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Impact of Energy Consumption on the EE Performance of School Buildings in Kosovo

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Abstract: ***The Kosovo Energy Efficiency Project which includes design and supervision support for implementation of the Energy Efficiency Improvements in Public Buildings in Kosovo, funded by EU office in Kosovo, has involved the energy efficient refurbishment of 63 schools as part of public buildings in Kosovo. The major goal of the project has been implementation of the energy efficiency improvements in public buildings in Kosovo and the verification of the energy and cost savings as well as CO2 emission reductions achieved through implementation of the energy efficiency measures. This activity is in line with the Kosovo Education Strategic Plan (KESP) 2011 -2016 (1) which provides an important tool to make the education system more qualitative improving school infrastructure. The strategic priorities, issues that KESP addresses, and corresponds with the EU concepts of implementation of Energy Efficiency Measures in schools, and with the international experience and literature (7) on aspects of school infrastructure which can influence non-cognitive outcomes as well-being and behavior are linked between others on the quality indicators as conditions of school buildings, and criteria on the amenity and physical comfort of school buildings (temperature, acoustics, lighting and ventilation).***

Keywords: Schools, Energy Efficiency Measures, Energy Consumption, CO2 Emission

1. Introduction

Schools are the most suitable type of building for the application of energy efficiency and good indoor air quality measures. This is justified by the fact that such measures can promote sustainability to the future citizens, and even more, ensure a comfortable and healthy environment for educational purposes. Unfortunately, in practice school buildings face the same, or even more intense, energy performance and indoor air quality problems as any other building.

The purpose of this study was to implement the energy efficiency measures which impact thermal environment and indoor air quality in 63 school buildings around Kosovo. Prior performed energy audit of these buildings (2) shows problematic building envelope, lack and/or the improper control of heating and lighting systems, the absence of proper legislative measures and, above all, the lack of interest concerning the efficiency of such buildings are the main factors in the reported very low efficiency.

The building envelope should be efficient in keeping the building thermally stable and comfortable. Heat transfer through envelope components is quite involved and multifaceted. Thermal resistance, heat capacity, and exterior surface condition should be considered to optimize the achievement of energy efficiency and thermal comfort (4).

The building envelope can contribute to energy savings and increased indoor environmental quality that may significantly heighten student and staff productivity, lower energy costs, allowing budget shifts toward other school needs. In addition, the shape of the building envelope has significant impact on the thermal comfort of the building. For example, window placement and direct sunlight infiltration affect the amount of heat that enters the building.

The overall objective of this paper is to present detailed and comprehensive information regarding the efforts in implementation of EEM in above mentioned school buildings and expected savings, improvement of comfortable and healthy environment for educational purposes as well as CO2 emission reductions to be achieved through implementation of energy efficiency measures. A cost on carbon emissions from energy use increases the return on energy efficiency investments because energy is more expensive, making some cost-ineffective projects economically feasible (5).

The applied energy efficient measures will focus on improving the thermal performance of the buildings' fabric and heating system by installing air tight windows and doors with lower U values, improving roof and external wall insulation, as well as installing more efficient mechanical systems and controls.

This paper summarizes outcomes of EEMK through energy and carbon savings as well as investment payback period. The results are presented in the following section.

2. Methodology

A total of 63 schools in various regions of Kosova have participated in the project with the purposes of Energy Efficiency improvements in the retrofitted public buildings in Kosovo, by implementation of energy efficiency measures on building envelope, heating system and interior lighting, hence make heating more affordable and use of renewable energy resources that will reduce the harmful impact on environment. Data base of participating public buildings is compiled with respect to region, space heated area, energy consumption before and after implementation EEM and savings as well as is depicted in Fig.1

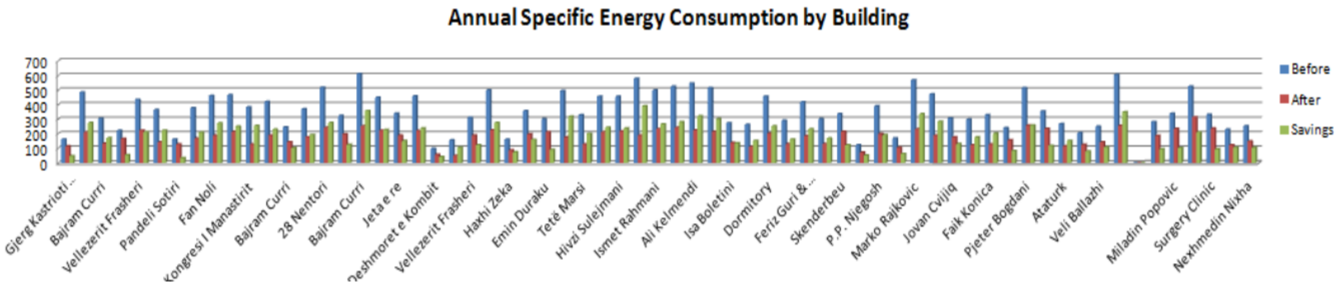

Figure 1: Annual specific energy consumption by building

Project strategy was, that the approach to verifying savings will be to carry out through the analysis on a "whole facility" basis, i.e. rather than trying to isolate the savings from one individual measure, such as lighting improvements or improved U values. We have followed an approach that adheres to the International Performance Measurement and Verification Protocol (IPMVP) as set out by the Efficiency Valuation Organization (EVO 10000 –1:1012).

Furthermore, we have used as the basis document for building energy auditing EPBD (Energy Performance of Buildings Directive) 2002/91/EC, i.e. recast 2010/31/EU. Implementation of this document is based on respect of standards that define particular fields of interest and relevant technical characteristics. Likewise are used CEN (European Committee for Standardization), with produced standards supportive for the implementation of the EPBD. National Laws and Regulations were consulted as the relevant documents and important document, relevant to assessments, calculations and specifications in this project.

For each school, we would seek to gather the following baseline data, over the last 12 months (to cover all four seasons), to be able to model the impact of driving factors on energy use.

3. HVAC Measurements

During the measurements of the first group of the schools, we have used standard testing methods, according to procedures which are based on national or international standards, test procedures provided by the manufacturer, international recommendations and guidelines.

4. Equipment and Instruments used

During the measurements, monitoring, verification and evaluation "before" and "after" implementation of energy efficiency measures in schools will be used different instruments and equipment which in different way support realization of the correct measurements and collecting of the results.

For the measurement of the thermal flux and identification of the buildings structure U- value it will be used brand new instrument, measuring thermal flux in W/m2 and U-value in W/m2K using the multifunctional instrument and outdoor thermometric wireless probe to determine the coefficient of the thermal transmittance.

The important tool in field measurements was thermal imaging camera, with sensor system of infrared radiation. This camera was intended to be used to identify areas of energy waste, through infrared imaging as a valued tool in identifying problems related to energy and much more. A thermal imaging camera identifies patterns of heat loss that are invisible to the naked eye. Thermal imaging quickly indicates the air leaks within a building and measurement data are easily compiled into a report as is presented below in Fig.3.

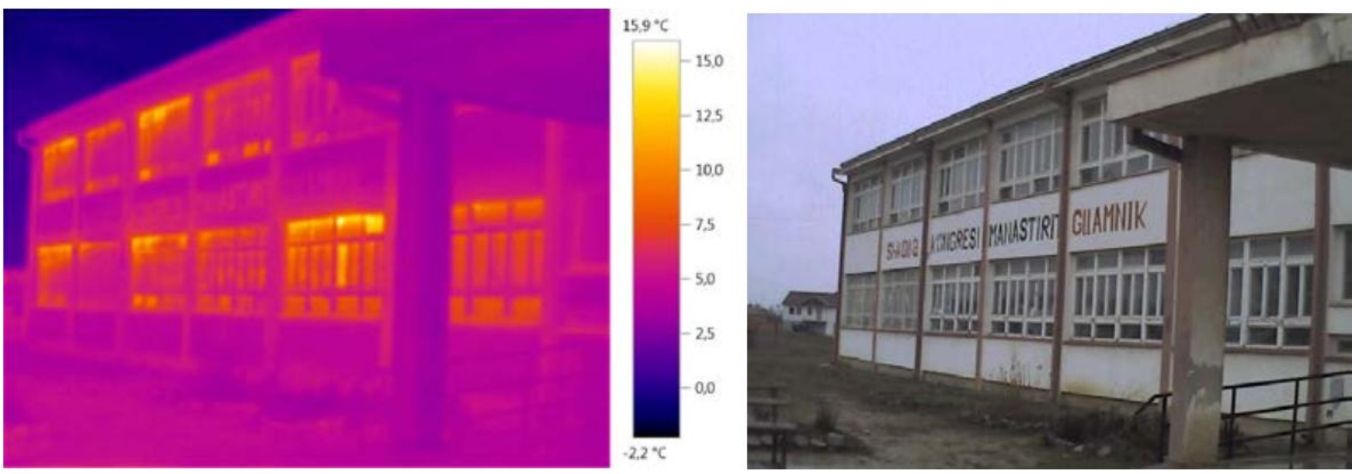

Figure 2: Thermograms by thermal imaging camera

Combustion analyzers are used to determine the composition of the flue gases in the fux duct. The fux duct is the large piping arrangement of circular configuration and is used to flush out the combusted gases to the chimney. The values for the different components of the flue gases are volume-based and used for analyzing of the boilers heating capacity.

5. Results and Discussions

5.1 Energy savings

Analyzing results from the Audit Report, comparing with the preliminary field measurements after implementation of Energy Efficiency Measures we found significant discrepancies in foreseen savings. Therefore, all analysis regarding the comparison of average annual unit energy consumption before and after retrofit and achieved savings after retrofit is based in more realistic information collected during the intermediate control measurements realized on January 2014.

From the chart presented in Fig 1. the highest specific energy consumption is for four schools in range from 435 kWh/m2 up to 605 kWh/m2. The average of energy consumption for 63 schools is 355,66 kWh/m2 annually and is much higher compared with the specific consumption identified in schools in region. Average of energy savings is 183.55 kWh/m2 annually. This value will be finally verified after completion of implementation measures and surveys planned to be performed in winter 2014/2015. While average measured energy consumption for post retrofitted two and schools is CCA. 205 kWh/m2 and expected savings are 153 kWh/m2 respectively!.

Energy consumption reduction of around 50% for 63 schools is expected to be achieved by implementing of selected energy efficiency measures. Higher energy consumption of compared to that of schools was due to higher indoor set point temperatures and around the clock business hours. Expected energy consumption reduction is lower, approximately 35% after implementation of EEM. Detail breakdown of energy conserving measures applied per building along with energy consumed before and after refurbishments is presented in Figure 2

Figure 4 summarizes post retrofit total measured energy consumption over a heating season for all buildings and achieved savings. Amount of saved energy could cover heating needs of 16 refurbished schools for a 2 years period.

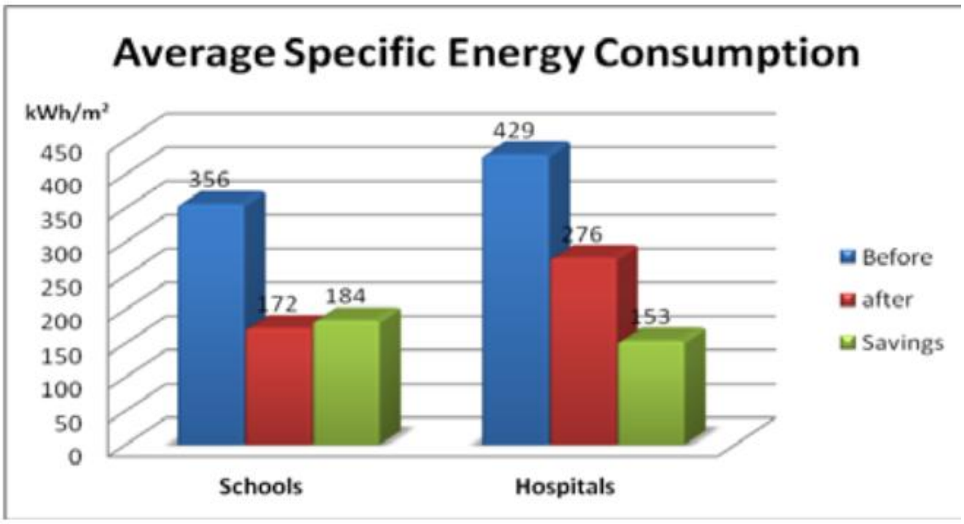

Figure 3: Comparison of average annual

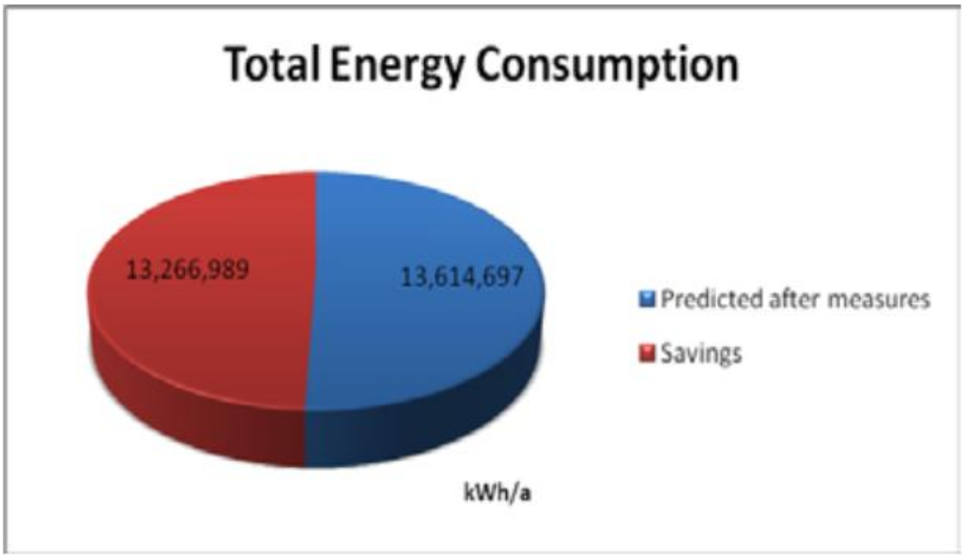

Figure 4: Total measures energy consumption before and after retrofit and savings consumption and achieved savings

Figure 5 shows clearly that even after implementation of energy efficiency measures results with higher values for both schools and comparing with achieved results in the regional projects (6) and recommendation from German and

UK standards, with 172 kWh/m2a for schools, respectively 276 kWh/m2a for schools for in Kosovo.

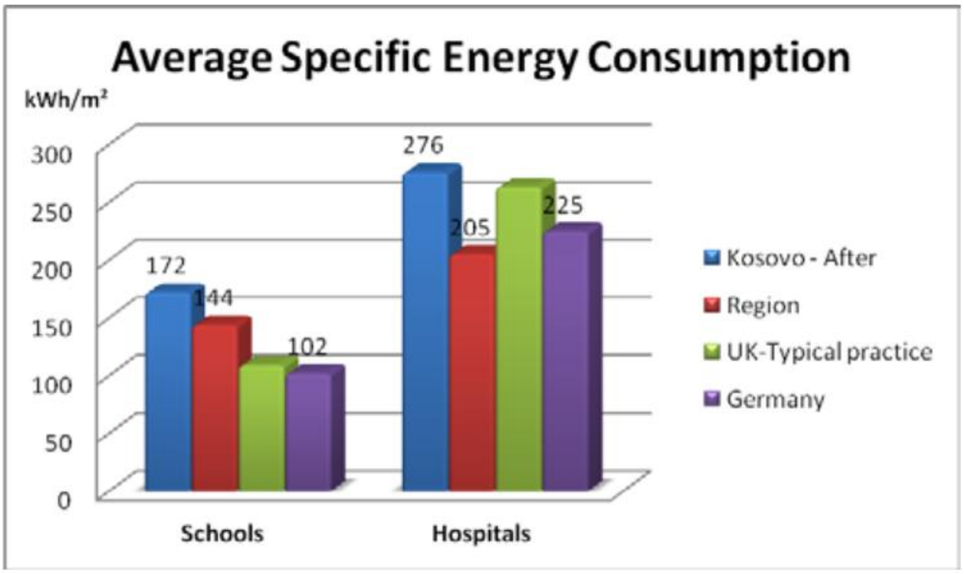

Figure 5: Comparison of school building energy benchmarks in Kosovo, Region, UK and Germany (CIBSE TM 46, 2008) (EnEv, 2007)

5.2 Carbon emission savings

For calculation of CO2 emission factor for external walls and ceiling presented through heating oil, value used in the calculation was 0.3kg/kWh, while value for CO2 emission factor for electricity used in the calculation was 1.5kg/kWh.

Difference in average annual specific CO2 emissions pre and post retrofit follow is calculated based on annual energy savings (5). Results indicate an average of 42% of carbon emission reductions for schools. Significant carbon emission reductions are achieved after retrofit and depicted in Figure 6. Amount of 6738t CO2 is saved over a heating season for all school buildings, while for individual buildings we have savings of 423 t/a of CO2.

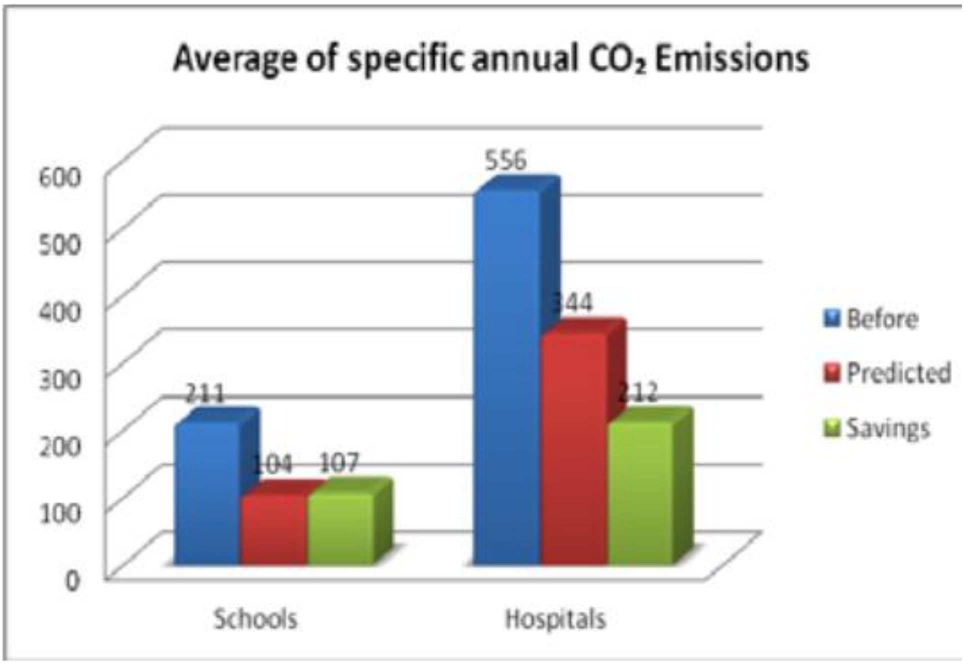

Figure 6: Comparison of average

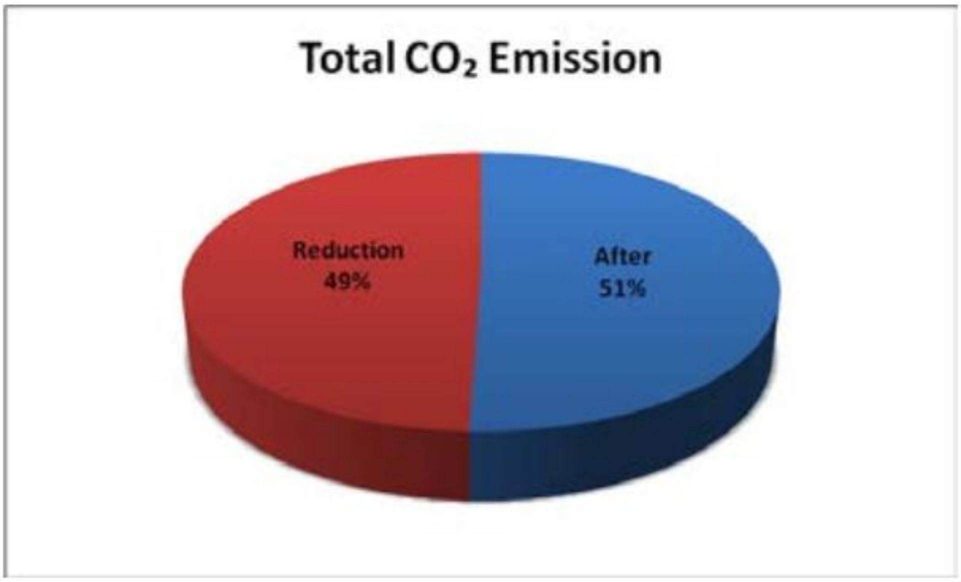

Figure 7: Total CO2 emission Annual CO2 emission and achieved reduction

6. Conclusions

The Energy efficiency measures implemented on building envelope and heating system in 63 schools as retrofitted public buildings in Kosovo have been analyzed and presented.

Replacement of existing windows has been the most frequent measure applied into buildings.

The best results are identified in building with replacement of all windows, complete new building envelope and new heating system as schools with the savings between 250-350 kWh/m2a.

The significant energy savings and carbon emission savings, of cca. 40% have been achieved. While measured average unit energy consumption for and schools has been found to be cca.205 kWh/m2 and 144 kWh/m2 respectively "after" refurbishment, monitored energy consumption has been found to be 339 kWh/m2 and 243 kWh/m2 respectively "before" refurbishment.

Carbon emissions are influenced by energy consumption and fuel type. The simple payback period on investment is found to be 5.05/5.8 years for /schools, respectively.

Analysis of answers on questionnaires shows that there was a stark contrast in satisfaction levels between students attending schools with good quality infrastructure as compared with those in schools with poor infrastructure, before implementation of measures. Without a doubt, we were able to conclude that school infrastructure definitely contributes to the well-being of students.

Referring back to the fundamental question raised during the investigations ("Can differences in students' well-being be attributed to the quality of their school's infrastructure?), the answer is yes (7). Differences in students' well-being can be linked to the quality of the infrastructure of the schools they attend. So, regardless of these criteria, the quality of school infrastructure definitely has a strong impact on an individual's perception of his well-being.

References

[1] Government of Kosovo, Ministry of Education "Kosovo Education Strategic Plan 2011-2016", June 2011
[2] ALAnet, 2011, Study on Energy Efficiency Measures in Public Buildings in Kosovo Municipalities, EU Project, FWC BENEF 2009 EUROPEAID/127054/C/SER/MULTI
[3] Supervision of energy efficiency measures in schools and in Kosovo, Contract No 2012/302-059, Inception Report, 2013
[4] EN 15217 Methods of assessment for energy certification of buildings, guidelines for certification schemes;
[5] EN 15603 Overall energy use, primary energy and CO2 emissions
[6] Stankovic et al., Evaluation of energy efficiency measures applied in public buildings (schools &) in Serbia, Spatium International Review, nr.20, September 2009, pp 1-9.
[7] Cuyvers K,, De Weerd G., Dupont S., Mols S., and Nuytten C.,, "Well-being at school: does infrastructure matter?" Institute for Educational and Information Sciences, Instructional and Educational Science, University of Antwerp, OECD 2011