

Recycling of plastics in the European Union – exploring the potential domestic adaptation of best practices from other Member States

Náhlik, András¹ – Pankotay, Fruzsina Magda² – Németh, Nikoletta³

Abstract: The ratio of plastic waste, especially plastic packaging, within waste is big. To address this issue, the European Union has developed a plastics strategy that it expects Member States to adopt. The EU’s waste policy models are known as the Waste Hierarchy and the Circular Economy Model, which both deal with plastics. Waste management efficiency differs among the Member States. Unfortunately, Hungary ranks among the states with the worse results. This thesis aims to define the situation at the EU and the Hungarian level. The investigation utilized primary and secondary sources. The primary sources focused mainly on Hungary and comprised in-depth interviews with nine relevant Hungarian actors in the plastic waste industry, researchers, specialists from public and private companies, and an Austrian researcher. The interviews allowed

¹ NÁHLIK, András MA Student
(<https://orcid.org/0009-0005-6430-3726>),
University of Sopron Alexandre Lamfalussy Faculty of Economics, Sopron, Hungary
(andras.nahlik@gmail.com)

² Dr. PANKOTAY, Fruzsina Magda PhD Teaching Assistant
(<https://orcid.org/0000-0002-1057-7351>),
University of Sopron Alexandre Lamfalussy Faculty of Economics, Sopron, Hungary

³ Dr. NÉMETH, Nikoletta PhD Assistant Professor
(<https://orcid.org/0009-0000-5868-8678>),
University of Sopron Alexandre Lamfalussy Faculty of Economics, Sopron, Hungary

Supported by the ÚNKP-22-2-2-SOE-109 New National Excellence Program of the Ministry for Culture and Innovation from the source of the National Research, Development and Innovation Fund.”



for comparisons between the countries. According to the respondents, the Hungarian situation is underdeveloped. Hungary has developed nearly the same infrastructure level as Western Europe, but Hungarian attitudes about recycling differ vastly from Western European attitudes. Developing an effective plastic recycling system requires changing behaviour first. Concerning the recycling infrastructure in Hungary, only a few improvements are needed to include certain types of plastic (e.g., PET bottles) that are not currently recycled.

Keywords: *plastic, recycling, circular economy, EU policy*

JEL Codes: *Q53, Q58, Q59*

Introduction

Increases in consumption lead to increases in waste, 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.

Literature review

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 and co-authors (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 and co-authors (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, circular economy is a closed process replete with environmentally-friendly solutions. 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 one involves reforming and remanufacturing used materials and products.

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 and co-authors (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 and co-authors (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.

Kirchherr and co-authors (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.

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.

Amadei and co-authors (2022) analysed 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 and co-authors (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, 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 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%.

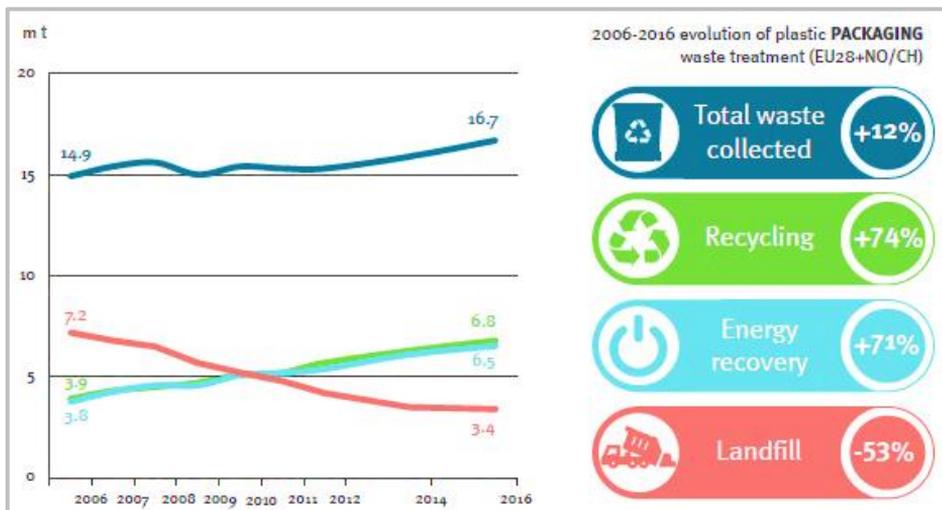


Figure 1: Evolution of plastic packaging waste treatment in the EU

Source: PlasticEurope, 2017

The plastic packaging is most common type of plastic waste. Therefore, the waste hierarchy model for plastic packaging should be treated as

a priority. In the next two graphs we can see the evolution of plastic packaging waste all over European Union (*Figure 1*) and separately in Hungary (*Figure 2*). We can see similar tendencies. The generated plastic waste increased in both cases, but the non-utilized plastic packaging waste do not decline in Hungary opposite the total EU statistics.

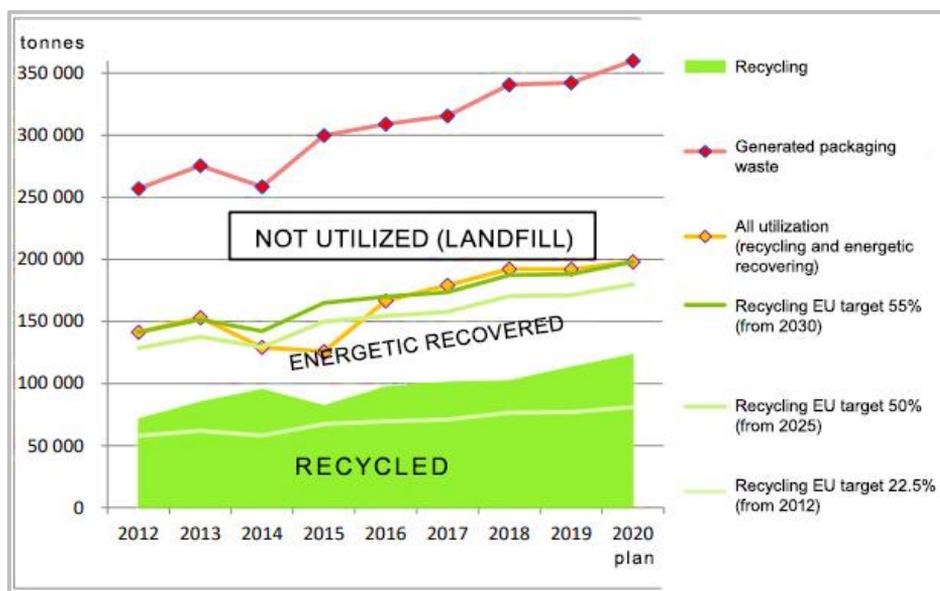


Figure 2: Recovery of plastic packaging waste in Hungary

Source: Hungarian National Waste Management Plan 2021–2027

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. 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. Ireland was the largest plastic packaging waste-generating country for both years. *Figure 3* exhibits packaging plastic waste by countries in 2019.

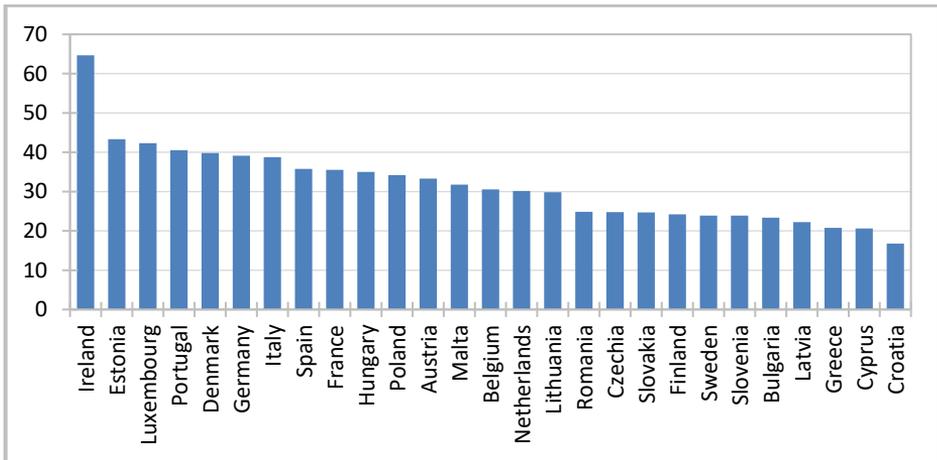


Figure 3: Plastic packaging waste per capita in kilogram by countries

Source: Own edition based on Eurostat

Other Eurostat statistics made in 2018 and published in 2020 directly present the recycling packaging rate by every member state, which was still in the community at that time. 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%.

Navarre and co-authors (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.

Methodology

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, two Hungarians (R1, R2), and one Austrian (R3), two specialists from public service companies (PC1, PC2), and five specialists from for-profit companies. Among these was specialist, how were from granulates recycling company (FP1), polyethylene and polypropylene recycling company (FP2), mixed waste recycling company (FP3), PET bottles recycling company (FP4), and the last interviewee was from an environmental adviser company (FP5).

The research included three groups of question. In the first group includes the questions related to the domestic situation in Hungary. 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?

Results

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. The answers from the Hungarian interviewee we can find on the table, end of “The Hungarian situation” part.

This question was taken to the Austrian researcher, but it concerned to the Austrian situation. 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. The detailed answers you can find in the *Table 1*.

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.

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.

The following question was “Is plastic waste recycling worthwhile in Hungary?” FP5 and FP3 said yes, but FP1 said based on market no. In the followings (*Table 1*) we can see some important answers from the first group of question in a structured table.

Table 1: 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?	Is plastic waste recycling worthwhile in Hungary?
R1	Population not very disciplined, 50% of waste collected.	In my opinion, a 100% circular economy will never be achieved.	
R2	The population is not very disciplined, so up to 50-60% of the waste collected.	According to the Third Law of Thermodynamics, a 100% circular economy can never be achieved.	
PC1	Selective waste contains between 30-50% of foreign matter.	Yes, it is very efficient in companies, and the population is developing.	There is not the aim for the public companies to make profit.
FP1			Not in itself; not on a market basis.
FP2	Tragically, the company has made an investment in processing infrastructure, cannot pay for itself.	You cannot produce the same amount of waste from the same amount of waste, the inherent odors are retained.	
FP3		Not everything can be done, e.g. cut packaging, PET bottles (tipping), not everything is solved. Depends on the material.	It will be worth it, but it will be exciting to use electricity. Material flow example.
FP4	It is in transition; currently MOL concession tenders take up more issues – this creates uncertainty.	Yes. PET bottle recycling makes, the cycle is not endless.	
FP5		A deposit scheme would definitely be an incentive	As it is an existing market segment, it can be made to be worth it, but it depends on the type of plastic.

Source: Own edition based the research

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.

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 (FP4, 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. Not every practices are good in Western-Europe. For example, exporting and importing waste is harmful to the environment. Two of the respondents (FP1, FP3) noted that in Sweden a large capacity for plastic waste burning exists, which contradicts to the Waste Hierarchy.

Table 2: 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? Are 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.	Slovenia - awareness raising and mobilization of the public worked well.
R2	More or less.	Not so much in processing, like in collection and sorting.	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 infrastructure.
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.	
FP2	The EU standards are adopted by our country but not fulfilled, KV.		Germany and Scandinavian countries are the best, but Romania has huge capacities a well.

Source: Own edition based the research

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.

Corporate 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.

In the first 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 Vagyongazdálkodó 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.

Conclusions and Summary

Conclusions

The primary and secondary research established that EU member states have not been equally successful in the field plastic waste management. The leadership of the European Union would like to achieve an efficient plastic waste management system. 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, there are also problems in western Europe. 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 and co-authors (2019) also miss the complexity of waste policies, and one of the interviewees also criticised the directives as well. The main object was the practically side of the laws.

The result shows that Hungary is among the less successful countries. 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 and co-authors (2018) which was mentioned at the beginning thesis. That study also concluded that the main problems are cultural barriers and people's behaviour.

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 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. The primary research clarified that financial incentives are the most effective type of motivation for the companies, and the private sector as well. 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).

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. 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 material and financial loss.

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.

Summary

During the course of the research, the thesis confirmed the statement that plastic waste problems are among the biggest environmental issues. 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 for economic science as well. The secondary research introduced the legislation, plans, and statistics. The study aimed to present some plastic recycling practices from around the European Union and explore the adaptation possibilities to Hungary. 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.

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. 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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