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**MEGVALÓSÍTHATÓ-E A KÖRKÖRÖS GAZDASÁG? A MŰANYAG
ÚJRAHASZNOSÍTÁS VIZSGÁLATA MAGYARORSZÁGON
IS IT POSSIBLE TO TALK ABOUT CIRCULAR ECONOMY?
INVESTIGATION ON PLASTIC RECYCLING IN HUNGARY**

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1. INTRODUCTION

Environmental questions and issues caused by overpopulation, overconsumption, clean water scarcity, food scarcity and climate change are extremely pressing nowadays. Vast differences exist among countries around the world, which the World Bank classification well describes and well defines. The organisation demarks four different groups of countries: “Low income”, “Low middle income”, “Upper middle income”, and “High income” countries, based on GNI per capita in current USD. The differences are remarkable. Low income countries like Chad in Africa, Tajikistan in Asia, and Haiti in North America (Hamadeh, et al., 2021) struggle under malnutrition, high infant mortality rate, and illiteracy (Keats et al., 2021).

In other parts of the world pollution emissions, sustainable industry and innovation, and overconsumption rank as major issues. Brown and Cameron (2000) discuss the problem from the level of the individual. They define the mission of ecologists, economists and other behavioural scientists and the roles these scientists could play in preventing overconsumption. Kjellberg (2008) notes three issues that emerge in the intersection of market exchange and consumption. These are calculation – how to calculate overconsumption; performativity – the role of marketing as a driver of overconsumption; and agency – what the term overconsumption means exactly. According to Tóth and Szigeti (2016), changes in consumption are neither incremental nor linear and that trends shifts or other changes in the increasing of consumption are noticeable. Heidbreder et al. (2022) claim that the effects of overconsumption, such as the presence of plastic bags and bottles in nature or the ocean, are undeniable. The study focused on the physiological aspects of private and public behaviours and demonstrated that rational cost-benefit considerations, as well as moral factors, can lead to reductions in plastic consumption.

Increases in consumption lead to increases in waste (Buenrostro – Bocco, 2003), which presents major environmental challenges to waste management. Companies, cities, governments and large international organisations such as European Union draft and implement waste policies and management plans to meet the challenge, but the quality of waste management that individual countries and companies develop and practice vary considerably. Plastic represents a major form of waste because it is seemingly ubiquitous and utilized by all aspects of society, including households, businesses, institutions, companies, and governments. Unfortunately, the quantity of plastic waste continues to increase (Chow et al, 2017).

When it comes to plastic waste management and recycling, Hungary ranks among the less efficient EU member countries. For example, the average recycling rate for packaging in the EU 41 percent, while in Hungary this rate is only slightly above 10% (portfolio.hu, 2021), which implies that Hungary needs to improve its rate of separately collected plastic waste. The present study explores how Hungary can improve its plastic waste management. The thesis introduces examples, practices and statistics demonstrating how other EU member countries earn better plastic waste management and recycling results than Hungary. The thesis utilizes these examples, practices, and statistics to offer suggestions and recommendations on how Hungary could improve its plastic waste management programs and, thereby, improve its EU ranking.

The aforementioned overconsumption and the increase in waste have created new challenges for various actors in society, such as politicians, business leaders and scientific researchers. How can we simultaneously increase the welfare of society and reduce the consumption of available raw materials and pollution? In order to answer this question, stakeholders have started to develop model plans and strategies. One of the most widespread today is the circular economy, which aims to reduce the production of new materials by recycling those that are already used so that they can be reused.

The question arises as to whether this model could be applied to plastics, possibly reducing the emissions associated with the production of plastics. Can the same plastic be used more than once? Is it possible to achieve a perfect cycle for plastics? these are the questions I am looking for answers to in my thesis.

2. LITERATURE OVERVIEW

2.1. ENVIRONMENTAL POLICIES IN THE EUROPEAN UNION

Waste management, recycling, and the circular economy comprise the most important parts of EU environmental policy. Original member states did not consider the environmental problems during the EU's founding because climate change and other associated environmental issues were not considered key issues in the 1950s. In October 1972, the EU heads of state and government decided to elevate environmental policies to the EU level, resulting in common legislation and action plans. The first action plan – with six action programs, 300 pieces of legislation, and 80 main directives – entered into force in 1973 (Volger, 2011). The second followed in 1977 and the third in 1983. The first two plans achieved moderate effects and failed to produce the expected results; however, the third action plan clearly described its aims by focusing on environmental damage prevention rather than on solving environmental problems. The third action plan also includes the EU's environmental principles, which serve as the foundation of current EU policies (Horváth, 2011).

The concept of sustainable development was first mentioned in the 1992 Maastricht Treaty. It became the foundation for the main principles of the 1997 Treaty of Amsterdam, entailing that all policymaking was required to consider sustainable development. The Treaty of Lisbon in 2007 made climate change a major focus and ushered in the concept of a common energy policy (Horváth, 2011).

The European Union renews its environmental action plans periodically. For example, the 2022 environmental plan marks the eighth plan in force and is officially referred to as the 8th Environment Action Programme (EAP). The plan serves to guide EU environmental policy until 2030 and supports the European Green Deal, which demands every stakeholder rise to the challenge of ensuring successful environmental performance. The aims of the latest and most current EPA are: accelerating the fight against climate change, implementing resource efficiency management for companies, and using renewable energy sources.

2.2. WASTE POLICIES IN EUROPEAN UNION TOWARDS CIRCULAR ECONOMY

The environmental policies of the European Union have three prominent fields: water pollution, air pollution, and waste (Horváth, 2011). The European Union subsequently created its own definition for a circular economy: 'Circular economy is an economic flow process, which has no input and output side, the goods flow in circles, and consider not only financial welfare but

environmental problems as well.” Waste management and accelerating to transition to a circular economy (CE) are considered important factors. The European Commission adopted its first circular economy action plan in 2015 and its first circular economy package in 2018. That package consists of communication on monitoring framework and supporting legislation on plastics.

The monitoring framework for the circular economy defines how to transform the EU economy and make it more sustainable. Based on two different methodologies, Grdic et al. (2020) concluded that market actors can achieve a genuinely better economic outcome in terms of GDP in a circular economy. The research study constructed an econometric model where GDP was an independent variable and the dependent variables included municipal waste per capita, the recycling rate of municipal waste, the recycling rate of packaging waste by type of packaging, the recycling of bio-waste, and the recycling rate of e-waste.

Mao et al. (2016) offer a definition of circular economy by describing it as an economic form, which is started by material flow, leading the economic activities to consider ecological laws. In brief, the aim is to achieve “low mining, high utilization, and low emission”, with a minimal distribution of environment. The book also outlines the main differences between a circular economy and a traditional economy. While traditional economies tend to possess a one-directional material flow, the circular economy is a closed process replete with environmentally-friendly solutions. The authors also mention the three main principles of circular economy: reduce, reuse, and recycle. The first concerns material, energy consumption, and the avoidance of luxury and waste. Cleaning and reusing empty plastic bottles provide a good example of the second principle, while the third involves reforming and remanufacturing used materials and products.

Mao et al. (2016) created a three-material scale detailing material recycling. The first group consists of easily recyclable materials such as glass, paper and some forms of plastic. Moderately difficult-to-recycle materials like building materials, packaging materials, and solvents comprise the second group. The third group contains difficult-to-recycle materials such as paints, herbicides and other chemical products. An important consideration concerning the categories presented is that since 2001, many of the products the book lists in the easy-to-recycle category can be reused rather than recycled.

Kirchherr et al. (2018) completed a large-N study with over 200 survey respondents and 47 expert interviews. Their results concerning the barriers of the circular economy show that cultural barriers – such as a lack of consumer interest and awareness and the scarcity of suitable

company environmental policies – are a bigger obstacle than a lack of technology in preventing the wider dissemination of a circular economy.

The European Union has initiated the process of implementing a circular economy as a major goal. Through this goal, the organisation seeks to support the creation of local jobs and construct competitive advantages for Europe in the world. Achieving this goal involves developing the industrial sector, which entails renewing the EU industrial policy strategy with new priorities. The EU Commission has created a new webpage containing all the indicators connected to this subject (EU - monitoring framework, 2018)

Creating a circular economy is a complex and difficult task for every stakeholder. Each material requires different strategies, and strategy effectiveness is difficult to measure. Figure 1 presents these strategies in a diagram that is potentially helpful for every stakeholder. In the bottom half of the diagram, recycling is integrated into the flow of materials and products. It also shows material quantity: the EU produces altogether eight billion tonnes of material annually for its energy and products.

Only 0.6 billion tonnes of this eight billion tonne total originates from recycled materials. This equals a rate of 7.5% on the input side. The EU generates 2.2 billion tonnes annually, of which 0.6 will re-enter the system as recycled materials, equalling a rate of 27.3%. According to the EU's official paper, these rates are very low, but the opportunity to improve the recycled waste rate is accessible. This thesis suggests the following course of action: increase the share of materials recycled as secondary raw materials and reduce waste production.

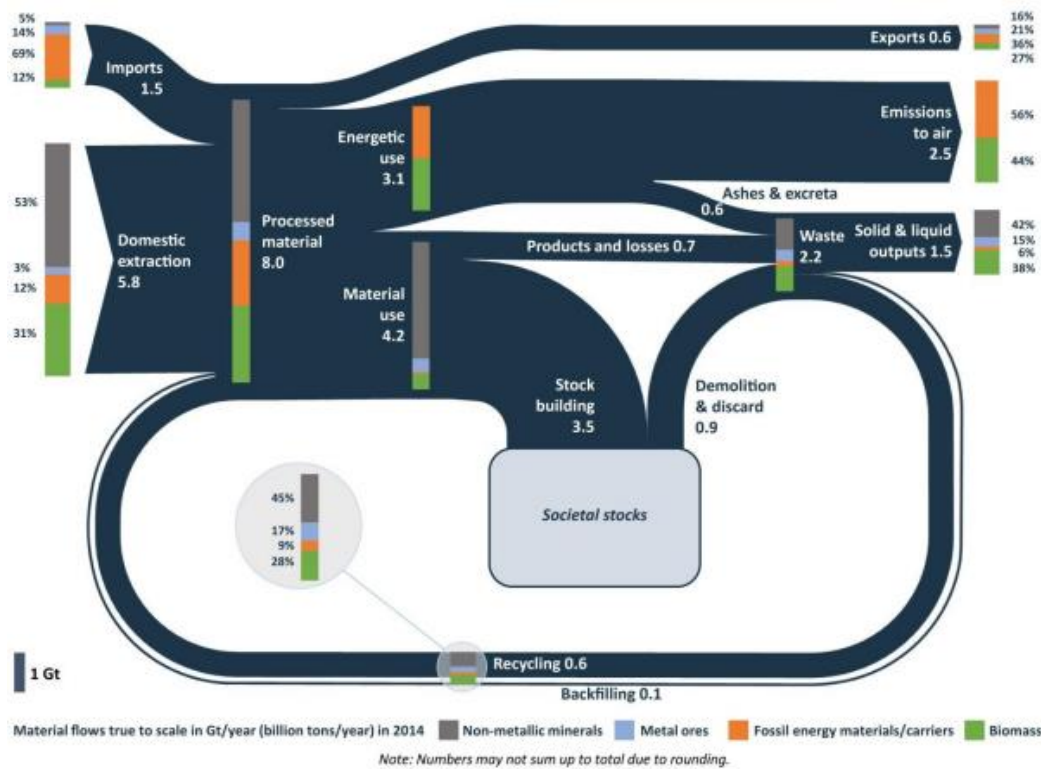


Figure 1.: Material flow in economy completed by the circular economy concept

Source European Commission – monitoring of framework

The following part of this EU document about the circular economy describes the measurement of CE. The EU uses four groups of methods to analyse this: “Production and consumption”, “Waste management”, “Secondary raw materials”, and “Competitiveness and innovation”. The four groups consist of 10 different indicators.

The first group includes EU self-sufficiency for raw materials, which entails that the raw materials must be produced in the EU. These are then put on the production line and used in products for the internal market. The first group also includes green public procurements and minimizes waste generation, which is supported by waste policy principles in the case of plastic: Strategy for Plastic. The first indicator group includes the measuring of food waste. Discarding food has significant negative effects on the environment, climate, economy, and society.

The second group is about waste management indicators. The overall recycling rate, the aim of which is reflected in its name: to aim for 100% recycling of the waste generated. The other indicator is the recycling rate for specific waste streams. That reflects the critical waste measuring.

Secondary raw materials are in the third group. How raw materials from recycled waste contribute to the total raw materials can be measured as can the trade of recyclable raw materials. The fourth group includes competitiveness and innovation with two indicators. The addition of private investments and jobs reflects how CE affects job creation and economic growth. The last indicator in this paper is patents. The local innovative solutions can get easier to move on to the circular economy and start an eco-friendly economic development.

Pires and Martinho (2019) analyse and criticize the European Union's waste policies. Their main critique is that the framework measures waste treatment operations like recycling, incineration, and landfilling separately. The authors recommend a new indicator: the waste hierarchy index within a circular economy context. In developing this indicator, they consider recycling, and preparing for reuse as positive factors and incineration and landfilling as negative factors. The authors claim that this waste hierarchy index is the beginning of a new discussion about waste management statistics

Moraga et al. (2019) also analyse the indicators of the circular economy and parse the aforementioned EU's monitoring framework. According to this discussion, most of the indicators focus on material preservation. Among their criticisms is the fact that each indicator only highlights a subset of indicators, and the study argues that an indicator that provides a complex overview of the effectiveness of CE is needed.

Mayer et al. (2018) suggest other indicators to measure the circular economy. They argue that additional indicators are needed to indicate the total material and waste flow as well as consider socioeconomic and ecological loop closing. Haupt and Hellweg (2019) also critique the circular economy indicators. According to them, the indicators inadequately cover the environmental aspects; therefore, they suggest a complementary environmental-impact-based indicator that measures environmental value via remanufacturing, repairing, recycling, and the total life cycle.

European Union member states are not all at the same level of economic development. Minelgaitė and Liobikienė (2019) highlight that the development of the member state determines the level of waste generation. According to the two authors, there is also a significant relationship between waste generation and recycling behaviour, which was at the highest levels in Germany, Austria, and Belgium and at the lowest levels in Bulgaria, Cyprus, and Romania. Nevertheless, in Romania and Bulgaria, plastic waste reduction is higher than in Spain, by

nearly double. The cultural and political differences between countries coupled with citizen motivations contribute to these differences.

2.3. PLASTIC WASTE MANAGEMENT IN EUROPEAN UNION

This study concentrates on plastic waste management and covers the kinds of plastic waste and plastic waste management in the European Union. Many different directives are present in plastic waste management.

Figure 2. depicts the waste hierarchy model, which is adopted in the European Union and around the world. The model stresses the basics of waste management, offers a proposal, about how we can manage our waste, and indicates what kind of opportunities must be preferred. This is a priority sign; the closer to the top an item is, the more environmentally-friendly and recommendable the offered solutions are. The bottom of the graph notes the most environmentally damaging solutions that should be avoided in the interest of reducing the size of the ecological footprint. Prevention is the best way because it produces no waste, while landfill disposal is marked as the worse way (environment.ec.europa.eu).



Figure 2.: Waste hierarchy model

Source: environment.ec.europa.eu

Directive 2008/98/EC is a Waste Framework Directive consisting of the basic definitions of practices like recycling and recovery; end-of-waste criteria; and the main principles, such as the polluter-pays principle. The directive defines recovery and recycling targets. One of its main

aims is to emphasize how every member state can improve concerning waste types (including plastic), most of which originate in households. The set goal states that each member state should seek at least a 50% improvement in the separately collected waste by 2020. Hungary has not and will not achieve this aim. That directive also insists that every member state ensures the operation of a selective waste collection system for commonly-used materials, which includes plastic.

One of Directive 2008/98/EC amendments – Directive 2018/851 – includes several points concerning plastic waste regulation. The majority of the plastic waste found in oceans and seas originates from the land, primarily because of bad practices and poor waste management infrastructure. Therefore, member states have been tasked to create prevention measures, which they must renew at least once every six years. The 2018 amendment confirms that the member states must ensure and establish the selective collection of waste. The overarching aim is to avoid using raw materials, which appear in the waste hierarchy model in the less recommended lower level. Member States are required to create a collection system and establish the sorting infrastructure needed to sort the waste after the collection process. Sorting is essential because much of the collected waste contains unsuitable materials, which is attributable to a poorly informed section of society. The documents also explain how much municipal waste must be prepared for recycling in specific years. The current rates are 50% for 2020, 55% for 2025, 60% for 2030, and 65% for 2035.

The Packaging Waste Directive is Directive 94/62/EC, which details how to prevent or reduce packaging waste. The previously mentioned EU Action Plan for a Circular Economy adopted by the Commission has also been of key importance in plastic waste management since December 2015. The directive was updated in March 2020, and in this update, the new Action Plan the Commission reinforces a rethinking of current measures to ensure that they genuinely promote waste reduction and prevention. The new action plan also concentrates on the creation of a new plan and how to purchase and use bio-based plastics. The Commission has initiated a sustainable product policy legislative (Jamison et al. 2021).

In 2019, the European Union accepted another principle – the 2019/904 directive the Single-Use Plastics Directive. This Directive sets the EU's targets, which are: a 90% collection rate for plastic bottles supported by deposit return schemes. This Single-Used Plastics Directive also includes bans for products such as plastic cotton buds, cutlery, plates, straws, beverage stirrers, balloon sticks and all products made from oxo-degradable plastic. In 2020, the European Commission published an implementing regulation for single-used plastics – 2020/2151

– which entered into force on 3 July 2021. In February 2021, the Parliament called upon the Commission to create more regulations related to plastic packaging and waste (Jamison et al., 2021).

Package waste is the most common type of plastic waste. This thesis examines the legal implications of packaging waste in the EU. The EU member states have to ensure producer responsibility schemes, which are created for all packaging materials. The community has its own targets including in what proportion each type of packaging material must be recycled. The current targets for plastic are 25% by 2025 and 50% by 2030. The EU packaging directives aim to coordinate member state directives to improve the role of environmental protection, optimize the functions of internal markets, prevent packaging waste, and support re-using and recycling (Packaging waste, environment.ec.europa.eu).

The following paragraph lists other directives regarding plastic packaging waste from European Parliament Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste. The directive appears in the second annex of this document. The directive states that plastic packaging should be produced with a minimal quantity of plastic that is enough for the volume and weight of the product. The producer is responsible for planning, designing, and producing the packaging, which must ensure both sustainability and recycling. The producer has to consider the reduction of noxious materials and other hazardous substances.

Other requirements in this directive concern the reusable nature of packaging; more specifically, the property of packaging needs to be suitable for multiple uses, which supports the creation of a circular economy. Furthermore, the processes for preparing materials for reuse cannot be detrimental to human health. Packaging producers must consider the specific requirements of reusable plastic, such as when the plastic becomes unrecyclable and becomes waste.

The directive also contains regulations concerning the recoverable nature of packaging. The European Union created a ratio that measures the percentage of weight that recyclable materials should contain. The packaging must have a minimum calorific value and must allow the possibility for energetic recovery. Packages produced in the EU must also be physically, chemically, thermally or biologically recyclable.

Another document, drafted by the European Parliament and Council in 1994, provides a good example regarding questions surrounding waste management and sustainable environmental protection. Packaging and packaging waste are the main issues within this directive, which aims to coordinate national policies. The European Parliament and the Council issued

Directive (2015/720) that amends Directive 94/62/EC with the aim of regulating lightweight plastic bags. This directive emphasizes the environmentally damaging effect of lightweight plastic bags and demands strict regulations and restrictions in this regard.

STATISTICS OF PLASTIC WASTE MANAGEMENT

Environmental e-journals, official pages of statistical offices, and scientific publications contain many statistics, approaches, and methods related to plastic recycling with the overarching aim to provide an overview of plastic waste management statistics.

In 2018, European Union countries generated an average of 5,234 kilograms of waste per capita (Waste statistics, 2021); however, the differences between individual countries were vast. With 1879 kilograms per capita, the Hungarian statistic was the fourth lowest in the community, followed by Portugal, Croatia and Latvia. Conversely, Finland, Bulgaria, Estonia and Luxembourg generated the most waste per capita in the EU.

According to the Eurostat statistic, the European Union generated 505 kg of municipal waste per capita in 2020, and from this, 48% was recycled as material recycling and composting (Municipal waste statistics, 2021). The article details the data by country, and compares the 2020 data with the 2005 data, which was the base year. The data indicates that the quantity of municipal waste has not changed at the EU level during these 15 years. In 2005, the amount was 506 kilograms per capita, while in 2020 it was 505 kilograms per capita; however, changes do exist at the level of countries. For example, the Czech Republic, Belgium, Austria, and Slovakia, all posted significant increases in the quantity of common waste, whereas Bulgaria, Romania, Spain, and Ireland all observed decreases. Hungary also experienced a decrease, but in a much smaller quantity than the previously mentioned four countries.

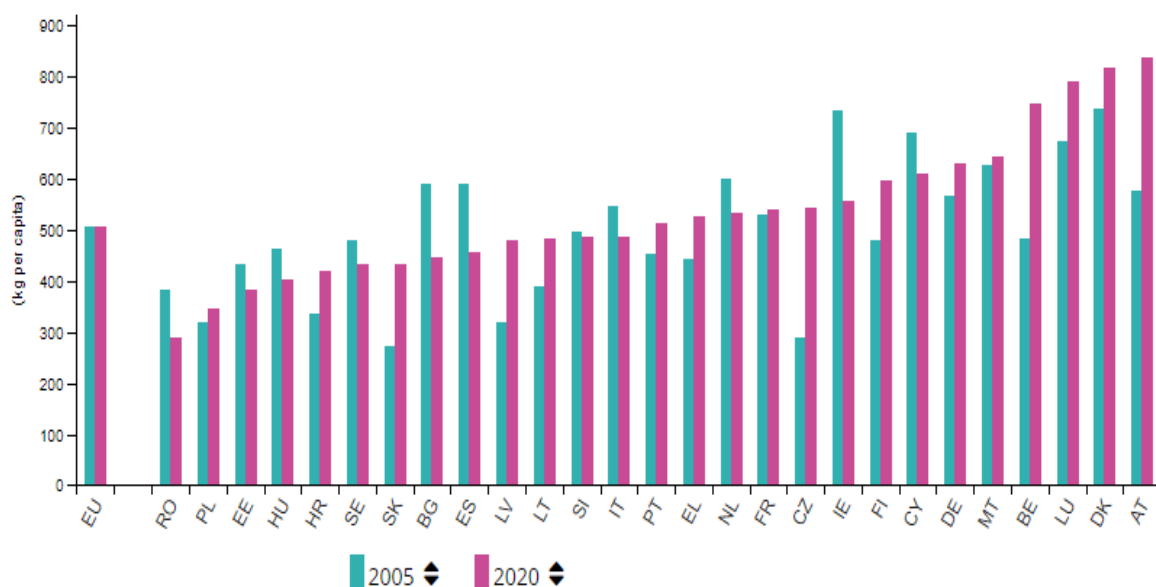


Figure 3.: Municipal waste generated in the EU, by countries

Source: Eurostat

Amadei et al. analysed (2022) the plastic footprint in European Union and found different data in the scientific literature and consumption statistics. For example, consumption statistics in the scientific literature was 84 kilograms per person, while the PRODCOM consumption database recorded 129 kilograms per person. In the literature, packaging contributes 27.9% to the total footprint; however, in the database, that rate was 23.6%. Within the scope of this discussion, dominant among the total plastic waste were LDPE, PP and PET types of polymers.

Geyer et al. (2017) noted that the world generated approximately 6300 metric tonnes of plastic waste up to 2015, of which 79% was accumulated in landfills or the natural environment, and only 9% of which had been recycled. The rest was incinerated. This study also determined that the differences among the regions and countries are vast. Some countries have exceptionally low recycling rates. Packaging waste is one of the most common types of plastic waste. According to the article, 407 million tonnes of plastic were produced in 2015, from which 302 million tonnes became waste. Furthermore, nearly half of this waste – 141 million tonnes – originated from packaging, indicating that the packaging plastic waste rate amounted to 46.7% of all plastic waste.

Eurostat has been accumulating statistics about plastic packaging waste as well. It published a graph in 2022 covering the 11-year period from 2009–2019 (Figure 4.) that clarified the statistics and showed that the quantity of the generated plastic packaging waste increased continuously within that period. In 2009, packaging waste totalled 28 kilograms per capita per

year; however, by 2019, that figure increased to 34.5 kilograms. Moreover, the quantity of recycled packaging waste also increased from 10 to 15 kilograms per capita per year in the 2009–2019 period, implying that the rate of recycled packaging plastic also increased from all packaging plastic. The quantity was 7.2%, up from 35.7% to 42.9%.

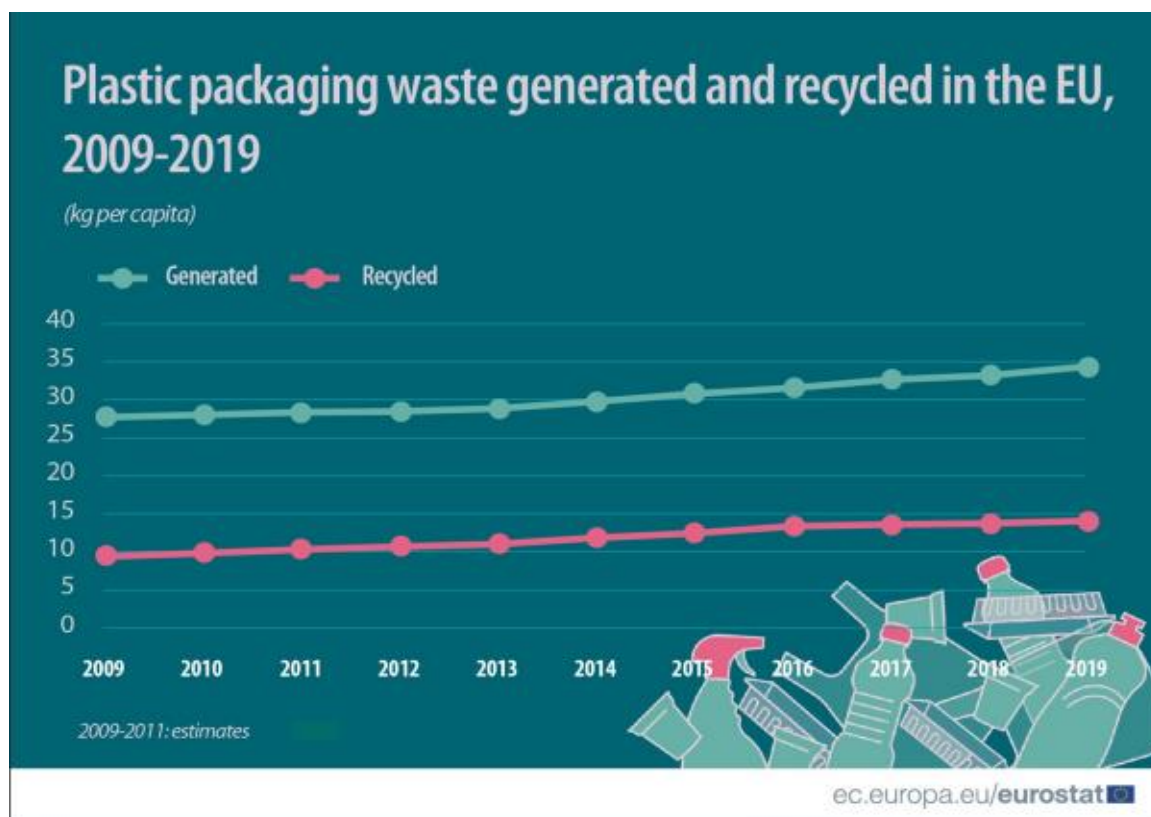


Figure 4.: Plastic packaging waste generated and recycled in the EU

Source: Eurostat

Examining plastic packaging waste per capita in kilograms by countries also offers much useful information. The official page of Eurostat lists statistics covering the 2000–2019 period. This paragraph focuses specifically on 2005 and 2019 featured in Figure 5. A comparison of those two years reveals an approximately 5% increase. Differences by country were variable. The largest increase occurred in Estonia. On average, an Estonian generated 23 kg of plastic packaging waste in 2005; by 2019, this had increased to 43 kg. The largest decrease occurred in Cyprus which went from 46 kg per capita to 21 kg per capita. Ireland was the largest plastic packaging waste-generating country for both years. The 2019 figure for Ireland was extremely high among the other Member States, well over the upper limit according to the outlier analyses. Plastic packaging generation per capita also increased by a large amount in Hungary rising from 19 kg to 35 kg. The following diagram exhibits packaging plastic waste by countries in 2019.

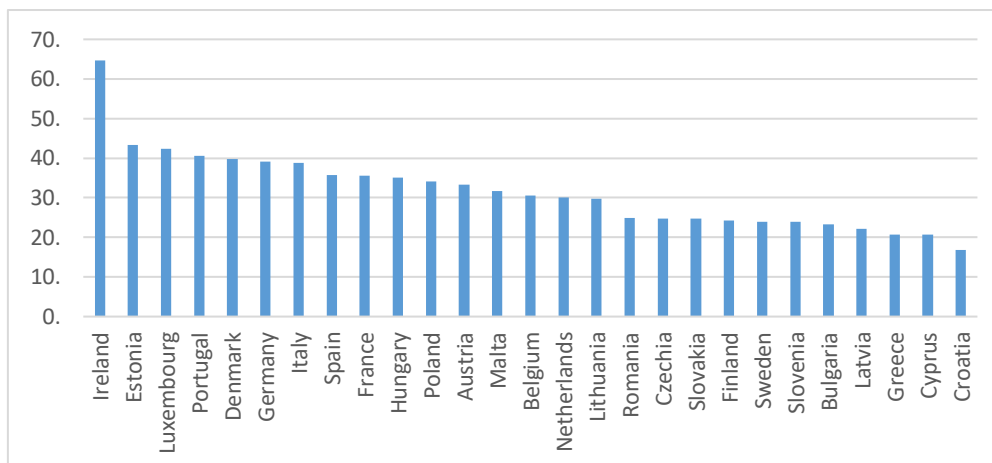


Figure 5.: Plastic packaging waste per capita in kilogram by countries

Source: Eurostat

Other Eurostat statistics made in 2018 and published in 2020 directly present the recycling packaging rate by every member state plus the United Kingdom, which was still in the community at that time. The statistics also include non-member countries Norway, Iceland and Lichtenstein (Figure 6.). The expected recycling packaging rate the EU had set was 22.5%, but among the member states, only Malta fell under that expected rate. Unfortunately, Hungary was among the countries with the worst ratios. The EU-27 average was slightly above 40%. The best rates were in Lithuania, Slovenia, Bulgaria and Czechia. Their rates were around 60%.

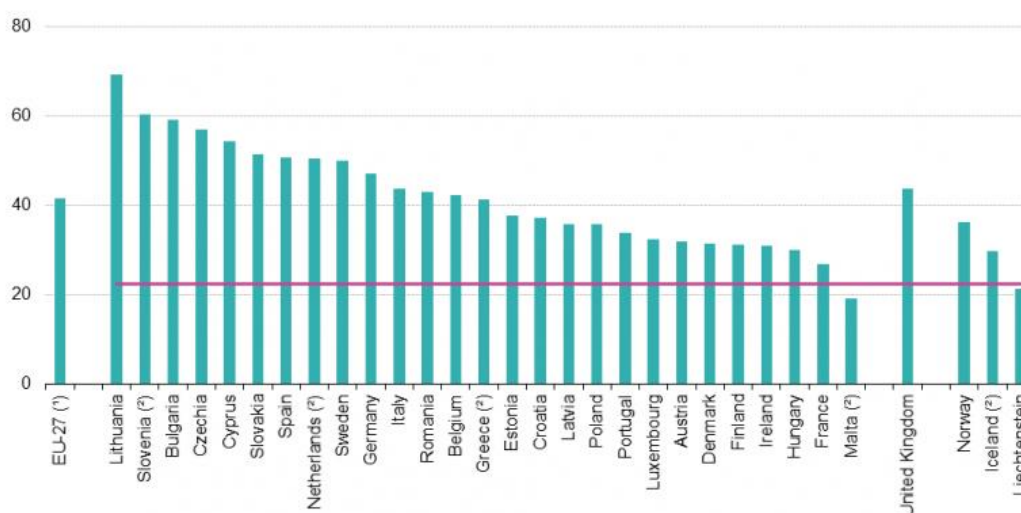


Figure 6.: Plastic packaging recycling rate by countries

Source: Eurostat

Navarre et al. (2022) analysed food packaging waste in the Netherlands, where the recycling rate of plastic food packaging waste is 78%, and determined that the country generated 296 kt of food packaging waste annually, of which 37 kt/year was exported beyond the territory of European Environment Agency. From the 37 kt/year, 6 kt leaked into the marine environment. Accordingly, the article suggests that the country's leadership should help prevent some of the plastic waste generated from ending up in the sea by developing its own infrastructure and assisting in the infrastructure development of the countries to which it exports its plastic waste, such as Malaysia or Turkey.

Jang et al. (2020) examined the plastic waste recycling situation in South Korea and found that the average South Korean consumes 11.8 kg of single-use plastic, which equals 638 pieces per year individually and 32.6 billion pieces for the entire South Korean population. South Korean households generated three million tonnes of packaging plastic waste in 2017. The article also found the rate of material recycling and recovery to be very low. An additional problem in the country is the danger that packaging plastic waste poses to rivers, seas and oceans as it leaks from waste collection systems.

Another publication, about Trinidad and Tobago, written by Millette et al. (2019) explores the key question of whether the material flow analyses support the strategic decision for creating a circular economy in a developing country. The article discovered that much of the packaging plastic waste originates from imported goods (48%). The authors contend that this presents a challenge for the country because it lacks the companies needed to establish, process, and implement a circular economy.

2.4.GOOD PRACTICES IN PLASTIC WASTE MANAGEMENT

The Hungarian parliament ordered an analysis of plastic and packaging waste management in some other European Union members in 2019. The other countries' governments received a list of questions related to plastic and packaging waste management. The following were the three main topics for the questions: What kind of legislative environment does the respondent country have? What are the key elements of these legislations? What incentives does the country use to reduce plastic and packaging waste? Among the member countries, 15 responded to the questionnaire solicited by the Hungarian Parliament. The United Kingdom was among the respondents because it was still an EU member in 2019 when the questionnaire was issued. The following presents a selection of Member countries that were analysed and researched for this thesis. These countries are Austria, Czechia, and Estonia.

Austria is Hungary's western neighbour and many Hungarian citizens work there. Overall, Austria is a more developed country, with more financial resources. Hungary has traditionally looked upon Austria as an example to follow. Austria has both a packaging regulation and a waste management law. The current packaging waste regulation entered into force on 1 January 2015 (wko.at) with the aim to renew the Packaging Ordinance of 1996. Several important elements have changed. When someone imports packaging into Austria, it is treated as a part of the circular economy, which means the importer must ensure the packaging is recycled. In the field of household packaging, there must be competition among the collection and recycling systems. The Austrian government ordered a strict law that concerns the household and commercial recycling of plastic waste. The registration period for waste became shorter. They specify as packaging waste various materials, pallets for loading, packaging aids, handling, protecting, delivery and presentation of goods.

The principle of producer responsibility for packaging plastic waste has been in force in Austria since 1992. Manufacturers, packers and importers are required to join the common collection and recovery system. The collection system can be publicly or privately owned. The polluter pays principle is also present in the country. The Federal Waste Management Plan and the Waste Prevention Programme both went into force in 2017. These pertain to all Austrian inhabitants and highlight the circular economy and the waste hierarchy model. The Federal Waste Management Plan revealed that the country produced between 5000 and 7000 tonnes of plastic bags, but this has not proven to be a big problem because the population is generally environmentally aware and considers the waste hierarchy.

Figure 7 illustrates the total packaging amount in Austria according to raw materials. Plastic is the most common type of waste, but with the proper implementation of a circular economy, it does not present a big problem. Plastic experienced a jump around 2010, which was related to overconsumption

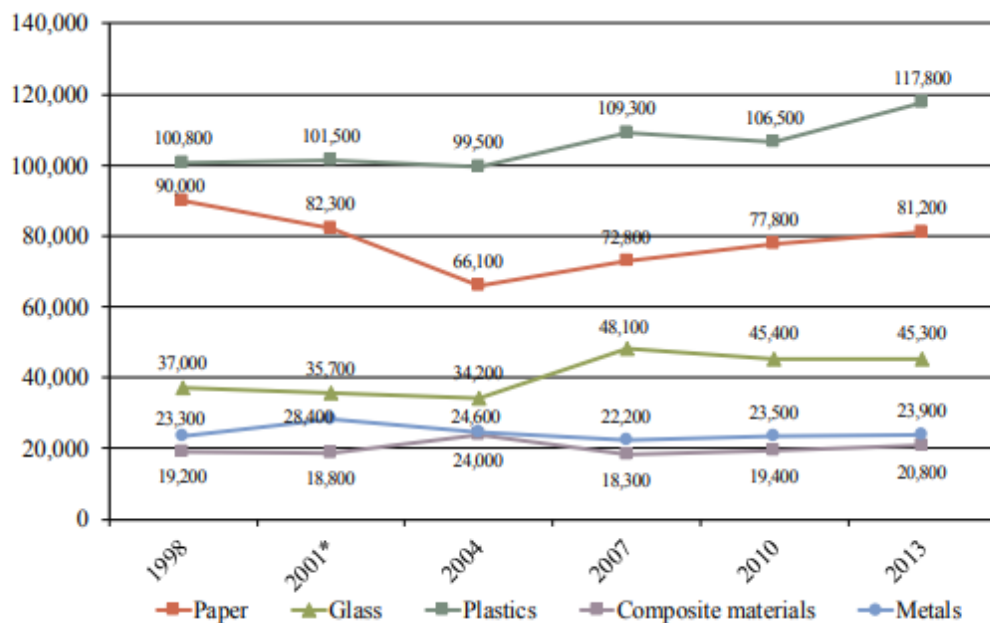


Figure 7.:Total packaging amount in Austria by raw materials

Source: Federal Waste Management Plan, Austria

The European Union requires packaging waste to be recycled at a ratio of 22.5%. At 34%, this ratio is good in Austria, and the country is striving to reach a 50% target by 2050. However, with more efficient use of raw materials, this is an impractical target. To successfully achieve successfully, Austria considers all European Union waste policies including the circular economy system and packaging regulations. Austria utilized 99% of plastic and is a world leader in that field. By 2030, the country's leadership would like to recycle 75% of plastic packaging waste (wolfplastic.eu).

The government of Austria also recognizes the problems related to increasing amounts of plastic and for that reason created a plastic budget based on material flow analyses, quantifying the situation using 2010 as the base year. According to Van Eygen et al. (2017), the main source of plastic waste in Austria is the packaging. The country is not self-sufficient in plastic; however, one-third of collected plastics contribute to the country's stocks.

Czechia is similar to Hungary both in size and recent historical developments. Czechia's population is slightly larger, and its territory is slightly smaller than Hungary's population and area (World Bank data). The present thesis chose to focus on Czechia because, according to the research of the Plastic Europe Association, the country is in the top two EU Member states in terms of recycling rates for plastic packaging.

According to the cms.law webpage, Czechia has three different pieces of legislation concerning plastic and packaging waste. These are Act number 477/2001, as amended, this is the Packaging Act, Act No. 541/2020, the Wastes Act, and Act No. 542/2020 the End-of-life products Act. The primary aim of these acts is to protect the environment and prevent the environmental damage caused by waste. All three regulations are based on European Union principles. The most important principle is the general obligation of prevention, which includes producers being mandated to use the least amount of packaging possible. All producers are obligated to follow a producer responsibility scheme, which entails that they must ensure packaging collection and recycling. For those packaging where recycling is possible, a deposit return scheme could be introduced. The waste collection is free if the packaging does not become waste. In Czechia, there is no extra tax connected to plastic packaging.

In September 2022, the Government of the Czech Republic introduced new restrictions and bans for plastic waste, which entered into force on 1 October 2022. The regulation bans single-use plastic bags, including the production, trade, and delivery of all such products. The regulation extends to plastic cutlery, plates, straws, beverage stirrers, food containers made of expanded polystyrene, beverage containers and drinking cups. According to the new laws, single-used plastics must contain 25% recycled plastic by 2025 and 30% by 2030 (Rundtová – Skvorová, 2022).

The literature on the Czech plastic waste situation has been relatively extensive. For example, in 2018, Tyl noted that the plastic waste trade was in crisis due to a lack of awareness about selective waste collection. As a result, Tyl recommended increasing motivation activities to inform the public that selective waste is much more valuable than municipal waste. This statement also relates to plastic waste. The article also explains that people should choose the nearest plastic processor company because the most expensive part of plastic recycling is transport. Also, the rate of selective plastic collecting is higher in the corporate sector than it is in the household sector. Within the primary, in-depth interview research in this thesis, one of the interviewees confirmed this statement.

Plastic waste increases are not a recent phenomenon. On the contrary, plastic waste has been increasing for decades and has increased 29 times between 1999 and 2008. Nevertheless, Czech citizens still sorted 33.1 kg of waste on average in 2008. The second most common type of waste was plastic (23%) followed by paper. At that time, the recycling rate for plastic was 52%, (eea.europe.eu, 2010).

Figure 8 depicts the recycling rate of plastic waste in the Czech Republic. It shows that the country good has had good results in plastic waste recycling that stretch back in time. The rate stagnated around 2010, but it began to increase again in 2014 and reached 75% by 2016.

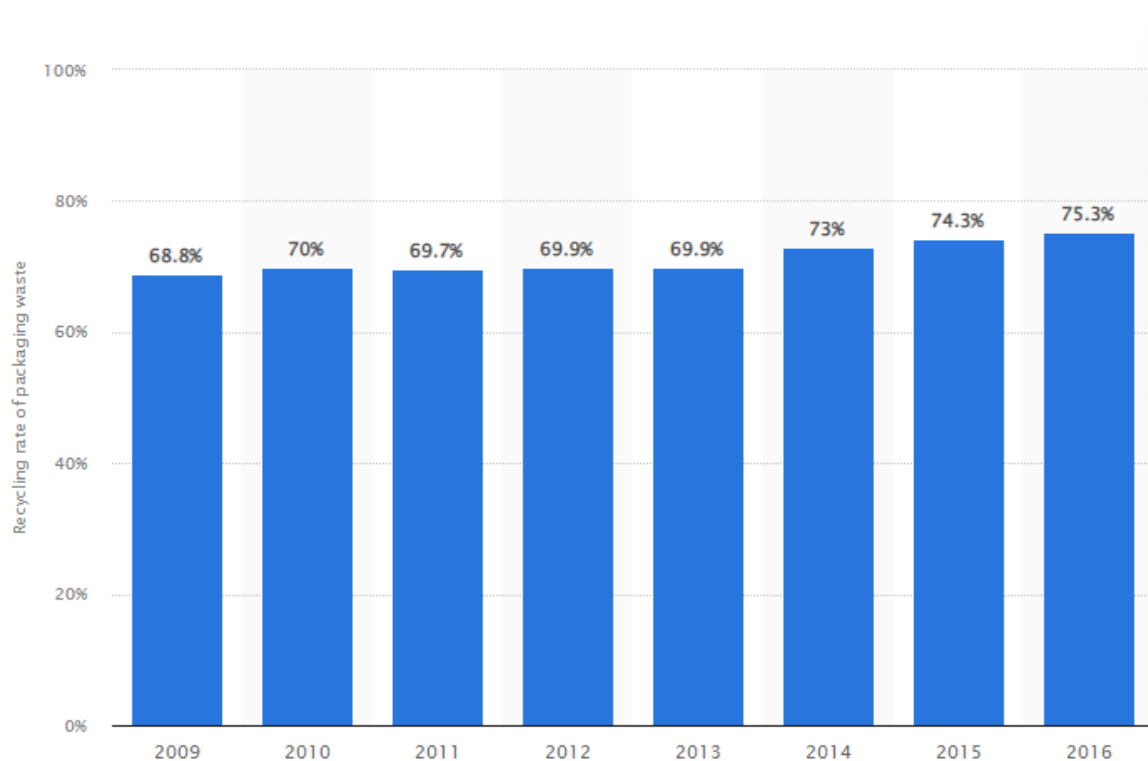


Figure 8: The rate of recycled plastic waste, in all plastic waste in the Czech Republic

Source: statista.com

Next, the focus will shift to the targets of the country related to the topic. Czechia has a Waste Management Plan that covers the period from 2015–2024. Czechia would like to improve its plastic packaging recycling rate to 50%, its packaging waste rate to 70%, and its overall re-usage of packaging waste to 80%. The longer-term aims are connected to municipal waste. Czechia aims to fulfil the following recycling targets: 60% by 2025, 65% by 2030, and 70% by 2035. According to the previous statistics, these goals have already been achieved.

Estonia is a post-Soviet country that has experienced an intense amount of development in the past 30 years. The country has a packaging law, a waste law, a waste prevention plan, and a “Selective collection of municipal waste and definition of categories of separately collected waste”, which is approved legislation.

Estonia introduced its first packaging waste law – the Packaging Act – in 2004. The regulation included the producer responsibility system and entered into force in 2005 and

determined that 50% of all packaging waste needed to be recycled by 2012 (expra.eu). To achieve this goal, Estonian importers producers and retailers established the “Estonian Recovery Organization”. This law also covers the number of packaging recovering companies and declares no limit on the numbers as long as certain criteria are met. Manufacturing companies are obliged to hand over plastic waste to a processing company; if they do not do so, they have to ensure internal recycling themselves.

In the middle of the 2000s, the Packaging Act still included the Deposit Return System. This is a monopoly market because Eesti Pandipakend is the only company present in the plastic packaging deposit scheme in Estonia. The company’s activities include the packaging of water, soft drinks, beer, and many others products. The official homepage of this company includes the types of plastic packaging included in the country’s deposit system. This includes bottles, with stickers indicating their suitability for the deposit scheme.

The Estonian Packaging Act (2004) was amended in 2021. The packaging register has been differentiated in the country and determines which packaging waste goes in which group, including conditions such as sales or the transport quantity of packaging. Introducing reusable packaging requires entering data on quantity into the register first; the required data includes information on the average annual number and how many time the type of packaging may be reused. The system leaves an adequate timeframe to allow for proper data entry. Initially, companies are mandated to engage in this process in 2023, and in the future, the agreement between the transferor and the recovery firm must be entered into the packaging register. These measures will promote transparency. This amendment includes targets for packaging producers, who must recycle at least 50% of their plastic waste by 2025 and 55% by 2030. To accomplish this, companies abide will have to abide by the producer responsibility scheme.

As noted above, Estonia introduced a deposit system in the middle of the 2000s; however, in the United Kingdom, the Deposit Return System is still in its planning stages. Snowdon (2019) presented the possible benefits of introducing the system. According to his article, the recycling rate of beverage bottles is around 70–75%; however, with the introduction of the deposit system, this number can improve to 85–90%. Notwithstanding, the first-year costs to implement the system are estimated to be in the area of one billion pounds, a figure which is then forecast to fall to about 800 million pounds per year in subsequent years. Overall, the estimated benefits of the system will total less than 100 million pounds. From a purely financial perspective, it is an extremely inefficient business. However, the study also considers the benefits of decreasing amounts of communal waste, which amounts also costs one billion pounds

annually. From this perspective, the process is suddenly far more economical. All the same, the article concludes that the introduction of a deposit return system is not economically justifiable.

Outside Europe, the Japanese community is very engaged in selective waste collection. Japan encourage its inhabitants to employ different methods. For example, specific containers, publication and broadcasting, different activities and family education (Chow et al., 2017). Yoda (1999) claims that selective plastic waste management in Japan has existed for some time. Groupings have also been made within plastics, e.g. separate the PET bottles and the PP bottles caps. The Japanese inhabitant created voluntary organisations, and they take away the collected plastic waste from the households and sell them to recyclers. In Japan, recycling is present in family life as well, as Chow and his co-authors note (2017). The family collection system was created by the municipal governments. The country's plastic recycling rate was 77% in 2010, making Japan among the most successful countries in the world, according to McCurry's report in *The Guardian* (2011). The development was very fast; the rate was already 39% in 1996. The outstanding result was due to the list of plastic items, which pertains to all stakeholders and actors.

Taiwan initiated its new recycling item, the so-called "4-in-1 Recycling Program", in 1997. The four contributors are the stakeholders: including community residents, recyclers and collectors, local governments, and the local recycling fund. Chow et al. 2017 also wrote extensively about the program. According to Huang (2013), the program works well and has resulted in a decline in municipal waste and an increase in selective waste collection. This tendency is similar to other countries with recycling plans. Tsai (2021) includes the opinion that the regulated plastic containers have contributed to the increase in separately collected waste. This article also said that the COVID-19 pandemic caused a decline in the number of selectively collected plastic due to consumption changes during that period (e.g. mask use).

In Hong Kong, the government wrote and published a teacher's guidebook describing how to educate students concerning the responsible management of waste. Chow et al. (2017), also cover the Environmental Protection Department Hong Kong governmental document (2015). Hong Kong's government started a campaign in schools called "Reduce Your Waste and Recycle Your Plastics Campaign"; the main goal was to encourage students to bring home-generated empty bottles to school and put them in recycling bins.

Of course, not only governments have plastic waste policies – various smaller and bigger companies also have waste policies that play key roles because the majority of the materials

people use are produced by companies, and it is important to think about recycling opportunities at the manufacturing stage. However, this approach has some barriers, as noted by Maitre-Ekern (2021) whose study claimed that the EU's waste-related laws are often not expanded to the producers. Consequently, the author suggested that the European Union's new waste legislation consider the total life cycle of products

Shell, the British-based multinational oil company, also has plastic waste policies because it uses many materials and products containing. Shell has three main principles in plastic waste management: reduce, reuse, and recycle. The company's aim is to process 1 million tonnes of plastic waste yearly, for which it uses Shell's Energy and chemical parks in Bokum Island, Singapore (Shell Annual Report and Accounts, 2021). Other oil companies like OMV have also adopted the circular economy concept. OMV believes that shifting to a circular economy decreases carbon-dioxide emissions and reduces dependency on other economic actors. Recycling polyolefin is of key importance in OMV Group's Strategy 2030. The company would like to recycle 350 kta of polyolefin by 2025, and 2000 kta by 2030 (Circular Economy-omv.com).

The Hungarian Oil and Gas Public Limited Company, abbreviated from the Hungarian as MOL, also deserves mention. The environmental policies of this company also include waste management policies based on European Union regulations, which aim to reduce health and environmental damage. MOL has adopted the Waste hierarchy model and maintains a Total Waste Management system (molgroup.info).

An article published in the spring on portfolio.hu, a Hungarian online economic newspaper, details MOL's acquisition of ReMat, a major Hungarian market leader in plastics recycling. The profit after tax was 70 million Hungarian Forint in 2020. This is not a unique example, but it demonstrates how MOL has improved its share in the recycling market. In 2019, MOL also purchased the German company, Aurora Kunststoffe GmbH.

Although selective waste management has not attained a highly-developed level in Hungary, some smaller and bigger companies that have a more developed structure in recycling do exist. The following highlights some good practices from Hungary. The Novotel in Budapest is currently engaged in sustainability and is participating in the Planet21 program, which consists of seven pillars and 21 promises, including selective waste management. Novotel selectively collects its waste, including plastic. In addition, they also have a waste shredder and compactor, which reduces the amount of municipal waste (Wágnerné Tomcsik (edit), 2015).

2.5.THE PLASTIC WASTE LOWS IN HUNGARY

Like the other European Union countries, Hungary also has laws concerning plastic packaging management. The main basic law in this in this area is Act CLXXXV of 2012 on waste. This law defines what waste is and the other terms that are strongly related to waste, such as recycling, material recovery, waste disposal, energetic recovery, selective waste collection, and the deposit system. The law also defines plastic as a waste type. The law requires public service providers to ensure the selective collection of plastics as well. Here the aim is to achieve a 50% recycling rate by 31 December 2020. Every statistic shows that this target has not been achieved. The law requires that the impact of plastic on the environment must be reduced, in accordance with the Directive of the European Parliament and the Council.

Hungary introduced the New Waste Management Code in Act II of 2021. Following the guidelines set by the European Union Directive, this Act outlines how the country must shift toward a circular economy by focusing on the point that the material should not be recycled only once but reused several times This law regulates the prevention of formation waste, the provisions to eliminate illegal dumping, the public management of waste, the regulations with concession, and the creation of a circular economy. The legal document also contains the basic requirements for an extended producer responsibility scheme. The code includes the introduction of a deposit scheme for plastic bottles (PET) to increase the efficiency of selective plastics collection (jogegylet.hu, 2021.)

Hungary has a waste plan for 2021–2027. This is the National Waste Management Plan. The plan includes target numbers and the methods about how to achieve these aims. Of course, plastic waste management targets are an important part of this document. The documents also mention the goals of previous plans, for example, the previous EU plans of 2008/98/EC, where the target was to achieve 50% recycled plastic by 2020, and the EU plan for decreasing the environmental damage effect of plastic. The Plastic Strategy is also highlighted, particularly concerning moving to a more sustainable plastic use and preventing plastic waste that ends up in seas and oceans.

As noted earlier, plastic packaging is the most common type of plastic waste. According to the National Waste Management Plan, Hungary is ready to initiate mechanical and chemical recycling for many types of plastic PET bottles, polyethylene (PE), and polypropylene (PP). These types are easy to recycle. Figure 9 shows the use of plastic waste and exhibits the quantity of plastic packaging and the increase in recycled plastic packaging. The tendency the figure

depicts is similar to the European Union level. The figure also makes it clear that Hungary did not achieve the European Union target in the 2010s. Unfortunately, a significant amount of plastic waste ended up in landfills during that decade.

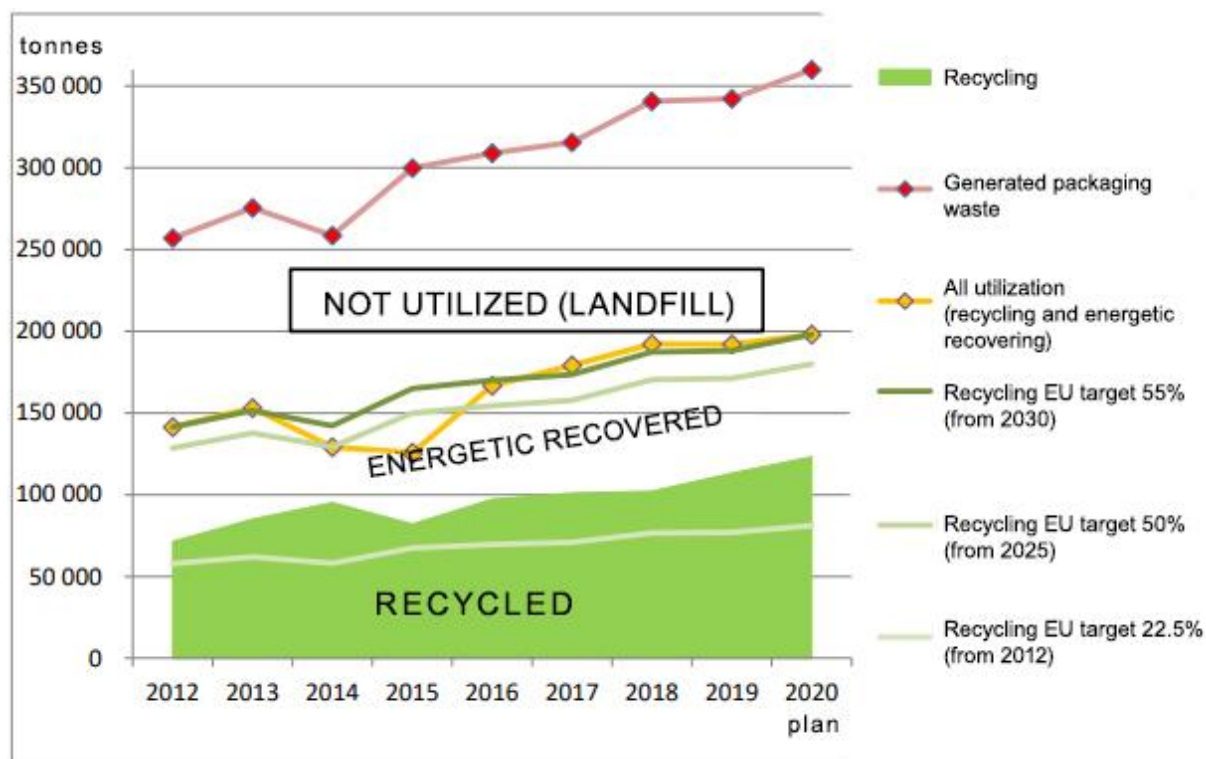


Figure 9.: Recovery of plastic packaging waste in Hungary

Source: Hungarian National Waste Management Plan 2021-2027

2.6.PLASTIC WASTE MANAGEMENT

To help achieve the European Union goals, the “European Association of Plastics Recycling and Recovery Organisations” (EPRO) – which is an international partnership among the companies and organisations interested in plastic recycling – works toward successful collaboration to achieve the EU’s goals and national targets via projects involving prevention, recycling, recovery, technology, new technologies evaluation, and improving the quality of recycled plastic. The members of this organisation are primarily plastic recycling companies, and the organisation’s head office is in Brussels (epro-plasticsrecycling.org –Who we are).

The official page of EPRO contains statistics related to plastic waste. According to this page, 40% of packaging plastic waste was recycled and nearly 80% was totally recovered in 2016. The 40% was from 16.7 million tonnes of plastic waste of which 6.8 million tonnes were

recycled, which is much more than the EU's common target (22.5%). This statistic demonstrates that according to EPRO the Extended Producer Responsibility is effective. The same applies to national targets based on the EU directive on Packaging and Packaging Waste (94/62/EU). Ranking the countries finds Czechia ahead of Germany and the Netherlands. The majority of packaging waste was from households (64%), and the rest was from trade and industry. At 46.5%, the recycling rate was higher in industry and only 37.8% in households (epro-plasticsrecycling.org – EPRO statistics).

The rate of recycled packaging waste is better than the rate for all packaging waste. Some countries operate a deposit system for beverage bottles (e.g. Germany, Finland, Sweden) in which people are compensated for returning bottles to the retailers from which they purchased them. An interviewee in the primary research of this thesis confirmed that Hungary has no official intention to introduce a deposit system in the country. In France, the Extended Producer Responsibility comprises all plastic packaging, and the energetic recovery rate was 38.8% in 2016. As a result, plastic packaging waste that ended in landfills was barely 20 %, which amounts to 3.4 million tonnes (epro-plasticsrecycling.org – EPRO statistics).

A concession process for waste management was initiated in Hungary in 2016 in which the country committed to managing five million tonnes of municipal waste, including plastic. The procedure will begin on 1 July 2023 and continue for 35 years. The primary focus will be plastic management and its related investments, and it will be managed by the Hungarian State with the aim of supporting the circular economy, improving the recycling rate indicators, and developing the sorting methods. The concession winner was MOL Magyar Olaj- és Gázipari Nyrt., a Hungarian market leader in the oil industry, and it is obligated to pay an annual concession fee of 100 million HUF to the Hungarian state (portfolio.hu, 2022). MOL will also have investment obligations of around 185 billion Forint within the initial ten years of the concession agreement, in which they must improve the energy recovery capacity (MOL group, 2022). Among its other obligations, MOL has signed on to increase the recycling rate to 65%, and decrease the landfill going rate to under 10% (infostart.hu, 2022).

2.7.SURVEY RESULTS IN PLASTIC WASTE MANAGEMENT

The Association of Plastics Manufacturers performed analyses about plastic waste, production and other aspects connected to plastic waste recycling (PlasticEurope, 2017) They define plastic as basic use material. Around the European Union, there is a quite big industry, with altogether more than 1.5 million employees, close to 60.000 companies, 350 billion euros turnover, and

about 15 billion euros trade balance. The plastic recycling industry contributes about 30 billion euros to public finance and welfare. The European plastic industry is ranked seventh among industrial value-added industries and produced plastics worth over 8.2 million euros value in 2016.

According to this document (PlasticEurope, 2017), the use of plastic materials from 2015 to 2016 rose from 58 million tonnes to 60 million tonnes. From the perspective of global plastic production, China ranks as the largest producer at 29%. From a wider perspective, Asia produces half of the plastic in the world, while Europe produces 19 % and the countries within North American Free Trade Agreement manufacture about 18%. The document also notes that 80% of European-converted plastic demand is concentrated in the six largest Member States, including the Benelux Union. The document shows that the packaging industry is the source of the highest plastic waste with nearly 40%; the second is from the construction industry with almost 20%, and the third is from the automotive industry with 10%. The situation with European plastics converter demand by polymer types is also crucial, especially as it pertains to PP in food packaging, PE-LD in reusable bags, and PE-HD in toys and milk bottles.

With this in mind, it is worth investigating the recovery of plastic waste, particularly in 2016, which marked the year in which more plastic was recycled than landfilled (PlasticEurope, 2017). This watermark signifies a positive outlook for the EU and hints at continued positive trends in that direction (Figure 10.). Recycled materials amounted to 31.1% and only 27.3% of plastic went to landfills. The rate of energy recovery (burning) was logged at 41.6%. The following graph displays the plastic waste recycling tendency between 2006 and 2016. In 2006, nearly three times more plastic to landfill, than was recycled, which marked a very intensive development. Plastic waste recovery is very uneven among the Member States. The Benelux States, Germany, Austria, Denmark, Sweden, and Finland have introduced some landfill restrictions that have precipitated low landfill rates. Differences appear once these countries are removed from consideration. Overall, Western European countries tend to have lower landfill rates, while Eastern European countries, including Hungary, tend to have higher landfill rates.

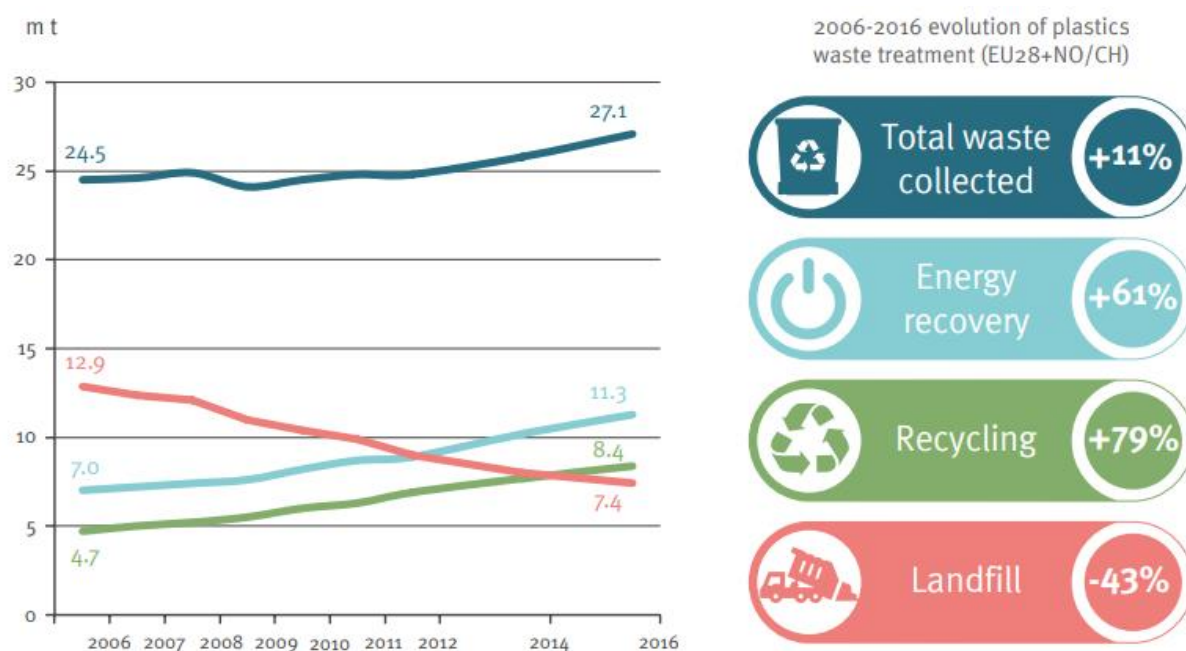


Figure 10.: Evolution of plastic waste treatment in the EU

Source: PlasticEurope, 2017

Another important diagram in the 2017 PlasticEurope document is the one detailing the Member States individually to determine rates among recycling, energy recovery, and land-filling. Differences between the countries become readily apparent wherever landfill bans are in effect. For example, plastic is no longer disposed into landfills in Austria. The situation is quite the same in Germany, Sweden, the Netherlands, and Denmark. From this statistic, the differences between Western and Eastern Europe are apparent. For example, the rate of plastic waste in landfills is around 75% in Bulgaria and in Greece.

The previous two paragraphs presented statistics on all plastic waste but the situation concerning only plastic packaging waste requires further examination (Figure 11). The rate of recycled packaging is 40.9%, higher than the same rate for all packaging waste (31.1%). The rate of energy recovery and landfilling is less for plastic packaging than for all plastic waste. In the case of energy recovery, the ratio was 38.8%, and for total waste, the ratio was 41.6%. Landfilled plastic waste for packaging was 20.3% and 27.3% in total. For packaging plastic waste, the situation is much better in packaging waste than it is in all plastic waste, as the graph shows. Six years earlier, in 2010, more packaging plastic went to recycling than all plastic.

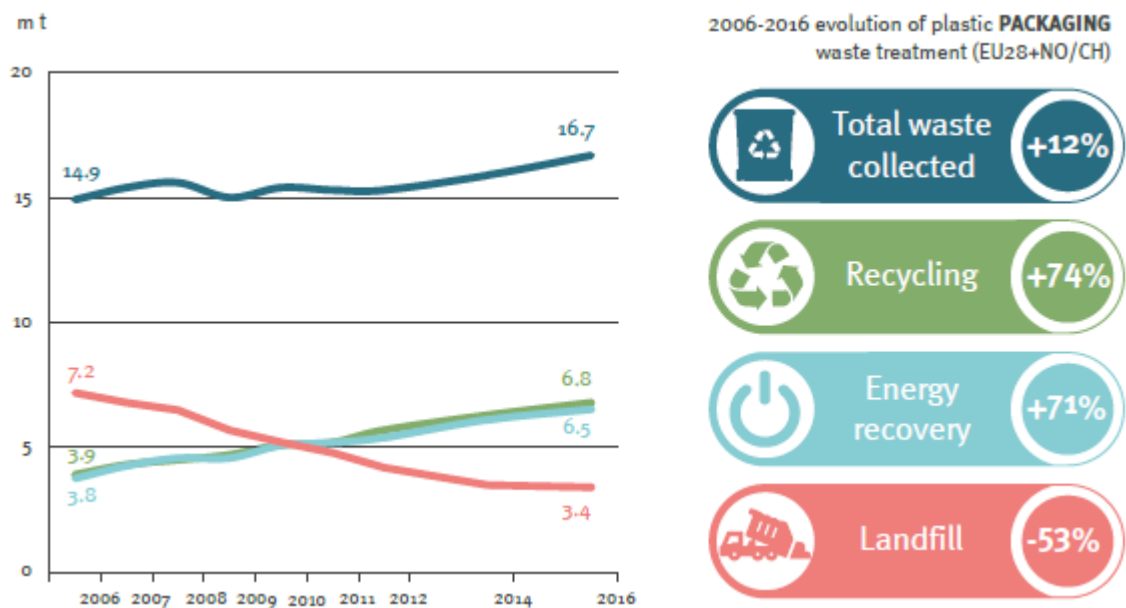


Figure 11.: Evolution of plastic packaging waste treatment in the EU

Source: PlasticEurope, 2017

Nowadays most of the European Union countries recycle above 35% of plastic packaging waste (PlasticEurope, 2017). Germany and Czechia are the two leaders in this indicator, and they recycle plastic packaging at around 50%. Unfortunately, in some countries, including Hungary, this rate is under 30%. Among these Member States, Finland and France are surprisingly under 30%; this group does include not Romania and Bulgaria. Overall, the EU's plastic packaging rate is close to 41%.

2.8.WASTE MANAGEMENT EDUCATION

Improving the rate of separately collected plastics involves legislative and technological background and raising awareness in the general population. The literature brims with studies connected to public education on waste management. Chow et al. (2017) wrote a study on plastic waste management education and mentioned three methods to achieve this goal: direct teaching, hands-on teaching, and simulation game-based teaching.

Education for sustainability is present in some universities as well. Budihardjo et al. (2021) concentrated on the case of Indonesian Diponegoro University. This study provides a good reference for other universities as well. The aim of this study was to give an overview of the waste situation on the campus of this university. All the university's faculties have courses related to sustainability, but the quantity of material covered depends on the faculty's focus and

subject matter. The university gathers statistics about waste quantities and staff and student awareness. The conclusions of the article also recommend that other higher education institutions implement programmes to track and measure solid waste management.

According to an Indonesian study (Syahmani, 2021), the so-called STEAM approach is another effective method to increase levels of awareness in the public. The STEAM approach improves environmental literacy across five different disciplines: science, technology, engineering, art and mathematics. This article notes the low number of articles concerned with waste management education using STEAM methods. The authors recommend educating other authors and researchers to become involved in the STEAM approach which has been proven to lead to better results in selective waste management.

Waste management in educational institutions is important because schools and universities generate large amounts of waste. According to Jayaprakash and Jagadeesan (2019), an educational institute with 1200 people generates 500 kg of vegetable and food waste per day and 8000 kg of paper waste per month. Unfortunately, the study contained no information pertaining to plastic. Waste also incurs financial damage and environmental damage. This article is based on the example of AC Tech, Anna University in Chennai, India. Using that example, the study concluded that waste management presents a big challenge for universities. Therefore, the study suggests creating waste plans for higher education institutions, including items such as colour-coded bins, suitable hygiene for workers and students, and bans on waste dumping within the campus.

A'yunin et al. (2022) created a questionnaire about waste management knowledge that received 398 responses. The research examined connections between the same questions using a chi-square test and p-values. The results revealed a relationship between attitudes and waste management, and also between waste disposal facilities with waste management – both p values were under 0.05. The study found no relationship between age and waste management, and education level and waste management as for both of these the p-values were over 0.05. The authors suggested the creation of a good waste management plan.

Klein et al. (2021) also researched how to improve waste management efficiently at higher education institutions. Their article analyses the topic through the lens of lean management. One of the important goals of lean is to become acquainted with the concept of being unthrift and to avoid it. The study interviewed university leaders and based on the received responses, drafted a hierarchy model from waste types. This hierarchy can help universities

organize their activities. They suggest creating a quantity register for some types of waste and suggest it is beneficial to analyse the environmental policies and determine how these can be adapted to lean management.

Raicu et al. (2011) present an optimisation waste collection method for the Romanian capital, Bucharest. This method is based on a geographical information system (GIS), which consists of some algorithms. The complex geodatabase structure allows efficient selective waste management in a large dimension, at the level of universities. The study is important because Bucharest has 15 higher education institutions that are attended by over 250,000 students. The system considers the local road map and the place of selective waste rubbish bins. This method is informational and offers technological help for public authorities and selective waste collection operators.

3. METHODOLOGY

During the research, the aim was to introduce the plastic recycling system, including the actors. There is some required knowledge of the current situation, directives, legal documents and best practices. The first part of the thesis focused exclusively on these issues, which were based on secondary research. The present thesis also indicated that some other European Union Member States are trying to achieve sustainable plastics management, using the circular economy model with some domestic legislation and practices. The thesis aims to determine; how does it work the circular economy model by plastic in practice.

The thesis explored the Hungarian (domestic) situation. The aim of the primary research is to confirm the statements noted in the review of the literature. To this end, the present study organised in-depth interviews with relevant actors in plastic recycling waste management. Interviewees included representatives of public and market-oriented institutions. Otherwise, the questionnaire was slightly altered for university researchers. The questions focus on Hungary, but to compare the situation with another country, an in-depth interview was conducted with an Austrian researcher with theoretical and practical experience in plastic recycling.

The primary research questions were structured before interviews began, according to the content of the questions. The questionnaire consists of three parts. The first group regards the current plastic waste recycling situation in Hungary. The majority of the questions were asked in order to allow the interviewee to express his/her views and experiences on the issue. For example: “How do you currently see the situation of selective waste collection for plastics in Hungary?” Apart from this question, the study sought to discover how satisfied respondents were with the current plastic waste recycling situation.

The following topics also were asked: the circular economy of plastics in the country, the trends in selective plastic collecting by households and by the industrial sector, opinions on the current plastic recycling laws and directives, and general opinions concerning the waste hierarchy model and the economic actors involved in plastic waste (e.g. producer companies, where plastic waste was produced, the public companies, and the processing for-profit corporation).

The second group of questions related to the plastic waste situation in the European Union. The opinions the industry actors and the researcher interviewed about the waste policy of the European Union are interesting, especially pertaining to whether domestic efforts are in line with the main directions of the Union. The questions also focused on the differences between the Member States, including how modern it is, and within the Hungarian situation. Which

countries can we take examples to adopt our country? Another interesting question was the motivation with financial affairs, such as the current situation with the introduction of a deposit system for PET bottles. Another question concerns any information the interviewees might have had about integrating plastic waste management into the educational system at different levels (primary, secondary, and high school).

The third group of questions was about the activities of plastic recycling companies, both public and private. In general, public sector companies engaged in the collection and sorting activities, while profit-orientated companies engage in the recycling process, the result of which is a finished product that can again go to a producer for reuse. One of the questions in this group is: “Is it worthwhile to recycle plastic waste in Hungary today?” Questions concerning the support from the Hungarian Government or the European Union were also included. It was also interesting to learn how developed the infrastructure is and the situation with supply and demand. Another question aimed at discovering the main motivation of customer companies who recycled plastic goods – sustainability or cost-effectiveness?

The in-depth interview was conducted with nine respondents. Among these were three researchers, two interviewees from a public company, and five from private, for-profit companies. The survey is not representative but relevant because most of the respondents have decades of experience in plastic collecting, sorting and reprocessing. The selection process determined that respondents who hailed from for-profit companies also work in other segments of plastic reprocessing. From the for-profit companies, respondents were company specialists for a granulate recycling company, polyethylene, and polypropylene recycling company, a mixed plastic waste recycling company, PET bottles recycling company, and a leading environmental consulting company.

All of the interviews were completed in September–October 2022, which was a difficult period for the companies because in the past two years most companies had to operate under several restrictions related to the COVID-19 pandemic. These restrictions were followed by a rise in electricity and gas prices in 2022 and a general but significant rise in inflation in Hungary and Europe, all of which have brought about significant changes for economic actors whose priorities have shifted to surviving these crises. The electricity and gas costs have skyrocketed in plastic reprocessing as well. Another interesting development in the industry during the research period was the concession won by the Hungarian oil company, MOL, which has unleashed uncertainty in plastic waste management.

4. RESULTS OF PRIMARY RESEARCH

4.1. THE INTERVIEWEE

As was mentioned in the “Methodology” chapter, this thesis consists of in-depth interviews. Firstly, the introduction part of the answers will be presented. Most of the interviewees have worked at least two decades in their professions. As previously mentioned, this information was obtained via three University researchers: R1 (researcher) and R2 were from a Hungarian University, and the third, R3, was from an Austrian University. R1, whose research territory includes the processing of plastic streams, has completed practice research in plastic recycling. R1 has researched 52 plastic reprocessing companies. The research topic of R2 includes polymers recycling. The main research territory of R3 involves processing technology of waste management, in particular, sorting technology.

An in-depth interview was conducted with a Public Service Company leader (Public Company 1 – PC1 in the following) whose company services a Hungarian county. PC1 has worked in the company for about 20 years and works to supply around 250 settlements and around 60000 people. The company is responsible for collection and sorting. Another in-depth interview was with another public company’s Deputy Director (PC2). That company is also a state-owned company but the service territory is different. The company is headquartered in a Hungarian city, and it services in the territory of two other Hungarian counties. The company also engages in waste collection and sorting.

As previously mentioned in the “Methodology” Chapter, interviews with private companies were also conducted. One of these companies was originally founded for recycling, but now makes new packaging plastic, from which it generates most of its total revenue. The company processes pure and mixed plastic to manufacture tools used in environmental protection (e.g. water, and air cleaning tools). Beyond recycling, the company produces plastic wraps from new raw materials, which cannot be recycled or is very difficult to recycle. The interview was conducted with the leader of this company (FP1, as in, for profit 1)

A representative from a company that reprocesses polyethylene and polypropylene was also interviewed: the leader (FP2), who has more than 40 years in the profession. Another interview was conducted with a leader from the FP3. This individual has extensive experience in plastic waste management and was educated about the topic abroad. This company has a good

position in its segment. It works with different types of plastic by grinding it and pressing it with machines to produce goods for the packaging, plastic, and construction industries.

The main profile of the next company is PET bottle recycling and aluminium bottles. Only the former is relevant to this research. The company has been on the market for 20 years. Their partners are public waste management companies, industrial companies and trade companies. During the research, an employee from FP4 was interviewed about the working process of the company, which the employee also showed the researcher first-hand. The final interview involved the managing director of an environmental consultancy company (FP5). The leader graduated as an environmental engineer and has 25 years in this work field. The firm is in Budapest. Their activities include waste management and their partners include producers of plastic products, waste recyclers, handlers, automotive companies, manufacturers and assemblers of electronic equipment.

4.2.THE HUNGARIAN SITUATION

The first group of questions concerns the domestic situation in Hungary. The first question was “How do you see the current situation of separate waste collection in Hungary (especially plastic)?” The situation is not so good according to the interviewees. Three of the respondents (R1, R2, and FP5) said the Hungarians are undisciplined in selective waste management. Fifty per cent of the material collected in plastic bags for recycling is unsuitable for recycling, according to R1; FP2 confirmed this rate. R3 said this rate is between 50% and 60%. According to PC2, this rate is between 30% and 50%, but this ratio also includes rubbish.

FP5 noted that the value of plastic waste depends on how sorted it is, so the best thing would be for inhabitants to collect it correctly. R1 said that we can improve with material incentives. FP4 highlighted that the plastic recycling industry is quite uncertain currently, primarily because of the MOL concession. FP1 stated that selective plastic recycling worked well but would work better when municipal solid waste is also sorted.

FP2 views the situation tragically. According to examples he noted in his company, they made an equipment investment for 4000 tonnes polyethylene and polypropylene recycling annually, but they can buy only 600 tonnes of waste yearly. FP2 assumes the situation is heading in the wrong direction due to a year when the company received 2000 tonnes. This interviewee highlighted a bad tendency. Opposite FP2, the two interviewees at public companies were optimists, with both seeing positive tendencies in public plastic collection. PC2 stressed that

domestic recycling of plastic has developed significantly over the years, but some types of plastic require more investments (e.g. PET bottles). Both selective waste companies have been involved in selective waste management activities since the 1990s.

R3 highlighted Austria's high level of waste management. Austria has no landfilling for municipal solid waste due to the shift to energetic recovery (burning) 15 years ago. On the other side, the recycling rate is rather poor (25%). Moreover, according to the local legislation, this has to improve to 50% by 2025. According to the Austrian researcher, this presents a big challenge for the country. Plastic is one of the materials with the most to do in recycling in Austria.

As noted in the secondary research section of this thesis, implementing a circular economy is one of the main directives of waste management in the European Union. Therefore, an important question in the questionnaire was: "Is it possible to talk about a circular economy for plastics anywhere?" There are conflicting opinions on this question. Of the eight respondents, four said yes, and five answered no. R3 takes into the account that it is a really important directives for the European Union. In Germany, the waste law is called the circular economy law. In Austria, the government detached the circular economy from the law in the previous year but reattached it in October 2022.

Among the people saying no were two researchers (R1, and R3). They explained that a 100% circular economy does not exist. R3 cited the reason in thermodynamics III main theorem; all the recycling processes have losses. According to FP2, the circular economy has some barriers. Shampoo cannot be put back into shampoo bottles and cold-cut packaging cannot be reused for cold cuts. FP2 cited PET bottles. FP3 is also among the naysayers and noted the cleaning barriers. FP3 drew attention to the fact that the chief problem resides in plastic types. Polyethylene and the polypropylene hinder collection. No problem exists in the processing infrastructure for the cable plastic part of the collection and the infrastructure is good. Concerning the market problematic, for PET bottles, the collection, the market, and the materials are adequate, but the technology needs further development. PC2 also responded negatively but noted the many experiments PC2 designed to achieve this goal. Based on my respondents, we cannot talk about circular economy by plastic, as I mentioned, there are many barriers.

Opposite the naysayers, some respondents answered yes. For example, PC1 said it still works at producer companies. FP1 said it works for polyethylene and polypropylene. FP4 said also yes, but not unending. PET can be recycled back into PET, or, for example, polar sweaters

and strapping tape. FP5 said if there are no capacity barriers (In Hungary there in capacity barriers) some types are able for it, for example, shrink film or colourful plastics.

The next question concerned plastic recycling infrastructure, how new it is, and whether there was enough of it. More respondents are unsatisfied with that, including the two Hungarian researchers. The two researchers said the same: The technical infrastructure is of a low technical standard and outdated. When companies cannot see a financial return on infrastructure expansion, they tend to avoid such expansions, which leads to underdeveloped or undeveloped infrastructure.

FP4 was of quite the same opinion – the infrastructure needs improvement, but the supporting systems do not provide such opportunities. FP5 critiqued the low number of processing companies. FP1 has a relatively small company with old machines, but there are companies, which have more developed infrastructures. Outside the processing infrastructure, the sorting infrastructure is also an interesting item. At that time, it was a task for public waste companies in Hungary. PC1 claimed that there are 68 sorter places in the country. But after the previously mentioned concession, won by MOL, the oil company decided to reduce the number to 30. PC1 noted proximity principles. As previously mentioned in this thesis, PC1's company is located in a rural city, and it is easier for it to do business with a Romanian reprocessing company than with a Transdanubian one.

R3 explained that Austria has a reprocessing infrastructure for plastic waste and that every province has different reprocessing companies. They have no problem with that. The infrastructure is too much for the Austrian plastic waste, so they have to import plastic waste from the neighbouring countries to utilize the total infrastructure.

The next question was “Is separate waste collection included in education?” The focus here was on primary and secondary-level education. Some interviewees were not sure how to answer. The two Hungarian researchers had no information, but all the respondents said it would be important. The two staff members of public service providers said that these public companies have motivational activities for the public. According to PC1, we can affect recycling behaviour most easily since these have the biggest impulsiveness. But they have some actions with the primary school students. Inspiring motivation in secondary school is a difficult thing because teenagers are not open to the topic. Two years ago, a study (Náhlik, 2020) in selective waste management, and another public service waste company director found the

same as PC1 in that year. PC2 said that their public company is constantly trying to raise public awareness and motivate people to collect selective waste.

FP5 answered that an environmental education subject is important, but a good example from family is also an important method. FP1 said that the education system in Western Europe focuses on these themes, as does the Hungarian system, but it does matter, whom we educate. According to FP2, selective waste education is important, but it is important to emphasise why it is important to collect selectively. FP3 responded by pointing out that the biggest problem is in plastic recycling; that there is no plastic recycling building at the higher education level.

The Austrian researcher, R3 also regards this topic as extremely important. In his experience, many teachers talk to children about the issue. R3 has completed presentations for public school students. At the university level, some studies related to the environment, which have topics about waste management, do exist. They have also buildings for recycling technologies.

The following two questions were combined during the interviews. These were: “What is your opinion on the current plastic waste regulations in Hungary?” and “Do you think that there is enough public awareness to think consciously about the fate of our plastics?” These questions were recorded in the same paragraph because it was assumed that the answers would be inter-related. The Hungarian researcher answered that average people engage in collecting plastic packaging waste, but they often break the rules and behaviour standards. R3 noted that the main challenge for plastic waste management is to sort the mixed waste. From this, the thesis concludes that the composition of mixed waste must be regulated in some ways.

FP2 does not see any regulations that efficiently influence the population. According to FP2, in theory, everybody collects plastic separately, but nobody does it in practice. FP1 answered that the separate waste collection works well with paper, and glass but not with plastic. Most people regard plastic as a homogeneous material, which makes the recycling process more difficult. In their responses, FP4 and FP5 mention the product charge system, which will probably reduce the quantity of plastic waste in landfill and support the realisation of plastic.

The other questions concern the domestic trends, specifically the question: “What are the trends in selective waste collection in your country, it means recycling rates and the ecological footprint of plastics? Is it different from the rest of the European Union?” R1 and R2 answered that it is similar anywhere, but the economic structure of a given country determines the recycling trends, the statistics and the rates. If the economy would be based more on producer companies, the recycling rates would be higher because the producer companies can move to

the circular economy more easily – was the opinion of R1. According to R3, globalisation also affects recycling trends and R&D projects, which differ among countries.

The two respondents at public service companies said that the tendencies are clearly positive. Every household in a detached house in the service area of PC1 was provided with a 240-litre collection container, which doubled the collection of selective waste immediately and led to increasing amounts ever since. PC1 is satisfied with the tendency. FP5 and FP1 also see increasing. FP1 adds that selective plastic still increases, despite a big recession. On this FP3 insisted that during crisis periods, surviving becomes the first goal for the company, and sustainability is relegated to the background. FP2 also mentioned a similar negative tendency.

The next question was “Could financial incentives be used to promote a more efficient separate collection of plastic waste?” Six of the respondents answered this question. All of them find the idea a good one, but most of them said no all the same. According to PC1, one of the best ideas is to introduce the deposit system for PET bottles, and the plan is that it will be introduced in 2024 in Hungary. After that, PET bottles will be twice as expensive, but when half the price will be reimbursed if the bottles are returned. FP1 and FP3 said this system still works in Germany. According to a research result, most Hungarians support a deposit system for PET bottles. The noted research was completed by a Hungarian mineral water producer company (penzcentrum.hu, 2022). FP5 finds this deposit system to be a good idea as well since it will reduce landfill waste, but FP5 also opines that not every idea is good. For example, smaller rubbish bins for municipal waste, because it is not self-evident that the inhabitants will choose recycling in an effort to reduce municipal waste.

There is another tendency in plastic packaging waste – the thinning of plastic packaging materials, which also reduces the amount of plastic consumption. This tendency has been covered in the literature as well; for example, Munib et al. (2021) mentioned it as a target. FP2 said there is a wide range now in plastic packaging but much of it is unrecyclable.

R3 referred to the Austrian example here. To improve selective waste collection, the country harmonized the system at the country level and created more sorting capacity, including more automatic processes. Austria also adopts more new recycling technologies, including chemical methods and innovative molecular-based methods, but it is not known if these methods will be successful.

The next question was “What do you think about the selective waste collection habits in our country?” This was only for the three researchers because they have a better view of that

question. The Hungarian researchers all responded similarly. Both thought that the collection concentrated on households, basically the door-to-door collection, has a good result in the country. They have confirmed that we have to improve on the quantity and quality sides. The quality side means that more needs to be sorted, which requires increasing the knowledge and discipline of the population.

Another question focused on attitudes. Here the general opinion was that Hungarians were undisciplined in selective waste management. Both researchers suggest that the population must be made economically motivated and, on the other side, education is very important. Overall a sense of responsibility is absent in the public when it comes to plastic waste. R3 also noted that the inhabitants have to first do the sorting, but changing the behaviour of the people is one of the difficult things. But the Austrian researcher said that people can solve the problem together.

The Hungarian researchers were questioned about the situation of public waste management companies, how they work, and what their situation is in connection with state support. Both consider the matter to be unclear, and both preferred that the selective waste management be based on the market or that in a state responsibility. According to R3, market-basing works to create competition between companies and improve the quality of service. The next answers of the researchers reinforce the claim noted by PC1. The question was whether the concept of the circular economy works for producers or trade companies. They said that by producer companies yes; this was confirmed by PC1, who noted that it does not work at the trade companies. The explanation resides in the production where they can easier reuse the production. R3 sees any aspiration at trade companies as well. R1 and R3 said that the relevant economic actors do not consider the waste hierarchy model, which is one of the most basic models of waste policy in the European Union.

In the followings (1. table) we can see some important answers from the first group of question in a structured table

1. Table: Answers about the Hungarian situation

	How do you see the current situation of separate plastic waste collection in Hungary ?	Is it possible to talk about a circular economy in plastics anywhere in Hungary?	Could financial incentives be used to promote more efficient separate collection of plastic waste?
R1	Business practices vary from area to area, population not very disciplined, national average is about 50% of waste collected is not for separate collection Undisciplined, education, continuous and proactive awareness raising, make it economically viable	In my opinion, a 100% circular economy will never be achieved, just think of the losses due to the efficiency of the various technical solutions, even with the best intentions	With the right incentives, yes.”
R2	Unfortunately, the practice is not uniform, but varies from area to area, and the situation is further complicated by the fact that the population is not very disciplined, so up to 50-60% of the waste collected is not destined for the separate collection	According to the Third Law of Thermodynamics, a 100% circular economy can never be achieved because entropy can only increase in a closed system. If nothing else, it is enough to think of the losses due to the non-100% efficiency of certain technical processes, even with the best intentions	Yes. with the right ones.
PC1	Selective waste contains between 30-50% of foreign matter.	Yes, it is very efficient in companies, and the population is developing,	Yes. PET bottles: from 2024, there will be a return system
FP2	Tragically, the company has made an investment in processing infrastructure, cannot pay for itself. Fifty percent of the material collected in the yellow bins does not belong there. It is sorted by the waste management company	You cannot produce the same amount of waste from the same amount of waste, the inherent odors are retained. You cannot put cold cuts in a cold cuts package again. With PET you can consider it.”	
FP3		Not everything can be done, e.g. cut packaging, PET bottles (tipping), not everything is solved. Depends on the material cable waste collection good, infrastructure good, market not so good, propylene market is there, infra is there, collection not so good, PET - technology needs to be developed	Yes
FP4	It is in transition; currently MOL concession tenders take up more issues - this creates uncertainty	Yes. PET bottle recycling makes PET suitable for recycling, either as a pet bottle or in other products (e.g. polo sweaters, strapping tape) The cycle is not endless	
FP5		A deposit scheme would definitely be an incentive	Yes, Deposit R. S.

Source: Own edition

4.3.SITUATION AT THE EU LEVEL

The second group of questions was related to the European Union waste policy and the other Member States. The first question was “What is the EU’s waste policy, looks in your opinion? Do domestic efforts match this?” Most respondents claim it is good in theory but not in practice. R3 answered that the domestic targets more or less match the EU’s waste policies According to FP5, the legislation of the EU aims to preserve the materials in the economy. This study introduced that aspect in the secondary research, namely, the circular economy. This statement was confirmed in this research by FP3, who also stated that the EU does not force the required raw material flows to the stakeholders. FP3 provided a lucid example to support this. The bumpers on older models of cars were made from one propylene material, which could be recycled, but now bumpers are multi-material and safer; however, they are not recyclable. This raises a pertinent question – is safer/better more optimal than recyclable?

FP1 finds the EU’s principles theory good, but in his opinion, the problem resides on the practical side. The opinion of PC1 was quite the same: in practice the implementation takes time, but PC1 sees that the Hungarian plastic waste recycling situation is always closer to the EU’s average. FP2 regards the issue differently – indiscipline on the part of the population is the reason why Hungary cannot meet the EU’s expectations. PC2 emphasises the waste hierarchy model and the circular economy here as primary targets with their aim of preventing plastic waste generation that goes to landfills.

Another question put to the respondents was: “Are there significant differences in people’s attitudes to plastic recycling between EU Member States? Do you think people’s attitudes are influenced by legislation?” R1 noted the differences are present, but we cannot eliminate these differences because they are connected to differences in people’s living standards, and in poorer regions of the Community, basic livelihoods, not sustainable waste management, remains the key issue. R3 has a similar opinion and adds that economic structure is also different, and that best practices are difficult to adopt. R3 states that the integration of best practices is not a serious aim in politics.

The next question regards the differences or recycling process infrastructure. This question received only four answers, but the question is relevant all the same because the first respondent is a researcher (R3) and the other three respondents are recycling company leaders with much experience (FP2, FP2, FP3). R3 and FP2 responded by noting there is no big problem with infrastructure. The problem arises from the amount of plastic that is properly sorted into

types – polyethylene, and polypropylene – but there is a segment where the infrastructure is less underdeveloped; more precisely, PET bottle recycling. The infrastructure must be developed further, claimed FP4, and FP3.

The company specialists were also asked whether the European Union provides financial support for recycling activities. The respondents from Public Service Companies answered that the EU supports big investments, for example, to construct new, automatized sorting systems, such as the so-called optical sorting machine. The for-profit companies respondents FP2, and FP1 claim that they get no money from the European Union. FP3 was in a Horizon 2020 project financed by the EU.

The next question was “Which countries are examples in plastic waste recycling? How are we doing in plastic recycling among Member States?” R1 said Slovenia because education was successful. R2 provided no specific country as an example, but mentioned that financial incentives to encourage the public to collect plastics separately are desirable; however, it is unclear as to who would provide these incentives. PC1 and FP2 alluded to mainly West-European and Scandinavian countries and both mentioned Germany as a good example. Both leaders also mentioned Romania where much infrastructure has been implemented in recent years. PC1 explained that 90% of waste processed by the Public Service Company flows abroad.

The next question was: “What best plastic recycling practices do you know of that our country uses? Please also mention household, business and packaging practices that prevent plastic waste and/or promote the transition to a circular economy?” For this question, R1 once again referred to the fact that Hungary cannot adopt this practice because every society is different. According to FP2, current practices in the country are ineffective because the behaviour of people does not change over the years. FP3 said that PET has a deposit system in Germany. Sweden is on the wrong path according to FP3 because of the plastic-burning capacity that was built there. FP3 added that the burning results in big losses because valuable raw materials end up being emitted in the form of gas. According to FP5, the economic actors have to be motivated. A big question is motivation. R3 answered that producer responsibility is an important European Union regulation, but we cannot name one practice to solve the problem.

There are some bad examples as well. For example, exporting and importing waste is harmful to the environment due to the CO₂ emissions associated with transport. Two of the respondents (FP1, FP3) noted that in Sweden a large capacity for plastic waste burning exists, which, according to the Waste Hierarchy, is more optimal than landfilling, but much worse than

recycling. An example of waste export was when plastic waste was exported from Italy to Sweden.

The last of the questions in this group of questions regards the differences. The situation in Hungary is interesting when it is compared to other Member States. As far as R1 is concerned, differences exist. FP1 identifies the differences are large but narrowing. According to FP2, Hungary has been lagging behind in plastic packaging waste. Hungary selectively collects between a 30% to 35% rate, but the EU target is well above that at 50% to 60%. Here, FP1 answered that the state considers “plastic a harmful material” because when it exits the circular economy or is, then the negative effect of plastic on the environment is low, and plastic would be a more sustainable raw material. FP4 and FP5 disagree with that statement; they claim that plastic always stays in an environmentally harmful position.

In the following table (2. table) I summarized some important questions and answers from the EU level part.

2. table: Answers about the situation at EU level

	What is your opinion about EU waste policy? Are the domestic efforts line with EUs policies in Waste management?	What is the condition of plastic recycling infrastructure? Is there big differences among the Member States?	Which countries are examples? How do we rank among Member States in terms of plastic recycling?
R1		The technology is outdated, it is a question of modernization and expansion, and expansion Both cost money and the question is: will it pay off? Whose financial responsibility is it, market based or state?	Slovenia - awareness raising and mobilization of the public worked well
R2	More or less	Not so much in processing, like in collection and sorting. The technology is everywhere, the question is whether it is not exploited for economic and political reasons.	Regulation alone cannot achieve the required results, so financial incentives are needed
PC1	The EUs directions are good. but there are also theories from the EU that are impossible to fulfil.		Western countries, Germany, Austria, but also Romania have good recycling.. A lot of plastic waste are delivered from East-Hungary to Romania
FP1	The principles are good in theory, but in practice they can be problematic	Old equipment, no own site, no long term vision, very energy intensive industry, 10x the electricity bill, can't pass it on to customers e.g. polypropylene very high costs not worth it	
FP2	The EU standards are adopted by our country but not fulfilled, the reason is the system, the people do not comply, it is not the public service provider that gets the money, it is the NHKV		Poorly, Germany and Scandinavian countries are the best, but countries in the region are ahead Romania has huge capacities
FP3	The direction is good. Recycling is taken seriously by EU, but there is some practical problem		
FP4		We have to keep the competition improving with other recyclers	

Source: Own edition

4.4.COMPANIES SECTOR SITUATION

The last of the group questions address the situation at processing companies. “Is it recoverable remanufacture plastic for the for profit companies?” The question was posed to the for-profit companies’ workers, and from the representative of public firms, with other questions, which were asked of the respondents.

The first question was “Is plastic waste recycling worthwhile in Hungary?” FP5 and FP3 said yes. FP5 mentioned that this market segment is present; therefore, companies can engage in the practice profitably. FP3 answered that currently yes, but the raised energy costs are a big question for reprocessing companies. FP1 responded with a no, after the MOL concession affair, which is a big issue, especially concerning the percentage of profit paid to MOL, and how many companies will ultimately stay in plastic recycling. Some respondents also mentioned, that the MOL concession kills market competition, and is bad for innovation and the free market. PC1 noted that the public companies do not aim to make a profit, but they see the positive collection tendency in that field, in residential houses, but in the housing estate areas the question is more difficult because the collection places are fewer there. R3 answered that the recycling process is not a huge business including the collection; the reasons are: there is significant market competition, which reduces prices, and because plastic is made from oil, the oil prices also affect plastic prices.

The next question in this group was: “How can we persuade customers (companies) not to use newly produced packaging but to buy and use recycled packaging?” Six respondents answered that the primary reason to buy recycled packaging is the price. The companies search for the cheapest packaging solution. The company FP1 works for produces granulates from recycled plastic. The new granulates are twice as cheap. FP1 answered: When it is cheap, it is good for the environmental policy of the company; however when the recycled granulates become more expensive, customers stop buying. FP2’s opinion is the same. Buying cheap buy is a major motivation for companies to buy recycled plastic packaging. FP3 adds that before the COVID-19 pandemic and the economic crises, sustainability was a major concern, but the changing conditions have placed most companies into survival mode. R3 notes that lower expenditure is the main reason during that time. FP4 and FP5 also see price as one of the most important things. Only PC1 declared sustainability to be an important factor together with low prices and added environmental friendliness as another significant factor. To support this view,

PC1 took the French transnational company as an example. The conclusion from the answers reveals that low price provides the largest motivation for purchasing recycled plastic goods.

The questionnaire also enquired if the companies in which the respondents worked received any support from Hungarian State and/or the European Union. State support is the primary financial means for public companies, but this money rarely arrives directly because the government supports the “Nemzeti Hulladékgazdálkodási Koordináló és Vagyonkezelő Zártkörűen Működő Részvénytársaság” (NHKV PLC.) and this firm finance the local Public Service Companies. The big question resides in its effectiveness. Four respondents provided answers concerning the financial companies. There was only one, who do not get any support from the state. The for-profit companies, which are supported by the state as well, get support for collection, and for reprocessing. In the case of EU support, the Public Service Companies get them for the investments to develop the technology. Three of the respondents from for-profit companies answered the question regarding EU support. Among these, two obtain support from the EU, one does not.

The next question was: “Would consumers be willing to pay more for more environmentally friendly packaging?” The answers unequivocally show that financial concerns outrank environmental protection concerns. Companies that have to buy plastic packaging purchase the environmental friendly options only when these are cheaper than plastic packaging from new raw materials. FP2, FP3, and FP5 view this question at that point.

The last of the questions was: “If we could get plastic to stay out in its cycle, would it be more sustainable than its alternatives?” This question refers to the alternatives of paper and glass. Among the four answers, two claimed yes – when plastic remains in the circular economy it remains a sustainable raw material (FP1, FP2). The other respondents said plastic will never be a sustainable raw material.

3. Table: Answers about the companies sector situation

	Is plastic waste recycling worthwhile in Hungary?	How can we persuade customers (companies) to stop using newly produced packaging and to buy and use recycled packaging?	Do you get any supports from the Hungarian state?
FP1	Not in itself; not on a market basis. New Waste Act - The Hungarian state has given the entire waste market to MOL on a 35-year concession. All waste generated in Hungary will be owned by MOL, and it will decide how much it pays for it, what it does.”	It has to be cheaper than new material, the price of new materials has grow up, hence the renaissance of recycling	Yes, we do. We get between 10 and 40 HUF/kg support from the Hungarian State for the collecting and utilizing. The account after the support is exact for State, and for the National Tax and Customs Office as well
FP2		This is a basic interests, because it is cheaper, than the new ones. Only the material aspect motivates buyers.	They can take over waste that they could not do without supports
FP3	It will be worth it, but it will be exciting to use electricity. Material flow example. Polypropylene price has gone down; we use it for white goods, electronics automotive; no demand; upside market is limited: they compete with concrete	No way, now what's cheap is what they take, before the crisis it was about being greener. The multinational companies are not thinking long term, it's the opposite of sustainability.	There is no support from the Hungarian State
FP4		The financial incentives, and to improve the quality of second-made products	Trought tenders for collecting and utilizing, but it does not cover the costs.
FP5	As it is an existing market segment, it can be made to be worth it, but much depends on the issue; it depends on the type of plastic.	Pricing, demand supply right adjustment. Also depends on the product, if it's marketing material it can be environmentally friendly, in the car industry there are different considerations.	

Source: Own Edition

5. CONCLUSIONS

The study explored and tried to answer the question: Does in Hungary exist the circular economy in plastic? The first half of the thesis focused on a literature review and detailed the European Union waste policy. Environmental policies have been at the forefront of EU policy-making since the beginning. The chief aim was the establishment of common action against climate change and other environmental problems and issues. This prompted several pieces of legislation and action plans in the 1970s. Waste management is one of the three main pillars of the environmental policies. The three main targets within these three pillars are: disposing of and reducing waste at the point of production, supporting recycling, and reducing the environmental damage caused by waste burning.

To achieve this goal the European Union created two models: the Waste Hierarchy model, and the Circular Economy model. These two models are easy to understand for each stakeholder and most of the research respondents were satisfied with them overall. The waste hierarchy describes the order of supported and less supported roles of waste; the most supported is recycling and the least supported is landfilling. The thesis also deals with the Association of Plastics Manufacturers analyses, which are called PlasticEurope documents. They analysed the evolution of plastic waste treatment for all plastic and for packaging plastic only from 2006–2016. Both diagrams showed that in the 21st-century people started to consider the Waste Hierarchy Model. In 2006, most plastic waste went to landfills, and the recycling of plastic was in its infancy, but in 2016 the situation changed, and more plastic went to recycling than to the landfill. In that year, the energy recovery rate was higher than the recycling rate.

The other important model is the Circular Economy model. That means, the value chain has no input and no output side but must be a cycle that involves the collecting, sorting, and reprocessing to get new products from still-used materials. It is very important to consider this model for macro sectors: households, business, and government sectors as well. The circular economy model is very sustainable and a well-suited for avoiding the use of new raw materials, but in practice, it is impossible to implement without financial loss. The result of the primary research was that plastic raw materials cannot be recycled in any number. On the one hand, it is unhygienic, and on the other hand, plastic degrades and loses its original quality over time.

The primary and secondary research revealed that some countries and companies import and export waste. This is present in Hungary and in other Member States as well. This is a very unsustainable solution because the transport of waste among countries is costly and harmful to the environment, mainly because of CO₂ emissions. For example, Sweden has a large capacity for plastic burning, and Italy delivers waste to Sweden via ship. Two of the questionnaire respondents happen to mention this environmentally-unfriendly practice. The secondary research also introduced Austria, which also imported and exported plastic materials and waste. However, those who import plastic materials must ensure that plastic participates in the circular economy.

The primary and secondary research established that EU member states have not been equally successful in terms of complying with these two models and the other waste policies. With a few exceptions, it is mainly western and northern European Member States that are successful in complying with the directives. The leadership of the European Union would like to achieve the same target. This is for plastic as well. Therefore, they expect the Member States to draft legislation, policies, plans and targets that are in concordance with the EU waste policy. The research has found that the Member States completed these plans, but that legislation is insufficient to ensure success.

The results clearly indicate that being productive in the plastic recycling targets is a significant challenge for countries that perform well in waste management. As this thesis discussed, the Austrian researcher in plastic waste management stated that the Austrian plastic recycling habits also had to develop as well because the regulations differed by states there. The EU waste policies are good overall, but research revealed some points of criticism. For example, the EU measures the parts of recycling processes separately (Pires – Martinho, 2019). Moraga et al. (2019) also miss the complexity of waste policies. One of the interviewees also criticised the directives, which are theoretically good, but problems arise in the implementation of the practice. Nevertheless, most of the interviewees regard the EU's waste management policies on plastic positively.

The result shows that Hungary is among the less successful countries, but there is no direct way to become successful. According to several interviewees, the biggest challenge is to raise the awareness of Hungarian citizens and not the lack of the processing infrastructure. This result is the same as Kirchherr et al. (2018) which was mentioned at the beginning thesis. That study also concluded that the main problems are cultural barriers and people's behaviour.

The main type of plastic waste is plastic packaging waste. This is regulated by the European Union and the Member States. The different governmental actors have made goals. The common EU target is for the recycling rate of plastic packaging to achieve 50% by 2025 and 55% by 2030. The achievement of these targets depends on the behaviour of the inhabitants and how the actors can motivate them. According to a Eurostat survey, recycled and generated plastic packaging waste has continually increased between 2009 and 2019.

Other statistic shows that the quantity of plastic packaging waste has increased in most of the Member States, including Hungary. The Eurostat statistics and the Hungarian Waste Management plan both indicate this. Another statistic shows that Hungary is among the countries with the worst ratio, but this ratio still exceeds EU expectations. From these statistics, the present thesis concludes that Hungary needs to earn better results in plastic packaging waste. The generation of plastic packaging waste must decrease with substitute products e.g. plastic bags, and the country must also improve the collection and recycling rate of plastic packaging. The first step must involve appropriate information for the inhabitants. That is also the result of primary research as supported by several of the respondents who stated similar opinions.

The primary research clarified that financial incentives are the most effective type of motivation. The questionnaire respondents drew attention to Germany, where the deposit system work still for PET bottles. The secondary research focused on another example in Estonia, where the country introduced the deposit system in the 2000s. From 2024, Hungary will also introduce a deposit system for PET bottles. It seems that it will be good for all the economic actors in Hungary. Most company specialists found the measure to be good and added that people also considered it a good idea, according to the results of a representative questionnaire, completed in the household sector (penzcentrum.hu, 2022).

In 2022, the Hungarian government made a concession in the waste market. The winner of this was the Hungarian oil industry company, MOL. That means this company will be responsible for all waste, including plastic waste, for a period of 35 years. The concession creates uncertainty in the plastic reprocessing market. One of the questionnaire respondents bluntly noted that the concession kills market competition, which may lead to less innovation and development.

The primary research in this thesis was in the form of in-depth interviews. One consideration before the beginning of the research was which individuals are able to provide the most relevant information pertaining to the research goals of the present thesis. It was decided to

contact university researchers, and company experts, including public service, and for-profit companies as well. Three researchers, including the Austrian researcher, responded, as did two professionals at public service companies, and five employers or employees at private, for-profit companies. The research was not representative, but this thesis provides a relevant view of the Hungarian situation as it concerns plastic collecting, sorting, and reprocessing. The questions were structured into three main groups: “Hungarian situation”, “European Union situation”, and “Companies situation”.

The plastic waste management situation in Hungary is diverse by region. The biggest problem is that the inhabitants collect under the expected ratio, and in this collected quantity there is a big ratio that does not belong there. The consequence is that people are not well-informed, and motivated about plastic waste management. Providing motivation and information is the task of public service companies. Both public companies in which in-depth interviews were conducted engage in motivational activities, but overall, the budget is too low for this. The state must finance these activities to a greater degree. Teachers can also help support motivation via environment lessons, as can parents. Conversely, children can bring home their knowledge of selective plastic collection from schools and teach parents how to selectively collect plastic waste. It would be very effective if the people could motivate each other.

On the other side, the volume of selective plastic collection was bigger in the late 2010s than in the past three years. The reason is the COVID-19 crisis, which was immediately followed by the electricity and gas crises. Due to these problems, people do not pay enough attention to plastic waste management. The primary research provided an overview of sorting, and recycling infrastructure and determined that this is not as big a problem as people’s behaviour. Nevertheless, much of the infrastructure is old, outdated and unsuitable for some types of plastic (for example PET bottles). In any case, both public and private companies must engage in modernisation and automation, but they will do it only when such upgrades are supported by the Hungarian State or European Union because the companies themselves do not earn big profits with which they invest in such improvements. But among the respondents, one said that there are no big differences between the Hungarian and Western-European plastic recycling infrastructure.

This chapter must highlight that an in-depth interview with an Austrian plastic recycling researcher was conducted. The conversation reveals that Austria is one of the most developed EU countries in recycling, but according to the researcher, the country has to educate and motivate the people more. They have no problem with the reprocessing plastic infrastructure.

Plastic regulation was different by states for a long time and with plastic recycling, more difficult. Nowadays there are on the right track, and plastic recycling is more effective than earlier. Austria has better results in plastic recycling indicators; for example, the “Plastic packaging recycling rate”, which was previously demonstrated in this thesis. It is not a realistic expectation for Hungary to complete a perfect performance in plastic recycling management in the near future.

The aim of this study, as we saw in the title to diagnosticate, and answer the question, “Is it possible to talk about circular economy?”. From the primer research we can clearly see, that the answer is no, and we cannot achieve it in the future. This model is only good theoretically. All the case the recycling processes have losses. Even so I would like to emphasis, this is a very important model, and shows the sustainable direction for all the stakeholders.

6. SUMMARY AND ACKNOWLEDGEMENTS

6.1.SUMMARY

During the course of the research, the thesis confirmed the statement that plastic waste problems are among the biggest environmental problems. Therefore, there are many pieces of legislation, plans, and aims related to the issue. Of course, this topic is relevant for material, technological, and environmental scientists, and of course for economic science as well. The secondary research introduced the legislation, plans, and statistics. The thesis discussed the plastic waste management, and tried to answer the question in the address of this study: The primary research was based on in-depth interviews with professionals in plastic recycling management, including researchers, public and private company employers and employees. The primary research is not representative because it involved ten people, but it is still relevant because the respondents have much experience in plastic recycling.

The primary research determined that there are two models that define the main directives in plastic waste management. These are the Waste Hierarchy Model and the Circular Economy Model, which are a big help to every stakeholder in society. Next to the legislation, there are some targets with numbers. In Europe, the main type of plastic waste is plastic packaging. Therefore, it is the responsibility of EU institutions and the Member States to create laws for plastic packaging waste. The aim is to reduce single-use plastic bags to a minimum level. This research showed that in the case of plastic it is impossible to create a circular economy.

It is clear, that the main problem with plastic recycling is the behaviour of the inhabitants. Before the pandemic and the energy crisis, plastic waste collection experienced higher volumes, but since then, survival has become the main focus of the household and the economic sector. The experts must explain that packaging waste represents value and that it should be collected separately, not only for economic reasons but also for environmental reasons. The motivation should start in nursery and primary school. The most effective type of motivation for adults is financial motivation.

From 2024, Hungary will introduce the deposit return system for PET bottles, which works in other Member States, for example in Germany. There is a big chance that this programme will also be successful in Hungary. According to most respondents, we cannot adopt every good practice from other countries because every society and economic structure is different; sometimes differences exist even at the regional levels within countries.

The results shows also that creating a perfect plastic recycling system is an unrealistic expectation for Hungary because of the existing barriers – barriers other Member States with higher developed systems, like Austria, do not experience, in the case of plastic we cannot achieve perfect circular economy of plastic in Hungary. The results related to infrastructure indicate no large problems. Hungary has plastic reprocessing companies; for some types of plastic like polyethylene, and polypropylene, more infrastructure than recyclable waste exists, but for others like PET bottles, the quantity of infrastructure requires improvement.

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ANNEXES

1. ANNEXES: INTERVIEW QUESTIONS FOR RESEARCHERS

I please you to introduce yourself shortly, and say about your meeting with selective waste management. When did you meet with the topic firstly?

Austrian situation

How do you currently see the situation of selective waste collection in Austria? Are you satisfied with that?

What is your opinion about the plastic recycling habits in your country?

What is your opinion on the current plastic waste regulations in Austria? Are the current ordinances sufficient for a circular economy? Do more stringent measures need to be taken? Or is it the stricter enforcement of the current rules that is missing to increase efficiency?

Are you satisfied with the selective plastic waste management in Austria?

What needs to be changed in Austrian legislation to make the transition to a circular economy for plastics more efficient?

Is it currently possible to talk about a circular economy in any economic sector in your country?

Attitudes of economic and social actors

What is your opinion about the attitudes of the Austrian inhabitants in the issue of selective waste collection? How can we achieve better result in a point of your opinion?

What do you think about the attitudes of waste management companies towards separate collection? Do these companies receive adequate support from the Austrian State to expand and modernise their recycling systems?

How far do you think domestic legislation is helping to increase the recycling rate of plastics?

Is it possible to say that internal recycling is currently (even partially) taking place in some production companies?

Can it be stated that internal recycling is currently (even partially) taking place in some trading companies?

Do you see an effort in the trading companies to encourage customers to collect separately the plastic waste generated by the products they buy? Are there any companies where plastic packaging can be returned to the retail unit?

Do you think the average consumer thinks responsibly about their plastic waste?

Do you think the relevant economic actors take into account the waste hierarchy model for plastic waste?

Dates, and statistics

Do you have data on where and from what sources (e.g. packaging) most plastic waste is generated in our country?

What kind of statistics do you have about plastics recycling and circular economy?

What are the trends in plastic recycling in your country? (I am thinking here of the recycling rate or the ecological footprint of plastics) Is it different from other EU countries?

Based on your research date, which of the plastic waste type are generate the most plastic waste?

Is there a result of the which types of plastic waste recycling in Austria are good and bad (LDPE PP PET)?

Recycling/practices

How do you see the recycling of plastics in your country?

What is your opinion on the Austrian plastics recycling infrastructure?

What is the state of technology in this field in the companies engaged in this activity? Is there a need for expansion? (either in terms of upgrading existing technology or increasing the number of companies involved) Is it financially worthwhile to process used plastics?

What best plastic recycling practices are you aware of that are used in our country? Please also mention household, business and packaging practices that prevent plastic waste and/or promote the transition to a circular economy?

Questions related to EU

How do you see the European Union's waste policy, with its emphasis on the selective recycling of plastics and the shift to a circular economy? Do these attach with Austrian efforts?

Do you have any information, how your country's situation looks like compares with other countries in the EU in terms of plastics recycling?

Are there significant differences in governmental attitudes to plastic recycling among EU Member States? In your opinion, where does Austria stand? What types of practices should be adapted from other Member States to Austria?

Which countries are good examples in the field of plastic waste management? Have EU rules contributed to their success? Is there a "secret to success" for these countries?

Are there significant differences in people's attitudes in plastic recycling between EU Member States? Do you think people's attitudes are influenced by legislation?

Are there significant differences among EU Member States in the processing infrastructure for plastic recycling?

To what extent is education for responsible waste management present in the education system in each Member State? How is our country doing in this respect? Is there a need to integrate education for responsible waste management into the curriculum: are there examples of this in the world?

What are your opinion on financial incentives for the selective collection of plastic? For example, should there be less municipal tax, who has smaller bins?

Have you got any information to compare Austria and Hungary in plastic waste management? If yes, what are the similarities, and the differences?

2. ANNEXES: INTERVIEW QUESTIONS FOR COMPANIES EXPERTS

I please you to introduce yourself shortly, and say about your meeting with selective waste management. When did you meet with the topic firstly?

Hungarian situation

How do you currently see the situation of selective waste collection in Austria? Are you satisfied with that?

What is your opinion about the plastic recycling habits in your country?

What is your opinion on the current plastic waste regulations in Austria? Are the current ordinances sufficient for a circular economy? Do more stringent measures need to be taken? Or is it the stricter enforcement of the current rules that is missing to increase efficiency?

Are you satisfied with the selective plastic waste management in Hungary?

What needs to be changed in Hungarian legislation to make the transition to a circular economy for plastics more efficient?

Is it currently possible to talk about a circular economy in any economic sector in your country?

Attitudes of economic and social actors

What is your opinion about the attitudes of the Hungarian inhabitants in the issue of selective waste collection? How can we achieve better result in a point of your opinion?

What do you think about the attitudes of waste management companies towards separate collection? Do these companies receive adequate support from the Hungarian State to expand and modernise their recycling systems?

How far do you think domestic legislation is helping to increase the recycling rate of plastics?

Is it possible to say that internal recycling is currently (even partially) taking place in some production companies?

Can it be stated that internal recycling is currently (even partially) taking place in some trading companies?

Do you see an effort in the trading companies to encourage customers to collect separately the plastic waste generated by the products they buy? Are there any companies where plastic packaging can be returned to the retail unit?

Do you think the average consumer thinks responsibly about their plastic waste?

Do you think the relevant economic actors take into account the waste hierarchy model for plastic waste?

Recycling/practices

How do you see the recycling of plastics in your country?

What is your opinion on the Hungarian plastics recycling infrastructure?

What is the state of technology in this field in the companies engaged in this activity? Is there a need for expansion? (either in terms of upgrading existing technology or increasing the number of companies involved) Is it financially worthwhile to process used plastics?

What best plastic recycling practices are you aware of that are used in our country? Please also mention household, business and packaging practices that prevent plastic waste and/or promote the transition to a circular economy?

Questions related to EU

How do you see the European Union's waste policy, with its emphasis on the selective recycling of plastics and the shift to a circular economy? Do these attach with Hungarian efforts?

Do you have any information, how your country's situation looks like compares with other countries in the EU in terms of plastics recycling?

Are there significant differences in governmental attitudes to plastic recycling among EU Member States? In your opinion, where does Hungary stand? What types of practices should be adapted from other Member States to Hungary?

Which countries are good examples in the field of plastic waste management? Have EU rules contributed to their success? Is there a "secret to success" for these countries?

Are there significant differences in people's attitudes in plastic recycling between EU Member States? Do you think people's attitudes are influenced by legislation?

Are there significant differences among EU Member States in the processing infrastructure for plastic recycling?

To what extent is education for responsible waste management present in the education system in each Member State? How is our country doing in this respect? Is there a need to integrate education for responsible waste management into the curriculum: are there examples of this in the world?

What are your opinion on financial incentives for the selective collection of plastic? For example, should there be less municipal tax, who has smaller bins?

Issues related to the operation of company

Is it worthwhile to recycle plastic waste in Hungary today?

Do they receive any support from the Hungarian State? If so, under what conditions?

What is your opinion on the Hungarian laws and regulations currently in force regarding selective waste management and the implementation of the circular economy of plastics?

Do they receive support from the European Union? If so, under what conditions? What is the current state of infrastructure?

What are your views on the EU laws and legislation currently in force on the implementation of selective waste management, including the circular economy of plastics?

How can you persuade customers (companies) to stop using virgin packaging and to buy and use recycled packaging? What is attractive about working with plastics processing companies?

Are there any public or EU tenders for plastic processing companies? In your opinion, are they really a way forward and do they really promote a circular economy for plastics?

Do you feel that the demand for plastics processing has changed over the last decade? If so, is this due to a change in attitudes of people/businesses or is it due to a change in laws/regulations that has caused the trend to change?

How would you define your company in the plastics recycling market?

Which service would you describe as the most successful?

What trends do you see in the recycling of plastic food packaging?