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Analysis of Computer Simulation Software's for Energy Audit in Albania

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ABSTRACT

Energy efficiency is one of the biggest challenges that energy sector is actually facing in Albania. Due to the design and construction of the existing building stock which is not in compliance with the laws and their regulatory, regarding energy performance, the residential sector has the highest electricity consumption with a share of 60% of the total electricity in the country, representing 30% of the total energy consumption. One of the best ways toward energy efficiency in buildings is through energy audit process. The aim of this paper is to present the detailed audit of a residential building by assessing the suitability of three different energy simulation tools for energy audit simulations in Albania. Applied simulation tools are: RETScreen Expert, iSBEM and Termolog. Based on data for a sample residential block located in Tirana, three different simulation models are developed using these three simulation tools. All three cases of simulation are referred to this residential block, in order to be able to compare the outputs obtained using the different tools. Furthermore, the benefits and drawbacks of the tools are analyzed based on the required input data and output data. Based on the result's analysis, challenges of using each software for Albanian conditions and other consideration, this paper concluded in selecting the appropriate software to recommend for energy audit process in Albania.

Keywords: Energy efficiency, energy audit, residential building, software simulations.

1. INTRODUCTION

Albania is a small country within South East European (SEE) region. It has a population of 2 909 958 and a total surface of 28 750 km^2 [1]. The country's power supply system is based on hydropower.

Albania has low energy consumption per capita, which reveals low economic activity and a modest level of comfort. It is also characterized from a level of energy intensity that is 0.332 TOE/000€ [2]. Energy intensity is a synthetic indicator showing the level of development of energy sector, especially related to energy efficiency. At the same time, energy demand is increasing, often in an unsustainable way. For this reason, Albania should focus on reducing demand and improving energy efficiency.

In Albania major energy resources are represented by petroleum (≈ 55%), electricity (≈ 30%) and firewood (≈9%) [2]. In terms of final energy consumption, the residential sector with a share of 30% represents the second largest sector after transport sector (with 43%). When it comes to final electricity consumption, the residential sector stands for 60% of the total final electricity consumption [2]. The use of electricity in the residential sector is mainly for space heating and domestic water heating, with a consumption share of 60 % and 25 % respectively. [2].

According to a study conducted by International Finance Corporation in collaboration with AKBN (Albanian National Agency of Natural Resources), the residential sector is a large consumer of energy, especially electricity, which leads to an urgent need for energy efficiency [3]. To improve energy efficiency, the Albanian Parliament has approved the law for "Energy Efficiency" in 2015, and the law for "Energy Performance in Building" at the end of 2016. Both these laws are drafted according to European Directives and their regulatory acts are still being implemented. A strong driving force toward energy efficiency is devoted to pollution problematics [4] and certification of energy building performance through the process of energy audit [5]. Energy audit in Albania has started with efforts to implement the "Methodology of Calculation for Energy Building Performance".

The purpose of this paper is to conduct a study based on the assessment of three different software that can be used for energy audit simulations. In this way, it is intended to contribute in developing a methodology for the realization of energy audit in Albania.

2. MATERIAL AND METHODS

This paper represents the analysis of a detailed energy auditing process for a residential block. The object referred for the analysis is located in Tirana with a total useful area of 5044 m^2. For this purpose, three different software are used to analyze the actual energy consumption and to improve energy efficiency. These software are also used in previous studies with the same purpose, building energy performance analysis [6-8].

2.1 Software description

The applied tools in this study are: RETScreen Expert, iSBEM and Termolog. A brief description of the tools are given here:

2.1.1 RETScreen expert

RETScreen expert is the newest version of the Canadian free-of-charge software [9]. It is a software system that can be used for project feasibility analysis such as energy efficiency, renewable energy and cogeneration as well as ongoing energy performance analysis. It represents an intelligent decision support tool for a much broader range of stakeholders over the entire project life cycle.

This software requires project input parameters such as data on benchmarks, costs, facilities, products, archetypes and finances to build a database. Also RETScreen is linked to NASA's satellite weather data which are configured with any project location. One of the main activities of this software is the Financial Risk Assessor and project lifecycle Performance Tracker. Output data of this software also provides the direct user savings and the reduction of greenhouse gas emissions.

2.1.2 iSBEM software

iSBEM, an interface of SBEM is again a free-of-charge-software designed with the purpose of producing reliable evaluations for non-domestic buildings, especially for

Building Energy Performance Certification and Building Regulation Compliance [10]. Simplified Building Energy Model (SBEM) is a software for providing an analyses of the energy consumption in a building. It calculates monthly energy use and CO2 emissions when requiring building geometry, construction, use of HVAC and lighting equipment as input data.

This software together with the Energy Performance Certificate provides a list of recommendations relevant to the largest losses in the building.

2.1.3 Termolog software

Termolog is a software for the calculation of thermal losses, energy needs and energy consumption of buildings [11]. This software calculates the energy performance indices for winter air conditioning, hot water production, summer air conditioning, ventilation, lighting and single-unit transport, buildings with centralized or multi-unit heating units. TERMOLOG is a modular software where each of the modules can be used for a certain purpose, or the modules can be combined together to create an integrated package.

2.2 Gathering data for the building

The data used for this analyses of computer simulation software's was provided from different sources. The monthly energy and water consumption data was provided by the factures of householders, using the bills for the year 2016. The detailed information of energy consumption by home appliances was provided by the labels of main appliances used in the families of this residential block. The building geometry and building envelope data was provided by mortgage office. Each of the software's contains in their database the climatic data, respectively iSBEM provides the climatic data of United Kingdom and TERMOLOG provides the climatic data for all the regions of Italy, while RETScreen provides the data for every country in the world.

2.3 Calculating the energy performance

For this study it was necessary to calculate the energy performance for the building, according to the National Methodology of Energy Performance, in order to have a statement of the current situation. The global coefficient of thermal insulation, in accordance with the Albanian legislation is used as an indicator for the energy performance. This coefficient is calculated so to evaluate the volume of heat loses because of heat transfer. It is a performance criteria of the energy consumption required in the operation of buildings, used to calculate the amount of heat needed to heat a cubic meter of volume building during a year [12].
The calculation of the global coefficient of thermal insulation is:

$$Gv_t = Q/V\,(t_{in} - t_{out}) \qquad (W/m^3K)$$

Where:

Gv_t - the global coefficient of thermal insulation ($W/m^3\,K$)

Q - total losses (Watts)

V - the internal volume that needs to be heated (m^3)

According to the official regulation, this coefficient should not exceed the normative Gv_{tmax} values, values that are recommended for 3 different climatic zones and is related to the characteristics of the building (ratio *S/V*), where *S* is the surface of the dwelling where the heat is transmitted during heating and *V* is the volume heated zone:

$Gv_t \leq Gv_{t\,max}$

3. RESULTS AND DISCUSSIONS

In this section will be discussed the results obtained from the analysis using the three different software.

Taking as a reference the base scenario which represents the actual situation of the building, new scenarios are developed by making simulations in order to increase the energy performance. For each case it is shown the reduction of energy consumption and greenhouse gas emissions according the simulated interventions.

3.1 RETScreen software

RETScreen makes a full analysis of energy consumption, costs and GHG emission of the base case scenario when considering the actual conditions of the building. After obtaining the results from the base scenario, the user can propose different measures regarding building envelope and its operational systems for improving the situation and obtaining new results.

By analyzing the actual conditions of the building and the actual energy consumption it results that a significant amount of energy goes for domestic hot water.

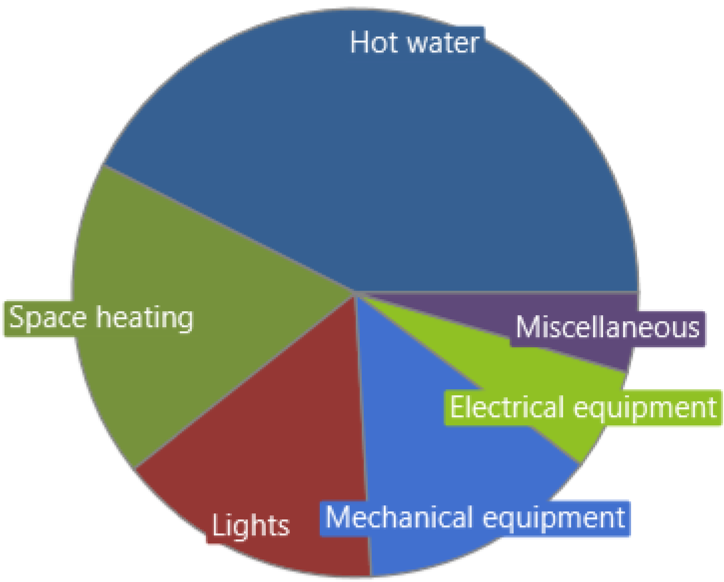

Figure 1. The share of energy consumption in the building.

Considering the high amount of energy that goes for DHW it is thought to take as a measure the implementation of the solar thermal system. By taking into consideration the available surface and the technical conditions of their installation, the software predicts the number of units installed and their cost.

Other measures taken into consideration consist on heating and cooling systems as well as lighting system. After implementing all the measures, the software performs an analysis of initial investment costs, system operation and maintenance savings, and the timing of the investment repayment. The summary of these measures is presented in the table below.

Table 1. Cost analysis for the simulated measures.

Show: All / Fuel saved	Heating kWh	Cooling kWh	Electricity kWh	Incremental initial costs $	Fuel cost savings $	Incremental O&M savings $	Simple payback yr	Include measure? ☑
Heating								
Heating system	0			0	0	0		☑
Heating system (1)	0			8,100		675	12.0	☑
Heating system (2)	0			5,400		150	36.0	☑
Cooling								
Cooling system		0		0	0	0		☑
Cooling system (1)		0		8,100		1,250	6.5	☑
Building envelope								
Building envelope	0			0	0	0		☑
Ventilation								
Ventilation		0		0	0	0		☑
Lights								
Lights				158	0	31.5	5.0	☑
Hot water								
Hot water	3.8			0	0.44	0	0.0	☑
Heating								
Solar water heater	177,289		0	137,561	20,211	-350	6.9	☑
Total	**177,293**	**0**	**0**	**159,318**	**20,211**	**1,757**	**7.3**	

For all these measures we will have an initial investment cost of $ 159.318 and for this investment the payback period will be 7.3 years. The investment cost includes the purchase and installation of all equipment ranging from split air conditioning units, solar panels and new lighting system.

The total time of the investment repayment of 7.3 years is explained by the market economy, where due to the increase in long-term profits, the repayment time is reduced.

Based on the results, RETScreen expert software represents a decision support tool for energy efficiency investments since one of the biggest advantages of this tool is the financial and risk analysis. Another advantage of this software is that it provides the climatic data for every location of the object. However, RETScreen does not provide an energy performance certificate and recommendations for improvements.

3.2 iSBEM software

The main purpose of conducting energy audit with this software is to provide the energy performance certificate when ranking the building according to the energy performance. In this analysis the building under study is ranked in the D class based on the building structure and its operational systems. Along with the energy performance certificate the software generates a recommendation report by listing different improvement measures to increase the energy performance. These measures are grouped in different categories of profitability based on their payback periods such as (short, medium and long payback period). The short payback period is 3 years, medium payback period is 3-7 years, and more than 7 years for the long payback period.

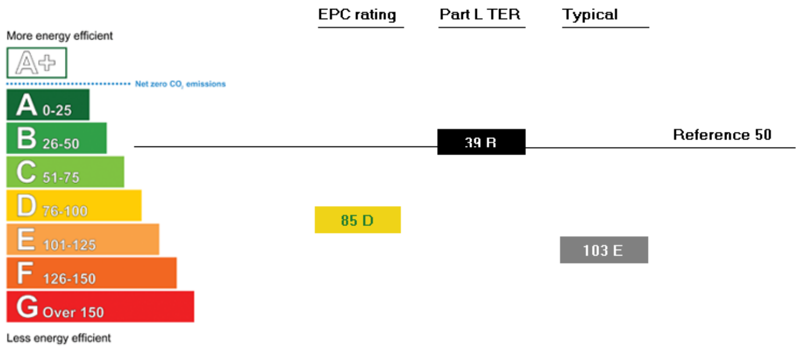

Figure 2. Energy performance certificate for base case

In this case the measures recommended by the software are of a short payback period and consist on improving the lightening system by implementing the LED technology and also by improving the heating system in some apartments. After simulating these measures, the energy efficiency in the resident block increases from D class to C class. The software again generates recommendation report for further measures, which will result in higher ranking.

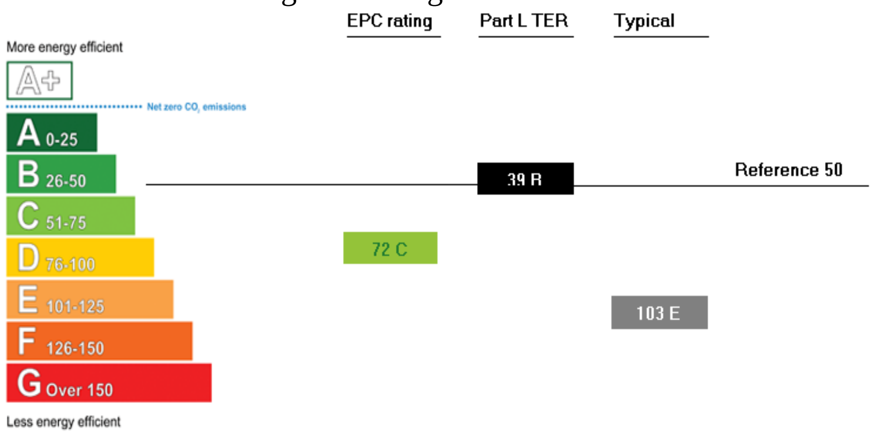

Figure 3. Energy performance certificate after improvement

3.3 Termolog software

The CERTIFICATION module of Termolog generates an energy performance certificate based on the data for building envelope and energy consumption. Also it provides financial and risk analysis after implementing improvement measures recommended by the software. Unlike the two software used in the study, TERMOLOG makes it possible to calculate heat losses for all structures, taking into account heat transfer coefficients and orientation of the building.

In addition to analyzing heat losses, this software specifically analyzes the heating, cooling, hot water system and lighting system, which can be autonomous systems or centralized systems. This analysis is carried out by determining the energy need for the operation of these systems based on the conditions of the facility, such as general habitable surfaces and heat losses.

In this case, after analyzing the heat losses from the structure of the object and analyzing the operating systems in it, the object is classified in grade C.

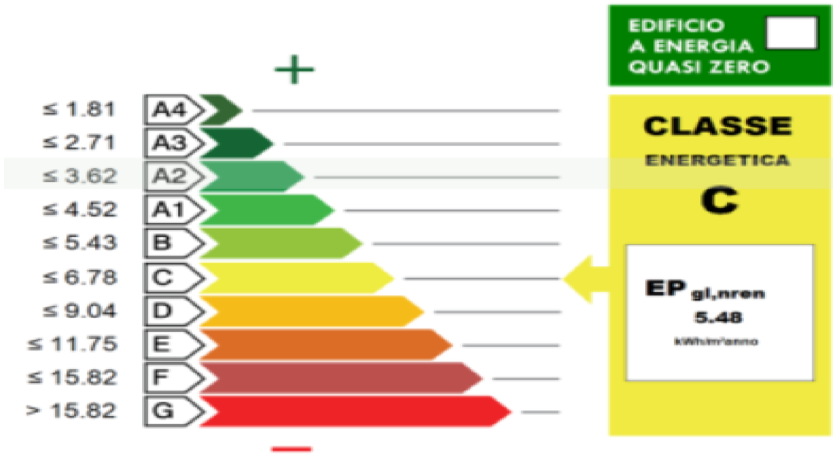

Figure 4. Energy performance certificate for base case

After analyzing the current situation and forming a basic scenario where the object results in a C class energy performance, TERMOLOG offers the possibility of comparing with a new scenario. This new scenario, which provides measures to improve energy efficiency, is automatically generated by the software. Measures taken are suggested by TERMOLOG, based on the results generated by the baseline scenario.

After the simulation carried out by the system, where implementing new measures, the object increases its energy efficiency by going to class B.

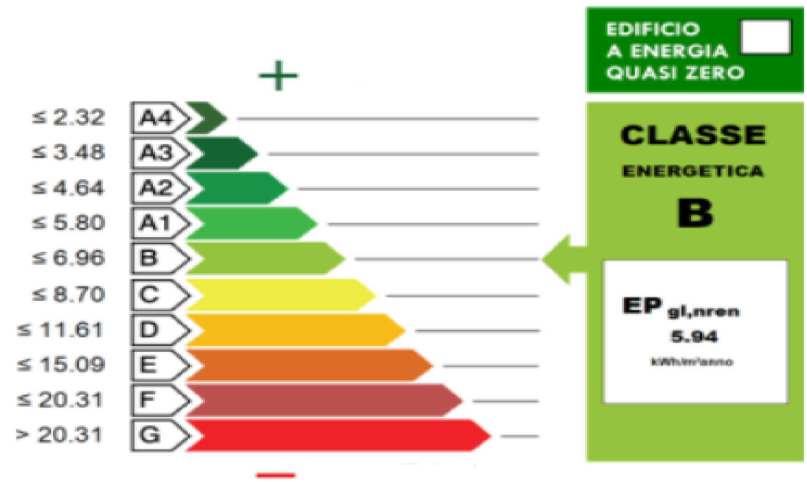

Figure 5. Energy performance certificate for the new scenario

3.4 Comparison

All three software present a view of the current building situation as well as an opportunity to improve energy performance. After getting the results from each software it is possible to make a comparison between them, as represented in the tables below.

Table 2. Summarizing results

Software	Energy Certificate	Cost-benefit analysis	GHG emission analysis	Recommendations	Origin place
RETScreen	No	Yes	Yes	No	Canada
iSBEM	Yes	No	Yes	Yes	UK
TERMOLOG	Yes	Yes	Yes	Yes	Italy

Table 3. Advantages and disadvantages of the software

Software	**Advantages**	**Disadvantages**
RETScreen	• Evaluates investments in the energy field • Provides financial analysis • Free of charge • Climatic data configured with any project location	• Does not provide energy performance certificate • Does not give any recommendation
iSBEM	• Provides energy performance certificate for buildings • Gives recommendations • Free of charge	• Climatic data configured only for UK • Does not make a financial analysis
TERMOLOG	• Variety of modules • Provides energy performance certificate • Provides recommendations • Provides financial analysis	• For sale • Climatic data configured only for Italy

4. CONCLUSION

Considering the need for energy efficiency improvement in the residential sector in Albania, it is necessary to make efforts for solutions. Being aware that the process of energy audit is a powerful tool in the energy policy of the country, this computer simulation analysis is intended to be an indicator for the implementation of energy audit methods.

Analysing the benefits and drawbacks of each software and comparing the results of energy auditing for the same object, it is concluded that the Italian software TERMOLOG is the most appropriate for Albania. TERMOLOG performs in accordance with the Italian low and since Albanian energy legislation is in line with Italian legislation, the software has a greater approach for its use in Albania. Also having into consideration the similarity of climate conditions between the two countries, this software is more preferable for conducting the energy audit in Albania.

CONFLICT OF INTERESTS

The authors would like to confirm that there is no conflict of interests associated with this publication and there is no financial fund for this work that can affect the research outcomes.

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