LEGISLATIVE ENVIRONMENT AND THE IMPORTANCE OF ACCOUNTING ENVIRONMENTAL COSTS IN THE LIGHTING BODY INDUSTRY

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ABSTRACT
Due to the increased growth of the market in the lighting equipment, in conjunction with the reduction of the energy consumption with the appearance of the LED luminaires, the orientation of the consumers towards the "Eco friendly" behavior within the consumers, we consider this area of activity of interest. In view of the worldwide legislation to get out of market inefficient lighting technologies, but also the obligation to highlight the marketing of electrical lighting equipment (EEE), and waste electrical and electronic equipment (WEEE) resulting from the process of production, knowledge of environmental costs and the role of environmental management accounting in this field have a particularly important role in making decisions on optimizing the profit of a production entity in the field of electric lighting equipment, but also sustainable development based on sustainability. The success of the economic activity of an entity on the market of electric lighting equipment is conditioned by the quality and diversity of the products obtained. The implementation of environmental management accounting can give us a perspective on the efficiency of the activity in different fields of activity.

KEYWORDS: *environmental costs, environmental legislation, environmental management accounting, sustainable development.*

1. INTRODUCTION

Knowing the environmental costs and implementing the environmental management accounting can give us a perspective on the efficiency of the activity in different fields of activity. The need to prevent pollution by economic entities is the result of two main factors: (1) the industrial products market follows the rapid pace of technology development, modeling and adapting to the demands of the moment, and especially in the field of LED luminaires production, the innovative technology used in the production process occupies a very important place because, for the moment, it is a very efficient method, being able to produce high quality products of various sizes and models; and (2) in order to achieve managerial performance, economic entities must establish an efficient system of reporting to internal and external environmental regulations. Managers are increasingly focusing on improving the quality and reducing the defects of the products of their services or activities. A defect rate considered normal in the past is no longer tolerable today. The managers know that a reduction of defects also means a reduction of costs and an increase of the competitiveness of the economic entity. Highlighting and recording the costs of defects as they occur helps managers had better determine what needs to be done regarding these defects and the costs involved. Wastes are scraps of materials that appear because of making a product. If companies realized that treating and

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disposing of waste is less expensive than producing waste, then those companies would be committed to reducing costs by minimizing waste.

2. LITERATURE REVIEW

In each country, the requirements, the legislation, the design of buildings and the practice of constructions, the culture and the climatic characteristics are different. At present, the tendency is to align and adapt the specific legislation and to intensify the technology transfer within the European Union (Pană, 2011). According to the policies for the promotion of environmental management accounting (EMA), according to some specialists and to the EMA organizations, the most common categories of environmental policy instruments used are: regulatory, economic, information and social tools (IISD, 1997; UNDSD, 2000; Bouma, 2000). Government regulations allow the EMA to explore or review issues related to: financial reporting regulations; National statistics reporting regulations; environmental reporting regulations; Planning rules; EMS regulations; Business licensing requirements. Numerous attempts to clarify the notion of EMA have been made by specialists but have not reached a concrete result due to the fact that EMA and EA are similar to overlapping subjects and tasks (UNDSD, 2000; Jasch, 2003; Bennett et al., 2003; Dillard et al., 2005; Cullen and Whelan, 2006; Jonäll, 2008; Collins et al., 2011; Bowen and Wittneben, 2011). Another element of confusion was the ambiguous nature of the information that had to be measured (Alcouffee et al., 2008) as the EMA accounted for the environmental costs. Environmental accounting (EA - Environmental Accounting) emerges from the financial accounting under which it develops and contributes to solving: environmental problems (Christmann, 2000; Fussel & Georg, 2000), insurance procedures (Dixon et al., 2004; Özbirecikli, 2007), financial performance (Gadenne et al., 2009; Moneva & Ortas, 2010). The clear delimitation of the environmental information contained in the EMA and EA was achieved by IFAC (2005), which issued a document that was accepted as a standard text by academics and practitioner organizations. EMA is a management system that reflects economic and ecological issues (Buritt et al, 2002; UNDSD, 2000; IFAC, 2005) in the decision-making process (de Beer & Friend, 2006). In practice, there are gaps in the academic environment for the implementation of the potential EMA for the analysis of environmental costs and their identification in the production process in order to achieve superior economic performance (Christ & Burritt, 2013; Ván, 2012; Ferreira et al., 2010; Schaltegger et al., 2010; Burritt et al., 2009). The factors that contribute to the success of the EMA implementation within a company refer to: the support of senior management, strategic management, internal group policies and regulations, raw material prices, environmental regulations.
In the current scientific context, we have as main objective to analyze the environmental legislation in the context of sustainable development, taking into account the legislative environment and the existence of an environmental policy within this sector of activity. The analysis and identification of the environmental costs within the products are of major importance for making good managerial decisions in order to achieve the objectives of reducing the environmental costs, but also in order to improve the environmental performance, taking into account the current, future and potential environmental costs.

3. RESEARCH METHODOLOGY

The researcher intends to discuss the various conceptual approaches of Environmental Management Accounting (EMA), its evolution and policies to promote it nationally and internationally. Considering the interaction with the environment within the companies producing electrical lighting equipment, we analyzed the products according to the activity fields and the product categories related to these fields. We established the research methodology according to the topics addressed by analyzing them in depth. Keywords are established based on relevant research in the literature, focusing on the most recent studies, both Web of Science, Scopus or other relevant international databases indexed. The results expected from the research are aimed at increasing the level of optimization of the environmental costs within the entities producing luminaires, because the regulations affecting the lighting products are a determining factor of the future market in the field. It is intended that the research should also include environmental management accounting, so that the results can also be used for teaching purposes. From the point of view of the research methodology, as the main instrument of environmental management accounting (EMA) for cost analysis, investment evaluation and performance management within the company studied, we chose a mathematical (statistical) method.

4. EMA IMPLEMENTATION WITHIN A COMPANY IN THE PRODUCTION OF ELECTRIC LIGHTING EQUIPMENT

In general, the activity of a company that deals with production in the field of electrical appliances will interact with the environment in different ways, at different stages of the technological flow. Within the company wastes result at different times of activities, namely: by unpacking the raw materials that are usually packed in cardboard, or in plastic bags; by processing during the production process from which it produces ferrous or non-ferrous scrap, pieces of plastic or glass; packaging of products before delivery can result in scraps of paper, cardboard or plastics. These wastes are transferred to a third economic agent, who deals with their recovery. In exchange, the production company receives money, and the price depends on the nature of the waste collected for recovery.
The environmental costs of the company are affected, however, by another aspect, namely that the company puts on the market products that affect the environment. For this reason, the company must pay taxes in three directions, each tax being to offset a certain aspect of environmental degradation or to contribute to the payment of works to prevent environmental degradation. The three important directions envisaged for the prevention of environmental problems are: a) Avoidance of environmental pollution by throwing out used electrical appliances; b) Avoid environmental pollution by discarding used batteries; c). Avoiding the pollution of the environment by throwing away cardboard and plastic packaging, stains, containers, etc.

4.1 Environmental costs due to the marketing of electrical products

It is known that the tax paid to CCR Logistic is proportional to the weight of the production (the total weight of all the devices placed on the market). Monthly a declaration and which constitutes a basis for calculating the environmental tax related to this component. Adding all the amounts invoiced by CCR Logistic during the years 2017-2018 and reporting the result to the total quantity of products placed on the market during these years, it results in an average cost per kg of product delivered to the market:

$$c^{PRODUCT} = \frac{22527{,}92\ lei}{47474\ kg} = 0{,}4745\ \ lei/kg \qquad (1)$$

If noted with

n the number of product types the company produces;

g_i weight of product "i" in kilograms;

b_i the number of pieces of product "i", delivered in one month;

then you can calculate the environmental cost related to the marketing of the products of that month, cost to be paid to CCR Logistic

$$C^{LOGI} = (b_1 g_1 + b_2 g_2 + \cdots + b_n g_n) c^{PRODUCT} \qquad (2)$$

Or

$$C^{LOGI} = c^{PRODUCT} \sum_{i=1}^{n} b_i g_i \tag{3}$$

4.2 Environmental costs due to the marketing of batteries

It is also known that the fee paid to CCR ReBat is proportional to the weight of the batteries placed on the market. Based on a thinking similar to the one presented above, one can calculate the average cost for 1 kg of batteries delivered to the market

$$c^{BATTERIES} = \frac{3729{,}05\ lei}{521\ kg} = 7{,}1575\ \ lei/kg \tag{4}$$

The environmental costs paid to CCR ReBat in one month can be calculated with the relationship:

$$C^{REBAT} = c^{BATTERIES} g_B \tag{5}$$

in which it was noted with g_B the weight of the batteries placed on the market during that month

4.3 Environmental costs due to the marketing of packaging

If regarding the environmental costs caused by the marketing of products and batteries, things are clear in the sense that these costs depend on the weight of the products respectively of the batteries placed on the market, in the case of packaging things are a little different. The amounts paid to Ecological 3R depend on several factors. Of course, the weight of the packaging plays an important role and its influence is well reflected in these costs. Ecological 3R, based on the legislation in force, makes the calculations of the amounts owed by SC Electromax but to see how the environmental costs of each product manufactured and placed on the market depend, we will approach the problem from a statistical perspective.

Through a representation in the same axis system of the evolution of the quantities of packaging launched on the market month by month as well as of the amounts paid monthly to Ecologic 3R it can be observed that there is a correlation between the two variables. Fig.1

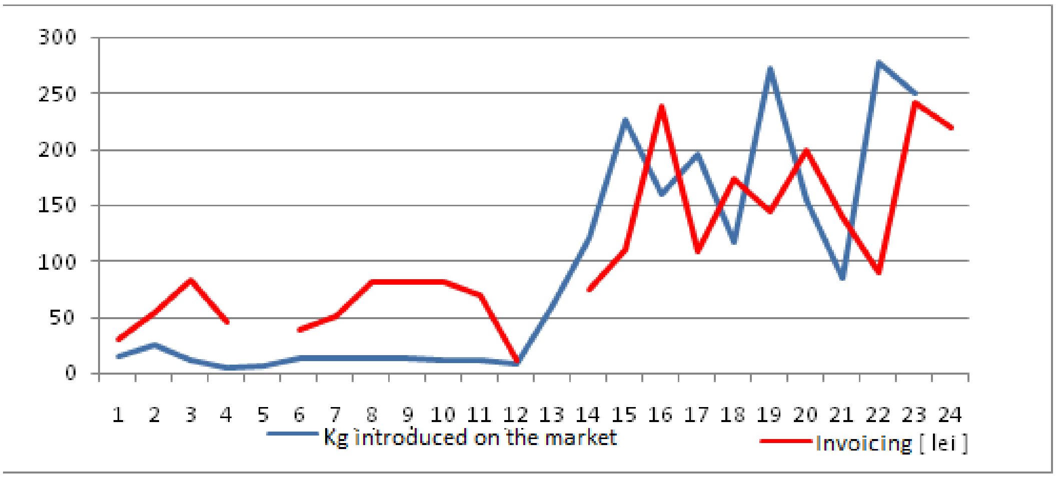

Figure 1. The correlation between the quantities of packaging placed on the market and the environmental costs

Source: own systematization

For a more precise determination of the level of correlation between the two variables (weight of the packages and the amount paid) the Pearson correlation coefficient is calculated:

$$r = \frac{\sum_{L=1}^{24}(x_L - \bar{x})(y_L - \bar{y})}{\sqrt{\sum_{L=1}^{24}(x_L - \bar{x})^2 \sum_{L=1}^{24}(y_L - \bar{y})^2}} \tag{6}$$

In which

x_L represents the quantity of packaging placed on the market in month L

y_L represents the amount paid to Ecological 3R in month L

$\bar{x}$ represents the average of the values x_L for the 24 months taken into account (2017 – 2018);

$\bar{y}$ represents the average of the values y_L for the 24 months.

Calculating the Pearson correlation coefficient according to Table 3 we obtained:

$$r = \frac{85079{,}22}{\sqrt{216276 * 118231}} = 0{,}53 \tag{7}$$

Upon careful observation of the representation in fig. 1, there is a difference between the shapes of the two graphs of 1 unit (1 month) on the horizontal axis. The difference is explained by the fact that the amount paid (invoiced) in one month takes into account the activity of the company in the previous month.

If the values paid (invoiced) are translated one-month back, they will be correlated with the activity of the company from the previous month:

The Pearson correlation coefficient obtained this time is equal to

$$r = \frac{151992{,}9}{\sqrt{216276 * 123313}} = 0{,}93 \tag{8}$$

Knowing that if

r ⊂ [-0.25 to +0.25] → There is no correlation;

r ⊂ (0.25 to +0.50] ∪ (-0.25 to -0.50] → the correlation is weak;

r ⊂ (0.50 to +0.75] ∪ (-0.50 to -0.75] → correlation is moderate;

r ⊂ (0.75 to +1) ∪ (-0.75 to -1) → the correlation is strong;

r < 0 dependence is inversely proportional;

r > 0 dependence is directly proportional;

we deduce that a correlation coefficient of 0.93 represents a very strong direct proportional dependence. This means that the following formula can be used to determine the environmental cost due to the placing on the market of the packages, based on the weight of the packages placed on the market. The result estimates the amount owed to Ecological 3R very well

$$C^{ECOL} = c^{PACKAGING} g_A \tag{9}$$

In which g_A represents the weight of the packages placed on the market in the respective month expressed in kilograms and $c^{PACKAGING}$ represents the specific cost paid per kilogram of packaging placed on the market. This can be determined statistically from the situation known in recent months:

$$c^{PACKAGING} = \frac{2365{,}60\ lei}{2058{,}7\ \ kg} = 1{,}1491\ lei/kg \tag{10}$$

4.4 Total environmental cost, due to the placing of packaged products and batteries on the market

This cost results from the sum of the costs previously determined:

$$C = C^{LOGI} + C^{REBAT} + C^{ECOL} \tag{11}$$

This calculation can be detailed in a form that shows the dependence of the cost on the number of pieces of each product manufactured, packaged and put on the market in that month. In the matrix form this dependence is expressed in this way:

$$C = \begin{pmatrix} b_1 & b_2 & \dots & b_n & 1 \end{pmatrix} \begin{pmatrix} g_1 & 0 & 0 \\ g_2 & 0 & 0 \\ \dots & \dots & \dots \\ g_n & 0 & 0 \\ 0 & g_B & g_A \end{pmatrix} \begin{pmatrix} C^{PRODUS} \\ C^{BATERII} \\ C^{AMBALAJ} \end{pmatrix} \tag{12}$$

For example, for April 2018, taking into account the reports and production details in table 2, the average cost for the respective month with the relationship can be calculated by the relation:

$$C = \begin{pmatrix} 103 & 1 & \dots & 3 & 1 \end{pmatrix} \begin{pmatrix} 0{,}8 & 0 & 0 \\ 6 & 0 & 0 \\ \dots & \dots & \dots \\ 1 & 0 & 0 \\ 0 & 1 & 160 \end{pmatrix} \begin{pmatrix} 0{,}4745 \\ 7{,}1575 \\ 1{,}1591 \end{pmatrix} \tag{13}$$

4.5 Waste valued by the lighting equipment company

As can be seen from figure 1, there are wastes that the company can use, namely: aluminium scrap, cuttings, scrap iron, cardboard, glass, plastic. Because Electromax (lighting equipment manufacturing company) stipulates by contract with Ecologic 3R (environmental service provider) that cardboard and plastic waste be collected by the service provider free of charge, it means that Electromax company does not recover money from waste of cardboard and plastic. But the company capitalizes on aluminium, aluminium cuttings and scrap iron. Taking into account the recovered values, the relationship that expresses the environmental costs becomes:

$$C = \begin{pmatrix} b_1 & b_2 & \dots & b_n & 1 \end{pmatrix} \begin{pmatrix} g_1 & 0 & 0 \\ g_2 & 0 & 0 \\ \dots & \dots & \dots \\ g_n & 0 & 0 \\ 0 & g_B & g_A \end{pmatrix} \begin{pmatrix} C^{PRODUCT} \\ C^{BATTERIES} \\ C^{PACKAGING} \end{pmatrix} - V_{D1} - V_{D2} - V_{D3} \tag{14}$$

In which

V_{D1} represents the amount in lei collected from the recovery of waste type 1 (aluminium)

V_{D2} represents the amount in lei collected from the recovery of type 2 waste (aluminium cuttings)

V_{D3} represents the amount in lei collected from the recovery of type 3 waste (scrap iron)

It is important to analyse which products produce such waste. It is well known that in the manufacturing process there are products that result in a greater quantity of waste (scrap) while from other products the amount of waste is insignificant or even no waste. For example, if a product does not contain aluminium, then aluminium cuttings will not be produced in the manufacturing process due to that product.

For this purpose, it would be important to know the function that expresses the dependence between the number of pieces of each manufactured product and the amount of waste resulting. We consider the case of the aluminium waste expressed by a polynomial function of the form:

$$V_{D1} = f_1(b_1, b_2, b_3 \dots b_n) = a_{11}b_1 + a_{12}b_2 + a_{13}b_3 + \dots + a_{1n}b_n \tag{15}$$

Analogously, it is considered a polynomial function for the aluminium cuttings as well as for the scrap iron:

$$V_{D2} = f_2(b_1, b_2, b_3 \dots b_n) = a_{21}b_1 + a_{22}b_2 + a_{23}b_3 + \dots + a_{2n}b_n \tag{16}$$

$$V_{D3} = f_3(b_1, b_2, b_3 \dots b_n) = a_{31}b_1 + a_{32}b_2 + a_{33}b_3 + \dots + a_{3n}b_n \tag{17}$$

In the above expressions, the following notations were used:

b_k is the number of pieces manufactured from product k

a_{1k} is a coefficient expressing the participation of a piece of product k in the formation of aluminium waste

a_{2k} is a coefficient that expresses the participation of a piece of product k in the formation of aluminium cuttings

a_{3k} is a coefficient that expresses the participation of a piece of product k in the formation of the scrap iron

If one of the coefficients "a" has zero value, it expresses that the respective product does not participate in the formation of the waste. If the value of the coefficient is very small it means that, the product has a participation in the formation of the waste but the participation is negligible. If the value of the coefficient is significant, it means that the participation of the product in the formation of the waste is significant.

In matrix format, the total of the amounts resulting from waste recovery is:

$$V_{D1} + V_{D2} + V_{D3} = (1,1,1)\begin{pmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ a_{31} & a_{32} & \dots & a_{3n} \end{pmatrix}\begin{pmatrix} b_1 \\ b_2 \\ \dots \\ b_n \end{pmatrix} \tag{18}$$

In order to analyse the way in which the manufacture of certain types of products leads to the formation of waste, a hierarchy of the types of products was made according to the weight of the total production of the company during the period 2017-2018. The hierarchy presented as a very high share (as weight) in production has the products of the category of Apollo projectors and those for halls, and the lowest share in production have the adjustable spots. In order to determine the dependence between the product categories and the resulting waste, only the first five product categories were considered, as example. Thus, the quantity of waste recovered reflects the activity of the production for several months, more precisely, over the entire period of time since the previous recovery of the waste. In the following, a model for determining the dependence between aluminium waste and the five main product categories will be presented. In essence, the determination of the dependence consists in fact in determining the coefficients a_{11}, a_{12},…,a_{15} with the meanings presented previously in the paper, so that, by applying them on the volume of production (monthly or cumulative for a longer period) of each category b_1, b_2,…,b_5 it leads to a result as close as possible to the value of the waste recovered for the respective period. From a mathematical point of view, things can be expressed in this way:

$$a_{11}b_1 + a_{12}b_2 + a_{13}b_3 + a_{14}b_4 + a_{15}b_5 = V_{D1} \pm \varepsilon \qquad (19)$$

In which it was noted with ε the deviation (the difference) between the real value of the waste V_{D1} and the value calculated on the basis of the dependency coefficients. It is desirable that the value ε be as small as possible for each time interval included in the equation, including cumulative values for different periods of time from 1 to 24 months.

$$\begin{array}{rrrrrr}
89\cdot a_{11}+ & 33\cdot a_{12}+ & 165\cdot a_{13}+ & 60\cdot a_{14}+ & 128\cdot a_{15}- & 736=\varepsilon_1 \\
875\cdot a_{11}+ & 3663\cdot a_{12}+ & 909\cdot a_{13}+ & 370\cdot a_{14}+ & 1105\cdot a_{15}- & 2296=\varepsilon_2 \\
2227\cdot a_{11}+ & 6425\cdot a_{12}+ & 2040\cdot a_{13}+ & 596\cdot a_{14}+ & 2222\cdot a_{15}- & 2816=\varepsilon_3 \\
3263\cdot a_{11}+ & 6885\cdot a_{12}+ & 2620\cdot a_{13}+ & 633\cdot a_{14}+ & 2720\cdot a_{15}- & 3390{,}6=\varepsilon_4 \\
3949\cdot a_{11}+ & 7138\cdot a_{12}+ & 2710\cdot a_{13}+ & 679\cdot a_{14}+ & 2993\cdot a_{15}- & 3975{,}6=\varepsilon_5 \\
4397\cdot a_{11}+ & 7604\cdot a_{12}+ & 2991\cdot a_{13}+ & 741\cdot a_{14}+ & 3441\cdot a_{15}- & 4058{,}8=\varepsilon_6 \\
4766\cdot a_{11}+ & 8566\cdot a_{12}+ & 3222\cdot a_{13}+ & 877\cdot a_{14}+ & 3989\cdot a_{15}- & 4136{,}8=\varepsilon_7
\end{array} \qquad (20)$$

It is observed that the system is not an ordinary algebraic one in the sense that the number of equations is not equal to the number of unknowns. Among the unknowns of the system are even the coefficients a_{1k}, $k = 1 ... 5$ which define the dependence or more precisely express the participation of a product of category k, in the production of aluminium waste.
Such a system is solved by additionally attaching the condition

$$\sum_{j=1}^{7} \varepsilon_j^2 = minim \qquad (21)$$

The problem is essentially a problem of optimization, or of finding an extreme (the minimum of the squares of deviations) from which also results the set of values a_{1k}, $k = 1… 5$
To solve the problem, the function is built:

$$F_1 = \varepsilon_1^2 + \varepsilon_2^2 + \varepsilon_3^2 + \cdots + \varepsilon_7^2 \qquad (22)$$

The following values are then replaced ε_1 , ε_2 ,…,ε_7 depending on a_{11}, a_{12},…,a_{15} , using the relationships from the previous system. Thus the function F_1 will be expressed according to the variablesa_{11}, a_{12},…,a_{15} which also play the role of unknowns.

$$F_1 = F_1(a_{11}, a_{12}, \ldots, a_{15}) \qquad (23)$$

The minimum of this function will be ensured by the conditions:

$$\frac{\partial F_1}{\partial a_{11}} = 0$$
$$\frac{\partial F_1}{\partial a_{12}} = 0$$
$$\frac{\partial F_1}{\partial a_{13}} = 0$$
$$\frac{\partial F_1}{\partial a_{14}} = 0$$
$$\frac{\partial F_1}{\partial a_{15}} = 0 \qquad (24)$$

With the help of the initial values given to the unknowns a_{11}, a_{12}, ..., a_{15} values of the produced aluminium wastes were calculated, and following the completion of this information we found the following results:

No.	Production from category Categ 1	Categ 2	Categ 3	Categ 4	Categ 5	Aluminium waste
1	89	33	165	60	128	736
2	875	3663	909	370	1105	2296
3	2227	6425	2040	596	2222	2816
4	3263	6885	2620	633	2720	3390,6
5	3949	7138	2710	679	2993	3975,6
6	4397	7604	2991	741	3441	4058,8
7	4766	8566	3222	877	3989	4136,8
	a11	a12	a13	a14	a15	
	0,10249	0,3531	0	1,06453	0	

Figure 2. The contribution of the aluminium waste according to the product categories
Source: own calculations

Meaning of solutions:
- The largest contribution in the production of aluminium waste belongs to the products of category 4 (Proton projectors) followed by those of category 2, respectively 1
- Products of category 3 and 5 have no influence on the production of aluminium waste

The estimated V_{D1} value to be collected from the recovery of type 1 waste (aluminium) can be calculated with the relation:

$$V_{D1} = 0{,}10249 \cdot b_1 + 0{,}3531 \cdot b_2 + 0 \cdot b_3 + 1{,}06453 \cdot b_4 + 0 \cdot b_5 \qquad (25)$$

In which b_1, b_2, b_3 ... b_5 are the quantities of products in the production plan, for each product category. As a test of the dependency relation, the relation was applied to the volumes of production performed at the level of each category (quantities contained in table 8) and the results calculated with the established dependency relation were compared with the actual ones, those actually achieved during 2017-2018. The results are compared in Figure 2.
You can see that the results are extremely close. The biggest difference between the results is found at the level of the first stage of the recovery of the aluminium waste that took place in January 2018. It is observed that the real value of the aluminium waste is much higher than the calculated value because its calculated value was based only on the products manufactured in January 2018 while the real aluminium waste was also generated by the production during the last months of 2017, which was not taken into account.

5. CONCLUSIONS

According to the mathematical model for determining the dependence between aluminium waste and the volume of production on each category of products, other types of dependencies can be determined. Thus, a function f_2 can be determined for estimating the value V_D2 of the scrap waste according to the production by product categories

$$V_{D2} = f_2(b_1, b_2, b_3 \dots b_n) = a_{21}b_1 + a_{22}b_2 + a_{23}b_3 + \dots + a_{2n}b_n \qquad (26)$$

In addition, it is possible to determine a function f_3 for estimating the value V_{D3} of the scrap iron according to the production by product categories

$$V_{D3} = f_3(b_1, b_2, b_3 \dots b_n) = a_{31}b_1 + a_{32}b_2 + a_{33}b_3 + \dots + a_{3n}b_n \qquad (27)$$

It is possible in this way, an overview of the environmental costs expressed by a relationship of the following form.

$$C = (b_1 \quad b_2 \quad \dots \quad b_n \quad 1)\begin{pmatrix} g_1 & 0 & 0 \\ g_2 & 0 & 0 \\ \dots & \dots & \dots \\ g_n & 0 & 0 \\ 0 & g_B & g_A \end{pmatrix}\begin{pmatrix} C^{PRODUCT} \\ C^{BATTERIES} \\ C^{PACKAGING} \end{pmatrix} - (1,1,1)\begin{pmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ a_{31} & a_{32} & \dots & a_{3n} \end{pmatrix}\begin{pmatrix} b_1 \\ b_2 \\ \dots \\ b_n \end{pmatrix} \qquad (28)$$

The relationship is also useful for analysing how a product in category k affects environmental costs. For this purpose the partial derivatives are calculated, that is, the function C is derived in turn, in relation to each variable b_k all the other elements in the composition of the expression C being constant known. Such a derivative expresses what would happen to environmental costs if production with another product in category k were to increase.

$$\frac{\partial C}{\partial b_k}, \quad cu\ k = 1 \dots n \qquad (29)$$

By comparing the values of the derivatives, one can identify those product categories that most affect the environmental costs. A large derivative expresses a strong contribution to the environmental costs of a product of category k in relation to which the derivation was made.
In another aspect, the presence of a large value in the matrix with elements a_{JK} indicates that the manufacture of a product of category k produces a significant contribution to the category J of waste. In such a situation, a review of the technology used to manufacture products of category K is

required, at that point of manufacture where the use of raw material J is made so that it is not unduly lost in a category J waste.

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