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ORIGINAL PAPER

Prospects of legal regulation in the field of electronic waste management in the context of a circular economy

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Abstract
The purpose of the study is to identify the existing problems in the field of electronic waste management and to consider the possibilities and prospects of their legislative regulation. The method of political and legal analysis and the legal forecasting method made it possible to trace the evolution of international legislation in the field of management and disposal of electronic waste, the dynamics of its development, and make a forecast regarding possible vectors of its development. The research aims to answer the question of what are the existing problems in the field of e-waste management within their interdependence with the "circular economy" concept and what are the possibilities and prospects for their legislative regulation. The study analyzes the perspective directions of the formation of international policy and legal regulation in the field of electronic equipment waste management and disposal. The issues of the transfer of electronic waste to developing countries, the difficulties associated with the lack of proper legal regulation and enforcement in these countries, the protection of the labor rights of workers in the field of electronic waste disposal were considered. In addition, the practice of application and prospects for introducing into the legislation the principle of extended producer responsibility are considered. This study is intended to contribute to a better understanding of current trends in the field of electronic waste management in order to demonstrate the need to improve the existing international legal framework, adapt it to modern challenges and show the main directions of its changes.

Keywords Basel Convention · Electronic equipment · Legislation · Linear economy · Processing · Recycling

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1 Introduction

The implementation of activities with the least negative effect on the environment and society causes a growing interest in the issue of recycling electronic devices (Abdimomynova, Kolpak, Doskaliyeva, Stepanova and Prasolov 2019; Khabrieva and Chernogor 2018). At the same time, modern policies for the processing and disposal of electronic equipment are often closely linked to a broader concept—the concept of a circular economy (Mazahir, Verter, Boyaci and Van Wassenhove 2019).

A circular economy paradigm is based on the fact that planet reserves are not unlimited and humankind is forced to abandon the linear model described as "take, make, dispose" model of production (Ryder and Zhao 2019). The concept of a circular economy is based on the ideas of K. Boulding, who argued that in order to guarantee human life on Earth in the long term, circular economy in a global context is inevitable (Geisendorf and Pietrulla 2018). A circular economy is an economy in which the cost of products, materials and resources lasts as long as possible, minimizing the loss and use of resources (European Commission 2017). In other words, it is a system that allows regenerating resources, i.e., a system in which used primary resources and waste, emissions and energy losses are minimized by improving technological processes (Alizade, Volevodz and Tatarinov 2019). This can be achieved through advanced design, maintenance, repair, reuse, restoration and disposal. This contrasts with the linear economy, which is a "take, make, dispose" production model (Tsindeliani 2019).

On December 2, 2015, the European Commission adopted the EU circular economy action plan. Its goal is to stimulate the transition to a circular economy, increase global competition, ensure sustainable economic growth and create new jobs. The EU circular economy package contains measures applicable to the entire product life cycle: from production and consumption to waste disposal—there are 54 different activities that can benefit both the environment and the economy, while also contributing to social well-being (European Commission 2017).

In 2018, the European Commission published a mini-package of the circular economy, including the so-called Plastic Strategy (Circular Economy 2018). It is designed to fundamentally change the principles of the development, production, use and return to circulation of plastic and plastic products. According to this strategy, by 2030 all types of plastic packaging will have to be recycled, the consumption of single-use plastic will be reduced, and the intentional consumption of microplastics will be limited. Based on the strategy, the return to circulation will become profitable for entrepreneurs, the amount of plastic waste and garbage at sea will be reduced, investments and innovations will receive support. In addition, the package includes 10 indicators for monitoring the circular economy, which will help assess successes, and a directive to reduce the number of plastic products. A directive contains various measures for disposable plastic products, taking into account both the behavior and the needs of consumers and the capabilities of enterprises.

In 2019, a report was compiled on the implementation of the European Commission's circular economy action plan, which describes the results of the implementation of 54 measures over the past 4 years. The report also summarizes the main achievements in the implementation of the action plan, as well as future challenges in the formation of the economy and the transition to a climate-neutral circular economy (Circular Economy 2020). The usual approach to the production, use and disposal of products is gradually changing. Instead, within the framework of the circular economy model,

society is looking for solutions that maximize resource efficiency and minimize losses during the life cycle of the product and the economy as a whole.

A circular economy implies waste-free production and the most efficient use of resources. At the end of each product's life cycle, the raw materials used to create this product are processed or redistributed. Secondary processing of products should significantly reduce the need for resources and minimize environmental pollution. According to Accenture consulting company, the global economy can not only improve climate conditions (Lukyanets, Nguen, Ryazantsev, Tikunov and Pham 2015), but also save $4.5 trillion by eliminating waste (Musin 2019).

E-waste, a relatively recent type of waste, includes mobile phones, computer equipment, household appliances, televisions, electronic boards, chips, electronic toys, etc. The first international recognition of e-waste as a high-priority waste stream was in 2002 under the leadership of the United Nations (United Nations Environment Programme 2017). Besides, Solving the E-waste Problem (StEP) initiative regularly operates under the auspices of the United Nations University (UNU). However, in the past, during these key political events, there was no reliable scientific data on the risks associated with e-waste, and the corresponding technical capacity necessary to work with data in the context of rapidly growing rates of e-waste production was not used.

Policy implementation was further complicated by a number of challenges, including the transnational movement of electronic waste, employment and labor rights issues, the desire to support humanitarian organizations providing used electronics to developing countries, and concerns about environmental pollution and human health risks (Awasthi, Li, Koh and Ogunseitan 2019).

The issue of introducing a circular economy is inextricably linked with the concept of sustainable development. The 8 and 12 United Nations Sustainable Development Goals (SDGs) provide the basis for exploring the various aspects of collaboration needed to transform informal e-waste management. In line with the principles of a circular economy, the SDGs encourage policies that can create jobs through partnerships with public and private enterprises, diversification of high-value-added and labor-intensive sectors, protection of labor rights, as well as the creation of safe and secure working conditions for workers, including minimizing the impact on the environment and human health. The United Nations Environment Programme (UNEP) has stated that the information and communications technology (ICT) sector, consisting mainly of electronic products, offers many opportunities and challenges for sustainable development. E-waste is a serious environmental problem, although it is also considered as a secondary resource material that can satisfy the need for raw materials for the production of new products, if justified by economic considerations (Awasthi, Li, Koh and Ogunseitan 2019).

The main problem associated with electronic waste, as in the field of any other waste, is environmental pollution. However, in the case of high-tech waste, the problem is more acute, since, for the most part, they are toxic. Poisonous substances fall into groundwater, causing irreparable damage to the health of people, animals, plants.

Another problem is the growing consumption culture, associated with the frequency of buying new electronic devices driven by advertising. Scientists have estimated that a person with an average income, depending on the country, uses a mobile phone from 18 to 24 months, and then buys the next one. Fashionable novelties are coming out more often, technologies are developing faster, the variety of electronic devices is also growing rapidly (Bayanova et al. 2019).

Cheap and low-quality electronics also significantly increase the amount of waste. Such technology often breaks down and requires the replacement of electronic elements, or it

quickly becomes unusable and thrown away. It is also important that 30% of electronic materials simply cannot be recycled, and given the amount of such waste, this is a big problem. According to a January 2019 World Economic Forum report, e-waste is currently the fastest growing waste stream in the world. Thus, in 2018, the volume of e-waste amounted to approximately 48.5 million tons (Leblank 2019). In Asia, e-waste is growing rapidly, with China taking the lead (Leahy 2017).

According to a study conducted in 12 countries of East and Southeast Asia in 2015, 16 million tons of electronic waste was produced containing both toxic and valuable materials—which was 63% more than in the previous 5 years. In China, only in 2015, the amount of discarded televisions, telephones, computers, monitors, electronic toys and small household appliances increased by 6.7 million tons. This is 107% more than in the previous 5 years (Leahy 2017).

According to Greenpeace, it is expected that the amount of e-waste in China by 2030 will increase to 27.22 million tons (Rick 2019). At the same time, it is not the e-waste itself but its uncontrolled distribution, improper handling and disposal that pose a significant problem. Thus, in accordance with the provisions of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (hereinafter—Basel Convention), states must ensure the proper disposal of failed electronics. However, the question of determining what is waste and what is not and, accordingly, what is intended for reuse, has been the subject of discussion in the context of the Basel Convention for a long period of time.

In countries where a waste management system is lacking or not yet sufficiently developed, e-waste is typically disposed of, incinerated, sold or recycled using low-quality technologies (Baldé, Forti, Gray, Kuehr and Stegmann 2017). In countries with targeted policies and legislation on e-waste and with developed infrastructure, e-waste that is not recorded as collected and processed by official recycling systems is often disposed of with ordinary household waste. In the EU, which has traditionally focused on environmental issues, only 35% of e-waste ends up in official records of waste collection and recycling systems (UNECE 2017). A significant amount is also processed by metal processing companies and waste traders or shipped to countries with economies in transition and developing countries, usually as second-hand items that are recyclable. The key problem here is that a significant part of such waste is virtually non-reusable and many developing countries lack adequate strategies and legislation to create the necessary infrastructure to ensure the environmentally sound management of electronic waste; waste management and disposal are often not regulated. According to a study conducted in 2015–2016, EU member states imported to Nigeria about 77% of the used electrical and electronic equipment, China and the USA–7.3% each. One of the largest informal landfills and recycling sites in Africa, around 215,000 tons of e-waste, is located in the Agbogbloshie region of Ghana (WHO Regional Office for Europe 2018). For this reason, resolving this issue is currently considered the most important task for a number of international organizations, including the International Telecommunication Union (ITU), the International Labor Organization (ILO), UNEP and other members of E-Waste Coalition (Ryder and Zhao 2019).

Despite the fact that there is a lot of researches devoted to the issue of e-waste considering it from different prospects, it can be argued that the issue of determining the perspectives for the development of legislation is considered only partially and in the general context (Nnorom and Osibanjo 2008; Robinson 2009). Most of the works on this topic are devoted to the environmental and economic-political component of the issue (Geisendorf and Pietrulla 2018). However, the modern scientific researches predominantly do not consider the issue from the point of view of international law–namely legal forecasting. In

addition, those current studies in the field of e-waste management that address the issue in a legal context do not provide a holistic view of the problem. This study is intended to provide a comprehensive picture of what the prospects for legislative regulation in the field of electronic waste management exist. At the same time, the author gives an opinion on the improvement of some mechanisms in the field of legislative regulation of these issues. With the use of the method of political and legal analysis and the legal forecasting method, the research aims to identify the existing problems in the field of e-waste management within the correlation the "circular economy" concept and to give an answer to the question concerning the possibilities and prospects for their legislative regulation.

The relevance of the topic of this study is based on the increasing attention of the world community to the problems of management and disposal of electronic waste, the need to anticipate possible scenarios for the development of policies and legislative regulation in this area at different levels. The world community is also concerned with environmental safety issues and, accordingly, the realization of the right to safe and a favorable environment, enshrined in the laws of most countries of the world.

Limited research on this topic is due to dynamic changes in international law and national laws of different countries. In this regard, there is a need to update the existing developments in this field of research. The basis of the study is a review and synthesis of the existing issues, as well as a review and determination of trends and prospects in the field of international regulation of electronic waste disposal.

2 Materials and methods

This study is based on the analysis of international legislation in the field of electronic waste management, analytical materials of international organizations, in particular, reports, information notes, conference materials. During the study, the method of political and legal analysis and the legal forecasting method were used. Using these methods, there was carried out an analysis of legislative changes in the existing regulatory field, trends in the sphere of scientific researches, the integration of scientific ideas into legislative regulations. The analysis of the existing legislative base is limited to the study of international legislation, while the national regulation of the management and disposal of electronic waste is considered only in the context of international practice.

It should be expected that the development of legal regulation in the field of electronic waste disposal in the coming years (taking into account the growing production of electronic devices and the growing level of international trade) will become increasingly significant. Despite the rather voluminous and effective regulatory framework in this matter and considerable attention from international organizations and national governments to the problem of managing and disposing of electronic waste, the study confirms the fact that, nevertheless, many legal relations in this area remain unresolved. However, one should note the high interest in this issue in the scientific community, as well as take into account the awareness of the subjects of power in the above issues and their willingness to make important political decisions. In practical terms, this means that there is an important prerequisite for the development of new regulatory acts at the national and international levels, designed to address in more detail the issues of electronic waste disposal.

When conducting the study, the attention was paid to the current regulatory framework in matters of electronic waste operations. Electronic waste is subject to the Basel Convention, which prohibits the transport of hazardous wastes between developed and developing

countries. However, compliance is difficult to monitor, since there is no reliable data on the volume of exported electrical or electronic equipment that would be unambiguously classified as electronic waste. Moreover, some analysts argue that current international law does not contribute to accounting for transboundary flows of electronic waste and thus limits the potential for eliminating impacts on vulnerable populations.

Special attention should be paid to EU legislation, as one of the main subjects of legislative initiatives in the international arena. The following key components of the EU regulatory framework related to e-waste can be identified:

- Waste Electrical and Electronic Equipment Directive (WEEE) (2002/96/EC), aimed at preventing the generation of electronic waste, promoting the reuse, recycling and other forms of recovery, as well as improving the environmental life cycle of the above equipment;
- Waste Electrical and Electronic Equipment Directive (WEEE) (2012/19/EU) (revised);
- European Commission Regulation 1013/2006 on waste transport, which includes guidelines for the transport of waste electrical and electronic equipment;
- Directive 2005/32/EC as of July 6, 2005, "Establishing a framework for the setting of eco-design requirements for energy-using products";
- Restriction of Hazardous Substances Directive (RoHS) (2002/95/EC and revision 2011/65/EU), which aims to protect human health and the environmentally friendly recycling and disposal of electronic waste;
- Regulation No 1907/2006 of the European Parliament and Council as of December 18, 2006, concerning Registration, Evaluation, Authorization and Restriction of Chemicals (REACH), which entered into force in 2007, aimed at ensuring a high level of protection of human health and the environment from the risks associated with chemicals;
- The EU Waste Framework Directive (2008/98/EC), which provides a legislative framework for the collection, transport and disposal of waste (WHO Regional Office for Europe 2018).

With regard to EU countries, it is worth noting that the European Union (EU) Directive 2002/96/EC on the disposal of electrical and electronic equipment (WEEE) is the most well-known legal act, according to which original equipment manufacturers (OEM) are responsible for the collection and disposal of expired products (European Union 2009). This Directive was often criticized for overlooking the potential for reuse of recyclable products. However, the original WEEE Directive did not provide any specific incentive for reuse of the product. This fact was taken into account when developing the WEEE Directive 2012/19/EU (revised), adopted in July 2012. The latter recognizes the reuse of the product as important as recycling, stating that disposal, preparation for reuse and processing of WEEE should be aimed at achieving the objectives set out in this Directive (Mazahir, Verter, Boyaci and Van Wassenhove 2019).

It should be noted that despite the fact that much effort has been made to identify weaknesses of the WEEE Directive, the scientific literature does not have sufficient information regarding the comparative environmental and economic indicators of Directive 2002/96/EC, Directive 2012/19/EU and proposed amendments to the last one (Mazahir, Verter, Boyaci and Van Wassenhove 2019). As one of such indicators there can be considered an ITU global target: in 2018, ITU Member States set an ITU global e-waste target for 2023 to increase the global e-waste recycling rate to 30%, and the share of the states with e-waste legislation to 50%. They also pledged to reduce the volume of redundant e-waste by 50% (ITU 2020).

Currently, only 78 out of 193 countries of the world (40% of the total) have policy, legislation or technical regulation regarding e-waste (ITU 2020). As for the issues of national legislation directly, it's worth mentioning that the legislation on e-waste is valid in a total of 67 countries. As a rule, acts of national legislation contain provisions based on the concept of extended producer responsibility, when a small fee for new electronic devices subsidizes the collection and disposal of expired goods (PACE 2019).

However, in many countries, there is no national e-waste legislation. In many regions of Africa, Latin America or Southeast Asia, electronic waste does not always occupy an important place on the political agenda and often it is not properly managed. When it comes to exporting electronic waste to developing countries, it is governed by the Basel Convention, which has been ratified by 188 countries; other similar conventions exist at the regional level. At the same time, despite the adopted convention, large volumes of e-waste continue to be transported illegally. The difference in enforcing conventions and transposing e-waste legislation globally means that the regulatory environment can be complex and fragmented (PACE 2019).

In the USA, which are not parties to the Basel Convention, there is national legislation on the disposal of electronic waste. However, only 26 states have committed themselves to recycling electronic waste. Almost all of these states require the manufacturer to take responsibility for financing recycling. California, by contrast, uses recycling fees paid by consumers to support the disposal of old televisions, computer monitors and DVD players. It should be noted that there is no law on the disposal of electronics at the federal level (Leblank 2019). In the USA, consumer electronic products included in the Environmental Protection Agency series of reports are electronic products used in homes and businesses and are classified as video, audio and information products. Thus, many electrical and electronic appliances, such as all refrigeration and freezing equipment, most equipment, such as dishwashers and dryers, small equipment and lamps are not included in the US regulatory area (Kumar and Singh 2019).

National e-waste policies and legislation play an important role in the management and disposal of e-waste, as they establish standards and control measures to manage the actions of stakeholders related to e-waste in the public and private sectors. In addition, these policies and laws should define a workable and equitable financial and economic model that must be sustainable and functioning properly. Therefore, it is imperative that policy makers, along with stakeholders, create a financial model to cover collection points and logistics, as well as physical processing itself. In addition, it is necessary to raise awareness of the proposed system and ensure that interested parties fulfill their obligations and configure IT systems to receive and process data. In addition, the types of e-waste covered by law vary significantly across countries. It also explains the difficulty in coordinating the amount of collected and recycled e-waste. Many of the countries that have already enacted e-waste legislation can still increase coverage to include all products.

In the long term, the introduction of circular economy models should significantly reduce the impact of e-waste on the environment and health. This problem can be solved by significantly increasing the reuse and recycling of related equipment. Such measures will reduce the share of devices with an expiring lifetime, the components of which will be recycled. To this end, proposals for amendments to the RoHS Directive were included in the report on the implementation of the EU Action Plan for the circular economy in order to increase the period of use of electrical and electronic equipment before the end of their service life and disposal. Thus, the formation of additional hazardous waste can be avoided (WHO Regional Office for Europe 2018). Considering the foregoing, one of the promising

scenarios for developments in the field of legal regulation in this area is the introduction of amendments to the current version of the RoHS Directive.

3 Results

Prospects for reforming current legislation should be considered in the context of the existing trends in the management and disposal of electronic waste. As noted in the present study, over the past few years, electronic waste has entered the political agenda in many countries, and the number of participants and project activities has increased significantly. Interest in used equipment is projected to increase as demand for sustainable development grows, but at the same time, responsibility for product manufacturing continues to grow. Manufacturers focus on continually improving their new products, mainly to ensure commercial success and survival, and they continue to develop more environmentally friendly products that have lower carbon footprint and a higher degree of extraction of raw materials from the processing of waste products (Goodship, Stevels and Huisman 2019).

Currently, special attention is paid to the development of a product design called design-for-disassembly. The latter was originally intended to reduce costs so that products could be easily sorted into main groups of materials for subsequent processing (plastics, metals, precious metals, etc.). The design-for-disassembly approach also facilitates the refinement process through faster and easier replacement of components and assemblies, for example, through the use of plastic clamps rather than parts that are screwed with metal screws. For those manufacturers who are actively engaged in the supply of used equipment, such activities will continue to be a small unambiguous percentage of their total revenue from equipment sales. Thus, competition will continue to focus on the design and manufacture of increasingly sophisticated new products.

As is the case with WEEE legislation in the EU, manufacturers will only act (and bear the cost) if compliance is required. Currently, WEEE legislation covers liability for electrical and electronic equipment only if it is recognized and treated as waste, but future extensions to this legislation may go to that part of the product life cycle when the equipment is used or reused. Legislation on recycled electrical and electronic equipment can provide manufacturers with goals to contribute to sustainability of raw materials through reuse or expanded use of previously manufactured products (Goodship, Stevels and Huisman 2019).

The trends of the recent years indicate that the growth in production and sales of electric vehicles, driven by ideas to decarbonize personal vehicles to meet the global goals of reducing greenhouse gas emissions and improving air quality in urban centers, must revolutionize the automotive industry. In 2017, sales of electric vehicles worldwide exceeded one million vehicles per year for the first time. Based on the average technical characteristics of car batteries, it can be assumed that at the end of the life of these vehicles, the resulting packaging waste will include about 250,000 tons and 0.5 million m^3 of untreated packaging waste (Harper, Sommerville, Kendrick, Driscoll, Slater, Stolkin, et al. 2019). Despite the fact that reuse and ongoing recycling processes may divert some of this waste away from the landfill, the cumulative burden of electric vehicles waste is significant given the growth trajectory of the electric vehicles market. This waste presents a number of serious and widespread problems, both in terms of storing batteries before reuse or final disposal, and in the manual testing and dismantling processes required for any of them, and in chemical separation processes that recycling entails (Harper, Sommerville, Kendrick, Driscoll, Slater, Stolkin, et al. 2019).

At the same time, there should be noted that factor that large concentrations of waste—both for the purpose of repair, processing, dismantling and final disposal—can create serious problems for the environment. For instance, a warehouse tire fire in Powys, Wales had been smoldering for 15 years from 1989 to 2004. Since the electrode materials in LIB are much more reactive (as batteries generate energy through a chemical reaction) than rubber tires, without a proactive and cost-effective LIB waste management strategy they potentially pose more serious hazards associated with the accumulation of end-of-life LIBs (Doughty and Roth 2012). A landmark case, when the safe disposal of LIB question was raised was an incident in 2016 when Samsung suspended sales and asked customers around the world to stop using Galaxy Note 7 smartphones after a series of battery explosions that could have caused harm not only to users, but also cause irreparable damage to the company itself. The situation with defective Galaxy Note 7 has caused high concern among environmentalists, as Samsung initially did not announce its plan for the safe disposal of smartphones (Greenpeace 2016). However, in the aftermath, under the influence of pressure from NGO's and individual petitions, Samsung made a commitment to recycle the millions of recalled Galaxy Note 7 phones (Greenpeace 2017).

A Times magazine article "The World Has an E-Waste Problem" quotes Kyle Wiens, founder of iFixit, a company that publishes do-it-yourself repair guides. "Our products today do not last as long as they used to, and it is a strategy by manufacturers to force us into shorter and shorter upgrade cycles," said Kyle Wiens. At the same time, the importance of switching to extended producer responsibility is noted in the article. Thus, the authors write that, according to some environmental groups, multibillion-dollar companies such as Apple and Samsung should bear the cost of processing the devices they sell (Semuels and Fresno 2019). The idea that it is necessary to lay the responsibility for the disposal of products on the enterprises producing them poses the following question. Is this idea achievable in terms of creating the necessary legislative mechanisms for its implementation and what are the real scenarios for the management of electronic waste? The United Nations University (UNU) is considering four scenarios for e-waste management.

The first, most preferable, is the controlled collection of electronic waste from the population, when manufacturers and sellers of electronics are involved in the process, as well as local authorities. Each item of equipment—precious metals, plastic, chemical elements of batteries and so on—is processed separately and then returned to production. In this case, a chain of actions can be implemented:

– use (users from all sectors of the economy—private, industrial, commercial, institutional);
– primary collection (household collection, municipal collection, waste collectors, professional installers);
– waste consolidation (accumulation of volumes in places of consolidation);
– processing by type of materials and components (processing, extraction and disposal of hazardous waste);
– extraction of useful materials and return to circulation as secondary resources.

The second scenario is the disposal of electronic waste along with other solid household waste. The danger of this approach is that the equipment either contains toxic elements that fall into landfills and poison the environment, or, if improperly processed, emit toxic compounds.

The third scenario is the collection of e-waste by private companies. In this case, private companies can not only hand over the equipment for processing, but also after sale to resell it to third world countries, or on the secondary market in their country.

The fourth scenario, probably the worst of the scenarios, is the purchase of electronic waste by private companies and their subsequent disposal in third world countries. The equipment is disassembled into spare parts, and non-working residues are thrown into a landfill, polluting the environment (Baldé, Forti, Gray, Kuehr and Stegmann 2017).

As already noted, at present, numerous specialized acts of the national legislation of different states in the field of electronics management and recycling contain provisions based on the concept of extended producer responsibility. Thus, the concept of "extended producer responsibility" (EPR) arose in academic circles in the early 1990s. As a rule, it is considered as a political principle, according to which manufacturers should take responsibility for all stages of the product life cycle, including after-service management.

EPR principle implies the possibility of consolidating responsibility either on an individual basis, when manufacturers are responsible for their products, or on a collective basis, when manufacturers of the same type or category of products share responsibility for such products management at the end of their service life. The implementation of a system as close as possible to that based on the individual responsibility of the manufacturer (IRM) can help stimulate improved product design, since the manufacturer is interested in obtaining the benefits provided by the corresponding improvement. At the same time, the complexity of such a system still hindered its development, as a result of which preference was given to policies and legislation providing for collective rather than individual responsibility (Baldé, Forti, Gray, Kuehr and Stegmann 2017).

It should be noted that the legislation on EPR applies to EU countries, in addition, the relevant legislation is valid in Norway, Switzerland, Iceland, provisions regarding EPR are contained in the legislative acts of some countries of South America (Baldé, Forti, Gray, Kuehr and Stegmann 2017), also in Japan, South Korea, Taiwan and China (Evangelopoulos, Kantarelis and Yang 2019).

Within a circular economy, extended producer responsibility is essential to bridge the widening gap between e-waste generation and the extraction of scarce resources, including rare earth metals. Currently, EPR is the subject of voluntary initiatives, primarily stimulated by levers of economic influence. The rapid pace of technological innovation and the miniaturization of electronic products indicates that economic incentives to restore resources as an excuse for EPR may be unsustainable. Financing the infrastructure for e-waste collection can be effective if there is a mandatory EPR due to the need to manage various categories of e-waste, including products that do not contain precious materials, which could, in turn, offset the costs of extracting useful resources. Instead, workers involved in such infrastructure are limited to collecting electronic waste containing low value but toxic components to prevent environmental pollution and exposure that is harmful to public health (Awasthi, Li, Koh and Ogunseitan 2019).

Support by manufacturers of mandatory EPR will require the development of a policy that ensures a level playing field, so that small producers are not burdened with collecting used products from distant parts of the world disproportionately, where their brands are sold at retail, used and disposed of. Instead, EPR should begin with a collective "superfund" mechanism through which all electronic product manufacturers contribute financially and manufacturers are compensated for adopting green chemistry or eco-design principles that eliminate the use of hazardous materials that jeopardize environmental quality and health. To be effective, the EPR Superfund must also include the recovery of used products and the reuse of recycled materials, with manufacturers

contributing proportionally to the number of products sold, and an independent agency develops and implements strategies for collecting, sorting and recycling obsolete electronic products worldwide. This circular economy model may be more achievable for large, easily labeled and traceable electronic products for which technical knowledge on their repair or restoration is not widely available to the labor force engaged in restoring resources in emerging market economies. For this category of electronic waste, the prevention of unsafe and unprincipled elementary processing is a priority for integration into the proposed EPR super fund and the structure of the circular economy (Awasthi, Li, Koh and Ogunseitan 2019). At the same time, the possibility of competition between OEMs and IPs (independent processors) in order to profit or fulfill EPR obligations is not ruled out (Dato 2017).

Along with the concept of EPR, it is worth mentioning another important tool for protecting the environment from the harmful effects of WEEE, concerning environmental management in organizations—the ISO 14,001 certificate. The ISO 14,001 certificate is an official document of the international level that is issued to confirm the quality and reliability of the environmental management. The ISO 14,001 standard certifies the compliance of the enterprise with the requirements and standards established by law. The improvement of the environmental situation in the electronics industry may be realized by creating the so-called green electronics, in which toxic materials in the production of electronics are replaced by non-toxic and easily degradable in the environment. Despite the voluntariness of use, the implementation of standards at enterprises that establish requirements for environmental management systems is an important component of promoting the most effective and efficient environmental management practices at enterprises and organizations. An organization's ISO 14,001 certification indicates that the organization has sufficient resources to carry out successful environmental activities of its production (Kuhre 2018).

In 2012 in Germany, as a result of achieved by the EU countries on waste regulations, there was developed the Circular Economy Act (CEA), which included waste prevention and extended producer responsibility concepts. According to the above document, there was created a waste prevention program that emphasizes the importance of waste prevention in the waste management hierarchy within the CEA, however without the stipulating legal obligations. The program has mapped the capacity for administrative authorities to prevent waste for the first time in a systematic and comprehensive manner. The program also introduced 34 specific waste prevention measures along with evaluations of their effectiveness (Sakai, Yano, Hirai, Asari, Yanagawa, Matsuda, et al. 2017).

It is worth considering that the first UNU scenario is implemented in Canada. Thus, in Canada, there is an Electronic Product Recycling Association (EPRA). EPRA brings together OEMs, representing Canada's 20 largest electronic equipment manufacturers (Leclerc and Badami 2020). EPRA originally developed the criteria for its recycler qualification program (RQP) for the selection of collectors and recyclers for the Quebec provincial e-waste program (the same criteria are used in Alberta, although this state has its own program developed and used). RQP requires third-party audits and certificates to ensure that the products are managed in an environmentally friendly manner that also guarantees the health and safety of workers, from initial processing to final disposal. The fact that the producers themselves jointly developed and imposed this standard on processors—in contrast to the US voluntary approach—the authors call a good example of corporate social responsibility (Leclerc and Badami 2020).

It should be noted that the above opinions to one degree or another boil down to supporting the first scenario of the UNU electronic waste management, as more optimistic and preferable. There is a reason to believe that in the near future legislative regulation will

develop in this direction. This scenario seems to be not only the most acceptable, but also the only possible option.

3.1 The problem of exporting e-waste to developing countries

Illegal transportation occurs not only due to the imperfection of international legal regulation, but also because of the difficulties in identifying non-reusable electronic waste. Therefore, the two main information problems associated with the e-waste market are inadequate monitoring and inaccurate information on the status of the waste transported. These two problems create the prerequisites for transporting electronic waste to developing countries. The negative externalities associated with the hazardous components of e-waste are significant enough as developing countries do not have the appropriate knowledge and/or tools for the proper management of e-waste (Dato 2017).

In the context of this issue, the question remains whether the provisions of the WEEE Directive and other international laws affect the export of electronic waste to developing countries and the management of electronic waste in these countries. Given that there are already more than 10 years of discussions on this issue in the scientific community (Nnorom and Osibanjo 2008). With the globalization of a market economy and outsourcing of products, a large number of ICT equipment is currently sold and used around the world—even in the most remote areas of third world countries. How effective will EPR be if the waste products in developing countries are not properly managed? To achieve a "real" closed production cycle, EPR must be implemented globally. Thus, the question remains regarding the legislative regulation of the transportation of electronic and electrical waste to developing countries, in particular, countries of the African continent.

The above question is closely related to the question of the possibility and need for an inventory of e-waste located in African countries (on the example of Ethiopia and Ghana). Such a procedure in the countries of the African continent can be used to forecast trends in the production and import of electronic waste for many years and in order to help the responsible authorities to actively participate in the development of national regulations to address this problem. An inventory also provides the basis for measuring progress and identifying problems. However, this task may encounter many difficulties, as African countries do not have accurate data or reliable sources from which such data could be obtained, given the fact that some of the waste goes to countries through illegal routes and, therefore, information is not recorded anywhere. Even those goods that were produced domestically often go to landfills or are collected by garbage collectors without due regard (Asante, Amoyaw-Osei and Agusa 2019).

In 2015/2016, EU Member States accounted for approximately 77% of used electrical and electronic equipment (UEEE) imported into Nigeria. Sometimes used equipment was virtually defective upon arrival and should have been considered electronic waste. Even if some parts were repairable or could be used directly as second-hand goods, they were likely to become electronic waste anyway. Since e-waste management infrastructure is generally less developed in low-income countries than in higher-income countries, these trends are disturbing and measures need to be taken (Baldé, Forti, Gray, Kuehr and Stegmann 2017).

Today, most African countries are aware of and are concerned about the risks associated with inappropriate e-waste management. However, in most countries, the legal framework and infrastructure necessary to ensure good governance have not yet been established. Only a very limited number of countries (including Uganda and Rwanda) have formally

developed documents to ensure the implementation of state policies on e-waste management. In addition, despite the fact that almost all African countries have ratified the Basel Convention, most of them have not implemented it in the form of relevant legislation regarding the various waste streams (Baldé, Forti, Gray, Kuehr and Stegmann 2017).

3.2 Prospects for legislative protection of workers' rights in the processing industry of electrical and electronic equipment

Special attention is required for the legislative protection of workers' rights in the processing industry in the field of recycling of electronic equipment. Thus, on April 17, 2019, under the auspices of ILO, a meeting was held in Geneva dedicated to the protection of workers from toxic electrical and electronic waste. The meeting participants called on all states and all employers to take decisive measures to organize the safe processing of electronic garbage. During the meeting, James Towers, vice-chairperson of the workers' representative group, raised a rather pressing issue regarding the protection of the rights of workers involved in e-waste management. "Workers handling e-waste have no voice, no bargaining power, they are breaking hazardous materials by their hands," Towers said (Seth 2019). While exploring this topic, the authors studied the ILO analytical note "Decent work in the management of electrical and electronic waste (e-waste)." The latter states that workers in the field of electronic waste disposal are directly exposed to hazardous substances during processing. Moreover, not only substances contained in the electronic waste themselves are hazardous, but also those that are used to extract valuable minerals from waste (ILO 2019a).

For example, in India, where about two million tons of e-waste is produced annually, and which is the fifth largest e-waste producer country, the e-waste industry falls under unregulated self-employment. Consequently, the main emphasis was placed on disparate and unstable groups of self-employed workers belonging to socially stigmatized, vulnerable groups of migrants, children and women, where the key points are their physical work, health hazard, poisoning by toxic elements (Rick 2019).

In addition, according to ILO data in India, workers working in waste sites are exposed to higher levels of silver, copper and rare earth metals compared to other workers. In the Philippines, it was found that workers inhaled smelting dust and were exposed to toxic fumes and corrosive liquids.

In Akormedi, Asampong and Fobil (2013), among other things, examples of dangerous working conditions of workers are given and attention is focused on their social and legal insecurity. At the same time, the study of Viegas, Dias, Almeida, Caetano, Carolino, Gomes et al. (2020) informs that workers with a large number of contacts with waste have shown increased exposure to bioburden (the totality of microbes coming from numerous sources, including raw materials, production and assembly processes, etc.).

In order to eliminate the risks faced by waste collectors, in 2010, the ILO developed a training methodology "Work Adjustment for Recycling and Managing Waste" (WARM). Using simple, low-cost improvement measures, it aims to increase the safety, health and efficiency of waste collection and is currently being adapted for use in the informal e-waste economy in India. Due to the informal nature of most e-waste work and the lack of unions and employer associations in the sector in many countries, the vast majority of e-waste workers and employers face significant challenges in practice. They are not given the opportunity to gain sufficient knowledge about industry dynamics and risks to safety and health, to create organizations, to contribute to national policies and strategies related to

e-waste (Borisova, Panfilova, Zhukov, Matulis, Matveev and Teymurova 2019). They cannot establish relationships, including in terms of membership, with representative workers and employers to ensure their representation in industry dialogue with other stakeholders in the e-waste value chain (ILO 2019a).

The ILO calls for urgent action to improve the management of the toxic flow of electrical and electronic waste (e-waste) generated worldwide so that it can be turned into a valuable source of decent work. In addition, the organization confirms the need to protect people working with electronic waste that is toxic and dangerous and adversely affects workers and the environment (ILO 2019b).

Thus, there is a need to resolve this issue at the level of international law, designed to protect the rights of workers involved in the processing and disposal of electronic waste. In the legislation of the EU countries, the issue regarding the protection of the rights of workers working with asbestos materials (Directive 2009/148/EC on the protection of workers from the risks related to exposure to asbestos at work) is legally regulated. Thus, the existing practice should be applied to similar legal relations in the field of electronic waste disposal.

4 Discussion

Legislation is an important but not the only component of an e-waste management system. In almost all cases around the world, the initiative to develop and implement legislation related to electronic waste belongs to governments or to local authorities. Proper collection and processing require funding that is not automatically provided by merchants and e-waste processors, while revenues from recyclable materials cover costs. Funding might not be allocated to cover logistics costs, removal of contaminants through negative intrinsic value. Consequently, the beginning of the development of an e-waste system usually means market intervention (if any) through political levers and waste disposal rules. However, the following must be considered: legislation is vital, but not the only component for successful e-waste management. As a rule, this is considered necessary and even the main focus for many countries starting to develop their e-waste system. However, the latter cannot function without proper implementation and enforcement, as well as simultaneous structural financing of the collection and processing, development and transfer of technologies and infrastructure, as well as the cooperation of all participants involved in the electronics life cycle. In addition, the actual effectiveness is largely determined by the social, economic and cultural conditions of individual countries (Goodship, Stevels and Huisman 2019).

The thesis voiced in the report of the International Telecommunication Union (ITU) that circular economy models should be introduced to stimulate “loop closure” due to better component design, disposal, reuse, etc., while reducing environmental pollution, is correlated with opinions of many authors who have devoted their work to this topic. Thus, the circular economy concept opens up broad prospects for the economy and employment with regard to e-waste management. In this regard, it is necessary to develop appropriate and data-based legislation on e-waste management that would make clear the environmental and economic benefits of improving e-waste management (Baldé, Forti, Gray, Kuehr and Stegmann 2017).

Based on the studies, it can be concluded that in the near future, a legislative initiative at the international and national levels in the field of electronic waste management and disposal will be developed taking into account the circular economy concept, an approach of

extended producer responsibility. This assumption is correlated with scenario No. 1 of the United Nations University (UNU), which has been described earlier.

A gradual transition to the circular economy concept seems almost inevitable, and this is without a doubt a positive trend. However, it should be taken into account that EPR can affect the decrease in overall well-being, especially when one considers that the recycling of equipment carried out by manufacturers of original equipment can compete with more cost-effective activities of independent processors (Esenduran, Atasu and Van Wassenhove 2019). It is argued that the best environmental practices cannot be implemented in full, given the fact that the best available technologies are not distributed internationally or are not applied accordingly to situations in different parts of the world.

Regarding the question of the possibility of developing a regulatory framework regarding the transportation of electronic waste to developing countries, in particular, African countries for its disposal, researchers generally agree on the need to create effective legal levers to limit the flow of recycled electronics to such countries. For example, the ITU D Study Group 2 in its Final Report on Question 8/2: "Strategies and policies for the proper disposal or reuse of telecommunication/ICT waste material" states the following. Namely, the disposal of WEEE in developing countries is a latent issue, given that the economies of such countries are mainly based on informal enterprises and do not provide any means of protection for workers living in poverty. No due attention is also paid to environmental protection in terms of the extraction of valuable materials (ferrous and non-ferrous metals, precious metals, etc.) using rudimentary technology and illegal sale of products received. Informal processing plants collect equipment, sort and separate it manually and/or using tools, and then use rough technologies using heat and chemical compounds. The most common methods include:

- open burning of printed circuit boards and cables;
- burning printed circuit boards to separate them into components and isolating solder;
- chopping and melting plastic;
- burning cables to produce copper;
- heating and acid etching of printed circuit boards;
- removing gold from printed circuit boards using cyanide and salts or nitric acid;
- etching using mercury amalgam;
- manual disassembly of picture tubes;
- open burning of plastics.

The scale of this problem is growing, and the illegal nature of such activities complicates the implementation of appropriate control by the responsible authorities (government, ministry of health, etc.), which leads to an increase in sickness rate due to exposure to more than 1000 toxic compounds that may be contained in WEEE (ITU-D Study Group 2 2017).

In May 2016, the Basel Action Network completed a 2-year study involving the deployment of tracking devices for an electronic global positioning system on old electronic equipment in the USA, and found that "34% of the 205 implemented tracking devices moved abroad, with 31% of the total to developing countries" (Liu and Middleton 2017).

Thus, according to estimates, from 20 to 50 million tons produced annually, from 75 to 80% goes to the countries of Asia and Africa for "processing" and disposal. "Loopholes" in the current regulatory framework for e-waste allow one to export e-waste from developed to developing countries under the guise of "donations" and "disposal" (Perkins, Drisse, Nxele and Sly 2014).

The import of obsolete products of electrical and electronic equipment into African countries is led by "local" business entities that do not take into account the long-term consequences of their trade, further complicating efforts to solve the problems of electronic waste (Tetteh and Lengel 2017). However, at the same time, it is worth noting the efforts of individual European states in helping African countries manage waste. For example, the Swiss State Secretariat for Economic Affairs (SECO), as part of its e-waste program, is working on developing e-waste management strategies in developing countries.

E-waste management is a significant issue for African countries, due to growing global WEEE production, lack of clear government action plans for e-waste management and infrastructure for proper waste management. As a lever of influence on the growing threat, it is proposed to harmonize the policies of African countries in the field of e-waste management, to take measures to prevent the import and disposal of e-waste in Africa (Asante, Amoyaw-Osei and Agusa 2019).

Such scientific views give reason to argue that the provisions of the Basel Convention, which is, perhaps, the only international legislative instrument to prevent the unhindered transport of WEEE to developing countries, at the same time, do not contain an effective sanction and enforcement mechanism. Ambiguous formulations allow exporters to identify gaps in the Convention and continue to export potentially hazardous waste to developing countries basing on formal reasons. Due to the lack of uniformity in definitions of terminology, such as “hazardous” and “waste,” the requirements are left for interpretation by a state legislation. Improper use of the Basel Convention regulations can create a situation where an environmental agreement can do more harm to the environment than good. Most of what is called “waste” is valuable elsewhere and can be reused and recycled. Thus, exporters are allowed to send their waste to developing countries, declaring that they are sent there for processing, and not just dumped. This is called “fictitious” recycling and is another way of legally trading hazardous waste. Based on current challenges, the transportation of potentially hazardous waste from one state to another, with a view to its further disposal, must take into account guarantees that these wastes will be disposed of properly. So, there arises the question of developing an appropriate international act providing for the proper disposal of potentially hazardous waste during their transboundary movement and the responsibility of the parties regarding the proper implementation of such a procedure.

At the same time, there is another point of view regarding the uniqueness of the negative consequences for developing countries, in particular, African countries. Contrary to the widespread belief that e-waste sent from advanced economies to developing countries tends to be detrimental, there are some positive external effects produced by importing e-waste in sectors such as the aftermarket and repair services. In these sectors, the growth of e-waste has had a positive impact and contributed to local innovation (Amankwah-Amoah 2016).

Another important area of legal regulation in the field of management and disposal of electronic waste is the need to develop special standards for the protection of workers in the field of electronic and electrical waste. Based on the results of research on this topic, it is possible to state a consensus in the views of the scientific community and political actors, since the issue of protecting human life and health is the main priority in the development and adoption of any legislative or by-law act. Nevertheless, in practical terms, no changes have been made in the international regulatory framework in terms of protecting the rights of workers in the field of recycling WEEE, despite the concern over the above issue.

Thus, back in 2009, scientific sources indicated that workers working with e-waste experience negative health effects (Robinson 2009). A survey by the Associated

Chambers of Commerce of India (New Delhi, India) found that nearly 76% of e-waste workers have respiratory illnesses, including shortness of breath, coughing, asthma and bronchitis. At the same time, for almost a 12-year period at the international level, unified standards for workers in the field of electronic waste processing have not been adopted (Robinson 2009).

In the near future, the issue of forming a regulatory framework relating to the protection of the rights of workers in the field of processing electronic equipment should become one of the top priorities among issues related to the management of electronic waste. The subjects of legislative initiative should take measures to create safe work systems, which should include training and protection of workers' rights, etc. A multisectoral e-waste policy should cover the environmental, economic, social and health aspects of the various stakeholders involved in such policy's design and implementation (Heacock, Kelly, Asante, Birnbaum, Bergman, Bruné et al. 2016).

This study evokes the opinion that the development of an international hard law legislative act governing the question is necessary, however, a very lengthy and extensive process. This circumstance is related not only to the realities of legal systems, but also to the budgets of different countries, which may not meet the requirements for the implementation of such laws at national levels. Closely connected with the previous question is the technical support and logistics of workers involved in the processing of electronic waste. However, a lengthy legislative process comes into conflict with the conditions of an objective need to resolve the issue of protecting the health and prevention of occupational diseases of workers in the field of processing and recycling e-waste as soon as possible, since people's lives and health are directly dependent on this. At the same time, the development of the ISO standard could in many ways contribute to such a legislative process by simplifying it to a certain extent. The need to adhere to this standard can be stated as a legal provision. At the same time, an international legislative act containing such a provision should stipulate the regulations regarding the reporting of member countries on the results of the implementation of such a standard into their national legislation, including liability measures.

In addition to the above, the possibility of training informal sector workers with government assistance should be considered, since such training will provide more professional knowledge on recycling, such as standardized methods for the classification and treatment of various wastes. Legislation on the disposal of electronic waste, development of recycling systems, etc. are of relevance as well (Yang, Ma, Thompson and Flower 2018). The creation of cooperatives and associations by informal processors can bring a positive effect. The creation of such cooperatives can create the preconditions for legitimizing the activities of the informal recycling sector, allowing further funding for social programs such as expanded health care and childcare.

Of great importance in the formation of approaches to the management and recycling of e-waste is raising awareness of the valuable contribution made by the informal sector of e-waste management, as well as changing public attitudes toward workers involved in this field. International cooperation, in particular through the SDGs, will be necessary to improve waste management and increase the well-being of those involved in informal waste management. At the same time, strict observance of laws and regulations in the field of electronic waste disposal by workers in this field will be important for improving waste processing and protecting workers' rights to safe working conditions (Yang, Ma, Thompson and Flower 2018).

5 Conclusions

Legislative initiatives at the international and national levels in the field of management and disposal of e-waste will develop with the consideration of the concept of a circular economy as well as the extended producer responsibility approach. The study confirms the adherence and lack of alternative to such a legislative policy for many countries. Considering the above, this study provides a holistic view of the vector of development of legal policies in the field of handling e-waste and their priority at the international, regional and national levels. Herewith, besides the need to develop effective legislative mechanisms regarding the implementation of supranational regulations based on concepts and approaches such as the concept of a circular economy and the extended producer responsibility approach the modern issues in the field of e-waste management, which often do not have the necessary legislative regulation, include the exporting electronic waste to developing countries as well as insufficient legal protection of workers in the field of disposal of electronic waste.

The future of e-waste in a circular economy has significant potential for increasing jobs, increasing the efficiency of the use of natural resources and reducing the harmful effects of rare metals and other chemical elements contained in them on the environment. This study gives the opportunity to conclude that world politicians are gradually abandoning the use of the linear economy model in favor of a circular economy. It can also be assumed that, despite numerous obstacles regarding the practical implementation of WEEE management policy at different levels, the future legislative regulation in matters of management and disposal of e-waste at the international and national levels will be based on the circular economy concept.

One of the main trends is the increasing attention shown by civil society to the issue of extended producer responsibility. It should be noted that the approach of extended producer responsibility today is not a formally defined legislative category. Therefore, it does not contain clear instructions or requirements, which is a prerequisite for developments in the direction of legal regulation of this issue, in particular, the development of unified criteria, EPR levels, economic incentives, etc.

Using the concept of a circular economy in the management and disposal of electronic waste maximizes the amount of valuable electronic waste that is returned to the production of new electronic products and components. To achieve this result, more countries, especially in the developing world, will need to enact e-waste legislation, such as the introduction of expanded producer responsibility, and create an official recycling industry. This will not only mitigate some of the worst consequences, but also create enormous opportunities for economic growth and decent work.

In the long term, the introduction of circular economy models should significantly reduce the impact of e-waste on the environment and health. Nevertheless, while many circular economics methods are still under development, it is necessary to immediately eliminate the danger to the environment and human health associated with the export of electronic waste to developing countries, where waste processing facilities do not meet modern requirements and are unsafe.

In most developing countries, there is no proper legal basis and infrastructure necessary to ensure the efficient management and disposal of electronic equipment. Thus, there is a need to create appropriate legislation providing for a ban or restriction on the import of electronic waste into developing countries, including African countries.

It is also necessary to highlight the issue of protecting the rights of workers in the field of electronic waste processing, regarding the creation of unified rules and standards, and as a result, the implementation of the developed norms in national legislation. The solution to most problems in the field of electronic waste management and disposal is possible using an integrated approach, consisting of a combination of environmental, economic, technological and legal means. At the same time, particular attention should be paid to improving existing legislation in this area, since it is the legal methods of influence that create a stable basis for regulating public relations in this area. Legal regulation also ensures the development of the market of secondary resources (material and energy ones) and facilitates a gradual and consistent reduction in the level of negative environmental impacts from accumulated waste of production and consumption.

The current legislation in the field of e-waste management and disposal needs system improvement aimed at the formation and implementation of economic incentives for business entities to introduce low-waste technologies and equipment. The treatment of certain types of waste should be regulated for the purpose of environmentally safe disposal. It is also of relevance to develop the waste processing industry.

This study is intended to contribute to a better understanding of current trends in the field of e-waste disposal in order to illustrate the need to improve the existing international legal framework and adapt it to modern challenges.

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References

Abdimomynova, A., Kolpak, E., Doskaliyeva, B., Stepanova, D., & Prasolov, V. (2019). Agricultural diversification in low-and middle-income countries: Impact on food security. *Montenegrin Journal of Economics, 15*(3), 167–178.

Akormedi, M., Asampong, E., & Fobil, J. N. (2013). Working conditions and environmental exposures among electronic waste workers in Ghana. *International Journal of Occupational and Environmental Health, 19*(4), 278–286. https://doi.org/10.1179/2049396713Y.0000000034

Alizade, V. A., Volevodz, A. G., & Tatarinov, M. K. (2019). Legal security in fuel and energy complex: Statement of problem. *SOCAR Proceedings, 3,* 97–122. https://doi.org/10.5510/OGP20190300403

Amankwah-Amoah, J. (2016). Global business and emerging economies: Towards a new perspective on the effects of e-waste. *Technological Forecasting and Social Change, 105,* 20–26. https://doi.org/10.1016/j.techfore.2016.01.026

Asante, K. A., Amoyaw-Osei, Y., & Agusa, T. (2019). E-waste recycling in Africa: risks and opportunities. *Current Opinion in Green and Sustainable Chemistry, 18,* 109–117. https://doi.org/10.1016/j.cogsc.2019.04.001

Awasthi, A. K., Li, J., Koh, L., & Ogunseitan, O. A. (2019). Circular economy and electronic waste. *Nature Electronics, 2*(3), 86–89. https://doi.org/10.1038/s41928-019-0225-2

Baldé, C. P., Forti, V., Gray, V., Kuehr, R., & Stegmann, P. (2017). *The Global E-waste Monitor 2017.* Bonn, Geneva, Vienna: United Nations University (UNU), International Telecommunication Union (ITU) and International Solid Waste Association (ISWA).

Bayanova, A. R., Kuznetsov, V. V., Merculova, L. V., Gorbunova, L. N., Pervozvanskaya, O. A., Shalamova, O. O., & Vorobyova, C. I. (2019). Student performance interrelation with gadget use at lessons. *Journal of Environmental Treatment Techniques, 7*(3), 432–437.

Borisova, V. V., Panfilova, E. E., Zhukov, P. V., Matulis, S. N., Matveev, V. V., & Teymurova, V. E. (2019). Information support in the enterprise risk management. *International Journal of Management and Business Research, 9*(1), 158–169.

Circular Economy. (2018). Implementation of the circular economy action plan.WECOOP2, European union. https://www.greeninvest-ca.eu/content/circular-economy. Accessed 17 March 2020.

Circular Economy. (2020). European union circular economy package. https://ringmajandus.envir.ee/en/european-union-circular-economy-package. Accessed 17 March 2020.

Dato, P. (2017). Economic analysis of e-waste market. *International Environmental Agreement Politics, Law and Economics, 17*(6), 815–837. https://doi.org/10.1007/s10784-017-9350-4

Doughty, D. H., & Roth, E. P. (2012). A general discussion of Li ion battery safety. *Electrochemical Society Interface, 21,* 37–44. https://doi.org/10.1149/2.F03122if

Esenduran, G., Atasu, A., & Van Wassenhove, L. N. (2019). Valuable e-waste: Implications for extended producer responsibility. *IISE Transactions, 51*(4), 382–396. https://doi.org/10.1080/24725854.2018.1515515

European Commission. (2017). The role of waste-to-energy in the circular economy. Communication from the commission to the European Parliament, the council, the European economic and social committee and the committee of the regions. Brussels, 26.1.2017 COM 34 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1581603094761&uri=CELEX:52017DC0034. Accessed 17 March 2020.

European Union. (2009). Directive 2009/148/EC on the protection of workers from the risks related to exposure to asbestos at work. Official Journal of the European Union. https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:330:0028:0036:EN:PDF. Accessed 17 March 2020.

Evangelopoulos, P., Kantarelis, E., & Yang, W. (2019). Waste electric and electronic equipment: Current legislations, waste management, and recycling of energy, materials, and feedstocks. In M. T. Taherzadeh, J. Wong, K. Bolton, & A. Pandey (Eds.), *Sustainable resource recovery and zero waste approaches* (pp. 239–266). Cham: Elsevier.

Geisendorf, S., & Pietrulla, F. (2018). The circular economy and circular economic concepts—a literature analysis and redefinition. *Thunderbird International Business Review, 60*(5), 771–782. https://doi.org/10.1002/tie.21924

Goodship, V., Stevels, A., & Huisman, J. (2019). *Waste electrical and electronic equipment (WEEE) handbook*. Sawston: Woodhead Publishing.

Greenpeace (2016). Dumping 4.3 million Samsung phones is an environmental disaster warns Greenpeace. https://www.greenpeace.org/eastasia/press/1259/dumping-4-3-million-samsung-phones-is-an-environmental-disaster-warns-greenpeace/. Accessed 17 March 2020.

Greenpeace (2017). You did it! Samsung will finally recycle millions of Galaxy Note 7s. https://www.greenpeace.org/international/story/7072/you-did-it-samsung-will-finally-recycle-millions-of-galaxy-note-7s/. Accessed 17 March 2020.

Harper, G., Sommerville, R., Kendrick, E., Driscoll, L., Slater, P., Stolkin, R., et al. (2019). Recycling lithium-ion batteries from electric vehicles. *Nature, 575,* 75–86. https://doi.org/10.1038/s41586-019-1682-5

Heacock, M., Kelly, C. B., Asante, K. A., Birnbaum, L. S., Bergman, Å. L., Bruné, M. N., et al. (2016). E-waste and harm to vulnerable populations: A growing global problem. *Environmental Health Perspectives, 124*(5), 550–555. https://doi.org/10.1289/ehp.1509699

ILO. (2019a). Decent work in the management of electrical and electronic waste (e-waste). Issues paper for the global dialogue forum on decent work in the management of electrical and electronic waste (E-waste). Geneva, 9–11 April 2019. https://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---sector/documents/publication/wcms_673662.pdf. Accessed 17 March 2020.

ILO. (2019b). Urgent action needed to better manage e-waste. https://www.ilo.org/global/about-the-ilo/newsroom/news/WCMS_686640/lang--en/index.htm. Accessed 17 March 2020.

ITU (2020). Creating a circular economy for ICT equipment. https://www.itu.int/en/mediacentre/backgrounders/Pages/e-waste.aspx. Accessed 17 March 2020.

ITU-D Study Group 2. (2017). Final report. Question 8/2. Strategies and policies for the proper disposal or reuse of telecommunication/ICT waste material. 6th Study Period 2014–2017. ITU telecommunication development sector. https://www.itu.int/dms_pub/itu-d/opb/stg/D-STG-SG02.08.1-2017-PDF-E.pdf. Accessed 17 March 2020.

Khabrieva, T. Y., & Chernogor, N. N. (2018). The law in the conditions of digital reality. *Journal of Russian law, 1*(253), 85–102.

Kuhre, W. L. (2018). *ISO 14001 Certification: Environmental Management System.* Prentice Hall.
Kumar, S., & Singh, V. (2019). E-Waste: Generation, environmental and health impacts, recycling and status of e-waste legislation. *Journal of Emerging Technologies and Innovative Research, 6*(1), 592–600.
Leahy, S. (2017). China's booming middle class drives Asia's toxic e-waste mountains. The guardian, 16. https://www.theguardian.com/environment/2017/jan/16/chinas-booming-middle-class-drives-asias-toxic-e-waste-mountains. Accessed 17 March 2020.
Leblank, R. (2019). E-waste and the importance of electronics recycling. The balance small business. https://www.thebalancesmb.com/e-waste-and-the-importance-of-electronics-recycling-2877783. Accessed 17 March 2020.
Leclerc, S. H., & Badami, M. G. (2020). Extended producer responsibility for E-waste management: Policy drivers and challenges. *Journal of Cleaner Production, 251,* 119657. https://doi.org/10.1016/j.jclepro.2019.119657
Liu, N., & Middleton, C. (2017). Regional clustering of chemicals and waste multilateral environmental agreements to improve enforcement. *International Environmental Agreements: Politics, Law and Economics, 17*(6), 899–919. https://doi.org/10.1007/s10784-017-9372-y
Lukyanets, A. S., Nguen, T. K., Ryazantsev, S. V., Tikunov, V. S., & Pham, H. H. (2015). Influence of climatic changes on population migration in Vietnam. *Geography and Natural Resources, 36*(3), 313–317.
Mazahir, S., Verter, V., Boyaci, T., & Van Wassenhove, L. N. (2019). Did Europe move in the right direction on e-waste legislation? *Production and Operations Management, 28*(1), 121–139. https://doi.org/10.1111/poms.12894
Musin, A. (2019). Circular economy. How mining companies have to earn money with a new business approach. *Kapital*. https://kapital.kz/economic/81981/ekonomika-zamknutogo-tsikla.html. Accessed 17 March 2020.
Nnorom, I. C., & Osibanjo, O. (2008). Overview of electronic waste (e-waste) management practices and legislations, and their poor applications in the developing countries. *Resources Conservation and Recycling, 52*(6), 843–858. https://doi.org/10.1016/j.resconrec.2008.01.004
PACE. (2019). A new circular vision for electronics time for a global reboot. The platform for accelerating the circular economy. https://www3.weforum.org/docs/WEF_A_New_Circular_Vision_for_Electronics.pdf. Accessed 17 March 2020.
Perkins, D. N., Drisse, M. N. B., Nxele, T., & Sly, P. D. (2014). E-waste: a global hazard. *Annals of global health, 80*(4), 286–295. https://doi.org/10.1016/j.aogh.2014.10.001
Rick, A. (2019). China's e-waste worth $23.8 billion by 2030. Greenpeace Asia. https://www.greenpeace.org/eastasia/press/1397/chinas-e-waste-worth-23-8-billion-by-2030-2/. Accessed 17 March 2020.
Robinson, B. H. (2009). E-waste: An assessment of global production and environmental impacts. *Science of the total environment, 408*(2), 183–191. https://doi.org/10.1016/j.scitotenv.2009.09.044
Ryder, G., & Zhao, H. (2019). The world's e-waste is a huge problem. It's also a golden opportunity. *World Economic Forum, 24*(1), 1–5.
Sakai, S., Yano, J., Hirai, Y., Asari, M., Yanagawa, R., Matsuda, T., et al. (2017). Waste prevention for sustainable resource and waste management. *Journal of Material Cycles and Waste Management, 19,* 1295–1313. https://doi.org/10.1007/s10163-017-0586-4
Semuels, A., & Fresno, C. (2019). The world has an e-waste problem. Time. https://time.com/5594380/world-electronic-waste-problem/. Accessed 17 March 2020.
Seth, N. (2019). Turn toxic e-waste into a source of 'decent work', UN labour agency urges. *Un News*. https://news.un.org/en/story/2019/04/1036781. Accessed 17 March 2020.
Tetteh, D., & Lengel, L. (2017). The urgent need for health impact assessment: Proposing a transdisciplinary approach to the e-waste crisis in sub-Saharan Africa. *Global Health Promotion, 24*(2), 35–42.
Tsindeliani, I. (2019). Public financial law in digital economy. *Informatologia, 52*(3–4), 185–193.
UNECE (2017). UNECE Working Paper Series on Statistics, Issue 3, March 2017. https://www.unece.org/fileadmin/DAM/stats/publications/2017/Issue3_Waste.pdf. Accessed 17 March 2020.
United Nations Environment Programme. (2017). Implementation of Basel declaration on environmentally sound management of priority waste streams. https://www.informea.org/en/implementation-basel-declaration-environmentally-sound-management-priority-waste-streams-electronic. Accessed 17 March 2020.
Viegas, C., Dias, M., Almeida, B., Caetano, L. A., Carolino, E., Gomes, A. Q., et al. (2020). Are workers from waste sorting industry really protected by wearing filtering respiratory protective devices? The gap between the myth and reality. *Waste Management, 102,* 856–867. https://doi.org/10.1016/j.wasman.2019.12.001

WHO Regional Office for Europe. (2018). Circular economy and health: opportunities and risks. https://www.euro.who.int/__data/assets/pdf_file/0004/374917/Circular-Economy_EN_WHO_web_august-2018.pdf?ua=1. Accessed 17 March 2020.

Yang, H., Ma, M., Thompson, J. R., & Flower, R. J. (2018). Waste management, informal recycling, environmental pollution and public health. *Journal of Epidemiology and Community Health, 72*(3), 237–243. https://doi.org/10.1136/jech-2016-208597