An assessment of energy efficiency measures in a public building in Albania in the prospect of cost and emissions reduction

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Abstract: *The building sector in our country has an important share of energy consumption. According to Eurostat data, final energy consumption in the residential sector was estimated about 35 % of the total consumption. On the other hand about 75% of the electricity consumption takes place in the building sector. It should be noted that currently this sector faces many challenge, as the quality of energy supply (heating) in public buildings and the residential sector remains at low rates. Nevertheless, reducing energy consumption is one of the main targets set in the National Energy Strategy 2018-2030. By 2030 this target suggests 15.5 % of the energy reduction. This study has at its core the assessment of energy consumption in a public building placed in the city of Durres. Determining the typology and thermo-physical characteristics of the building is of primary importance. The evaluation of the energy performance of the building in the dynamic regime was carried out through the Hourly Energy Analysis (HAP) software. The implementation of energy efficiency measures is carried out taking into account the energy and cost criteria. A cost analysis of EE measures was performed using the dynamic Net Present Value method.*

Keywords*: PUPBLIC BUILDINGS, ENERGY EFFICIENCY, COST, EMISSION*

1. Introduction

Energy consumption in building represents more than 38 % of the total energy in Europe [1]. On the other hand, buildings are responsible for approximately 35 % of greenhouse gas emissions. Albania is part of this energy consumption trend. According to INSTAT (Institute of Statistics) energy consumption of non-residential building is approximately 20.6 % of the total energy consumption [2]. In the recent years a number of initiatives in the Albanian energy sector have been recorded. The Energy Efficiency Directive established a set of binding measures to achieve the 20% target in Energy Efficiency (EE) [3]. On the other hand Albania has made a significant progress in preparation of the National Energy and Climate Action Plan (NEACP). In order to maintain a high economic growth rate, Albania has to provide power supply, which is long-term, reliable and within the means to pay for it [4]. On the other hand, the country needs to use energy in an efficient way and to diversify its energy sources. Energy demand in the residential sector represents a permanent challenge. The general classification of climatic zones in Albania according to heating degree days is divided into three main categories: zone A, B and C. Most of area of public buildings, which makes up 57%, is located in climate zone A. It is followed by the area climate B with 26% of the area and finally the area climate C with 17% of the surface. Public buildings with all the sub-categories have a significant contribution on energy demand in buildings. For this reason this study is focused on the A climatic zone. In absolute values the climatic zone A results the largest percentage of energy savings. This paper discusses the energy performance of a public building situated in climatic zone A.

2. Energy consumption in buildings

Electricity is often the main energy source for space heating, especially in urban areas. Share of electricity consumption in Albanian households according to Eurostat [5] is 31.7 % for space heating, 29.8 % goes for cooking, whereas 21.4 % and 11.7 % for domestic hot water and lighting/electrical equipment respectively. Recently Albania introduced changes to the law of energy efficiency in country, in order to insert mandatory energy efficient targets for public, private and large consumers of energy. Therefore, from September 2021 the public sector is obliged to renovate a minimum of 3 % of the overall stock of public buildings [6]. This should be realized annually to meet the minimum requirements of energy performance. The law obligates municipalities to prepare local action plans for energy efficiency that includes policies and measures to save energy. In general, Albanian dwellings are partially heated, and only for a few hours a day. The continued use of old firewood stoves brings many problems to the environment and health of citizens. Findings on the final energy consumption need for thermal energy services in the residential sector in 2015 speak of 4.9 billion kWh, of which 54% were met by electricity, 37% by wood consumption, and 9% from liquid gas. The sector emitted 96,000 tons of CO_2 associated with the consumption of liquid gas. The final consumed energy calculated on the basis of the geometric and thermal properties of buildings, as well as the features of the installed energy systems, differ substantially from the energy balance. A view of energy sources share for space heating is given below in Figure 1.

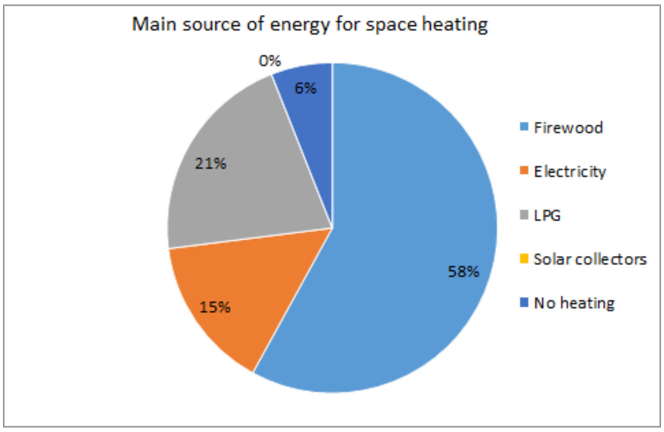

Fig. 1 Main energy sources used for space heating purposes

3. Case Study

An administrative office building was considered for this study. The building is placed in the port city of Durres. The gross floor area of the building is approximately 925.9 m^2 which is organized in two floors. Total window area is estimated 137 m^2, whereas wall transmission area results 442 m^2. The roof transmission area according to the plan is 438 m^2. The building serves as an administrative and office space running 8 hours per day and 6 days a week. The actual energy flows in the building, include lighting, office equipment, HVAC system. Electricity is the main energy source in the building. As for the time of this study no other fuel source supplied the building facilities. It is obvious that electrical equipment consists in the largest energy consumer in the investigated building. However, the first attempt was to highlight the current energy performance of the building. Overall heat transfer coefficient prior the energy efficiency measures was estimated U=1.023 W/m^2K, whereas for windows this value was U=3.147 $W/(m^2k)$. For the roof the estimated value was U=2.05 $W/(m^2K)$. In Figure 2 is given the front view of the building studied in this paper. Before estimating the energy performance a thermal imaging of the building was performed using infrared Testo camera. The result is shown in detail in Figure 3.

Fig. 2 *Front view of the office building [8]*

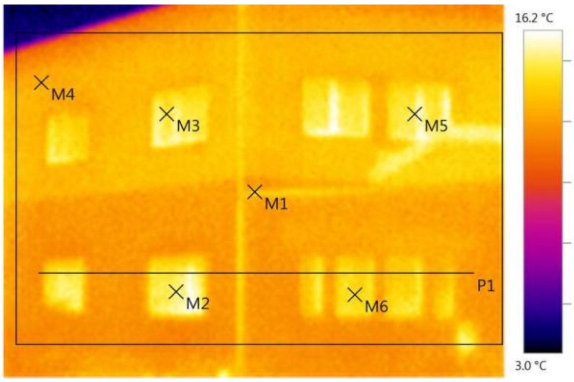

Fig. 3 *Temperature distribution of the measured building side*

In this case study thermal insulation was considered as the first energy efficiency measure. For this a 50 mm polystyrene XPS was predicted as an effective energy efficiency measure. It was obvious from the beginning that the share of heating and cooling in the total energy consumption is not very high due to geographic location of the city in the west part of the country. However we expect large consumption in cooling during summer season in both cases. It is a fact that in this study the no intervention on windows replacement was introduced, due to the relatively good condition observed during the investigation of the building. On the other hand, window replacement would require extra financial sources that were not predicted by the administrative staff of the building.

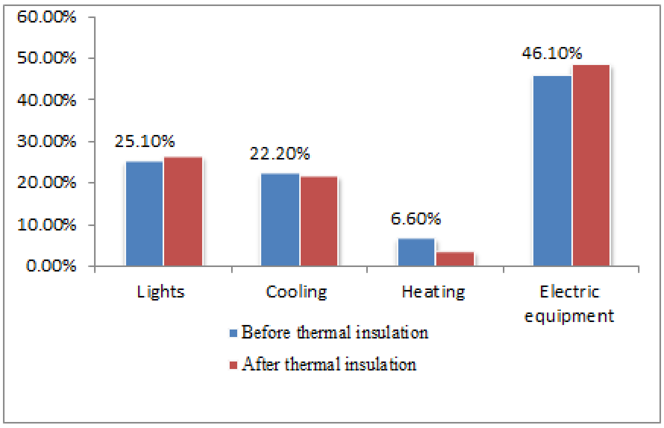

Fig. 4 *Distribution of energy consumption in the building before and after EE measures*

A view of energy consumption in the building is presented in Figure 4. The graph shows the real distribution of energy flows in building before and after thermal insulation assumed. The results suggest that introduction of such an EE measure could have a considerable impact on heating, by a reduction by half. On the contrary, a slight impact is observed in cooling where this reduction is less than in heating. In Hourly Analysis Programme (HAP) is performed the monthly energy consumption by each consumer in the building inserting all the input data, such as lighting load, HVAC load, equipment load, working hours, technical description of energy consumers, employees etc. The results are presented in the Figure 5 to Figure 7.

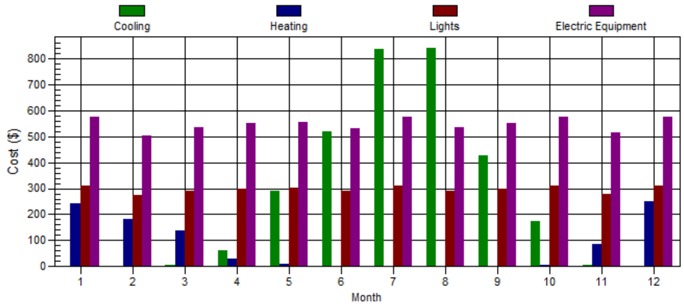

Fig.5 *Monthly component cost estimated in USD in HAP software.*

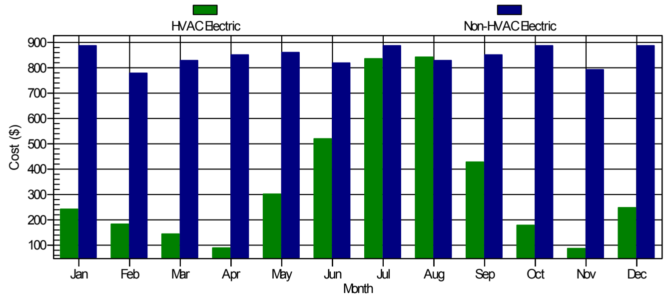

Fig.6 *Monthly energy cost for HVAC and non-HVAC components prior introducing thermal insulation*

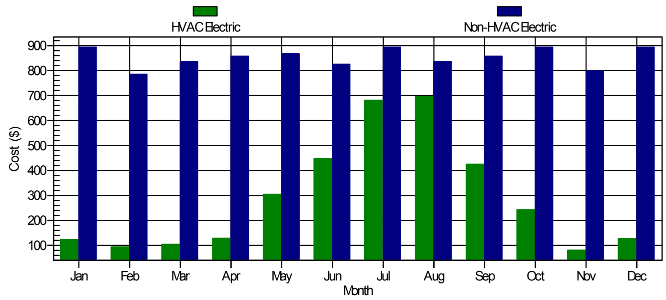

Fig.7 *Monthly energy cost for HVAC and non-HVAC components after applying thermal insulation*

What we can observe from the results taken from simulations is the dominant energy consumption by non HVAC equipment, such as lighting and electric appliances for office purposes. However this trend sharply changes during summer days where solar irradiance is higher. As a consequence the energy cost for cooling would increase during summer season. As mentioned above the application of thermal insulation of the walls would only slightly decrease the cooling load during summer. It is clear that the highest influence is on the windows, since their U-value is higher than in opaque structures. Nevertheless, observing the Figure 7, a new discussion can be made. Since the share of lighting and electrical equipment is approximately equal throughout the year with minimal variation and the demand for electricity is constant over the year it was estimated appropriate introducing a photovoltaic PV system on the rooftop of the building.

3.1 PV System generating electricity

A grid connected photovoltaic system made of Si polycrystalline cell was simulated using PVSol software. The PV generator surface estimated at 181 m2 covered by 88 PV modules arranged on the roof of the building. Numbers of inverters were four and total PV output is assessed 34.32 kWp. The inclination was taken 30^o and orientation South 172^o. The simulated results are listed below in Figure 8.

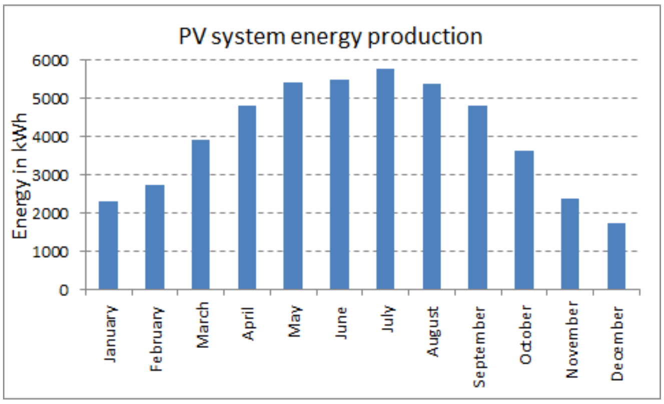

Fig. 8 *Energy production by PV system on rooftop of the building*

From the simulations we are able to determine the specific annual yield which results 1418.74 kWh/kWp and annual contribution of PV system on the grid results 48,691 kWh/year. The stand-by consumption evaluated about 64 kWh/year. On the other hand generating electricity using solar energy will directly contribute on the reduction of CO_2 emissions. The avoided CO_2 emissions result in 29,215 kg/year. Furthermore an economic analysis was performed using the simple payback method. For the financial analysis specific investment cost was selected 750 Euro/kWp, which is accordance with the nowadays market price of PV modules. The assessment period was chosen 20 years and amortization period 5.9 years. Total investment cost resulted 25,740 Euro. No bank loan was predicted for the investment during the simulations. The results are given in Figure 9.

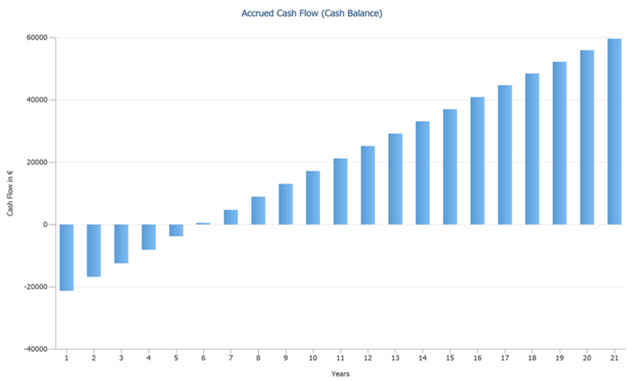

Fig. 9 *Accrued cash flow balance*

4. Conclusions

In this research paper a typical public building placed in the city of Durres was considered. Durres city is part of the A climatic zone, in which the public buildings dominate with more than 57 % located in this area. The building is a two floor structure which is firstly investigated using infrared thermal camera. From the investigation carried out in the building four main energy consumers are lighting, cooling, and heating purposes. Energy consumption of electric equipment result on approximately 46 % of the total electricity consumption. First attempt to include energy efficiency measures was to introduce the thermal insulation. Due to this EE measure the impact on energy reduction in heating is significant, whereas for other energy consumers this measure has a slight effect. The second EE measure applied in this study was the introduction of a grid connected PV energy system applied on the roof of the building. Total PV capacity assessed was34.32 kWp with an annual yield about 48,691 kWh of electricity. This figure will significantly contribute on the CO_2 emission reduction estimated at 29,215 kg of CO_2 per year. Energy consumption in public buildings requires more accurate data which can be supplied at sight. The analysis needs to deepen thoroughly in order to improve the energy performance in building by introducing effective energy efficiency measures with low cost ensuring greenhouse gas emission reduction and increasing the energy performance of the building in generally.

5. References

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