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THE VALUE OF THE GARBAGE – AN ANALYSIS OF THE VIABILITY ECONOMIC RECYCLING OF SOLID WASTE URBAN OF PORTUGAL

O VALOR DO LIXO – UMA ANÁLISE DA VIABILIDADE ECONÔMICA DA RECICLAGEM DOS RESÍDUOS SÓLIDOS URBANOS DE PORTUGAL

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ABSTRACT

This article deals with the economic values of domestic solid waste being disposed of in the garbage in Portugal through the application of the Thomas Duston reverse logistics model; however, with the adaptation of this author. In the first part, there is a dissertation and a conversation with the authors about the current state of the public policies of waste management adopted by the country from the 90's, in compliance with the guidelines of the European Community. In the second part, there is an explanation of the destinations, types and characterization of urban solid waste, as well as the public policies directed to the adoption of results that aim at the best performance of the resources adopted and applied in the mechanical-biological treatment plants. The third and final part describes the billions of euros that are being dumped in landfills, the waste families and their economic values that are having their economic gains and their losses due to the non-recycling and use of the waste, and the possible public policies and private partnership for the best destination of waste, as well as the generation of employment and income for thousands of Portuguese citizens who could have reduced their public accounts with the collection of waste and, in contrast, could generate jobs with this ecologically healthy practice to Portugal and the planet Earth.

KEYWORDS: Urban solid waste. Reverse logistics. Public policy. Recycling. Sustainable development.

RESUMO

O presente artigo trata dos valores ec onômicos dos resíduos sólidos domésticos que estão sendo deitados no lixo em Portugal, através da aplicação do modelo da logística reversa de Thomas Duston, com adaptação deste autor. Na primeira parte há uma dissertação e uma conversa com os autores sobre a situação atual das políticas públicas de gestão dos resíduos adotada pelo país a partir da década de 90, em atendimento às diretrizes da Comunidade Europeia. Na segunda parte há uma explanação dos destinos, tipos e caraterização dos resíduos sólidos urbanos, bem como as políticas públicas direcionadas para a adoção de resultados que visam o melhor desempenho dos recursos adotados e aplicados nas plantas de tratamento mecânico-biológico. Na terceira e última parte são descritos os bilhões de euros que estão sendo deitados nos aterros sanitários, as famílias dos resíduos e seus valores econômicos que estão tendo seus ganhos econômicos e suas perdas pela não reciclagem e aproveitamento dos resíduos, e as possíveis políticas públicas e parceria privada para o melhor destino dos resíduos, bem como a geração de emprego e renda à milhares de cidadãos portugueses que poderiam ter reduzidas suas contas públicas com a coleta dos resíduos e em contra partida ainda,a geração de empregos com esta prática ecologicamente saudável para Portugal e o planeta Terra.

PALAVRAS-CHAVE: *Resíduos sólidos urbanos. Logística reversa. Políticas públicas. Reciclagem. Desenvolvimento sustentável.*

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1- INTRODUCTION

Humanity has been reaching significant advances in various areas of knowledge since the Middle Ages, and this has altered the way we live and relate with planet Earth. Productivity and global consumption patterns have shown through indicatives, worked out in this article that the system is in crisis. And these changes do not yet have a universal outline defined, much less an adequate medium-and long-term solution. The rich nations have found a very convenient solution: they export their worthless rubbish to the underdeveloped nations, mainly to Africa and Asia as pointed out in the report of the International Labor Organization – ILO, 2013; thereby injuring the Convention of Basel of 1995 in which establishes a structure of control of cross-border movement of waste, which would be the movement across borders between countries. In this case, it would be prohibited to export garbage, waste could be exported with secondary use, but in practice 80% of what is sent to these nations has no use whatsoever (UNEP – UNEP, UN, 2009).

The modern technology of production could bring an alternative to the leftovers of society, but, contrary to what was expected, it happens to be used for the obsolete generation of goods that will be disposable in less than 60 days until the creation of a new one, with design differentiated and performing more attractive with the help of a universalist and transversal media to cement global consumption homogeneously. Companies act globally in their production and distribution but continue to centralize profits in the countries of origin of the capital, on this premise, only remain the ideology of sale and profit.

Everything is going to end up in the trash, like discard, when there's no apparent value anymore. The packaging is undoubtedly the great villain because of an ephemeral life cycle in which often does not complete a month and are already being thrown in the trash. As a dissertation MÉSZÁROS, (2002, p. 639), "the rate of decreasing utilization is, in a sense, directly implied in the advances made by the productivity itself (...) Where the disposable society finds a balance between production and consumption. " This utopian equilibrium is always broken with new technology and new products, put to the test of an artificial society and subjugated in its understanding of the complexity of environmental epistemology as LEFF says, (2006).

The environmental problem is attributed to the historical process from which modern science emerges and the Industrial Revolution. It is the man trying through philosophy create a relationship between subject and object of knowledge. Even today none of them have even their defined outlines!

In this context, the nations of the world have not yet found a definitive exit to the problem of generation and disposal of solid urban waste versus economic growth. The level of economic development of a society can, to a certain extent, be adequately measured by its generation of urban waste, considering that the income is directly linked to the generation of waste.

The problem is not the incompatibility between economic growth and environmental issues, or the management of public policies focused on the proper treatment of municipal waste. Questioning is how technology is used inappropriately to produce goods with persistent and harmful materials to the environment and the planned and perceived obsolescence used to foster this process, raising even more the risks and sets of environmental problems for planet Earth soon (MAGERA, 2006).

However, man has always spawned garbage on the planet, but this changes from his sedimentation, whereas nomad he was just collector and generator of organic waste, which breaks down in a few days, but when he goes to live in community, his fixation changes his relationship with the environment and the social organization. Thus, the work represents a method of domination, and the agriculture and handicraft of utensils used in the everyday life of the communities are the greatest expression of this control.

Thus, there is an accumulation of nearly 4 billion years of natural capital being exploited by man, as if the resources were infinite and his leftovers did not exist. Garbage is not seen as a problem, while there was room left to put it and its generation per capita did not exceed 0.300 grams daily at the end of the 17th century (HAWKEN, 1999), but today, according to the UN, the average world generation already exceeds 0.5 kg per habitant a day, something around 1.3 billion tons a year. But, the system itself signals an inconsistency in the process, because while an American generates 2 kg per habitant a day, an African does not exceed 0.4

kg per habitant a day. Despite representing only 5% of the world's population, Americans produce more than 30% of all waste generated on the planet.

Man's aggression to the environment intensifies from the Industrial revolution of the 18th century. With a new concept of producing goods, whose goal was to generate more production, decrease the workforce, and increase the profit of the capitalist, changes the organic composition of the capital, increases the constant capital (machine/technology) and decreases the capital variable (Labor), (k = cc/cv) (MARX,1996). And this linear process of production and reproduction fails to see the environmental liabilities provoked daily to the planet, as if nothing had consequence of its fierce acts of wanting ever more! Putting aside the people who live in this system.

By attacking the environment with technology and differentiated production, man also brought an improvement in the apparent quality of life of humanity, and consequently an increase of the population, which goes from 1 billion in 1800 to 7.6 billion in 2018 (UN, 2018). However, it is noted that humanity took 200.000 years to reach a billion inhabitants and just over 200 years to multiply this number by six times more. This exponential growth of humanity has brought an even greater pressure for natural resources, which according to the UN already meets a deficit of 40%, and increases 2,5% per year (UN, 2017). If we continue at this rate of growth and consumption, we will need three Earth planets to provide us with natural resources and we do not have three, we have only one, and the way our relationship will be with planet Earth in the coming decades will define the survival of humanity on this blue ship (WORLD BANK, 2017).

This economic and population growth of nations has not been accompanied by a fair and equitable income distribution. The world today is more unequal than it was 200 years ago. Technology has not brought with it a social justice, although in the last hundred years life expectancy has increased, the world wars have ceased, but local and regional conflicts have intensified. And garbage generation continues, even with sustainable development policies and cleaner and safer technologies, there has not yet been a homogenization of global actions in this sense of transferring technology to underdeveloped nations.

The poorest nations continue to provide cheap raw material with low aggregate value (*commodities*) and buy from rich nations, products with high technology, a mismatch towards garbage generation and the perpetuation of global dependence. What has been seen in the last decades is a transfer, but not technology, but rubbish with no residual value. In recent decades there has been a transfer of polluting companies from developed countries to the underdeveloped. Thus, transferring environmental problems to nations that cannot even take care of their own urban waste.

The world thus is divided between rich North and poor South, and each time, more economic and political blocks are formed that aim at geopolitical strengthening of their nations and borders. The common European block is one of them that succeeded in achieving success in various political, economic areas and imposing homogeneous political actions for its members, mainly in the management of urban waste.

Portugal, as part of the European Community, benefited from the urban waste management policies addressed to the European Commission, 2006, and the European Directive 94/62/EC of 20 December 1994; it was transposed into the national legal order through of Decree-Law n 366-A/97 (Lisbon, 1997), and of the gate N 29-B/98 (Lisbon 1998) in which it imposes on the country measures of public policy management to its municipal wastes aiming at reducing the final deposition in landfills and a good practice of management of solid waste, with recycling rates and targets to be reached up to 2020.This directive updated subsequently by Directive 2004/12/EC of 11 February 2004 (Strasbourg, 2004), set recovery and recycling targets for all Member States, leaving at the discretion of these the choice of policies and management models of municipal waste.

In the 90, the Portuguese Government began a new phase in the treatment of its domestic waste, creating local and inter-municipal public policies with investments in infrastructure, public and private partnership in the final treatment of its municipal waste, leaving to bring the open-air dumps and the garbage cans that were used to give destination to their waste. A new beginning for a country that hitherto did not care about the waste of raw materials that were thrown into the ground and paid for it! Millions of euros that have been buried

and this article will aim higher to show the economic values of good management of reverse logistics, urban solid waste and how this money (which comes from garbage, recovered, through recycling and reuse) can be used in the generation of employment and income for thousands of Portuguese citizens.

In this article, the authors analyze the questioning of the urban solid wastes under an optics of environmental epistemology and its dictates in the European Community, as well as the adoption of public policies and private partnerships adopted by Portugal in the residual solution of the generation of its garbage. Not to mention the environmental, political and social variables of this segment that bring to the long history consequences in the budget structure of the municipalities, and thus creates a market linked to the municipal waste that was previously deposited in landfills, what caused a waste of natural resources and thousands of euros for Portuguese taxpayers, who now have a more sustainable destination, causing a generation of employment and income, as will be seen in the item that contains the discussion of the results and the conclusions of this study.

The method of authors to achieve the desired results, which is to show that garbage has economic, social and environmental value, and it can and should be used by society and the market, were structured analysis of reports published by APA – Agência Portuguesa do Ambiente (Portuguese Environment Agency), and SPV – Sociedade Ponto Verde (Green Dot Society), on domestic municipal waste in recent years (2014, 2015 and 2016), as well as the results of ERSUC accounts reports, 2016, on urban waste management. This company, a public service provider, serving 36 municipalities, covering an area of 6700 square kilometers with approximately 1 million inhabitants. The graphs and analyses of INE – National Institute of Statistics were also used as quantitative data and metrics for weighted analysis of the values used in the calculations of recycled urban waste.

In this walk towards the creation of a method that meets not only the objectives of this work, but the threshold of a epistemological understanding, adopts the matrix of the reverse logistics of Thomas Duston, explaining the calculations and their results that end up calling the attention when it is indicated that billions of euros are still being taken to waste (for landfills), and that Portugal fails to give a more sustainable and suitable destination for its urban waste, when only 14% of its urban waste provides for selective collection (waste separated by type) and 86% is still in the undifferentiated collection structure (garbage mixed with organic matter and other types). Therefore, new urban waste management policies should be adopted by Governments, not only regional, but as a State policy, thus leading the country to adopt the circular economy as a more sustainable and environmentally appropriate way for Country standards.

However, the article will also bring the costs, investments, expenses and benefits that can be achieved with the recycling process, the use of resources to save virgin raw materials and the dynamics of reverse logistics, providing the generation of employment and income to thousands of people who can live in this segment, which today is poorly treated and is not seen as a productive economic alternative of social goods. It creates a process with an expensive infrastructure, and that brings only residual and punctual results in some respects but leaves aside the real reason for the reuse of the garbage. Garbage is not rubbish, it is raw material which can and should be reused as shown in this work.

2- THE MONEY GOING TO END UP IN THE TRASH – THE ECONOMY INDICATING THE IRRATIONALITY

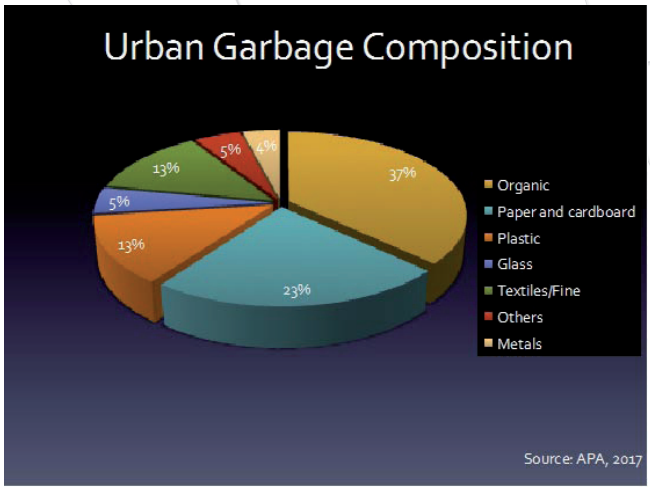
With the eradication of the dumps, in the late 90, several multimunicipal and inter-municipal systems were created for the good management of urban solid waste, with selective collection practices and a more suitable destination for household waste. In 1996 the first national plan for the solid waste sector was approved, the strategic plan for the management of urban solid waste (Persu I), (1996-2006), and after the years 2007 a 2017, Persu II. Always aiming to meet the strategic guidelines governed by the European Community's Urban waste management policy (PERSU, 2020).

The Ministries of Economics and the Environment, on 1 October of 1997, created the Sociedade Ponto Verde (SPV), which is a private non-profit organization that aims to promote selective collection, screening, recovery and recycling of waste Urban solids. In turn the APA – Agência Portuguesa do Ambiente, which licenses the operations of waste management and en-

tities linked to this segment, including SPV, holds most of the market and two smaller ones, the new green and AMB 3E. This process is responsible for the packaging generators in the national market offering two options to comply with their environmental public policy obligations; they can create their own system of collection and reuse or recycling of packaging (this system needs to be approved by the APA), or can join the integrated system managed by SPV, new Green and AMB 3E, to resume non-reusable packaging. According to the APA, 100% of the generators use their services for the destination of the packaging. (CRUZ, MARQUES, 2014).

Using this national strategic plan of public policy of urban waste, the APA creates more than 23 public companies with private partnership for the management of urban waste and provides the placement of 43000 ecopoints throughout the country, giving an average of an ecopoint for every 240 inhabitants, thus serving the goal that was one for every 500 inhabitants. In the ecopoints are placed the wastes such as: paper and cardboard, glass, plastic and metal. These materials are collected weekly from ecopoints and taken for sorting, pressing and subsequent sale to the recycling industries, and much of this material is exported to Spain, thus generating foreign employment for the country.

Portugal today produces 4.6 million tons of urban solid waste per year, according to the Portuguese Environment Agency-APA, 2017. What it represents, 472 kg/hab/year or 1.29 kg/hab. Dia. This rubbish has the following composition, considering the organic, paper/paperboard, plastics, glass, textiles, metals and others:

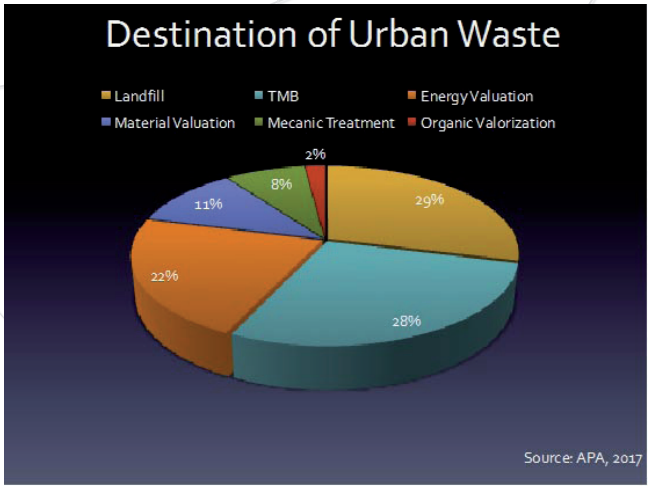


Graph nr. 1

When analyzing Graph Nr.1 of the composition of municipal waste, it is noted that 37% is organic matter and 63% inorganic matter. The so-called dry urban wastes are the ones that have the highest value of the immediate market and that only in a few actions of a selective collection and sorting, would already give an added value for their marketing. Values that could be generated in a few weeks of work, in a mill of sorting and pressing of dry urban waste, thus generating employment and income to dozens of people, with little investment in infrastructure, since every 6 tons of waste, a minimum wage job is generated.

The paper and paperboard represent 23%, followed by the plastics and textiles with 13%, the glass with 5%, and the metals that are the most market value, with 4%, of this composition only 10% are aluminum and 90% of ferrous metals (steel). This composition of municipal waste favors the implantation of a more intense selective collection in municipalities, to the detriment of the undifferentiated collection that today represents 86% of the collection, according to the APA, (2016), getting the selective collection with only 14%. When the undifferentiated collection is practiced there is a contamination of the waste and its price is not very attractive in the market, not counting the rejects that reach 30%, (ERSUC, 2018).

If we consider the destination of this material, according to the logic of public management of urban solid waste, segmented by the regional and national market, we come up with:



Graph nr.2

Analyzing graph Nr. 2, we have 29% of the waste of a total of 4.6 million tons produced per year in Portugal, which would give 1.334.000 tons, are being taken to landfills annually. And worst of all, you are paying for it! The amount paid for treatment and disposal in the landfill is € 53.9 euros per ton, which gives an **expenditure of € 71.902.600,00 euros per year**. That would generate 10,000 new jobs, if we consider the minimum wage of € 580 euros/month, according to ERSUC Annual report, 2018.

The biological mechanical treatment represents 28% of urban waste destinations, this process separates organic waste from inorganics through a technology where the bags of undifferentiated collections are opened and deposited on a treadmill, in the end, on waste that will be deposited in landfills, it is estimated that 30% on average end up going to the landfill. The whole process generates waste, even recycling, so it is normal this high index of rejects. But if the waste was a selective collection source, this index would reduce to something around 10%. In this way it would make it more productive and less costly since this process would give another 18% of urban waste for marketing.

The valuation of waste for generation of energy through its burning is considered by the international community linked to the preservation of the environment as inadequate, since in the burning of urban wastes generates the dioxins that are highly carcinogenic. There is no healthy level of dioxins, and even a small amount can be dangerous, exactly because it builds up in the body. The World Health Organization (WHO) and the European Union have established the dosage of 2.3 pg/kg/day (Picogram/kilo/day-1 - Picogram is equivalent to 10-¹ ² gram or a trillionth of grass) as limit. Even so, 22% of all urban waste from Portugal ends up going to the furnaces for use in electric power generation. The use of these wastes in the form of raw material reused for other purposes would bring a better economic value, without considering the greater good to the environment.

Only 11% of the municipal waste generated annually has its appreciation in the form of material – large part from the selective collection, the ecopoints. If we consider the composition of the dry urban waste and its value applied to the public tender by SPV, we have the following values potentially that could be achieved if the collection and recycling took advantage of the full potential of the garbage of Portugal: paper and Card 23%-total of 1.058.000 tons; Plastic 13%-total 598.000 tons; 5% Glass-Total 230.000 tons and metal 4%-total of 184.000 tons, being 165.600 steel and 18.400 aluminums.

Paper and card	= 1.058.000 x85	= € 89.930.000,00 euros per year
Plastic	= 598.000 x 240	= € 143.520.000,00 euros per year
Glass	= 230.000 x15	= € 3.450.000,00 euros per year
Steel	= 165.600 x65	= € 10.764.000,00 euros per year
Aluminum	= 18.400 x 650	= € 11.960.000,00 euros per year

Overall Total = € 259.624.000.00 euros per year, by the 2.070.000 tons sold for the recycling market, by a medium average mix of € 125,42 euros per ton – price paid by the market on average weighted to recycled products, selected, separated by family-type and in uniform for the SPV company.

If we consider the 29% of the municipal waste being inadequately shipped directly to the landfill, this account is even more salty, when we have: 1.334.000 tons per year being deposited in the landfill, excluding the 37% of organic, plus the 13% Textiles/fines and 5% of others, we have 1.334.000 – 733.700 = 600.300 tons of dry waste per year that are deposited in the landfill annually, which would give in monetary terms: if we consider the average mix of€125,42 per ton, a total of€ **75.289.626,00 euros per year**, being wasted from the public purse.

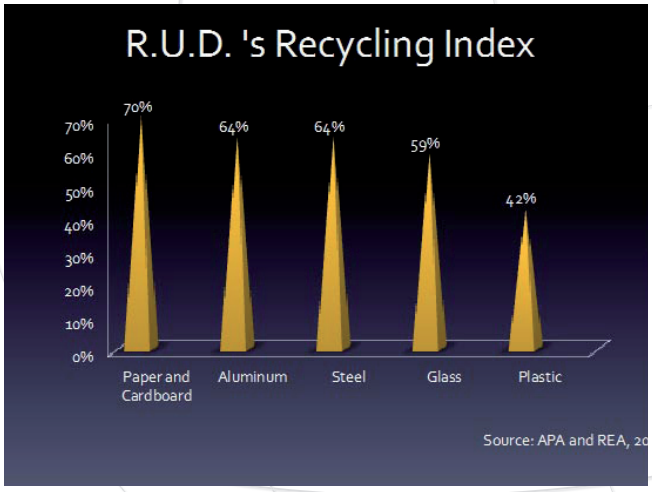
The biological mechanical treatment and mechanical treatment, which are also recycling processes, which through mechanical and technological actions are the type of urban waste in the family category (organic from the inorganic – damp of the dry), when added the two treatments have 36% of the total waste generated, i.e. 1.656.000 ton. Of this value we must take out the organic that represents 37%, or 612.720 tons and the rejects that represent 30%, which corresponds to 496.800 tons, thus giving a total of 1.109.520 tons, subtracting from the total of 1.656.000 tons generated by this process we have 546.480 tons, which multiply by the mix of €125,42 euros per ton, we will have:€ **68.539.521,60 euros per year.**

Organic valuation represents only 2% of all waste generated per year, which would give 92.000 tons of material potentially to be used in agriculture and other application. The cost of organic valuation is higher than its economic benefit, according to data from the APA it-

self, 2016, reaches 50% of loss per ton sold. Therefore, we will not use the economy of recycling organic waste, since they do not aggregate economic values, within the standards today established by the management of urban waste of Portugal.

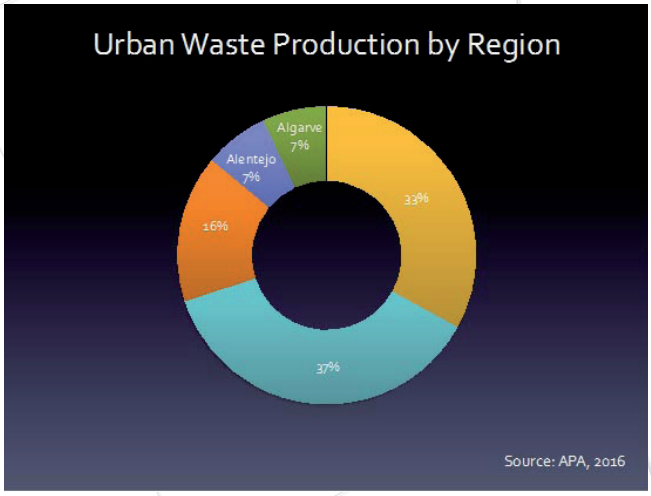
Regarding the indices/rates (Graph N 3) of recycling of solid urban waste, they have grown in recent years, but are still far from achieving the goal of the European Community (2020), which lays down for this year a recycling around 70%. The chart below brings the rates disclosed by the intermunicipal and multimunicipal companies linked to ecopoints, SVP and APA.

Public policies for urban waste generation could increase recycling rates through a greater incentive for selective collection and within the own management of the destination of waste seek to increase the valuation of materials, decreasing the burn for energy generation as well as reducing the undifferentiated collection and the destination of more than 29% of the municipal waste that will end up in the landfill.

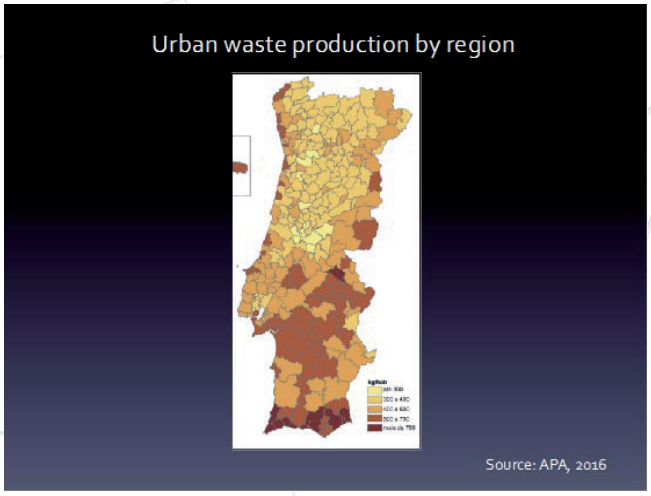


Graph nr. 3

The generation of urban waste by region draws attention, since despite the largest generation *per capita* of waste being in the south of the country, the largest generation by volume is in the North and center, with more than 50%, demonstrating that there is a larger demographic density in the north compared to the south. But when the look is economical, the *per capita* income is larger figure in the south of the country. This is reflected in the generation of urban waste *per capita* when in the south we have 1,7 kg/inhabit/day, or 650 kg/inhabitant/year, against 1,20 kg/inhabitant/day of the northern region, as chart below. It is important to emphasize that the municipalities coastal, has a generation of urban waste that reaches 20% more than municipalities with the same geographical and economic characteristics of the center of the country. In the number 5 graph this is best evidenced.



Graph nr. 4



Graph nr. 5

3- THE REVERSE LOGISTICS OF URBAN WASTE OF PORTUGAL-THE APPRECIATION OF THE PRODUCTION CHAIN

The interdisciplinary management of garbage involves an articulated set of regulatory, operational, financial and strategic planning actions that a State policy needs to develop in conjunction with civil society and partnerships with the private sector.

Garbage recycling presents itself as an econo-

mical and environmentally correct alternative, when, in addition to creating income and employment, it minimizes the environmental problems generated by garbage, and this is one of the aims of this article, to show that garbage recycling can be economically viable, and for this we will use as an object the urban garbage of Portugal.

The methodology used for analysis will be the model proposed by Thomas Duston, perfected by this author and applied in the green Software – economic viability of solid waste recycling, program created in 2004 by this author at Unicamp, IFCH, as work of completing a doctoral in Sociology. The economic measurement of the recycling process of the urban waste of Portugal can be decomposed in two results: the gain obtained and the loss with such process. (MAGERA, 2013). The calculations presented in this article used the generation of domestic municipal waste published by the Agência Portuguesa do Ambiente in the year 2017, whose value is 4.6 million tons of officially registered waste in the country.

So, we have the equation:
G= (V-V) – C +E +W+M+H+A+D
G= Gain with Recycling
V= Sale of Recycled Materials
-V= Purchase of Recycled Materials
-C= Cost of Recycling Process
E = Cost avoided with Collection, Transportation and Final Disposition
W = Gain arising from the Economy in Energy Consumption
M= Gain arising from the Raw material Economy
H = Gain arisingfrom the Economy of Water Resources
A= Gain with Environmental Control Economy
D= Other Economic Gains

The item (V) appears twice in the equation: one with positive value and another, negative, since for the sellers of the recycled products it represents a gain, therefore it is positive, but for the industries that buy the recycled material represents an expenditure or spent, and in this case, the V is negative; by overriding the values in the equation. The environmental gains and other economic gains will not be calculated in this work. The cost of the recycling process comes with the negative sign in the formula (-C) because it is an expense, an expenditure, which must obtain the economic gain with the recycling, so it will have to be subtracted from the result of the sum of the gains.

GAIN WITH ALUMINUM CAN RECYCLING
Data used for calculation:
a) Recycling rate 64%
b) Composition in the Waste 4% (whereas only 10% is aluminum)
c) Value of electricity € 55 Euros per MWh
d) Bauxite € EUR 48 per ton (5 tons for one aluminum required)
e) Weight of aluminum tin 15,6 grams
f) Electrical energy savings obtained in production by means of reuse of recycled can 16.900 KWH per ton

It is known that the participation of metal in the composition of the municipal waste of Portugal is 4%, being 90% of this value steel and 10% aluminum. Therefore, to calculate the total tons of aluminum we must calculate the total value in metal and then find the aluminum, so we have: 4.6 million x 4% = 184.000, of this total we must find 10%, which is equal to 18.400 tons. We must apply the aluminum recycling index that is equal to that of steel, 64%. So, we have, 18.400 x 64% = 11.776 tons that are recovered from the trash and 6.624 tons that are buried every year in landfills. Considering the weight of the can, it played annually 424.615.384 aluminumcans in the landfill.

The gain for this recycling is obtained by multiplying the electric energy economy in production, of 16.900 KWH per ton. Knowing the electricity tariff, € 55 Euros per MWh, the following result is: 16.900 kWh x 11.776 t/year x 55 euros per mwh = € **10.945.792,00 Euros per year**. To calculate the lost electricity with the non-recycling of aluminum can, just consider the difference of the index that is 6.624 ton. Replacing this value in the above formula, we have: 16.900 kWh x 6.624 t/year x 55 euros per MWh = € **6.157.000,00 Euros per year** is the value buried in landfills in Portugal.

The raw material used in the production of aluminum is bauxite, the composition of which represents 5 by 1 in the production of aluminum per ton, at a cost of € 48 euros/ton; we have: 11,776 x 5 x 48 euros/ton = € **2.826.240,00 Euros per year.** Value earned annually

by recycling aluminum can. The raw material lost by the non-recycling of the aluminum may be: 6,624 x 5 x 48 euros/ton = € **1.589.760,00 euros per year;** this value is buried in raw material – bauxite – in landfills in Portugal.

Electric energy saving obtained by recycling aluminum can	€ 10.945.792,00 euros per year
Lost power economy by non-recycling aluminum can	€ 6.157.000,00 euros per year
Raw material economics arising from aluminum can recycling	€ 2.826.240,00 euros per year
Lost raw material economy arising from non-recycling of aluminum can	€ 1.589.760,00 euros per year
Overall Total provided by the recycling economy of aluminum can	€ **13.772.032,00 euros per year**
Overall Total lost by non-recycling aluminum can	€ **7.746.760,00 euros per year**

Table N 1, drawn up by the author.

Gain with the recycling of steel can

Data used for calculation:

a) Recycling rate 64%
b) Composition in the waste 4% (whereas only 90% is steel)
c) Value of electricity € 55 Euros per MWh
d) Steel € 300 euros/ton
e) Electrical energy savings obtained in production by means of reuse of recycled can 5,06 MWH per ton
f) Water economy from recycled material use, 4 cubic meters per ton
g) Water price per cubic meter, € 2 euros

It is known that the participation of metal in the composition of the municipal waste of Portugal is 4%, being 90% of this value steel and 10% aluminum. Thus, to calculate the total tons of steel we must calculate the total value in metal and then find the steel; so, we have: 4.6 million x 4% = 184,000, of this total we must find 90%, which is equal to 165,600 tons. We must apply the recycling rate of steel that is 64%. So, we have, 165,600 x 64% = 105,984 tons that are recovered from the trash, and 59,616 tons that are buried every year in landfills.

The gain for this recycling is obtained by multiplying the electricity economy in the production of 5,06 MWH per ton. Knowing the electricity tariff, € 55 Euros per MWh, the following result is: 5,06 MWh x 10.984 t/year x 55 euros per MWh = € **29.495.347,00 Euros per year**. To calculate the lost electricity with the non -recycling of aluminum can, just consider the difference of the index that is 59.616 tons. Replacing this value in the above formula, we have: 5,06 MWh x 59.616 t/ year x 55 euros per MWh = € **16.591.132,00 Euros per year** are buried in the landfills in Portugal.

The raw material used in the production of steel is pig iron, which is quoted on the international market in € 300 euros per ton, so we have: 105.984 x 300 euros/ton = € **31.795.200.00 euros per year.**The raw material lost by the non-recycling of the steel can will be: 59.616 x 300 euros/ton = € **17.884.800,00 Euros per year** are buried at the price of raw material of pig iron in the landfills in Portugal.

The economy achieved by reducing water consumption will be 4 cubic meters per ton of reused material, so we will have: 105.984 tons x 4 m³ x 2 euros/ m³ = € **847.872,00 euros per year** in economics in Water. And the economy lost by the non-recycling of the material will be: 59.616 ton. X 4 m³ x 2 euros/m³ = € **476.928,00 euros per year** in water that will stop at the landfill.

Electric energy saving by recycling steel can	€ 29.495.347,00 euros per year
Lost economy of electric power by non-recycling of steel can	€ 16.591.132,00 euros per year
Economy of raw material arising from the recycling of steel can	€ 31.795.200,00 euros per year
Lost raw material economy arising from non-recycling of steel can	€ 17.884.800,00 euros per year
Economy in the consumption of water due to the recycling of steel can	€ 847.872,00 euros per year
Lost economy with water by non-recycling steel can	€ 476.928,00 euros per year
Overall Total provided by the economy of the recycling of steel can	**€ 62.138.419,00 euros per year**
Overall Total lost by non-recycling of steel can	**€ 34.952.860,00 euros per year**

Table Nr. 2, drawn up by the author.

Gain with the recycling of glass

Glass like aluminum can be recycled infinitely times without damaging its composition. Being wholly recyclable, there is no loss of material during the melting process, so for each ton of glass shard, a ton of new glass is obtained, and the compensation in the raw material is even greater, for each ton of shard saves 1.2 to virgin raw material (Calderoni, 1996). Portugal has six factories that produce approximately 16 million of glass packaging per day (AIVE, 2018).

Data that will be used for the calculation:

a) Recycling rate 59%

b) Participation of the glass in the trash 5%

c) Estimated annual quantity of glass for packaging 230.000 tons

d) Estimated annual quantity of recycling, considering the index of 59%, is: 135.700 tons

e) Estimated annual quantity that will stop at the landfill; 94.300 tons per year

f) Electrical energy savings from production with shards; 640 KWH per ton

g) Value of electricity € 55 Euros per MWh

h) Cost of manufacturing the Soda-lime glass (90% of all glass produced in the world, consisting of 58% sand, 19% barrel, 17% limestone and 6% feldspar), from the mixture of 40% recycled glass, estimated value in € 280 euros/ton.

The electric energy economy generated with the recycling of glass is possible considering an economy of 640 KWh per ton in the production of glass from reused glass shards. Considering the recycled amount of 135.700 ton/year, the value will be: 135.700 x 640 kWh x 55 euros MWh = € **4.776.640,00 euros a year.** The economy lost by non-recycling will be: 94.300 ton. X 640 kWh x 55 euros MWh = € **3.319.360,00 euros a year.**

In calculating the economy of raw materials with the recycling of glass, the formula will be the amount of tons/year recycled and multiply by the cost of manufacturing the Soda-lime glass, using 40% recycled glass, value already known in the production process that is of € 280 Euros per tons produced using shard in this proportion. So, we have: 135,700 ton. X 280 euros/ton. = € **37.996.000,00 euros a year.** The economy lost in raw materials by non-recycling will be: 94.300 ton. X 280 euros/ton. = € **26.404.000,00 euros a year.**

Electric energy savings obtained by recycling the glass	€ 4.776.640,00 euros per year
Lost power economy by non-recycling glass	€ 3.319.360,00 euros per year
Economy of raw material arising from the recycling of glass	€ 37.996.000,00 euros per year
Lost raw material economy arising from non-recycling of glass	€ 26.404.000,00 euros per year
Overall Total provided by the economy of glass recycling	€ **42.772.640,00 euros per year**
Overall Total lost by non-recycling of glass	€ **29.723.360,00 euros per year**

Table 3, drawn up by the author.

Gain with plastic recycling

The English Alexander Parkes, invented in 1862 the plastic (pulp-based organic material, which when heated could be molded), but its production intensified with the advent of the Second World War (1939), mainly replacing metals. Now produced not with cellulose, and yes, an artifact derived from petroleum and manufactured from resins (polymers). The plastic is a gas and, for its production are needed on average, 4% of the refined oil. In Western Europe the average consumption is 45 kg per capita year.

Data that will be used for the calculation:

a) Plastic recycling index **42**%
b) Plastics participation in the garbage 13%
c) Quantity consumed annually 598.000 ton
d) Recycled quantity annually 251.160 ton
e) Unrecycled quantity annually 346.840 ton
f) Electric energy savings per ton produced from recycled material 5.300 KWH per ton
g) Price of ton of plastic, using as base the thermoplastic resins that make up the product € 2.000,00 euros per ton
h) Value of electric power €55 euros per MWh

Plastic recycling enables an electric energy economy, from production with recycled material, of the order of 5300 KWH per ton, meaning almost 80% of electric energy savings, compared to production with virgin raw materials. If we consider that Portu-

gal recycles 251.160 ton per year, we will have the following electric energy savings per year in euros: 251.160 ton.X 5.300 kWh/ton. X 55 Euros MWh = € **73.213.140,00 Euros per year**. The economy lost in electricity by non-recycling will be: 346.840 ton. X 5.300 kWh x 55 euros MWh =€ **101.103.860,00 euros per year**.

The calculation of the raw material economy provided by recycling in Portugal is based on the price of thermoplastic resin on the international market, which is € 2.000,00 euros per ton (for each ton of plastic another resin is used). The raw material economy will therefore be the amount of recycled plastic multiplied by the price of the resin; 251.160 ton. X 2.000, 00/ton. = € **502.320.000,00 Euros per year.** The economy lost by non-recycling will be: 346.840 ton. X 2.000/ton. =€ **693.680.000,00 Euros per year**.

Electrical energy savings obtained by recycling plastic	€ 73.213.140,00 euros per year
Lost power economy by non-recycling plastic	€ 101.103.860,00 euros per year
Economics of raw material due to plastic recycling	€ 502.320.000,00 euros per year
Lost raw material economy arising from non-recycling plastic	€ 693.680.000,00 euros per year
Overall Total provided by the economy of plastic recycling	€ **575.533.140,00 euros per year**
Overall Total lost by non-recycling of plastic	€ **794.783.860,00 euros per year**

Table nr. 4, drawn up by the author.

Gain with paper and card recycling

In Portugal, the recycling of paper and paperboard is around 70%, the largest index among recyclables, considering their participation in the composition in the country's garbage that is 23%, we will have a total of 1.058.000 tons year of paper and paperboard, considering the total generation of 4.6 million tons generated annually by the country.

Data that will be used for the calculation:

a) Paper and card recycling index 70%
b) Paper and cardboard participation in the garbage 23%
c) Quantity consumed annually 1.058.000 tons
d) Recycled quantity annually 740.600 tons
e) Unrecycled quantity annually 317.400 tons
f) Electric energy savings per ton produced from recycled material 3.51 MWH per ton
g) Ton price of paper and cardboard raw material € 600 euros
h) Value of electric power € 55 Euros per MWh
i) Price of water per cubic meter, € 2 euros

The recycling of paper and cardboard provides a great economy of electric energy in production. With the recycling of 740.600 ton, we will have the following electric energy economy obtained: 740.600 ton. X 3,51 MWh/ton. X 55 euros/ton. = € **142.972.830,00 euros per year**. On the other hand, there is also a loss of energy savings, because of tons annually stopping in landfill sites. Thus, we have that the power economy lost by the non-recycling paper and paperboard corresponds to: 317.400 ton. X 3,51 MWh/ton. X 55 = € **61.274.070,00 euros per year**.

The calculation of the economy of raw materials by recycling the paper is obtained by multiplying € EUR 600 per ton which is the price of virgin raw material by the amount of recycled paper, so we will have:

740.600 ton. X 600 euros/ton. = € **444.360.000,00 euros per year**. The economy of raw materials that is lost by the non-recycling of this material that is played in the landfills will be: 317.400 ton. X 600 euros/ton. = € **190.440.000,00 euros per year**.

Another important component saved with the recycling of paper and cardboard is water, with every ton of recycled paper, are saved 29.202 liters of water or 29,20 cubic meters. Thus, to calculate the water economy provided by the recycling of paper and paperboard in Portugal we have: 740.600 ton. x 29,20 m3 x 2 euros/m3 =€ **43.251.040,00 euros per year**. Already the economy lost water for the non-recycling will be: 317,400 ton. x 29.20 m3 x 2 euros/m3 = € **18.536.160,00 euros a year.**

Electrical energy savings obtained by recycling paper and paperboard	€ 142.972.830,00 euros per year
Lost power economy by non-recycling paper and cardboard	€ 61.274.070,00 euros per year
Economics of raw material due to paper and paperboard recycling	€ 444.360.000,00 euros per year
Lost raw material economy arising from non-recycling of paper and paperboard	€ 190.440.000,00 euros per year
Economy in water consumption due to paper and paperboard recycling	€ 43.251.040,00 euros per year
Economia perdida com a água pela não reciclagem do papel e cartão	€ 18.536.160,00 euros per year
Overall Total provided by the economy of paper and paperboard recycling	€ **630.583.870,00 euros per year**
Overall Total lost by non-recycling of paper and card	€ **270.250.230,00 euros per year**

Table nr. 5, drawn up by the author.

4- ECONOMIC VIABILITY OF THE RECYCLING OF THE WASTE (INORGANIC) OF PORTUGAL- APPLICATION OF THE FORMULA

The cost of the recycling process (-C) that is part of the economic viability formula is € 189 euros per ton, representing the average value obtained by some of the companies providing services in the municipalities studied (a total of 36, ERSUC report, 2016). Whereas, for each ton of recycled materials, the costs occur in the same proportion of €189 euros per ton, which represents the selective collection and recycling of materials, is: Aluminum tin 11.776 ton. + Steel tin 105.984 ton. + Glass 135.700 ton. + Plastic 251.160 ton. + paper and cardboard 740.600 ton. = **1.245.220 tons per year** recycled from the five types of materials that composes domestic municipal waste from Portugal.

To reach the cost of the recycling process (-C) The total in tons is multiplied by the value/cost of the companies in the segment, which will be:

1.245.220 ton. 189 euros/ton. = € **235.346.580,00 euros per year.** The industries linked to urban waste management spend to recycle urban waste in the process of selective collection and destination for the recycling industries.

The expense of waste management companies with the final disposal of garbage in landfills is € 53,9 euros per ton, including the administration of the landfill and infrastructure. Then, the expense avoided by the practice of recycling (E) will be: 1.245.220 ton. X 53,9 euros/ton. = € **67.117.358,00 euros per year**, the country saves by performing the practice of selective collection.

The Electric Power Economy (W) provided by recycling aluminum can, steel tin, glass, plastic and paper/cardboard will be: € **261.403.749,00 euros per year**. The power economy lost by non-recycling will be: € **188.445.422,00 euros per year**.

The raw Material Economy (M) provided by recycling aluminum can, steel tin, glass, plastic and paper/paperboard will be:€**768.137.440,00 euros per year**. The lost economy in raw material for non-recycling will be:€ **583.158.560,00 euros a year.**

The water Economy (H) provided by recycling aluminum can, steel tin, glass, plastic and paper/cardboard will be: €**891.123.040,00 euros per year**. The lost water economy for non-recycling will be:€ **495.464.160,00 euros per year**. To obtain the result of the economic viability of recycling the waste in Portugal, the application of the formula is required:

Economy obtained annually with the recycling of urban waste

G= -C + E + W + M + H>**G = € 1.156.570.879,00 euros per year**

Where:

-C= € 235.346.580,00 euros (Cost of recycling process and selective collection)

E = € 67.117.358,00 euros (Cost avoided with selective collection and recycling)

W =€ 261.403.749,00 euros (gained from the electricity economy)

M =€ 1.019.297.440,00 euros (gained from raw material economics)

H =€ 44.098.912,00 euros (gained from the water economy)

Economy lost annually with non-recycling of part of urban waste that are directed to landfills

Whereas, for each ton of non-recycled material, costs occur in the same proportion of € EUR 189 per

ton, which represents the selective collection and recycling of the materials, which were intended for landfills, is: Aluminum tin 6.624 ton. + Steel tin 59.616 ton. + Glass 94.300 ton. + Plastic 346.840 ton. + paper and cardboard 317.400 ton. = **824.780 ton per year** not recycled from the five types of materials that composes domestic municipal waste from Portugal and which ended up in the landfill.

To reach the cost of the recycling process (-C) The total in tons is multiplied by the value/cost of the companies in the segment, which will be:

824.780 ton. 189 euros/ton. = € **155.883.420.00 euros per year.** The industries linked to urban waste management would spend to recycle the municipal waste that was destined for landfills.

The expense of waste management companies with the final disposal of garbage in landfills is € 53,9 euros per ton, including the administration of the landfill and infrastructure. Then, the expense avoided by the practice of recycling (E) will be: 824.780 ton. X 53,9 euros/ton. = € **44.455.642,00 euros per year**, the country saves the practice of selective collection in these tons of urban waste that went to the landfill.

The electric power economy lost by the non-recycling aluminum can, steel tin, glass, plastic and paper/cardboard will be:€ **188.445.422,00 euros per year**.

The lost economy in raw material by the non-recycling of aluminum can, steel tin, glass, plastic and paper/paperboard will be:€ **583.158.560,00 euros a year.**

The lost water economy by the non-recycling of the steel can and paper/cardboard will be:€ **495.464.160,00 euros per year**.

To obtain the result of the economic loss due to the non-recycling of part of the urban waste in Portugal, the application of the formula is required:

G= -C + E + W + M + H>**G = € 1.007.016.204,00 euros per year**

-C= € 155.883.420,00 euros (Cost of recycling process and selective collection)

E = € 44.455.642,00 euros (Cost avoided with selective collection and recycling)

W= € 188.445.422,00 euros (Electric Power)

M= € 929.998.560,00 euros (Raw material)

H= € 19.013.088,00 euros Water

Economy obtained annually by recycling garbage in Portugal€ 1.156.570.879,00 euros
Economy lost annually by non-recycling part of urban waste in Portugal € 1.007.016.204,00 euros
The possible economy to be achieved annually with the recycling of domestic waste in Portugal € 2.163.587.083,00 euros

Table nr. 6, drawn up by the author.

5- CONCLUSION

This article brings a contribution to the government, entities linked to the recycling segment of urban waste, as well as to environmental organizations that care about the environment and a sustainable economy, when it shows that the policies public management of urban waste in Portugal are preventing 1.245.220 tons per year from being played in landfills and have a better use, generating thousands of jobs and income. And the urban waste recycling figures have shown that the government has been investing to achieve its goals for the year 2020, although this investment is not focused on selective collection.

The government needs to improve the selective collection that still does not exceed 14%, against 86% of the undifferentiated collection. Selective collection adds greater value to the urban waste, providing a best quality in the sorted products, when in their homes the garbage generators are displaced by type and the ecopoints are more used. However, it is in the process of the undifferentiated collection that the use of the waste is greater, even if its destination is not environmentally correct.

Analyzing the use of urban waste, it is noted that 22% of the waste is being referred to the generation of energy, this gives more than 1.012.000 tons per year, generating dioxin and polluting the atmosphere, when they could through use of the selective collection generate €126.925.040,00 euros per year, or 18.000 new jobs of a minimum wage.

Even more unfeasible solution that incineration is the values of urban waste that are being laid down in landfills that correspond to 29%, or 1.334.000 tons per year. Portugal stops raising millions of euros in raw materials, water and electricity, and with this political positioning, pays annually, € 71.902.600,00 euros to the owners of sanitary landfills. Part of this material that today is playing in landfills, due to lack of infrastructure for recycling, could be better used for the generation of

electricity if there were more investments in incineration plants. Garbage in the landfill is more damaging to the environment than when it is incinerated.

The South region is the largest generator p*er capita* urban waste, as well as coastal cities, but it is the north and central region that concentrates the largest generation of urban waste, exceeding 50% of the country's total, this data is highlighted in the graphs of number 4 and 5. According to the publication of INE, the income is also greater in the southern region and in the coastal cities that has the contribution of tourists, whose power of consumption is greater. In 2017 Portugal received more than 20 million of tourists, being 8 million nationals, with an average of 3 sleeps to an expense of € 96 Euros *per capita* and a generation of urban waste of 1.5 pounds a day.

If we look at the selective collection process just from the market side of the selected products, the proceedings give loss, when the *mix* of the value of a selected ton has its value of € EUR 125,42, and the cost to reach this ton is € 189 euros, disregarding investment in infrastructure and return of capital, which would raise even more the financial loss, when it would reach € EUR 268 per ton tracked. (CRUZ, MARQUES, 2014). So, there are € EUR 63,58 per ton for balance, which leaves the action of dumping in the landfill the most advantageous waste, since the cost is € EUR 53,9 per ton (using the undifferentiated collection in the process). But this process cannot and should not be seen only by the market side, when we have millions of tons of raw materials being dumped in the trash annually and their values are not being accounted for. But when you apply reverse logistics, the real values of urban waste appear.

When using reverse logistics in the economic measurement of the urban waste of Portugal, applying the matrix of Duston, it is effectively found that the country is gaining macroeconomically with selective and undifferentiated collection, through recycling, € 1.156.570.879,00 euros annually, considering the economics of raw materials, electricity and water. But, Portugal is still dumping in the landfill annually about€ 1 billion euros in raw materials, energy and water. Values that could be better applied in public policies of urban waste management, generating employment and income for thousands of Portuguese, who today pay for the destination of their waste.

Recently the Government has authorized the entry of two more packaging waste management companies, the new green and AMB 3E – began current in the recycling market from 2017 – which can improve the repurchase values of recyclable products, making it more economically attractive to selective collection, since SPV maintained the monopoly of this segment.

Thus, it is expected that the government will look more closely at this sector, and that it seeks adequacy in the management of urban waste, investing more in the selective collection and thus increasing the appreciation of the materials that is currently at 14%, and also recognizing the gains economically, through the application of reverse logistics, which proves mathematically and economically, through official data that garbage gives positive results to the economy, without taking into consideration the great advancement in the framework of sustainability for a medium more balanced and fair environment for everyone!

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