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MODERNITY IN ENGINEERING

Edited by
Dorota Anna Krawczyk
Iwona Skoczko
Ewa Szatyłowicz



FACULTY OF CIVIL ENGINEERING
AND ENVIRONMENTAL SCIENCES
BIALYSTOK UNIVERSITY
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ASSOCIATION
OF SANITARY ENGINEERS
AND TECHNICIANS



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European experience of waste management and implementation of best practices in Ukraine

Keywords: sustainable development; waste management; circular economy

Abstract: Development of waste management system in the European Union is studied. The waste management practice in a range of the EU countries is analyzed. Main principles of solving the problem of managing waste in the EU are revealed. Comparison of indicators for waste management in the EU and Ukraine is provided. The dominant European trends among other areas of waste – “zero waste” and “circular economy” – are identified. The regulatory framework for waste management developed in Ukraine as a step towards international environmental safety standards is discussed.

Introduction

Our generation is responsible for solving the environmental problems facing the world. Improving living conditions (public health) and productivity of natural resources depend on the quality of waste utilization, so the issues of reducing the environmental hazards caused by waste accumulation are actively discussed in the scientific community. In Ukraine, the main attention is paid to the assessment of the polluting impact of waste storage sites. To a lesser extent, general issues of waste management, in particular environmentally sound management, have been addressed. To ensure their effectiveness, it is necessary to study the experience of other countries, especially the European Union (hereinafter – EU), for which, regardless of the level of economic development, a common policy in the field of waste management is developed. The proposed ways to solve this problem can be useful for study and implementation in Ukraine.

The aim of the study is to analyze the development of the waste management system that has been developed in the EU and to illustrate it by the practice of the most developed countries in this regard (within the execution of the Jean Monnet Module “An interdisciplinary approach to waste management study: implementing the EU practices” (621029-EPP-1-2020-1-UA-EPPJMO-MODULE).

Legislative aspects of waste management in the EU

The main ways for waste management for the world community were identified at the International Conference on Sustainable Development in Johannesburg in 2002 [1]. These include waste prevention, maximum reuse and recycling, and the use of alternative environmentally friendly materials. Implementation of the planned ways will minimize the negative impact of waste on humans and the environment and increase the efficiency of secondary resources.

In the EU countries, along with national measures, the development of general strategies makes a great contribution to waste management. The processes of generation, accounting, processing and disposal of waste are regulated by a number of documents, which can be divided into two major groups – programme and regulatory. Programme (Action Programmes) ones – have a framework character, define the main goals for the EU countries in the medium or long term (usually from 3–5 to 10 years or more). Normative documents (agreements, directives, rules, regulations, etc.) are the ones required for execution. They can be of a framework nature (for example, the Waste Framework Directive) or relate to specific tasks (for example, regulation of emission limit values for waste incineration, landfill technology). The EU Action Programmes are strategic documents that set specific targets to be achieved in the long or medium term.

For example, in developing an EU Sustainable Development Strategy, it was decided that the link between production growth and waste generation should be broken. General waste management issues are covered in the Waste Framework Directive (2006) [2]. The document provides a list of substances that can be classified as waste, individuals or organizations are required to bear the costs of waste disposal (the polluter pays principle), establishes a hierarchy of desired methods of waste management: “Prevention of generation or minimization of sources → reuse → processing into raw materials and products → composting → incineration or burial with energy → burial without energy → incineration without energy“. It took 20 years for Poland to reduce the share of municipal waste disposal from 98% to 42%. The EU financial support has been one of the determinants of this shift. It took the Czech Republic the same amount of time to reduce this figure from 93% to 49%. Financial support from businesses through the Extended Producer Responsibility (hereinafter – EPR) policy approach has been one of the main drivers of such progress. In addition, in 4

years, the Czech Republic will have a complete ban on the disposal of unsorted mixed municipal waste, which has been in force in many EU countries since the early 2000s. The development of waste management systems in some countries will be discussed later in the paper.

The Environment Action Programme for 2002–2012, adopted by the European Parliament and the European Council [3], reflected a gradual reduction in the amount of waste destined for disposal: by 20% in the period of 2000–2010 and by 50% by 2050. Therefore, waste generation should grow 15% slower than the gross national product of the EU. The Waste Incineration Directive [4] sets emission limit values for incinerators and cogeneration units. It lists the fractions of municipal waste that must be collected separately and are not subject to incineration. The Landfill Directive [5] sets out measures to reduce the risk to human health. It regulates the treatment of waste before burial, separation and separate processing of hazardous and safe waste, control over landfills during their operation and after closure.

In the United Kingdom (hereinafter – UK), a project on the distribution of biodegradable packaging materials is being implemented on the basis of a voluntary agreement between supermarkets and the Waste and Resources Action Programme [6]. The agreement was signed by 35 large retail chains and distributors, representing 92% of the country's grocery market. At the same time, the country is developing a project to “halve landfills”, aimed at reducing waste generated during construction or demolition. In France, Eco-Emballages [7] provides training and advice to anyone, but mostly engineering students, on packaging waste minimization. Belgium is implementing a regional program (Flanders) [8] to significantly reduce household waste, while part of the waste after grinding is used for energy. In Ireland, the so-called Green Business Initiative operates under the auspices of the National Waste Prevention Committee, which provides assistance to businesses and organizations in three areas – waste, water and energy [9].

“*It's smart with less waste*” programme is being implemented in Finland. It works with private entrepreneurs, municipalities and households. In Hungary, the re-use of building materials and their exchange between construction companies is becoming more common: exchange items cover 12 categories – brick, tile, wooden components of construction, window frames and others. In Austria, the Act on Waste Management (2002) regulates the initial ecodesign of products, the appropriate organization of production and distribution processes and work with consumers [10].

Waste reduction is one of the key reforms of the Grenelle Environment Round Table [11], which proposed legislation aimed at increasing recycling to 35% in 2012 and 45% by 2015. This has been successfully implemented. The annual recycling of waste, mainly household waste (28 MT), municipal waste (14 MT) and industrial waste (90 MT), which together account for 132 MT, represents only 16% of the total amount of waste generated (849 MT), including waste from agricultural and construction activities (717 MT). However, France offers a better solution for the recycling

process: in this country, 38.7 million tons of material is recovered from the waste stream and converted into 31.9 million tons of raw materials. This sector is represented by 2,400 companies employing 31,500 people.

Since 1992, eco-packaging has played a key role in the organization of selective processing, in the work of organizations specializing in specific materials, such as Aliapur (rubber tires), Valorplast (plastic / household packaging), Ecopse (polystyrene), Recyfilm (plastic films), Ecofut (plastic containers), Motus-Véolia (paper and documents) and Adivalor (agricultural waste). These companies have set tariffs for the repurchase of waste from collectors and purchase prices for processing plants. This sector is particularly attractive to international investors.

The legal regulation of hazardous waste disposal in England and Wales is almost entirely based on the EU legislation. One of the most important documents in the field of waste disposal regulation in the EU legislation today is the Waste Directive 2008/98 / EC3 [12]. British legislation on the disposal of hazardous waste is based on two regulations adopted in accordance with the EU law. These are The Waste (England and Wales) Regulations (2011) [13], and the List of Wastes (England) Regulations (2005) [14] which implements into the English law the European Waste Catalog approved by the above Decision of the European Commission 2000/532/EC6 [15]. The main principle of The Waste Regulations is the need for strict accountability of enterprises engaged in the processing and disposal of hazardous waste.

The most important document regulating the waste incineration process in the EU is the Industrial Emissions Directive 2010/75/ EU8 [16]. This document sets out the specific technical requirements that waste incineration plants must meet, including those aimed at generating electricity. In 2013, this Directive was implemented in English legislation by amendments to the Environmental Permitting Regulations in 2010. The public policy program can be reduced to the six theses, which were previously formulated in the Strategy for Hazardous Waste Management in England 2010 published by the Department of Environment, Food and Rural Affairs of Great Britain [17].

“Economy of recycling” is being paid attention nowadays: recycling turns waste into a resource and prevents the costs that would occur if they were disposed of at the landfill. This type of waste treatment also creates additional jobs. It is established that the removal of 10 tons of waste to the landfill creates 6 jobs, and the recycling of the same 10 tons – 361 jobs. Additional economic effect is achieved when recycled waste is used “on site”, eliminating the need to import this category of materials from other places or other countries. A country may not produce paper, but receives it by recycling waste: this is the strategy that increasingly is being implemented in the EU. Recycling, like no other waste management method, paves the way for significant resource savings. In the production of aluminum, it saves up to 95% of energy, copper – 85%, steel – 74, lead – 65% [18]. Glass can be recycled any number of times without loss of quality or purity, while acquiring a variety of shapes; at the same time for each ton of recycled glass a ton of natural raw materials is saved. An important and not always easy to solve problem is the processing of construction

waste and demolition of buildings (hereinafter – construction waste). Construction waste accounts for a third of all EU-controlled waste: concrete, brick, tile, wood, glass, plastic, gypsum, bituminous mixtures and resins, metals (ferrous and non-ferrous), stones, insulating materials, chemicals, packaging materials etc. The main task in this direction is to reduce this class of waste by 70% (by weight) by methods of reuse and / or recycling: today in the EU countries reuse ranges from 10 to 90% [19].

Due to the rapid development of organic agriculture and methods of production of alternative fuels, the recycling of biowaste is becoming increasingly important. This category includes: 1) food waste; 2) organic waste (“any waste of vegetable or animal origin”); 3) biodegradable waste (“any waste that decomposes anaerobically or aerobically, such as food or garden waste as well as paper and cardboard”); 4) biowaste (“green mass of gardens and parks, food and kitchen waste from households, restaurants, cafes and food enterprises”) [20]. Composting is an ideal way to recycle organic kitchen, garden and agricultural waste. Large composter plants are covered by the European Compost Network, which has 72 associate members from the 27 EU countries and serves more than 3,000 companies [21]. A network of “eco-volunteers” has been created in Italy. They have conducted trainings among the population on “selective” collection of food waste, which later began to be used by up to 80% of households in the communes; 90% of households, as the analysis testified, have mastered the methods of home composting “at the appropriate level”; fee for the removal of household waste has been reduced everywhere. In the county of Kent (UK), in a similar project 95 thousand households were involved.

The next level of the “waste management hierarchy” is “other uses”. In the EU documents, this is covered by the term “waste-to-energy”. The physical basis of the technologies used in this area is the incineration of waste in special plants. In some EU countries (Germany, Belgium, Sweden, the Netherlands, Austria, Denmark) the percentage of waste sent to landfills today is in the range of 1–2%; while 35–50% of waste is incinerated in different ways and 50–60% is recycled and composted. In all these countries, landfilling without prior treatment is prohibited by law [22].

In this regard, special attention is drawn to the concept of “energy balance”, proposed by the working group of the World Energy Council: the energy obtained should cover the energy costs of waste recycling. Another promising way to recycle waste for energy purposes is the biogas production. Directive 2009/28/EC, known as the Renewable Energy Directive, set a goal for Member States to achieve 20% renewable energy consumption by 2020 “in all sectors” and at least 10% in the transport sector [23]. In the future, it is estimated that biomass will provide up to two-thirds of renewable energy in Western Europe. The share of biogas as a transport fuel is growing systematically in Germany, France, Sweden and Switzerland and the “green transport” appears.

With regard to landfills, it should be noted that the EU documents define this method as the “least desirable option”, which should be kept to a minimum. According to the European directive it is forbidden to place the following types of waste

on landfills: 1) liquid; 2) flammable; 3) explosive or oxidizable; 4) medical (because there is a risk of infection); 5) car tires; 6) some other species. The directive also stipulates that landfills are only permitted for pre-treated waste.

In 2015, the European Commission adopted the program “Closing the loop – An EU action plan for the Circular Economy” [24]. The central idea of the programme is “everything that is possible should be recycled”: “the transition to a more circular economy, where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised, is an essential contribution to the EU’s efforts to develop a sustainable, low carbon, resource efficient and competitive economy”. Nowadays sustainable development is shaped with the principle of using fewer resources per unit of output and the concept of circular economy is being developed as a fundamental component of the “green economy” [18; 25].

According to the estimations of the Ellen MacArthur Foundation [26], the EU companies which produce durable goods will be able to save up to 630 billion dollars annually in 2025 due to the emphasis on the circular economy. At the level of households, transport, housing and food industry costs may decrease by 25% in 2030. The financial platform of the circular economy in recent years has focused mainly on the following three tasks: promotion of best practices in order to attract potential investors and other stakeholders; analysis of specific projects and their financial needs; financial consulting; coordination of the activities of enterprises operating in the circular economy; promotion of circular economy projects and organization of their financial support; lending to business organizations engaged in the circular economy, especially for medium- and long-term projects. In 2020, 40 billion euros were spent on municipal solid waste management by the European Investment Bank [25].

Waste management practice in the selected EU countries

It should be noted that the most active environmental policies are implemented in Sweden, Denmark, Germany, and the Netherlands.

Sweden has a system for sharing responsibility for waste collection and treatment. Households (municipalities) are responsible for the separate collection and disposal of waste in appropriate containers; collection points are usually within 300 m of any household. Homeowners pay an average of SEK 2,000 a year for waste collection. The number of fractions (different factions are taken out on different days of the week) varies from municipality to municipality and can reach a number of 10–15. Garbage collection on the roadsides is also organized.

Depending on the profile of their activities, Swedish manufacturers are responsible for the organization of systems and the order of collection of their waste; at the same time, they must provide consumers with relevant information. There

is the responsibility of all kinds of business structures: they collect everything else that is not collected by households and producers. According to established practice, the manufacturer can either organize the collection and export of their packaging and containers (which is burdensome and almost impossible), or on certain contractual terms to transfer this responsibility to companies that are part of the “dual system”. In the latter case, under the terms of the license, such manufacturer receives a “Green Dot” (der Grüne Punkt) – a special sign (icon), which means that the manufacturer has covered in advance all the costs of processing their waste and guarantees the receipt and recycling of labeled packaging material. Subsequently, the “dual system” along with paper and cardboard packaging covered a range of waste – plastics, glass, aluminum and composite materials.

Today, the level of landfills in Sweden has dropped to less than 1%. Approximately 6,000 recycling stations operate separately, collecting packaging, newspapers, all other waste paper and other types of waste: the network is built on the principle of EPR, which ultimately finances this work. The upper level of this system is thermal power plants (unless the waste is sent to biogas production): today in Sweden there are more than 30 powerful incinerators. Their combined capacity is such that they lack their own fuel to ensure smooth operation, and Sweden imports significant amounts of waste, mainly from Norway, the UK and Ireland: more than 1.5 million tonnes a year [27]. Around 20% of domestic demand for domestic heat today is covered by waste incineration.

Today, two-thirds of the country’s bus fleet runs on renewable fuels. Transport biomethane is produced in a dozen of cities in Sweden – in Örebro, Uppsala, Västerås, the provinces of Södermanland and Östergötland, around Stockholm and elsewhere.

The Danish model of waste management [28] is shaped with a clear division of roles, responsibilities and competencies between members of the system – state, regional and local authorities, waste generators and waste management companies. The structure of all waste management activities: the system covers all types of waste (domestic, industrial and hazardous); the full responsibility lies with the local government, which determines the methods of waste collection and further treatment – the rules that are strictly guided by waste generators; strict adherence to the “polluter pays” principle; the whole process is based on the principle of separate collection. The national goal set out in the Energy Agreement is to ensure full independence of Denmark from fossil fuels by 2050, in connection with which a sharp increase in funding for bioenergy projects is expected.

Kalundborg is a city in Denmark, which created the world’s first industrial symbiosis with the concept of a circular economy. The interaction of the participating companies is based on the principle that the balances from the production of one company become a resource for another, and at the same time all reduce economic costs and reduce CO₂ emissions. In addition to the environmental impact, the consortium members save € 24 million on operating processes each year.

According to its technical level, the waste management system in Germany is one of the most developed in the world where level of various waste streams treatment had significantly exceeded the average European level. Thus, more than 90% of household waste is recycled, while for Europe as a whole this figure (in average) accounts for 37%. The overall recycling rate of various materials in Germany exceeded 80%; more than 70% of paper, 94% of glass and 45% of steel are being made from “secondary” materials [29]. Recycling plastic bottles saves such an amount of energy that would supply heat to almost 2 million Berliners in 130 days. Data on German experience in waste disposal, waste incineration and recycling are shown in Fig. 1.

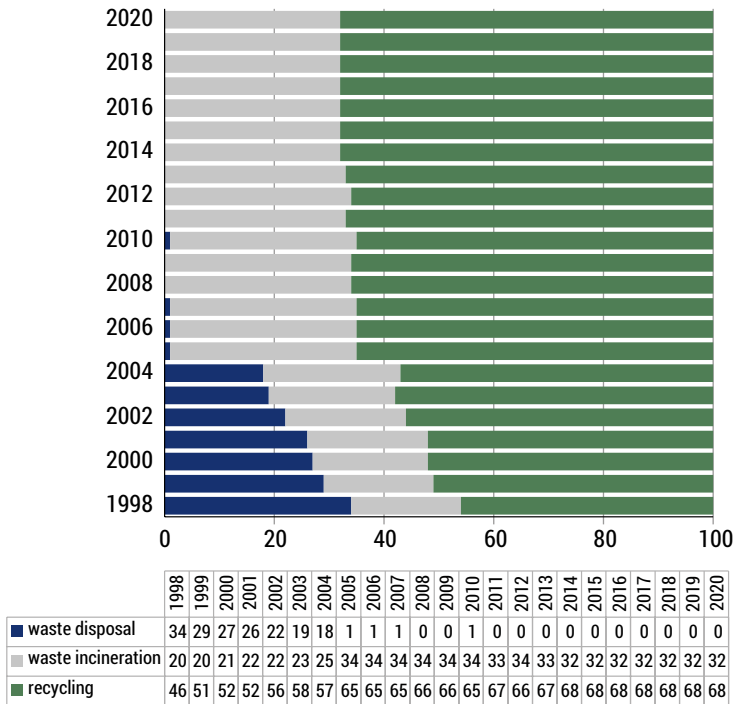


FIG.1. German experience in waste disposal, waste incineration and recycling in 1998–2020, %

Back in the 1960s, there were more than 50,000 existing landfills in Germany, no significant security measures were envisaged at the landfills. Most of them have been closed since 1980, and about 150 large and well-organized landfills have continued to operate. In 2005, the disposal of household waste at landfills without intensive pre-treatment has been prohibited. Today, household waste that cannot be recycled is incinerated or undergoes intensive mechanical and biological processing. All valuable materials, in particular metals, must be removed and put back into circulation, and elements with high heat capacity must be used as fuel substitutes. The remaining waste is fermented and decomposed, i.e. treated biologically so that when placing

humus on the landfill no gases are released and there is no risk of subsidence. Separate collection of recyclable waste has been identified as a necessary component for an efficient waste management system and has become mandatory for major recyclables. Today most of the waste can be handed over directly to the area adjacent to the house.

That is why today in Ukraine inside residential areas there are separate containers for residual waste (gray container), paper (blue container), packaging (yellow bag or basket) and organic waste (green or brown container). Glass is mainly collected in separate containers, usually divided by the color of the glass (white, green, brown or multicolored). In addition, you can recycle large waste, including electrical equipment. Many types of waste, such as batteries, fluorescent lamps, etc. can be handed over at the place of purchase of these goods. The obligation of the point of sale to accept this waste is regulated by the relevant laws [30].

In the Netherlands, the task of gradual progress to the circular economy is approved at the state level and is the national priority. In 2014, a special program, RACE – “The Realization of Acceleration of a Circular Economy” [31], has been developed. Since 2016, the so-called “government-wide” program “Circular Netherlands until 2050” has been initiated. Since 2016, the “government-wide” programme “Circular Dutch Economy by 2050” was initiated. The programme provides two time periods, where for the first one until 2030 – an (interim) objective of a 50% reduction in the use of primary raw materials (minerals, fossil and metals). There are five priority sectors (programmes) that need priority attention in terms of expanding the “circular economy”: biomass and food, plastics, the manufacturing industry, construction sector and consumer goods.

Dutch experts identify nine levels of the “circular economy” – the so-called 9 Re: refusal to overuse raw materials (Refuse); reduction of raw material use (Reduce); Reuse; maintenance and repair (Repair); Refurbish; production of new products from elements of the old (Remanufacture); use of the product for other purposes (Repurpose); recycling and reuse of materials (Recycle); energy production from materials (Recover).

Increasingly, “circular” methods are used in urban construction. In circular Amsterdam, as the Dutch experts write, “the emphasis is on “reasonable demolition” (structural elements and materials are preserved that can still be used in new construction). Houses are built in a “modular and flexible” way, which provides for the possibility of remodeling houses without radical reconstruction [32].

Poland, on the basis of the EU directives, has adopted the Act on Maintaining Cleanliness and Order in Municipalities (1996), the Act on packaging and packaging waste management (2013) and other laws which define the terms and basic principles of waste management, as well as methods of processing, utilization and disposal of waste. The permit for waste generation is issued by the voivodship (regional council) or county (district council). This permit applies only to waste generation by enterprises. The commune (gmina, local government) does not receive a permit for waste generation. Legislation in the field of waste management in Poland regulates the development of waste management plans at two levels: national and voivodship (regional). The plans should apply two basic principles of waste management: self-sufficiency and proximity of location.

The dynamics of changes in the structure of solid waste management in Poland over the period of 1998–2018 is shown in Fig. 2. The situation with landfills in Poland began to change after the country joined the EU. Poland has agreed with the EU on a transitional period for landfills. An important stage in solving the problem of waste was the so-called “waste revolution” during 2012–2013, when the state fully transferred the issue of municipal waste to local governments. Since then, it is the local authorities in Poland that set the prices for the residents of the houses for garbage removal, and are also responsible for the implementation of the EU directives in this area, including waste sorting and recycling. In order to minimize the possibility of fires in landfills, Poland has banned the storage of flammable and explosive substances on them. Many Polish landfills have been modernized and technically equipped with the EU funds. In 2015–2016, six new waste incineration plants were opened in Białystok, Bydgoszcz, Kopin, Kraków, Poznań and Szczecin and in 2018 – in Rzeszów. The European Commission has approved the allocation of 100 million euros for the construction of two new incinerators in Poland.

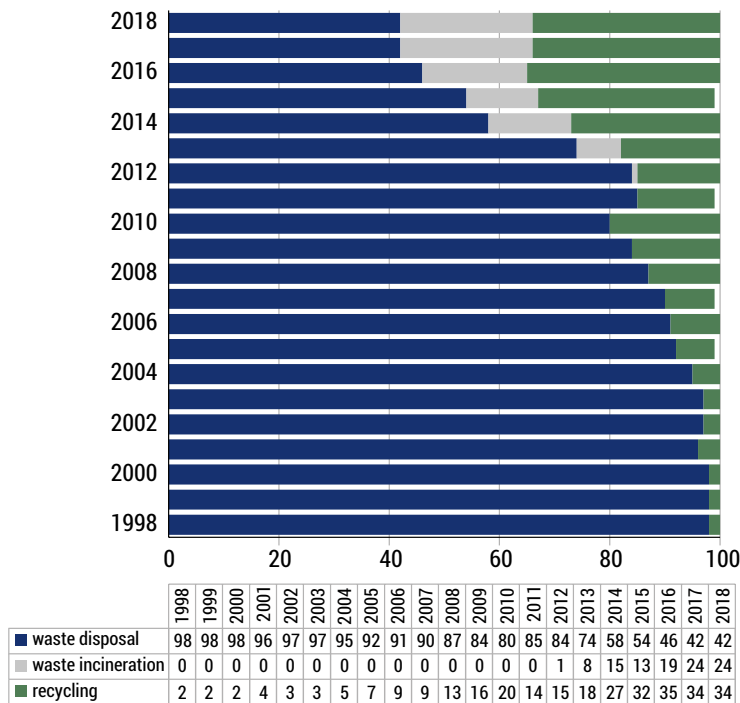


FIG. 2. Polish experience and dynamics of change in the structure of solid household waste treatment in 1998–2018, %

SOURCE: [33–35]

In the early 2000s, Poland was similar to Ukraine as it is now, both in the volume and morphology of solid waste and in the state of waste management infrastructure.

In 15 years, the country has managed to reduce waste disposal from 97% to 42%. First, the recycling industry has been developed successfully, due to work with the public to encourage sorting in particular. Secondly, there was a real boom in the construction of incinerators in the country. By moving from the lowest level of the waste management hierarchy (disposal) to the penultimate (recovery), Poland has strengthened its energy independence through the use of waste-to-energy technology. The requirement for the treatment of used oils is not to burn, but to regenerate. Legislation also regulates the management of biodegradable waste (greens and food), as well as the obligation to collect and compost it separately. There are two areas of waste management that are subject to biodegradation: composting, with the resulting methane emitted into the atmosphere and anaerobic fermentation with its subsequent combustion and generation of electricity. According to the waste management plan, municipal waste cannot be taken out of the region. This requirement does not apply to certain hazardous wastes, the recycling facilities of which are not available in the region. GOAP [36] and waste collection companies control the movement of machines and the accuracy of the declared number of persons in the submitted declaration. In Poland, the law regulates the issuance of a mandatory waste transfer card, which is issued by the waste-generating company in triplicate. The waste generator is responsible for what happens in future with the waste.

The experience of Slovenia is also worth of attention. Residents of the city of Ljubljana pay up to 10 Euros per month from one household, which has a conditional 2.2 people. Residents have the opportunity to sort waste in five different containers: mixed waste, organic waste, packaging, glass, paper. All waste is taken by the municipal company. However, residents pay only for mixed and organic waste. Exemption of the rest waste is covered by the sale of this waste as a secondary raw material and due to the operation of EPR systems (for packaging), which was proposed by the EU Directive. Access to public containers for displacement is created using an electronic resident card. Residents of individual houses have their own waste containers and float for waste depending on the volume of the containers. Significant role in Ljubljana in measures to prevent waste generation is given to municipalities and the local waste prevention programme is adapted and designed to involve all stakeholders. Individual composting and design changes for certain products (such as coffee capsules), access to drinking water in public places (to minimize the number of plastic bottles), the opening of repair shops, collection points for used products which can be reused, introduction of a green procurement system for municipalities, approval of rules and standards for public events by the municipality, development of a food waste management programme etc. can help prevent the waste generation.

The public company Snaga Ljubljana [37] is the largest Slovenian municipal waste management company. Snaga also manages municipal public and green areas, public toilets etc. The company supports Ljubljana's regional parks. It created an expert

group for the care and maintenance of urban trees. Snaga sees itself as a leader in developing and implementing sound waste management solutions that can be delivered in an environmentally conscious and cost-effective way. The main focus of the company is on waste prevention, in particular through cooperation with the municipality and encouraging the transition of Ljubljana to a closed-cycle economy, waste reuse and recycling. Thirteen years ago, Snaga Ljubljana started collecting biowaste separately. From them pure and qualitative compost by anaerobic fermentation is made. Such compost is sold to residents or farmers. During the production of such compost, biogas is formed, which is burned to produce electricity.

The path of the Czech Republic can be characterized in several stages. The data on waste disposal, waste incineration and recycling in this country is shown in Fig. 3. The first steps were taken in 1986–1989 when the old incinerators in Brno (248 thousand tons of waste per year) and in Prague (310 thousand tons of waste per year), which were built in 1905 and 1930 respectively, were reconstructed. The first Waste Act 1991 was adopted in 1991.

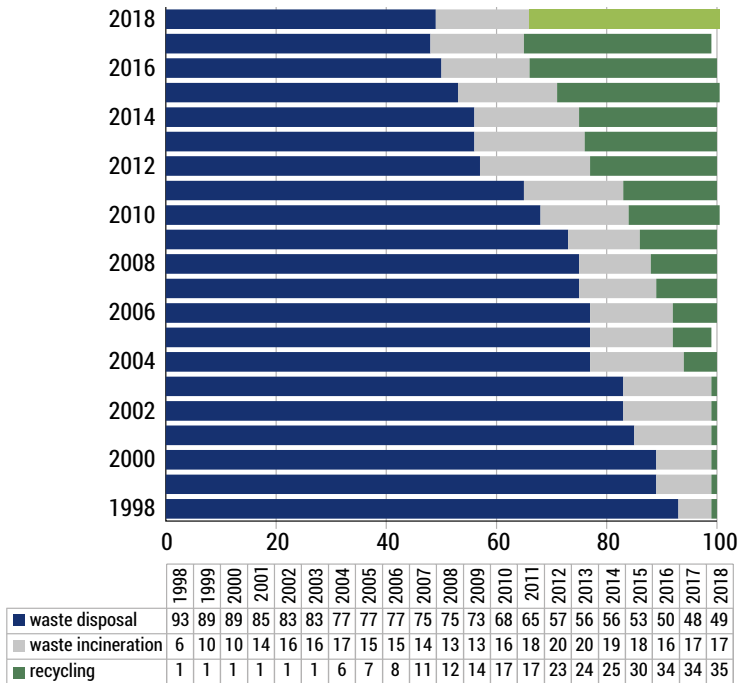


FIG. 3. The Czech Republic experience in waste disposal, waste incineration and recycling in 1998–2018, %

In 1992 a tax on waste disposal (up to 1 euro per ton) was introduced and the State Environmental Fund was established. In 1999, a waste incineration plant was built in Liberec (96 thousand tons of waste per year), and in 2001 the waste hierarchy

was determined, the foundations of EPR were laid, and tariffs for waste management, including waste disposal, have been determined (Waste Act 2001). In 2002 the extended principles of the EPR of packing (Waste Act 2001) have been fixed, in 2003 Waste Management Plan until 2014 (2003–2014 Waste Management Plan) has been approved. In 2004, the Czech Republic joined the EU and in 2007 an amount of 776 million euros became available to the Czech Republic under the EU Waste Management Program (2007–2014). In 2009, the landfill tax was increased to 19 euros per tonne (in 2007 it used to be 15 euros, in 2002 – 7 euros). In 2014, a ban on the disposal of unsorted mixed municipal waste from 2024 has been introduced. The next step was to approve a program to prevent waste generation by 2024 in various sectors of the economy, including: dissemination of quality information among businesses and households, inclusion of lessons in schools, research etc. (2015–2024 Waste Prevention Program). The waste management plan until 2024 focusing on waste prevention, recycling, reuse, transition to a circular economy (2015–2024 Waste Management Plan) has also been approved.

Since 2015, mandatory separate collection of biowaste has been introduced in all municipalities. The main priorities from 2019 remain: increasing the landfill tax, avoiding the construction of an excessive number of incinerators and mechanical and biological plants, increasing the level of recycling, including biowaste, using the principle of “pay-as-you-throw”. The Ministry of the Environment of the Czech Republic has drafted a law on waste. One of the innovations is new garbage cans. It is assumed that black tanks should be filled the slowest and garbage from them will have to be removed less often than from others. By 2030, the Ministry plans to raise the fee for waste disposal by more than three times. In addition, due to the new tracking system, City Hall will be able to calculate the unauthorized release of waste and remove it. From 2025, textile sorting will be introduced. By 2026, all the EU member states are obliged to reduce the consumption of plastic tableware.

The Lithuanian experience in waste management is also worth of being studied. Regulation of the waste management system in Lithuania began in 1998 (with the adoption of the Law on Waste Management). Waste management in Lithuania is coordinated by 10 regional centers in 10 waste management regions. Self-governments are the main institutions that organize the management of waste generated on their territory. The main goal of self-government is to create an effective solid waste management system. The tasks of local governments are: to ensure the availability and high quality of services in the field of solid waste management; equip places for separate collection of secondary raw materials (paper / cardboard, glass, plastics, metals), large and hazardous waste; to ensure the collection and treatment of municipal waste that can be biodegradable; perform tasks to reduce waste at landfills. Since 2013, 75% of municipal waste has been collected, recycled or otherwise used separately; only treated solid waste is deposited at landfills. The share of solid waste processing in Lithuania is shown in Fig. 4 (government data). Today in Lithuania more than 800 old landfills are already closed and rehabilitated.

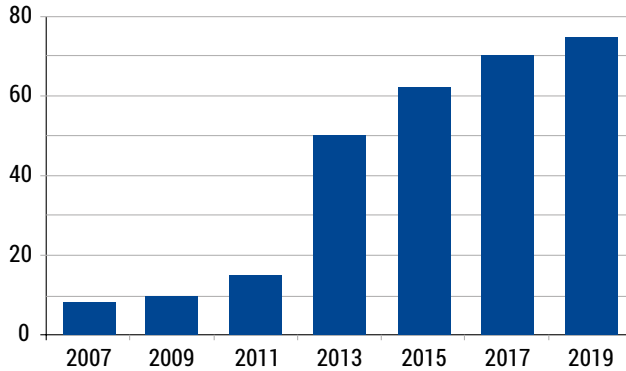


FIG.4. The share of solid waste processing in Lithuania in 2007–2019, %

Eleven regional modern landfills for solid waste have been opened and operated. Currently, there are 70 sites for the collection of bulky waste in Lithuania and 13 sites for composting green waste (capacity $\approx 34,000$ tons / year).

In the city of Klaipeda there is a thermal power plant that uses solid waste (after pre-sorting) as fuel together with biomass. In Lithuania, there are: one nationwide hazardous waste landfill with an area of 7880 m^2 near the city of Siauliai, 32 additional sites for composting green waste, 7 additional sites for bulky waste, 9 mechanical and biological treatment plants, 2 “waste to energy” stations in Vilnius and Kaunas, the system of using the high-calorie fraction of solid waste at the cement plant. Data on biodegradable solid waste disposal in Lithuania in the period of 2007–2020 is given in Fig. 5.

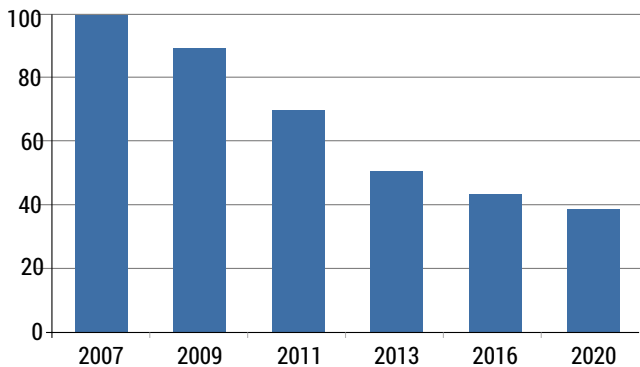


FIG.5. Disposal of solid household waste in Lithuania, 2007–2020, in %

Thus, today the European trends of “zero waste” and “circular economy” among other areas of waste are dominant and aimed at benefiting the environment, rather than polluting it.

Ukraine's performance in the area of waste management

For several years, within the requirements of the Association Agreement between Ukraine and the EU, the regulatory framework for waste management in Ukraine has been developed. In particular, the National Waste Management Strategy until 2030, the Law of Ukraine “On Housing and Communal Services” and the draft Law of Ukraine “On Waste Management” 2207–1d, which passed the first reading in the Verkhovna Rada, are aimed at accelerating the country's movement towards international environmental safety standards. The comparison of some indicators for waste management in Ukraine and the EU is given in Table 1.

It should be noted that despite the smaller volume, the indicators of waste management efficiency in Ukraine, unfortunately, are not in favor of Ukrainians. And this applies not only to the areas of separate collection and processing, but also to basic indicators. For example, 22% of the Ukraine's population does not have access by household waste removal services at all. And even where there is an adequate infrastructure, there are other problems, such as unauthorized landfills. In 2019, about 27,000 such illegal dumps were discovered.

TABLE 1. Indicators for waste management

Indicators	Municipal recyclable waste, including composting	Municipal waste buried in landfills	Separate waste collection	Penalty for separate waste collection
EU countries	48%	23%	89%	€ 5000
Ukraine	3%	94%	5%	€45

SOURCE: [38; 39]

The National Waste Management Strategy until 2030, approved by the Cabinet of Ministers of Ukraine in 2017, has many goals for Ukraine. For example, the level of municipal waste disposal should decrease from 94% to 35% by 2030 (Fig. 6).

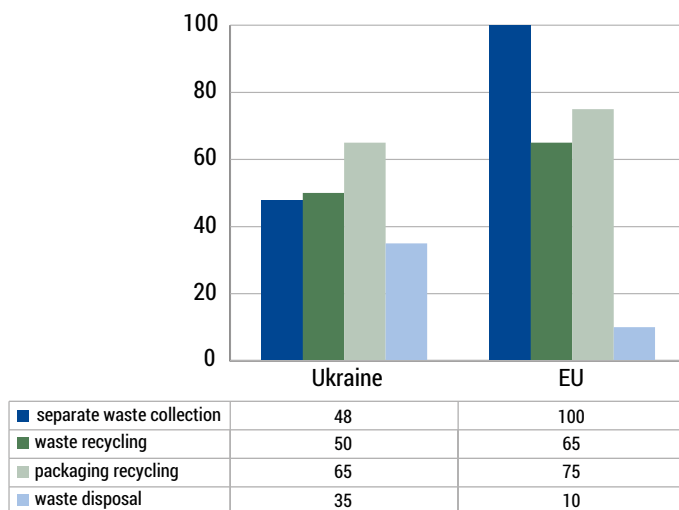


FIG. 6. Waste management indicators until 2030 in Ukraine and the EU

That is, in 13 years Ukraine needs to go the way that other countries took almost twice as long. Achieving the indicators set out in the National Waste Management Strategy and the National Waste Management Plan requires effective joint work of all stakeholders: central and local authorities, business, the publics, international partners and volunteers. The main tasks facing Ukraine in the light of the implementation of the EU practices are analyzed and comparison with the best European practice is given (Fig. 7).

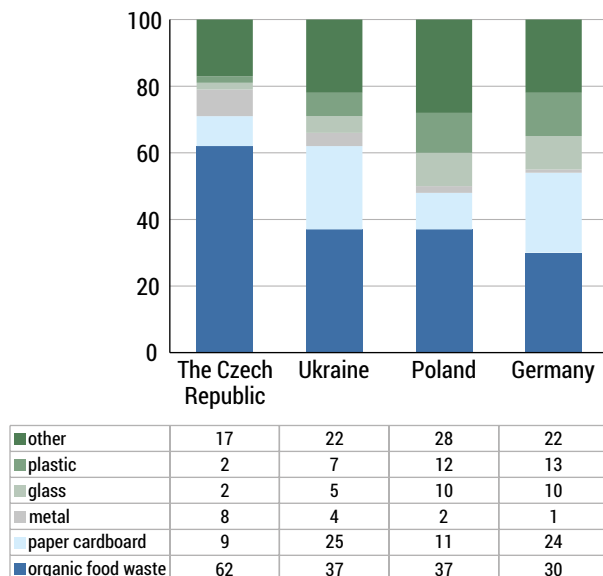


FIG. 7. Composition of solid waste in the Czech Republic, Ukraine, Poland and Germany, %

SOURCE: [40]

One of the priority tasks is the introduction of mandatory separate collection of household waste. Organic food waste in Ukraine accounts for 37% of total solid waste, so the issue of sorting and further management of biowaste is of great importance. The EU experience also testifies that the inclusion in the system of separate collection of biowaste significantly increases the quality of dry household waste sorting.

The main fractions into which household waste can be divided are: plastic, paper/cardboard, glass, metal, biowaste, clothing/footwear, mixed waste (residual waste that does not belong to the previous fractions). Hazardous waste should also be collected separately.

The development of waste management infrastructure remains an important issue and the situation in Ukraine is to be discussed. In 2019, the Kyiv city authorities initiated a pilot project to develop a separate solid waste collection system. During the year, 3.5 thousand tanks were installed in the city. In 2019, about 4.5% of the collected waste went to processing plants. This is 1% more than in 2018. However, according to “Kyivkomunservis”, in the first months of the project only about 15–20% of waste collected separately was suitable for recycling due to the low quality of sorting by the population.

The public project “Ukraine without garbage” (creates sorting stations and raises the level of citizens’ consciousness) has been working since 2015 and aims to improve the environment by involving communities in waste sorting.

In Ukraine, there are 17 enterprises for the processing of waste paper, 39 – for the processing of polymers, 19 – for the processing of PET raw materials, 16 – for the processing of cullet.

It is important to work in this direction at all levels of government. In particular, the central authorities: enshrine at the legislative level the mechanism of separate waste collection; approve methods of calculating targets for preparation for reuse and recycling of household waste; approve the procedure for setting tariffs for household waste management services in compliance with the principle of “pay-as-you-throw”, except for payment for waste; develop universal instructions for labeling products, waste from which is subject to separate collection; develop and approve general requirements for the design of containers for separate collection, in particular, ease of use, information support and general rules for the use of colors for the collection of various types of waste. Local authorities are responsible for: organization of separate collection of household waste, including creation of municipal waste collection points; ensuring the implementation of target indicators and quality parameters for biowaste recycling and treatment of other household waste products. On the business side, it is advisable to: ensure simple labeling of products, waste from which is subject to separate collection in accordance with the approved instructions; inclusion of separate collection in waste management plans at the enterprise level. The population is obliged to sort waste and treat it if wished.

The introduction of the EPR System [41] is one of the target areas for the implementation of the European waste management experience. In 30 years, the number of EPR systems in the world has reached 400. The legal framework for the development of EPR at the EU level consists of both framework legislation on waste and sectoral directives aimed at regulating the waste of certain types of products, including packaging, waste from electrical and electronic equipment (WEEE), end-of-life vehicles (ELV), batteries and accumulators (B&A). There is no strict obligation in the EU to introduce EPR systems for packaging manufacturers. Despite this, at least for household waste, the most EU member states (25 out of 28) have chosen the EPR path. In the case of the introduction of the EPR packaging system in Ukraine, there will be potential for the development of the domestic market of secondary raw materials. Currently, due to the high cost of materials, processing companies are forced to import secondary raw materials from abroad.

One more direction for the implementation of the European waste management experience is raising public awareness and educational activities. The experience of countries that have made significant progress in the field of waste management testifies that raising public awareness is a prerequisite for creating sustainable waste management systems. The results of educational initiatives can be observed in 5, 10 or even more years, but without proper training of the population, the waste management system will not be able to function. In many countries, environmental education begins in kindergarten and primary school. Some countries 15–20 years ago have conducted educational campaigns at the state level and managed to form the mentality of the nation in relation to the environment. Among such initiatives the following ones can be mentioned: introduction of waste sorting with the participation of children in kindergartens and schools, environmental lectures, integration of waste management in children's daily lives through cartoons, books, toys, involving children in special environmental projects. In addition to educating children, informational and educational activities among the adult population are mandatory. Communication must be sustainable and carried out at the national level. It should be borne in mind that the media space on waste management is quite active. However, the focus of the discussion is blurred and does not always stimulate action and change the behavior of the population. In addition, there is no reliable and transparent source of comprehensive data on the sector's work, which does not make it possible for interested citizens to explore issues and get involved in solving problems or implement public control where appropriate.

In order to implement the European experience, the infrastructure for separate collection and the quality of waste sorting must be improved. Today the current state of infrastructure in Ukraine is as follows: 34 waste sorting lines for household waste, 1 waste incineration plant "Energy" for municipal waste, ≈5 thousand landfills for municipal waste, 3 incinerators for municipal waste, > 27 thousand unauthorized landfills, the need to build 384 new landfills.

Data on waste management in Ukraine in 2011–2020 is shown in Fig. 8.

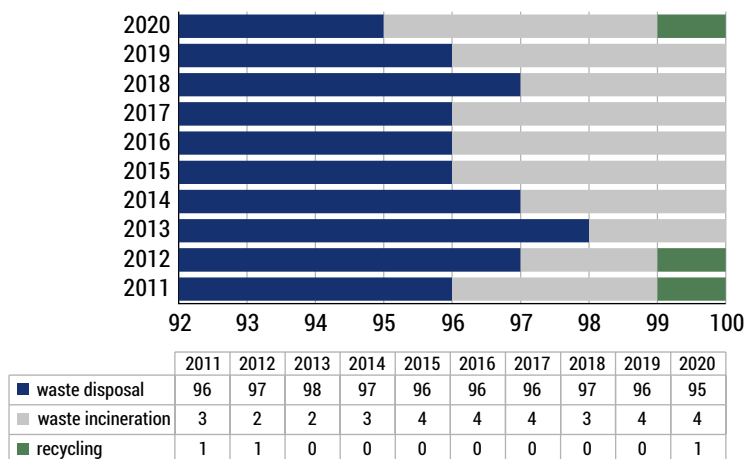


FIG. 8. Waste management in Ukraine in 2011–2020, %

It should be noted that the level of waste disposal in Ukraine compared to European countries remains insufficient, which is primarily due to the limited amount of organized collection of municipal waste and this contributes to uncontrolled waste disposal. The lack of technical capacity to recycle or dispose of certain categories of waste is a prerequisite for uncontrolled emissions and disposal. Many existing waste disposal facilities, such as landfills and incinerators, do not meet legal requirements and modern technical standards. In addition, the syndrome “my house is on the edge” further complicates the construction of new facilities and structures for recycling. It is also affected by the continued operation of some facilities etc., which are directly related to the danger to the environment.

In this regard, Ukraine, based on the experience of the European countries, has adopted the main strategic goals to be achieved by 2030.

Summary

The implementation of the EU’s best waste management practices is of great importance for Ukraine. The stated objectives are general and can be applied to the waste management strategy based on the European experience as a whole. Among the important priorities of the strategy are:

- reducing the risk of adverse effects on human health and the environment in Ukraine in the early stages, improving waste management practices based on hierarchy principles and assumption criteria;
- optimizing opportunities for new generation and minimizing existing waste, increasing the amount of waste destined for recycling, re-utilization and restoration, where it is economically viable and financially feasible;

- increasing the volume and improving the quality of waste collection;
- development of waste management facilities, restoration and disposal in accordance with the latest technical standards;
- reducing the risks to human health and the environment from the spread of landfills;
- strengthening the influence of institutions responsible for waste management at the national, regional and local levels;
- providing comprehensive and reliable data on waste production, management and disposal;
- increasing sectoral investment and expanding the application of the principles of “extended producer responsibility” and “polluter pays”;
- raising public awareness and involvement, increasing efforts to address the waste management issues within the country.

Among the quantitative tasks that must be performed in Ukraine the following ones should be named:

- dissemination of the municipal waste collection service;
- reuse and recycling of household and similar waste into paper, cardboard, plastic, glass and metal;
- reuse and recycling of construction and demolition waste;
- specific tasks for certain types of waste, including packaging waste, disposal of waste electrical and electronic equipment, batteries and accumulators, end-of-life vehicles, and the use of waste petroleum products must also be ensured.

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