Energy Effectiveness – New Energy Performance Indicator to Optimize the Industrial Energy Consumptions

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Abstract— **The purpose of this paper is to continue the ODEX Energy Efficiency Analysis and the Energy Savings Assessment that have been defined in [5], and add new indicators of energy performance which allows optimizing industrial energy consumptions by highlighting the evolution of productive and unproductive consumptions as well as energy savings and energy losses.**

Keywords— ***energy effectiveness, productive consumptions, unproductive consumptions, energy savings, energy losses, energy efficiency.***

I. INTRODUCTION

In the face of the unprecedented challenges posed by the negative influence of energy dependence on fossil fuels on the environment, energy efficiency contributes in a cost-effective way to reducing greenhouse gas emissions and therefore to mitigating climate change [1].

In industry, energy efficiency is achieved mainly by changing the way energy is managed, rather than by installing new technologies. Thus, efficiency can be continuously improved.

In the case of industrial consumers, the improvement of energy efficiency can be obtained and maintained only using methods of energy analysis of energy consumption and of the results obtained that allow a better understanding of how energy is used.

The most effective way to persuade the management team of the need for improving an energy management program is to present results through energy efficiency calculations and statistical analysis of energy consumption and energy costs.

Energy analysis, as a method of promotion and tool for assessing energy efficiency in final consumers, has two forms:

- Energy audit - a tool for assessing energy efficiency, and
- Energy management – a tool for capitalizing with maximum efficiency of energy consumption.

An energy audit provides an accessible picture of how energy carrier flows enter, distribute, transform and consume within the balance sheet, it also highlights the energy losses and where the processes can be rescaled [2] [3].

Energy Managers are interested in improving energy efficiency because this can save energy, resulting increased energy performance, the way they can do this is the application of various methods of energy analysis [4]

We can start saving energy only after we truly understand how we're using it. To be efficient, we must:

- Consume only as much as necessary;
- Consume only where is necessary;
- Consume only when is necessary;
- Consume only as needed.

The role of the Energy Manager is not to save energy by himself but to know how to encourage, stimulate and persuade others to do so.

This paper continues the presentation of the new method of energy analysis presented in [5] and, by introducing along with energy effectiveness of a new set of energy performance indicators, allows the optimization of industrial energy consumption by highlighting the evolution of productive and unproductive consumption as well as energy savings and energy losses.

Energy effectiveness is a new and very useful indicator of the energy performance helping to truly understand how we're using energy.

II. THE ENERGY ANALYSIS – METHOD OF PROMOTION AND TOOL OF THE ENERGETIC MANAGER FOR ASSESSING ENERGY EFFICIENCY TO THE INDUSTRIAL END-USERS

For the purpose of this paper, we will continue using the ODEX Energy Efficiency Analysis and the Energy Savings Assessment that have been defined in [5], and add new indicators.

The Energy Effectiveness, the Productive energy consumption and the Unproductive energy consumption are indicators of energy performance that have been defined in [5].

It has been defined the Productive Energy Consumptions in the year 1 as:

$$C_1^{pr} = VP_1 \div E_1^{max} \quad (1)$$

It has been defined the Productive Energy Consumptions in the year 2 as:

$$C_2^{pr} = VP_2 \div E_2^{max} \quad (2)$$

The Unproductive Energy Consumptions for those two years have been defined as:

$$C_1^{npr} = C_1 - C_1^{pr} \quad (3)$$

$$C_2^{npr} = C_2 - C_2^{pr} \quad (4)$$

The Productive Energy Consumption that would have been needed in year 2 if the monthly production values achieved in year 2 were obtained with the same monthly energy efficiencies as those of year ($C_{2:1}^{pr}$) is defined as the ratio between the Value of Production in the year 2 (VP_2) and the Maximum Value of Monthly Energy Efficiency registered in year 1 (E_1^{max}):

$$C_{2:1}^{pr} = VP_2 \div E_1^{max} \quad (5)$$

The Unproductive Energy Consumption that would have been needed in year 2 if the monthly production values achieved in year 2 were obtained with the same monthly energy efficiencies as those of year 1 ($C_{2:1}^{npr}$) is defined as the difference between the Energy Consumption in the year 2:1 ($C_{2:1}$) and the Productive Energy Consumption in the year 2 ($C_{2:1}^{pr}$):

$$C_{2:1}^{npr} = C_{2:1} - C_{2:1}^{pr} \quad (6)$$

The productive ODEX indicator corresponding to those two consecutive years for which the Energy Efficiency analysis is made ($ODEX_{2:1}^{pr}$) is define as:

$$ODEX_{2:1}^{pr} = C_2^{pr} \div C_{2:1}^{pr} = E_1^{max} \div E_2^{max} \quad (7)$$

The Productive Energy Savings in year 2 compared to year 1, obtained by the evolution of the energy effectiveness ($EH_{2:1}^{pr}$) is defined as:

$$EH_{2:1}^{pr} = C_{2:1}^{pr} - C_2^{pr} = C_2^{pr} \times (1 \div ODEX_{2:1}^{pr} - 1) \quad (8)$$

The Unproductive Energy Savings in year 2 compared to the year 1, obtained by the evolution of the energy effectiveness ($EH_{2:1}^{npr}$) is defined as:

$$EH_{2:1}^{npr} = C_{2:1}^{npr} - C_2^{npr} \quad (9)$$

The Energy Savings through Energy Efficiency in the year 2 compared to the year 1 is thus determined as:

$$EE_{2:1} = EH_{2:1}^{pr} + EH_{2:1}^{npr} \quad (10)$$

The paper introduces new energy performance indicators, as follows: The Productive Energy Savings and The Unproductive Energy Savings.

These new energy indicators, resulting from the analysis of energy efficiency, highlight the evolution of the performance of energy consumption use.

Together with the other indicators of energy performance defined in [5] they are the basis of the Energy Analysis for industrial End-Users.

Fig. 1 presents the stages of Energy Analysis for industrial End-Users:

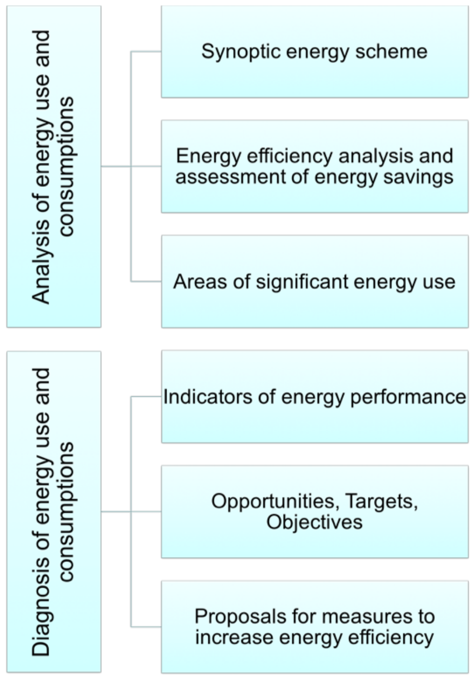

Figure 1. The stages of energy analyses for industrial End-Users

Synoptic energy scheme – is a document showing synoptic scheme of energy use in the Energy Analysis Centre.

Energy efficiency analysis and assessment of energy savings – is a document analyzing the evolution of the energy efficiency and energy effectiveness as well as productive and unproductive consumptions for the assessment of the energy savings/losses.

Areas of significant energy use – is a document developed to identify within a company the facilities, systems, processes, equipment and staff working for or on behalf of the organization that significantly affect how the energy is used and consumption of energy.

Indicators of energy performance – is a document developed to identify the appropriate energy performance indicators for measuring, calculating and monitoring energy performance.

Opportunities, targets, objectives – is a document developed to identify the opportunities and targets for improving energy efficiency.

Proposals for measures to increase energy efficiency – is a document developed by identifying those optimal and realistic measures to improve energy efficiency.

The Industrial Energy System is defined as the assembly consisting of installations for the production, transformation, distribution and use of a form or energy carrier, with all basic and auxiliary equipment and installations, including all control, protection, adjustment, measurement and automation equipment, nominated as fixed means of production for the endowment of an enterprise or industrial platforms. [6]

From the point of view of the use of fuel and energy, of their transformations in the industrial energy system, four subsystems are distinguished:

- Fuel subsystem burned directly in technological processes - SSC1
- Subsystem of transforming fuel into thermal energy under the form of hot water, steam and electricity - SSC2
- Subsystem of electricity used directly in technological processes - SSE1
- Subsystem of transforming electricity into other forms of energy carriers - SSE2 [6]

Optimizing the energy consumptions can be done by identifying and applying measures to maximize Productive and Unproductive Energy Savings, using Energy Analysis as presented in Fig. 1.

The application of the energy effectiveness analysis method described is made separately both for the registered Productive consumption and for the registered Unproductive consumption

In order to do this, it is necessary that the energy consumption monitoring system be designed so that Productive consumption (SSC1 + SSE1) and Unproductive consumption (SSC2 + SSE2) specific to the analyzed analysis center can be recorded separately.

III. Practical Example

For greater clarity, the practical example presented below will be made for the same case as in [5 [, thus being a continuation of the presentation of the new method of energy analysis.

Recording data for two consecutive years of analysis helped to collect the monthly statistical data for the energy consumption and production value – as shown in Fig. 1.

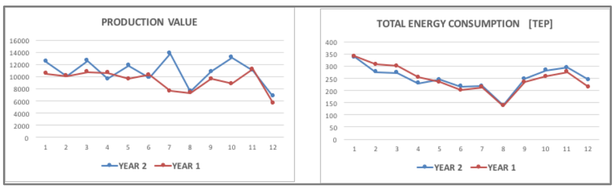

Figure 1. Evolution of the production value and the total energy consumption

Fig. 3 presents the monthly evolution of electricity and natural gas consumption for those 2 years of analysis:

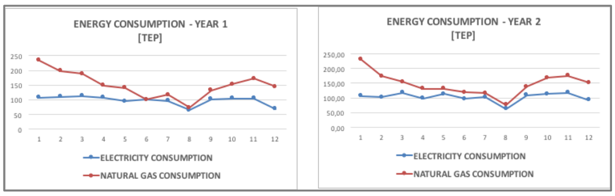

Figure 2. Monthly evolution of the electricity and natural gas consumptions

Fig. 3 presents the productive and unproductive electricity consumption in year 2 compared to year 2:1.

Fig. 4 presents the monthly evolution of the electricity consumption savings in year 2 compared to year 1.

Fig. 5 presents the quarterly and annually evolution of the electricity consumption savings in year 2 compared to year 1.

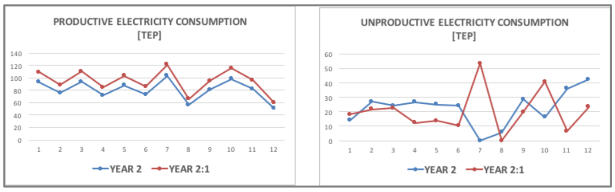

Figure 3. Productive and unproductive electricity consumption YEAR 2 and YEAR 2:1

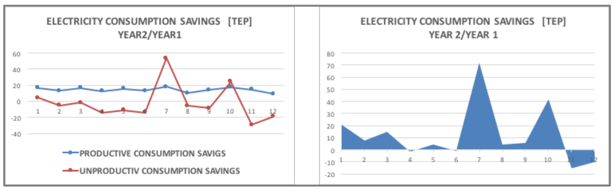

Figure 4. The monthly evolution of the electricity consumption savings in YEAR 2 compared with YEAR 1

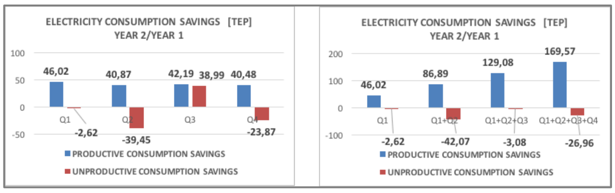

Figure 5. The quarterly and annually evolution of the electricity consumption savings in YEAR 2 compared with YEAR 1

Fig. 6 presents the productive and unproductive natural gas consumption in year 2 compared to year 2:1.

Fig. 7 presents the monthly evolution of the natural gas consumption savings in year 2 compared to year 1.

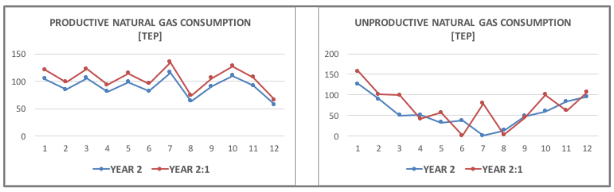

Figure 6. Productive and unproductive natural gas consumption

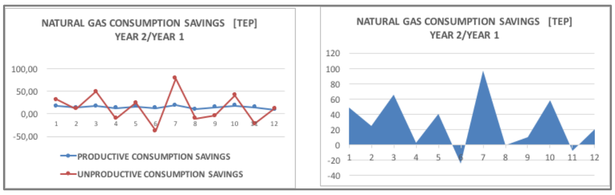

Figure 7. The monthly evolution of the natural gas consumption savings in YEAR 2 compared with YEAR 1

Fig. 8 presents the quarterly and annually evolution of the natural gas consumption savings in year 2 compared to year 1.

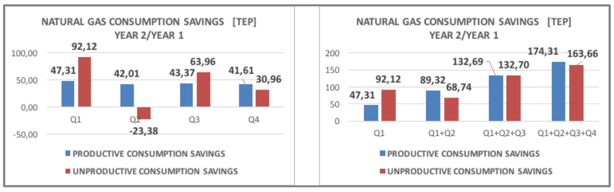

Figure 8. The quarterly and annually evolution of the natural gas consumption savings in YEAR 2 compared with YEAR 1

Fig. 9 presents the monthly evolution of the TOTAL energy consumption savings in year 2 compared to year 1.

Fig. 10 presents the quarterly and annually evolution of the TOTAL energy consumption savings in year 2 compared to the year 1.

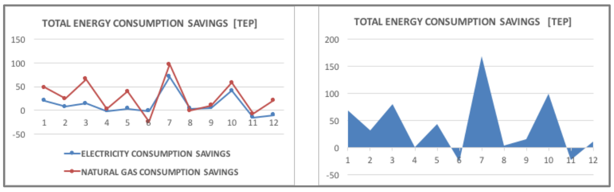

Figure 9. The monthly evolution of the TOTAL energy consumption savings in YEAR 2 compared with YEAR 1

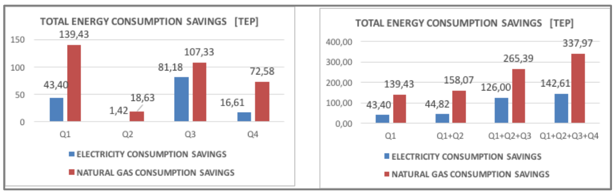

Figure 10. The quarterly and annually evolution of the TOTAL energy consumption savings in YEAR 2 compared with YEAR 1

IV. Conclusions

Without replacing the energy balance sheet but by completing it, the new Energy Effectiveness analysis method proves very useful for the monitoring, analysis and optimization of industrial energy consumptions, and becomes a valuable tool when elaborating the Energy Efficiency Improvement Plan.

The new energy efficiency and energy effectiveness analysis presented brings forward a new solution to how Energy Effectiveness can be new and very useful indicator of the energy performance helping to truly understand how we're using energy.

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