new one. On that occasion, a roof insulation of 15 cm was installed with the same characteristics as those of the wall. In the economic analysis of achieved effects regarding energy efficiency, only the price of roof insulation was taken into account and not the price of the entire roof reconstruction. Roof reconstruction is not a direct measure for the increase of energy efficiency.

The investment for this measure amounted to KM 108,000 KM or USD 73,459[4].

Replacement of Windows and Main BuildingExternal Door

Windows with PVC frames have been installed. They are white with front walls 2.6 mm thick, reinforced by galvanized profiles 1.5 mm thick. The heat transfer coefficient (U-value) of the frame is approximately 1.4 W/m^2K and of the glass approximately 1.1 W/m^2K.

The total area of the replaced windows and the door is about 320 m^2. The openings are of the same dimensions as the old windows. The technical characteristics of the windows and the door fulfill general and special requirements crucial for their intended purpose in building construction, and they are specified in compliance with regulation BAS EN 14351-1 (resistance to wind load, water tightness, air permeability, heat and sound insulation). The production and installation of windows had to be carried out in compliance with the applicable Regulations on Technical Characteristics for Windows and Doors (published in the "Official Gazette of the Federation of Bosnia and Herzegovina, Nos. 2/06, 72/07 and 32/08"). The windows were installed with external aluminum molding and the old internal sills made of stone were re-installed.

The warranty for window characteristics, including paint, is 10 years.

The investment in this measure amounted to KM 130,000 or USD 88,422.

[4] *1USD = 1.470217 KM (15 Jun 2013)*

5. Baseline Heat Energy Consumption

On the basis of available data concerning only the total consumption of firewood for heating and known outside temperatures, the average monthly consumption of heat energy is established as shown in Figure 2. Unfortunately, this is a very rough estimate of heat energy consumption, but at this moment, it is not possible to provide more accurate data. Originally, it was proposed to establish a monitoring & verification (M&V) program; but due to a lack of resources, this idea has been temporarily abandoned.

Under the present conditions, it is necessary to provide for daily measurements of outside temperature, daily measurements of firewood consumption and occasional control of temperatures in heated rooms. It is also necessary to devote special attention to the boiler load at the time when the school is in operation and during interruptions (nights, holidays and weekends). Since firewood as fuel parameters are not known, it is necessary to ensure at least basic data from suppliers (type, calorific value, humidity, etc.).

The expected monthly consumption of heat energy depending on the average monthly outside temperature after the application of measures for the increase of energy efficiency is given in Figure 2.

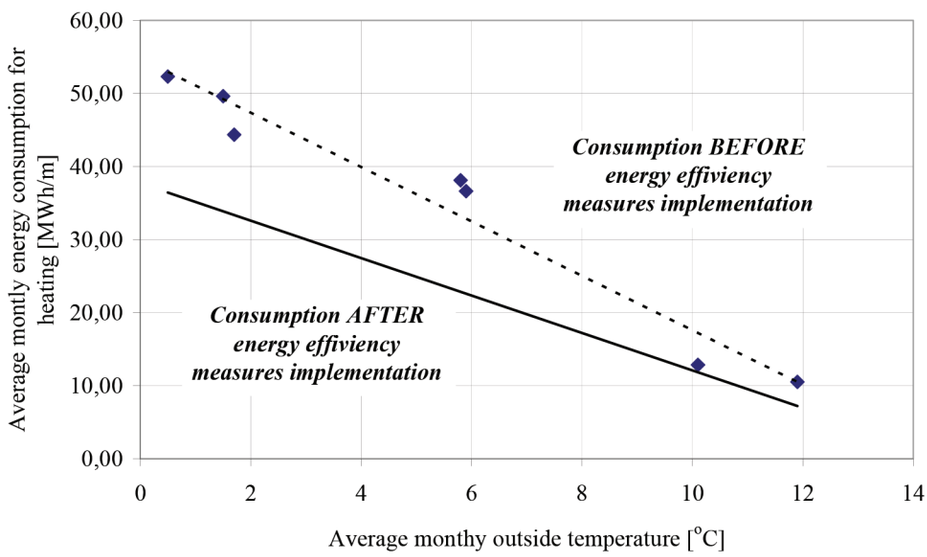

Figure 2. Target Line of Heat Consumption versus Average outside Temperature

6. Financial Evaluation

The total investment in the implementation of measures for the increase of energy efficiency is:

I_{total} = 240,000 KM

Energy saving for heating purposes in the 2012/2013 heating season is 0.312 × 244.4 = 76.25 MWh/a.

The equivalent of this energy in firewood is:

$$\Delta D = \frac{76.25 \cdot 1000}{5.5 / 3.6} = 50 \text{ cubic of wood per year}$$

The price of a cubic meter of firewood is 80 KM. The value of the reduced cost of wood is 4000 KM per year.

The project cost is: Pilot Project Value: 290,000 KM (RS Ministry of Education 50,000 KM, City of Prijedor 90,000 KM, USAID 3E 150,000 KM).

These savings cannot and should not be compared with the investment (290,000 KM). Namely, windows have been replaced not only because of the fact that they were not energy efficient, but also because they were in poor condition and had to be replaced for safety reasons. In addition, the price of firewood is low and amounts to only 0.05 KM/kWh in comparison to the price of fuel oil, which is around 0.21 KM/kWh. Also, the efficiency of wood fired boilers is lower than the efficiency of boilers fired by fuel oil or heating oil.

Prior to the pilot project, the school boiler could not adequately heat the school. Now, thanks to the project, the school does not need to reconnect to the district heating system to provide adequate thermal comfort. Thus, one can also analyze the project savings by comparing the current heating costs to the costs that would be incurred if the school was connected to the district heating system.

The measures reduced energy consumption by approximately 30%. Before the pilot project implementation, BrankoĆopić Primary School was connected to the fuel oil-based district heating network and was paying 85,000 KM for heating based on the heated area (square meters). Today, the school is heated using its own wood fueled boiler, and during the 2012/2013 heating season, the school used 110 m^3 of wood at a cost of 80KM/m3, totaling 8800 KM, with a savings of approximately 76,000 KM/52,000 USD annually. That means that the investment is recovered during a payback period of four years.

If BrankoĆopić Primary School were to be reconnected to the fuel oil-based district heating network and paid for actual heating energy consumed, it would pay, based on today's prices, approximately 36,000 KM/25,000 USD.[5] In that case, the payback period would be about eight years.

[5] *117,94 KM/MWh x 168MWh=**19,784KM**, plus a fee for heating capacity of 16571KM calculated 0,389*100KM/kW x 426kW=**16,571 KM***

7. Environmental Impact Analysis

Firewood is a renewable energy source; therefore, the emission of carbon dioxide is zero.

In this case, it is useful to calculate the reduction of CO_2emissions compared to the case of using the district heating system.

The factor of the equivalent emission of carbon dioxide for energy conversion of fuel oil is 0.2674 $kgCO_2e/kWh$. The reduction of emissions is equal to:

$$\Delta CO_2(\text{fuel oil}) = 0.2674 \cdot 244{,}400 = 65{,}353\ \text{kgCO}_2\text{e/a}$$

8. Conclusion

Expected and significant savings were achieved relative to the consumption of energy for heating purposes. Unfortunately, not all of the anticipated measures have been implemented due to a lack of financial resources. It is proposed to continue the project as soon as circumstances allow.

After energy management is improved and energy consumption is monitored as proposed, it is possible to expect further reduction of energy consumption.

In the next stage of the project, it is necessary to install thermostatic valves on heating radiators and improve energy management, primarily by means of measurements of energy consumption and regulation of the heating process in accordance with the outside air temperature.

The major benefits attained by this project are as follows:

- Improved thermal comfort through building envelope insulation and new windows;
- Increased public awareness of benefits of energy efficiency measures;
- Motivation of local governments to financially support such projects;
- Support of the local economy, as a local company performed the works;[6]
- Reduction of CO_2 emissions;
- Improvement of public health.

[6] *As the practice of paying for actual energy consumed is introduced, local companies will install thermal insulation, windows and repair the roof.*

2.7 Energy Efficiency Increase in "Dalibor Perković - Dali" Sport Hall, Livno

(Report finished in July 2013)

1. Introduction

The˝DaliborPerković – Dali˝ Sports Hall is funded and owned by LivnoMunicipality. Although the official working hours of the Sports Hall are from 08:00 to 22:00 (14 hours), in practice, they are much shorter because of widespreadeconomic problems. There are four employees in the building, and there are approximately 150 daily visitors. Below is a photo of the Sports Hall in Figure 1.

Figure 1. Photo of the Sports Hall in Livno before reconstruction

The Sports Hall was built in 1982, with a thermally inadequately insulated roof and outside walls. However, because of improper maintenance, the roof covering needed replacement (3/4 of the roof was repaired and insulated in 2010). The windows were single paned and caused high heat losses. The building had two floors with a total area of 1,743 m2. Originally, the building used to have radiator heating and air heating/ventilation system, but only the radiator heating system is working. The hot water is provided by a fuel oil boiler and central storage tank. Funds available for heating costs are insufficient and, as a result, the heating is turned off very often. The incompletely insulated roof and single paned windows, combined with frequent interruption of heating, resulted in low temperatures in the hall and inadequate thermal comfort. There was no air-conditioning system; and since the hall is rarely used in the summer, additional investment in the air-conditioning system was not justified.

The proposed project was to reduce thermal losses in the building, to use biomass for heating and improve comfort of visitors.

2. Basic Data

Year of construction	1982
Number of floors	2
Heated area	1,700 m^2
Heated volume	13,200 m^3
Outside wall area	596 m^2
Window area	236 m^2
Roof area (335 m2 was insulated during this reconstruction)	1,793 m^2
Duration of heating season in Livno	about 214 days
Calorific value of light fuel oil boiler	300 kW
Estimated average annual heating energy consumption	200MWh
Estimated annual cost of heating (only for fuel oil)	47,000 KM (2013 price)

3. Recommended Measures

After the Site Visit Report and Pilot Project Proposal evaluation, the following energy efficiency measures were proposed and implemented:

a. Reconstruction of Building Envelope to Improve Thermal Characteristics of the Building

The existing windows were removed and replaced by new PVC frames, white in color, with a minimum front wall thickness of 2.6 mm, strengthened by galvanized U or square metal profiles of 1.5 mm minimum thickness. The heat transfer coefficient (U-value) for the window frame is 1.4 W/m^2K and 1.1 W/m^2 K for the glass package.

The technical properties of windows should fulfill general and special requirements important for their intended purpose in the building and should be specified per BAS EN 14351-1 Standard (resistance to wind, water tightness, air impermeability, heat transfer and sound insulation). The manufacturing and the installation of the windows had to be done as per the existing Regulations for Technical Properties for Windows and Doors (published in the "Official Gazette FB&H, Nos. 2/06, 72/07 and 32/08). The windows were installed with the aluminum window sill outside and the PVC window sill inside.

b. Reconstruction of Radiator Heating System

The radiator system and heating installations were partially refurbished and 17 new radiators were installed. The radiator heating system is used to cover basic heat losses in the hall and for heating utility rooms. Thermostatic radiator valves were installed too.

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[7] *The calculations for the heat energy consumption and the cost for the Sports Hall are based on the assumption that the building is adequately heated during the whole heating season.*
[8] *1 US$ = 1.48 KM*

c. Reconstruction of the AHU System

The existing air handling unit (AHU) is completely deteriorated since it has not been used. Therefore, a complete reconstruction is required. The distribution of ducts for air supply and exhaust is shown in Figure 2.

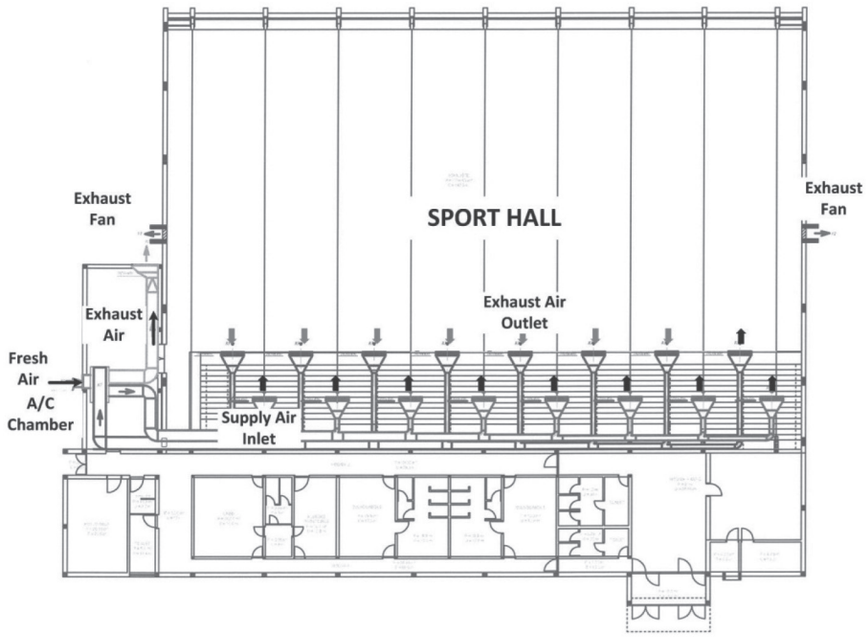


Figure 2. Drawing of Supply and Exhaust Air Ducts of the AHU system

The new air handling unit is equipped with a recuperator that extracts heat from thewarm exhaust air from the main hall to heat fresh, cold air being supplied. The recuperator of the AHU system is shown in Figure 3.

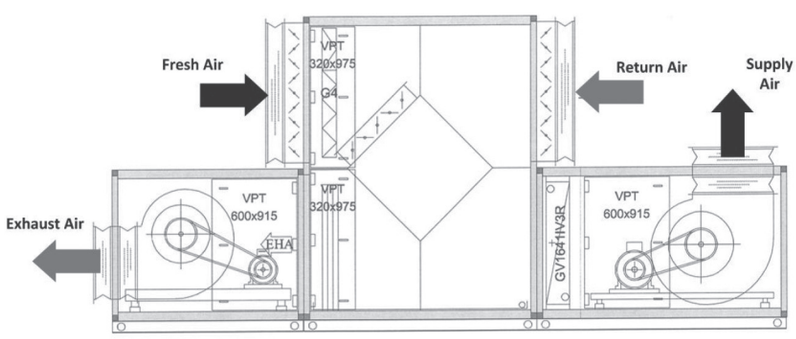


Figure 3.Recuperator of the New AHU System

d. Construction of Local 2-Pipe Heating System

The City of Livno is expanding the district heating system to include the buildings around theDaliborPerković-Dali Sports Hall. This facility is also included in this expansion. The system is indirect, and the substation is within the Sports Hall.

Figure 4 shows the cross-section of the building in which the substation is located, as well as the domestic hot water preparation system, electrical distribution and air handling unit (AHU).

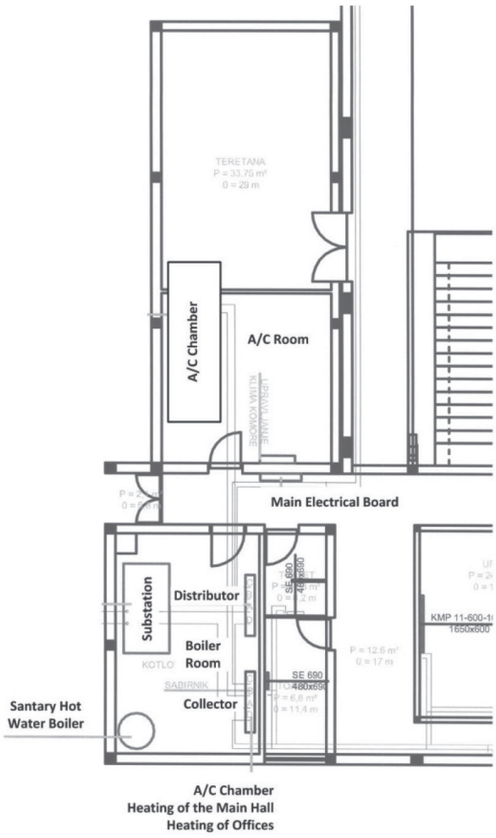


Figure 4. Disposition of Energy Supply Equipment

e. Reconstruction of Domestic Hot Water Preparation System

The existing domestic hot water preparation system was extended with a new solar heating system. Ten solar collectors were installed. The hot water tank volume is approximately 2.5 m3 and the capacity of the electric heaters is 3 × 10 kW. The tank is connected to the central heating system and to the solar collectors. The switching order of the heaters is: (1) Solar Collectors, (2) District Heating System and (3) Electric Heaters. Switching is performed manually.

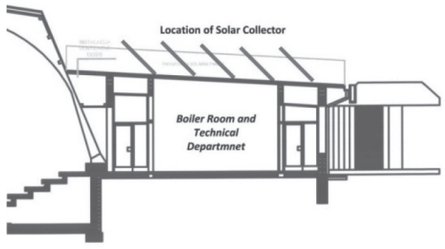


Figure 5. Location of Solar Collectors

f. Monitoring & Verification System

The remote system for monitoring energy consumption at the DaliborPerković- Dali Sports Hall consists of measuring circuits for:

1. Heat energy consumption (one measuring point);
2. Inside air temperature (four measuring points, three in the main hall);
3. Outside air temperature (one measuring point);
4. Heat energy generated by solar collectors.

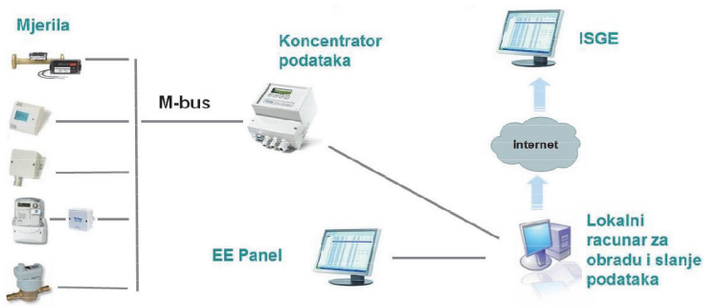


Figure 6. M&V System atthe DaliborPerković-Dali Sports Hall – Livno

4. Rationale of Proposed Energy Efficiency Measures

Prior to the Project's works, the Sports Hall was heated by a 300 kW fuel oil boiler located in the boiler room. Domestic water was heated by the same boiler during the heating season and by an electric heater after the heating season. Because of the very high cost of fuel oil, the heating system in the Sports Hall was often turned off to save money. To reduce costs and use a local energy source, the Sports Hall should be connected to the existing district heating network based on biomass boilers. The district heating system is owned by the ESCO Eco Energija Company (the Livno Municipality owns 10% of this company).

The type of biomass used is waste biomass. The ESCO Eco Energy Company collects wood waste from the wood processing industry and has entered into negotiations with the competent authorities for the following services:

- Cut and collect branches growing over roads that may impede traffic;
- Collect branches and trees from waterways; and
- Collect branches left in the woods after logging operations.

These activities were expected to create new jobs locally and utilize locally available resources thatpreviously had not been used.

The boilers used in the district heating system were designed and manufactured by a company from Bosnia and Herzegovina and had proved their quality and reliability over the past years.

This example of constructing a biomass-based district heating system can be followed by other municipalities that are using fuel oil as their main fuel source for public buildings, although biomass is locally available. This will further create new jobs and result in savings and lower dependence on imported fuel.

Waste biomass is considered an environmentally friendly fuel, since it is carbon neutral fuel, which means that it neither contributes nor reduces the amount of carbon dioxide emissions. The boiler's advanced design ensures complete combustion, high efficiency and a minimum amount of pollutant emissions.

To connect the Sports Hall to the district heating network, it was necessary to construct the supply pipeline and heating substation. The existing heating system was improved to provide adequate heating. The radiator system needed to be repaired, and the ventilation system neededa new air handling unit with heat recovery. The ventilation system was required according to the Building Code for such buildings. Also, the ventilation/air heating system in combination with the existing radiators would help in achieving an adequate indoor temperature more quickly.

The roof was not properly insulated; and in the summer of 2010, the municipality had already replaced most of the roof covering with a new covering of adequate thermal insulation. The same should be done with the remaining part of the roof. The outside walls were already thermally insulated since they were made of two rows of bricks with mineral wool sandwiched in between.

The windows were metal framed, single-paned and caused large heat losses. Therefore, it was necessary to replace them. There were also large areas covered with double-paned glass panels ('kopelit') which were damaged and should be replaced. If additional funds become available, replacement of 'kopelit' with polycarbonate panels should be considered.

One of the goals of the project was to introduce the practice of energy management. In order to manage energy consumption, it was necessary to monitor it. The monitoring and verification system serves to monitor energy consumption and verify projected (calculated) energy savings. Energy consumption, indoor and outdoor temperatures were monitored and recorded on an hourly basis and sent to a database that enabled easy data overview and analysis. Continuous monitoring will identify cases of excessive energy consumption and allow timely investigation and removal of its causes.

When planning and applying measures to increase energy efficiency, there is a large problem occurs where facilities are not used during sufficient periods of time. There are long breaks in heating, and then there is a short period in which the facility is used. This is positively reflected on the overall energy consumption but does not allow the establishment of a reliable system to monitor the effects of applied measures to increase energy efficiency. Under such conditions, it is not possible to establish an adequate and reliable baseline.

5. Assessments of Energy Efficiency Measures Effects

The advantages and benefits of this project were:

- To demonstrate practical energy savings and the use of renewable energy and improved thermal comfort through new windows, thermal insulation, biomass-based district heating, and energy monitoring;
- Partnership with one of the first ESCO companies in B&H, to promote the ESCO business concept through the USAID 3E pilot project;
- To promote the application of these measures through achieved energy and financial savings and improved comfort and to motivate citizens and governments to save energy and invest in energy efficiency measures;
- To motivate local governments to implement such projects; and
- To stimulate the local economy.

The estimated energy consumption, before and after measures, for the Sports Hall is shown in Table 1.

Energy Carrier	Unit	Present	After Measures	Savings
Heat energy	MWh	200	120	80

Table 1 Energy Consumption

Besides reducing energy consumption in the Sports Hall, additional financial savings would be achieved by connecting to the biomass-based district heating network, since the price for energy is lower. The cost of district heating was negotiated between the Municipality of Livno and the ESCO Eco Energy Company, and for the heating season of 2011/12, the cost was 98.2 KM/MWh plus VAT. The cost of fuel oil for that heating season period was approximately 200 KM/MWh, and the efficiency of the fuel oil boiler is assumed to be 75% on average. This is a very strong motive to implement the proposed measures.

The main problem in this building was an inadequate and uncomfortable temperature for sports and cultural activities of lower than 18 °C, while the standard temperature for comfort is from 21°C to 24°C in this type of facility. There were several factors influencing low temperatures in this building:

- Outdated and old joinery;
- Insufficient thermal insulation;
- Poor and inefficient heating system.

The management of the Sports Hall allocated insufficient funds for heating purposes. Out of the total energy costs, 32% were heating costs, and this did not provide a satisfactory temperature for people in the building. When the poor characteristics of the building were added to the insufficient use of energy fuel for heating, this building did not fulfill its function at all.

6. Baseline Energy Status

- kWhs of energy consumed monthly/annually, tonnes of fuels, amounts (KM) paid currently for electricity/heating/water;
- Average costs in this building related to electricity, water and heating energy are 26,112 KM in total per year and include (for the 2010/2011 heating season):

  - electricityat 12,372 KM;
  - waterat 5,316 KM; and
  - heating energy at 8,424 KM.

- From the energy aspect, an annual consumption of:

  - electricity is 90,256 kWh;
  - water is 3,038 m^3;
  - heating energy is 61,993 kWh.

The average consumption of primary energy for heating was 61,993 kWh, calculated on the basis of 5,491 liters of heating oil consumption. It must be noted that the building was operated with long breaks with and/or without insufficient indoor temperatures. The average annual heat energy consumption with this fuel oil consumption is only 36.5 kWh/m^2 year, which is very unlikely to be sufficient to provide adequate heating comfort, taking into account the construction (thermal) characteristics of the building.

The annual heat energy consumption estimated based on calculated heat losses would be about 200 MWh/year, if the building was continuously heating up to the designed temperature. After reconstruction of the building and energy system, the heat energy consumption was estimated at 120 MWh/year. This value was subsequently confirmed by measurements with the new M&V system of 122 MWh/year.

The current status (after reconstruction) of the building in terms of its construction requires about 122,000 kWh of final or useful energy to achieve the comfort level from the aspect of indoor temperature. The difference between these two values (pre- and post-reconstruction) shows that the consumption of 5,491 liters of heating oil per year in the facility's boiler room was not sufficient for continuous achievement of the required temperature. Therefore, the management of the Sports Hall was forced to save energy use by means of breaks in the heating regime and lower consumption of heating oil.

Based on the energy assessment, it was concluded that the condition of the current construction of the Sports Hall required10,806 liters of heating oil to cover122,000 kWh heat energy losses per year.

The source of information for heating oil consumption was the management of the Sports Hall in Livno.

The total investment for the proposed energy efficiency measures for the Sports Hall Livno amounted to205,700 USD (330,000 KM) and expected energy savings were estimated at about 78MWh per year. The financial savings are mainly a result of switching to a cheaper fuel. Measures

implemented on the sports hall itself represent renovation measures that provide adequate thermal comfort and functional heating/ventilation system.

Since the M&V equipment has been in place, it is possible to obtain some new data on energy consumption for heating. Thus the following values were measured:

October 2012:	7.59 MWh
November 2012:	16.68 MWh
December 2012:	27.89 MWh
January 2013:	27.19 MWh
February 2013:	22.43 MWh
March 2013:	15 MWh
April 2013:	5 MWh

For the whole heating season, it amounted in total to about 122.5 MWh. The specific consumption per m^2 of heated area is 72 kWh/m^2 per year. This is a very good consumption level.

The installed capacity of the substation was as much as 500 kW. There are 17 plate radiators (22K/600/200) of 4336 W, each providing heat capacity of 73.7 kW, and there are 257 Lipovica SE 690 radiator fins with a fin capacity of 168 W. The heat capacity of these radiators is 43.2 kW. The heat capacity of heaters of the air conditioning unit is about 130 kW; thus, the total installed heat capacity is 247 kW. This is a much lower capacity than that of the substation. The substation has been built in anticipation of new consumers in the future.

Measured heat energy consumption of 122 MWh in the season 2012/2013 indicates a low utilization of the installed capacity. Namely, if the season lasted for 200 days and the system was used 10 hours a day, heating power would be 61 kW, meaning that heating was used only in certain parts of the building that were occupied. For the purpose of proper estimation of energy for heating and for a proper estimate of the system's efficiency, it is necessary to monitor the occupancy of the building, indoor temperature at several characteristic places, outdoor temperature and exact times when the heating system is turned on and off, and the times of emergency heating operations preventing freezing of installations and relatively quick achievement of theoperating temperature. The M&V system enables monitoring of all the aforementioned parameters except occupancy.

Based on available data the first baseline consumption versus outside temperature was established (Figure 7).

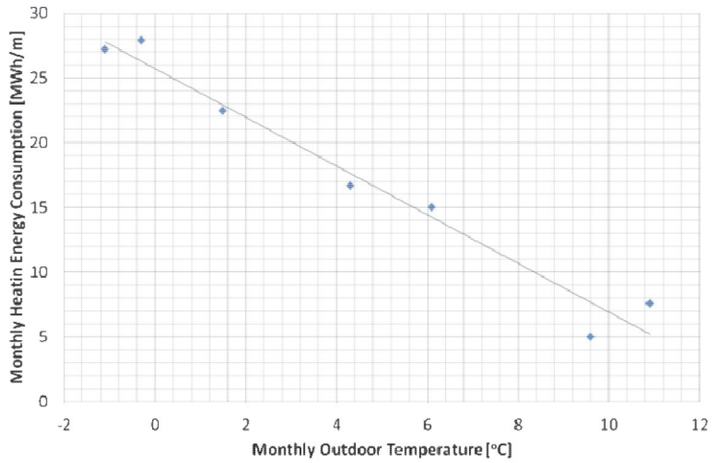


Figure 7. Heat Energy Consumption versus Monthly Outdoor Temperature for Reconstructed Heating System

7. Investments and Savings

ESCO Eco Energy Company and Livno municipality have memorialized their obligations in a contract relevant to the total financing of this project.

Proposed EE measures	
Install district heating supply line (used also for two apartment buildings)	$81,000
Replace and repair windows and replace the part of the roof cover	$51,000
Install heating substation	$13,500
Repair existing heating and ventilation system	$40,000
Solar heating collectors	$10,200
Install Monitoring and Verification System	$10,000
Total	$205,700

Table 3. Cost of EE Measures Implementation

The total project cost was 330,000 KM (Municipality of Livno146,000 KM; GIZ 6,000 KM; UNDP 7,000 KM; USAID 3E 171,000 KM).

In the 2012/2013 heating season, heat energy consumption was 122 MWh compared to the calculated heat energy consumption of 200 MWh necessary to provide the same comfort. Heat energy savings are thus40%, or 80 MWh/year. To produce 200 MWh of heat energy with a boiler that has an efficiency of 75%, it is necessary to burn 267 MWh or 26,500 liters of fuel oil at a cost of 2KM/liter, which equals 47,000 KM/a. In the 2012/2013 heating season the Sports Hall paid 14,000 KM for the 122 MWh they used.This means a cost savings of 33,000 KM/a. The investment (excluding the investment in additional boiler capacity) has a payback period ofapproximately10 years.

2.8 Heating – Reconstruction of the Boiler House in Public Building: Convention Hall - Museum – School of Music, BIHAĆ

1. Introduction

The Bihać Cultural Center Complex pilot project involved three separate buildings: the Cultural Center, the Cantonal Museum and the Art School.

Basic data about the project:

- The project is to reduce thermal losses in the building (only in the Cultural Center Complex), install a biomass boiler and connect the other two buildings to the heating system (Cantonal Museum and Art School)
- The Cultural Center was constructed in 1960
- The building is not thermally insulated
- Number of floors (basement + 3 floors)
- Heated area 1,245 m^2
- Heated volume 5,230 m^3
- Outside wall area 1,107 m^2
- Window area 455 m^2
- Number of operating days is about 188
- Heating supplied by individual electric heaters and firewood stoves
- Estimated annual heat energy consumption: 200 kWh/m^2 or 250 MWh[9]
- Estimated annual heating cost for the Cultural Center building: 38,000 KM ($29,000)
- Estimated annual heating cost for the Cantonal Museum and the Art School: 22,000 KM ($17,000)

    - Electricity 14,000 KM, 90 MWh
    - Firewood 8,000 KM

The Cultural Center Complex is located in downtown Bihać and it is the center of the town's cultural activities (Figure 1). It houses the largest auditorium used for concerts, plays and exhibitions. The complex was once owned by the army, but it is now used and financed by the Municipality of Bihać. The Cantonal Museum and the Art School are located in close proximity to each other and to the Cultural Center. In Figure 3, the yellow building on the left is the Cantonal Museum, and the grey building is the Art School.

[9] *The calculations for the heat energy consumption and the cost for the Cultural Center is based on the assumption that the entire building is adequately heated using electric heaters, which is the only available alternative at the moment.*

Figure 1. Cultural Center in Bihać

Figure 2. Art School in Bihać

Figure 3. Museum (Left) and the Side of the Art School (Right) in Bihać

2. Recommended Measures

After the Site Visit Report and Pilot Project Proposal evaluation, the following energy efficiency measures were proposed and implemented:

- thermal insulation of the façade and top floor ceiling in theCultural Center building;
- installation of a common biomass (pellet) heating systemfor all three buildings; and
- implementation of a system for Monitoring and Verificationof energyconsumption.

The façade is made of 35 cm thick brick walls, and the top ceiling slab is made of reinforced concrete, covered by a tin roof. The façade and the roof were not thermally insulated, which caused very significant heat losses (much higher than allowed by today's Building Code). The roof insulation has a short payback period.

The original windows were two separable, back to back, single panes in wood frames. The windows were not painted regularly and were in poor condition. They allowed outside air and dust to infiltrate the building and they were also a poor barrier to outside noise. One quarter of the windows had been replaced by aluminum framed, double paned windows, but aren't in good condition and do not satisfy today's Building Code requirements.

Two attached buildings are located less than 50 m from the Cultural Center. Originally, all three buildings were connected to a common heating system, with a boiler house located nearby. The boiler house was destroyed during the 1992-1995 war, but all three buildings have radiators and internal heating distribution networks. There is a heating distribution substation in the Cultural Center, but it has been out of operation for several years. It had outdated equipment and needed to be replaced. The Cantonal Museum was fully renovated, while the internal heating distribution networks of the other two buildings needed minor repairs to be put into operation. Before reconstruction under the auspices of this project, the buildings were only partially heated using electric heaters and firewood stoves, which was highly inefficient. To solve the problem, two biomass (pellet) boilers and a heating distribution substation were installed in the Cultural Center and heating distribution pipes were laid to heat the Cantonal Museum and the Art School. Since no improvements in the thermal characteristics of the Cantonal Museum have been made in this project, it will consume the same amount of energy. Because of the higher efficiency of pellet boilers compared to firewood stoves, there would be some reduction in fuel consumption in the Art School buildings. Instead of using electricity for heating, both buildings would use biomass after implementation of the measures - a much cheaper and environmentally friendly fuel.

One of the special goals of the project was to introduce the practice of energy management. In order to manage energy consumption, first it must be monitored. A monitoring and verification system serves to monitor energy consumption and verify projected (calculated) energy savings. Energy consumption, indoor and outdoor temperatures are monitored and recorded on an hourly basis and sent to a database that enables easy overview and analysis of data. Continuous monitoring identifies cases of excessive energy consumption and allows timely investigation and removal of its causes.

3. Technical and Financial Analysis

The proposed measures were renovation measures. While the payback period is rather lengthy (10 years), the major benefits they provide must be given weight, such as proper thermal comfort of a building that is of great public importance. The estimated energy consumption, before and after measures, for the Cultural Center building, Cantonal Museum and the Art School buildings are shown in the following table:

	Energy Carrier	Unit	Present	After Measures
Cultural Center	Electricity	MWh	250	0
	Pellet	MWh	0	120
Cantonal Museum	Electricity	MWh	35	0
	Pellet	MWh	0	35
Art School	Electricity	MWh	60	0
	Firewood	MWh	160	0
	Pellet	MWh	0	160

Table 1. Energy Consumption

The reduction of CO_2 emissions achieved by implementation of the measures (replacing electricity with pellets) is about 181tonnes per year (Appendix 3).

Besides reduced energy consumption in all three buildings, additional financial savings will be achieved through the use of pellets instead of electricity in all three buildings.

The cost for the project and the payback period is shown in the following table, which assumes that the price per kWh remains the same and the payment for actual energy consumed is introduced.

Energy efficiency Measures	Investment [$]	Annual Savings Est [$]	Simple Payback Period [Year]
Thermal insulation (roof and walls) (77000 $US); Replacement and repair of windows (75000 $US); Installation of biomass boiler, heating substation and distribution piping to adjacent buildings (140000 $US); Monitoring and Verification System (25000 $US)	360,000	35,000	10.3

Table 2 Preliminary Cost - Benefit analysis for Recommended Measures

4. Conclusions

Numerous analyses of additional investments in the improvement of thermal insulation proved their economic and environmental justification in the majority of cases. In addition to a permanent reduction of costs for heating, better thermal insulation of the building also implied better climate and comfort inside the building, healthier utilization and a longer service life of the building.

By implementing this project, the following benefits were achieved:

- Energy savings, the use of renewable energy and improved thermal comfort through new windows, thermal insulation, biomass heating and energy monitoring were practically demonstrated;
- Application of these measures through achieved energy and financial savings and improved comfort was promoted, and citizens and governments were motivated to save energy and invest in energy efficiency measures;
- Local governments were motivated to financially support such projects and the local economy – local companies will implement measures and use the acquired experience to expand their businesses;
- Reduced use of electricity and firewood;
- Reduced CO_2 emissions;
- Improved public health.

2.9 SOS Children's Village in Gracanica (Heating System Energy Efficiency Improvement of Two Buildings)

1. General Information

The USAID Project Enterprise Energy Efficiency - 3E, in cooperation with the SOS Children's Village in Gračanica, implemented pilot projects in two buildings. The works on the reconstruction of energy systems involved:

EEM 1 Repair of windows in two buildings

EEM 2 Installation of solar collectors for domestic hot water preparation

Name	Building No. 1	Building No. 2
Address	SOS Children's Village	Children's Village
Year of construction	1998	1998
Number of floors	2 + cellar	2 + cellar
Heated area (m^2)	225	193
Volume of heated area (m^3)	585	502
External walls area (m^2)	184	148
Area of windows (m^2)	38	48
Number of tenants	7	7
Duration of heating season (days)	184	184
Annual consumption of energy for heating	3964 liters of fuel oil (45MWh)	3279 liters of fuel oil (37MWh)
Annual heating costs (KM)	8000	6500

Table 1. Main Characteristics of Buildings

Figure 1. Photographs of Buildings 1 (Larger House)(on the Left) and 2 (Smaller House) (on the Right)

The works included in EEM 1 represented **investment maintenance measures** for the building and investments in the revitalization of windows in order to maintain the designed quality of the building as a whole, i.e., the quality of operating conditions and anticipated energy costs. The measures of investment maintenance increased the value of the building, i.e., the compensation of depreciated value of the building.

Works anticipated by EEM 2 **required new investments** in the system for domestic hot water preparation, which will directly increase the value of the building.

2. Technical Requirements of the Project

EEM 1 Repair of Windows in Two Buildings

The windows were as old as the building (13 years old). However, they were made of low quality and insufficiently dried wood. As a result, the windows did not seal properly and allowed outside air and dust to infiltrate the building; further,theywere a poor barrier to outside noise. Replacing them was not financially reasonable since they could be adequately repaired at a much lower cost.

EEM 2 Installation of Solar Collectors for Domestic Hot Water Preparation

In each building, there were electric water heaters in bathrooms and small counterflow water heaters in the kitchen. Within the EEM 2, it was necessary to reconstruct the existing domestic hot water system, reconstruct the installations and connect a new hot water tank of 300 liters that will be placed in the cellar. Solar collectors should be installed on the roofs of buildings. The operational schematic for the new system of domestic hot water preparation is given in Figure 2.

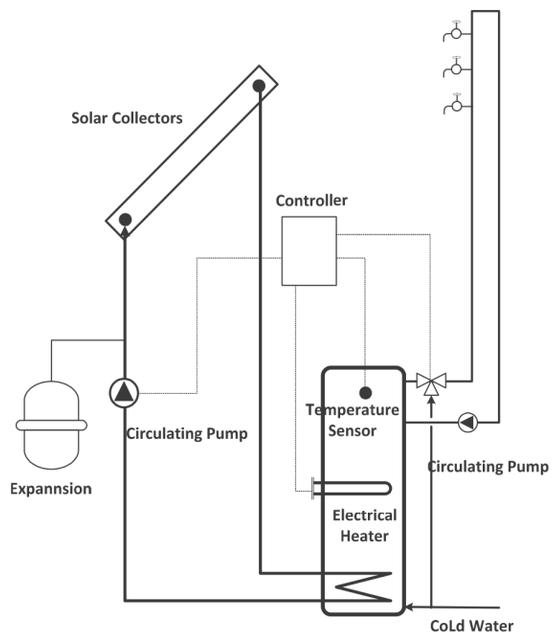


Figure 2.Operational schematic of Domestic Hot Water Preparation System

Table 2 provides details related to the reconstruction of joinery in the small house. In the large house, the volume of works is almost identical and will not be given separately.

Walls	**North**	**East**	**South**	**West**
Ground floor, [m^2]	30.85	23.65	30.85	23.65
Windows, [m^2]	1.47			
Doors, [m^2]	1.85			
Windshields, [m^2]	1.80			
GROUND FLOOR joinery	5.89	8.72	4.42	10.19
FLOOR joinery	5.89	8.72	4.42	5.89
Total area of joinery	11.79	17.44	8.84	16.09
Total area of walls	49.91	29.86	52.86	31.21
Total heated area	190			
Total heated volume	475			

Table 2. Area of Doors and Windows to be Replaced (Small House)

Table 3 gives average energy consumption per house. The specific energy consumption for heating is very high, and it is very likely that the main reason therefor is poor quality joinery.

LFO consumption per house	3279	Liter
Calorific value of LFO	11.29	kWh/kg
Fuel energy	37019	kWh
Annual fuel consumption	6722	KM
Electricity consumption per house	11500	kWh
Energy price	2153	KM
Specific consumption of heating energy	194.8	kWh/m^2 y

Table 3. Energy Consumption in the Small House

In the initial stage of the project, it was planned to introduce a Monitoring & Verification system that would include a system for remote reading of energy consumption (similar to the project in Mostar). Since this implied a relatively high investment that would considerably increase the payback period, this measure was abandoned.Monitoring & Verification can be implemented with manual readings of energy consumptions and indoor and outdoor temperatures.

3. Investments

Proposed EE measures after USAID 3E analysis:

-	Repair of windows (2 houses)	8,200 KM
-	Installation of 2 solar water heating systems	$17,800 KM
	Total cost of proposed EE measures	**26,000 KM**

4. Technical, Environmental and Financial Analysis

The estimated energy consumption, before and after measures for both houses is shown in Table 4.

Energy carrier	Unit	Present	After measures	Savings
Light fuel oil	MWh	82	66	16
Electricity	MWh	23	18	5

Table 4. Energy Consumption

The estimate for heating energy savings was done on the basis of assessed effect of reduced air infiltration.

The estimate of electricity savingswas done on the basis of solar collector capacity and calculated electricity equivalent for water heating.

In Appendix 3, there are coefficients for the calculation of CO_2 emissions. The coefficient for electricity from the grid is 0.5246 $kgCO_2e/kWh$, and for light fuel oil (diesel)is 0.2517 $kgCO_2e/kWh$. The reduction of CO_2 emissions is as follows:

$$E_{CO2}[kgCO_2/a] = 16000 \cdot 0.2517 + 5000 \cdot 0.5246 = 6650 \ \ [kgCO_2/a]$$

The cost of measures and the payback period is shown in Table 5, assuming that the price per kWh remains the same.

Measures	**Investment [KM]**	**Annual Savings Estimate [KM]**	**Simple payback period [year]**
Repair of windows, installation of a solar water heating system, establishment of a Monitoring and Verification System	26,000	3,500	7.4

Table 5. Preliminary Cost - Benefit Analysis for Recommended Measures

5. Conclusions

The expected significant savings are achieved relevant to the consumption of energy for heating purposes and hot water preparation.

The major benefits attained by this project are as follows:

- Improved thermal comfort through windows and outside door refurbishment;
- Demonstration of benefits of solar energy application for hot water preparation;
- Increased public awareness of benefits of energy efficiency measures;
- Motivation of local governments to financially support such projects;
- Stimulation of local economy – as energy costs continue to increase, local companies will install thermal insulation, windows and solar thermal systems;
- Reduction of CO_2 emissions; and
- Improvement of public health.

2.10 Utilization of Biomass in "Olovo" Elementary School and "Musa ĆazimĆatić" Secondary School, Olovo

1. Introduction

The schools are located near downtown Olovo, about 50 meters apart. The layout plan of schools and the new common boiler house are presented in Figure 1, and Figures 2 and 3 are photographs of the schools. Despite their close proximity to each other, each school previously had its own boiler house. The primary school used light fuel oil and the secondary school used coal. Both schools are owned and funded by the Cantonal Ministry of Education. The schools' business hours are Monday to Friday from 8 a.m. to 7 p.m.,with variable hours during weekends.

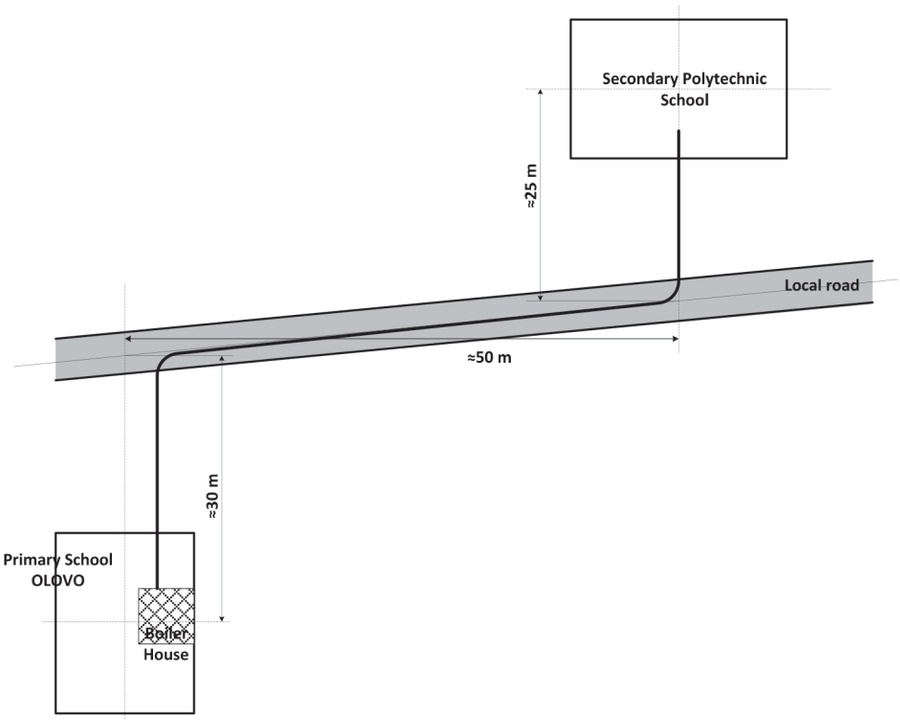


Figure 1. Layout Plan of Schools

Figure 2. Photos of the Primary School "Olovo" in Olovo

Figure 3. Photos of the Secondary Polytechnic School in Olovo

2. Basic Data

"Olovo" Primary School	**Secondary Polytechnic School**
- Year of construction = 1975 - Number of floors = 2 - Heated area = 2500 m^2 - Top floor ceiling area = 750 m^2 - Heated volume = 7,500 m^3 - Outside wall area = 600 m^2 - Window area = 600 m^2 - Number of students = 630 - The building is not thermally insulated - Number of operating days = 150-180 days - Heat source = light fuel oil - Heating supplied by two light fuel boilers, 2x230 kW - Annual total energy consumption = 30 tons of light fuel oil (350 MWh) - Total annual light fuel oil costs = 65,000 KM (50,000 USD)	- Year of construction = 1967 - Number of floors = 3 - Heated area = 2140 m^2 - Top floor ceiling area = 500 m^2 - Heated volume = 6,000 m^3 - Outside wall area = 800 m^2 - Window area = 550 m^2 - Number of students = 450 - The building is not thermally insulated - Number of operating days = 150-180 days - Heat source = coal - Heating supplied by a coal boiler, 320 kW - Annual total energy consumption = 90 tons of coal (400MWh) - Total annual coal costs = 18,000 KM (13,000 USD)

3. Recommended Measures

After the Site Visit Report and Pilot Project Proposal evaluation, the following energy efficiency measures were proposed:

a) Construction of a new boiler house with a biomass boiler that will be used by both schools.
b) Installation of a Monitoring & Verification System
c) Installation of thermostatic valves in both schools

Due to insufficient funding, the third measure was not implemented and it was recommended to the school management to implement it independently from the project as soon as possible.

a. Construction of a new boiler house with a biomass boiler that will be used by both schools

The conceptual engineering design envisioned a woodchip-based boiler house as a separate building located near the secondary school. The boiler was to be connected to the heating system of each school through new heating pipelines. The old boilers were to be left as fully functional backups that could be put into operation by manually closing and opening valves.

Architectural design of the boiler house and design of electrical and mechanical systems was completed in March 2012, and construction began in September 2012 after the construction permit was issued in August 2012. The boiler house was put into operation in February 2013.

Some details of the new boiler house are given in Figure 4.

Figure 4. Photos of the New Boiler House

b. Installation of a Monitoring & Verification System

The remote system for monitoring energy consumption and temperatures at the primary and secondary schools in Olovo consists of measuring circuits for (Figure 5):

1. Heat energy consumption (one measuring point for each school)
2. Electrical energy consumption of the boiler house (one measuring point)
3. Inside air temperature (three measuring points in each school, 6 in total)
4. Outside air temperature (one measuring point)

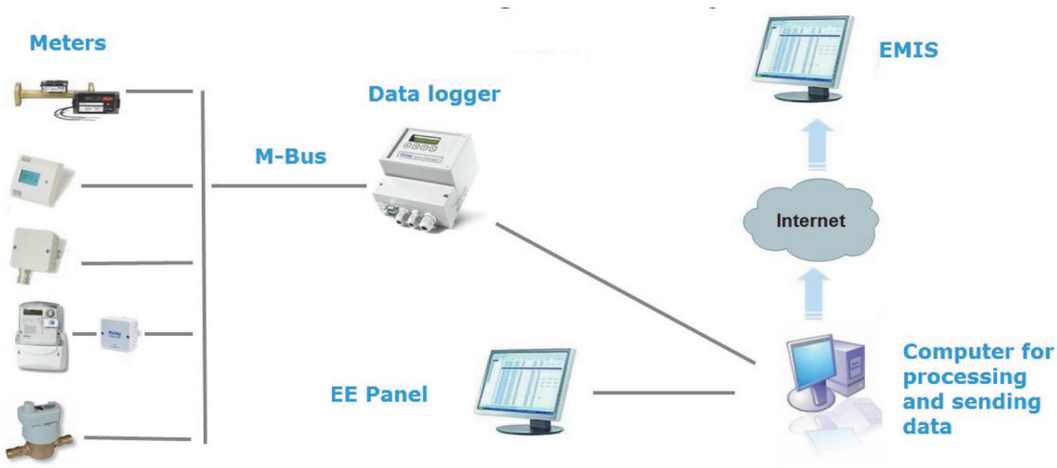


Figure 5. M&V System at Primary and Secondary Schools in Olovo

4. Rationale of Proposed Energy Efficiency Measures

The primary school used light fuel oil, and the secondary school used coal for heating. A single boiler house based on biomass (wood chips) should have been constructed for several main reasons:

1. Biomass is a renewable resource and there were a number of wood processing plants in the area where the schools are located that could provide the wood waste (wood chips).
2. Waste biomass is considered an environmentally friendly fuel since it is carbon neutral fuel, which means that it neither contributes to nor reduces the amount of carbon dioxide emissions. The boiler's advanced design ensured complete combustion, high efficiency and a minimum amount of pollutant emissions.
3. Biomass (wood chips) was priced similarly to coal and was a lot less expensive than light fuel oil, which would result in significant financial savings.
4. The type of biomass boiler that was installed was able to handle different types of biomass such as briquettes and logs, and was designed for automatic operation burning wood chips made of bark, branches and general wood waste from the wood processing industry. Wood chips are the most economical type of biomass and the primary fuel, but because of the flexibility of the boiler, the schoolswere able to use briquettes and logs should market conditions such as availability make their use prudent.

5. The schools were very close to each other, and their having only one boiler house and one type of fuel would reduce maintenance and operational costs (other than lower fuel costs).
6. The boiler was designed and manufactured by a company from Bosnia and Herzegovina and had proved its quality and reliability over the past two years in the district heating system for the Municipality of Livno.
7. This example of constructing a biomass-based district heating system could be followed by other municipalities that are using fuel oil as the main fuel source for public buildings,even though biomass is locally available. This will further create new jobs and savings and lower dependence on imported fuel.

a. Promotion of ESCO financing model

An additional goal of this pilot project was to promote the Energy Services Company – ESCO model in energy efficiency projects. The ESCO market was almost non-existent in BiH, mainly because ESCO companies did not have enough capital to finance larger projects and loans were difficult to obtain and had high interest rates. Also, the risk (perceived and actual) of the customer, public or private, not paying regularly for the service provided by the ESCO was high. Since the judicial system was overburdened and slow, litigation may take a long time, even years, during which the ESCO must continue paying for its loan and litigation costs.

Both schools should have been thermally insulated and have their windows replaced, and those measures would have been the first logical step in improving energy efficiency. However, in this project, those measures have a longer payback period than switching to biomass and thus were not as attractive as an ESCO project. Switching from coal to biomass was also not attractive as an ESCO project; but since the primary school uses fuel oil, the whole project became financially feasible. Even so, because of the undeveloped ESCO market, very few companies were ready to get involved in such projects. Thus, USAID 3E provided approximately half of the investment as a grant, while the other half was provided by Caritas Suisse and an ESCO company (Dvokut Pro from Sarajevo) to be repaid over a period of five years. A tripartite contract was signed between the Ministry of Education of Zenica-Doboj Canton, Caritas Suisse and Dvokut Pro, providing that Dvokut Pro would provide heating to the two schools and the Ministry would pay for this service annually, over a five-year period, the same amount it paid for the fuel for the two schools in the 2011/2012 heating season. During the five-year period, the Ministrywais protected from an increase in fuel costs and the cost for the biomass boilers house was paid from savings in the fuel cost.

b. Energy Management

One of the goals of the project was to introduce the practice of energy management. In order to manage energy consumption, it was necessary to monitor it first. A Monitoring and Verification system serves to monitor energy consumption and verify projected (calculated) energy savings. Energy consumption, indoor and outdoor temperatures are monitored and recorded on an hourly basis and sent to a database that enables easy data overview and analysis. Continuous monitoring would identify cases of excessive energy consumption and allow timely investigation and removal of its causes.

5. Assessment of Energy Efficiency Measures Effects

The advantages and benefits of this project are:

- Demonstration of practical financial savings by switching to a cheaper fuel source;
- Usage of renewable and environmentally friendly fuel;
- Promotion of the ESCO business model;
- Motivating local governments to implement such projects;
- Stimulating the local economy.

The main goal of the project was financial savings, not energy savings, even though some energy savings would be achieved through higher boiler efficiency.

The assessed heat energy consumption in both schools before reconstruction was as follows:

Secondary School :

Coal: About 90 t/year = 90000 [kg/year] × 16 [MJ/kg]/3600 = 400 MWh/year
Average efficiency of a coal fired boiler is 0.7.

Elementary School :

Light fuel oil: about 30 t/year = 30000 [kg/year] × 42 [MJ/kg]/ 3600 = 350 MWh/year
Average efficiency of a light fuel oil fired boiler is 0.8.

The estimate of total heat energy delivered to the radiators was :

$$Q_{\Sigma} = 400 \cdot 0.7 + 350 \cdot 0.8 = 560 \text{ MWh / a}$$

Average efficiency of both boilers is 560/(400+350) = 0.75

After the installation of a biomass boiler, fuel consumption would be as follows:

$$Q_{new} = \frac{560}{0.8} = 700 \text{ MWh / a}$$

The average efficiency of a new biomass boiler was assumed to be 0.8.

The expected reduction of energy consumption was (450+350)-700 = 50 MWh/a.

In February 2013, the new plant was put into operation and the heat meterfor the primary school measured heat energy consumption of 185 MWh and of 133 MWh in the secondary school for the period February to May 2013, or one-half of the schools' heating seasons. Measurements were carried out on the water side.and the consumption of wood chips and briquettes (used as ancillary fuel) amounted to around 400 MWh. At the annual level, this would imply fuel consumption of around 800 MWh, which was confirmed in calculation checks.

6. Baseline Energy Status

Secondary Polytechnic School

- Annual total energy consumption = 90 tons of coal (400 MWh)
- Heated area = 2140 m^2
- Specific energy consumption is 400,000 kWh/2140 m^2 = 187 kWh/m^2 a

"Olovo" Primary School

- Annual total energy consumption = 30 tons of light fuel oil (350 MWh)
- Heated area = 2500 m^2
- Specific energy consumption is 350,000 kWh/2500 m^2 = 140 kWh/m^2 a

No indoor temperature measurements prior to project implementation were available; and in view of the very poor thermal characteristics of the buildings, it was possible that even specific energy consumption was high and that indoor temperatures were below 20 ^{o}C.

7. Project Costs

Projects costs are given in Table 1. For the construction of the boiler house and hot water pipeline, 268,796 KM were spent. The costs for setting up M&V were 30,372 KM. The cost for the feasibility study, design documentation and supervision was 24,200 KM. Finally, total project costs were 323,368 KM (24,200 + 268,796 + 30,372 = 323,368 KM).

		KM	**KM**
A	**BOILER HOUSE**		**48581**
1	Preliminary works	580	
2	Terrain preparation	995	
3	Concrete works	13855	
4	Asphalting	2052	
5	Masonry works	10897	
6	Hydro insulation	4562	
7	Locksmith works	4760	
8	Roof construction	8295	
9	Painting	969	
10	Façade	1616	
B	**EQUIPMENT FOR BOILER HOUSE**		**144465**
11	Mechanical works	132919	
12	Energy consumption meters	0	
13	Equipment	2631	
14	Electric equipment	8915	
C	**PIPELINE**		**36694**
15	Earthworks for the pipeline	9817	
16	Pipes, valves etc.	25127	
17	Rinsing the installation, cold and hot testing of pipeline	1750	
	TOTAL without VAT		**229740**
	VAT 17%		**39056**
	TOTAL including VAT		**268796**

Tabela 1. Troškovi projekta

8. Investments

For the boiler house and the pipeline, 268796 KM were paid as follows

- USAID/3E – 120,000.00 KM with VAT (grant)
- Caritas Switzerland – 124,350.03 KM with PDV (funds that will be repaid)
- Dvokut pro d.o.o. Sarajevo – 24,450.00 KM with VAT (funds that will be repaid)

Caritas paid in total 148,550 KM (124,350 KM for the boiler house and 24,200 KM for the feasibility study, design documentation and supervision of construction works).

Costs of 173,000 KM are to be repaid over 5 years (148,550 KM to Caritas Switzerland and 24,450 KM to ESCO service, i.e., to Dvokutpro d.o.o.)

The Ministry pays 85,000 KM annually: 35,000 KM goes to repayment of investment costs over 5 years and 175,000 KM will be repaid to Caritas Switzerland and Dvokutpro d.o.o.

9. Conclusions and recommendations

The pilot project achieved several important goals:

- Half of the project costs were financed via an ESCO model;
- The ESCO model enabled financing of the project without the Ministry having to take out a loan and kept the energy costs fixed over a period of five years;
- Coal and fuel oil were replaced with renewable, locally available, cheaper and CO2 neutral wood chips;
- Better thermal comfort was provided to students and staff, which was monitored continuously via thermometers included in the automated Monitoring and Verification (M&V) system; and
- The installed Monitoring and Verification (M&V) system presented a basis for introduction of energy management, which led to continuous reduction of energy costs while preserving the required comfort.

Even though the solicitation was published in the daily newspapers with the highest circulation, only three companies submitted offers for project implementation. The solicitation requirements were to build the boiler house and to provide heating to the schools including maintenance, operation and procurement of fuel for a period of five years. Based on 3E's experience in implementation of other pilot projects, many more offers would have been received if only the construction of the boiler house were required. The low number of offers shows how undeveloped the ESCO market is, even though the project is financially feasible given the low price of wood chips at the time. In September 2013, the cost of wood chips within 20km of the wood processing plant in Olovowas approximately 15KM/m3 or approximately 47 KM/ton for mixed wood with less than 35% moisture content, having a calorific value of approximately 11.2 MJ/kg, which results in an energy price of 15.1 KM/MWh. That is much cheaper than fuel oil (210 KM/MWh) or coal (45KM/MWh).

There was risk for the ESCO company that the price of wood chips would increase while the price for providing heating is fixed at 50,000 KM/year. Currently the price of wood chips in Croatia is about 80 KM/ton, which would increase the energy price to 25.8 KM/MWh. Also, public institutions in BiH often take a long time to pay their bills.

An additional problem was the lack of application of standards regulating the quality of wood chips. The European standards such as "EN 14961-5:2012 Solid biofuels - Fuel specifications and classes - Part 5: Firewood for non-industrial use" and "EN 15234-4:2013 Solid biofuels - Fuel quality assurance - Part 4: Wood chips for non-industrial use" had been adopted by the Institute for Standardization of BiH but they were not applied in the market. The result was that the buyer could not be confident in the quality of wood chips, unlike the quality of fuel oil, thereby increasing the risk. For example, an oversized piece of wood chip can damage the transport system in the boiler house and result in stoppage of the heating system and significant repair costs.

To develop the ESCO wood chip market it is necessary to do the following:

- Implement more ESCO pilot projects with the involvement of international development organizations until the confidence of private companies and public institutions is such that business arrangements reach a level that involvement of international development organizations is no longer necessary,
- Provide necessary conditions (publicly owned laboratories) and enforce application of adopted European standardsregulating the quality of wood chips.

2.11 Travnik Municipal Building (Building Envelope Reconstruction)

1. Introduction

The Travnik Municipality building (Figure 1) was used by the administrative staff (110 employees), the Municipal Assembly, the Cantonal Assembly, and citizens. Energy costs for the building were paid from the Travnikmunicipal budget. The building was connected to the coal fired district heating network. The heat energy consumption was measured by a heat meter and billed according to consumption.

The Municipality building is located in the center of town. The building has three floors and a total usable area of 2,500 m2. In one part of the building, an additional floor was constructed in 2009, and the roof on this new floor was thermally insulated. The window frames in the old part of building were made of wood and were in poor condition. In the upgraded part of the building, as well as the Municipality hall room, the windows had been changed and aluminum-framed double paned windows had been installed. Poor building insulation led to increased heat losses during the winter, as can be seen in Figure 2.

Figure 1. Photos of the Travnik Municipality building before (left) and after (right) energy efficiency measures

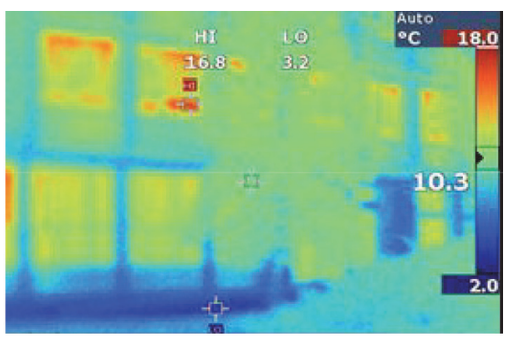


Figure 2. Thermography photo of Travnik Municipality building with areas of heat losses clearly visible

2. Basic Data

- Heating provided by the coal fired district heating network
- Heat charged based on actual consumption
- Year of construction = 1960
- The building was not thermally insulated
- Number of floors = 3 (including ground floor)
- Building area = 2,500 m^2
- Heated area = 1,883 m^2
- Top floor ceiling area = 466 m^2
- Heated volume = 5,064 m^3
- Outside wall area = 990 m^2
- Window area = 380 m^2
- Number of employees = 110
- Number of daily visitors (approximate) = 300
- Number of operating days = 260 days per year
- The time of the building use was 8.5 hours a day, from 07.00 to 15.30
- Heating supplied by a heating substation of the district heating network
- Heating elements were radiators equipped with thermostatic valves
- Heat energy consumption for the 2011/2012 heating season = 189,430 kWh
- Heating was charged according to consumption (heat meter)
    - Cost for energy was 0,1805 KM/kWh
    - Monthly cost for capacity (12 months per year) = 2,915.73 KM (6,125 KM/kW*406,87 kW=2492,08 KM + VAT)
- Electricity consumption in 2011 = 126,000 kWh
- Electricity cost in 2011 = 27,400KM

3. Recommended Measures

After the Site Visit Report and Pilot Project Proposal evaluation, the following energy efficiency measures were proposed:

a) Replacement of old, wood-framed windows
b) Insulation of façade and un-insulated parts of the roof
c) Installation of a Monitoring & Verification System

a. Replacement of old, wood-framed windows

The old, wood-framedwindows were to be replaced with PVC-framed windows having a total value of heat transfer coefficient of 1,4 W/m^2K or less. The total area of windows that need to be replaced is 290m^2.

b. Insulation of façade and un-insulated parts of the roof

The façade was to be insulated with 10cm EPS and un-insulated parts of the roof with 15 cm EPS. The façade area of was 820m^2 and the area of un-insulated parts of the roof was 530m^2.

c. Installation of a Monitoring & Verification System

The remote system for monitoring energy consumption and temperatures at the Travnik Municipality building consisted of measuring circuits for:

- Heat energy consumption (one measuring point)
- Electrical energy consumption of the boiler house (one measuring point)
- Inside air temperature (three measuring points)
- Outside air temperature (one measuring point)

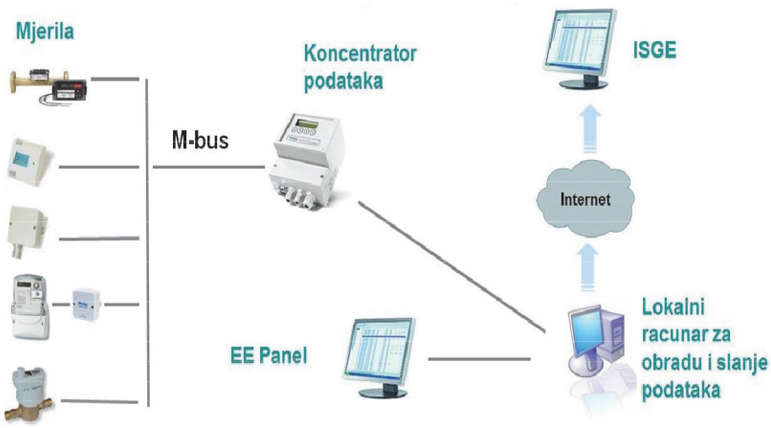


Figure 3. M&V System at the Travnik Municipality building

4. Rationale for Proposed Energy Efficiency Measures

The Municipality of Travnikwas interested in reducing energy consumption and signed the Covenant of Mayors. Reduction in the building sector played a crucial rolein achieving the targeted reduction in overall energy consumption. A number of buildings, including schools, commercial and apartment buildings,were connected to the coal-fired district heating network. A large number of the buildings had large specific energy consumption. To motivate citizens to save energy and invest in energy efficiency measures, the practice of paying for actual energy consumed had already been introduced in the Municipality building. By improving the energy efficiency of the building envelope, this method of payment for energy use would be further promoted and showcased through this pilot project.

To reduce heat losses the un-insulated parts of the building had to be insulated and energy inefficient windows replaced with energy efficient ones. The façade and roof had to be completely insulated. The wood-framed single paned windows were in poor condition and very energy inefficient and had to be replaced (Figure 3). The aluminum-framed double paned windows were energy efficient and did not need to be replaced.

Figure 3. Photos of the old wood-framed windows (left) and the new PVC-framed windows (right)

Energy management

One of the goals of the project was to introduce the practice of energy management. In order to manage energy consumption, it was necessary to monitor it first. A Monitoring and Verification system serves to monitor energy consumption and verify projected (calculated) energy savings. Energy consumption, indoor and outdoor temperatures are monitored and recorded on an hourly basis and sent to a database that enables easy data overview and analysis. Continuous monitoring will identify cases of excessive energy consumption and allow timely investigation and removal of its causes.

5. Baseline Energy Status and Assessments of Energy Efficiency Measures Effects

Insulation of the façade, un-insulated parts of the building and replacement of inefficient windows with energy efficient ones should, according to calculations, result in significant savings. However, in this pilot project, the heat energy consumption, as measured by the heat meter, significantly increased, as shown in Table 1.

Energy efficiency measures 3a and 3b were implemented in summer 2012, so the difference in energy consumption was made by comparing the 2011/2012 heating season to the 2012/2013 heating season. The heat energy consumption for the 2012/2013 heating season increased by about 22% in comparison to the 2011/2012 season. The electrical energy consumption was in both seasons practically the same.

2011-2012	HEATING ENERGY							ELECTRICITY										TOTAL KM/month
	kWh	KM/kWh	KM total kWh	kW	KM/kW	KM total kW	total KM	kWh VT	price KM/kWh VT	KM total VT	kWh MT	KM/kWh MT	KM total MT	kW	KM/kW	KM total kW	Elect.total KM	
October	19.190	0,1805	3.464	406,9	6,1250	2.492	5.956	6.618	0,1452	961	3.715	0,0726	269,74	52,38	14,4900	759	1.990	7.945
November	34.830	0,1805	6.287	406,9	6,1250	2.492	8.779	8.761	0,1452	1.272	3.261	0,0726	236,73	56,30	14,4900	816	2.325	11.103
December	34.140	0,1805	6.162	406,9	6,1250	2.492	8.654	8.274	0,1452	1.201	3.705	0,0726	269,00	49,58	14,4900	718	2.189	10.843
January	34.410	0,1805	6.211	406,9	6,1250	2.492	8.703	8.449	0,1452	1.227	4.065	0,0726	295,13	56,240	14,4900	815	2.337	11.040
February	34.040	0,1805	6.144	406,9	6,1250	2.492	8.636	8.816	0,1452	1.280	3.975	0,0726	288,61	57,680	14,4900	836	2.404	11.041
March	19.900	0,1805	3.592	406,9	6,1250	2.492	6.084	6.590	0,1452	957	3.927	0,0726	285,07	42,740	14,4900	619	1.861	7.945
April	12.920	0,1805	2.332	406,9	6,1250	2.492	4.824	5.800	0,1452	842	3.827	0,0726	277,84	41,480	14,4900	601	1.721	6.545
kWh total	**189.430**							**53.308**			**26.476**						**79.783**	

2012-2013	HEATING ENERGY							ELECTRICITY										TOTAL KM/month
	kWh	KM/kWh	KM total kWh	kW	KM/kW	KM total kW	total KM	kWh VT	price KM/kWh VT	KM total VT	kWh MT	KM/kWh MT	KM total MT	kW	KM/kW	KM total kW	Elect.total KM	
October	11.620	0,1805	2097,41	406,9	6,1250	2.492	4.589	6.569	0,1452	953,79	3.699	0,0726	268,55	52,800	14,4900	765,07	1987,41	6.577
November	31.570	0,1805	5698,39	406,9	6,1250	2.492	8.190	6.616	0,1452	960,57	2.926	0,0726	212,41	39,684	14,4900	575,02	1748,00	9.938
December	45.370	0,1805	8189,29	406,9	6,1250	2.492	10.681	7.552	0,1452	1096,52	5.044	0,0726	366,22	40,320	14,4900	584,24	2046,97	12.728
January	53.700	0,1805	9692,85	406,9	6,1250	2.492	12.185	8.234	0,1452	1195,62	4.699	0,0726	341,12	39,996	14,4900	579,54	2116,28	14.301
February	45.920	0,1805	8288,56	406,9	6,1250	2.492	10.781	6.972	0,1452	1012,34	4.498	0,0726	326,56	40,584	14,4900	588,06	1926,96	12.708
March	38.310	0,1805	6914,955	406,9	6,1250	2.492	9.407	6.787	0,1452	985,52	4.830	0,0726	350,65	40,356	14,4900	584,76	1920,93	11.328
April	17.010	0,1805	3070,305	406,9	6,1250	2.492	5.562	5.939	0,1452	862,33	3.755	0,0726	272,59	38,580	14,4900	559,02	1693,94	7.256
kWh total	**243.500**							**48.669**			**29.450**						**78.119**	

Table 1. Heat and electrical energy consumption from September 2011 to April 2013

6. Investments

The total costs of the measures were:

No.	Measure description	Cost
1	Partial roof reconstruction and insulation, window replacement, thermal insulation of façade	**184,259.31 KM**
2	Installation of a system for remote monitoring of energy consumption	**13,617.63 KM**
	TOTAL	**197,876.94 KM**

The measures were financed by the Travnik Municipality, UNDP and USAID 3E in the following manner:

Institution	Amount
Travnik Municipality	69,059.31 KM
UNDP	115,200.00 KM
USAID 3E	13,617.63 KM

7. Conclusions and recommendations

The measurement of the heat meter shows that the energy consumption increased after energy efficiency measures were implemented, which is counter to the purpose of the implemented measures. However, there are several possible explanations/causes:

1. The heat meter was faulty;
2. The heated area increased significantly;
3. The indoor temperature increased significantly;
4. Windows are kept open for extended periods of time for ventilation; and/or
5. Improper setting of thermostatic valves.

At the time when the report was written (October 2013) the exact cause(s) of the increased energy consumption were not known. The first step was to examine the heat meter. If the heat meter proved to be functioning properly, the increase in energy consumption was likely caused by a combination of the other four factors. According to the information that 3E was given, the heated area increased by about 150m2, or about 8%. The indoor temperature was not measured prior to the implementation of the project, so no objective comparison is possible, but at 11:00 a.m. on April 9, 2013, the three indoor temperature sensors, included in the system for remote monitoring of energy consumption, recorded an average temperature of 24°C. Based on this measurement it is quite possible that the indoor temperature increased by 2°C, which would result in an increase of 12% in energy consumption. No further information on indoor temperature values for the 2012/2013 heating season was available, since continuous measurement of indoor temperature started on April 18, 2013.

The thermostatic valves should have been adjusted and locked to ensure that the building was not under- or overheated;however, the installed thermostatic valves could not be locked, thus allowing unauthorized adjustment. Unauthorized adjustment of thermostatic valves and excessive ventilation are likely the causes for the remaining increase in energy consumption.

2.12 Improving Energy Efficiency of the Street Lighting in Bijeljina, Srebrenica and Trebinje Municipalities

1. Introduction

This pilot project represents improvement of the energy efficiency of the street lighting in the downtown areas of Bijeljina, Srebrenica and Trebinje. Several streets were chosen in each town where the existing lamps were replaced with Light Emitting Diode (LED) lamps, achieving a savings of 67% in energy consumption. Through this project, 3E can demonstrate energy efficiency measures for public lighting for towns that use old and/or obsolete technology, which is very common in Bosnia and Herzegovina.

Figure 1.Photo of the Old Street Lighting in Trebinje

2. Basic Data

BIJELJINA

Number of lights changed = 109 lights. All old lights are mercury vapor.

	Quantity	Old lights	New Lights
Unit power of light (W)	109	250 W	115 W
Installed capacity (W)		27,250 W	12,535 W

SREBRENICA

Number of lights changed = 100. All old lights are mercury vapor.

	Quantity	Old lights	New Lights
Unit power of light (W)	87	400 W	115 W
	13	250 W	78 W
Installed capacity (W)		38,050 W	11,019 W

TREBINJE

Number of lights changed = 151. All old lights are mercury vapor.

	Quantity	Old lights	New Lights
Unit power of light (W)	120	400 W	115 W
	31	250 W	78 W
Installed capacity (W)		55,750 W	16,218 W

3. Recommended replacement of existing street lighting with LED street lights

After the Site Visit Report and Pilot Project Proposal evaluation, a replacement of existing street lighting with LED street lights was proposed at all three locations.

The main problem of the public lighting system in Bijeljina, Srebrenica and Trebinjewas the high cost of the outdated, high consumption and inefficient technology used for lighting. The majority of street light lamps have mercury light bulbs, and the remaining mainly have halogen and sodium bulbs. Because of these inefficient technologies, 95% of the electricity in the public lighting system was lost in the form of heat energy. Also, the old light bulbs frequently burned out due to technical characteristics and age. The only way to decrease the costs was to increase the efficiency of the lights used in the public street lighting system by changing the lighting technology used.

4. Rationale of Proposed Energy Efficiency Measures

Mercury vapor lamps, which comprise a majority of the installed lights, are an obsolete technology for street lighting, and they are not energy efficient.

These measures can be replicated across Bosnia and Herzegovina, since most of the street lighting systems across the country are outdated.

5. Assessments of the Effects of the Energy Efficiency Measures

The advantages and benefits of this project are:
- Significant energy savings;
- Better road visibility;
- Stimulation of local economy in that local firms will be hired to do the work;
- Increased awareness of the local government;
- Practical demonstration of benefits of new energy efficient lighting technologies;
- Demonstration of energy savings through LED lighting technology;
- Increase of public awareness of benefits of energy efficiency measures, and that energy costs should not be regarded as a fixed cost;
- Motivation of local governments to financially support such projects;
- Reduction of CO_2 emissions;
- Improvement of public health.

The main goals of the project are energy and financial savings.

6. Baseline Energy Status

BIJELJINA

Average operating hours per day = 11 h.
Number of operating hours per year = 11 × 365 = 4015h.
Electrical energy cost = 0.1508 KM/kWh.

	Old lights	New Lights
Installed capacity (W)	27,250 W	12,535 W
Total electricity consumption per year (kWh)	109,408 kWh	50,328 kWh
Total electricity cost per year (KM)	16,498.83 KM	7,589.46 KM

SREBRENICA

Average operating hours per day = 11 h
Number of operating hours per year = 11 × 365 = 4015h.
Electrical energy cost = 0.1508 KM/kWh.

	Old lights	New Lights
Installed capacity (W)	38,050 W	11,019 W
Total electricity consumption per year (kWh)	152,770 kWh	44,241 kWh
Total electricity cost per year (KM)	23,037.83 KM	6,671.54 KM

TREBINJE

Average operating hours per day = 11 h.
Number of operating hours per year = 11 × 365 = 4015h.
Electrical energy cost = 0.1508 KM/kWh.

	Old lights	New Lights
Installed capacity (W)	55,750 W	16,218 W
Total electricity consumption per year (kWh)	223,836 kWh	65,115 kWh
Total electricity cost per year (KM)	33,754.47 KM	9,819.38 KM

7. Energy Savings and Environmental Impact

Calculations of the emission reduction effects of the implementation of these pilot projects are presented in the table below. In addition to great savings in electricity consumption, there are also large reductions of CO_2 emissions (Attachment 3).

Electricity Savings and CO_2 Emission Reduction

	Electricity Savings	Emission Reduction
	kWh/a	t_{CO2}/a
Bijeljina	59.080	31,0
Srebrenica	108.529	56,9
Trebinje	158.721	83,3
TOTAL	326.330	171,2

8. Project costs and investments

Project costs:

BIJELJINA
84,042.27 KM (Including VAT)

SREBRENICA
80,730.00 KM (Including VAT)

TREBINJE
111,148.83 KM (Including VAT)

Investments:

BIJELJINA
Municipality of Bijeljina: 35,000.00 KM (Including VAT) – for park lighting
UNPD: 42,021.13 KM (Including VAT)
USAID 3E: 42021.13KM (Including VAT)

SREBRENICA
Municipality of Srebrenica: 40,000.00 KM (Including VAT)
USAID 3E: 40,730.00 KM (Including VAT)

TREBINJE
Municipality of Trebinje: 31,148.83 KM (Including VAT)
UNDP: 40,000.00 KM (Including VAT)
USAID 3E: 40,000.00 KM (Including VAT)

9. Conclusions and Recommendations

The presented calculation shows the undeniable savings of electricity consumption achieved by replacing old technologies for street lighting with new. The total savings of electricity for these three pilot projects is as much as 67%. In these three projects alone, the expected reduction of CO_2 emissions is 171.2 t per year.

These results should persuade all municipalities in BiH to take into considerations the costs of street lighting and to evaluate possibilities for the application of available modern technology (LED).

2.13 "Nikola Tesla" Student Dormitory in Banja Luka (Heating of Domestic Hot Water by Heat Pump that Extracts Heat from Waste Water)

1. Introduction

The USAID Enterprise Energy Efficiency - 3E Project, in cooperation with the "Nikola Tesla" Students' Dormitory in Banja Luka, UNDP and the City of Banja Luka, is implementing a Pilot Project in the Nikola Tesla Students' Dormitory in Banja Luka. This project involves the following:

a. Preparation of a Detailed Design Documentation Package for a domestic hot water preparation system that will use waste heat from sewage wastewater as a heat source by means of a heat pump. This new system should be integrated with the existing system for domestic hot water preparation.
b. Construction, purchase and installation of equipment for the new system for domestic hot water preparation.

2. Basic Characteristics of the Building and Domestic Hot Water System

- The Nikola Tesla Students' Dormitory comprised two pavilions with five floors each. The pavilions were built in 1969 and 1971 (http://www.studentskiparlamentbl.com).
- Accommodation capacities of the Dormitory were approximately 1000 students.
- The Dormitory was connected to the city's district heating system.
- Domestic hot water was prepared and stored in two tanks of 4000 liters each. Water was heated by electric heaters (108 kW), 160 kW electrical boiler and during the heating season, heat energy from the district heating system was used. Domestic hot water preparation was done by the means of plate heat exchangers.
- The domestic hot water preparation system was in very poor condition and required revitalization and better maintenance.
- This Project implied the system's reconstruction, with an aim to increase its reliability and energy efficiency.

Figures 1 and 2 provide photos of some parts of the domestic hot water preparation system.

Figure 1. Photo of Plate Heat Exchanger for Domestic Hot Water Preparation

Figure 2. Photo of Two Tanks of 3 m³ each for Domestic Hot Water Preparation and Storage

3. Description of the New Domestic Hot Water Preparation System

Heat pumps use environmental energy sources, normally groundwater or air. However, both elements have a disadvantage in that their energy level decreases in winter, whereas in summer, the air and groundwater temperatures rise, which makes it difficult to use them as energy source or sink for the air conditioning of buildings, while wastewater possesses a significant heat potential even during cold months. The intake of shower and laundry waste water ensures that the temperature level in the sewer rarely falls below 12 °C. In summer, the soil serves as isolation against hot sunshine and ensures that the maximum temperature does not exceed approx. 20 °C. This narrow range between minimum and maximum values makes municipal wastewater the ideal medium for the operation of heat pumps.

The reason why wastewater heat recovery has not been used so far is likely the fact that the coarse material and contaminants contained within wastewater impair the function of heat pumps, and purification of wastewater is an unjustifiable expense. The new commercial system includes not only the wastewater heat exchanger but also optimized extraction of wastewater from the public sewer.

This waste energy technology is being implemented for the first time in BiH and the goal of the project is to promote this technology as well.

The Project requires application of the heat pump, which will, on the evaporator's side, use the heat of wastewater from the Students' Dormitory. The heat in the condenser will be used for cold water heating. The heat capacity of the heat pump is 101.8 kW. The COP of the heat pump is 5.28 for a temperature regime of 10/50 °C. The nominal water flow rate in the condenser is 4.5 m^3/h and the maximum temperature at the heat pump outlet is 70 – 75 °C.

The cold water flow that should be heated in the heat pump is 4.5 m^3/h (1.25 l/s). The temperature of inlet water is on average 15 °C, and the outlet temperature after the heat pump is 50 °C.

Sewage wastewater has an average temperature of about 20 °C. Special consideration is devoted to the structure of the wastewater collector from which filtered wastewater is pumped to the heat pump's evaporator. The collector is located in the courtyard of the Students' Complex after obtaining consent from the Dormitory's administration and other relevant institutions. Dimensions of the collector are L 3.4 × W 1.2 × H 1.4 and its volume is about 4.1 m^3.

Installations for energy supply by means of wastewater require, in addition to normal building approval, legal permission concerning the protection of streams and rivers. Additionally, an agreement with the sewage operator and sewage treatment plant is required.

The sketch for a domestic hot water preparation system is given in Figure 3. Details of the separator can be seen at http://www.tehnix.hr/Description.asp?CatID=23&DescID=89&LangID=0.

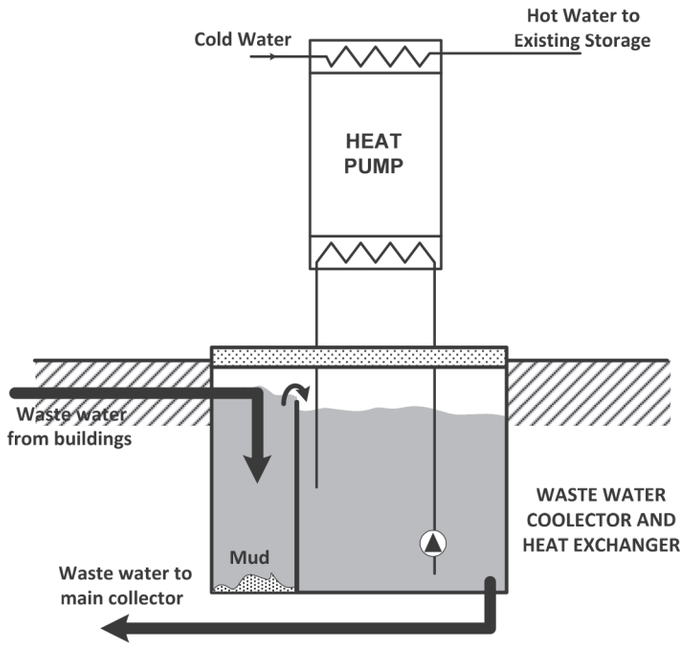


Figure 3. Sketch of Domestic Hot Water Preparation Plant

In the preparatory stage of this Project, measurements were taken relevant to the consumption of cold water and hot domestic water in the Student's Dormitory. The results of six day measurements are given in Figure 4.

In the period from October 2 to 8, 2012, the consumption of cold water was 3.16 m^3/h (StDev 1.18 m^3/h). In that period, in total 461.4 m^3 of cold water was used. In that period, the number of the occupants in the Dormitory was 600-700, meaning that the utilization capacity was 70%. The full capacity of the Dormitory is 1000 students.

In the same period, 264.9 m^3 of hot water was used. The average flow of hot water was 1.81 m^3/h (StDev 1.03 m^3/h). Out of the total used cold water, 57% was heated.

The total potential of waste water in the full capacity is :

$$m_{ww} = \frac{3.16}{0.7} = 4.5\ [m^3/h]$$

The capacity of the heat pump in the condenser is 101.8 kW. Supposing that the medium COP = 4.5, it follows that the capacity of the compressor is equal to:

$$P_c = \frac{101.8}{4.5} = 22.6\ [kW]$$

Therefore, the available heat capacity for the evaporator is 79.2 kW.

The temperature difference in the evaporator is :

$$\Delta t_{eva} = \frac{79.2}{4.5/3.6 \cdot 4.18} = 15.1\ [^oC]$$

Wastewater is cooled by 15.1 °C in the evaporator. This is a fairly large temperature difference and should be controlled in order to prevent freezing of the evaporator in certain regimes of operation.

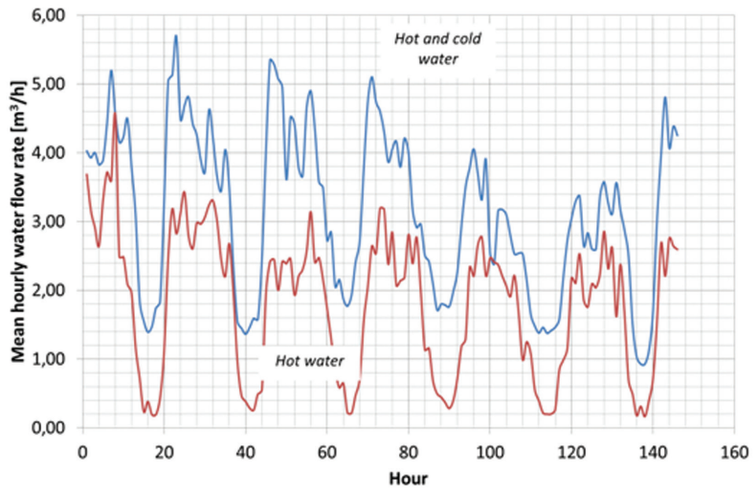


Figure 4. Measured Cold and Hot Water Flow Rate

At the time this Report was written, the works on the construction of this plant were underway, so there was no information on operational experience.

4. Technical and Financial Analysis

The potential savingsare determined on the basis of recuperated heat from the wastewater. This estimate is done on the basis of 300 days of operation in a year and the degree of utilization with a capacity of 70%. If it is supposed that the mean temperature difference of wastewater will be 10 °C, then it is possible to expect that the recuperated heat during a year is equal to :

$$Q_{rec} = 300 \cdot 24 \cdot 0.7 \cdot 4500 \cdot 4.18 \cdot 10 = 948{,}024{,}000\ [\mathrm{kJ/year}] \qquad = 263.3\,[\mathrm{MWh/year}]$$

The use of waste heat energy in the heat pump will enable the production of 338.5 MWh/year of domestic hot water. For that, it is necessary to use 75.2MWh/year of electricity to drive the heat pump. The consumption of 75.2 MWh/year of electricity generates 338.5 MWh/year of heat energy. When this heat energy was produced by direct use of electricity, the consumption was 338.5 MWh/year.

The achieved savings of electricity is 263.3 MWh/year. The expected annual savings of electricity is 34,229 KM (average price of electricity is 0.13 KM[1]/kWh – VAT is included).

The cost of the measure and the payback period are shown in the following table. It is assumed that the price per kWh remains the same.

[1] *1 $US=1.4657 KM (20 Aug 2013)*

Measures	Investment [$]	Annual Savings Est [$]	Simple Payback Period [year]
Heat Pump for Wastewater Heat Recovery	115,000	23,353	4.9

Table 1. Preliminary Cost - Benefit Analysis for Recommended Measures

5. Environmental Aspects

The emission of CO_2 is 0.5246 $kgCO_2e/kWh$ (Electricity from the grid - Annex 3). Assuming that only electricity is used for the production of domestic hot water (in winters, district heating system was used) the, the average emission of equivalent CO_2 is equal to:

$$E_{CO_{2e}} = 0.5246 \cdot 263{,}300 = 138{,}127 \ [kgCO_2 / year]$$

3. CAPACITY BUILDING ACTIVITIES AND PUBLIC AWARENESS ACTIVITIES

USAID 3E Capacity Building Activities and Public Awareness Activities were devised to inform all key energy sector stakeholders of the benefits of using energy efficient technologies and methodologies. 3E has worked to ensure effective communication to different target groups to successfully disseminate information, educate information recipients on technical issues to explain the benefits of implementation of energy efficiency measures,communicate effectively on various political and business-related levels and raise support and cooperation for the implementation of the project activities.

Some of the key Capacity Building Activities and Public Awareness strategies USAID 3E used are outlined in the following sections.

3.1 Energy Efficiency Knowledge Days

Energy efficiency (EE) means the consumption of less energy, thus saving money, while maintaining an equivalent level of service in our homes, offices, factories, and transport networks. However, the concept was not well understood in Bosnia and Herzegovina. The USAID Enterprise Energy Efficiency Project (3E), United Nations Development Pro-gramme (UNDP), the German Society for International Cooperation - GIZ (formerly GTZ) and the City of Sarajevo organized the Sarajevo Energy Efficiency Knowledge Days from December 14 – 16, 2011, to promote and raise awareness of the importance of energy efficiency among the general public, representatives of local authorities and small and medium-sized enterprises.

During the EE Knowledge Days event, USAID, GIZ, UNDP and experts from various fields of energy efficiency presented their experiences and knowledge from their energy efficiency projects through workshops, presentations and lectures that were free to the public.

The topic of the first day of the event was Energy Management in Cities, Municipalities and Cantons, targeted primarily to representatives of local municipalities and cities. On the second day, activities took place in two venues: the Mechanical Engineering Faculty and the Hotel Europe. The presentations at the Faculty were on the topic of "Energy Audits, Energy Management and EE Technologies" and related to the development of the MEF building as a 3E pilot project for energy efficiency. A number

of companies also presented their equipment and expertise. The presentations in the second venue were directed to BiH consumer associations and focused on the need for individual energy billing as a prerequisite for energy efficiency in buildings. This event gathered representatives from consumer associations from towns all over Bosnia and Herzegovina. Importantly, it was agreed that because of the benefits of EE measures in buildings, individual measuring for heating and other types of energy consumption – currently not the norm for consumers – needs to be implemented in the country.

On the third and final day, events were held at several different locations throughout the city of Sarajevo, including the Chamber of Commerce of Sarajevo Canton and the University of Sarajevo Faculties of Economics Architecture, Civil Engineering, Electrical Engineering and Philosophy.

At the EE Info desk located on the old town main walking street of Ferhadija, interested citizens were informed of the benefits of EE and advised on energy efficiency measures that were recommended for implementation in their households through a free brochure on "22 Energy Efficiency Tips" containing hints on how to reduce energy consumption in homes and thus save money. The brochure was also inserted in 122,000 copies in three daily newspapers (Oslobodjenje, Avaz and Glas Srpske). These events attracted approximately 800 people.

3.2. Energy Efficiency Library Publications

The USAID 3E Project, UNDP, and GIZ jointly developed and published educational publications in order to establish the Energy Efficiency Library for Bosnia and Herzegovina. The EE Library consists of seven education books that contain information on energy efficiency that is related to systematic energy management in cities, conducting energy audits of buildings, monitoring and measurement of energy consumption, actual ways of financing energy efficiency measure implementation projects and organizing offices in accordance to "green office" recommendations. The books were written by authors from the South East Europe region, who are experts in the various fields of energy efficiency. The books are a valuable reference and information resource to all those who are interested in energy efficiency and are professionally related to the field.

The books are available as electronic copies on all partner websites and in all nine American Corners across Bosnia and Herzegovina. The EE Library was presented in each American Corner, and 10 sets of books have been donated to each of the Corners so that citizens and EE professionals may find and read them.

PR events were organized for public presentation of each EE Library established in different locations and cities in Bosnia and Herzegovina. The editors of the EE Library have presented the books at various events. Local EE professionals were invited to the events, as well as journalists, and the events were covered well by the media, which enabled promotion and information dissemination about the EE Library to its future users and readers.

3.3. Courses on Energy Management in Buildings and Green Office Practices

USAID's Enterprise Energy Efficiency (3E) project held one-day courses in Sarajevo, Tuzla, Mostar, Banja Luka and Bihac on the subject of energy management in buildings and green office practices. The courses were held at the Engineering faculties in these cities, in partnership with UNDP.

The courses were designed to introduce the ideas of energy management in buildings and green office practices and how they can help the public and private sectors save energy and money while protecting the environment. The lectures on energy management in buildings described the process of continuous management of expenses related to energy consumption with the goal of reducing those costs while retaining the same level of comfort. The lectures covered the steps and organizational structure necessary for establishing systematic energy management in buildings, analyzing energy consumption data and economic and the financial aspects of energy efficiency projects. The green office practices lectures introduced the attendees to the activities that employees can employ in offices to reduce the negative impact on the environment and increase the efficiency of resource consumption. The covered topics included the use of office equipment and supplies, and procurement that takes into account the use of energy and other resources. Around 325 representatives from small and medium enterprises, public institutions and international organizations participated in the courses and received Certificates of Attendance.

3.4. Energy Efficiency Festival

The EE Festival brought energy efficiency into every home - Promoting EE through fun activities

USAID Enterprise Energy Efficiency – 3E project organized the EE Festival in Sarajevo, June 5-10, 2012, to promote and familiarize citizens with the benefits of implementation of EE measures and technology in their homes and offices.

Mr. Allan Reed, USAID BiH Mission Director, at the Gala Dinner, organized to raise funds for MCEE

The aim of the six-day Energy Efficiency Festival, which included 14 events, was to raise awareness of energy efficiency and popularize the Festival theme in an indirect way through interesting and inclusive events. The citizens of Sarajevo and BiH had a chance to attend cultural and entertaining events, concerts, street fairs, sporting events, art exhibitions and movies that carried the theme of Energy Efficiency, Renewable Energy and Environmental Protection. The EE Festival was a new approach for promoting energy efficiency that included citizens of all ages.

The first day

Mayor of Sarajevo Mr. AlijaBehmen expressed his satisfaction at the opening of the EE Festival that the City of Sarajevo was an honorary sponsor of this Festival: "A lot of people do not know what energy efficiency is: simply – it means producing a quality product and service, using the least energy. We are aware that our resources are limited and we need to preserve them and protect them. The City of Sarajevo opened an energy efficiency office, in which citizens and companies can find information about energy efficiency measures."

Dancers and graffiti artists entertaining crowds in front of the Cathedral

The Energy Efficiency Festival was opened with an art exhibition held in the BiH Art Gallery in Sarajevo. All art objects were made by students from the BiHArtAcademies in Banja Luka, Trebinje, Sarajevo and ŠirokiBrijeg, based on an energy efficiency theme.

The second day

The Science Fair for primary and secondary schools was held at Dom mladihSkenderija on the second day of the Festival. Primary and secondary schools from Sarajevo Canton exhibited their science projects on the themes of energy efficiency, renewable energy and environment protection. On the same day, "The City Dark", a movie by Ian Cheney, was premiered in the Sarajevo multiplex. "The City Dark" is a multiple award-winning documentary about light pollution, the disappearance of full darkness and the generations that don't even know what a starry night looks like, all due to too much artificial light in cities.

Students at the Science Fair, presenting their works on Energy Efficiency and Environment protection.

Mini Fair in front of the BBI Centre

The third day

The third day of the EE Festival started with the "Mini Fair" in front of the BBI shopping center, where citizens could visit different educational info stands to get information how to make their homes more energy efficient.

That same day there was a German documentary film that premiered – "The Fourth Revolution – Energy Autonomy" by Carl Fechner. The documentary concerned a vision of a global society that lives in a world where energy is produced 100% with renewable energies, indicating a complete reconstruction of the economy to reach this goal. In addition, an exhibition of photographs on the themes of energy efficiency, renewable energy sources and environment protection was opened in the Boris Smoje Gallery at RadićevaStreet.

Thereafter, in the evening of the third day, a fashion show was held right in front of the fashionable BBI shopping center. Designers and models from the Modiko fashion association participated in the fashion show. Also, students from the Primary school Mula Mustafa Bašeskija created attractive outfits from recycled materials and showed them on the runway.

Some of the electricity needed for the fashion show was produced by a stationary bike, with the help of a local bicycle club volunteer.

Producing electricity by stationary bike, Fashion Show in front of the BBI Center

The fourth day

On the fourth day of the Festival, young graffiti artists and dancers from BiH entertained the crowd with their performance in the square in front of the Cathedral. From 10:00 a.m. to the late afternoon hours, graffiti artists sprayed panels to illustrate their take on energy efficiency, environmental protection and renewable energy sources. Educational brochures about energy efficiency were distributed to passersby. The same brochures were distributed at the Sarajevo Beer Festival concerts, which was held on the same and the following day.

Koncert u sklopu Sarajevo Beer Festivala

The fifth day

On the fifth day of the Festival, interested children had a chance to make play tennis for the first time at four mini tennis playgrounds opened on VilsonovoŠetalište. While children had fun playing tennis, their parents had a chance to educate themselves about energy efficiency. In the evening hours of the same day, a Zumba party was held at Grbavica Youth Center. All participants had a great Zumba workout, as the party was led by well-known Zumba trainers from the region, led by Elma Višo, the first licensed Zumba instructor in BiH. Another attraction on the same day was a waterpolo match between the „Mladost“ and „Torpedo“ clubs, held at the Otoka Olympic Pool.

The Energy Efficiency Festival ended with a "Family Day" and concert on VilsonovoŠetalište on the last day. The citizens had a chance to enjoy an interesting entertainment program. The youngest had a special treat as the program included a puppet show, little eco-school, drawing school and theater for kids.

Mini tennis atVilsonovošetalište

Family Day at the Vilsonovošetalište

The Honorary Sponsor of the Festival was the Federation Ministry of Education and Science. Mr. Damir Mašić, the FBiH Minister of Education and Science, stated: "Development of renewable energy sources is a necessity for survival, not only of the environment but also of mankind. That is why the promotion of energy efficiency is important for society as a whole. We can now assert that we have young people who are aware of this."

Approximately 20,000 people visited the various events, and approximately 10 TV media representatives followed the Festival and reported on it in their regular and special programs. Also, numerous press editions in many daily papers followed the Festival, as did internet websites. The EE Festival was also presented in interviews with 3E by the following TV stations: TVSA, FTV, BHT1, Face TV, TV1, with the material shown in the peak hour daily news reports.

Mr. Damir Mašić, FBiH Minister of Education and Science, at the opening of the EE Festival

4. LOCALIZED SOLUTIONS FOR ENERGY EFFICIENCY (Energy Efficiency Year in Tuzla Canton)

The USAID Enterprise Energy Efficiency (3E) Project, together with the municipalities of Tuzla Canton, the Government of Tuzla Canton and the UNDP, organized a kick-off Conference on June 19, 2013, to mark the start of the "Energy Efficiency Year in Tuzla Canton" activities. To actively promote energy efficiency, renewable energy sources and energy management in public buildings and communal systems, the thirteen Mayors of Tuzla Canton municipalities and Tuzla Canton's Prime Minister signed an **Energy Charter** that obliges them to promote a sustainable energy future in their municipalities and canton.

Energetska Povelja

Mi, načelnici općina Kantona Tuzla i premijer Kantona Tuzla, duboko smo zabrinuti zbog porasta potrošnje energije, povećanih troškova za energiju, povećane ovisnosti Bosne i Hercegovine o uvozu fosilnih goriva, te njihovim utjecajima na okoliš i privredu.

Prepoznajemo i razumijemo bitnu ulogu energije u kvaliteti življenja i stanju okoliša, te prednosti održive proizvodnje i održivog korištenja energije koji doprinose ekonomskom razvoju i očuvanju životne sredine.

Svjesni smo da su energetska efikasnost i obnovljivi izvori energije jedan od najvažnijih faktora održivog razvoja. Stoga ćemo kontinuirano povećavati energetsku efikasnost, koristiti obnovljive izvore energije, te sistematski upravljati energijom u našim općinama i Kantonu. Time ćemo poticati otvaranje novih radnih mjesta, regionalni ekonomski razvoj, te povećavati sigurnost snabdjevanja energijom.

Aktivno ćemo promovisati energetsku efikasnost, obnovljive izvore energije i upravljanje energijom, kako u našim zgradama i komunalnim sistemima, tako i u domovima svih građana, te u poslovnom sektoru.

Potpisivanjem ove povelje želimo sva naša nastojanja usmjeriti ka boljoj i održivoj energetskoj budućnosti u našim općinama i Kantonu, a na dobrobit svih naših građana.

Vlada Tuzlanskog Kantona — Sead Ćaušević
Banovići — Bego Birpatić
Čelić — Sead Murinović
Doboj Istok — Kemal Bratić
Gračanica — Nusret Fejić
Gradačac — Edis Derviškapić
Kalesija — Kasim Omeragić
Kladanj — Jusuf Čavkunović
Lukavac — Dževad Mujkić
Sapna — Ismet Omeragić
Srebrenik — Sane Buljubašić
Teočak — Fajis Murinović
Tuzla — Jasmin Imamović
Živinice — Hasan Muratović

Tuzla, 19.06.2013.

UZ PODRŠKU

USAID

UNDP

Within the "Energy Efficiency Year in Tuzla Canton," USAID 3E focused its efforts on two fronts: one is technical assistance to the municipalities in establishing an energy management structure, and the other is the educational and public awareness effort aimed at the general public.

The technical assistance started with the appointment of energy efficiency personnel or teams (depending on the size of the municipality) that were the driving force behind 3E's activities in setting up a systematic energy management approach. Energy management is a process of continuous monitoring of energy consumption in order to detect and correct excessive energy consumption, all of which results in a decrease of the costs spent on energy. The first goal was to make an energy consumption baseline for the municipalities, and 3E's findings were that a total of almost 5 million KM was spent on energy in the public sector in Tuzla Canton in 2012. This is a significant amount, which confirmed that there was a lot of room for savings through the implementation of energy efficiency measures.

Alongside the technical effort, a comprehensive public outreach campaign was planned that will include setting up an Energy Efficiency Info Center in Tuzla, to be a hub for a network of Energy Efficiency Info points to be located in each Municipality.

The goal of the USAID 3E project has been to create a systematic energy management approach in one BiH region that can be replicated throughout the country and create a climate for investment in the field of energy efficiency by educating and informing the citizens to the potentials of these technologies and practices.

4.1. Technical Assistance

The technical assistance to Tuzla Canton had three components:

1. Training of municipal energy management teams
2. Developing studies related to increasing the use of renewable energy sources and improving energy efficiency
3. Improving efficiency of public lighting through installation of LED lighting

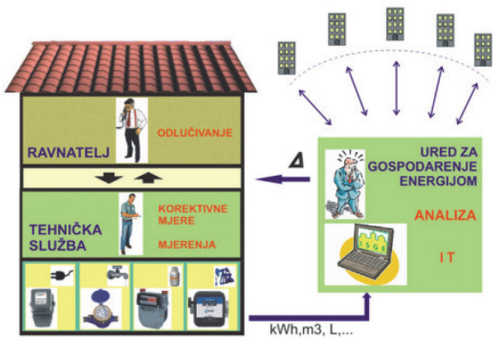
4.1.1.Systematic Energy Management workshops for Municipal Energy Management teams

The four workshops held in the period of November 5, 2013 to March 18, 2014and the final roundtable with municipal mayors on April 23, 2014,helped municipal energy managers and energy management teams accomplish the following:

- Understand the procedures, organizational structure and tools necessary for establishing systematic energy management in buildings and public lighting
- Determine goals for reduction in energy consumption and CO2emissions included in the Municipal Energy Policy Statements adopted by Municipal Councils

The energy management teams started the following activities:

- Collect and enter into the EMIS database the key data describing the construction property of buildings and their energy systems
- Collect and enter into EMIS database the key data for public lighting
- Develop methods for monitoring and reducing energy consumption
- Develop a strategy to continue implementing energy management and energy efficiency projects without support from USAID 3E



4.1.2 Energy studies and audits

The USAID 3E project has supported municipalities in Tuzla Canton by conducting energy audits of four buildings in four municipalities and preparingtwo studies:

- Study on energy savings through management of street lighting in DobojIstok Municipality
- Study on biomass potential in the region of Sapna Municipality

The energy audits and studies provided guidance formunicipalities on how to plan investments in their buildings, public lighting and district heating. This went along with the case studies based on the 17 pilot projects USAID 3E implemented in BiH to provide a wealth of knowledge and local experience to supplement the workshops.

4.1.3 Increasing quality and efficiency of public lighting

Public lighting costs represent more than 60% of total municipal energy costs in Tuzla Canton municipalities; and in some municipalities, the cost of public lighting represents 10% of the municipal budget.

To help municipalities reduce public lighting costs, LED lighting replaced the existing public lighting on most important streets in seven municipalities, providing electricity savings and significantly improved quality of lighting.

Gradačac – KadicMahalaStreet before (left) and after (right)

4.2. Educational Activities

4.2.1. Student Energy Club

The Student Energy Club in Tuzla was established on July 25, 2013, as part of the "Energy Efficiency Year in Tuzla Canton." The promotion of the club's establishment was held at the amphitheater of the Mechanical Engineering Faculty in Tuzla. This Club was establishedwithin the Expert Association for Solar Energy in BiH (SUSE ENERGA SOLAR) to raise awareness and promote energy efficiency and renewable energy sources, first among students and then branching out wider through public activities. The Student Club is a platform for students from different faculties and fields of study that are interested in energy efficiency and renewable energy sources, especially the Electrical Engineering, Mechanical, Construction and Economic faculties, as well as local and foreign organizations active in the fields of interest.

A further goal is to connect Student Energy Clubs throughout BiH into a network to enable students to exchange ideas and experiences about energy efficiency and renewable energy sources among themselves, thus expanding the reach of each of the Student Energy Clubs. The members of the Student Energy Club from Banja Luka were present at the promotion of the Tuzla Student Energy Club, and they shared their experiences, activities, implemented projects and explained how their engagement in the Student Energy Club enabled them to get practical experience that was beneficial and helped them at job interviews after they completed their studies. This is one of the reasons USAID 3E supported this student club.

The members of the Student Energy Club Tuzla helped to implement a number of project activities, such as the Panonica EE On Our Lakes event, the Think of Tomorrow school program, and Student Energy Advisors for the EE Info Center.

4.2.1.1. Promotion of Energy Efficiency at Panonica Lakes

USAID 3E organized a public awareness event "Energy Efficiency On Our Lakes" to present the practical benefits of energy efficiency and renewable energy sources to the visitors of the Panonica Lakes in Tuzla. Visitors of the Panonica Lakes in Tuzla enjoyed an exhibition of working models of devices powered by solar energy, which were produced by the Center for Development and Support (CRP) Tuzla. The models included a photovoltaic panel for electricity production that powered a refrigerator and other electric devices, solar collectors for the production of sanitary hot water with an installed shower, a Solar-powered cart that children had an opportunity to drive, and a solar concentrator that showed the power of concentrated solar energy by melting a tin can and burning wood.

The Panonnica event was a great opportunity for all visitors of the lakes in Tuzla to enjoy a practical demonstration of solar power, renewable energy sources and energy efficiency technologies and share ideas with the Student Energy Club representatives.

4.2.1.2 Think of Tomorrow – Primary School Classes

School classes called "Think of Tomorrow," were organized to promote and raise awareness of energy efficiency and renewable energy sources. One class was given to fifth graders in all primary schools in Canton Tuzla by students from the Student Energy Club Tuzla who were selected and trained by the USAID 3E project staff. In each class, an animated video presentation was shown to present energy efficiency and renewable energy sources, followed by open discussion. The school class "Think of Tomorrow" was intended to develop environmentally friendly habits among youth, to promote the rational use of energy resources, and introduce energy efficiency measures and use of renewable energy sources. A total of 178 classes were held in 80 primary schools in Canton Tuzla attended by a total of 4,525 fifth grade students.

4.2.2. Energy Efficiency Info Center and Info Points Network

The Energy Efficiency Info Center and Info Points Network were intended to serve as an information sharing platform for citizens, in response to a clear need to provide a one-stopshop for citizens, where citizens can get informed and educate themselves on effective and attractive EE solutions that provide significant money savings and offer new business and employment opportunities. The EE Info Center also aims to become a meeting place for supply and demand of EE technologies, where companies can present their solutions and connect with potential buyers. As educated consumers, the citizens will be able to make informed decisions when buying EE products and services.

In addition to the Energy Efficiency Info Center, USAID 3E opened 13 EE Info Points for citizens, located in municipal buildings. The basic idea for establishment of the EE Info Points in the Tuzla Canton municipalities was for citizens to come into contact with useful information about energy efficiency via very visible promotional posters when they may be coming to the municipal building for other reasons. The EE Info Center in Tuzla acts as a hub for the 13 EE Info Points. This EE information and education network is a substantial EE knowledge sharing and public outreach structure in Tuzla Canton, which will be at the disposal of all citizens in the Canton.

4.3. Energy Efficiency Media Campaign

Within the Energy Efficiency Year of Tuzla Canton, a media campaign was implemented that was intended to raise public awareness about the importance of energy efficiency. The program was based on the structure of social networks, which integrated public communication tools, education programs, interpersonal communication, printed publications and communication using mass media. The animation "GET INVOLVED" has been broadcast on TV stations in Tuzla Canton and other BiH TV stations, as well as two radio jingles and a number of billboards across the Canton.

4.2.3.1.Promotional

In order to promote energy efficiency and disseminate information to the citizens, special tools for communication had to be developed to enable adequate usage of each media channel. The very special approach in audio-visual communication was implemented with animated graphics presenting two houses as personification of two close neighbors. One house was in color, and its energy certificate showed that it was very energy efficient. The other house was grey; but when it received information from its neighbor house and it started to implement energy efficiency measures, its energy certificate improved and finally, it was also presented in color like its mentoring neighbor house. The other grey houses also started to turn to color, and suddenly the whole town was energy efficient.

Through this approach, several key messages were communicated:

1. The invitation and slogan of the campaign "Get Involved!", asking the citizens to become more active in learning about energy efficiency and responsible consumption of energy;
2. The suggestion to the citizens to seek good examples in their neighborhood and learn from them;
3. The suggestion to the citizens to use educational brochures and seek more information at the website and info-points, but also to call the info-line to get advice from the EE advisors;
4. Some of the key energy efficiency measures were clearly presented through animated graphics.

The matrix of media for dissemination of the messages included television, radio, newspapers and Internet; but it was also supported with sufficient PR activities, mostly related to the presentation of newly established info-points informing the citizens of their locations and purpose.

4.2.3.2 Educational

In order to disseminate to the citizens more and wider-ranging information about benefits from implementing particular energy efficiency measures, a special television series was developed and produced in cooperation with Television of Tuzla Canton (TVTK). The first part of the series was related to the production of special educational films and was based on selected pilot projects successfully implemented by the USAID 3E project throughout Bosnia and Herzegovina. The second part of the seriesthat was related to the production and broadcast of special television shows consisted of two parts: the first part was related to the premiere of each educational film; afterwards, the second part consisted of constructive discussion in the studio among journalists, experts and the beneficiaries of pilot projects related to implemented energy efficiency measures and the achieved results presented in the educational videos.

5. CONCLUSIONS AND RECOMMENDATIONS

Municipalities, Cantons and individual institutions (local counterparts) showed a great interest in implementing pilot projects in cooperation with USAID 3E and submitted a large number of proposals. The local counterparts were prepared to co-finance pilot projects in a significant percentage (up to 50%), which is much more than the usual co-financing percentages in projects funded by international donors. This readiness for high levels of co-financing demonstrated the awareness of local counterparts that energy efficiency projects are paid back in a relatively short period of time, increase the value of public property and improve the comfort of users.

In the case of the only pilot project implemented in privately owned buildings (20 family houses) the co-financing percentage was even higher —80%. Hundreds of home owners applied for this project and the readiness of home owners to finance the project in such high percentage shows that the awareness about energy efficiency and its benefits is quite high among citizens. This is very encouraging because much more energy consumption occurs in residential buildings than in public buildings, and the largest savings in energy can be achieved in the residential sector.

The BiH design and construction companies demonstrated a high level of competence and familiarity with the equipment and materials used for improvement of energy efficiency in buildings. For all pilot projects, except for Banja Luka, BiH companies developed design drawing packages (Main Design-glavniprojekt), installed and commissioned the designed systems. Many components were imported as such equipment is not manufactured in BiH, but the BiH companies showed very high familiarity with the imported equipment. Even in Banja Luka, the subcontractors for the main Croatian contractor were BiH companies, which designed and implemented the system under the supervision of the Croatian contractor.

Not all key equipment used in pilot projects was imported. There are companies in BiH that produce high quality, energy efficient equipment that they export to the EU. All windows installed in the pilot projects were manufactured (using imported components) and installed by BiH companies. At least two of window manufacturers involved in pilot projects export windows to EU. Five pilot project buildings are now heated by biomass (pellet and woodchip) boilers designed and manufactured in BiH. There are several factories in BiH that produce expanded polystyrene (EPS) which was used to thermally insulate pilot project buildings.

As discussed in the Preface, the goal of the pilot projects was to implement commercial technologies well-adapted to end users. However, the pilot projects included two technologies that, to the knowledge of 3E team, haven't been previously implemented in BiH:

- Systems for remote monitoring of energy consumption for Monitoring and Verification (M&V) in old buildings , and
- Wastewater heat recovery via a heat pump for heating of domestic hot water.

In new buildings in BiH there are sophisticated systems for monitoring and regulation of energy consumption, but such systems do not existin old buildings. The systems installed in pilot projects provide hourly values of energy consumption and indoor and outdoor temperatures. Monitoring of energy consumption and indoor and outdoor temperatures form the necessary basis for energy management in buildings. Readings can be performed manually; but with these automatic systems, human error is eliminated, and the frequency of readings is much higher, providing much better insight into the functioning of energy systems.

Wastewater heat recovery via a heat pump for heating of domestic hot water is a technology proven in the developed countries, but such a system has not yet been installed in BiH. Such systems are expensive (KM/kW), but payback periods are relatively short despite the relatively low cost of electricity in BiH. These systems are well suited for all buildings with large consumption of domestic hot water, e.g., dormitories, public swimming pools, hotels and hospitals.

Through the implementation of seventeen projects, large energy savings have been achieved and CO_2 emissions have been significantly reduced. It is of particular importance to emphasize that these projects covered the whole territory of BiH. Events accompanying project implementation,such as workshops, festivals and issued publications, have accomplished the educational objectives of the project. Of significance is the fact that many projects involved young people.

The pilot projects showed that local companies are capable of manufacturing materials and equipment used in energy efficiency projects and implementing them. Thus, energy efficiency projects in buildings represent an important development opportunity for BiH that can provide many jobs and improved standard of living for its citizens.

Recommendations

Implementing energy efficiency in public buildings is in the interest of the public institutions that own them and is also a requirement by the Energy Community. BiH is obligated to improve energy efficiency in 2% of its building stock annually from June 2015 to 2020 and 3% onwards. The pilot projects demonstrated various measures in different types of buildings with different types of energy sources. These experiences should be used by public institutions in planning projects to fulfil this requirement. A functioning mechanism to help finance these projects must be established. At present, the funds disbursed by the Fund for Environmental Protection of FBiH and the Fund for Environmental Protection and Energy Efficiency of the RS are not sufficient to meet the requirements. The presented reports should also encourage all interested people to deal with projects aimed at increasing energy efficiency and the share of renewable energy sources in meeting the energy demand.

The Law onEnergy Efficiency in the RS and the draft of the Law on Energy Efficiency in FBiH contain requirements that will help BiH to reduce energy consumption and fulfill its obligations toward the Energy Community: efforts should be made to implement these Laws.

Since the residential buildings are the largest consumer of energy in the building sector, steps should be taken to help citizens reduce energy consumption. The Energy Renovation of 20 Residential Houses Pilot Project has shown that a subsidy of 20% of investment value and the provision of technical advice and supervision is sufficient to motivate owners to thermally insulate their houses. Since there are tens of thousands of uninsulated family houses in BiH and reducing thermal losses is usually the first step in energy efficiency in buildings, efforts should be made to provide funds and set up a program to subsidize thermal insulation of family houses. Motivating owners of apartments in buildings to implement energy efficiency measures in parts of a building that does not directly belong to them (façade, roof) is a more difficult task. The first step should be to introduce individual metering for buildings connected to the district heating system - paying for heating based on consumption. Individual metering is necessary for apartment owners to save on heating bills and pay back their investment and is required by the Energy Community be implemented by June 2018.

ATTACHMENTS

Attachment 1:
ENERGY AUDIT METHODOLOGY

a. General Approach

Consultants are primarily oriented towards the reduction of the customer's costs for energy by strictly abiding to national and local laws, regulations and standards applicable in the areas of energy and environment protection.

The approach used by consultants is based on the fact that only comprehensive energy management can lead to substantial energy savings (Figure 1). An energy audit is only one part of the overall process, which is designated as energy management.

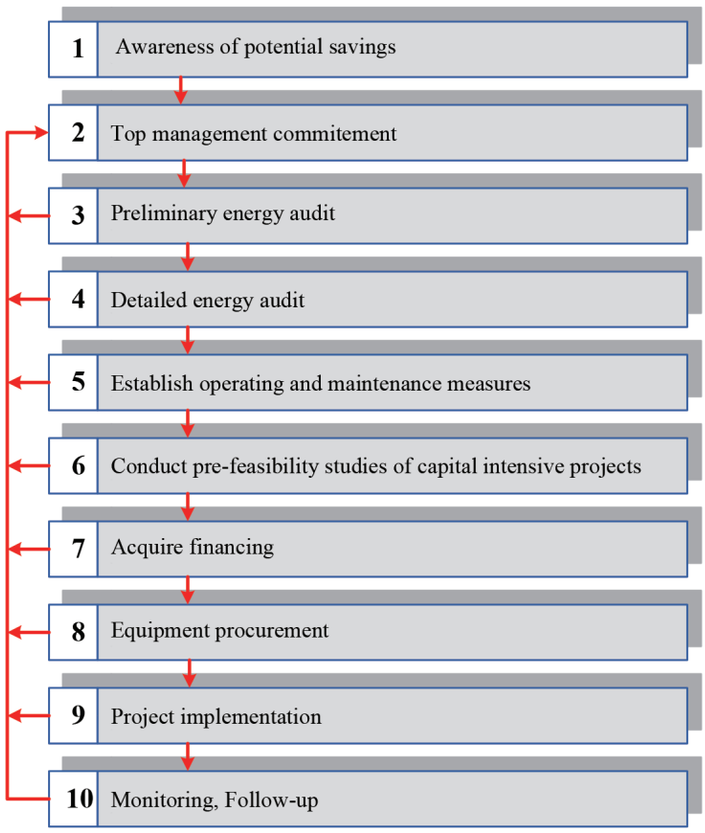


Figure 1.Step-by-Step Energy Management

b. Activities

A project starts with a meeting between a customer and an energy efficiency consultant. The team of consultants presents a methodology of energy audit that would be possible and necessary under given circumstances.

In order to take into consideration realistic opportunities for applying available measures for increasing energy efficiency, the consultant will first conduct a physical inspection of the building and energy system, and then analyze the actual procedures of systems management. At this stage, it is important to recognize and interview key people responsible for energy systems management. A team will be formed consisting of the consultant and people in charge of certain systems in the building.

The next activity is the review of relevant documentation (preliminary and detailed designs, daily records of operating parameters for energy systems and energy consumption, maintenance reports and system breakdown reports, etc.). In addition to that, basic measures will be carried out by deploying existing measuring equipment and, when necessary, additional equipment.

Data gathering will be carried out on the basis of a previously prepared questionnaire containing the following:

- Purpose of a building and basic activities carried out therein, the number of people in the building during working hours and afterward;
- Defininition of the period of time to which energy audit will refer (at least 12 consecutive months);
- Number of annual operating hours of the building and especially of heating and cooling days in the building;
- Fuels used, their energy characteristics and used tariff systems;
- List of energy systems (existing, those under construction and those anticipated for construction): devices for preparing hot domestic water, cooling systems, air conditioning systems, hot and cold water distribution systems and lighting.
- It is necessary to consider the following for all energy systems, if they exist:

  - Design documentation;
  - Daily plant operating logs;
  - Instructions for use;
  - Maintenance reports;
  - Minutes for the system breakdown incidents;
  - Expansion of the planned system that is underway;
  - Fuels, their quality, quantities, costs, etc.;
  - Information about the climate;
  - Energy management: organization, procedures that are used, records, equipment that is used, software;
  - Building plan;
  - Drawings for electrical, heating, cooling, air conditioning and other systems;
  - Pipes and ducts in the building;
  - Data about consumption of electricity, fuels and water.
- Computations, analyses and proposals of possible measures for increasing energy efficiency of certain energy systems:
  - Consideration of possible technical solutions;
  - Preliminary analysis of opportunities to use certain technical solutions relevant to concrete circumstances;
  - Preliminary economic analysis and harmonization with existing plans for further use of the building;

- Specifying projects for immediate implementation and projects requiring additional analyses.

• Rendering the Report and its presentation to the owner and to potential investors:

c. Criteria

Recognized measures for increasing energy efficiency (MEE) are then analyzed, with ultimate proposals being based on the following:

- Measures with higher potential for increasing energy efficiency will be favored;
- Proposed measures will be simple for utilization and provide substantial energy savings;
- Only modern and verified (commercial) technologies (methods, techniques, procedures, tools, machines and materials) will be proposed;
- Priority will be given to projects requiring lower investments and shorter payback periods;
- Projects will be implemented in a technically correct manner and in a logical sequence to avoid mutual interference.

Attachment 2:
CLIMATE DATA FOR BOSNA & HERZEGOVINA

In this Attachment, the average monthly data for B&H is presented. This data was used when more accurate data was not available.

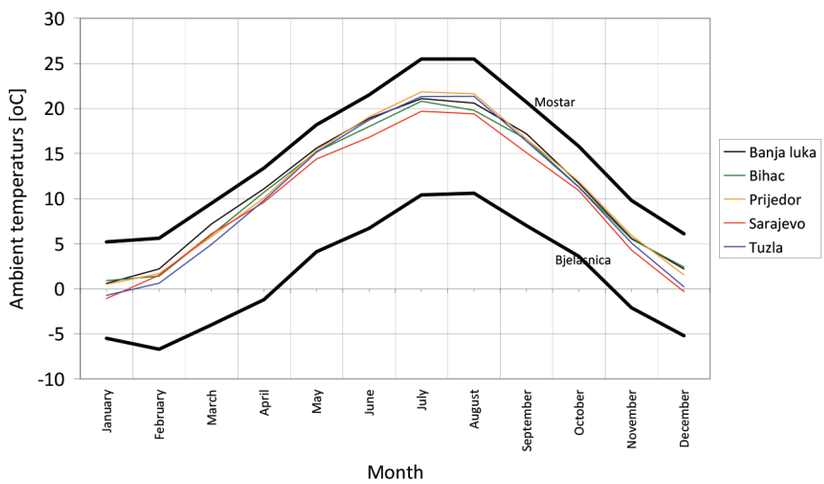


Figure 1. Average Monthly Outside Temperature of seven Cities in B&H

1. Detailed climate data for BANJA LUKA

Banja luka	Unit	Climate data location
Latitude	˚N	44,8
Longitude	˚E	17,2
Elevation	m	156
Heating design temperature	°C	-8,9
Cooling design temperature	°C	30,9
Earth temperature amplitude	°C	19,9

Month	Air temperature	Relative humidity	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days	Cooling degree-days
	°C	%	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	0,6	79,5%	1,18	100,2	1,5	-0,9	539	0
February	2,2	77,0%	2,02	100,0	1,5	0,6	442	0
March	7,2	71,0%	3,14	99,9	2,1	5,4	335	0
April	11,1	67,5%	4,29	99,6	2,1	10,3	207	33
May	15,6	67,5%	5,48	99,7	2,1	15,9	74	174
June	18,9	67,0%	5,76	99,8	2,1	19,8	0	267
July	21,1	65,5%	6,06	99,8	2,1	22,7	0	344
August	20,6	69,5%	5,21	99,9	2,1	22,3	0	329
September	17,2	74,0%	3,87	100,1	1,5	16,7	24	216
October	11,7	78,5%	2,48	100,2	1,5	11,3	195	53
November	5,6	81,5%	1,46	100,2	1,0	4,9	372	0
December	2,2	81,5%	0,92	100,1	1,0	0,1	490	0
Annual	11,2	73,3%	3,50	100,0	1,7	10,8	2.679	1.415
Measured at [m]					10,0	0,0		

2. Detailed climate data for BIHAĆ

Bihać	Unit	Climate data location
Latitude	˚N	44,8
Longitude	˚E	15,9
Elevation	m	246
Heating design temperature	°C	-9,6
Cooling design temperature	°C	29,8
Earth temperature amplitude	°C	19,7

Month	Air temperature	Relative humidity	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days	Cooling degree-days
	°C	%	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	0,9	75,5%	1,30	98,1	1,6	0,8	530	0
February	1,4	72,6%	2,14	97,9	1,5	2,2	465	0
March	6,0	67,5%	3,27	97,8	1,6	7,1	372	0
April	10,7	64,4%	4,06	97,5	1,8	11,8	219	21
May	15,2	67,9%	5,29	97,6	1,5	17,5	87	161
June	18,0	69,3%	6,01	97,7	1,3	21,7	0	240
July	20,8	69,7%	6,21	97,7	1,2	24,7	0	335
August	19,8	72,3%	5,39	97,7	1,1	24,1	0	304
September	16,6	74,8%	3,88	97,8	1,3	18,5	42	198
October	11,3	79,1%	2,35	98,0	1,4	13,0	208	40
November	5,5	79,5%	1,33	97,9	1,5	6,4	375	0
December	2,4	78,0%	1,05	98,0	1,7	1,7	484	0
Annual	10,8	72,6%	3,53	97,8	1,5	12,5	2.781	1.299
Measured at					10,0	0,0		

3. Detailed climate data for BJELAŠNICA

Bjelašnica MtnRng	Unit	Climate data location
Latitude	˚N	43,7
Longitude	˚E	18,3
Elevation	m	2.067
Heating design temperature	°C	-17,1
Cooling design temperature	°C	17,0
Earth temperature amplitude	°C	19,8

Month	Air temperature	Relative humidity	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days	Cooling degree-days
	°C	%	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	-5,5	76,8%	1,68	94,1	3,3	-0,9	729	0
February	-6,7	80,6%	2,44	93,9	3,6	0,4	692	0
March	-4,0	83,8%	3,48	93,8	3,3	4,8	682	0
April	-1,2	85,6%	4,15	93,6	3,2	9,5	576	0
May	4,1	84,9%	5,15	93,8	2,7	14,9	431	0
June	6,7	84,6%	5,99	93,9	2,7	19,1	339	0
July	10,4	80,3%	6,30	93,9	2,7	22,2	236	12
August	10,6	77,6%	5,49	93,9	2,8	21,9	229	19
September	7,0	82,0%	4,09	94,0	2,8	16,5	330	0
October	3,6	79,8%	2,65	94,2	3,1	11,0	446	0
November	-2,1	79,2%	1,60	94,0	3,3	4,9	603	0
December	-5,2	77,0%	1,38	94,1	3,6	0,2	719	0
Annual	1,5	81,0%	3,71	93,9	3,1	10,4	6.012	31
Measured at [m]					10,0	0,0		

4. Detailed climate data for MOSTAR

Mostar	Unit	Climate data location
Latitude	˚N	43,4
Longitude	˚E	17,8
Elevation	m	108
Heating design temperature	°C	-2,1
Cooling design temperature	°C	33,8
Earth temperature amplitude	°C	20,2

Month	Air temperature	Relative humidity	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days	Cooling degree-days
	°C	%	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	5,2	62,7%	1,68	95,8	3,6	0,3	397	0
February	5,6	60,2%	2,49	95,6	3,9	1,6	347	0
March	9,5	58,7%	3,67	95,5	3,6	6,0	264	0
April	13,4	60,7%	4,50	95,3	3,5	10,7	138	102
May	18,2	62,3%	5,64	95,5	2,8	16,5	0	254
June	21,5	59,0%	6,47	95,5	2,8	20,8	0	345
July	25,5	50,0%	6,71	95,5	2,8	24,1	0	481
August	25,5	49,7%	5,77	95,5	2,9	23,6	0	481
September	20,7	57,8%	4,34	95,6	2,9	17,8	0	321
October	15,8	65,2%	2,72	95,8	3,3	12,3	68	180
November	9,8	65,3%	1,67	95,7	3,6	6,0	246	0
December	6,1	62,8%	1,39	95,7	3,8	1,4	369	0
Annual	14,8	59,5%	3,93	95,6	3,3	11,8	1.829	2.163
Measured at [m]					10,0	0,0		

5. Detailed climate data for PRIJEDOR

Prijedor	Unit	Climate data location
Latitude	˚N	45,0
Longitude	˚E	16,7
Elevation	m	428
Heating design temperature	°C	-4,2
Cooling design temperature	°C	27,0
Earth temperature amplitude	°C	19,4

Month	Air temperature	Relative humidity	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days	Cooling degree-days
	°C	%	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	0,5	79,5%	1,31	96,9	2,9	-0,1	543	0
February	1,7	75,8%	2,10	96,8	3,1	1,3	457	0
March	5,8	70,1%	3,21	96,7	3,0	6,0	379	0
April	10,1	66,0%	4,06	96,4	3,0	10,7	238	2
May	15,4	61,3%	5,18	96,5	2,5	16,3	82	166
June	19,1	56,9%	5,87	96,6	2,5	20,3	0	272
July	21,8	51,5%	6,22	96,6	2,4	23,2	0	367
August	21,7	53,2%	5,30	96,6	2,5	22,7	0	361
September	16,6	62,4%	3,88	96,7	2,4	17,1	42	198
October	11,9	71,5%	2,36	96,9	2,7	11,9	189	59
November	5,9	80,1%	1,37	96,8	2,8	5,5	362	0
December	1,5	81,3%	1,08	96,9	3,0	0,9	510	0
Annual	11,0	67,4%	3,50	96,7	2,7	11,4	2.802	1.425
Measured at [m]					10,0	0,0		

6. Detailed climate data for SARAJEVO

Sarajevo	Unit	Climate data location
Latitude	˚N	43,9
Longitude	˚E	18,4
Elevation	m	637
Heating design temperature	°C	-10,3
Cooling design temperature	°C	29,4
Earth temperature amplitude	°C	19,8

Month	Air temperature	Relative humidity	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days	Cooling degree-days
	°C	%	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	-1,1	74,8%	1,68	94,1	3,3	-0,9	592	0
February	1,5	67,3%	2,44	93,9	3,6	0,4	462	0
March	6,1	61,4%	3,48	93,8	3,3	4,8	369	0
April	9,6	62,0%	4,15	93,6	3,2	9,5	252	0
May	14,4	65,5%	5,15	93,8	2,7	14,9	112	136
June	16,8	66,6%	5,99	93,9	2,7	19,1	36	204
July	19,7	63,8%	6,30	93,9	2,7	22,2	0	301
August	19,4	65,2%	5,49	93,9	2,8	21,9	0	291
September	15,1	70,5%	4,09	94,0	2,8	16,5	87	153
October	10,9	73,6%	2,65	94,2	3,1	11,0	220	28
November	4,3	75,9%	1,60	94,0	3,3	4,9	411	0
December	-0,3	77,6%	1,38	94,1	3,6	0,2	567	0
Annual	9,7	68,7%	3,71	93,9	3,1	10,4	3.108	1.113
Measured at [m]					10,0	0,0		

7. Detailed climate data for TUZLA

Tuzla	Unit	Climate data location
Latitude	˚N	44,5
Longitude	˚E	18,7
Elevation	m	479
Heating design temperature	°C	-5,8
Cooling design temperature	°C	26,7
Earth temperature amplitude	°C	20,1

Month	Air temperature	Relative humidity	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days	Cooling degree-days
	°C	%	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	-0,7	82,6%	1,46	96,4	3,0	-1,0	581	0
February	0,6	78,2%	2,24	96,2	3,4	0,6	486	0
March	4,9	70,4%	3,21	96,1	3,2	5,5	405	0
April	9,8	64,7%	3,99	95,8	3,1	10,7	246	0
May	15,2	59,9%	4,95	96,0	2,7	16,2	88	160
June	18,7	55,9%	5,57	96,0	2,6	20,0	0	262
July	21,3	51,3%	5,83	96,0	2,6	22,9	0	352
August	21,4	51,3%	5,15	96,1	2,6	22,6	0	352
September	16,4	59,8%	3,76	96,2	2,6	17,3	49	191
October	11,3	70,5%	2,46	96,4	2,9	11,7	209	39
November	5,1	80,9%	1,41	96,2	3,0	5,0	388	0
December	0,2	84,1%	1,15	96,4	3,3	0,0	551	0
Annual	10,4	67,4%	3,44	96,1	2,9	11,0	3.003	1.355
Measured at [m]					10,0	0,0		

Attachment 3:
CALCULATION OF CO_2 EMISSIONS[1]

a. General Approach

The use of fuel causes the creation of carbon dioxide (CO_2) and small quantities of other greenhouse gases (GHG), including methane (CH_4) and nitrous oxide (N_2O). For a given quantity of gas, the equivalent of CO_2 that creates identical greenhouse effect is called the equivalent quantity of carbon dioxide ($kgCO_2e$).

Specified conversion factors include the combined effect of CO_2, CH_4 and N_2O, and they are stated as the quantity of the equivalent of carbon dioxide per unit of used fuel.

The energy conversion factors used here refer to the total directly emitted quantity of carbon dioxide ($kgCO_2e$) created at the place at which fuel is used or, in case of electricity, at the place where it is produced.

Conversion factors specified herein do not take into account indirect emissions (except for biomass) that occur during the extraction of the energy source, e.g. natural gas and crude oil. Biomass fuel is specified as the total direct and indirect emission in $kgCO_2$ per unit of fuel (direct emission is insignificant).

- **Calorific Value of Fuel**

Upper calorific values of fuels specified in Table 1 should be used when there are no available data given by fuel suppliers.

Solid fuels	**kWh/ton**
Coal (medium grade)	7,500
Industrial wood	3,806
Three branches	3,084
Straw	4,389

Liquid fuels	**kWh/ton**	**liter/ton**	**kWh/liter**
Heavy fuel oil	12,029	1,024	12
LPG	13,668	1,968	7
Diesel	12,584	1,153	11
Waste oil	12,834	1,245	10
Gasoline	12,807	1,362	9

[1] *Energy conversion factors refer to the kilograms of the equivalent of carbon dioxide per unit of fuel.*

Gaseous fuel	kWh/ton	liter/ton	kWh/m³
Natural gas	-	-	11.13

- **Conversion Factors of Energy Units**

Units to kWh

Btu	2.931×10^{-4}	Btu = British Thermal Unit
MJ	0.2778	MJ = Mega Joule
toe	1.163x104	toe = Ton of Oil Equivalent
kcal	1.163×10^{-3}	kcal = kilocalorie

- **Energy Conversion Factors[2]**

Fuel	Unit	$kgCO_2e$ per unit
Electricity from the grid *	kWh	0.5246
Electricity from renewable energy sources	For electricity purchased at 'green tariff' it is necessary to use the factor used for electricity from the grid. For electricity produced at the place of utilization of renewable energy sources, the factor is zero.	
Natural gas	kWh	0.1836
Propane - butane	kWh	0.2147
	liter	1.4918
Refinery gas	ton	3528
	kWh	0.27857
	liter	3.0595
Heavy fuel oil	ton	3228
	kWh	0.2674
Waste oil	ton	3165
	kWh	0.2468
Diesel	ton	3188
	kWh	0.2517
	liter	2.6676
Gasoline	ton	3149
	kWh	0.2407
	liter	2.3117
Industrial coal	ton	2383
	kWh	0.3325
Wood pellets	ton	183.9
	kWh	0.039

Table 2. Energy Conversion Factors (ε)

[2]*Conversion factors - Energy and carbon conversions 2011 update, http://www.carbontrust.co.uk*

* This is electricity used at the point of consumption. The above-mentioned factor is calculated according to the energy mix valid in Bosnia and Herzegovina in 2010 (Source: Regulatory Commission).

- **Calculation Procedure**

The equivalent emission of CO_2 is calculated for the situation before the introduction of measures for the increase of energy efficiency and then after their introduction. The difference between these two figures is the reduction of emissions per annum.

BEFORE THE INTRODUCTION OF MEASURES

$$E_{CO_2}\ [kgCO_2e/god] = \frac{A\,[m^2] \times q\,[kWh/(m^2\ god)] \times \varepsilon\,[kgCO_2e/kWh] \times \xi\,[-]}{\eta\,[-]}$$

where

A Heated area of the building

q Specific annual energy consumption for heating purposes. Information from design documentation can be used or data obtained from measurements of annual consumption of fuel or energy carriers. This value is determined again after measures for the increase of energy measurements have been introduced

Q Annual energy consumption for heating (Q = q • A)
If measured values of annual heat energy consumption in the building refer to conditions when there are larger deviations from the preset temperature in the building (overheating or insufficient heating) then the consumption should be adjusted. The correction is made as follows:

$$Q = Q^* \cdot \frac{t_u - t_{s,god}}{t_u^* - t_{s,god}}$$

where

t_u Preset temperature, °C

t_u^* Measured or estimated temperature in the building, °C

Q* Measured annual consumption of heat energy, kWh

Q Real annual consumption of heat energy in the conditions of preset temperature, kWh

ε CO_2 emission corresponding to the energy carrier used for heating purposes.

η The efficiency degree of energy transformation when carried out within the building or at some virtual place outside the building. If heating is done by boilers, then the boiler's efficiency degree is taken; if the district heating system is used, some medium efficiency degree is taken according to Table 2 for fuel used in the boilers of the district heating system. The average efficiency degree of energy transformation of heat energy can be taken from Table 3 if data measured at the plant is not available.

Electricity from the grid	100%
Natural gas	96%
Propane - butane	96%
Refinery gas	96%
Heavy fuel oil	90%
Waste oil	90%
Diesel	94%
Industrial coal	60%
Wood pellets	91%

Table 3. Average Efficiency Degrees of Energy Transformation

ξ Occupancy coefficient of the building (ξ = 1 – residential buildings; ξ = 0.83 – schools and universities; ξ = 0.45 – public buildings). These coefficients are calculated on the basis of evaluated operating hours. This coefficient is used if it is not taken into account in the calculation of consumption in the design documentation. If measurements are used, then the reduction of consumption due to the interruption has already been taken into account and does not need to be calculated again.

Residential Buildings

$$\tau_1 = 180\,[\text{day / year}] \times \frac{16}{24}\,[\text{working hours per day / hours per day}] \approx 120\,[\text{days / year}]$$

Schools and Universities

$$\tau_2 = 180\,[\text{days / year}] \times \frac{6}{7}\,[\text{working days per week / days per week}] \times$$

$$\frac{16}{24}\,[\text{working hours per day / hours per day}] \approx 100\,[\text{days / year}]$$

Public Buildings

$$\tau_2 = 180\,[\text{days / year}] \times \frac{5}{7}\,[\text{working days per week / days per week}] \times$$

$$\frac{10}{24}\,[\text{working days per day / hours per day}] \approx 55\,[\text{daya / year}]$$

The calculation is repeated **AFTER THE INTRODUCTION OF MEASURES** for the increase of energy efficiency. The result is as follows:

$$\Delta E_{CO_2} = E_{CO_2}(\text{before}) - E_{CO_2}(\text{after}) \quad [\text{kg}CO_2\,/\,\text{year}]$$

EXAMPLE 1: Building in Tuzla
BEFORE:

A = 2624 m^2

Q = 276 MWh/year (This is heat energy consumption before the introduction of measures for the increase of energy efficiency. This is, as it can be seen from the notes, some medium values)

ε = 0.3325 $kgCO_2$/kWh (Taken from the Table. Since the district heating system is run on coal –TE-TO (Thermal Power Plant - Heating Plant, coal is taken as comparative fuel)

η = 0.6 (Recommended efficiency degree of energy transformation of coal is according to the Table 2)

ξ = 1 (This coefficient is adopted as for residential buildings since in schools there are no possibilities to turn off the district heating system during weekends. The building operates as if it is a residential one when heating is in question)

The CO2 emission before the introduction of measures for the increase of energy efficiency is:

$$E_{CO_2}^{BEFORE} = \frac{276,000\,[kWh/year] \times 0.3325\,[kgCO_2e/kWh] \times 1.0\,[-]}{0,60\,[-]} = 152,950\,[kgCO_2e/year]$$

AFTER:

Average savings are estimated to 67 MWh/year. Therefore, the emission is equal to:

$$E_{CO_2}^{AFTER} = \frac{(276,000 - 67,000)\,[kWh/year] \times 0.3325\,[kgCO_2e/kWh] \times 1.0\,[-]}{0,60\,[-]} = 115,821\,[kgCO_2e/year]$$

Now, the annual effect of CO2 reduction is equal to:

$$\Delta E_{CO_2} = 152,950 - 115,821 = 37,129 \quad [kgCO_2/year]$$