# ESSENTIAL ECONOMIC PARAMETERS USED IN THE MANAGEMENT OF ENERGY SUBSYSTEMS FROM INDUSTRIAL ENTERPRISES

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**Abstract:** The present paper treats three important economic parameters used in the energy management of an enterprise: the acquisition cost, the payback time and the average rate of the energy expenses. Calculations are done and conclusions are taken regarding the evolution of these parameters, when implementing within the enterprise the renewable energy producing systems, as sustainable development solutions.

**Keywords:** enterprise, acquisition cost, recovery time, energy expenses, turnover.

## 1. GENERAL ASPECTS

The global development of production activities together with the fossil fuels' burning led to global environmental pollution and putting in danger all existing ecosystems. In this way, the natural environment cannot be anymore ignored and the energy subsystems from the industrial enterprises have to respect the ecologic regulations, by implementing and using non-polluting systems [1]. Such systems are the renewable energy producing systems, especially solar collectors for producing boiled water and heat and also photovoltaic modules for producing electricity.

The energy subsystem represents a constituent part of the production function of the enterprise, belonging to the auxiliary processes, which have the aim to ensure the necessary conditions in the development of basic processes and which do not directly participate at their realization (materialization) [2]. The energy subsystem of the industrial enterprises includes all the equipments and installations that realize the energy transformation and transportation inside the enterprise, therefore any improvement in its structure will lead to important benefits in the economic indicators.

The economic parameters selected to be analyzed in this work have to respond to the energy efficiency of the enterprise and have to be found in the frame of all the energy producing systems (be they conventional or renewable). In this way, a comparison base can be created, which will characterize different energy producing systems with determined values of the essential economic parameters used in the management of energy subsystems.

## 2. THE ACQUISITION COST PARAMETER

### 2.1. Definition and data regarding different energy subsystems' costs

The *acquisition cost* parameter is composed of the negotiated acquisition price of a good registered in the invoice delivered by the supplier. At this price, possible transportation and supply expenses can be added (if they are

supported by the buyer), accessory expenses effectuated for a proper functioning of some fixed means and also other possibly taxes that cannot be deduced complete the definition of this economic parameter [3,4].
From the economic point of view, the acquisition cost of a system is reflected within the expenses of an enterprise and implicit in its profit [5]. If this cost is too high, the enterprise can modify its investment strategy, looking for other systems that offer viable solutions; if the acquisition cost is good, the enterprise can sketch an investment strategy that will differentiate it from the competitors, obtaining an important advantage against them.

The acquisition cost is formed from two main components [4,6,7]:

- *direct acquisition cost* – representing the acquisition price of the stocking elements, transport expenses, commissions, variable taxes and other taxes that cannot be deduced;
- *indirect acquisition cost* – include the expenses from the supply department, from taking delivery, handling, transport and stocking of material values.

By calculating the acquisition cost, it is ensured the determination of the input value of different material elements that will be used later on within the production process.

In the tables 1 and 2 there are presented the direct acquisition costs of some conventional thermal energy producing systems, used for heating the spaces and for preparing the boiled water within an enterprise. These costs have been identified by doing a survey on the Romanian market [8].

Direct acquisition costs for different gas fired wall mounted boilers and for condensing boilers - Table 1

| *Gas fired wall mounted boilers* | | | | *Condensing boilers* | | | |
|---|---|---|---|---|---|---|---|
| **Producer** | **Max. useful thermal power [kW]** | **Extra boiler [l]** | **Cost (VAT included) [€]** | **Producer** | **Max. useful thermal power [kW]** | **Extra boiler [l]** | **Cost (VAT included) [€]** |
| **Ariston** | 24 | - | 661,76 | **Buderus** | 42.9 | 160 | 4264.12 |
| **Baxi** | 24 | - | 984.17 | **Buderus** | 42.9 | 200 | 4287.36 |
| **Buderus** | 24 | - | 667.59 | **Buderus** | 60 | 200 | 5153.90 |
| **Buderus** | 28 | - | 804 | **Junkers** | 41.4 | 200 | 2973.81 |
| **Immergas** | 27.9 | - | 985.27 | **Junkers** | 65 | 300 | 6066.62 |
| **Junkers** | 24 | - | 646.02 | **Junkers** | 89.5 | 300 | 7216.16 |
| **Junkers** | 28 | - | 756.02 | **Viessmann** | 49 | 200 | 4001.97 |
| **Viessmann** | 24 | - | 720 | **Viessmann** | 66 | 300 | 5502.56 |

Direct acquisition costs of different boilers based on solid combustible - Table 2

| **Producer** | **Max. useful thermal power [kW]** | **Cost (VAT included) [€]** |
|---|---|---|
| **Buderus** | 20 | 1068.62 |
| **Buderus** | 26 | 1124.55 |
| **Buderus** | 42 | 1517.25 |
| **Junkers** | 25 | 1611.26 |
| **Junkers** | 33 | 1898.05 |
| **Junkers** | 36 | 2008.72 |
| **Viessmann** | 40 | 3448.17 |
| **Viessmann** | 80 | 5885.74 |

For the renewable thermal energy producing systems, the direct acquisition costs are detailed in the table 3.

Direct acquisition costs of solar collectors expressed in €/m$^2$ - Table 3

| **Collector type** | **Cost in €/m$^2$ (VAT included)** | |
|---|---|---|
| | **Minimal** | **Maximal** |
| **Flat plate collectors** | 238 | 730.12 |
| **Evacuated-tube collectors** | 608.44 | 1521.09 |

The direct acquisition costs expressed in the tables does not include the auxiliary equipments of the whole energy producing system, therefore they represent only the costs for the main component of each system [9,10].

### 2.2. Calculations and conclusions

In order to obtain a comparison between the conventional energy producing systems and the renewable producing systems taking into account the direct acquisition costs, it can be considered an estimation regarding the produced energy during the summer time. The summer months (June, July and August) represent a peak in the produced thermal energy for the renewable systems (solar collectors), which will be compared to the energy produced by a gas fired wall mounted boiler.

According to the values recorded for Brasov area, at *Meteorological Station Database* of the Centre for Sustainable Energy, from *Transilvania* University of Brasov and according to a medium efficiency of the flat plate collectors [11], it can be assessed that for the summer months it is available the following estimation:

*- a surface of 5 $m^2$ of flat plate solar collectors have the power to cover the produced energy of a gas fired wall mounted boiler having a maximal useful thermal power of 24 kW.*

Considering the tables 1 and 3, the average direct acquisition costs existing on the market can be determined. Therefore, a gas fired wall mounted boiler has an average direct acquisition cost of *736 €* and for the necessary surface of flat plate solar collectors (*5 $m^2$* ) this cost is: *484 · 5 = 2420 €*.

**Conclusions**:

- the acquisition of a thermal renewable energy system based on solar collectors, imply direct acquisition costs of at least 3.3 times greater than for a gas fired wall mounted boiler, which produces the same quantity of energy in the summer time for the region of Brasov, Romania;
- after the implementation of the renewable energy systems, the costs with thermal energy for the summer time will be insignificant, while in the case of the gas fired wall mounted boiler, these costs will cover the combustible used diminishing the natural gas global reserves.

## 3. THE RECOVERY TIME PARAMETER

### 3.1. Definition and relations

*The recovery time* parameter (known also as *payback period*) represents the ratio between the investment value expressed in monetary units and the benefit brought by that investment. Therefore, this parameter specifies the necessary time period for recovering the value of the invested capitals, by exploiting the system which is the investment object. The recovery time is usually expressed in years [3].

$$T_{rec} = \frac{investment}{benefit} = \frac{I_{tot}}{P_a} \text{ [years]} \tag{1}$$

Where: $T_{rec}$ – is the recovery time of the investment;
$I_{tot}$ – represents the total value of the investment;
$P_a$ – is the annual profit (benefit).

The recovery time plays a very important role in the process of adopting the investment decision of an enterprise considering all its subsystems, in consequence, the energy subsystem too [4,7,12,13].

The relation from above reflects a moment on the time scale, where the investment effort is equalized by the effect obtained (in this case, the benefit). Also, this relation presents the simple payback period which is not actualized, where the incomes and the expenses are considered as being constant over the whole period of study [3,4,12].

In order to determine the recovery time in the case of solar radiation conversion systems into thermal energy or electricity (systems based on solar collectors and photovoltaic modules), the expression of the recovery time calculated for an installed surface of one m$^2$ is the following [9]:

$$T_{rec} = \frac{C_{m^2}}{p \cdot q_e} \text{ [years]} \tag{2}$$

Where: $C_{m^2}$ - represents the acquisition cost (VAT included) for a m$^2$ of solar collector or photovoltaic module expressed in [€/m$^2$].

$p$ - is the price paid (VAT included) for the consumption of one kWh of thermal or electric energy expressed in [€/kWh];

$q_e$ - represents the annual average value of energy productivity for a m$^2$ of solar collector or photovoltaic module installed in a specific area. It is expressed in [kWh/m$^2$·year].

### 3.2. Calculations and conclusions

For calculating the recovery time of an investment in a solar thermal energy producing system, a concrete geographic area should be elected, a determined surface of solar collectors have to be accepted and also the collectors' type will play a significant contribution in the efficiency of the system. In this case, the selected area is the county of Brasov (Romania), the adopted surface of solar collectors is 5 m$^2$ and the collectors' type is flat plate collectors. This adopted surface can deliver during the summer time, the entire thermal energy necessary for a building (replacing any energy consumption of the gas fired wall mounted boiler). The calculation will be realized for a unit of one m$^2$ of flat plate collector installed, by using the relation 2 and the following data:

- the energy productivity for a m$^2$ of flat plate solar collector in Brasov area: $q_e$ = 550 kWh/m$^2$ per year;
- the average acquisition cost for a m$^2$ of flat plate solar collector is: $C_{m^2}$ = 484 €;
- the price of one kWh of energy (including the daily power reservation tax): $p$ = 0.14 [€/kWh].

For the data considered above, the recovery time in the case of flat plate solar collectors is:

$$T_{rec} = \frac{C_{m^2}}{p \cdot q_e} = \frac{484}{0.14 \cdot 550} = 6.29 \text{ [years]}$$

Since the solar electric energy producing systems based on photovoltaic (PV) modules have lower efficiencies than solar thermal collectors, it can be considered as an example for calculation, an energy productivity of a photovoltaic module being equal to maximum 50% from the productivity value of the flat plate solar collectors. Therefore, the energy productivity for Brasov (Romania) of a photovoltaic module can be considered for exemplification equal to maximum:

$$q_{ePV} = 550 \cdot 50\,\% = 275 \text{ kWh/m}^2 \text{ per year;}$$

The average acquisition cost for a m$^2$ of a photovoltaic module (having as example Kyocera modules) is:

$$C_{m^2} = 500\ldots565 \text{ € [14]}$$

In this way, the recovery time in the case of photovoltaic modules is:

$$T_{rec} = \frac{C_{m^2}}{p \cdot q_{ePV}} = \frac{500}{0.14 \cdot 275} = 12.98 \text{ [years]}$$

The recovery time related to the government support
of the investment (for solar collectors and PV modules) - Table 4

| Government support [%] | $T_{rec}$ for solar collectors [years] | $T_{rec}$ for PV modules [years] |
|---|---|---|
| **75** | 1.57 | 3.25 |
| **60** | 2.51 | 5.19 |
| **50** | 3.14 | 6.49 |
| **40** | 3.77 | 7.79 |
| **30** | 4.4 | 9.09 |

If the Romanian government, through European programs, will encourage the implementation of the renewable energy producing systems by supporting a part of the total investment, the recovery time will be reduced as it is presented in table 4.

**Conclusions**:

- the recovery time of photovoltaic modules, which produce electric energy is greater than the recovery time in the case of solar collectors, that produce thermal energy. The motivation is a lower efficiency of photovoltaic modules and greater acquisition costs in comparison with solar collectors;
- even if the recovery time calculated for the main component of solar thermal and electrical energy producing systems is not so encouraging, it should be also taken into account in time, the reduced costs with conventional energy and the market image of the enterprise, as a “green” environmental agent;
- this recovery time can be considerably reduced if European or national programs for sustaining the renewable energy producing systems will be implemented.

## 4. THE AVERAGE RATE OF THE ENERGY EXPENSES

### 4.1. Parameter definition and relations

*The average rate of the energy expenses* is an important economic parameter for the energy subsystem of an enterprise and also for the whole enterprise, because it shows the recorded modifications in the energy expenses for different analyzed periods, identifying the possibilities of reducing these expenses and increasing the profitability of the entire enterprise.

By analyzing this rate, important investment measures can be adopted, regarding the acquisition of some new systems and equipments or for improving their efficiencies. The implementation of renewable energy producing systems will reduce the energy expenses, according to the capacity installed [13].

The average rate of the energy expenses ($\overline{R}_{ENexes}$) for an enterprise is expressed either by dividing the energy expenses at 1000 turnover monetary units or by dividing these expenses at 1000 operating income monetary units [15,16]:

$$\text{Case a)} \quad \overline{R}_{ENexes} = \frac{ENexes}{t.o.} \, . \, 1000 \ \text{[m.u.]} \tag{3}$$

$$\text{Case b)} \quad \overline{R}_{ENexes} = \frac{ENexes}{o.i.} \, . \, 1000 \ \text{[m.u.]} \tag{4}$$

Where: *ENexes* - represents the energy expenses of the enterprise expressed in monetary units [m.u.];
*t.o.* - is the turnover of the enterprise in monetary units [m.u.];
*o.i.* - is the operating income of the enterprise expressed in monetary units [m.u.].

*The energy expenses* (*ENexes*) can be easily determined on the basis of the issued invoices regarding the thermal and electrical energy consumption of the enterprise. At the same time, the turnover indicator (*t.o.*) as well as the operating income (*o.i.*) indicator are expressed within the *income statement* of any enterprise [5,16,17].

### 4.2. Calculations and conclusions

In the table 5, there are presented the economic indicators of an enterprise, as they were expressed within the *income statement* and in the *issued invoices*, having as monetary units *the Romanian lei* (ROL) [18].

The values of economic indicators of an enterprise - Table 5

| Economic Indicators | Symbol | Yearly Value [ROL] |
|---|---|---|
| **Turnover** | *t.o.* | 15 625 209.9 |
| **Operating income** | *o.i.* | 17 127 072.5 |
| **Energy expenses** | *ENexes* | 270 569.5 |

According to the recorded values of the economic indicators presented in table 5, the average rate of the energy expenses can be calculated by using the relations 3 and 4 (for a and b cases).The calculated values can be improved, if the energy expenses of the enterprise will decrease in the future.

Case a) $\overline{R}_{ENexes}$ = 270 569.5 · 1000 / 15 625 209.9 = 17.32 [ROL]

Case b) $\overline{R}_{ENexes}$ = 270 569.5 · 1000 / 17 127 072.5 = 15.80 [ROL]

Considering that the enterprise will implement a surface of 20 m$^2$ of flat plate solar collectors for producing the thermal energy, and a surface of 20 m$^2$ of PV panels for obtaining the necessary electricity, taking into account the data from the point 3.2 of the present work, the energy expenses will be reduced as it follows:

Thermal energy: $q_e$ *·collectors' surface · p* = 550 · 20 · 0.14 = 1540 € ≈ 5236 ROL

Electric energy: $q_{ePV}$ *·PV modules' surface · p* = 275 · 20 · 0.14 = 770 € ≈ 2618 ROL *(exchange rate: 1€ = 3.4 ROL)*

**TOTAL yearly energy expenses saved: 7854 ROL**

After the implementation, the value of the average rate of the energy expenses for the enterprise is:

Case a) $\overline{R}_{ENexes}$ = 262 715.5 · 1000 / 15 625 209.9 = 16.81 [ROL]

Case b) $\overline{R}_{ENexes}$ = 262 715.5 · 1000 / 17 127 072.5 = 15.34 [ROL]

**Conclusions**:

- the energy expenses can be considerably decreased through the implementation of renewable energy producing systems, in spite of acquisitioning conventional energy more and more expensive. These expenses can also be reduced by adopting equipments with high efficiencies and low energy consumption;
- the average rate of the energy expenses can also be improved by the increase of the enterprise's economic results, especially of the turnover and operating income indicators.

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