CONSIDERATIONS RELATED TO ECONOMIC EFFICIENCY INDICES IN CASE OF ENERGY AUDIT FOR BUILDINGS

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Abstract

In the paper are presented the economic criteria on the basis of which the choice of selection of energetics modernization measures of existing buildings is made. The paper describes a synthesis of economic criteria from Romania and abroad on the basis of which the choice of technical solutions concerning the energetics modernization of existing buildings is made. Based on the article's conclusions, one can make proposals aimed at improving the legislation presently in force in this field.

Keywords: *Energy audit, building energy performance, building envelope, rehabilitation, thermal comfort.*

JEL classification: *C61, D61, G11, O13, Q40*

1. Introduction

General Considerations

It is well known that a major objective of all states is to decrease the energy consumption in order to protect the natural resources, and directly related to this aspect, to decrease the CO_2 emissions in the atmosphere. These are also the objectives set in Directive no. 91/2002/CEE on the energetic performance of buildings. This directive was transposed into the Romanian legislation in Law no. 372/2005 [2] - [7].

Terminology

The English word „audit" stands for book keeping review, balance sheet or finding. Within the framework of the sustainable development commitments, the energy audit was introduced in the USA in 1997, as a requirement for obtaining State subsidies granted within the Energy Conservation Project (SSEP), and then in order to guarantee loans. At present, the energy audit means the identification and the quantification of the energy consumption from a certain physical unit (industry, building, installation) [3].

The purpose presented in the article

In this article, we performed a study concerning the financial efficiency indices in case of the energy audit for buildings.

The added value of the present article

Based on the article's conclusions, we have made some proposals for the improvement of the legislation presently in force in this field.

2. The work method

2.1 Stages

The steps to be taken in order to perform the energy audit are the following (see figure no. 1):
- proposing technical solutions aiming at energetically rehabilitating or modernizing the building;
- estimating the yearly energy savings for each technical solution;
- eliminating those technical solutions that are energetically inefficient;
- estimating the investment value of the technical solutions that are energetically efficient;
- computing the economic efficiency indices for the technical solutions that are energetically efficient;
- eliminating those technical solutions that are financially inefficient;

- the technical designer is recommending the technical solution or the set of measures that are to be implemented;
- elaborating the energy performance certificate for the energetically rehabilitated or modernized building;
- elaborating the energy audit report;
- editing the final energy audit documentation.

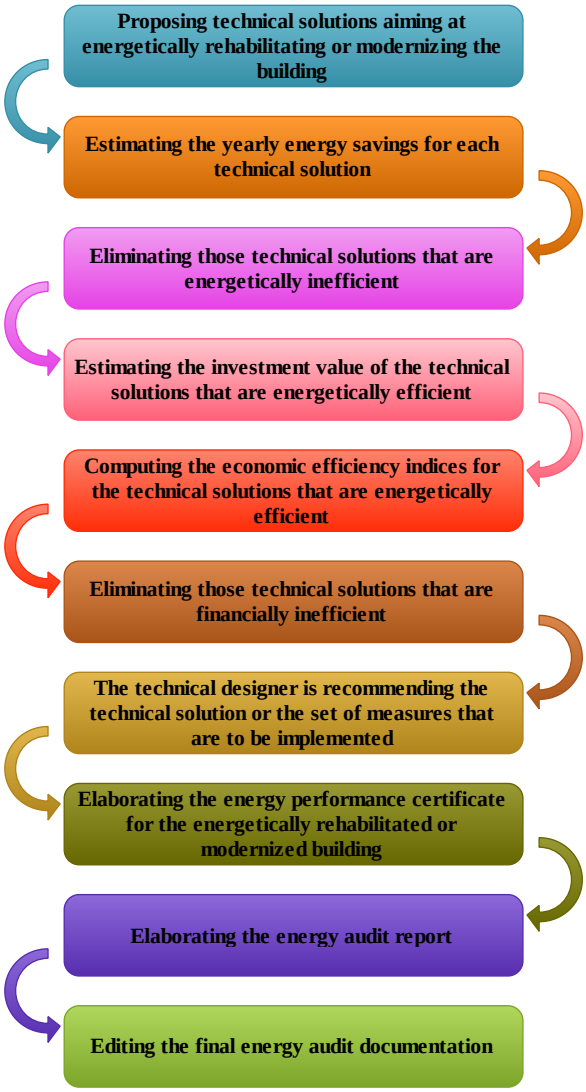

Figure no. 1 Energy audit steps

Hereinafter we shall present only the financial aspects concerning the financial efficiency indices in case of the energy audit for buildings.

2.2 Calculation algorithm

Generally, one assesses the investment projects by using several indices. The assessment practice without using the computer and taking into account the elements of the decision's theory too, rationally uses between five and nine indices [1].

Hereinafter we shall present the financial efficiency indices that are specific to energy audit and that are used in certain countries from Europe and Asia, as well as those used in Romania.

2.2.1 Computation Methodology Used in Certain Countries from Europe and Asia

According to the specialized papers from Bulgaria, the Czech Republic, Kazakhstan, the Republic of Moldova, Norway, Russia and Slovakia, the financial efficiency indices specific to the energy audit are the following:

a) Recovery period, "Tr";

b) Updated Net Value, "VNA";

c) Net Present Value Quotient "NPVQ";
d) Internal Rate of Return "RIR";
e) Payment Period "PO";
f) Maximal Investment [4].

2.2.2 Computation Methodology Used in Romania

The financial efficiency indices specific to the energy audit used in Romania are the following:
a) Updated Net Value „VNA";
b) Period for recovering the supplementary investment „Tr'';
c) Cost of the saved energy unit „e'';
d) Beneficiary's capacity of bearing the monthly installment „rc''.

Hereinafter we shall present the financial efficiency indices specific to the energy audit, according to the Mc 001-2006 Methodology [8]:

a) Updated Net Value „VNA''

The basic procedure used for comparing the technical and financial effects of applying the various solutions for the rational and efficient use of energy in constructions is the analysis of the updated net value of the costs involved in making the investments and in using the corresponding installations.

Considering that the yearly currency depreciation rate is constant and that there is a simultaneous uniform increase in the energy price, the "VNA" characteristic to the system is given by the formula: [8, page 12-15]:

$$VNA = Co + \sum_{k=1}^{3} CEk \cdot \sum_{t=1}^{N} \left(\frac{1+fk}{1+i} \right)^{t} + CM \cdot \sum_{t=1}^{N} \left(\frac{1}{1+i} \right)^{t} \quad (1)$$

where:
VNA is the updated net value corresponding to the investment, in Euros;
Co - the cost of the total investment in the year "0", in Euros;
CE - the yearly cost of the energy consumed, at the level of the reference year, in euros/year;
CM - the yearly cost of the maintenance operations, at the level of the reference year, in euros/year;
f - the yearly increase rate of the heating cost;
i - the yearly currency depreciation rate, in euros;
k - index depending on the type of the energy used (1 - natural gases, 2 - thermal energy, 3 - electrical power);
N - physical lifespan of the analyzed system, in years.

If one neglects the maintenance-related costs, the above formula shall be written in the simplified form:

$$VNA = Co + \sum_{k} CEk \cdot Xk \quad (2)$$

where:

$$Xk = \sum_{t=1}^{N} \left(\frac{1+fk}{1+i} \right)^{t} \quad (3)$$

By simultaneously analyzing two "VNA" values specific to a classic solution and to a energy conservation solution, where both solutions being characterized by an equal lifespan "N", one obtains the "VNA" corresponding to the supplementary investment, resulted from the implementation of the energy modernization design projects and from the energy saving obtained by implementing those design projects:

$$\Delta VNA(m) = C(m) - \sum_{k} \Delta CEk \cdot Xk \quad (4)$$

where:
C(m) represents the cost of investment corresponding to the energy modernization design project, at the level of the year "0", in euros;
ΔCE - decrease of the yearly using costs as a result of implementing the energy modernization design projects at the level of the reference year, in euros/year.

$$\Delta CEk = ck \cdot \Delta Ek \quad (5)$$

where:
ΔEk represents the estimated yearly energy saving "k", obtained by implementing an energy modernization measure, in kWh/year;

ck - the actual cost of the energy unit "k", in euros/kWh.

In order for an investment (in the energy modernization solution) to be efficient, the following condition must be fulfilled:

$$\Delta VNA(m) < 0 \quad (6)$$

respectively:

$$X > A \text{ where: } A = \frac{C(m)}{\Delta CE} \quad (7)$$

b) Period for recovering the supplementary investment

The period for recovering the supplementary investment resulted from implementing an energy modernization project, "Tr", is determined by enforcing the investment recovery condition:

$\Delta VNA(m) = 0$ [8, page 14]:

$$It - \sum_{k=1}^{k} ck \cdot \Delta Ek \cdot \sum_{t=1}^{Tr} \left(\frac{1+fk}{1+i} \right)^{t} = 0 \quad (8)$$

Eventually, one checks whether the supplementary investment recovery period si inferior to the remained lifespan of the investment, therefore this period shall be correlated with the provisions of the Romanian Government's Decision no. 2139/2004 [6].

c) Cost of the saved energy unit

The cost of the energy unit saved by implementing the energy modernization project in an already existent building (or the cost of one saved kWh) is determined with the formula:

$$e = \frac{It}{N \cdot \Delta E} \quad (9)$$

where:

e is the cost of the energy unit saved by implementing the energy modernization project in an already existent building [8, page 14].

d) Beneficiary's capacity of bearing the monthly installment

The actual implementation of an energy modernization project also supposes the eventual project funding analysis, from the point of view of the possibly applicable funding scheme and from the point of view of the beneficiary's capacity of bearing the costs.

The value of the monthly credit reimbursement installment (for a period of "Nc" years with a fixed annual interest) is determined with the formula:

$$rc = \frac{0{,}0833 \cdot (1 - ac) \cdot It \cdot (1+d)^{Nc}}{Nc} \quad (10)$$

where:

rc is the monthly credit installment;

ac - the ration between the money paid in advance and the total investment "It";

It - the total investment;

d - the annual interest;

Nc - the number of years for the credit reimbursement.

Practically, the "rc" value is compared to the monthly average income of a family who is making the energy modernization investment [8, page 15].

3. Case study

Hereinafter, we present a case study about the energy modernization of a building. The building is a block of flats consisting of underground floor + first floor + 4 floors, having an interior staircase, 30 apartments and a heated net area of 1778.92 m^2.

The project shall be financed according to the provisions of art. 13 of the Emergency Ordinance no. 18 from the 4th of March 2009 [9], namely:

a) 50 % from state subsidies;

b) 30 % from funds yearly provided for this purpose in the local budgets and/or in other legally constituted sources;

c) 20 % from the repairing fund of the owners' association and/or from other legally constituted sources.

We would like to mention that when the residence buildings are thermally rehabilitated using government guaranteed bank credits, according to the Emergency Order no. 69 from the 1st of July 2010 [10]:

- according to art. 9, the intervention works are finances as follows:

a) from the beneficiaries' own sources, representing minimum 10 % of the value of the intervention works;

b) from government guaranteed and subsidized interest bank loans in Romanian lei, representing maximum 90% of the value of the intervention works.

- according to art. 11, the reimbursement period for government guaranteed and subsidized interest bank loans is of maximum 5 years;

- according to art. 12. (1), the interest corresponding to government guaranteed and subsidized interest bank loans granted to beneficiaries is born from the State budget;

- according to art. 29. (1), the financer approves guaranteed loans within the limit of maximum 90 % of the estimate for the works, annex to the general estimate, but not more than the following cap amounts, as follows:

a) the Romanian lei equivalent including VAT of 1850 euro/residing room, in case of loans required by the owners' associations.

4. Results and discussion

4.1 The obtained results

We proposed the energetic modernization of the block of flats, and by applying the energetic modernization solutions of the building's envelope, we shall improve the performance of the building's thermal insulation, making it comply with the regulated requirements concerning the minimal corrected thermal strengths of the construction elements, R'min.

The financial analysis of the rehabilitation and energetic modernization solutions for the building's envelope are based on the following hypotheses and values:

- the value added tax representing 24 %;
- the exchange rate from the 30th of January 2013, namely RON 4.3853 for 1 euro;
- the yearly depreciation rate of the reference currency (euro), namely 1 %/year.
- the price of the thermal energy increases with about 3 % each year;
- the normal using period of 20 years;
- the specific cost of the thermal energy is of 0.0491 euros /kWh.

In order to determine the effects of the rehabilitation and energetic modernization measures of the building, the solutions were analyzed both individually and as a set of measures, we proposed three sets of measures, namely:

- a minimal one;
- an average one;
- a maximal one.

The designer recommends the implementation of the minimal set of measures. The technical solution recommended by the designer refers to:

- the energetic modernization of the building's envelope;
- the thermal insulation of the heating pipes located in the underground floor;
- the thermal insulation of the hot water pipes, located in the underground floor;
- installation of thermostatic taps for the heating elements;
- installation of heat cost allocators for the heating elements;
- auxiliary works.

For the technical solution recommended by the designer, we obtained the following results:

- the investment value C(m), euros 160172 (VAT not included);
- ΔVNA(m) = - 92678 euros;
- Tr = 13.55 years;
- e = 0.0384 euros/kWh;
- monthly installment of 62 RON/apartment.

4.2 Comments of the results

a) As a result of the analysis performed, we concluded that ΔVNA(m) < 0, which means that the investment shall be recovered based on the yearly heat savings made during the analyzed study period, namely 20 years.

b) As the investment recovery period is of about 13.55 years, it results that the investment shall be recovered in a shorter period than the study period taken into account, namely 20 years.

c) The cost of the saved energy unit was euros 0.0384 / kWh, which is inferior to the actual price of euro 0.0491 euro / kWh.

d) If the State finances 80 % of the investment, the owners of the block of flats are able to bear the installment for the loan.

According to the facts presented above, it is obvious that the investment fulfills the financial efficiency conditions, and therefore it can be financed.

5. Conclusions

a) Conclusions derived from the article

In order to finance the technical solutions or the set of measures that are to be implemented in the building that is to be rehabilitated or energetically modernized, the following requirements must be simultaneously complied with:

- thermal comfort;
- energetic efficiency;
- financial efficiency.

b) Contribution of the present work synthesis

When elaborating energy audit reports for buildings, one must enforce the principle of prudence from the accounting, mainly one must not:

- underrate the costs, namely the investment costs must be computed up to the level of the general estimate;
- overrate the benefits, namely the energy savings resulted. For the various measures proposed, the energy savings are not summed up simply arithmetically, but the formulas indicated in the computation methodology must be used.

c) The possibility of practical use of the study results

The conclusions of this study are useful both for the specialists who want to obtain the energy auditor license for buildings as well as for elaborating energy audit projects for buildings.

d) Outlook

Considering the facts presented above, in the future the computation methodology corresponding to the energy audit for buildings must provide the following:

- the elaboration of the general estimate for the technical solutions or for the set of measures to be implemented must be compulsory;
- a new financial index must be created, namely the specific investment, and the value of this index must be within the cost standards provided in the Romanian Government's Decision no. 1061/2012 [5].

6. Bibliografie

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