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Circular economy (CE) assumptions in WEEE management: Polish case study

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Abstract: It is currently emphasised at European level that an essential way to deliver the resource efficiency agenda established under the Europe 2020 Strategy for smart, sustainable and inclusive growth is through moving towards a more circular economy (CE). European Union (EU) documents indicate that greater and sustained improvements of resource efficiency performance can bring large economic benefits. One of the most important advantages of CE systems is to keep the added value in products for as long as possible and eliminate waste. This also applies to the Waste Electrical and Electronic Equipment (WEEE) regulations. The WEEE regulations are intended to reduce the amount of e-waste being disposed of and require EEE producers to pay for its reuse, recycling and recovery. According to Chief Inspectorate of Environmental Protection (GIOS) data, every Pole generates approx. 14 kg of electronic waste annually (in EU – 17 kg/capita annually) and only 4 kg of these waste is selective selected. This indicates that the recovery of raw materials from WEEE, i.e. cell phones, computers, screens, monitors, household goods is one of the largest potential sources of raw materials, but it is wasted. Currently, the management and recovery of materials from WEEE is on the agenda of the EU and many individual countries as its disposal in an improper manner could have a significant impact on the environment. Efficient WEEE management has become a key goal, due to the pollution that could potentially result from the hazardous substances its components contain, but also because reusing its materials can be an important potential supply of resources. It should be mentioned that action on the circular economy is closely linked with key EU priorities, including jobs and growth, the investment agenda, climate and energy, the social agenda and industrial innovation, and with global efforts on sustainable development. The paper presents the importance of economic actors in Poland, such as business and consumers, which play a fundamental role in moving to a more CE model. Their eco-innovative actions support the CE at each step of the value chain – from production to consumption, repair and remanufacturing, waste management, and secondary raw materials that are fed back into the economy. The proposed actions should be consistent with the local, regional, national and European level regulations, which are also presented.

Keywords: circular economy (CE), waste management, waste electrical and electronic equipment (WEEE)

JEL codes: O25, O32, O57

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1. Introduction

Over the last few years, the European Union (EU) has tried to establish the bases for the development of a circular economy (CE) where wastes would be considered as resources and thus used in a more efficient and sustainable way (COM, No. 398, 2014). Different directives were put in place in accordance with this objective and the WEEE Directive (Directive2012/19/EU) on the End of Life (EoL) management of wastes from electric and electronic equipment and the RoHS Directive (Directive2011/65/EU) on the restriction of the use of certain hazardous substances in electrical and electronic equipment are the most relevant examples. Among all the different waste streams, the attention of the European Commission was specially focused on the treatment of WEEEs because of a series of explicit warnings. Moreover, these wastes contain very important components which are on the list of critical raw materials in the EU (COM, No. 297, 2014). WEEEs represent the most wide-ranging source of wastes with the highest growth rate per year in the world (Cucchiella et al., 2015: 51).

Across the world approximately 30–50 million tons of WEEE is disposed of every year, and this quantity is rising by an estimated 3–5% annually. The recovery of expensive and scarce resources such as precious metals and critical materials from these products therefore represents a significant economic opportunity. However, current recycling technologies and business models have limited our ability to recover these resources, and associated recovery rates remain relatively low (ec.europa.eu). Moreover recycling of e-waste is more complex than household solid waste because of the high concentration of toxic compounds prevalent in these appliances.

According to Central Statistical Office (CSO) data, every Pole generates approx. 14 kg of WEEE annually. Only one third of these waste materials go to processing plants designed to dispose of used equipment in a professional manner (Kulczycka and Karaś, 2016). According to the research conducted, Poles leave the rest of the WEEE at home, often as a backup refrigerator or a washing machine, while nearly half of Poles, unfortunately, still throw these strategically important wastes in the rubbish bin (e.g. small e-appliances and mobile phones) (elektrosmieciwsieci.pl).

At the same time, scientists all over the world agree that effective e-waste management can create additional value for society (social, environmental and customer value). Moreover, business and informational benefits are supposed to be obtained for producers of EEE.

The CE issues became extremely important for more advanced e-waste management

because in addition to the increase in business value (part of which can be translated into permanent employment growth), moving towards a CE would lead to a decline in what are referred to as negative external effects on the environment (CO2 emissions, use of freshwater, land use, raw material use etc.).

One of the most ambitious objectives of EU policy is to increase the circularity of products in the electrical and electronic sectors. It will require first of all the strengthening of commercial activities that will enable the reuse of product components, the shared use of products and a higher rate of recycling (Bastein et al., 2013). However, the very first step which should be taken is to set up favourable regulations at the European and Member State level for fast and effective transition of the WEEE sector to CE performance. Only after establishing clear rules can Poland and the European community switch on the new process of e-waste treatment. For the time being one can observe the attempts of the EU authorities to work out and implement some actions which move Member States forward towards circular performance and develop closed loops for more profitable and environmentally friendly manufacturing, refurbishment and remanufacturing processes.

The present research is an attempt to estimate the CE influence on WEEE management at European level and see how a Poland case study appears with regard to increasing the circularity of products and wastes from the electric and electronic sector. It is important to know how favourable national regulations are and what perspectives exist for WEEE management from the CE perspective in Poland.

2. The assumptions of a circular economy and their possible impact on WEEE management at European level

European experience of the implementation of a CE shows that this concept started to be integrated into policy making in Europe in 2008 with Directive 2008/98/EC on waste and further in the Europe 2020 Strategy for smart, sustainable and inclusive growth for 2014-2020. The EU's next step was made by the European Parliament in December 2014. It adopted the communication from the European Commission, "Towards a Circular Economy: a Zero Waste Programme for Europe" (COM, No. 398, 2014). This document emphasised the necessity of innovation in order to, inter alia, boost recycling and prevent the loss of valuable materials;

create jobs and economic growth; show how new business models can emerge; move Europe towards zero-waste through eco-design and industrial symbiosis (Smol et al., 2015:95); and reduce greenhouse emissions and environmental impacts (Koellner et al., 2007: 11). On 2 December 2015, the European Commission put forward a package to support the EU's transition to a CE (COM, No. 614, 2015). The package is composed of a set of both general and material-specific actions. The proposed actions will contribute to 'closing the loop' of product lifecycles through greater recycling and re-use. It will bring benefits for both the environment and the economy. This transition will be supported financially by the European Structural and Investment Funds (ESIF). In total €650 million will come from Horizon 2020, the EU funding programme for research and innovation, and €5.5 billion from structural funds for waste management and investments in the CE at national level. The Investment Plan for Europe (ec.europa.eu) will also play an important role in this context.

The EU's new strategic direction on implementing CE policy has influenced policy making regarding different types of waste. As mentioned above, WEEE represents a very important and one of the most dynamically developing categories of waste, so the implementation of CE principles requires a more coherent policy on the regulation of e-waste at European level. The new policy has shown that the previous basic principles covering the treatment WEEE are not sufficient and new approaches should be identified and implemented.

The core of the CE Package is that it establishes a concrete and ambitious programme of action, with measures covering the whole cycle from production and consumption to waste management and the market for secondary raw materials. According to the CE Package, WEEE legislation should be revised, clear targets for the reduction of waste should be set, and an ambitious and credible long-term path for waste management and recycling (ec.europa.eu) should be established.

The document emphases that new economic incentives should be developed and used for stimulating producers to put greener products on the market and support recovery and recycling schemes inter alia for EEE.

The EU Action Plan for the Circular Economy highlights some priority sectors, which face specific challenges in the context of the CE. "These sectors need to be addressed in a targeted way, to ensure that the interactions between the various phases of the cycle are fully taken into account along the whole value chain" (COM, No. 614, 2015). One of the priority areas

highlighted in the Action Plan is critical raw materials (CRM), because they have great economic importance for the EU. Digital innovation in the EU is significantly dependent on these resources. At the same time the CRM sector is very vulnerable to pricing pressures and in the majority of cases the sector's products cause significant environmental impacts. The products of the sector are mostly represented by EEE which has a low rate of recycling, so the Action Plan emphasises that "increasing the recovery of critical raw materials is one of the challenges that must be addressed in the move to a more circular economy" (COM, No. 614, 2015).

The Action Plan is setting up the following policies for the improvement of the recovery of CRM from WEEE:

EU Member states should:

- provide conditions for the high–quality recycling of electronic wastes (existing legislation encourages recycling but does not have special requirements and restrictions as regards the quality of the recycling process);
- improve the performance of systems for collecting, dismantling and recycling products that contain CRM;
- increase the economic viability of the recycling process through better product design of electronic devices.

At the same time the Action Plan identified the following barriers to effective recovery of CRM from WEEE:

- insufficient information exchange between manufacturers and recyclers of electronic products;
- an absence of recycling standards, and a lack of data for economic operators on the potential for recycled critical raw materials.

Hence, due to problems with data collection and information exchange, the European Commission is going to ensure a coherent and effective approach to these data which will be carried out through better management of key data sources concerning critical raw materials in the circular economy.

The Commission is going to take centralised actions on data collection at the European level and encourage the Member States to revise their regulations on WEEE regarding those most important for CRM recovery.

Due to the special focus on proper data collection for WEEE, some legislative

amendments regarding WEEE were proposed as part of the CE package in order to prepare better regulations. These relate to EU Directive 2012/19/EU on WEEE and regulations connected with the collection of data and Member States' reporting to the European Commission.

The current version of EU Directive 2012/19/EU indicates that all Member states have to send the commission reports at three-year intervals and defines the questionnaire on which it should be based. The proposed amendments contain more specific and broader requirements and restrictions regarding registration, information and reporting on WEEE.

The main proposed changes are presented in the Directive of the European Parliament and of the Council amending Directives 2000/53/EC on end-of-life vehicles, 2006/66/EC on batteries and accumulators and waste batteries and accumulators, and 2012/19/EU on waste electrical and electronic equipment:

1. Member states have to collect and report the data relating to WEEE to the Commission each calendar year.
2. The data reported by Member States should be accompanied by a quality check report.
3. The reports should also contain an assessment of the organisation of the data collection, the sources of the data and the methodology used in Member States as well as the completeness, reliability, timeliness and consistency of that data. The assessment may include specific recommendations for improvement.
4. The EC is going to work out a new format for data reporting.

Such amendments provide a significant step towards a more transparent approach to WEEE data. It opens up new opportunities and perspectives for the creation of standardised and centralised data about WEEE within the EU countries. And it would also be helpful in overcoming the problems which existed with illegal trade in WEEE in Poland and other EU-countries and were recently described in (Kulczycka & Karaś, 2016; euromanuforum.com).

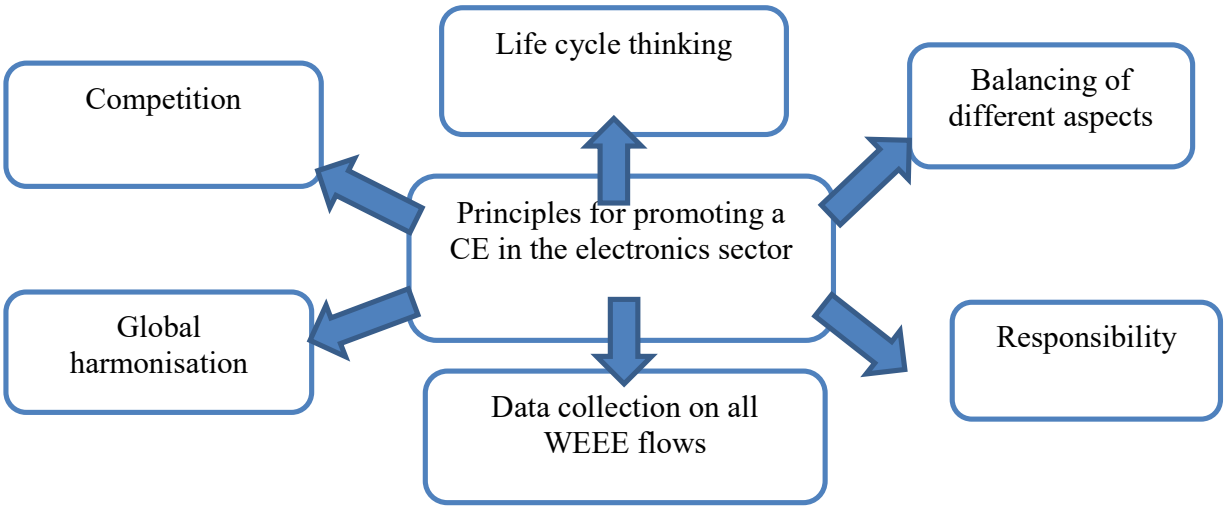
3. Appropriateness of the action plan for greater circularity of WEEE

From the point of view of more effective WEEE management, the main principles which were presented by the DIGITALEUROPE group should be mentioned during assessment of the practical application and adequacy of the Action Plan for the Circular Economy. The group represents the digital technology industry at the EU level. Their members include the world's

largest IT, telecoms and consumer electronics companies and national associations from every part of Europe (60 Corporate members and 37 National Trade Associations).

The group has highlighted the areas that are of particular importance in supporting the further development of the CE in the electronics sector. "The Circular Economy is composed of different building blocks, each of which needs to be promoted in coherence with the overall concept". According to the joint opinion of the group, better policy and specific regulations promoting a CE should be based on a set of coherent principles (Figure 1).

Figure 1. Coherent principles for amendments to WEEE policy and regulations



Source: Author's own scheme based on: (digitaleurope.org).

DIGITALEUROPE (digitaleurope.org) has put the following interpretation on the principles for WEEE:

The Life Cycle Thinking Principle: environmental considerations should be integrated at the stage of product design with the aim of reducing all the relevant potential environmental impacts over its entire life cycle. The consequences resulting from acting on a specific part of the product lifecycle for the overall system should be systematically assessed in order to avoid rebound effects and maximise environmental benefits.

- *Balancing of Different Aspects:* Balance environmental aspects, such as emissions, resource, and potential toxicity aspects, between themselves and also with other aspects such as economic, technical, and safety aspects.

- *Responsibility Principle*: Attribute responsibilities to those actors in the product life cycle that can be held accountable for the results.
- *Data Collection on all WEEE flows*: Proper capture of data on the circular economy is essential for achieving the goals of a circular economy. E.g. in order to measure the collection rate of WEEE correctly, it is vital that Member States collect data on all flows of properly treated WEEE.
- *Competition Principle*: Allow market forces to drive competition in a technology neutral, level playing field, and avoid the creation of monopolies. Features of the CE should not stifle the innovation capacities of the industry. Develop guidance to facilitate collaboration without breaching competition rules.
- *Global Harmonisation Principle*: Foster global harmonisation of environmental policies for products in order to avoid barriers to trade. A closed EU CE is undesirable.

All these principles are significant and were generally reflected into "Closing the loop – An EU action plan for a CE", but there are still a lot of aspects which should be developed to create a better framework for the transition to a circular economy at EU level.

The Action plan also contains statements regarding improvements in the design of electrical and electronic products. The document emphasises the importance of the eco-design of products for consumers and the possibilities available for recovering valuable materials from WEEE (e.g. rare earth elements in electronic devices) for producers and recyclers. The Eco-design Directive 2009/125/EC is noted because these aspects have a great impact on energy-related products. At the present moment the Directive is mainly targeted on energy efficiency, but in the future such aspects of eco-design as reparability, durability, upgradability, recyclability or the identification of certain materials or substances will be taken into account and systematically examined (COM, No. 614, 2015).

4. WEEE in Poland

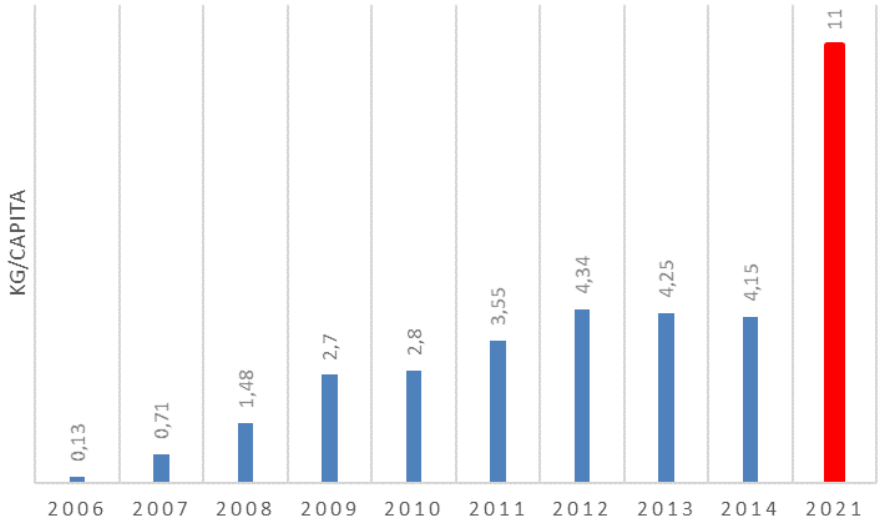
According to data from the Chief Inspectorate of Environmental Protection, the quantity of EEE presented on the market in 2014 was 518 868 tons. The largest element, 51.23% (265 840 tons), of this amount is made up of large household appliances and 10.59% (54 997 tons) is composed of IT and telecommunication equipment. The smallest proportion is automatic dispensers – 0.5%

(2 611 tons).

As for WEEE collection in Poland in 2014, a total of 168 932 tons was collected, including 159 756 tons (94.56%) from households and 9 175 tons (5.44%) from other sources. The largest categories of this waste are composed of large household appliances – 79 562 tons (47.09%) and IT and telecommunication equipment – 24 965 tons (14.72%). The smallest element is composed of wastes of automatic dispensers – 115 tons (0.06%) (CSO, 2015).

The level of WEEE collection in 2014 is 34.74% (size of EEE presented on the market in 2013 in comparison with WEEE collected in 2014). In 2014 there was 4.15 kg of WEEE collected per capita. However, Poland will be obliged to recover 11 kg/person (Cholewa et al., 2014) in 2021. The amounts of WEEE collected in 2006-2014 and the prediction for 2021 are presented in Figure 2. It can be seen from the amount of WEEE collected that the waste mass will be certain to drastically increase in the coming years, so ways of processing and recovery of this waste are becoming increasingly important.

Figure 2. WEEE collected per capita in Poland



Source: (CSO, 2015).

At the same time the total amount of WEEE treated was 162 362 tons (96.11%): the largest category of this waste was large household appliance waste - 80 054 tons (49.30%), while the smallest was automatic dispensers –139 tons (0.08%). Detailed data about WEEE in Poland is

presented in Tables 1 and 2.

Table 1. WEEE in Poland in 2006-2014 [Mg]

WEEE	2006	2007	2008	2009	2010	2011	2012	2013	2014
Introduced	257 726.1	556 470.7	564 179.2	447 725.4	487 108.3	515 666.8	481 230.9	486 180.0	518 868.3
Treated	6 040.1	25 154.7	49 790.1	101 127.8	103 689.8	151 859.0	159 413.7	160 290.1	162 362.8
Collected	5 031.2	27 173.9	56 425.8	108 792.5	112 246.2	143 339.8	157 178.3	171 727.6	168 932.1
Processes other than recycling	349.7	1 538.6	628.8	1 516.1	302.5	816.1	1 033.7	914.8	1 113.9
Recycling	457.1	15 085.6	22 137.5	87 884.4	88 162.5	129 054.2	133 701.2	129 771.0	127 190.1
Reused	0.1	13.9	9.0	823.1	340.3	582.3	795.8	1 139.1	658.0

Source: (Kulczycka & Karaś, 2016:1).

Table 2. WEEE in Poland in 2006-2014 (kg per capita)

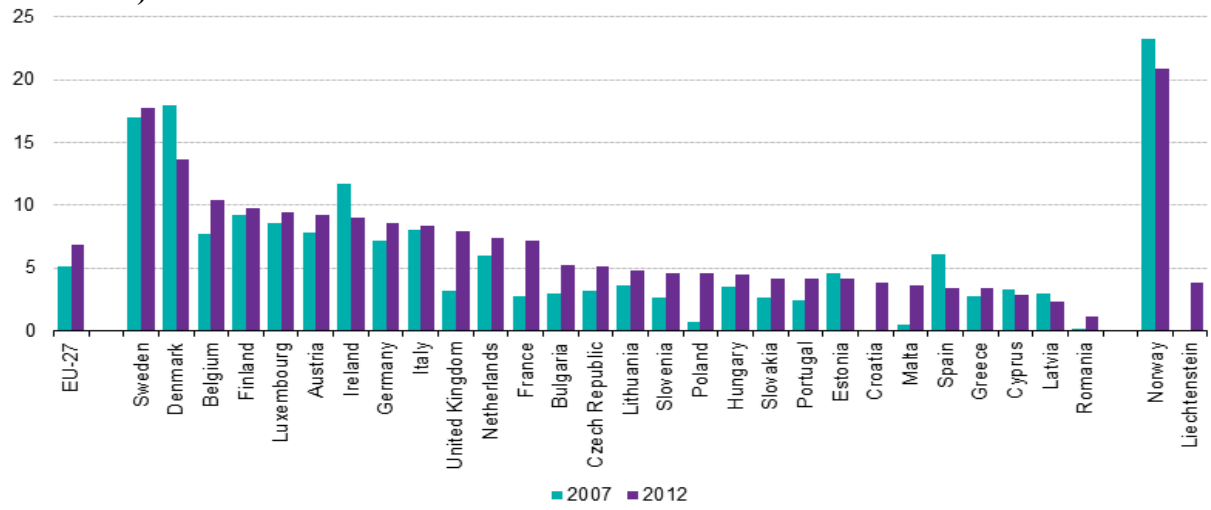
WEEE	2006	2007	2008	2009	2 010	2011	2012	2013	2014
Introduced	6.76	14.60	14.79	11.73	12.75	13.50	12.44	12.63	13.48
Treated	0.16	0.66	1.31	2.65	2.71	3.98	4.12	4.14	4.22
Collected	0.13	0.71	1.48	2.85	2.94	3.75	4.06	4.44	4.39*
Processes other than recycling	0.01	0.04	0.02	0.04	0.01	0.02	0.03	0.02	0.03
Recycling	0.01	0.40	0.58	2.30	2.31	3.38	3.46	3.35	3.31
Reused	0.00	0.00	0.00	0.02	0.01	0.02	0.02	0.03	0.02
Population [thousand people]	38 122	38 116	38 135	38 173	38 204	38 200	38 690	38 496	38 484

* based on General Inspectorate of Environmental Protection Report - 4.15 kg/person

Source: (Kulczycka & Karaś, 2016: 1).

The level of WEEE collection in Poland is still not high enough in comparison with leading European countries. In 2012, the amount of WEEE collected varied considerably across EU Member States, from 1.2 kg per capita in Romania to 17.7 kg per capita in Sweden. Norway collected 20.9 kg per capita. The considerable variation in the amounts collected reflects differences in EEE consumption levels as well as different performance levels in the waste collection schemes in place (Figure 3).

Figure 3. WEEE collected by country in 2007 and 2012 (kg per inhabitant)



Source: (ec.europa.eu/eurostat).

5. WEEE management regulations in Poland and their coherence with the circular economy approach

The law on waste is a branch of environmental protection law in Poland. The national legislator is currently promoting a broad development of this branch of law as a consequence of the EU and international obligations of Poland in this area (Karpus, 2013: 3). The legislation governing the management of WEEE in Poland is listed below:

- Act of 27 April 2001 on environmental protection law (Journal of Law 2001, no 62, item. 67);
- Act of 14 December 2012 on waste (Journal of law 2013, item. 21);
- Act of 1 September 2015 on waste electrical and electronic equipment (Journal of law 2015, item 1688);
- Act of 27 May 2015 amending the Act on the recycling of end of life vehicles and other acts (Journal of Law 2013, item. 933);
- Act of 29 August 2014 amending the Act on batteries and accumulators and some other acts (Journal of Law 2014, item. 1322);
- Regulation of the Minister of Environment of 24 August 2015 on a model certificate of

waste portable batteries or used portable accumulators collected and register certificates of waste portable batteries or used portable accumulators collected (Journal of Law 2015, item. 1329);

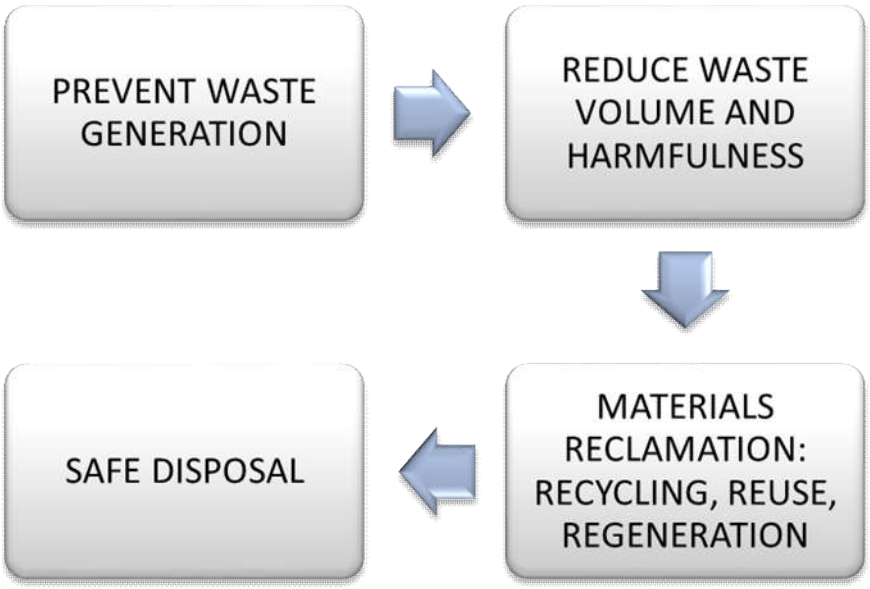
- Regulation of the Minister of the Environment of 21 December 2015 on the model for applications for the registration of a unit introducing equipment and its authorised representative and their method of transfer (Journal of Law 2015, item. 2353);
- Regulation of the Minister of Environment of May 5, 2015 on the report of the efficiency of the recycling process of waste batteries and accumulators (Journal of Law 2015, item. 657);
- Regulation of the Minister of Environment of 16 February 2015 on documents on separate confirmation and recovery and recycling (Journal of Law 2015, item. 278);
- Regulation of the Minister of Environment of 19 January 2015 on the model list of establishments processing waste equipment (Journal of Law 2015, item. 105);
- Regulation of the Minister of Environment of 28 December 2010 on model summary information regarding the data collected in the list of the mass of waste for recycling, energy recovery and disposal, coming from the breaking up of end-of life automobiles (Journal of Law 2010, no. 258, item. 1760);
- Regulation of the Minister of Environment of 10 November 2010 on the annual report on end-of life vehicles (Journal of Law 2010, no. 225, item. 1471);
- Regulation of the Minister of Environment of 12 February 2010 on the model list of plants processing waste batteries or accumulators (Journal of Law 2010, no. 31, item. 164);
- Regulation of the Minister of Environment of 22 December 2009 on the model of the annual report on the type and weight taken for treatment, and on waste batteries and accumulators, as well as about the levels of recycling achieved (Journal of Law 2009, no. 223, item. 1789);
- Regulation of the Minister of Environment of 3 December 2009 on annual levels of collection of waste portable batteries and accumulators (Journal of Law 2009, no. 215, item. 1671);
- Regulation of the Minister of Environment of 17 September 2009 on the model annual report on product charges due to failure to achieve the required level of collection of

waste portable batteries and accumulators, (Journal of Law 2009, no. 160, item. 1274);

- Regulation of the Minister of Environment of 12 May 2009 on the model report of waste from waste equipment (Journal of Law 2009, no. 81, item. 684);
- Regulation of the Minister of Environment of 12 May 2009 on the model report on processed waste equipment (Journal of Law 2009, no. 81, item. 683);
- Regulation of thr Minister of Environment of 12 May 2009 on the model report on the mass of waste equipment collected and transferred to a treatment facility (Journal of Law 2009, no. 81, item. 682);
- Regulation of the Minister of Environment of 22 August 2008 amending the regulation on the model annual report on the amount of the fee due on account of the lack of collection networks of vehicles (Journal of Law 2008, no. 162, item. 1009);

In relation to environmental protection, the umbrella law in the Polish legislation system is the Act on Environmental Protection Law (Journal of Law 2001, no 62, item. 67), which defines the rules for environmental protection and the conditions of use of resources, including the requirements of sustainable development. The Act on Waste (Journal of Law 2013, item. 21) implements the EU WFD as well as 12 other EU Directives mostly on waste management and various waste streams, including WEEE and industrial emissions (Grodzińska-Jurczak et al., 2006: 46). The priority in the Polish national waste management policy is to prevent waste generation or reduce its volume and harmfulness, next is materials reclamation by recycling, reuse, regeneration or other processes leading to the recovery of secondary materials, and finally safe disposal. The hierarchy of waste management is presented in Figure 4. In the first place, the prevention of waste generation is indicated, followed by reducing waste volume and harmfulness. In the next step, materials should be recovered from waste and the last option is safe disposal.

Figure 4. The hierarchy of waste management in Poland



Source: Author's own diagram based on: (Journal of Law 2013, item. 21).

As can be concluded from the above list of regulations, a number of changes were introduced in the WEEE legislation in 2015. The overall principles of proceedings to deal with WEEE are specified in the Act on Waste Electrical and Electronic Equipment of 11 September 2015 (Journal of Laws 2015. Item 1688). This specifies the tools for the protection of the environment and human health by preventing the negative impacts of WEEE generation and management or by limiting these impacts and the overall impacts of resource usage and improving the effectiveness of WEEE usage. Since 1st January 2016, the following changes have been introduced in the act on WEEE:

- All bodies introducing WEEE on the market (not only the equipment designed for households as before) are obliged to achieve minimum annual levels of WEEE collection, amounting to not less than 40% of the average weight of equipment placed on the market, and for light sources and light-emitting diodes (LEDs) - 50% of the average weight of equipment placed on the market.
- 1st January, 2016 - 30th December 2017: 10 groups of equipment are specified (1 - large household appliances, 2 - small household appliances, 3- IT and telecommunication equipment, 4 - consumer equipment and photovoltaic panels, 5 - lighting equipment, 6 -

electrical and electronic tools, except large-scale stationary industrial tools, 7 - toys, leisure and sports equipment, 8 - medical devices, except all implanted and infected devices, 9 - monitor and control equipment, 10 - vending machines, from 1st January 2018: these have been divided into 6 groups of equipment on the basis of the method and cost of processing.

- Large EEE stores, with an area in excess of 400 square meters, must receive small-dimension equipment waste from households without charge, e.g. Tesco has introduced containers for the selective collection of WEEE in all its stores.

The rules introduced in the Polish legislation system are consistent with circular economy principles., New opportunities for increasing circularity of WEEE disposal practices in Poland are possible through proper and everyday implementation of these restrictions and compliance with them.

6. Main perspectives for increasing the circularity of WEEE management in Poland

Currently, Polis bodies are focused on the legal, technological, ecological and market aspects, associated with the recovery of non-energy raw materials from WEEE. These issues are particularly relevant in the light of the changing requirements for recovery and recycling already introduced, as well as planned, in recent strategic documents in Poland. These include the National Plan for the Development of a Low-Carbon Economy as well as the National Strategy for Smart Specialisation. The significant issue in moving to the CE model in WEEE management is the development of new technologies, thanks to which it will be possible to process this waste.

Currently, the technology of WEEE treatment is focused on differences between devices. The automation of the processes is the main goal and should be improved. Better ways of dealing with WEEE could allow for a decrease in the time required for materials segregation in this first step of processing. There is a lack of information for recyclers about the location of parts containing dangerous substances which increases the time needed to break up electronic equipment. Right now the shredder process is the second most problematic step in the pre-treatment chain, particularly when the input is not dismantled. Although this process is designed to facilitate material separation (ferrous material, non-ferrous and plastic) no pure fractions are obtained so that significant quantities of dangerous substances are dispersed to all the fractions.

This causes problems in the subsequent recycling facilities. Therefore, efforts should be made to improve the process technology and to develop alternatives to this process. The exact treatment of WEEE could differ according to the WEEE category and technology used. Some treatment facilities utilise large-scale shredding technologies, whilst other use a disassembly process, which can be manual, automated or a combination of both. The biggest challenge facing WEEE processors is how to effectively remove all of the contaminations from this waste stream, while also recovering the profitable components at high levels of purity in the most cost-effective manner. The conventional WEEE treatment process typically entails the waste being collected and taken to a WEEE recycling facility to be initially hand-dismantled before being put through the shredding process and then smelted either on or offsite. Individual fractions are recovered and the residue is disposed of to landfill. Although some larger processors with high tonnage throughputs may have an onsite smelter, smaller plants with lower tonnage throughputs are forced into outsourcing their smelting. It creates a market for recycled materials. This approach is consistent with the CE model, where nothing is wasted. Whether WEEE recycling can ever be profitable and market driven without the payment of additional recycling fees revolves around how much demand there is for the resulting recycled materials and whether the recycled material can compete on cost with the original manufactured material. Creating a market for the recycled product at a competitive price has been a problem in a number of industries. The fundamental problem with the use of WEEE process technologies is the high costs associated with the processes, resulting in a much higher expenditure on products obtained by these methods than on products obtained using previous methods using fossil raw materials. However, more efficient development and transfer of ecotechnologies, as well as exercising a stronger orientation towards CE could bring benefits for the companies. Currently eco-innovativeness is an important factor owing to which enterprises are competitive on the national and international markets. Some EU policies and instruments already provide tools and incentives in line with the CE model. In each EU country, there are a consultation points where entrepreneurs can obtain information about current programmes supporting the development of eco-technologies under the EU Research and Innovation Programme (Horizon 2020) and its instruments, including the European Institute of Innovation and Technology, the European Structural and Investment Funds, the Eco-innovation Action Plan, the Green Action Plan for small and medium-sized enterprises (SMEs), and the European Consumer Agenda (COM 398, 2014). The environmentally friendly projects receiving

financial support could be both investment/modernisation projects of WEEE recycling and materials recovery. The enterprises will obtain the confidence and capacity to move to CE solutions. An important issue for the potential beneficiaries from the economic and environmental point of view is that they are required to take into account the whole life cycle in investment projects. Initially these solutions will be supported by European funds at the national and international level in the new programming period 2014-2020. The CE strategy includes the integration of environmental, technological, economic and social goals, particularly in EEE production, consumption and waste management. It is essential to plan, develop and disseminate the use of WEEE recycling technologies and to implement systematic sustainable market strategies to develop more favourable consumption trends.

7. Conclusion

As a consequence of EU restrictions, in 2015 Poland developed and implemented detailed guidance documents for those involved in the WEEE chain to help clarify and expedite inspections, monitoring, and reporting activities. The adopted law on waste set clear targets for the proper disposal of WEEE and established an ambitious and credible long-term path for waste management and recycling. To improve the environmental management of WEEE and to contribute to a CE and enhance resource efficiency the improvement of collection, treatment and recycling of EEE at the end of its life is essential. The management and recovery of materials from WEEE is on the agenda of the EU and many individual countries as its improper disposal could have a significant impact on the environment. Efficient WEEE management has become a key goal due to the pollution that could potentially result from the hazardous substances its components contain, but also because reusing its materials can be an important potential supply of resources. The eco-innovative actions of stakeholders support the CE in each step of the value chain – from production to consumption, repair and remanufacturing, waste management, and secondary raw materials that are fed back into the economy. The proposed actions should be consistent with local, regional, national and European level regulations.

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Założenia gospodarki o obiegu zamkniętym w zarządzaniu ZSEE w Polsce

Streszczenie

Zgodnie z założeniami Unii Europjeksiej (UE), przechodzenie na gospodarkę o obiegu zamkniętym (ang. circular economy - CE) jest niezbędne do realizacji inicjatywy na rzecz zasobooszczędności przewidzianej w ramach strategii „Europa 2020" na rzecz inteligentnego i zrównoważonego rozwoju sprzyjającego włączeniu społecznemu. UE wskazuje, iż dalsza trwała poprawa w zakresie zasobooszczędności jest osiągalna i może przynieść znaczne korzyści gospodarcze. W systemach gospodarki o obiegu zamkniętym istnieje możliwość zachowania jak najdłużej wartości dodanej produktów i eliminacja odpadów. Założenia te dotyczą także kwestii związanych z zarządzaniem zużytym sprzętem elektrycznym i elektronicznym (ZSEE). Znowelizowane przepisy dotyczące ZSEE mają na celu zmniejszenie ilości odpadów kierowanych na składowiska oraz wymuszają od producentów podjęcia działań w zakresie ich unieszkodliwiania - ponownego wykorzystania, recyklingu i odzysku. W Polsce wytwarzanych jest obecnie ok. 14 kg ZSEE/ 1osobę rocznie, z czego jedynie 4 kg ZSEE/ 1 osobę jest zbieranych selektywnie. Oznacza to, że jedno z największych potencjalnych źródeł surowców (odzysk z ZSEE, tj. telefonów komórkowych, komputerów, ekranów, monitorów, artykułów gospodarstwa domowego) jest niewykorzystane. Z uwagi na fakt, iż europejska dyrektywa wymaga od państw członkowskich UE powtórnego wykorzystania oraz odzysku i recyklingu komponentów sprzętów elektrycznych i elektronicznych, zakłada się poprawę w wykorzystaniu odpadów w charakterze zasobów. W pracy omówiono kluczowe znaczenie podmiotów gospodarczych i konsumentów w przechodzeniu na gospodarkę o obiegu zamkniętym, w tym ich eko-innowacyjne działania wspierające rozwój CE na każdym etapie łańcucha wartości - od produkcji do konsumpcji, naprawy i regeneracji, gospodarki odpadami i surowcami wtórnymi wprowadzanymi z powrotem do gospodarki. Proponowane działania powinny być zgodne we wskazanymi lokalnymi, regionalnymi, krajowymi i europejskimi przepisami.

***Słowa kluczowe**:* gospodarka o obiegu zamkniętym, zarządzanie odpadami, zarządzanie zużytym sprzętem elektrycznym i elektornicznym (ZSEE)