

## **ECO-EFFICIENT RECYCLING OF ELECTRICAL AND ELECTRONIC WASTE: ANALYSIS OF THE ROMANIAN COMPANIES**

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### **ABSTRACT**

*Waste management and WEEE are two concepts more and more important in the economical and social environment these days. These two concepts are related with the natural environment, the economy, the commercial activity and also with the energy and raw materials area. Romania, in its efforts of harmonization with the European frame, both as legislation as well as economic and social practices, makes clear and concrete efforts in this way.*

*This paper will achieve a clear image of this approaches made in Romania in this way, both in terms of quantity, based on information provided by Eurostat, and also from an operative and legal standpoint, based on the legislation in this field. Also we will analyze the trend of some activities regarding WEEE in Romania and we will calculate the interdependence of statistical data.*

**KEYWORDS:** *waste management, waste electrical and electronic equipment, (weee) eco-management, weee recycling, security.*

**JEL CLASSIFICATION:** M190

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### **1. INTRODUCTION - WASTE MANAGEMENT AND WEEE**

This paper will present the topic of WEEE management in Romania and internationally, trying to present some general and theoretical ideas, to indicate some specific aspects of this activity, internationally and in Romania, and also the trends of this activity.

For the working methodology some statistical data provided by Eurostat will be used, both for following their evolution as well as for estimating the trends (forecast) and analyzing the correlations between them.

#### **1.1 Why waste management**

The importance of Waste and Waste Management concept occurs since 1750, when in London we can find first waste treatment plants. Although very old, in the last decades the waste concept has a growing importance because of the society development, both in terms of quantity and in terms of technology, as well as in terms of the raw materials used in production.

Waste impact is visible on three axes, which are ecology, economy and society.

As a result of the increase of waste in society and economy, the waste management term and activity appears. This term, besides the complexity regarding the diversity of activities, also involves the complexity regarding the waste types. This way, for example, we can identify the electrical and electronic equipment category, that leads us to another term and notion, the WEEE term.

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## 1.2 Why WEEE

Starting from the Waste Management concept, WEEE is a particular case thereof, focused on a very clear and well defined group of products and substances. Its importance lies on the raw materials used for the EEE products, with an important ecological impact and also an important natural resources impact.

The WEEE concept is based on the European Community Directive 2002/96/EC and RoHS Directive 2002/95/EC. Based on these two Directives we have a group of products that, taken all together, materialize this concept. The categories of products underlying WEEE are: large household appliances, small household appliances, IT and telecommunications equipment, consumer equipment, lighting equipment, electrical and electronic tools, toys and sports equipment, medical devices, monitoring and control instruments, automatic dispensers, etc.

Practically, WEEE represents the waste of the electric and electronic equipments. Any device that is running plugged in an outlet or is running with a battery becomes the responsibility of its producer for the natural environment.

The importance of this concept grew in parallel with the penetration rate of the electronic components in more and more products (Goodship, 2012). This way, more and more equipments used in domestic life and also in the business and industrial environment have electric and electronic components, components that made the transit from their manual use to automatic use.

An example of awareness and also of presence of EEE in our life, on international plan, are the multinational companies focused on IT&C industry, which promote a responsible use of electric and electronic products. An example in this case is Orange, a company that assigns a distinct information space for its client regarding WEEE in his communication strategy.

Generally speaking, WEEE concept is a part of what we call eco-efficiency, concept that is a part of what we also call Sustainable Development (Olaru, 2012). In our days these notions are not and should not be ignored neither by the economic nor the social environment, because of their impact over the life quality.

## 1.3 Legislative framework and organizations

The two laws governing WEEE at European level are Waste Electrical and Electronic Equipment Directive (WEEE Directive) 2002/96/EC and Restriction of Hazardous Substances Directive (RoHS Directive) 2002/95/EC. These two laws define the legal framework for all activities regarding WEEE. WEEE Directive is focused on the general framework and RoHS Directive is focused on special products and raw materials, like mercury, lead, etc.

From an organizational standpoint, at European level, WEEE Forum is the most important organization that includes at this moment 39 local producer organizations from 22 countries, producers which feel responsible for the ecological implications of their activities (Goodship, 2012). Established in 2002, this non-profit organization represents the informational and know-how base upon which we build the collecting and recycling of EEE in Europe (in 2012 their members report collecting more than 2 millions tones of WEEE).

One of the most important projects managed by WEEE Forum is WEELABEX. Started in 2009, the project culminated in 2013 with the establishment of WEEELABEX Organization. This project had and still has two main directions. The purpose of the first direction is setting a bunch of standards regarding collecting, sorting, storage, transportation, preparation for reuse, treatment and processing WEEE (the three standards made by WEEELABEX refer to logistic, treatment and processing). The second direction is about a monitoring program of the member companies by audit processes (also called conformity check), auditors and operators being the involved parts.

Besides these standards, WEEE Forum has important contributions in special standards, for example in standards that refer to refrigeration.

Standards developed by WEEELABEX reach three important topics, which are administrative requirements, organizational requirements and technical requirements for collecting, treating and

logistic of WEEE. A special case is the treatment standard, that, besides the three subjects, also has a series of attachments about pollution, monitoring of remediation activities, requirements about the lots, determining of recycling and recovery rates (with concrete targets) and special requirements on some products. Specifically, this standard takes into consideration and refers to substances like mercury, asbestos, lead, etc., harmful substances that must be treated with special precaution (direct link to RoHS Directive 2002/95/EC).

In his attempt of being a center of excellence of what means WEEE, WEEE Forum developed his own reporting system, called WF-Rep Tool, which allows members to report periodical and unified their results by targets and criteria of interest defined by WEEE Forum.

The legal framework and the standards framework affect the whole parts that interact with EEE and WEEE. Here we can talk about producers, distributors, local authorities, collectors, treating plants, etc.

## **2. KNOWLEDGE STAGE IN WEEE**

We can not talk about knowledge stage in WEEE without mentioning a few facts about the knowledge stage in Sustainable Development. Why? Because WEEE, as we previously mentioned, is an intrinsic part of what we call Sustainable Development and eco-efficiency. This topic is launched since the 90s, and the time pass just proved it's perpetuate importance and actuality. Doctrine abounds in works about sustainable development and growth, an example being Moffatt, which published in 1996 Sustainable development: principles, analysis and policies, book which draws the big picture of this activity. In Romania we can mention the study made by Ciupagea in 2006 and called Strategic directions of Sustainable Development in Romania. Ciupagea approaches the subjects from many points of view, but also from a practical perspective, talking about the environment policy, energetic policy, economical and infrastructure policy, etc. Another example can be the study published by Olaru, Radu and Banacu regarding the link between eco efficiency and environment performance, study that focuses on the indicators for this activity.

Going back directly to WEEE, the academic environment also provided some papers on this subject. One of them and with a very large information load is The WEEE management system in Romania Dimension, Strengths and Weaknesses published by Ciocoiu, Burcea and Tartiu in Theoretical and Empirical Researches in Urban Management in 2010. The study approaches the framework and also particularities from Romania, from a statistical and operational approach, mentioning strengths and weakness of the Romanian WEEE industry. With a more practical approach, we can talk about the study entitled Performance of WEEE management system in Romania published by Ciocoiu, Hincu, Dobra and Colesca in 2011 about the efficiency of WEEE management system, efficiency in terms of a qualitative and quantitative perspective. In this study we have some conclusions about the performance of WEEE management in Romania, that are also found in this paper.

About the national knowledge stage we can mention some studies, each of them focused on a specific subject. Ivanus and Babaita published in 2008 Management Of The Electronic And Electric Equipment Waste In Romania, study that outlines the general WEEE activity in Romania, Tartiu published in 2009 The Management of Waste from Electrical and Electronic Equipment (WEEE) in the European Union, paper focused on WEEE activity in European Union, and last but not the least the study made by Pipas, Pica, Mihoc and Bejan, which published in 2013 an interdisciplinary approach under the title Management And Recycling of Electronic Waste, paper which looks over this activity from a technical standpoint and also from an economic and commercial perspective, considering the life cycle of the products.

However, the international approach is wider. It is important to mention, that in addition to some specialty papers we can also point some books about our topic. An example can be Waste Electrical and Electronic Equipment (WEEE) Handbook published by Goodship and Stevels in 2012. The book approach WEEE from almost all possible perspectives, considering theory, legislative framework, technical and organizational issues, local and regional features, etc.

### 3. WEEE IN ROMANIA

Considered like a strength in Romania regarding WEEE (Ciocoiu, 2010), our legislations is harmonized with the European legislation regarding WEEE management. This fact conducted to a similarity of our operational framework with the collecting and treating process of other countries from the European Union.

#### 3.1 Operative situation

To discuss the operational situation, the processes which are the basis of WEEE management, we must consider the following distinct operations: collecting, treating and recycling.

In Romania we can see the trend of separation of the activities: collecting, treating and recycling.

This way there are firstly recorded the attempts of the local authorities of collecting WEEE, and on the other hand the trend of developing some partnerships between local authorities and non profit organizations which are focused on these activities. An example thereof is RoRec, a non profit organization focused on WEEE collection, which developed some partnerships with almost all local administrations from almost all the cities in Romania for collecting WEEE.

The treating and recycling part is made in special plants, an example thereof being the industrial plant from Buzau – GreenWeee International.

#### 3.2 Quantitative data

The main statistical data supplier for WEEE in Romania is Eurostat, an European Commission institution, charged with statistical activities. Besides this data source, we also have information provided by the WEEE professional organizations. Unfortunately, this source is not very useful, because the data series do not have a continuous aspect and are not standardized. For this reason we cannot use them as statistical data.

Regarding the information provided by Eurostat about Romania we present the main statistical data provided for the activity until 2010:

We will analyze three categories of statistical data, the EEE amount put on the market, the WEEE collected and the WEEE recycled and reused. Based on this statistical data we will analyze in chapter four their trend and forecast and the link between them.

**Table 1. Waste Electrical and Electronic Equipment (WEEE) - Products put on the market**

	<b>Year</b>	<b>Quantity (tones)</b>
1	2006	140,849
2	2007	188,089
3	2008	244,050
4	2009	123,821
5	2010	151,317

Source: Eurostat, <http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home>

The above information show us the way which electronic and electrical products entered on our market (from many sources) from a quantitative approach between 2006 and 2010.

As a structure, depending on the type of the electronic and electrical equipments, we have the following distribution on 12 product categories provided by Eurostat:

**Table 2. WEEE - Products put on the market on categories**

	Category/year	2006	2007	2008	2009	2010	Total	%
1	Large household appliances	72,017	99,876	161,966	68,266	74,329	476,454	56%
3	Small household appliances	3,872	8,606	18,081	8,813	17,485	56,857	3%
4	IT & T equipment	25,199	31,746	19,715	11,139	31,944	119,743	7%
5	Consumer equipment	20,663	38,134	22,660	11,606	12,908	105,971	6%
6	Lighting equipment	6,233	2,203	3,927	2,420	1,234	16,017	1%
7	Gas discharge lamps		136	321	1,189	3,360	5,006	0%
8	Electrical and electronic tools	10,535	5,085	9,918	6,517	7,670	39,725	2%
9	Toys & sports equipment	353	1,160	466	628	954	3,561	0%
10	Medical devices	58	95	5,605	6,953	276	12,987	1%
11	Monitoring and control instruments	1,711	546	934	6,041	770	10,002	1%
12	Automatic dispensers	208	502	457	249	387	1,803	0%
	Total	140,849	188,089	244,050	123,821	151,317	848,126	
	%	17%	22%	29%	15%	18%		

Source: Eurostat, <http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home>

We can see two peaks, in 2008 we had a peak for the input of EEE on our market and from the categories perspective, we can see that large household appliances have the largest share, more than 50% from the EEE put on the market.

The second data category analyzed is represented by the amount of WEEE collected. The data spread across 12 categories is presented like this:

**Table 3. WEEE collected on categories**

	Category/year	2006	2007	2008	2009	2010	Total	%
1	Large household appliances	518	1,626	8,924	21,386	14,120	46,574	51%
3	Small household appliances	52	107	736	1,490	914	3,299	4%
4	IT & T equipment	274	1,164	6,253	9,104	6,460	23,255	25%
5	Consumer equipment	47	600	5,175	5,061	3,567	14,450	16%
6	Lighting equipment	8	8	206	32	63	317	0%
7	Gas discharge lamps			109	146	120	375	0%
8	Electrical and electronic tools	166	113	322	675	626	1,902	2%
9	Toys & sports equipment	1	3	33	112	63	212	0%
10	Medical devices		22	16	42	20	100	0%
11	Monitoring and control instruments	65	40	40	595	215	955	1%
12	Automatic dispensers		2	14	119	80	215	0%
	Total	1,131	3,685	21,828	38,762	26,248	91,654	
	%	1%	4%	24%	42%	29%		

Source: Eurostat, <http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home>

Also from the above statistical data we can see that the large household appliances have the largest share, and the year 2009 (after 2008 which had the largest share for EEE put on the market) had the biggest WEEE collected amount.

About recycling and reusing, Eurostat provide the following statistical data:

**Table 4. WEEE recycling and reuse on categories**

	Category/year	2006	2007	2008	2009	2010	Total	%
1	Large household appliances	0	267	3,181	18,267	12,624	34,339	58%
3	Small household appliances	0	9	162	742	743	1,656	3%
4	IT & T equipment	0	98	1,267	6,869	4,957	13,191	22%
5	Consumer equipment	0	28	783	3,821	2,948	7,580	13%
6	Lighting equipment	0	0	30	4	51	85	0%
7	Gas discharge lamps	0	0	0	121	107	228	0%
8	Electrical and electronic tools	0	2	69	467	516	1,054	2%
9	Toys & sports equipment	0	1	14	49	43	107	0%
10	Medical devices	0	0	0	0	0	0	0%
11	Monitoring and control instruments	0	0	8	346	179	533	1%
12	Automatic dispensers	0	1	6	80	70	157	0%
	Total	0	406	5,520	30,766	22,238	58,930	
	%	0%	1%	9%	52%	38%		

Source: Eurostat, <http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home>

Like in the first two cases, we can see a majority share for the large household appliances, and regarding the time scale, year 2009 have the largest share in recycling and reusing of WEEE.

A very important statistical indicator, the WEEE collected per capita put Romania on the last place in the European Union. Statistical data is shown in the following table. The importance of this indicator is that the European target is for 4 kg per capita, target which is very far from us at this moment and also for many other European countries

**Table 5. WEEE kilograms / capita in 2010**

Country	WEEE/capita	Country	WEEE/capita
Norway	22.04	Iceland	5
Sweden	17.21	Portugal	4.41
Denmark	14.95	Slovenia	4.23
Ireland	9.74	Estonia	4.21
Belgium	9.67	Greece	4.17
Italy	9.63	Slovakia	4.07
Luxembourg	9.51	Hungary	4.05
Germany	9.5	Malta	3.7
Finland	9.48	Spain	3.39
Austria	8.85	Cyprus	3.15
Netherlands	7.71	Poland	2.94
United Kingdom	7.64	Lithuania	2.88
France	6.69	Latvia	2.04
Bulgaria	6.09	Romania	1.3
Czech Republic	5.06		

Source: Eurostat, <http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home>

#### 4. STATISTICAL ANALYSIS

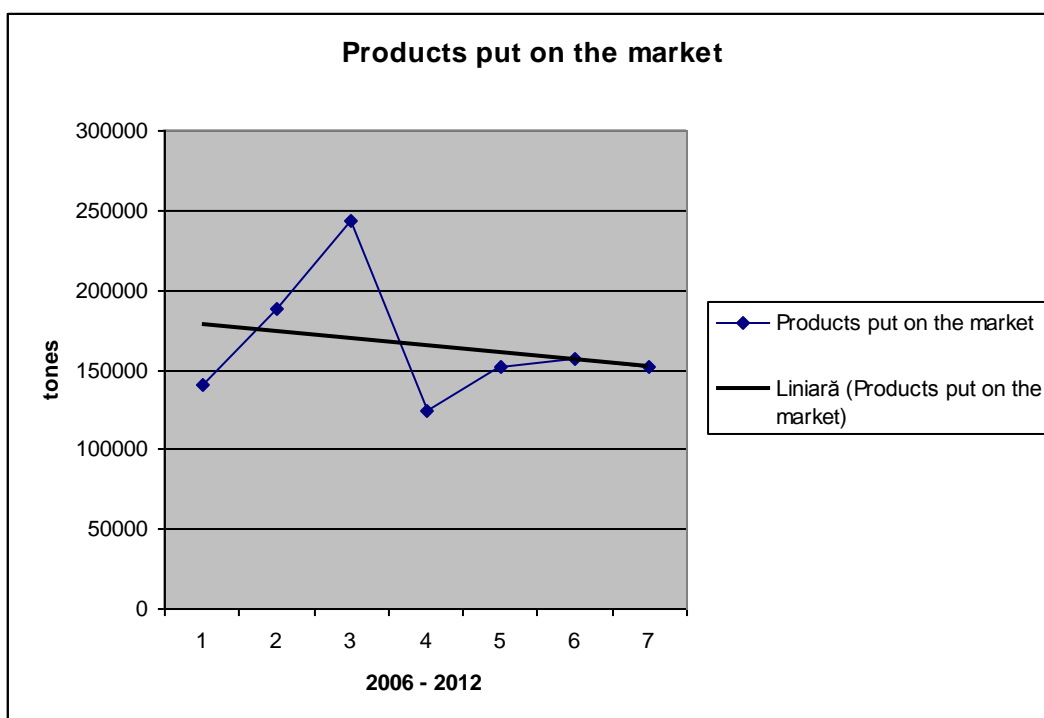
This chapter will analyze first the trend of the three data categories, the amount of EEE put on the market, the amount of WEEE collected and the amount of WEEE recycled, and secondly the correlation between the variations of this statistical data.

##### 4.1 Series trends

Using linear regression technique, we will estimate for years 2011 and 2012 the values for EEE put on the market, WEEE collected and WEEE recycled and reused. We will consider as known values the statistical data provided by Eurostat and the time period.

**Table 6. Products put on the market forecast**

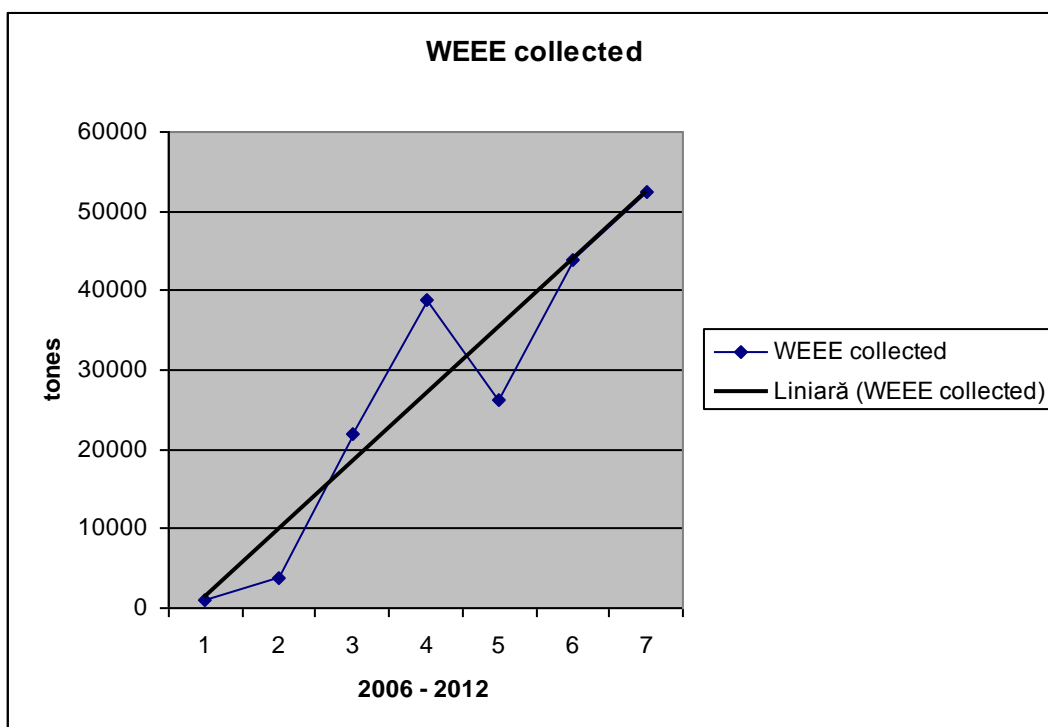
	Products put on the market	Time
1	140,849	2006
2	188,089	2007
3	244,050	2008
4	123,821	2009
5	151,317	2010
6	156,626	2011
7	152,292	2012



According to the proposed method, we can see that the trend for 2006 – 2010 is downward. Even if we had a growth moment (year 2008), the general trend that we anticipate is downward.

**Table 7. WEEE collected forecast**

	WEEE collected	Time
1	1,131	2006
2	3,685	2007
3	21,828	2008
4	38,762	2009
5	26,248	2010
6	43,924	2011
7	52,455	2012

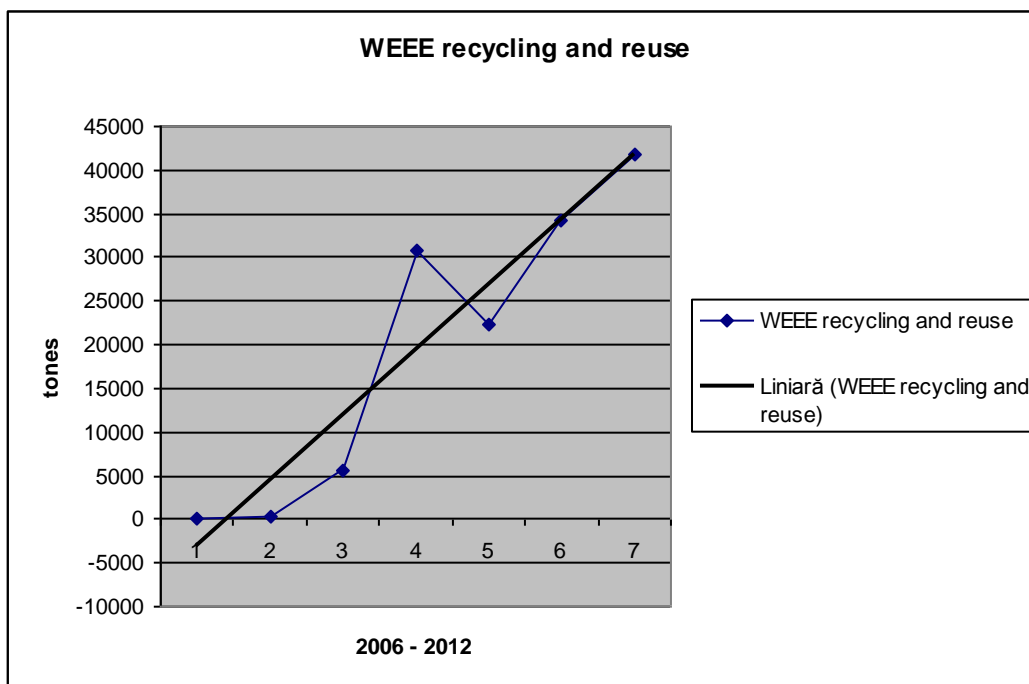


Despite the trend of EEE put on the market, for the WEEE collected we have an increase tendency for 2011 and 2012.

**Table 8. WEEE recycling and reuse forecast**

	WEEE recycling and reuse	Time
1	0	2006
2	406	2007
3	5,520	2008
4	30,766	2009
5	22,238	2010
6	34,237	2011
7	41,720	2012





Also in regard of this statistical data we have an increase tendency for 2011 and 2012. We must mention that processing this statistical data did not take into considered the demographical trend for Romania, a very important factor for this kind of estimations (Ciocoiu, 2010).

#### 4.2 Series correlations

To check the series correlation we will use the following formula:

$$Correlation(x, y) = \frac{\sum (x - \bar{x})(y - \bar{y})}{\sqrt{\sum (x - \bar{x})^2 \sum (y - \bar{y})^2}}$$

where  $\bar{x}$  and  $\bar{y}$  are the averages for the series that we correlate.

The result obtained on the above formula and statistical data are presented in the following table:

**Table 9. Series correlation**

	Products put on the market	WEEE collected	WEEE recycling and reuse
Products put on the market	1	-0,269401407	-0,481737239
WEEE collected	-0,269401407	1	0,968136862
WEEE recycling and reuse	-0,481737239	0,968136862	1

We can see that there is the highest correlation between the amount of WEEE collected and the amount of WEEE recycled and reused. In the same time we can see that this two series do not present a direct correlation with the EEE quantities put on the market.

### 4.3 Interpreting series trends

Based on previous points, where we presented quantitatively the amount of EEE put on the market, the amount of WEEE collected and amount of WEEE recycled and reused, we can observe an ascending tendency for the WEEE collected and recycled. More than that, the two statistical data series (WEEE collected and WEEE recycled) are correlated.

A special case is the statistical data for the EEE put in the market, series that have a slightly decreasing trend and which is not correlated with the other two.

From here draw the conclusion that the WEEE collected and WEEE recycled is not directly linked to the EEE put on the market.

### 4.4 Comparing Romania – Bulgaria - UK

For a clear image of the WEEE phenomenon in Romania, we will compare, from a statistical approach (quantitative) Romania with other two countries, EU members, Bulgaria and the United Kingdom. We chose this two countries because we wanted a country that is on the same level of EU integration with Romania (and which is Bulgaria) and with a similar economic and social level, and another country (second one), older in EU and with a higher economic and social level.

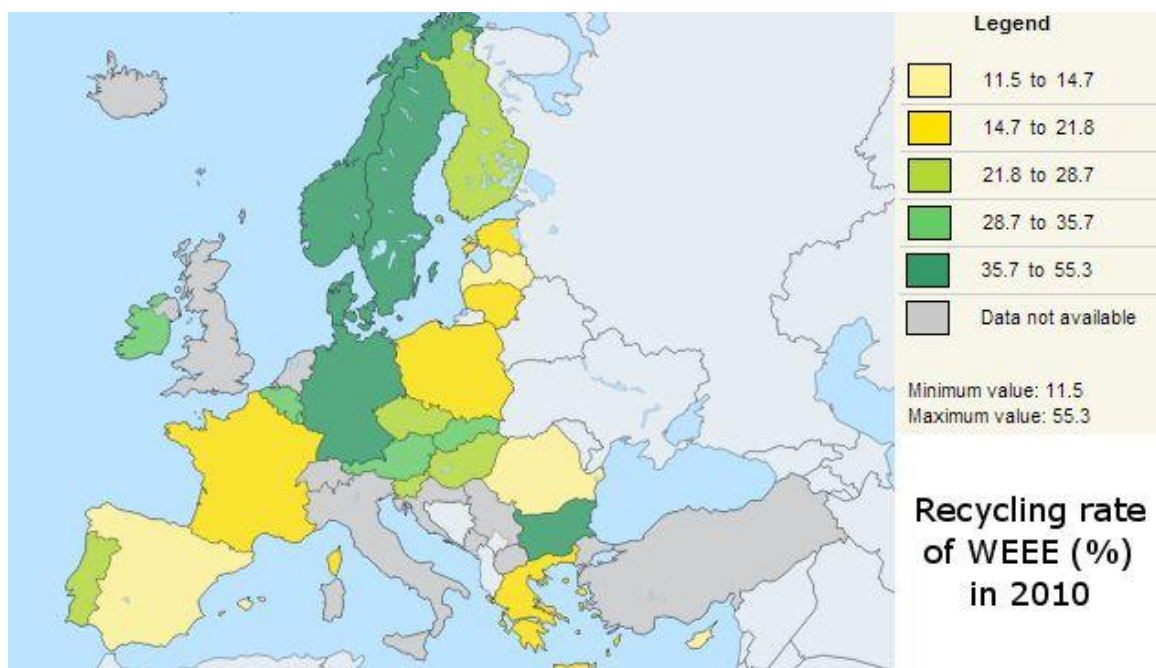
For comparison we chose the Kg per capita indicator. The statistical data is presented below:

**Table 10. WEEE in Bulgaria, Romania and UK**

	2006	2007	2008	2009	2010	Average
Products put on the market						
Bulgaria		13.55	13.65	7.53	6.92	10.41
Romania	6.65	9.01	11.88	6.08	7.47	8.22
UK		13.10	21.85	24.83	24.45	21.06
WEEE collected						
Bulgaria		2.94	5.39	4.49	6.09	4.73
Romania	0.05	0.18	1.06	1.90	1.30	0.90
UK		3.16	7.25	7.57	7.64	6.41
WEEE recycling and reuse						
Bulgaria		1.87	3.51	3.43	4.77	3.40
Romania		0.02	0.27	1.51	1.10	0.73
UK		2.46	5.51	5.88		4.62

From the above table we can see that for Bulgaria and UK the European experience is better noticeable regarding WEEE. Even if we talk about collecting or recycling, both UK and Bulgaria (in this order) are above Romania. Unfortunately, this statistical data can not offer information about the causes that conduct to this situation.

For this subject the image below is also relevant, that shows the general recycling rate for 2010 for WEEE in EU.



**Figure 1, Recycling rate of WEEE (%) in 2010**

*Source:* adapted from <http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home>

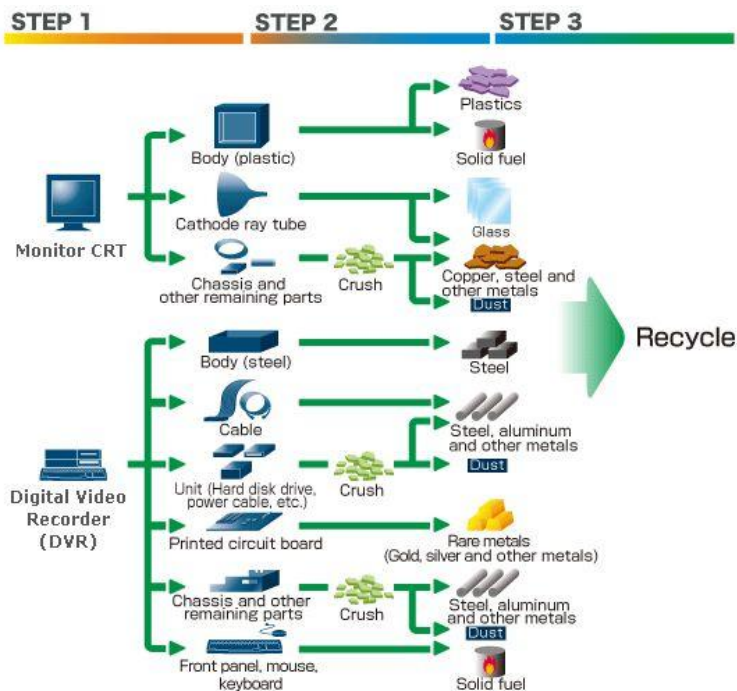
Sustaining the statistical data from Table 10, Figure 1 confirms the weak position of Romania regarding the recycling rate. The statistical data has been estimated on WEEE collected and average EEE for three years.

## 5. WEEE FEATURES ON SECURITY SYSTEMS

About features of this wide domain (WEEE) we can indicate technology sectors which in the last 10 or 20 years are growing and generating very important amounts of EEE, but which are not analyzed at this point from a quantitative and statistical approach, neither in Romania nor internationally. An example for this is the security systems market. For example we will look at the CCTV market in the UK, where we have between 1.8 and 4 millions video cameras running at this moment. Considering an average weight of 0.8 Kg / piece, we have between 1.44 – 3.2 millions Kg of EEE (only video cameras, a small part of what the CCTV systems represents and also of what security systems are). For a product life cycle of 7 years for this kind of equipments, we can estimate about 300 tones of WEEE per year only for this kind of products and only in the UK.

In Romania, the security systems market is about 300 millions EUR every year, market value that can not be converted into a value that represents the weight of the products (potential WEEE for one year).

Regarding the recycling process, we have an example of two important parts of the security and CCTV systems, the CRT monitors and the Digital Video Recorders (DVR). Decomposition on raw materials is as follows:



**Figure 2, Recycling process for security systems**  
 Source: adapted from <http://www.pc3r.jp/e/index.html>

Unfortunately, as we said before, the statistical data do not provide us information about recycling on specific equipments, but only on large groups of products, like IT, control, household equipments, etc. It would be very interesting if specific industries, like the security industry, together with the collecting and recycling agents would develop statistics for measuring the impact of their industry in the whole WEEE activity.

## 6. CONCLUSIONS

Going from general to particular, the first conclusion that we draw is that Romania is very weak developed regarding collected and recycled WEEE comparing to other EU countries, even if they are countries with tradition in EU or not, with a higher or lower level of life, conclusion also confirmed by other researches (Ciocoiu, 2011).

The statistical data presented by Eurostat for 2010 puts Romania on the last places at WEEE collected per capita, in fact the main indicator used by the actual legislation as a target.

Going to the statistical data that refers only to WEEE in Romania, we can notice an increasing trend for the amount of collected and recycled WEEE. Also, this trend is not in direct connection with the amount of EEE put on the market. These two facts conduct us to the conclusion that the collecting and recycling level is possible directly linked with the development of this activities from the non profit organizations approach and also the local authorities (administration).

Regarding the dynamic of the phenomenon we can underline that the year 2009 is a landmark in the evolution of collecting and recycling WEEE.

Regarding the product structure that is subject of WEEE, large household appliances are on the first place at collecting and recycling.

The final and general conclusion is that, even if we made important steps in implementing European Community Directive 2002/96/EC and RoHS Directive 2002/95/EC, Romania still has many steps to make until it will rise to the actual level of the rest of the European Union members. And the key for these steps is the non profit organizations and also the public authorities.

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