E-WASTE MANAGEMENT- TRENDS AND BEST PRACTICE SOLUTIONS IN EUROPE AND ROMANIA

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Abstract
Within the scientific community addressing the issue of the circular economy, there is a growing interest in the future of planetary resources, including finding the most consistent answers to the challenges posed by e-waste management (waste from electronics and household appliances).
Although e-waste is the fastest growing waste stream in the European Union, only a little less than 40% of it is recycled. As concerns Romania, at this moment, the situation has become particularly problematic: Eurostat statistics show that in 2018 (latest available data) only 11% of waste was recycled in Romania, which places it on the 26th place among the 27 EU member states. Also, it must be mentioned that many of the European Union member states are behind the targets set at national and European level.
This research will outline the evolution of e-waste management with a special focus on e-waste collection in European countries in order to establish what the future trends are. It will highlight the main issues of e-waste management in EU and will draw a parallel to highlight the national characteristics and trends of e-waste management in Romania with the ultimate scope of finding mechanisms useful for adjusting the national trends to the European targets.

Keywords: *e-waste management, circular economy, reduce-reuse-recycle*

Classification JEL: *Q53, Q56*

1. Introduction and context of the study

E-waste or WEEE (Waste Electrical and Electronic Equipment) reffer to discarded electronic and electrical devices such as computers, laptops, refrigerators, mobile phones, TV sets, vacuum cleaners, hair dryers etc. These devices are, most of the time, made of 50% iron and steel, 21% plastic, 13% non-ferrous simple or precious metals (copper, aluminium, gold, silver, platinum etc.), and 16% others.

More than 50 million tons of e-waste are generated every year on Earth, of which only 12.5% is recycled. 40 million tonnes of e-waste are transported by sea to developing countries (in Africa mostly) in only one year (2014) [16].

E-waste management is one of the domains with important potential for circular economy implementation. Circular economy is a model of production and consumption that implies reuse, repair and recycle of existing products for as long as possible [5]. E-waste is very suitable for implementing recovery and repair policies, prolonging the life cycle of equipments for as long as possible, in compliance with one of the main objectives of the circular economy mechanisms.

This paper will highlight how EU and Romania understand to implement e-waste management. Romania has committed to take all the measures necessary to implement economic instruments that facilitate the transfer to a circular economy [11].

Specific economic instruments are important for the e-waste mamangement modernization in Romania and for implementing of EU legislation in the domain. The economic tools used in Romania for the collection and recycling of e-waste are: public awareness campaigns, green stamp taxation, free e-waste collection campaigns and extended producer responsibility.

The most suitable for e-waste management in Romania has proven to be the extended producer responsibility (EPR). As can be seen from other studies on this subject [18], one of the main problems with the implementation of this economic instrument is the lack of a consistent database.

2. Conceptual background

The EU approach of e-waste management varys from one member state to another, even if a legislative framework is already in place.

Roman [17] presented an exhaustive analysis of e-waste management systems in northern EU member states: Norway, Sweden, Denmark and also in Switzerland. These countries are best practice examples, as their rate of recycling e-waste is the highest between Eu member states.

Favot et al [10] present the Italian system for e-waste management from households, with focus on the compliance organisations and their technical and economic performance. It analyses the complicated framework which comprise multiple actors (producers, compliance organisations, retailers, municipalities etc.) and many steps (from production and selling to the management of e-waste). The study highlights the lack of transparency in data colection which conducts to false results in analysis.

Zlamparet et al [20] perform an interesting analysis of e-waste management in two large capitals: Bucharest and Beijing. Interesting conclusions can be drown from compairing management methods in different continents and cultures.

E-waste is represented by high added value materials and hazardous components. Various authors from the literature underline the need to develop recovery processes and measures, in the attempt to return them to the productive cycle. These processes and measures should also take into consideration to minimize the impact on the environment and health [4].

In the area of e-waste management, various papers analysed the respective processes and policies. Cucchiella et al [7] analysed the framework supporting the decision - making process of the Waste from Electric and Electronic Equipments (WEEE) recycling centres, and the results showed that even low economic value materials might offer relevant contributions if available in high quantities.

Dwivedy et al [8] investigated the Extended Producer Responsibility (EPR) take-back policies in the case of India. The authors emphasize the importance of the e-waste take-back scheme profitability, taking into consideration the higher costs of e-waste recycling. Borthakur and Govind [2] analysed the measures adopted by the consumers of different countries to dispose the e-waste, with a focus on India. According to the authors, there are differences in e-waste disposal behaviour between the developed and developing countries, and also within countries.

Otto et al [14] discussed the fostering of the e-waste recycling. According to the authors, the e-waste collection campaigns that address social motives are more important than expensive structural improvements.

Xavier et al [19] analysed the recovery and classification of mineral material and urban mining procedures. The authors emphasized that it is important to use the technological routes to recover secondary raw material, if the target is the sustainability of the e-waste urban mining.

Condemi et al [3] identified Radio Frequency Identification (RFID) tags as the best tool for e-waste management and discussed some measures that might be adopted by producers of different RFID devices, such as: ecological design and prevention, reuse, recycle, and disposal.

Parajuly et al [15] explored the relation between behavioural sciences, circular economy, and e-waste management. The authors emphasized the opportunities for behavioural interventions, with the aim of improving e-waste management.

Ádám et al [1] investigated the trends and threats of e-waste management, with the focus on the need to conduct surveillance of compliance with e-waste trading and processing according to the Basel Ban Amendment. The authors underline the risk to the environment and to population health of the e-waste recycling activities and the need to reduce the negative impact on health and the environment.

Murthy and Ramakrishna [13] analysed the gap between the stakeholders and their knowledge on the roles and responsibilities regarding e-waste management, emphasizing the lack of awareness on extended producer responsibility EPR and producer responsibility schemes, and the importance of achieving a low-carbon, circular economy.

Other authors, such as Maurice et al [12] focused on recycling strategies for increasing the recovery of chemical elements from waste printed circuit boards (WPCBs). The authors identified retrieval methods for elements that can be recovered in an environmentally friendly way.

3. E-Waste Management in EU

Eurostat database is the main source of information regarding e-waste management in EU. The indicator that was analysed in order to assess the e-waste trend was *e-waste collected* [9]. It is expressed in kg per inhabitant and data are updated every year. Table 1 presents the evolution of this indicator for selected representative EU countries – the highest, some middle placed, and the lowest member states in regard to e-waste collection.

Table 1: Collected E-waste in Romania and some EU Countries (kg/inhabit./year)

Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
UE 28 (2013-2020)	6.9	6.9	6.7	6.8	6.06	6.2	6.91	7.99	8.02	7.84
Sweden	*16.53*	*17.21*	*18.69*	*17.71*	*18.39*	*14.94*	*14.69*	*16.45*	*14.06*	*14.19*
Germany	10.16	9.5	8.85	8.59	9.03	8.93	8.84	9.5	10.13	10.29
Italy	8.82	9.83	9.17	8.35	7.26	5.17	5.67	5.96	6.3	6.97
France	6.1	6.69	7.22	7.19	7.29	7.88	9.28	10.82	11.1	12.16
Bulgaria	4.49	6.09	5.5	5.26	4.84	5.86	8.64	8.63	7.7	7.49
Spain	2.96	3.39	3.29	3.38	4.49	3.98	4.97	5.38	6.16	6.85
Poland	2.8	2.95	3.77	4.61	4.51	4.55	5.24	6.13	6.49	6.73
Romania	1.9	1.3	1.04	1.15	1.66	1.62	2.06	2.37	2.54	3.28

Source: own compilation from Eurostat data.

The average EU level of e-waste collected has a very slowly yet constant growing trend [6]. Sweden, United Kingdom, France, and Germany are the group of countries with high level of collection of e-waste reported to EU average. On the top position is Sweden, with the highest values for every year in the analyzed period, although the national trend is going downward: from 16.53 kg/inhabitant in 2009 to 14.19 kg/inhabitant in 2018.

It must be mentioned that there are a group of member states with low e-waste collection level – Spain, Bulgaria, Romania. The national trend for these countries is upward, even if the value of the indicator is below the EU average.

Although Romania is on the last place in this analysis, for the entire analyzed period, there is an obvious ascendent trend, as the collected e-waste quantity has increased from 1.9 kg/inhab. in 2009 to 3.28 kg/inhab. in 2018.

As can be seen in Figure 1 bellow, Sweden is the only country with a high positive gap related to EU average. Also, Romania has the biggest negative gap, also related to EU average. The rest of the coutries presented in Figure 1 hae average, similar evolutions regarding the evolution of the e-waste collected during the analysed period of time, 2009-2018.

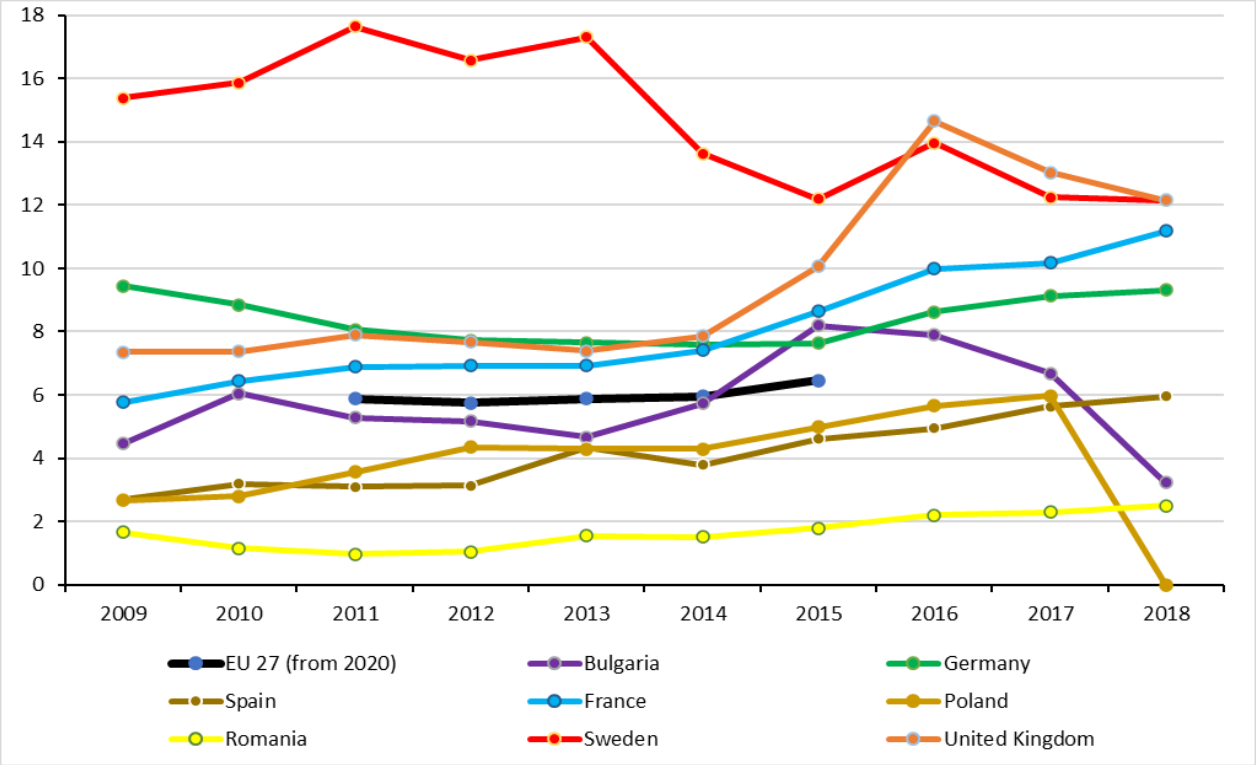

Figure 1: E-waste collected (kg/inhab.) in some EU countries (2009-2018)
Source: own compilation from Eurostat data.

It must be stated that e-waste statistical data presented in this analysis cover a 10-year period of time, the most recent available data from Eurostat. The 4-year gap from the last data available in the official European database to present time is, probably, due to difficulty of gathering data from national institutions responsible.

4. Analysis of Collected E-Waste in Romania

As the above analisys shows, and may be observed in Figure 1, Romania is on the last place in the EU, regarding the e-waste collected per capita, in every year of the analysed period.

Approximating the quantities of e-waste generated on national level is a necessity for defining collection targets, as stated in Article 7 of WEEE Directive 19/2012. Since 2021, Romania may set its own collection target in relation to EEE placed on the market (POM) or in relation to e-waste generated, as can be seen in Table 2.

Table 2: E-waste collection targets - EU Directive and derogations for Romania

Year	2014	2015	2016	2017	2018	2019	2020	2021
EU Dir. e-waste target	Min. 4 kg/pers. or average kg/pers. collected annually in 3 foregoing years (higher value)		Min 45% POM (average of 3 foregoing years)			65% POM (average of 3 years) or 85% from e-waste generated		
E-waste target for Romania	Min. 4 kg/pers. or average kg/pers. collected annually in 3 foregoing years (higher value)		Min 45% POM (average of 3 foregoing years)				**65% POM** (average of 3 years) or 85% from e-waste generated	

Source: ECOTIC Study 2019.

There are two possibilities for Romania: 85% of e-waste estimated to be generated per year or 65% of EEE put on market average for 3 previous years.

The e-waste collection in Romania involves several institutions, as Figure 2 shows. There are more than ten administrative institutions with different tasks in the flow of e-waste collection, transport and recycling.

Some of these institutions have financial role – Environmental Fund Administration, Responsibility Transfer Organizations – while others have a control (Environmental Guard) or a statistical and coordination role (NAEP).

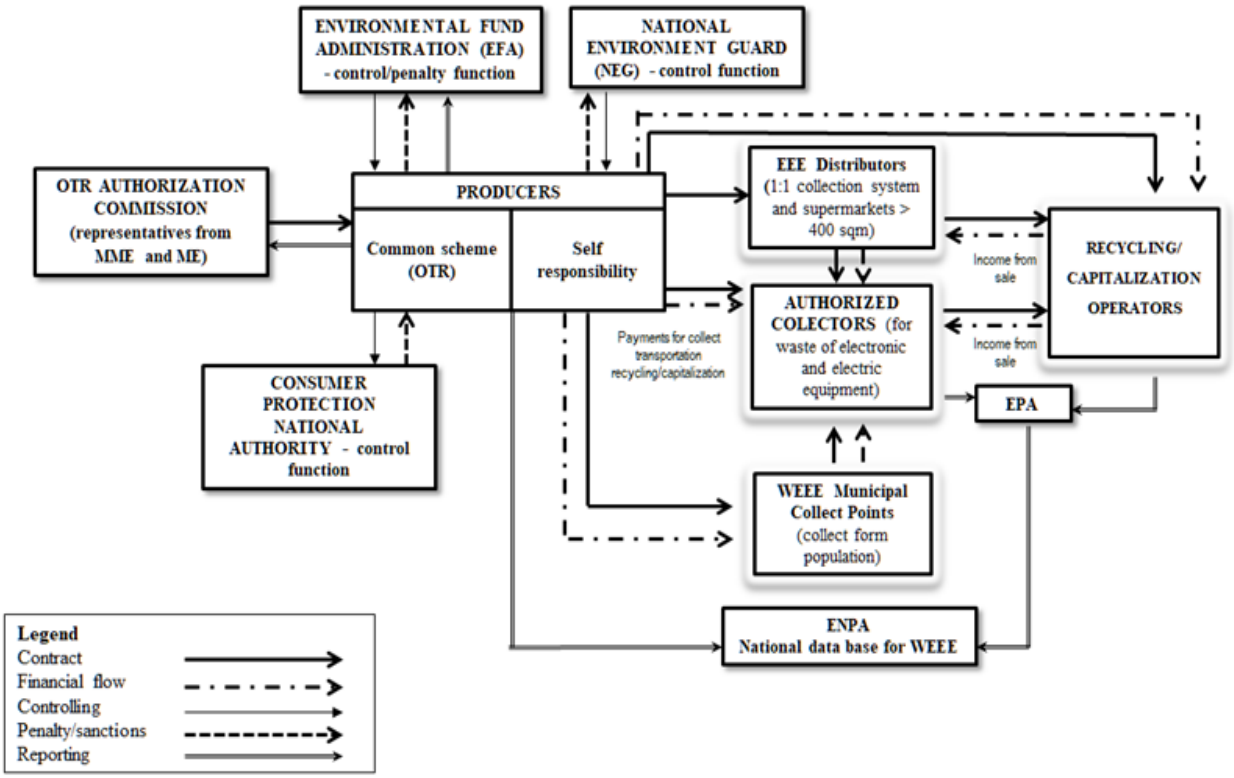

Figure 2: E-waste flow chart in Romania

Source: own compilation from (Platon et al, 2020).

This system is very sophisticated and entangles the information transfer between entities. However, it doesn't facilitate in any way the recovery / recycling of electrical and electronic equipment.

Conclusions

The European Union is the engine that drives the progress in e-waste management. It sets policy framework leading to reform in all member states. The sustainable e-waste management, with a good recovery, recycling and reuse of the most valuable and rare materials is one of the main objectives of the transition to a circular economy in the EU.

This paper presented a short analysis of selected circular economy indicators, namely e-waste collection and recycling in selected EU countries. The conceptual background consisted of quite a rich literature review on the latest approaches recommended for e-waste management. In order to analyze the recycling of e-waste, the evolution of collected and recycled e-waste was presented further, with a focus on Romania.

The research showed a slow but constant increase in e-waste management activities. The trend followed by all the EU is positive but very slow for the analyzed time frame (2008-2018).

The countries analysed are on different slopes, depending on their general level: the countries with strong economies (Sweden, Germany, France, United Kingdom) have higher levels of e-waste collection and recycling while the low-level economic countries are struggling to meet the EU targets, with very low levels of e-waste recycling (Romania, Bulgaria).

However, the prospects for increased efforts and investments for e-waste collection and recycling in all the EU member states are rather good now, due to the unfortunate political and military crisis happening in the North-Eastern part of Europe in 2022. The military conflict in Ukraine has strongly affected the availability of many raw materials used in the production of electrical and electronic equipment, thus obligeing the companies to seek increased recovery and reuse from e-waste.

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