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Energy Efficiency Analysis in Korça Regional Hospital

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ABSTRACT

In this research work, we have analysed some of the key challenges associated with energy efficiency (EE) in hospital buildings. As the building sector is one of the most important energy users in Albania, our focus will be on hospitals as a complex building typology. A general overview and analysis of the building envelope where energy consumption in hospitals will be given. Afterward the focus will be on energy audit as a process that will facilitate the improvement of energy efficiency in this building typology. In order to prioritise energy efficiency measures some economic indicators will be introduced. The aim is to present an alternative model for energy auditors and energy managers. All these analyses and procedures will be carried out at Korça Regional Hospital. This analysis will assist decision makers in selecting the most appropriate EE measures from among many influential parameters.

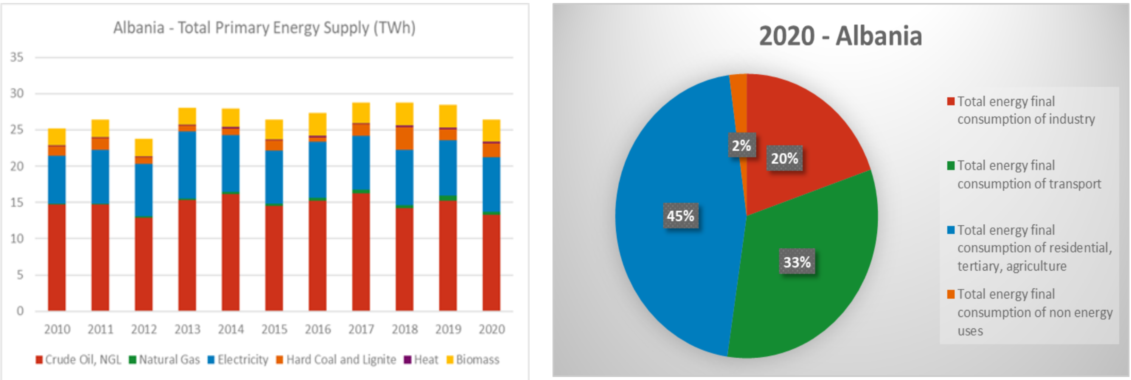
Keywords: Energy efficiency, Energy audit, Building, Hospital, measures.

1. INTRODUCTION

One of the main problems facing our society today is focused on energy crisis and environmental impact. This is mainly due to population growth and improvements in living standards. Another problem is that the consumer of the energy and the source of the energy are not located in the same region. In order to face these challenges, the main alternatives are as follows: (i) energy conservation, (ii) energy efficiency and (iii) renewable energies. In this context, even Albania, a small country, faces the same problems. From Figure 1a we can see that Albania is highly dependent on oil fuel and electricity, most of which is generated by hydroelectric power plants [1]. The residential sector, as for final energy use, is one of the major energy consumers as can be shown in 1b. This sector represents 60% of the total electricity consumed [2-5]. Among the many types of buildings, we chose the hospital, due to the complexity not only for its construction but also for its energy consumption. Are considered complex systems because they include many functions, such as heating, cooling, domestic hot water, cooking, laundry, etc. Hospitals are one of six types of public buildings in Albania. Hospitals are also known as large energy consumers, not only because of their complexity, but also because they are open 24 hours a day, 7 days a week. As they care for sick and injured people, they have special requirements for their indoor environment

(HVAC, humidity, lighting, hot water, etc.). This is another important factor influencing energy consumption. This type of building therefore has a huge potential for energy saving and efficiency.

An energy audit can play an important role in helping you achieve this goal [4-8]. Finding ways to reduce energy consumption is the primary objective for an energy audit. The energy audit is the preparation of the technical analysis on the basis of the energy performance assessment of hospital buildings. It is also a primary step toward building an energy saving strategy and program for the future. It is also a first step in the development of a strategy and a programme to save energy for the future. Another important aspect of an energy audit involves analysing the financial and investment costs involved. It helps us to choose the right and most effective investment scenario. In order to have a practical approach, the focus of our paper will be on a regional hospital in the Korça district.



a) b)

Figure 1. a) Primary energy sources in Albania, b) Final energy consumption by sector [1].

2. MATERIAL AND METHODS

The Albanian health system is mainly public. The state provides most services. The private sector covers mainly pharmaceutical and dental services and some specialised diagnostic clinics and hospitals. Health care in Albania takes place at three levels. There are 413 health facilities in the primary health care network, hospital services are provided by 43 public hospitals (municipal and regional) and the tertiary health care is provided by the University Hospitals located in Tirana [9]. As regional hospitals are the backbone of the system, we focused on them in this study. Korça Regional Hospital, the largest in south-eastern Albania, was chosen for this purpose. Korca is a city and municipality in southeastern Albania and the seat of Korce District. The municipality of Korca comprises 342 towns and villages and has a total population of approximately 86,000 inhabitants. The municipal budget in 2022 was USD 16.8 million, of which approximately USD 2.3 million was spent on energy for municipal services [11].

The hospital of Korça was built in 1925 and the main blocks in 1964. Number of patients is 61,000 per year (approx. 710 per day). Average length of stay for is 3 days. Number of staffs: 500 doctors and medical staff, 75 technical staff. Number of beds: 470, currently 40% of capacity. Indoor temperature during cold winter days and indoor humidity: 15-18°C, < 60% humidity due to low population. Korca is situated 900 m above sea level and the number of heating degree days is 2606 °C. Level of sanitary hot water supply: Demand is high and only about 85% of the demand is covered. The location of the hospital and a front view of the main building are shown in Figure 2 below. Assessing the buildings involved spending a day inspecting, interviewing staff, carrying out an audit and analysing the data collected. Many data were collected, especially regarding energy consumption for the last three years.

Figure 2. Location and view of the Regional Hospital of Korça, Albania.

Table 1. General data for Korça Hospital

Ownership	**☑ Public**	**❐ Private**
Year of construction		1925
No. of floors		4
Daily hours		24/24 hours
Working days/week		7/7
Medical staff (doctors and nurses)		500
Administrative staff		75
Number of beds		470
Bed occupancy per year		40%
Number of patients per year		61 000
Heated area		13 000 m^2
Conditioned area		2 600 m^2
Floor height		3 m
Heated volume		39 000 m^3
Air-conditioned volume		7 800 m^3

The audit process began with the collection and evaluation of design drawings and data relating to the equipment and current operations. Building layouts were prepared and reviewed to gain a better understanding of the building design and installed equipment. The auditor analysed data from site interviews, written documentation and monitored data. From this work, the findings were formalised and estimates of the associated energy savings and costs to implement were developed through the following activities:

- ✓ Description of the existing situation
- ✓ Present Energy Consumption
- ✓ Identified Energy Efficiency Potential
- ✓ Description of the recommended EE Measures
- ✓ Environment benefits/improvements

Based on the visit to this regional hospital, some additional information and findings are given below:

- ➢ The building is in good condition and the maintenance is in medium level.
- ➢ The last general refurbishment was in 2000. While emergency have been retrofitted partially in 2019.
- ➢ A new maternity block (approximately 1,000 m^2, 4 storeys, new equipment) is built at the eastern end of the hospital campus in 2018, replacing the maternity clinic in the city centre. The block is heated by wood pellet boilers.
- ➢ KfW is currently developing an energy supply strategy for the city of Korca, with particular emphasis on the improvement of the supply of heat to public and private consumers in the city centre. Possible supply scenarios for the heat supply of the hospital in mean period (5-7 years) are i) connecting to the natural gas system, ii) construction of a combined heat and power plant (CHP) with a district heating system to feed public buildings.

3. RESULTS AND DISCUSSION

Once the building has been inspected and the data collected, it is important to analyse all this information, in order to make the right decisions about energy efficiency measures. In the following Table 2, the most important figures relating to energy consumption and the baseline figures are presented.

Table 2. Consumption and normative of energy for Korça Hospital

Energy utility consumption	Units	Energy consumed	Normative demand
Heating	kWh/year	1,873,420	3,262,852
Sanitary Hot Water	kWh/year	160,000	172,420
Lighting	kWh/year	40,181	55,768
Electrical equipment	kWh/year	148,134	187,734
Total consumption	kWh/year	2,221,734	3,678,774
Specific consumption	kW/m^2*year	171	283

From this table, we can see that all the energy consumption figures are below the normative baseline for this type of building. It is therefore far from achieving the required thermal comfort. The energy supply strategy for the town of Korca (gas supply, new cogeneration plant with district heating supply), which is currently under development, opens up additional heat supply strategies for Korça Hospital in the medium term (5-7 years), which are briefly described:

- ➢ Alternative A: Supply of heat through a district heating system produced by a CHP plant.

- Alternative B: Using natural gas to produce its own heat in high efficiency gas boilers or producing heat and electricity for the hospital's needs in its gas-fired cogeneration plant (small to medium-sized, 400-800 kW).

Monthly data on electricity consumption for the year 2021 are shown in Figure 3. Compared to previous years hospital had a slight increase in electricity consumption, which is a good indicator. While in Figure 4 is given monthly fuel/pellets/thermal energy consumption. Also, regarding thermal energy consumption, we have a slight increase compared to previous years.

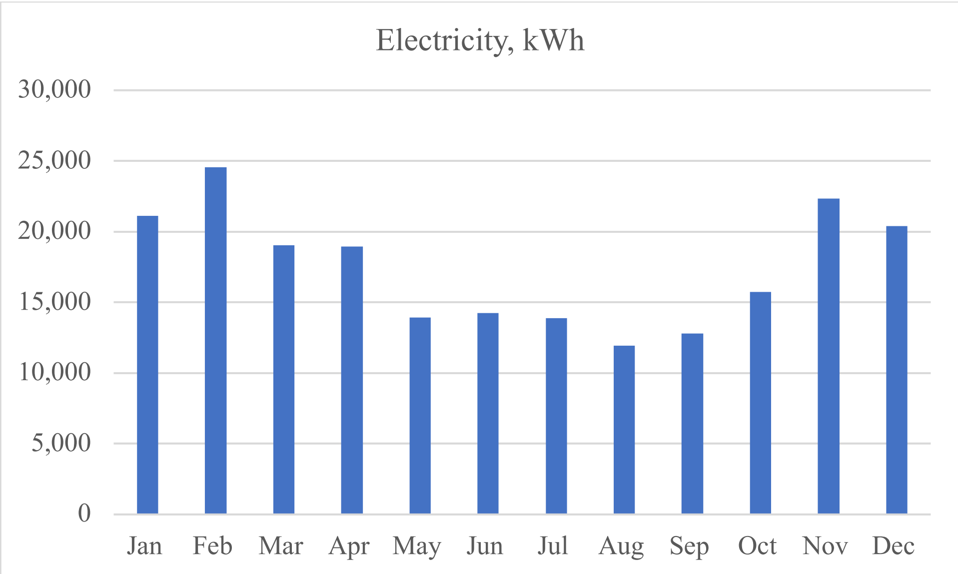


Figure 3. Monthly electricity consumption

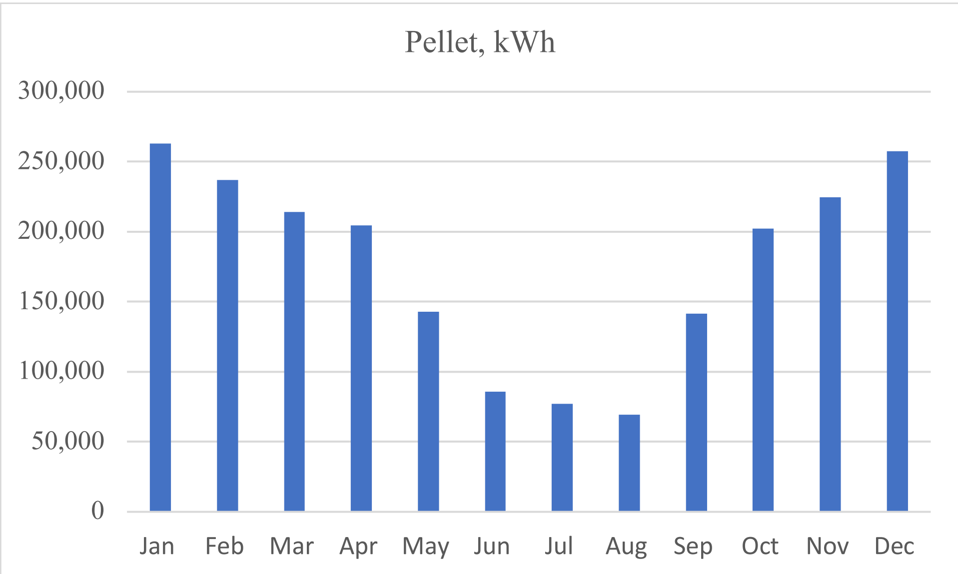


Figure 4. Monthly thermal energy consumption

Figure 5 below shows the breakdown of energy by all covered services. We can see that space heating and cooling is the largest energy consumer, followed by electrical appliances. Cooking and lighting are also significant energy consumers. This is understandable, as Korça is located in the climate zone C (the coldest climate zone in Albania). This is also evident from the fact that the majority of energy consumption is thermal (pellet or LPG).

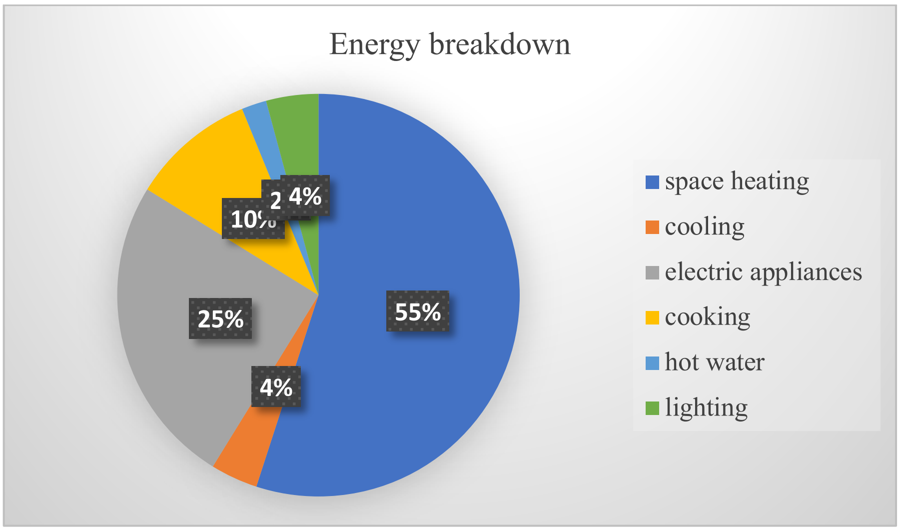


Figure 5. Energy breakdown for each service

This analysis also revealed insufficient thermal insulation for the buildings, as most of the heat loss comes from the walls. For this, the image from the thermal camera can help us to have a clear idea (see Figure 6).

Figure 6. Image of façades from thermal camera

Our analysis of heat loss showed that the majority of heat loss was through infiltration and then through walls and roofs. Figure 7 below illustrates the heat losses across each component of the building.

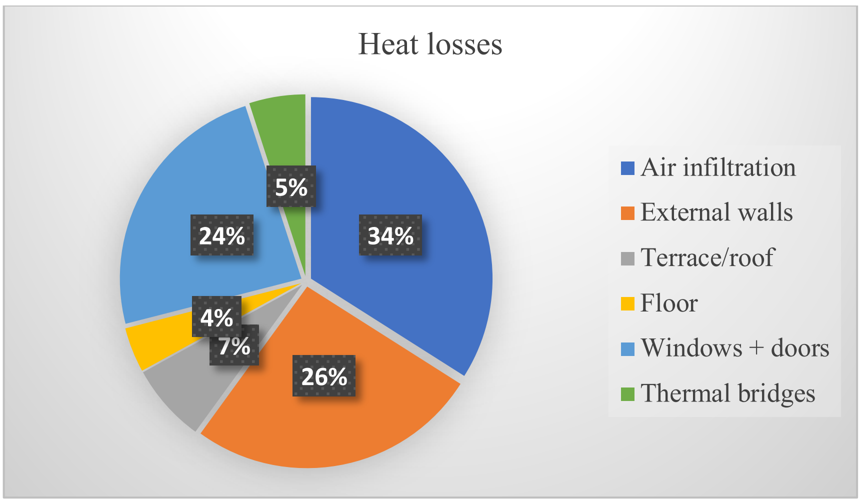


Figure 7. Individual building element heat losses

Another important aspect of this analysis is the economic one. This will help to list possible EE measures according to cost-benefit indicators. Payback period (PBP), net present value (NPV) and internal rate of return (IRR) are the main indicators used in this analysis. Their formulas are given shortly below:

$$NPV = \sum_{t=0}^{30} \frac{B_t}{(1+r_t)^t} - \sum_{t=0}^{30} \frac{C_t}{(1+r_t)^t} \quad (1)$$

$$NPV = \sum_{t=0}^{30} \frac{B_t}{(1+IRR)^t} - \sum_{t=0}^{30} \frac{C_t}{(1+IRR)^t} = 0 \quad (2)$$

$$\sum_{t=0}^{PBP} X_t \geq 0 \quad (3)$$

Where:

$t \rightarrow$ the cash flow period,
$r_t \rightarrow$ the nominal discount rate,
$B_t \rightarrow$ profits accrued under the project,
$C_t \rightarrow$ initial investment,
$X_t \rightarrow$ the cash flow in the year t.

Through analysis and decision making at each step, the energy audit fulfils the main objective we mentioned at the beginning. All the energy efficiency measures analysed and promoted for implementation at Korça Regional Hospital are presented in Table 3 below.

Table 3. EE measures proposed for Korça Regional Hospital

Recommended catalogue of EE measures (according to the actual needs of the building)	**Total investment costs (EURO), incl. installation works, 10% contingencies**	**Specific investment costs (EURO/m²)**
Replacement of doors with automatic closing mechanism	75,000	4
Insulation of roof, 150 mm EPS + hydro insulation	400,000	23
Insulation of floor ceiling (on basement ceiling, 100 mm EPS)	95,000	3
Ventilation system, decentral room based units with heat exchanger	250,000	15
Enhancement of heat distribution network	170,000	12
LED lighting indoor remaining 20-25%, new LED outdoor lighting	50,000	4
Solar collector for SHW (30 x 2.5 m² collector)	24,000	2
Automatic entrance doors (2) with air curtain and automatic doors at footbridges	18,000	2

Renewal of district heating pump (boiler house) by high efficient with VSD	8,000	0
Building Energy Management System	40,000	3
TOTAL	**1,130,000**	**170**

Based on the techno-economic calculations presented above, it has been possible to carry out simple financial calculations to evaluate the installation of thermal insulation, and the results for the baseline case are presented in Table 4, together with some other indicators, including the level of greenhouse gas reduction. These calculations can be cone in the same way for every EE measurement.

Table 4. Financial analysis of thermal insulation

Financial indicators	Unit	Value
Average Cost Saving	1000 Euro	62035
Discount Pay Back Period (years)	Years	6.37
Levelled Discount Unit Saving Energy Cost	Euro/kWh	0.1063
Internal Rate of Return	%	18.90%
Reduction of the GHG	tons/year	210.67

4. CONCLUSION

From the analyses made in this paper, it can be concluded that the energy audit is an important tool to find and implement the right and most crucial energy efficiency measures. Hospital buildings are an interesting case because of their complexity in terms of energy consumption. From the tecno-economic analyses made we can state that the EE measure with the fastest payback, shortest implementation time and least complexity is efficient lighting of the hospital as the most effective way to reduce budget expenditure.

The highest energy savings potential is identified by investments in energy savings for space heating through thermal insulation of the external walls, thermal insulation of the roof, efficient windows and the introduction of an efficient diesel heating system. Financial analysis will help us to have a good idea of which energy efficiency measures are the most feasible and which ones should be implemented. Implementing and upgrading the building management system is also an important measure.

The financial analysis of the proposed interventions has been carried out on the basis of the methods described in detail above: Simple Payback Period (PBP), Simple Internal Rate of Return (IRR) and Net Present Value (NPV). As a final conclusion of this analysis we can say that the application of all energy efficiency measures is profitable for this type of building. From the economic analysis we deduced that the IRR is 12.8% and the PBP is 6.8 years, while the NPV is positive.

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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