Circular Economy Management of WEEE in Italy

Subjects: Urban Studies

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Waste Electrical and Electronic Equipment (WEEE) management is one of the key waste value chains in the EU Circular Action Plan. Electrical and electronic devices are mainly used within urban systems as a consequence of increasing purchasing power, quality of life, and access to grid electricity. The consequent generation of WEEE requires appropriate management, based on urban collection centres and collection and recovery networks, an increase in awareness of the recoverable valuable materials, the need to prevent environmental impacts, and the potential for new jobs in the urban mining sector.

waste electrical and electronic equipment (WEEE) circular economy WEEE recovery

1. Introduction

Waste Electrical and Electronic Equipment (WEEE) management is one of the key waste value chains in the EU Circular Action Plan [1]. As a waste flow, it is growing rapidly, by about 2 Mt annually worldwide [2][3]. This is due to the continuous and fast development of new technologies, decreasing prices, and reduction of the lifetime of EEE—Electrical and Electronic Equipment [4], as well as their limited repair by users [5]. Consumers also appear even more interested in purchasing hi-tech, last generation products [6]. WEEE recovery is a complex series of processes due to their different natures: refrigerators, air conditioners, car batteries, smartphones, computers, electric engines and turbines, photovoltaic modules, and more [7]. Valuable materials are extracted from recovered WEEE, thereby generating circular economy opportunities [1][8]. Yet, the continuous growth of the amount of WEEE is raising relevant environmental and social concerns [3][4][5]. In fact, they should be managed by means of adequate processes and technologies, since the treatment and recovery process in all the needed steps may release toxic substances, such as polybrominated dibenzo-p-dioxins (PBDD), polychlorinated dibenzodioxins (PCDD), dibenzo-p-furans (PCDF), halogen-containing flame retardants, heavy metals, and PM10, among others, that could be sources of potential risks for humans and other species, if improperly managed [7][9]. Plants performing the recovery of metals (e.g., copper and precious metals) from WEEE by means of hydrometallurgical/pyrometallurgical processes are located in Germany, Belgium, Switzerland, Canada, Korea, and Japan [5].

Electrical and electronic devices are mainly used within urban systems as a consequence of increasing purchasing power, quality of life, and access to grid electricity. The consequent generation of WEEE requires appropriate management, based on urban collection centres and collection and recovery networks, an increase in awareness of the recoverable valuable materials, the need to prevent environmental impacts, and the potential for new jobs in

the urban mining sector. In fact, WEEE contain important resources such as iron, steel, aluminium, rare earths (e.g., lithium, cobalt), and precious metals (gold, silver, palladium, and platinum) [10][11], whose valorization would provide relevant benefits for the environment and global society [12][13] in terms of avoided extraction of natural resources and related environmental and social impacts [14][15][16][17]. For example, more than half (60%) of the world supply of cobalt (used in lithium batteries in mobile phones as well as electric car batteries) comes from the Democratic Republic of the Congo, where in many unregulated mines children are employed as miners, being exposed to huge health risks [17][18][19][20].

1.1. The EU WEEE Directives

The perception that WEEE recovery may become a valuable economic business is very recent, dating from 2002, with the adoption of the first WEEE Directive 2002/96/EC, when the EU started to promote formal WEEE collection schemes [21] and the circular economy model in WEEE management [22], with the goal of stimulating appropriate collection, reuse, and recycling. The second WEEE directive became effective on 14 February 2014 with the aim of overcoming some limitations of the previous 2002 Directive, such as the low achievements of WEEE treated in compliance with the Directive, the high amount of WEEE discharged in landfills, illegal WEEE trade to non-EU countries, the presence of a high amount of electric and electronic products manufactured not in compliance with the EU substance restrictions, and finally the very large differences in the collection rates among the EU countries [23]. The second WEEE Directive defined new and more ambitious targets in terms of minimum collection rates to be achieved and improved over time [13]. It is therefore after the second WEEE Directive that most EU countries started thinking in terms of “urban mining” and “sea mining” [24], identifying WEEEs as a major source of valuable materials and metals and promoting circular patterns to support other industrial processes.

The WEEE Directives are applied in many different ways across the EU member states [25], with rather heterogeneous performances in terms of collection and recycling rates [26][27]. Despite the fact that collection rates have grown over time, less than 40% of WEEE is recycled [28]. In order to improve the current state, the Circular Economy Action Plan pointed out the need for consolidating the existing measures and the adoption of new ones on both demand and supply sides by means of specific circular electronic initiatives [29]. These measures are aimed to strengthen the adoption of the circular economy model and its principles in WEEE management and with regard to the promotion of longer product lifetimes, the implementation of eco-design criteria and the right to repair, the durability of chargers, the improvement of collection, and recycling by means of the evaluation of an EU-wide take-back scheme for the return or sell-back of old mobile phones [1].

The Circular Economy Action Plan stresses the relevance for society and the environment to perceive solutions over the whole reverse supply chain and be more ambitious for WEEE management beyond the achievement of minimum collection targets and recycling rates to scale up the other circular practises/principles of the waste hierarchy beyond recycling, such as reuse and repair [24]. Moreover, another important issue is the mapping of the end-of-life flows of WEEE in the EU countries and the availability of information and data on these stages. A recent analysis underlined that more than half (54%) of the WEEE generated in the EU in 2018 was not reported in the WEEE collection system [26]. Concerning the Italian situation, a number of studies have analysed the current

performances of WEEE management systems by focusing on the generation and collection rates per capita and the factors affecting the collection in the whole country and across its regions [22][30][31] and provinces [7].

2. WEEE Management Systems in Italy and Selected European Countries

The first international studies provide evidence that the formal WEEE management system of Italy has much improved the annual collection rates per capita since the year 2008 [8][30][31] thanks to communication campaigns (and also initiatives in schools) aimed at informing students and citizens about the importance of collecting WEEE and how it should be managed and conferred. Further positive factors have been the integration of municipal WEEE collection points (ecological islands) in all the areas for urban waste collection (such as eco-points or eco-stops), the improvements of the national laws transposing the WEEE Directives, as well as the availability of more funds to improve the separated collection [31]. These latter authors compared the performance of the Italian WEEE collection system with the Romanian one from 2008 to 2013. Such a comparison allows us to identify the common factors affecting WEEE collection rates. Among these, communication has been found to be a significant factor, positively affecting WEEE collection by citizens in both countries [31].

Favot and Grassetti [30] showed that the number of collection points, the percentage of females in the population, and the percentage of household waste separately collected positively affect the rate of WEEE collection per capita. In their analysis, these authors estimated that a change of 1% in the presence of collection points determines a change of 0.25% in the collection results. The policy implications derived from the study considered the widening of the collection infrastructure in agreement with the local municipalities. The impact of the collection infrastructure on collection rates has been further explored and expanded with data at province level by several researchers [8][22], who also found that the Italian WEEE management system, although improving the collection performances over time, still shows a territorial divide between the Northern and Southern Italian Provinces as far as collection rates and collection centre infrastructures are concerned. Most of the provinces that perform better are in Northern Italy (Aosta, Bologna, Como, Gorizia, Isernia, and Nuoro), while those performing worst are in Southern Italy (provinces of Agrigento, Barletta-Andria-Trani, Caltanissetta, etc.) [8].

Ibanescu et al. [27] analysed and compared the WEEE management systems of selected European countries (including Germany, Sweden, Romania, Bulgaria, and Italy) in the years between 2007 and 2013 and found that Italy was the country with the highest amount of WEEE transported towards extra-EU countries. The results provide evidence that Germany performed well in all years from 2007 to 2014 in both reuse and WEEE recycling, highlighting that the recycling performances of Romania, Bulgaria, and Italy have substantially improved over the analysed period, increasing the amount of recycled WEEE [27]. Finally, the study also underlines the lack of data in some countries (including Italy) about the reuse of WEEE.

Berežni et al. [32] compared the WEEE management systems of Italy and Serbia, providing a thorough analysis of the weaknesses (institutional framework, organisation of the collection systems, collection, and treatment activities) of both management systems. Both Italy and Serbia share the possibility of WEEE collection in permanent facilities

and at retailer centres. In Serbia, “the old for new” scheme proved to be an efficient instrument to collect unused electrical and electronic equipment from households. The amount collected of WEEE in Italy was higher than that of Serbia (5.14 kg per capita versus 2.78 kg per capita) at the time of the study (year 2018), but still below the European target.

The authors also evaluated and compared the treatment capacities of Italy and Serbia at the single plant level. Two case studies of the recycling plants of Verona (Northern Italy) and Niš (Serbia) were compared by applying the Material Flow Analysis approach. The method provided interesting results for each category of WEEE, improving the understanding and traceability of the treatment stage by showing the original output from the dismantling of the WEEE and their weight compared to the total amount of each WEEE category. The authors conclude by highlighting four main points: (a) the need for reliable data on WEEE management systems, as they are essential for the design of e-waste management strategies; (b) the lack of infrastructure for WEEE treatment and international standards; (c) the adoption of best available technologies to increase the recovery of materials; and finally (d) the need for cooperation between developed and developing countries for improving the wellbeing of producers, recyclers, and users. **Table 1** summarises the existing literature discussed in this section, pointing out the main aspects investigated in each study, some results, and the adopted indicators.

Table 1. Literature dealing with Italian WEEE management systems or comparing them with other European WEEE management systems.

Authors	Subject	Main Results	Adopted Indicators
Berežni et al. [32]	Evaluation and comparison of WEEE collection systems in Italy and Serbia, their treatment performances, mass balance, and technological capacity.	The weaknesses and strengths of both management systems are presented. Lack of data in both countries at some stages of the end-of-life cycle of WEEE. In Italy, e.g., gaps are evidenced in the reporting system and evaluation method of the WEEE put on the market and the WEEE collected. There is no data on the quantity of WEEE delivered in other countries for reuse. Some EEE producers act as free riders, as they are not registered but benefit from the legal collection and treatment system.	• WEEE generated (kg per capita per year); • Number of collection points; • Total WEEE collected (t); • WEEE collection rate (kg per capita per year); • WEEE treated annually (t) at national and plant levels; • % of WEEE treated categories;

Authors	Subject	Main Results	Adopted Indicators
			• No. of employees in plants; • WEEE treated (t per employee per year); • Total no. of pre-treatment facilities.
Bruno et al. [22]	Analysis of the spatial accessibility of citizens to the collection network of WEEE by means of the identification of quantitative indicators that measure the the availability of collection centres and the accessibility of the citizens to these centres in Italy across regions and provinces.	Refers to the availability of indicators of PPR change across regions. It ranges between 2.90 collection centres per 100,000 inhabitants in Southern Italy (Sicily region) and 20.88 in North East Italy (Trentino Alto Adige), with an average national value of 6.81; Relates to accessibility indicators: in the northern regions, 80% of the population is covered between 2.3 (Trentino Alto Adige), and 3.7 km (Piemonte). In the central regions, the distance ranges between 4.4 (Lazio) and 4.9 km (Tuscany); in the southern regions, the distance is between 4.8 (Puglia) and 9.0 km (Calabria).	Availability indicators: • Percentage of served population; • Provider to Population Ratio (PPR) is defined as the total number of collection centres per unit of population. In the study, they are considered a unit of population of 100,000 inhabitants. Accessibility indicators: • Percentage of covered population within 1 to 5 km, 10 km, and 20 km; • Average Accessibility Distance (km) and Maximum Accessibility Distance (km).
Isernia et al. [8]	WEEE collection performances in Italy across Italian provinces and geographical areas. The focus is on the amount of WEEE collected and the distribution of the	Territorial divide across Italian provinces and areas in WEEE collection performances (WEEE collection rate and number of WEEE collection centres). WEEE collection performances are positively correlated with the number of collection centres.	• WEEE collection rate (kg per capita per year); • No. of collection centres;

Authors	Subject	Main Results	Adopted Indicators
	collection centres in the 110 Italian provinces.	A wider diffusion of collection centres and the organisation of events for disseminating the importance of virtuous behaviours by the citizens are key factors for improving WEEE collection performances.	• Distribution of WEEE collection centres by performing state (high, medium, and low) and geographical area.
Ibanescu et al. [27]	Assessment of WEEE management systems profile and sustainability in Germany, Sweden, Italy, Romania, and Bulgaria.	Germany and Sweden were the best-performing countries in collection and recycling in the investigated period. Italy is the great exporter of WEEE outside the EU and still shows inefficiencies in collection. Romania and Bulgaria showed progress by the end of 2014. Developed countries focus more on waste prevention than developing ones.	• WEEE collection rate (kg per capita per year); • % of WEEE collected from EEE put on the market; • Transport of WEEE, inside the country, in other MS or other countries (kg/capita and % of transported waste from collected waste); • Quantity of reused WEEE (t/year); • Quantity of recycled WEEE (t/year); • (%) waste recycled/waste collected; • Carbon footprint of recycled WEEE (t CO_2 eq./year); • GHGs efficiency indicator (total carbon footprint/treated waste).

Authors	Subject	Main Results	Adopted Indicators
Favot and Grassetti [30]	Performance of the WEEE collection system in Italy	The presence of collection points, the percentage of household waste collected separately, and the percentage of females in the population are positively correlated with the collection rate per capita per year. Population density is negatively correlated with the collection rate per capita per year.	• Presence of collection points (number of WEEE collection points per 100,000 inhabitants); • % of households where waste is collected separately; • % of females in the population; • Population density; • WEEE collection rate (kg/per capita per year).
Torretta et al. [31]	WEEE management in Italy and Romania	The involvement of citizens with communication campaigns, the improvement of legislative tools, and more funds have been found to be significant factors in increasing collection rates in both countries since the initial stages of the implementation of the first WEEE Directive.	• WEEE generated (kg per inhabitant per year); • WEEE collection rate (kg per capita per year); • % of WEEE collected during an event (an annual event) across regions; • Amount of WEEE collected (kg) in an event (an annual event) in a city;

1. European Commission. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions a New Circular Economy Action Plan for a Cleaner and More Competitive EUROPE COM/2020/98 Final.

Authors	Subject	Main Results	Adopted Indicators
			• % and amount (t) of materials recovered in WEEE collected in a year; • Share (%) of collected WEEE in a region compared to the total national amount collected; • Annual amount of WEEE collected (t).

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