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Economic Cost Recovery in the Recycling of Packaging Waste: The Case of Portugal

Abstract:

The recycling of packaging waste is an objective of the Community with clear targets set in the European law. The study of the institutional arrangements, recycling systems and of the costs that resulted from this environmental policy represents an ongoing effort. While each member state has currently its own packaging waste management system, there is still a lack of evidence regarding the actual costs of recycling and on how these costs have been distributed among stakeholders. This paper addresses the Portuguese framework and discusses the financial transfers undertaken by the entity that manages the Green Dot scheme. For this purpose, we use data from the entities in charge of selective collection and sorting of household packaging waste for the year 2010. We compare the financial transfers of the Green Dot company with the costs incurred by the local authorities (which are generally in charge of selective collection and sorting) and open a discussion on the extent to which the principles of the Directive on Packaging and Packaging Waste are being fulfilled in practice. Currently, the Green Dot company is only bearing 77% of the financial costs of the recycling systems in operation in Portugal. The unit cost of the selective collection and sorting of packaging waste is estimated to be 204 €/ton collected.

Keywords: green dot; packaging waste; Portugal; recycling.

1. INTRODUCTION

Experience shows that there are undeniable advantages in recycling some types of packaging waste (Lavee, 2007). Indeed, even before the Directive 94/62/EC on Packaging and Packaging

Waste (PPW) entered into force in 1994, significant quantities of packaging were already recycled in several member states (European Commission, 2006). In principle, the recycling of packaging waste should reduce the consumption of raw materials. Moreover, the resulting decrease in waste disposal is likely to increase the lifespan of sanitary landfills (Fullerton and Kinnaman, 1995). In addition to the potential financial savings with landfilling, reducing the quantity of waste to be disposed of in landfills or incinerated should reduce soil, water and air contamination (reduced emissions). By adopting a whole life-cycle approach, recycling can help the competent authorities to better manage natural resources (raw materials, territory, water and soil quality levels, etc.).

Recycling also generates additional financial costs either for the private (e.g. the industry) or public (e.g. waste management operators) sector stakeholders (Massarutto et al., 2011). These extra-costs are often translated into higher prices for goods or additional waste management tariffs or taxes. Moreover, recyclables and, more specifically, sorted packaging waste can have a rather low market value, sometimes even negative. This is particularly true when raw materials are inexpensive.[1] Among other aspects, the net economic sustainability of the recycling of packaging waste is therefore connected with the type of packaging material recycled. Recycling schemes are also highly prone to the "free-riding" problem (Yau, 2010). Free-riders, packers/fillers that do not pay the license fees to the entities in charge of managing the logistic chain of packaging waste recycling (e.g. Green Dot Agencies or similar structures), undermine the economic sustainability of recycling systems and create market distortions (Eichstadt and Kahlenborn, 2000). The logistics chain of recycling is usually quite complex. To set up an effective system requires high up-front costs (investments in new infrastructure for selective collection and sorting of packaging waste) and additional transport costs. Refuse collection can have direct links between drop-off containers and landfills, but the separated waste must be

[1] This is usually the case for glass, paper/cardboard, and plastics; the case of metal packaging might constitute the most notable exception.

transported to the sorting facility first, then to the storing or recycling facilities. Naturally, the whole process is not free of certain environmental impacts (Ettehadieh, 2011).

Taking these two conflicting aspects into account, one should also bear in mind that, recycling can be a source of technological innovation and job creation. Perhaps even more important, it might be a catalyst for making the industries internalize the environmental and social impacts associated with their activities. Ultimately, if one can find the optimal recycling rates[2] (for each type of material and considering the influence of other strategies such as incineration with energy recovery) it might be possible to achieve a lower overall economic cost (Highfill and Mcasey, 2001). However, these objectives might not be achieved if the imposed policy targets exceed the optimal recycling rates, undervaluing energy recovery or other alternative waste management strategies (Kinnaman, 2009). From the "public interest" point of view (i.e. what is best for society and well-being in general), to achieve an optimal solution within the European Union is also problematic due to the complexity and heterogeneity of the institutional arrangements/systems (Alwaeli, 2010).

According to the polluter-pays principle and the PPW Directive (Directive 94/62/EC on packaging and packaging waste) "those involved in the production, use, import and distribution of packaging and packaged products" must accept the responsibility for managing packaging waste (Bailey, 1999). Consumers and public authorities should cooperate with the economic operators (suppliers of packaging material, packaging producers and converters, fillers and users, importers, traders and distributors) in the implementation of measures to manage this waste in an environmentally sound manner, within a spirit of shared responsibility (Coggins, 2001). Nevertheless, at the heart of the PPW Directive lays the principle that the economic operators that introduce packaging to the market are fully responsible for the fate of this packaging. The concerned economic operators should enter into voluntary agreements with the

[2] Where the ratio of all benefits to all costs reaches its maximum.

competent authorities of each member state in order to fulfill the objectives and targets of the Directive (Bailey, 2002).

In this paper we examine the packaging waste management system of Portugal. After describing the various components of the system, we compare the costs incurred by the waste management operators with the financial support coming from the industry. In the analysis we include the cost savings that local/regional authorities attain by diverting waste from landfills and the return on capital that should have been provided by the construction of the new infrastructures and the acquisition of the equipment required for setting up the recycling system. Finally, this investigation opens a debate on whether or not the principles of the PPW Directive are being interpreted correctly by all stakeholders.

The remainder of this article is structured as follows: after the introduction, section 2 presents a brief overview of the life-cycle of packaging waste; in that section, we discuss the logistics chain of packaging waste, the specific impacts of the recycling system and the extended producer responsibility (EPR) principle. In section 3 we describe the Portuguese packaging waste management system while section 4 addresses the main financial transfers in detail. The data and methodology are presented in section 5 and section 6 comprises the results and discussion. Finally, section 7 concludes the article.

2. THE LIFE-CYCLE OF PACKAGING WASTE

In the life-cycle management of municipal waste, the "cradle" can be regarded as the moment that an item is perceived by a consumer as valueless and is discarded (Cleary, 2009). The usual "grave" of municipal waste occurs when it is turned into inert landfilled material.[3] However, for

[3] The percentage of waste that is simply transformed into air and water emissions (Özeler *et al*., 2006) should be minimal.

the specific case of packaging waste, one should bear in mind that it can have two distinct types of "graves": landfilling and recovery (its value is restored as energy – energy recovery, or a useable material – recycling). In the case of recovery, there is no actual "grave" since the materials are used for a different (and valuable) end.

Considering only the main material flows within the systems, figure 1 breaks down the possible paths of packaging waste (from "cradle to grave"). The post-consumption stages of the packaging life-cycle include collection, sorting, treatment and/or final disposal (Shmelev and Powell, 2006). Indeed, not all packaging waste enters into the recycling system. Even though some of the material placed in undifferentiated (or refuse) collection containers can be recovered (e.g. incinerated with energy recovery), most of it is landfilled. For systems with mechanical biological treatment (MBT) infrastructures, such as composting facilities, some of the packaging waste can be retrieved and reallocated to recycling (although, occasionally, the products of composting might be disposed of in landfills due to their low quality and/or market value).

[Insert figure 1]

Not all recycling systems are identical and several strategies can be adopted. Differences are associated with the form of collection, sorting, disassembly (if necessary) and recycling, the management models, the actors involved, the types of facilities available and the cost structure of each step of the life-cycle (Bohm *et al.*, 2010). Municipal waste management and, particularly, recycling systems have financial impacts (e.g. the costs of building and operating sorting facilities) and economic impacts (e.g. the savings attained by diverting waste from landfills). In truth, the valuation of environmental impacts (emissions affecting water and air ecosystems) should also be considered when performing cost-benefit analysis of recycling

programs (Shmelev and Powell, 2006). Cleary (2009) stresses the importance of defining the system boundaries and, by reviewing the relevant literature, he lists the following environmental impact categories as being the most common in life-cycle assessment (LCA) studies of waste management systems:

- Acidification potential;
- Global warming potential;
- Eutrophication of surface water;
- Resource consumption.

LCA has been considered as a useful tool to take into account all the "cradle to grave" impacts associated with a product or service (Barton et al., 1996). Currently, there is the notion that the LCA of a municipal waste system should include both an environmental and a financial life-cycle costing (LCC, Reich, 2005). Nevertheless, the environmental valuation techniques still include a high level of subjectivity. Also, the competent authorities strive just to have an accurate perception of the financial (extra) costs imposed on local waste management systems due to recycling. In this paper, we widen the scope of a strictly financial analysis, evaluating the impacts also from an economic viewpoint (see section 5).[4] While we perform a financial LCC of the packaging waste management system, we also take into account the indirect financial impacts resulting from the packaging waste diverted from landfills and the return on capital of the investments made on the recycling system.

Our study focuses on the segment of the life-cycle of packaging waste that goes from collection to the end of sorting (just before the items are sold to recyclers and reprocessed by them). We do this because our objective is to determine the added cost for the public sector entities and compare it with the financial transfers undertaken by the industry (i.e. the Green Dot company).

[4] Although in this paper we do not consider the positive and negative environmental effects of recycling and recovering packaging waste as in an environmental life-cycle costing (see Reich, 2005).

In other words, our approach consists of an assessment of the application of the EPR principle regarding the packaging waste sector. The EPR is "an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle" (OECD, 2001). Many authors have carried out work on this matter, often reaching diverging conclusions. For instance, Pearce and Turner (1992) suggest that EPR is might not be an efficient policy. They argue that many environmental effects have already been internalized, and EPR leads to "double taxation"; in their own words (Pearce and Turner, 1992, p. 12): "some of these costs, e.g. ambient air and water pollution costs, are already at least partially internalized by national and European Community environmental protection legislation. Thus there is the danger of a misspecification of targets and instruments in this packaging context, with the end result being the double counting of pollution damage costs (polluter pays twice)." Other authors have claimed that EPR is crucial for environmental sustainability (e.g. Hanisch, 2000).

3. INSTITUTIONAL FRAMEWORK

The PPW Directive was adopted in 1994 and had three main objectives (Bongaerts and Kemp, 2000): (1) reduce the impact of packaging and packaging waste on the environment; (2) harmonize national legislation on packaging and packaging waste in order to prevent barriers to trade and market distortions; (3) ensure the free movement of packaged goods. According to this Directive, by the end of 2001 the member states should at least have recovered 50% (with a maximum of 65%) and recycled 25% (with a maximum of 45%) of all packaging waste (see table 1). The minimum recycling rate for each type of material was 15%. In 2004 the Directive was amended (2004/12/EC) and the targets were updated. As shown in table 1, by the end of 2008, member states should have recovered a minimum of 60% by weight of packaging waste, where the recycling targets for each material were 60% by weight for glass, paper and board, 50% by weight for metals, 22.5% by weight for plastics and 15% by weight for wood (the

overall target for recycling was 55%, with a maximum of 80%). Greece, Ireland and Portugal were initially allowed to postpone the 2001 and 2008 targets (to 2005 and 2011, respectively) mainly due to the special physical constraints of these countries. In Portugal, the PPW Directive was transposed into the national law in 1997 and the new targets were laid down in 2006.

[Insert table 1]

The Portuguese Environment Agency (APA in the Portuguese acronym) has the responsibility of developing and monitoring the implementation of waste management strategies. APA issues licenses for all waste management operations and has operational and administrative control over waste transfers. Those responsible for introducing packaged products on the domestic market shall report annually to APA the statistics on the quantities of reusable and non-reusable packaging supplied, the quantities of packaging placed on the market that were effectively reused and recovered and also the quantities delivered to the entities responsible for recovery or disposal.

According to the national law, the responsibility for the management of packaging waste can be transferred by the industry to an entity duly licensed for this activity. The Sociedade Ponto Verde (SPV), a Green Dot company, is a private, non-profit organization with the aim of promoting separate collection, sorting, recovery and recycling of packaging waste in Portugal (encompassing packaging of fast-moving consumer goods and of industrial products). SPV is the main actor involved in the recycling of packaging waste. However, two other entities are responsible for specific packaging waste streams: Valorfito (agricultural packaging) and Valormed (pharmaceutical packaging); these types of packaging waste do not enter the municipal systems.

The responsibility of SPV regarding the collection and recovery of packaging waste is operationalized through contracts with municipalities or with multi-municipal or intermunicipal

systems that have been awarded the concession for the selective collection and sorting of waste, and with guarantors and/or recyclers of packaging materials.

Waste management activities can be categorized into "retail" and "wholesale" services, depending on the activities undertaken by the operators. In Portugal, the waste sector is clearly divided into these two segments (EIMPack, 2011a). The "retail" component covers the activities of refuse collection and transportation of household waste and is carried out primarily by municipal systems. The "wholesale" component encompasses the storing, transportation, sorting, treatment and disposal of urban waste. Massarutto (2006) uses the terms primary, secondary and tertiary market referring to "retail", "wholesale" and recycling services, respectively.

The Portuguese law states that municipalities are the competent authorities for the management of urban waste. However, local authorities often rely on multi-municipal companies for the delivery of "wholesale" waste services (in most cases, these entities are also in charge of selective collection, ERSAR, 2010). Multi-municipal companies consist of partnerships between a public company owned by the central state (Empresa Geral do Fomento – EGF) and the municipalities covered by the respective waste system. EGF owns 51% of the shares in these companies while the municipalities hold the remaining shares (minority participation). There are 12 multi-municipal concessionaries currently in operation. Alternatively, local governments can create intermunicipal companies (100% municipally-owned or resulting from institutionalized public-private partnerships) for the delivery of these services. There are eight intermunicipal companies delivering "wholesale" waste services in Portugal. Finally, there are four associations of municipalities (direct public management), two intermunicipal services (direct public management) and one private concessionaire operating in this segment. To refer to the waste management systems irrespectively of the actual institutional arrangement, we will use the term "municipal systems and local authorities" (SMAUT in the Portuguese acronym). Table 2 provides an overview of the current infrastructures for waste management in Portugal.

[Insert table 2]

In 1997 the Portuguese government created a sector-specific regulator for water and waste services. The Water and Waste Services Regulation Authority (ERSAR in the Portuguese acronym) is an uncommon watchdog as there is usually no external regulator in the waste sector throughout the world (Marques and Simões, 2008). ERSAR is the competent authority to ensure the structural regulation of the waste sector and to promote the comparison and public disclosure of the operators' performance through periodic reports (sunshine regulation via yardstick competition).[5] This entity has the mission to protect the users' interests and foster a good quality of service, always considering the economic sustainability of the utilities (Marques and Simões, 2009). Figure 2 provides a representation of the institutional framework described above.

[Insert figure 2]

In 10 years, the recovery rate of packaging waste in Portugal has increased significantly (from 34.8% in 1998 to 66.0% in 2009). As can be seen in table 3, the last figures on recycling and recovery of packaging waste in Portugal show that the overall targets of the PPW Directive (that should be attained by this country by the end of 2011) had already been achieved in 2009. In terms of each packaging material, glass is still below the specific recycling target (60%), although this deviation is expected to have disappeared by December 2011.

[5] Sunshine regulation is based on measuring and comparing the performance of the operators. Yardstick competition is the process of creating an environment of "virtual" competition through benchmarking.

Currently, there are no official figures regarding the amounts of household and non-household packaging waste generated in Portugal. However, using information from SPV (2010) on the quantities and the origin of the packaging waste recovered, we are able to provide estimates for the proportion of urban and non-urban packaging waste (see table 3).[6] Urban (or municipal) packaging waste includes materials coming from households and small businesses (see section 5 for more detail); this specific packaging waste stream comprises the 'household flow'. Packaging waste from other (non-urban) sources comprises the 'trade and industry flow'. In 2009, about 60% (1,031,564 tons) of all packaging waste was recycled, 6% (103156 tons) was incinerated with energy recovery, and 34% (584,553 tons) was landfilled.

[Insert table 3]

4. ANALYSIS OF THE FINANCIAL TRANSFERS

4.1 Green dot fee

In legal terms, packers or importers of packaged goods or products have two options: (1) develop their own system for taking back reusable packaging and non-reusable packaging – this system must be approved by the APA; (2) join the integrated system managed by SPV to take-back non-reusable packaging – SPV was first licensed by the Ministries of Economy and the Environment in 1997. Thus far, all packers/importers chose to join the SPV system.

The economic operators that join the integrated system transfer to SPV the responsibility for recycling and recovering the packaging they have produced and placed on the national market. These quantities are annually declared to SPV and reported to the APA. This transfer of

[6] We point out that, for all materials in table 3, the 'urban' quantities plus the 'non-urban' quantities equal the official figures reported by Eurostat.

responsibility is compensated through a Green Dot Fee (that may vary each year), corresponding to the unit values (per kg) of each type of packaging material (see table 4 for the 2010 values).

[Insert table 4]

Packers and importers calculate their annual contribution by multiplying the total weight of each type of packaging material placed on the market by the respective fee (SPV, 2010). The objective is that the financial transfers made by the industry to the SPV, plus the net take-back values (paid by guarantors/recyclers), match the costs that the waste management operators have with the selective collection and sorting of packaging waste (household flow and trade and industry flow) and any investments made by SPV (including costs with marketing and R&D).

4.2 Financial support for local authorities

The financial support for local authorities (FSLA) corresponds to the value paid by the SPV to the multi-municipal or intermunicipal systems managed by local (or regional) authorities for the selective collection and sorting of packaging waste that they carry out. As can be seen in table 5, this payment is calculated using the values that correspond to a certain *per capita* rate (of sorting of packaging waste); the financial support also depends on each type of material (see table 5). The model is based on the efficiency of the packaging waste management systems and their *per capita* potential (SPV, 2010).

[Insert table 5]

The FSLA model is implemented according to the scheme shown in figure 3. Until X1 the Green Dot agency pays P1 to the local authority, between X1 and X2 it pays P2, between X2 and X3 it pays P3 (and for the *per capita* values over X3, SPV pays P1). X1 represents the national average take-back carried out by the SMAUTs; X2 corresponds to the take-back *per capita* required to comply with the targets of the PPW Directive for 2011; X3 is the potential market for packaging (total packaging generated in Portugal–other than for industrial or similar use–divided by the population). This "stairway" payment scheme encourages municipalities and SMAUTs to maximize their commitment to separate collection and also allows for different levels of incentives regarding each type of packaging waste material. Once SPV pays the FSLA, the packaging waste becomes its property. Therefore, SPV can afterwards sell the sorted packaging materials to guarantors/recyclers.

[Insert figure 3]

4.3 Complementary report fee

The FSLA and the direct intervention of SPV concerning the final destination of packaging waste only encompasses the materials that come through the selective collection chain. Nonetheless, other packaging waste that is recovered or recycled through the "traditional" refuse collection chain (e.g. via composting or incineration) needs to be accounted for by the SPV. Hence, the Green Dot company pays a complementary report fee (CRF) to the entities in charge of the waste management systems. Table 6 presents the complementary report fee for 2010. This table contains the unit values that SPV pays to the SMAUTs, according to the type of recovery. Note that, for the incineration slag, the SMAUTs can opt for selling it directly to an

interested buyer (and they receive a value from SPV for the information), or for selling it to SPV (and they receive a value from SPV, according to the first two rows of table 6).

[Insert table 6]

4.4 Information and motivation fee

In a similar fashion to what happens with packaging waste not coming from selective collection, the SPV does not have a direct intervention regarding the circuit of non-household packaging waste (trade and industry flow). However, it collects information from the waste management systems on the trade and industrial packaging waste sent for recycling (SPV, 2010). The waste management operators (65 in 2009) report the amounts of all trade and industry materials collected and sent for recycling or recovery. For this reporting an information and motivation fee is paid per ton of packaging waste material, as it is shown in table 7.

[Insert table 7]

5. DATA AND METHODOLOGY

Our approach does not consider the "net take-back values" which correspond to the financial transfers between the SPV (who owns the packaging waste after paying the FSLA) and the guarantors/recyclers. One would have to account for these amounts (as benefits) if the objective was to compute the extra-cost of recycling from the industry point of view. Indeed, we only wish to assess the extra-cost incurred by local authorities due to the procedures, equipment and

infrastructure necessary for the recycling of packaging waste. Afterwards, we intend to compare this value with the revenues attained by local authorities for the same purpose.

An economic analysis regarding the degree to which the costs of recycling are being covered by the industry needs to take into account two components that are usually disregarded in a strictly financial analysis (Pires, 2011): (1) on the costs side, the return on capital employed (debt and equity) regarding the financing of the assets allocated to the recycling process (e.g. selective collection equipment and sorting infrastructures), even though, in Portugal (and in other countries, such as France, Le Bozec, 2008), the majority of the systems are managed by public entities; (2) on the benefits (revenues) side, the savings that derive from the diversion of waste from refuse collection and landfilling activities. Figure 4 shows the various components of the costs and benefits (direct and indirect revenues) of the recycling system in Portugal.[7] We should mention that, for a full estimation of the economic benefits and costs of recycling, one should consider the valuation of environmental externalities (e.g., reduced CO2 emissions). However, this is not done in the current paper. According to the PPW Directive, and if one perceives the EPR as being the main principle, it seems that the two first components of the benefits (FSLA plus the "other benefits attained from direct transactions with recyclers") should match all the (efficient) costs in figure 4.

[Insert figure 4]

To compute the average costs and benefits that local authorities have with recycling in Portugal, we have determined all the components shown in Figure 4 encompassing 27 entities for the year

[7] Note that the relative magnitudes of the various components of the bar charts are just illustrative and do not necessarily correspond to reality (e.g., the benefits could be less or more than the costs, as shown later in this paper).

2010 (the sample covers the whole Portuguese population, i.e., around 10.5 million). Our analysis concerns the management of the household flow which corresponds to around 60% of all the recovered material in Portugal (SPV, 2010). The trade and industry flow does not involve selective collection and sorting operations (the packaging waste is sorted at the source and collected by specialized waste management operators that receive the information and motivation fee). Hence, the analysis excludes the packaging waste generated by industrial and large commercial entities. Businesses that produce packaging waste that is similar in its nature and composition to that from households and whose production of packaging waste does not exceed 1100 liters/day are allowed to integrate the household flow (i.e. use the infrastructures provided by local authorities).

On the benefits side, the total FSLA was computed by multiplying the quantities of each material (declared by the entities in their annual reports) by the respective value (according to the scheme shown in table 5). The "other benefits attained from direct transactions with recyclers" were found in the companies' annual reports (among other sources, the revenue from selling non-packaging paper that is discarded in drop-off containers is accounted for in this component). The subsidies to the investments made on the equipment and infrastructure allocated to selective collection and sorting activities were also determined through the companies' reports; these subsidies are accounted for annually and adjusted in the same proportion as the depreciation of the subsidized assets. The cost saving which results from diverting waste from the refuse collection chain and landfilling was calculated separately and according to the following equations:

$$\text{Costs avoided with refuse collection}\ (€/\text{year}) = \text{Quantity of waste selectively collected}\ (\text{ton/year}) \times \text{Unit cost of refuse collection}\ (€/\text{ton}) \quad (1)$$

$$\text{Costs avoided with waste treatment}\ (€/\text{year}) = \text{Quantity of waste recovered}\ (\text{ton/year}) \times \text{Unit cost of treatment and disposal}\ (€/\text{ton}) \quad (2)$$

To estimate the unit costs of refuse collection a survey was sent to all municipalities. From the 308 Portuguese municipalities we obtained 196 answers, and the results pointed out to a unit cost of refuse collection of 49 €/ton (the unit costs were computed through a weighted average using the tons of refuse collected as weights). The unit cost of treatment and disposal was obtained through the annual reports for 2010, after the costs of recycling were removed, resulting in a value of 53.9 €/ton (weighted average). These unit values include operational and capital costs. To find out the efficiencies of the sorting of each material, a different survey was developed and sent to all 27 SMAUTs. We obtained the weighted (by the tons of selectively collected waste) values of 99% for glass, 93% for paper/cardboard and 63% for other materials. The quantity of packaging waste of each material collected through selective collection is equal to the quantity of packaging waste recovered, divided by the respective efficiency of sorting. The residues of the sorting process are usually sent to landfills, so this cost is not avoided for a small percentage of the packaging waste collected (note that for plastics this percentage is not irrelevant).

On the costs side, the operation costs of selective collection and sorting and the depreciation of the assets allocated to these activities were obtained from the survey results and from the annual accounts of the SMAUTs. The return on capital employed regarding the investments made on selective collection and sorting equipment and infrastructure was calculated through equations (3) and (4):[8]

$$\underset{\text{employed}}{\text{Return on capital}}\,(€/\text{year}) = \left[\text{Depreciation - subsidies}\right](€/\text{year}) \times \frac{\text{Useful life}}{\text{of the assets}}\,(\text{years}) \times \text{WACC}\,(\%/\text{year}) \quad (3)$$

$$\text{WACC}\,(\%) = \text{Cost of equity}\,(\%) \times \frac{\text{Equity}\,(\%)}{\left[1 - \text{corporate tax}\,(\%)\right]} + \text{Cost of debt}\,(\%) \times \text{Debt}\,(\%) \quad (4)$$

[8] WACC – Weighted Average Cost of Capital.

The values of useful life of the assets (9.6 years), percentage of equity in the capital structure (19.0%), corporate tax (20.3%) and the cost of debt (4.6%) were computed taking into account the survey and the annual reports of the SMAUTs. Note that we computed the useful life of the assets dividing the net assets by the net depreciation. All these constants correspond to average values weighted by the tons of selectively collected waste. The cost of equity (6%) includes both a non-risk component (of 3%) and a risk premium (of 3%) based on the German 10-year bond yields for 2010 (according to the Bundesbank). Taking into account these values, we obtained a WACC of 5.5%.

If one considers the revenue structure of SPV it is possible to develop a notion of the relevance of the sale of sorted material for the economic sustainability of the Portuguese recycling system. Indeed, one should bear in mind two aspects: (1) in Portugal, the Green Dot agency is a non-profit company (unlike what happens, for instance, in Germany, Bundeskartellamt, 2011); (2) in Portugal, once the Green Dot company pays the FSLA, it owns the sorted materials and has the responsibility/possibility of selling it to recyclers or guarantors (unlike what happens, for instance, in France, Eco-Emballages, 2011). Looking at the last four annual reports of SPV (2006-09), it is possible to ascertain that the net take-back values correspond to around 15% of the total financial transfers to local authorities.

6. THE EXTRA COST OF RECYCLING

After computing all the components of the revenues and costs shown in figure 4, we found that, on average, the SMAUTs benefit 369 € per ton of packaging waste that is sent for recycling (or 260 € per ton of waste selectively collected). Adopting a strictly financial perspective, the benefits amount to a total of 223 € per ton of packaging waste recycled or 157 € per ton collected. On the other hand, each ton of packaging waste forwarded to recycling costs the local

authorities an average of 289 €; if we compute this value for each ton of waste selectively collected, the cost is 204 €. All unit costs and benefits are weighted by the tons recovered by each SMAUT. These unit costs are shown in figure 5 using the tons of waste selectively collected and in figure 6 using the tons of packaging waste recycled. The differences are due to the efficiency of the sorting of each material and to the presence of non-packaging items in the drop-off containers.

As can easily be seen in figures 5 and 6, currently the cost coverage is around 127% considering an economic perspective but only 77% if the cost savings due to recycling are not taken into account. If one accepts that financial transfers should follow an economic approach (i.e. taking into account the savings derived from diverting packaging waste from landfill), the FSLA should be globally reduced by 42% ($\frac{204€ - 260€}{130€} \times 100 \approx -42\%$). On the other hand, if the policy was to make the industry 100% accountable for its packaging waste, exempting local authorities of any financial responsibility (such as in the German Dual System, MS2 and Perchards, 2009), the FSLA should increase by 37% ($\frac{205€ - (260€ - 103€)}{130€} \times 100 \approx 37\%$). This increase should even be higher if the (public) subsidies to the investments made on the assets allocated to selective collection and sorting activities are not considered on the benefits side (i.e. if one believes that no public money whatsoever should be financing what ought to be an exclusive responsibility of the industry).

[Insert figure 5]

[Insert figure 6]

To simplify the comparison with the costs of refuse collection and treatment, figure 7 provides the unit cost split between selective collection and sorting. In this figure the costs are presented in Euros per ton collected. As can easily be seen, sorting is around 72 €/ton (excluding return on capital, to be comparable with the unit costs obtained for managing mixed waste). Selective collection is around 117 €/ton (excluding return on capital).

[Insert figure 7]

These results are interesting mainly for three reasons:

(1) The discussion on whether the cost coverage should be strictly financial or consider an economic approach. If one was to consider the polluter-pays principle as the main issue in the recycling of packaging waste, it seems that the purely financial approach would apply. Furthermore, according to this principle, the industry should also pay for the fraction of packaging waste that gets landfilled (which currently does not happen). The only way to estimate the quantity of packaging waste that is currently landfilled is using the official information displayed in table 3. According to the latest available data, around 600,000 tons of packaging waste are landfilled with no costs for the industry $((1{,}061{,}635 + 657{,}639) \times (1 - 0.66) = 584{,}553\,\text{ton})$.[9]

However, this approach would face several difficulties. On the one hand, it would be very difficult to set a framework of incentives if local authorities would get paid irrespectively of what was the packaging waste final destination (although payments could differ between recycling and landfilling). Currently, it is already difficult to account for the actual cost-efficiency of the SMAUTs. A solution for this problem would be a dual

[9] We have already mentioned the quantity of packaging waste that was incinerated in 2009 $((1{,}061{,}635 + 657{,}639) \times (0.66 - 0.61) = 103{,}156\,\text{ton})$. Thus, the cost of treating this quantity of packaging waste should be approximately equal to $60{,}000{,}000€$ $((584{,}553 + 103{,}156) \times 102.9)$. One should note, however, that the SPV pays the CRF fee to the local authorities that recover packaging waste through composting or incineration.

system in line with the German model for managing packaging waste (e.g. see EIMPack, 2011b). However, in Portugal, local authorities own the infrastructure and the national law states that municipalities are the competent authorities regarding urban waste management. Hence, implementing a German-like system, where public authorities merely manage the "undifferentiated collection flow" while the industry is solely responsible for managing the "selective collection flow" (using their own infrastructures), seems unlikely in practice.[10]

(2) The possibility of performing cross-national comparisons regarding the costs and benefits of recycling packaging waste (from the waste management operators' perspective). Finding international benchmarks is crucial to assess the impacts of the PPW Directive in each member state. In fact, efforts could be made in order to harmonize these values. Furthermore, since waste management operators are monopolists in their territorial area, incentives for cost-efficiency could take into account these benchmarks (e.g. publicizing the graph in figure 7 for each operator could potentially be an effective whilst low-cost procedure to improve overall performance).

(3) The substantial difference between the unit costs of the undifferentiated collection and selective collection flows. The costs of refuse collection and waste treatment (e.g. landfilling and composting) are estimated to be around 102.9€ per ton of waste collected (note that this value includes depreciation but not the return on capital). Selective collection and sorting seems to be significantly more costly. In fact, if we compute the unit cost of selective collection and sorting per tons collected (which includes non-packaging items and waste that will be allocated to landfills during sorting) not taking

[10] Moreover, in Germany, the packaging waste recycling market was opened to competition and there are now nine private entities responsible for ensuring the recovery of packaging waste. Packaging waste is collected, treated and disposed under the direct intervention of these dual system companies (see EIMPack 2011b). The Duales System Deutschland GmbH (DSD) was the first of these companies; it was also the precursor of the Green Dot system, later adopted throughout the EU. Initially, DSD was a non-profit company such as SPV (Portugal) or Eco-Emballages (France).

into account the return on capital, the value for the "recycling flow" is considerably higher (around 189€ per ton of waste selectively collected). Although there might be some technical justifications for these differences, one cannot easily determine if this phenomenon is, at least partially, being driven by an attempt of the local authorities to allocate waste management costs towards the packaging industry. Moreover, it remains undetermined to what extent these costs are due to inefficiency. Currently, the SMAUTs do not have an accounting system that allows them to clearly report the costs for separate collection and sorting (i.e. disentangle them from the mixed waste management costs). It falls beyond the scope of this paper to address this issue in detail; nevertheless, our analysis shows that it is important to accomplish this in the near future.

Finally, regarding the total cost of managing household packaging waste in Portugal (the one which enters the separate collection flow), it should be approximately 85,000,000 €. This value was taken directly from the SMAUTs annual reports. The total cost of urban waste management in this country is approximately 630,000,000 €. This cost was obtained by adding up the costs incurred by the municipalities with refuse collection to the costs of the SMAUTs with the treatment of mixed waste. The cost of the collection and sorting of household packaging waste should therefore be around 13% of the total costs undertaken by local authorities with urban waste management: this corresponds to 0.05% of Portugal's GDP (total urban waste costs have a weight of 0.37% in the GDP).

7. CONCLUDING REMARKS

This study presents the costs and benefits of packaging waste recycling in Portugal and includes two components that can be left out of strictly financial assessments: the return on capital employed (debt and equity) regarding the financing of the assets allocated to the recycling process and the cost saving which results from diverting waste from the refuse collection and landfilling activities.

In addition to contributing with information regarding the unit (per ton) costs and benefits of selective collection and sorting of packaging waste (which are still unusual facts in the literature, EIMPack, 2011b) this paper opens a debate on whether or not the costs of the recycling system should be entirely borne by the economic operators (e.g. packers and importers). In Portugal, the costs of refuse collection and waste treatment (other than recycling) are not negligible (49.0€ and 53.9€ per ton collected, respectively) and in countries with more limited land resources these costs can even be higher. Hence, the question of whether these savings should be accounted for as a benefit of recycling is quite pertinent. On the other hand, comparing the costs of refuse collection and treatment (102.9€ per ton collected) with the costs of selective collection and sorting (268€ per ton of packaging recovered, or around 189€ per ton collected – excluding return on capital employed for both figures) leave us with a daring question: is it possible that local authorities are inflating their "recycling costs" because they are expecting retribution from the industry?

We believe that the return on capital employed on the assets allocated to selective collection and sorting of packaging waste should be accounted for even if waste management operators are public entities. Public money is increasingly regarded as yet another scarce resource and thus it should be managed with concerns for economic sustainability. Choosing between a financial or an economic approach is ultimately a policy decision. Currently, the principle of shared responsibility seems to be embedded in the Portuguese recycling framework. However, the main principle of the PPW Directive is that the industry should bear 100% of the costs of managing packaging waste (the EPR principle). The Green Dot Agency is only bearing 77% of the financial costs of the recycling systems in operation in Portugal. This figure would be even lower if one did not take into account the public subsidies for investments in selective collection and sorting infrastructures, which were accounted for as benefits of the waste management operators in the current study.

Although there are some similarities with the French model (Eco-Emballages, 2011), the Portuguese system for managing packaging waste is slightly different. In Portugal, the packaging waste belongs to the Green Dot agency once it pays the FSLA (this transfer includes the market value of recyclables implicitly). This way, local authorities are "protected" from fluctuations on the secondary raw material market. Nevertheless, the current system could be improved mainly in three areas: (1) providing incentives for cost efficiency to the SMAUTs; (2) developing a mandatory accounting system for the SMAUTs that allows them to report the costs of managing mixed waste and packaging waste separately (these costs should be disaggregated and easily audited); (3) ensuring that the industry pays for 100% of the efficient extra-costs of the SMAUTs due to the recycling system.[11]

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[11] That is to say that the industry does not have the duty of financing the possible cost-inefficiency of local authorities. For instance, SPV could cover the efficient benchmark costs of the selective collection and treatment services carried out by waste management operators.

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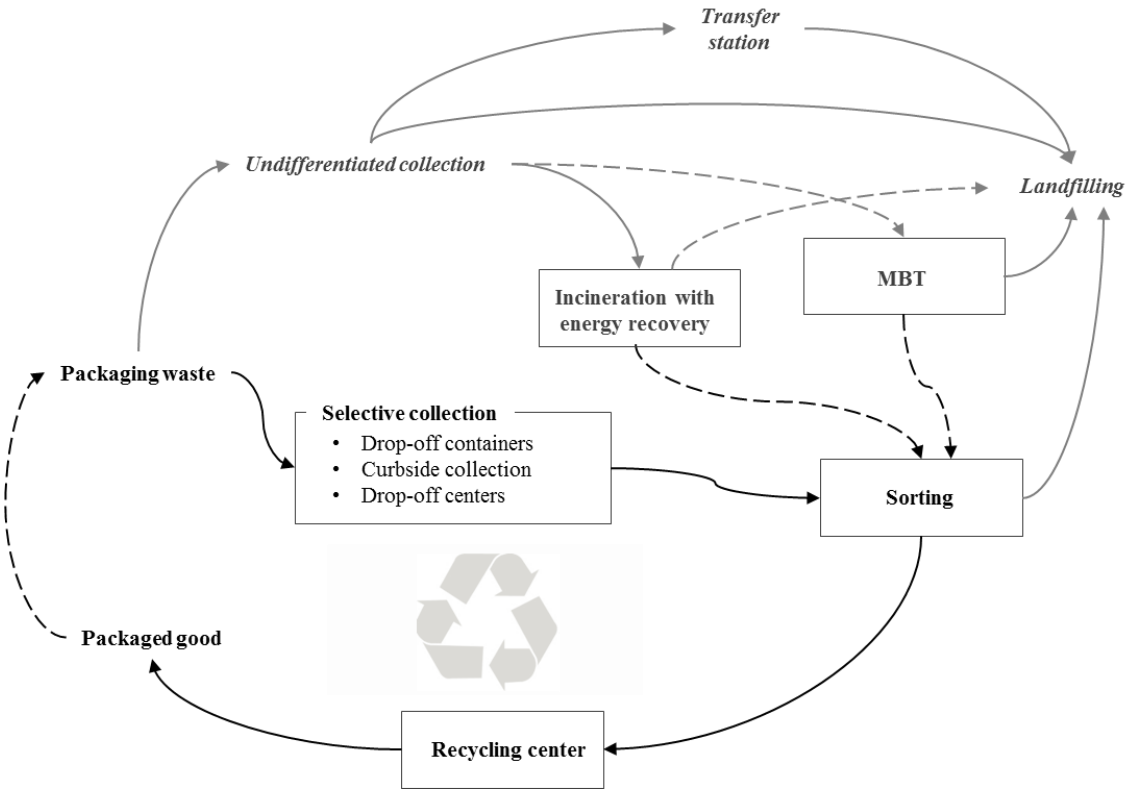

Figure 1 – The life-cycle of packaging waste: material flows (simplified)

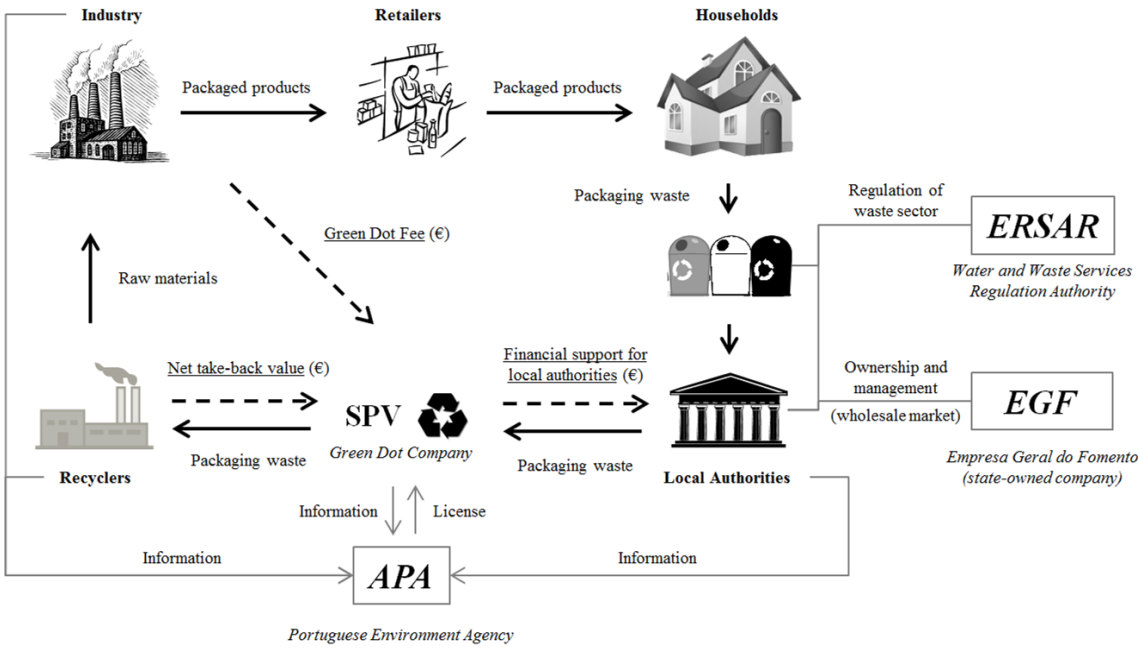

Figure 2 – Scheme of the Portuguese recycling sector (household flow)

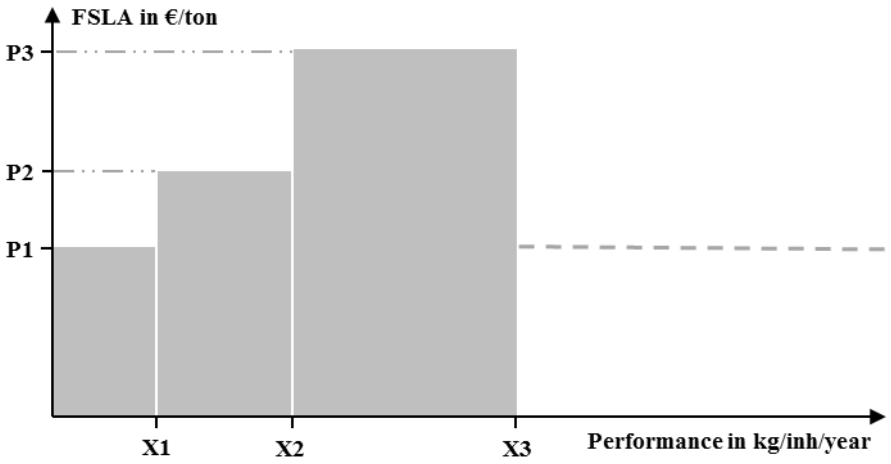

Figure 3 – Model for the application of the FSLA

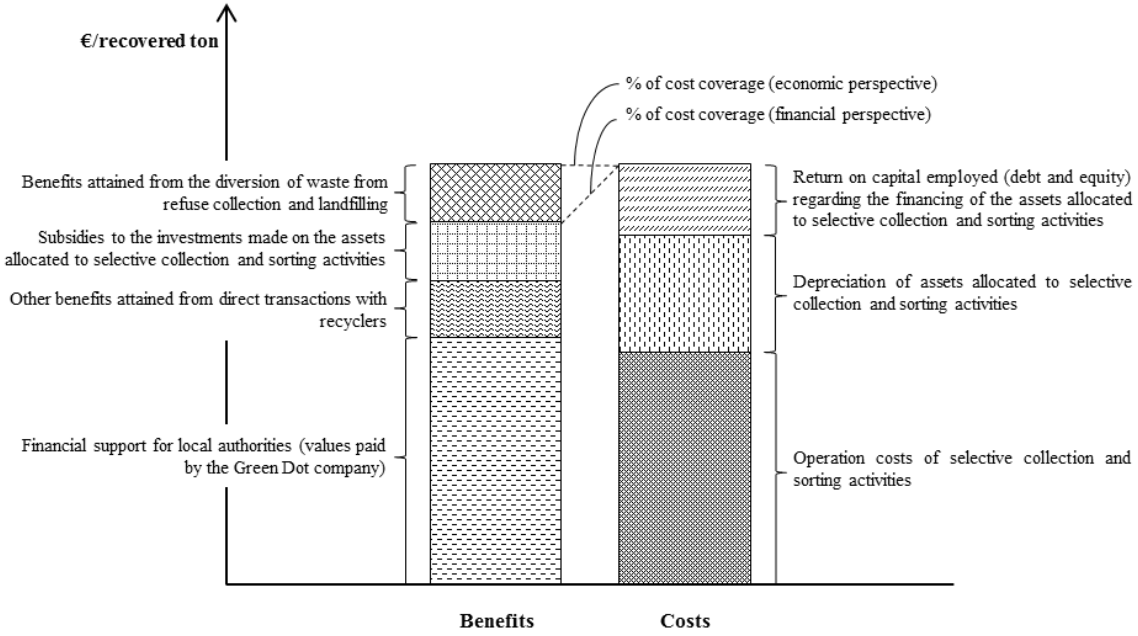

Figure 4 – Benefits (direct and indirect revenues) and costs of recycling of packaging waste in Portugal

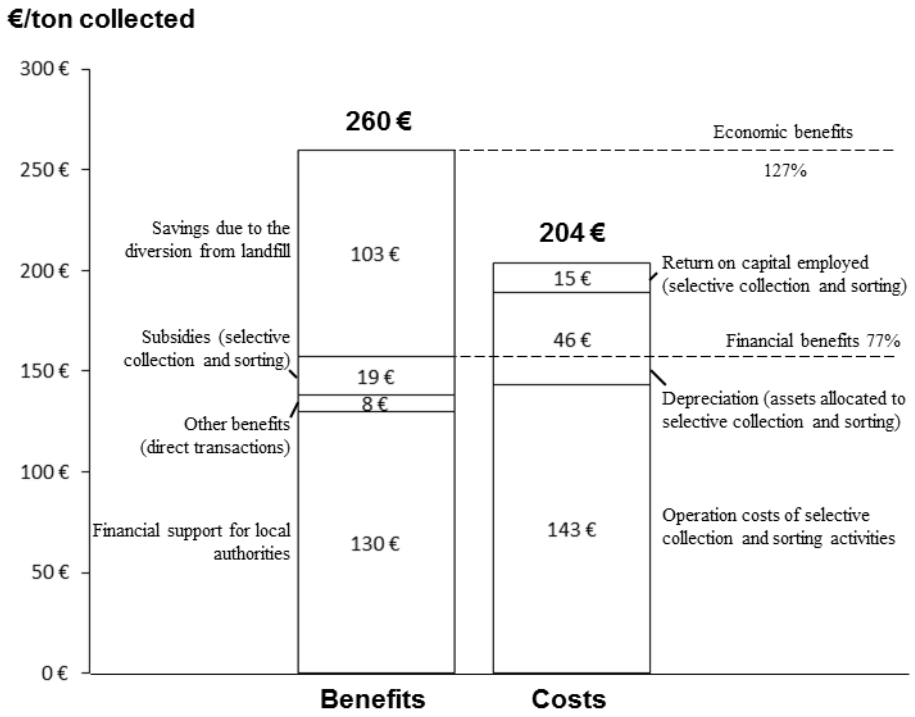

Figure 5 – Cost coverage considering aggregated tons (values in Euros per ton selectively collected)

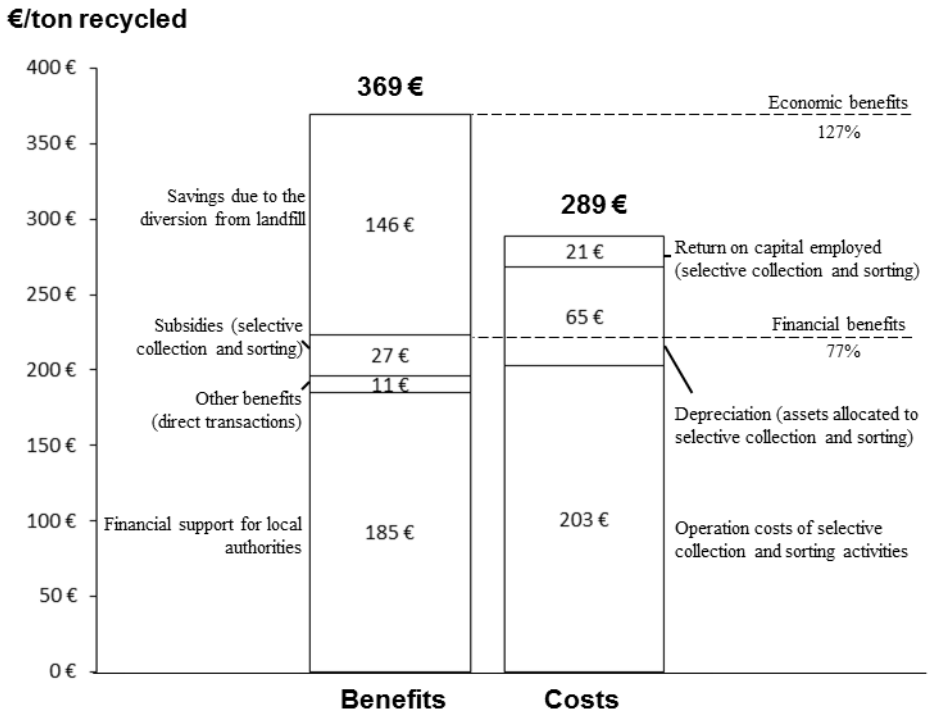

Figure 6 – Cost coverage considering aggregated tons (values in Euros per ton recycled)

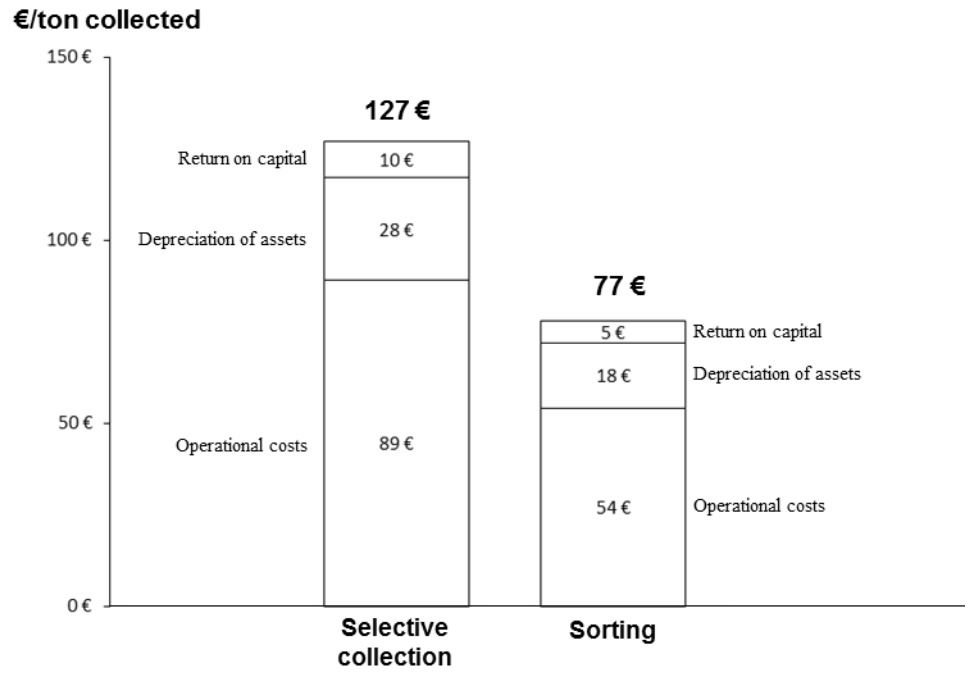

Figure 7 – Unit cost of selective collection and sorting per tons collected

Table 1 – Recycling and recovery targets (by weight of packaging waste) for EU member states

Directive	**Deadline**	**Recovery targets**	**Recycling targets**					
			Overall	Glass	Paper / Cardboard	Metals	Plastic	Wood
94/62/CE	31/12/2001	50%	25%	15%	15%	15%	15%	(–)
2004/12/CE	31/12/2008	60%	55%	60%	60%	50%	22,5%	15%

Table 2 – Infrastructure for urban waste management (SPV, 2010)

Infrastructure	**no.**
Landfills	41
Incinerators	3
Composting facilities	14
Transfer stations	91
Sorting stations	337
Drop-off centers	204
Drop-off containers	40,278

Table 3 – Recycling and recovery in Portugal in 2009 (Source: Eurostat)

Material	**Packaging waste generated (ton)**		**Recycling[a] (ton)**		**Recovery[b] (ton)**		**Overall recycling rate (%)**	**Overall recovery rate (%)**
	urban	**non-urban**	**urban**	**non-urban**	**urban**	**non-urban**		
Glass	418,259	1,858	231,435	1,082	231,435	1,082	55	55
Plastic	302,834	75,234	69,089	27,245	98,148	38,703	25	36
Paper and board	271,645	439,050	206,441	358,776	226,632	393,867	80	87
Metals	55,539	44,561	28,362	36,121	28,362	36,121	64	64
Wood	13,357	96,937	8,643	63,357	9,312	68,259	65	70
Total	1,061,635	657,639	608,111	422,440	667,928	463,993	60	66

[a] Recycling includes material recycling and other forms of recycling like composting;
[b] Recovery includes total recycling and incineration with energy recovery

Table 4 – Green dot fee for 2010

Packaging of fast moving consumer goods	**Primary (€/kg)**	**Secondary (€/kg)**	**Tertiary (€/kg)**
Glass	0.0183	–	–
Plastic	0.2282	0.0923	0.0238
Paper and cardboard	0.0836	0.0352	0.0070
Composite packaging	0.1294	–	–
Steel	0.0960	0.0417	0.0244
Aluminum	0.1644	–	–
Wood	0.0154	0.0142	0.0091
Other materials	0.2600	0.2600	0.2600
Packaging of industrial products	**Primary (€/kg)**	**Secondary (€/kg)**	**Tertiary (€/kg)**
Glass	0.0135	–	–
Plastic	0.0238	0.0238	0.0238
Paper and cardboard	0.0070	0.0070	0.0070
Steel	0.0244	0.0244	0.0244
Aluminum	0.0494	–	–
Wood	0.0091	0.0091	0.0091
Other materials	0.0550	0.0550	0.0550
Packaging of dangerous industrial products	**Primary (€/kg)**	**Secondary (€/kg)**	**Tertiary (€/kg)**
Glass	0.0135	–	–
Plastic	0.0238	0.0238	0.0238
Paper and cardboard	0.0070	0.0070	0.0070
Steel	0.0244	0.0244	0.0244
Aluminum	0.0494	–	–
Wood	–	–	0.0091
Shopping bags			
Plastic		0.2282	
Paper and cardboard		0.0863	

Note: the VAT at the current legal rate should be added to these amounts

Table 5 – FSLA for the period 2008-2010 (Source: Order No. 10287/2009)

Material	**X1**	**X2**	**X3**	**P1**	**P2**	**P3**
		kg/inh/year			**€/ton**	
Glass	14.30	24.50	40.80	35.00	48.00	60.00
Plastic	2.10	3.60	15.30	770.00	823.00	876.00
Paper and board	8.00	10.0	15.00	135.00	151.00	166.00
Steel	0.40	0.70	4.10	600.00	644.00	688.00
Aluminum	0.02	0.04	0.86	766.00	1.016.00	1.283.00
Composite packaging	0.30	1.80	3.00	770.00	823.00	876.00
Mixed plastics	–	–	–	245.00	245.00	245.00
Wood	–	–	–	15.87	15.87	15.87

Table 6 – Complementary report fee (2011)

Incineration slag (requested take-back)	
Steel	85.00 €/ton
Aluminium	575.00 €/ton
Incineration slag (direct transaction by collection operator)	
Steel	15.00 €/ton
Aluminium	35.00 €/ton
Composting (direct transaction by collection operator)	
Glass	5.00 €/ton
Cardboard	5.00 €/ton
Film	275.00 €/ton
HDPE	275.00 €/ton
PET	180.00 €/ton
Steel	15.00 €/ton
Aluminium	35.00 €/ton

Table 7 – Information and motivation fee

Material	
Glass	5.00 €/ton
Paper/cardboard	5.00 €/ton
Plastic	15.00 €/ton
Steel	15.00 €/ton
Alumnium	35.00 €/ton
Wood	5.00 €/ton