Proceeding Book of ISESER 2021

O 27. TECHNO-ECONOMIC EVALUATION OF ENERGY EFFICIENCY MEASURES IN BUILDING SECTOR, CASE STUDY FIER REGIONAL HOSPITAL

Altin Dorri[1*], Majlinda Alcani[1]

[1]*Polytechnic University of Tirana, Sheshi "Nene Tereza", nr. 4, Tirana, Albania*

E-mail: *adorri@fim.edu.al, malcani@fim.edu.al*

ABSTRACT: Energy efficiency is considered today as a source of energy. This paper aims to analyse some of most important energy efficiency measures to be taken in building sector. For this reason, a regional hospital is considered for study. Hospitals represent an important and very complex energy consumer for building sector in Albania. To achieve the objective an energy audit is performed and analysed. Some techno-economic indicators are represented and used to estimate energy efficiency measures. Then these measures are prioritised based on indicators described. These procedures will help decision-makers to select the most suitable measures according to many factors influencing in it.

Keywords*: Energy efficiency, hospitals, economic evaluation, energy audit*

INTRODUCTION

In the world of today when the cost of energy is increasing day by day, saving energy is becoming one of the main issue. So, energy efficiency it can be considered as source of energy. Efficiency mean producing same product or service with less energy (Dorri 2017). In Albania building sector represent one of the main energy consumers. In this sector hospital building represent an important public building typology. Hospitals are known for their complexity regarding energy consuming, for space heating/cooling, sanitary hot water, lighting, electric equipment, etc. The building conditions and the trends in the households/public buildings consumption of the energy and water play an important role in estimating the chances of accomplishing these ambitious objectives.
In this context efficient energy management possesses a key challenge for all building management and especially for hospitals. Adding the benefits of energy survey and audit as instrument to improve energy management has the potential to improve overall energy situation. In order to have a clear idea about energy consuming an energy audit is necessary. It give to us the balance the total energy inputs vs. it use and identify all the energy fluxes in a facility. The Energy Audit will give a positive orientation to the energy cost reduction, preventive maintenance and quality control programmes which are vital for production and utility activities (Thumann and Younger, 2008). In general, Energy Audit is the translation of conservation ideas into realities, by lending technically feasible solutions with economic and other organizational considerations within a specified time frame. The primary objective of Energy Audit is to determine ways to reduce energy consumption. An audit programme will help to keep focus on variations which occur in the energy costs, availability and reliability of supply of energy, decide on appropriate energy mix, identify energy conservation technologies, retrofit for energy conservation equipment etc.
Financial analysis and cost investment represent another important issue in an energy auditing process. It will give a clear picture for decisionmaker to select the right and most effective scenario of investment proposed by the energy audit process. To this aim actual work is realised for a regional hospital located in Fier county.

MATERIALS AND METHODS

Regional hospital of Fier is the biggest hospital in southern Albania, thus the number of patients that this hospital treats is quite big. It consists of 4 buildings which are located in a distance not very far from each other:

1) Polyclinic, which provides medical consultations for patients but no bedding for patients that require further treatment. The number of patients that are consulted in polyclinic is quite big, on average 152 746 patients during the whole year

2) Hospital (emergency)
3) Maternity
4) Pediatria

The regional hospital of Fier is constructed in 1958 and as the largest in southern Albania it serves about 171 662 patients (not including patients that are treated in paediatrics department). The district of Fier has a population of 302.506 inhabitants, about 40% more than number of patients in the hospital. Below we shown figures of the regional hospital complex of Fier.

Figure 5. Position and view of Fieri Regional Hospital

The initial site assessment consisted of spending a day in the building during August 2020, interviewing staff, inspecting equipment, performing an audit, and performing an analysis of the site-gathered data. The investigative process consists of first obtaining as much building documentation to become familiar with the building and its systems. Equipment lists, system schematic drawings and 3 years months of utility billing data are collected. The information contained in this paper is based on a range of sources that have been compiled during inspections; these sources include building monthly/annual energy consumption data, electrical meter readings, site observations, and discussions with site personnel and municipality officials in charge of hospital maintenance.

Table 3. General information for Fieri Regional Hospital

The hospital is ❒ Private Hospital ☑ Public Hospital The building of the hospital is ☑ Own ❒ Rented	
Construction Year	1936
Number of floors	3
Daily operating schedule (hours)	00.00 – 23.59
Days in a week on emergency	7
Which is the total number of the administrative officers and patient/doctors/client including the security people?	Administrative and working staff = 79 medical staff + nurses = 552

No of beds	780
Percentage of average annual bed occupancy?	58%
Annual number of incoming/outgoing patients	171 662
Heated spaces surface (m^2)	8 619
Air conditioned spaces surface (m^2)	1 724
Average height (m)	3
Heated space volume (m^3)	25 857
Air conditioned spaces volume (m^3)	5 172

Additional information and findings could be presented based on the site visit carried out on this regional hospital:

- The level of medical equipment is medium to high, e.g. new dialysis center, new emergency with advanced equipment (CT, MRT scanners, reanimation, etc).
- The general condition of the building is good. The level of damages of the building envelope and openings is low and maintenance level is medium
- The last general building retrofit took place in 2008. In 2018 the emergency complex (some 2/3 of main complex) has been renewed (emergency rooms, registration, entrance, policlinic partly).
- The building management (interviewed stakeholders director and facility managers) has a good understanding of retrofit and energy and efficiency aspects.
- Currently Municipality of Fier develops an development plan for the city of Fier with special focus of improvement of heat supply of public and residential customers in the city center. Supply scenarios which may have an influence for the heat supply of the hospital over medium time horizon (of 4-5 years) are: (A) connection with natural gas network, (B) construction of a combined heat and power plant (CHP) with district heating network, supplying the priority public buildings. A feasibility study for the CHP need to be done and will be part of the detail energy audit study.

The operation expenses of the hospital are covered by funding from the Ministry of Health and secondary funds.

RESULTS AND DISCUSSION

Preliminary evaluation of conditions is done according to visual inspection, verification measurement (on demand), interview with facility manager and expert estimations. The main determinants for the identification of prioritized sectors are a) hospitals energy spending, b) potential energy savings related to the relative energy intensity and c) the level of control by the energy consumption over sectoral budgets, regulation and enforcement power for energy efficiency and RES measures.
The main figures related to energy consumption related to baseline figures and is given in the table below.

Table 2. Energy consumption and needs for Fieri regional hospital

Item	Unit	BASELINE- REAL consumption	BASELINE - NORM supply demand
Energy consumption for heating, kWh	kWh/yr	1,174,451	961,539
Energy consumption for SHW, kWh	kWh/yr	160,000	333,678
Energy consumption for Lighting kWh	kWh/yr	19,996	40,682
Energy consumption for equipment kWh	kWh/yr	128,310	167,910
Total Energy consumption kWh	**kWh/yr**	**1,482,757**	**1,503,808**
Specific consumption total	kW/m^2 x yr	172	174

The ratio of norm supply versus real consumption baseline is 105%, which means the level of energy supply is 48% of its demand. The building is considerably under-heated by 95%.
The objective of the building's energy efficient retrofit is:

- ✓ to achieve sanitary indoor norms of illumination, space heat and hot water supply,
- ✓ to meet the indoor comfort temperature requirements of 20°C ,
- ✓ reduction of consumption of firewood for heating in the nature park area,
- ✓ to reduce energy expenditures for the public funding agency (Ministry of Health) and
- ✓ to enable a high-quality level of public service such as health care, education, social protection, administration.

The achievable energy savings - compared to the baseline - will lead to energy costs savings and additional benefits to increase the building's' functionality and comfort for users.

- ➢ Option A: Heat delivery by district heat system, produced in pellet boilers
- ➢ Option B: Heat delivery by district heat system, produced in CHP
- ➢ Option C: Use of natural gas for own heat production in efficient gas boilers, or production heat and power for own needs of the hospital in a own (small to medium size 500-900 kW) gas fired CHP.

The operating costs, energy savings, estimated on a yearly basis, are included into the part of the fixed costs, independent of the load of the plant. This includes the costs for the staff, costs for primary and auxiliary materials, the maintenance expenses and the cost for various services, loans and payments made to third parties. The cash flow is the difference between profits accruing each year from the selling of electricity, and the operating cost and the gross profit tax. Various methods have been and are being employed to produce a financial decision, including that on net present value (NPV), the internal rate of return (IRR), the wealth maximizing rate (WMR), and the payback period (PBP). The financial formulas most wide used include NPV and IRR, and their respective calculations are given in formula 1 and 2.

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

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

Where:
$t \rightarrow$ the period of the cash flow: varying from 0 (year of installation) to n (the last year equal to lifetime
$r_t \rightarrow$ the nominal discount rate (for the purpose of such financial analysis; 6-9% (it must also be noted that a sensitivity analysis has also been made) based on the reference values recommended by the Bank. In the sensitivity analysis, where variation of NPV is compared to rt, reference is made to the interval (6-9%);
$B_t \rightarrow$ profits accrued under the Project, which are obtained by multiplying the energy savings by the price of energy source for each year;
$C_t \rightarrow$ initial investment (only CO) and the operating cost of the Project, which is obtained by multiplying the energy savings by the price of energy source for each year.
Another approach towards making the financial decisions accommodates the concept around the payback period for the investments. The payback period has been determined as the least indispensable time required by all EE/RES measures, to ensure that, during such period, profits exceed costs. Let us mark by '*X*t' a cash flow in the year '*t*'; *X*t is negative if it represents the cost and is positive if it represents a profit. Let us mark the payback period for the investments by 'PBP.' Hence, the simplest formula for calculating PBP is obtained from the following:

$$\sum_{t=0}^{PBP} X_t \geq 0 \quad \text{where } Xt = Bt - Ct \quad (3)$$

Without discounting the cash flows, PBP has a significant gap since it ignores the time value

of money and therefore it should not be used any longer. As the discounting is included, then the equation for calculating the payback period will be:

$$\sum_{t=0}^{PBP} \frac{X_t}{(1+r_t)^t} \geq 0 \qquad (4)$$

In this case, the discounted cash flows accumulate until their sum becomes positive. For making a comprehensive financial ratio analysis of all EE/RES measures, all the financial formulas described earlier on, including NPV, IRR, LDC, and PBP, will be employed.
After financial calculations for purposed EE measures results are given in the table below"

Table 3. Investment for EE masures

Recommended catalogue of EE measures (according to the actual needs of the building)	Total investment costs (EUR), incl. installation works, 10% contingencies	Specific investment costs (EUR /m² heated area)[1]
Insulation of walls	268,853	31
Replacement of windows	180,986	21
Replacement of doors	30,408	4
Insulation of roof ceiling (attic)	150,833	18
Insulation of floor ceiling (in basement ceiling)	37,708	4
Ventilation system, decentral heat exchanger	491,400	57
Wood boiler replacement	0	0
Electric boiler replacement (decentral)	0	0
Diesel boiler replacement including heating network	0	0
Biomass boiler including network	0	0
Renewal of heating network + radiators	72,400	8
Heat pump for heating incl. Network	0	0
Combined Solar/ HP for heating	0	0
Combined Solar/ Biomass (wood) for heating	0	0
LED lighting indoor+ outdoor+ wiring	119,459	14
Renewal of AC system (split/ central)	0	0
Heat pump for SHW	0	0
Solar collector for SHW (2.2-2.5 m² collector)	12,600	1
Automatic entrance door with air curtain	6,300	1
Renewal of electric wiring	0	0
DH pump replacement, VSD	3,150	0
Replacement of laundry equipment	0	0
Energy management/ lighting control	18,100	2
TOTAL CAPEX	**1,392,196**	**162**

Recommendations are divided in three categories: with low, medium ang high costs. The conclusion of the analysis shows that the application of all EE & RES measures is beneficial for this building. While the net present value is positive, IRR = 13.6% and the investment maturity is 7.4 years.

CONCLUSIONS

The objective of technic-economic analysis is to achieve and maintain optimum energy procurement and utilization, throughout the organization and:

- ✓ To minimize energy costs / waste without affecting production & quality
- ✓ To minimize environmental effects.
- ✓ Produce benchmarks and design guidelines for ZenH
- ✓ Improve the technical capacity of professional staff operating energy systems in Fier Regional Hospital;
- ✓ Prepare detailed analysis and test the benchmark models for upgrading Fier hospital buildings into NZEB that will be ready to seek financial tools for their implementation.

This analysis presents the key findings and recommendations from the application of EE/RES measures for Fier Regional Hospital. Financial analysis will help us to be well oriented toward the most feasible EE measures that should implement. In our case the financial and economic profitability of the EE intervention with the recommended EE technology package is at a level of IRR 11% with 9.5years payback time, which can be evaluated as good level for public building retrofit.

REFERENCES

DCM No. 38, 2003, Albanian Energy Building Code, Tirana

Dorri A., 2017, Lectures on Energy Audit, Polytechnic University of Tirana.

Dorri A., Bidaj A., Kodhelaj S., 2019, Challenges for hospital energy efficiency in Albania, Proceedings of 9-th International Conference of Ecosystems, 8 June 2019, Tirana, Albania

Dorri A., Bidaj A., Kodhelaj S., 2019, Overview of Energy Efficiency for Public Building in Albania, Proceedings International Symposium for Environmental Science and Engineering Research ISESER2019, Konya, Turkey

Dorri A., Bidaj A., Kodhelaj S., 2020, Energy auditing in albanian hospitals, a case study for Lezha regional hospital, Proceedings International Symposium for Environmental Science and Engineering Research ISESER2020, Konya, Turkey

Dorri, A., Alcani, M., Ziu, D., Daci, E., & Gebremedhin, A., 2019, Analysis of Computer Simulation Software's for Energy Audit in Albania. International Journal of Innovative Technology and Interdisciplinary Sciences, 2(4), 307-315. https://doi.org/10.15157/IJITIS.2019.2.4.307-315

INSTAT, 2020, "Statistical Databases" http://www.instat.gov.al/en/themes/economy-and-finance/annual-accounts-by-institutional-sector/publication/2020/annual-sector-accounts-2017/

Thumann A., Younger W. J., 2008, Handbook of energy audits, Seventh Edition. The Fairmont Press, Inc., New York.