The sustainable management in the e-waste and municipal solid waste sectors

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Abstract: *The multiplication and diversification of the waste resulting from economic activities can be explained by the development of the society, which implies the waste as secondary effect. Apart from the positive effects on the global consumption, the economic activities have also negative effects on the humans and environment due to the waste generation. The sustainable management in the waste sector should increase the efficiency in the resources use and prevent waste generation, should find new production methods and new eco-designed products, so that the economic growth can be made with fewer natural resources and materials, with less energy consumption. The transition to a greener waste sector is an important issue for all the national economies and it suppose reducing and preventing waste generation, improving waste recycling and qualitative valorization, reducing the environmental impact of the waste, improving the existing national and international databases, encouraging green investments and a closer and a better collaboration between the local public administration authorities, the companies and the population and also between economic subjects from different countries.*

Keywords*:* sustainable management, e-waste, municipal solid waste, recycle, reuse, remanufacturing.

JEL Classification: A13, D12, D18, D62, E61, F42, I15, O21, O25, O33

1. Introduction

The development of the society implies the multiplication and diversification of all the types of economic activities, which, as secondary effect, causes the increase of the volume and diversity of the waste resulting from these activities, especially from production and consumption. "Wastes are material residues resulting from a technological (or domestic) process of making a particular product which can no longer be directly exploited in the production of the product. They can be substances, materials, objects, scraps of raw materials from economic, domestic and consumer activities. Most human activities are also sources of waste generation." [2] Under the "Waste Framework Directive 2008/98/EC", Art. 3(1), the European Union defines waste as "an object the holder discards, intends to discard or is required to discard." [7]

The sustainable management must be a priority in all economic activities, including the waste generation and processing. State intervention and the awareness of all economic agents, especially the producers and the consumers, on the need to practice a sustainable management in these areas are particularly important given the fact that a significant increase in the amount of waste is foreseen worldwide. In the future, the increase of the urbanization will lead to a rise in the amount of generated waste, especially of the municipal solid waste. Currently, the human society extracts and uses 50% more natural resources than just 30 years ago and uses 8 times more materials than 100 years ago.[5] Raising states awareness as well as individual entrepreneurs on the need for a better waste management should be a priority of all the world's nations. By practicing the sustainable management in these fields, the production activities can be more efficient and friendlier to the environment, will improve living conditions and will reduce social inequalities in the long run..

This paper aims to underline the importance to introduce together with the elements of the traditional management, the new principles of the green economy, the sustainable management, which will improve the resource efficiency, will lead to create jobs - most of them in the waste sorting and recycling sector, to save resources by increasing the energy production from waste and by increasing the compost production from organic waste, to reduce greenhouse gas emissions and to reduce the poverty.

The paper presents the most important issues concerning the transition to a greener waste sector, which highlights complex issues that are not always easy to solve, as highlighted in: "Towards a Green Economy. Pathways to Sustainable Development and Poverty Eradication" - "The environmental and social (including health-related) benefits from greening the waste sector have been stressed already for a long time. The impact of this has, however, been limited, as environmental and social concerns are often seen as competing with economic imperatives." [5]

In the last years was introduced the "Integrated Solid Waste Management (ISWM)" which aims to reduce waste and to improve the system of waste collection and processing, in order to protect population's health and the environment and biodiversity. "Integrated solid waste management refers to the strategic approach to sustainable management of solid wastes covering all sources and all aspects, covering generation, segregation, transfer, sorting, treatment, recovery

and disposal in an integrated manner, with an emphasis on maximizing resource use efficiency." [8]

The importance that the European Union gives to this sector is underlined by the fact that many studies are being carried out on the basis of the information provided by the member states on the structure and the quantity of the resulting waste, on the collection methods and on the costs required by treating them.

In Romania, the "National Waste Management Strategy" provides a series of measures that, in addition to reducing and preventing waste generation, aim to improve waste recycling and qualitative valorization and to reduce the environmental impact of the waste, which implies the improvement of the existing national databases, encouraging green investments and a closer and a better collaboration between the local public administration authorities, the companies and the population.

2. Literature Review

Regarding the importance of the waste sector for the European Union countries, the "European Commission", underlines the „Key elements of the revised waste proposal include:

- A common EU target for recycling 65% of municipal waste by 2030;
- A common EU target for recycling 75% of packaging waste by 2030;
- A binding landfill target to reduce landfill to maximum of 10% of municipal waste by 2030;
- A ban on landfilling of separately collected waste;
- Promotion of economic instruments to discourage landfilling ;
- Simplified and improved definitions and harmonised calculation methods for recycling rates throughout the EU;
- Concrete measures to promote re-use and stimulate industrial symbiosis –turning one industry's by-product into another industry's raw material;
- Economic incentives for producers to put greener products on the market and support recovery and recycling schemes (eg for packaging, batteries, electric and electronic equipment, vehicles). [9]

Romania's policy in this field is highlighted in the "National Waste Management Strategy, 2014-2020", which is an important element in the specific legislation implementation process. This Strategy refers to all the economic subjects: Government, industrial producers, agricultural producers, traders, non-governmental organizations and population.

"The strategy continues to fully recognize the following:

- The government is committed to pursuing a "recycling society".
- Sustainable waste management, including the prevention of waste generation, is a must to protect the environment in relation to climate change and the preservation of natural resources.
- One of the government's priorities is to decentralize local decision-making authorities to the local communities.
- Resource efficiency and sustainable waste management can provide significant savings.
- Energy recovered from bio-waste contributes to meeting the targets for the use of renewable energies with a long-term goal of climate change.

• Applying the principles of sustainable development implies a new approach using environmentally-friendly concepts to accurately measure the actions proposed in the area tackled by this strategy with existing environmental resources. Renewable and non-renewable resources and services provided by the Natural Capital components are the support for the production of goods and services provided to human socio-economic capital, directly affecting the quality of the population's health.

• The themes approached in the strategy support the requirements and opportunities of the framework in which the sustainable co-development of the components of Natural Capital and human socio-economic systems must be designed and implemented in view of the sustainable development of the national territory." [6]

In „Towards a Green Economy. Pathways to Sustainable Development and Poverty Eradication" [5], there are underlined the most important issues regarding the waste sector: „There is a substantial variation across countries in the magnitude of government spending on the waste sector..... developing countries typically spend more than half of their waste budget in collection alone (mainly on labour and fuel), although the collection rate remains low and the transport of waste inefficient. Spending on other segments of the waste management chain, such as technologies and facilities for treatment, recovery and disposal, is generally rather low.... Investment can be targeted, for example, at techniques such as route optimisation and transfer stations, which can bring down the capital and operational costs of providing waste services. In emerging economies with rapid growth and urbanisation, the need for increased investment in greening the waste sector is particularly strong. Greening the waste sector is expected to generate substantial economic, environmental and social benefits. They include: 1) natural resource and energy saving; 2) creation of new businesses and jobs; 3) compost production supporting organic agriculture; 4) energy production from waste; 5) reduced GHG emissions; and 6) contributions to equity and poverty eradication. Improved health, avoided health costs, avoided water contamination and the consequent cost of alternative water supply are also important streams of benefits."

The book „Waste Management: a Reference Handbook" the author describes an interesting chronology of the waste management, beginning from the XVIII century, especially in the case of developming cities as a result of the Industrial Revolution. [2]

On the importance of the electronic waste resulting from the development of industry and communications, the authors of the book „E-Waste Management. From Waste to Resource", analyses different national regulations worlwide regarding the reuse and recicle of e-waste, the perspectives of the management strategies in order to improve aspects related on environmental, social and economic area. „Electronics equipment significantly influences the way societies relate, and it is impossible to ignore the vast positive impacts of electronics use by society. Nevertheless, important concerns also exist related to the flow of electronics deemed obsolete by consumers (e.g. households, corporations, public agencies, schools) all over the world. These concerns intensify as the manufacturing and adoption rate, triggered by technological development of these devices, increases around the world. "[1]

3. Electronic waste

"Electronic waste" or "E-Waste" may be defined as discarded computers, office electronic equipment, entertainment device electronics, mobile phones, television sets and refrigerators. This includes used electronics which are destined for reuse, resale, salvage, recycling, or disposal. Others are reusable (working and repairable electronics) and secondary scrap (copper, steel, plastic, etc.) to be "commodities", and reserve the term "waste" for residue or material which is dumped by the buyer rather than recycled, including residue from reuse and recycling operations, because loads of surplus electronics are frequently commingled (good, recyclable, and non-recyclable), several public policy advocates apply the term "e-waste" broadly to all surplus electronics." [15]

The risks associated with e-waste from TV and video are related to the penetration of toxic heavy metals into the soil and water, increasing its acidity, as well as some glass and plastic scraps and also to the generation of toxic gas emissions in the air.

Also in the case of the e-waste, an important role has the recycling process, in which some metals such as lead, copper and gold have a special attention. 1 tone of metal scrap from PCs contains more gold that can be recovered than the one contained in 17 tons of natural deposits and 40 times more copper than in natural deposits. [5]

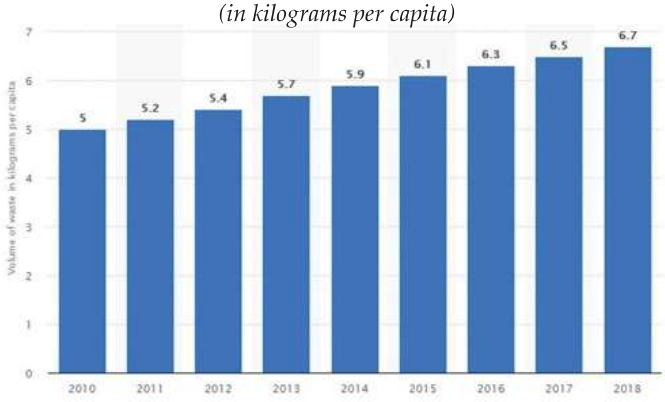
Recycling involves the decomposition of the electronic products by components and a separate treatment of each of them, depending on its characteristics. By reusing metals, natural resources are conserved because less of them are consumed. In the most situations, this process also contributes to reducing greenhouse gas emissions because it does not consume as much energy as the initial process. Much of the components, such as glass, plastic, even some metal components, can be remanufactured. The recycling process must be carried out with responsibility so as to be as little as possible harmful to human and environmental health. Besides these benefits, recycling often also involves relatively lower costs comparing to the initial process.

Since the 1990s, there has been a significant increase in e-waste recycling concerns both in Europe and the USA. In 1991, Switzerland introduced a recycling program for refrigerators, and then the EU launched the "Waste Electrical and Electronic Equipment Directive" (WEEE Directive, 2002/96 / EC). Worldwide, good results have also been achieved in Japan, Taiwan, South Korea and South Africa.

Recycling can also be done by consumers when they donate electronic products to individuals or companies who need them and can not buy them or when they return the products to their own producers in order to re-manufacturing them. One of the issues related to remanufacturing is that manufacturers do not always support the remanufacturing process because they think it is against the possibility of promoting their new products. Recycling by authorized companies is beneficial not only because it reduces the consumption of the existing resources but also because it creates many new jobs.

The first countries that generate the biggest amount of e-waste were, in 2015: USA, China, Japan, Germany and India. The countries which lead, in 2014, in per capita production of e-waste are Norway, Switzerland, Iceland, Denmark, United Kingdom, Netherlands, Sweden, France, Austria and USA.

Chart 1. Forecast of per-capita electronic waste generation worldwide from 2010 to 2018 (in kilograms per capita)



Source: https://www.statista.com/statistics/499904/projection-ewaste-generation-per-capita-worldwide/

"Recycling is also an expensive process, especially when it is done properly with secure and safe technology and conditions. So many countries export waste is to Asia and Africa, where the rules governing e-waste management are lax. In Europe, 47% of the e-waste export, and 50-80% of e-waste export was found to be illegal. The Asian and African countries, however, do not have adequate technology or the means to handle the e-waste. People, including children handle toxic components with bare hands, leading to health problems." [16]

In Romania, electronic waste, resulting from domestic production, as well as from imported goods, is classified in some categories which are resulting from the next table:

Table 1. Waste electrical and electronic equipment collected, 2010-2014 (Romania)

Types of e-waste	Amount of e-waste (tonnes / year)				
	2010	2011	2012	2013	2014
Large size households devices	14.119,93	9.987,33	11.398,81	20.315,61	20.465,24
Small size households devices	913,64	673,18	864,21	977,49	1.021,16
IT and telecommunications equipments	6.459,84	5.446,30	4.976,01	4.886,16	4.803,30
Widespread consumption equipments	3.567,23	3.199,49	3.513,5	4.671,74	3.513,27
Lighting equipments	182,66	291,95	776,99	837,26	1.140,05
Electric and electronic tools	625,81	743,07	691,64	702,87	815,37
Toys, sports and leisure equipment	62,73	94,57	59,84	89,82	65,60
Medical devices(except for all implanted andinfected products)	19,86	20,51	58,19	28,44	34,07
Supervision and control tools	215,41	464,17	686,63	505,58	236,42

Automated distributors	79,50	87,69	56,94	149,78	64,51
Total	26.246,61	21.008,26	23.082,76	33.164,75	32.158,99

Source: http://www.mmediu.gov.ro/app/webroot/uploads/files/2017-04-27_PNGD_versiunea_1.pdf.pdf – processed by the author

As in the rest of the world, for the management of this category of waste, in Romania the economic agents can act individually or by contracting some of the over 800 authorized economic operators. Among the most frequently there are: the low level of collection of this type of waste, some legislative aspects regarding the responsibility of the collection and the way of involvement of some institutions and organizations, issues related to the financing of the required investments.

The Emergency Ordinance no. 5/2015 on waste electrical and electronic equipment, which has been elaborated in the spirit of EU directives, refers to the separate collection of waste, its disposal and transport, the collection rate and the corresponding treatment.

According to the study on "Quantification of electrical and electronic waste in Romania": "in 2015, a Romanian person holds on average 72 kg of Electrical and Electronic Equipment (EEE). Of these, 7.35kg/person are disposed of as Electrical and Electronic Equipment Waste (EEEW). A maximum of 30% of what is generated is collected through official collection systems and reported as a national result, 21% reach relatives and friends, and the rest of the cases are characterized by negative habits: are going to garbage, are handed down to old or discarded street collectors at random. This is the real landscape of the generation, collection and recycling of EEEW in Romania."[17]

4. Municipal solid waste

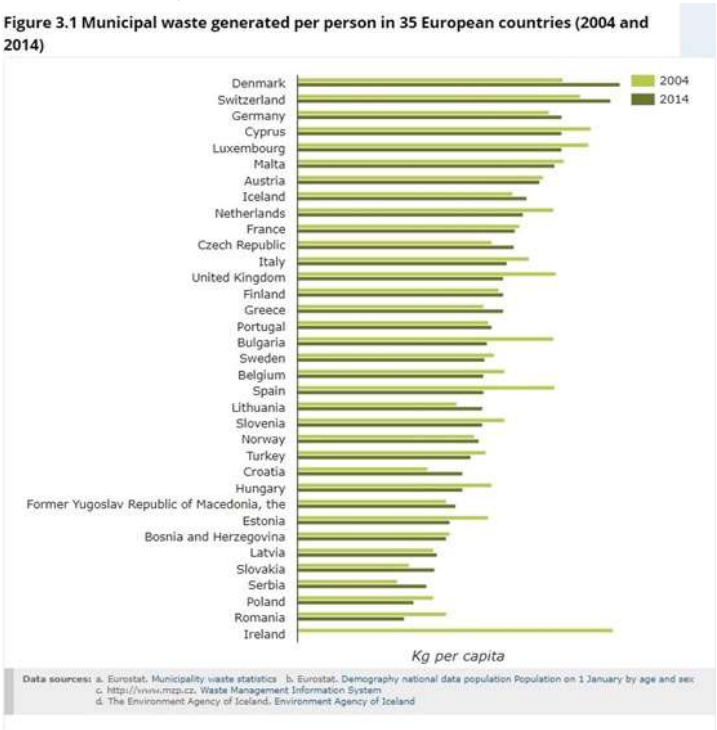
The composition of solid municipal waste is very different, depending on the degree of development of each city. In this category of waste, can be included the waste resulted from households, from the commercial units, from public and private institutions and from industrial enterprises. In most of the countries, the municipal solid waste does not include agricultural, medical and radioactive waste.

The waste management involves a series of chain-linked activities. An important operation before collecting waste is sorting it into categories. The main categories of solid municipal waste are plastic or other packaging materials, waste from construction or demolition processes, waste resulting from the products sales. One of the most important activities is the waste collection, which involves the transport of the waste either in special warehouses or to the companies which are processing them at transfer or firing stations. Much of solid municipal waste is eliminated by land filling, which raises serious health and safety problems for people and animals by creating the possibility of contamination through insects or groundwater. Accordingly, the activities of reuse of waste have a great importance. Currently, there is a possibility for interested economic operators to reuse the waste they can find free on various websites. In the recent years, the methods of purchasing energy based on waste have also been improved so as to reduce the percentage of eliminated greenhouse gases at the firing stations.

Within the European Union, especially from the beginning of the XXIth century, a special attention has been given to

the ways of preventing waste generation, storage and re-use. "In 2015, the European Commission proposed new targets for municipal waste of 60% recycling and preparing for reuse by 2025 and 65% by 2030." [12] Generally, at the level of all European countries, there is an increasing concern for the waste management, emphasizing the recycling activity, as an important generator of jobs and reduces the negative effects on the environment, which is included in the national development plans in most of countries. Countries with the highest recycling rates are Lithuania, Poland, Italy, the United Kingdom and the Czech Republic. For example, on Lithuania, "Municipalities are the main institutions organising municipal waste management, with the main responsibility to create effective waste management systems. 12 Local authorities are also responsible for reaching EU targets regarding recycling and recovery - with the exception of some waste streams (WEEE, packaging batteries and accumulation waste) which are managed by Extended Producer Responsibility schemes. They set out the terms of municipal waste collection, transport, treatment and disposal. They are also responsible for ensuring that the waste treatment installations function. In Lithuania, residents pay a monthly fixed fee for waste management. Municipalities are responsible for billing and collection of fees (Ernst & Young, 2011). Waste management is financed under the 'polluter pays' principle. Municipal waste management is conducted according to the municipal waste management rules". [7]

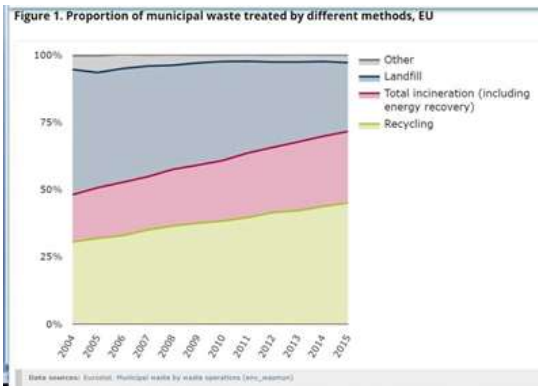
Chart 2. Municipal waste generated per person in 35 European countries (2004 and 2014)



Source: https://www.eea.europa.eu/themes/waste/municipal-waste/municipal-waste-management-across-european-countries#tab-related-interactive-charts

One of the main tools used in many European Union countries is to increase the level of charges for landfill of waste, as well as to increase incineration and, in particular, recycling activities.

Chart 3. Proportion of municipal waste treated by different methods, EU



Source: https://www.eea.europa.eu/airs/2017/resource-efficiency-and-low-carbon-economy/recycling-of-municipal-waste

In order to increase the recycling and reuse processes and to reduce lanfilling with long-term benefits, the European Commission created in December 2015 the „The Circular Economy Package (EC, 2015), includes a number of proposed targets and measures beyond 2020, which can move the EU towards this objective:

- a common EU target of preparing 65 % of municipal waste for reuse and recycling by 2030;
- a common EU target of preparing 75 % of packaging waste for reuse and recycling by 2030;
- a binding landfill target to reduce landfill to a maximum of 10 % of municipal waste by 2030;
- a ban on landfilling of separately collected waste;
- the promotion of economic instruments to discourage landfilling;
- simplified and improved definitions and harmonised calculation methods for recycling rates throughout the EU;
- concrete measures to promote reuse and stimulate industrial symbiosis — turning one industry's by-product into another's raw material;
- economic incentives for producers to put greener products on the market and support recovery and recycling schemes (e.g. for packaging, batteries, electrical and electronic equipment and vehicles)."[14] Among the measures which can lead to this aims, there are: to create an unique market for the fertilizers made from secondary raw materials, to encourage the cooperation between all the economic subjects involved in the innovation process, to encourage a better involvement of the local and national authorities in this process, to stimulate the eco-design of the products, to prevent food waste, to find more efficient ways of transforming waste into energy, as well as to develop the

awareness raising of those that can finance these activities.

"In the current funding period (2014-2020), ex-ante conditions for funding are in place to ensure that new investments in the waste sector are consistent with the waste management plans designed by Member States to meet their recycling targets. The EU support for the 2014-2020 period for innovation, SMEs, low carbon economy and environmental protection amounts to EUR 150 billion and many of these areas are contributing to the achievement of a circular economy." [4]

In Romania, were made in the last year several proposals to revise the legislative framework. The main objectives are to reuse and recycle 60% of municipal waste by 2025 and 65% of it by 2030. A number of laws have been drafted in this area, of which, in recent years: Law no. 249/2015 on how to handle packaging and the packaging waste, with subsequent modifications and additions; Law no. 212/2015 on how to manage vehicles and the end-of-life vehicles; Law no. 217/2017 on the reduction of food waste; GEO no. 5 / 02.04.2015 on waste electrical and electronic equipment.

Table 2. Generation of Municipal Waste, 2010-2014 (Romania)

Types of municipal waste	Amount of municipal waste (tonnes / year)				
	2010	2011	2012	2013	2014
Household waste	14.119,93	9.987,33	11.398,81	20.315,61	20.465,24
collected in the mixture and separated	3.367.325	2.955.517	2.654.525	2.817.947	2.900.695
Similar waste collected in the mixture and separated	1.176.870	917.794	852.591	874.591	902.144
Wastes from gardens and parks	123.514	100.700	3.513,5	4.671,74	3.513,27
	95.223	97.204	70.134	837,26	1.140,05
Wastes from markets	81.773	90.024	691,64	702,87	815,37
	71.270	61.330	54.170	89,82	65,60
Road wastes	343.550	294.478	313.823	391.168	340.948
Generated and uncollected municipal waste	1.250.112	857.650	1.056.687	828.564	687.985
Total of the generated municipal waste	6.343.144	5.216.162	5.044.121	5.070.805	4.956.075

Source:http://www.mmediu.gov.ro/app/webroot/uploads/files/2017-04-27_PNGD_versiunea_1.pdf.pdf – processed by the author

As structure, the largest weights in the municipal waste are occupied by the biological waste, followed by paper and cardboard waste, plastic and glass. Over the past few years, more than 70% of the waste was generated by the population, while the waste in the public services recorded an average share of 9-10%. Compared with the rate of change in GDP, starting with 2012, there was a reduction in the amount of municipal waste, along with the rising of the GDP growth. Waste management is carried out by authorized operators, sanitation, treatment, recycling and disposal operators. Municipal waste management is done through various methods, of which the most important are: material recycling, composting, co-incineration, elimination, storage, incineration. In the last years, the total municipal waste recycling rate averaged around 13% and according to the National Environmental Protection Agency, in 2014, the material recycling rate was about 5% and the rate of composting was about 8%. The Integrated Waste Management projects have been or will be implemented in Romania at the level of most counties.

The waste collection is made on three different categories (paper/cardboard, plastic/metal and glass) at special collection points, there are over 150 sorting stations, numerous composting stations, spread relatively homogeneously in the territory and the deposits exist in all the counties of the country. According to the Law 101/2006 "the sanitation service of the localities is a public service that is organized to meet the needs of the population and is under the control, leadership or coordination of local public administration authorities or intercommunity development associations"

8. Conclusions

The transition to a more efficient and environmentally friendly economy, to a greenest one, must be a general objective of all the economic subjects. Sustainable management strategies should take into consideration all the economic fields, in order to protect the future generations. There are necessary some new economic policy strategies, together with the population awareness and the voluntary action of the private sector. It is particularly important to create national and international regulations and increase the cooperation between all those involved in the implementation of the economic policies.

There are very important the new principles of the green economy and of the sustainable management, which will improve the resource efficiency, will lead to create jobs - most of them in the waste sorting and recycling sector, to save resources by increasing the energy production from waste and by increasing the compost production from organic waste, to reduce greenhouse gas emissions and to reduce the poverty.

The European Union gives a great importan ce at the waste sector and aims to create a unitary strategy, which has the same principles at the level of all the member states regarding the structure and the quantity of the resulting waste, the collection methods and on the costs required by treating them.

In Romania, it exists at the national level a strategy for the waste management, which contains detailed specifications for all the types of waste, having as aim to reduce and prevent the waste generation, to improve waste recycling and qualitative valorization, to reduce the environmental impact of the waste, to improve the existing national databases, to encourage the green investments in

this field and to promote a closer and a better collaboration between the local public administration authorities, the companies and the population.

Regarding the e-waste, one of the most important activities is the recycling and reusing the materials. Thus, the natural resources are conserved by a lower consumption, the emissions of greenhouse gas are reduced and it is encouraged the remanufacturing process, especially for glass, plastic, even some metal components, sometimes with lower costs comparing to the initial process.

Regarding the solid municipal waste, the management activities refers to collecting waste, sorting it into categories, the transport of the waste either in special warehouses or to the companies which are processing them at transfer or firing stations. Because most of the solid municipal waste is eliminated by land filling, the countries must manage the problems related on health and safety for people, animals and groundwater.

The European Commission created in December 2015 the „The Circular Economy Package (EC, 2015), which includes a number of proposed targets and measures beyond 2020 and in Romania this field is regulated in the "National Waste Management Strategy", 2014-2020, elaborated by the Ministry of Environment and Climate Change. The Integrated Waste Management projects have been or will be implemented in Romania at the level of most counties, which aims to reduce waste and to improve the system of waste collection and processing, in order to protect population's health and the environment and biodiversity.

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