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DEPARTMENT OF THE GLOBAL ECONOMICS

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on topic

"CIRCULAR ECONOMY PERFORMANCE OF THE EU COUNTRIES"

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ЗАВДАННЯ

на кваліфікаційну роботу здобувачу
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прізвище, ім'я та по батькові

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2. Керівник роботи _Кузьмінов Сергій Васильович, доктор економічних наук, професор.
(прізвище, ім'я, по батькові, науковий ступінь, вчене звання)

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3. Термін здачі здобувачем закінченої роботи _____

4. Цільова установка та вихідні дані до роботи_____
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5. Зміст роботи (перелік питань, які належить розробити):

6. Консультанти розділів роботи:

Розділ	Консультант (прізвище, ініціали, посада)	Підпис, дата	
		Завдання видав	Завдання прийняв

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№ п/п	Назва етапів кваліфікаційної роботи	Термін виконання етапів роботи	
		За планом	Фактично

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ABSTRACT

Hladka A. Circular Economy performance of the EU countries.

The paper analyzes the current state of the Circular Economy and the performance that the EU economy and individual EU countries can achieve applying the principles of circular economy, and also to point out the importance of waste management as a foundation for the successful transition towards CE. It is revealed that the benefits of the new economic model are reflected in increased resource productivity, reduced environmental impact, reduced dependence on imported raw materials, job creation, increased economic competitiveness thus fostering sustainable economic growth. A systematic analysis and comparison of the EU countries was performed to benchmark performance, foster policy learning and to help designing future perspectives towards a CE. Based on the examples from European countries strategies, which are focused on the economic shift towards CE, was noticed that every strategy on their beginning starts with methods of waste management. That is why, this paper aims to point out, the importance of the implementation of waste management method of separate municipal solid waste collection in Ukraine. The calculations represent an increase in the share of extraction of secondary raw materials from the applied method, that in its turn able to reduce the environmental burden by returning resources to economic circulation, that previously had a negative impact on the environment.

Keywords: Circular Economy, resource productivity, sustainable development, waste management, municipal solid waste, secondary raw materials.

АНОТАЦІЯ

Гладка А. Розвиток циркулярної економіки у країнах ЄС.

У роботі проаналізовано сучасний стан циркулярної економіки та результати, яких може досягти економіка ЄС та окремі країни ЄС із застосуванням принципів циркулярної економіки, а також вказано на важливість поводження з відходами як основи для успішного переходу до циркулярної економіки. Виявлено, що переваги нової економічної моделі відображаються у підвищенні продуктивності ресурсів, зменшенні впливу на навколишнє середовище, зменшенні залежності від імпорту вторинної сировини, створенні робочих місць, підвищенні економічної конкурентоспроможності, сприяючи тим самим стійкому економічному зростанню. Було проведено систематичний аналіз та порівняння країн ЄС для оцінки їх розвитку, для сприяння вивченню політики та сприяння розробці перспектив на майбутнє для циркулярної економіки. На основі прикладів стратегій європейських країн, які орієнтовані на економічний перехід до циркулярної економіки, було помічено, що кожна стратегія на їх початку починається з методів управління відходами. Саме тому, ця робота має на меті вказати на важливість впровадження методу поводження з відходами роздільного збору твердих побутових відходів в Україні. Розрахунки представляють можливість збільшення частки видобутку вторинної сировини за допомогою застосованого методу, що, у свою чергу, здатне зменшити навантаження на навколишнє середовище, повернувши ресурси в економічний обіг, що раніше мали негативний вплив на довкілля.

Ключові слова: Циркулярна економіка, продуктивність ресурсів, сталий розвиток, управління відходами, тверді побутові відходи, вторинна сировина.

TABLE OF CONTENT

INTRODUCTION

Only a few authors focused on the operative application at macro level for an extended geographical area (Europe), and followed a quantitative approach as well. This paper intends to contribute in bridging this gap. Firstly, the relevant knowledge is gathered and organized so as to rank the 28 EU member states according to their performances in terms of their transition towards the CE. In particular, the indicators, relating to environmental, economic and socio-economic variables, are used to assess outcomes and highlight good practices.

The performances of the 28EU Member State was analyzed in the period from 2008 and to the latest available. The study was developed, firstly carrying out a performance analysis of each Member State in terms of the implementation of CE. After that, the received research was used in practical part to present way of waste management in Ukraine.

The fundamental need for an alternative to the traditional linear growth model has led to a new discussion of the circular economy, which is described as an economy with closed material loops.

The most significant warning, that still is true for today, came from one of the most influential reports of the 20th century, “The Limits to Growth”, published in 1972 (Donella H., 1972). This report was about implications of exponential economic and population growth rate with a finite supply of resources. Five fundamental factors have been identified that determine and ultimately limit growth, namely: accelerated world population growth, depletion of non-renewable natural resources, industrialization, and environmental pollution. Concerning that, the new approaches in production and consumption patterns are becoming necessary.

Economic growth and increased production are associated with greater use of limited natural resources, which can result in a negative impact on the quality of the environment. Reduced extraction of materials, sustainable land use and rehabilitation,

ecosystem protection, resource efficiency and renewable energy sources – all linked to the circular economy – will help preserve natural capital.

The object of the thesis is related to studying the problem of environmental degradation through waste management and circular economy.

The subject of this thesis is related to the waste management with further use in circular economy strategies.

The working hypothesis is: Based on the research conducted and data collected can be concluded that the implementation of the method of separate collection of solid waste will allow to increase the share of recovery of secondary raw materials, which in turn will reduce the burden of the environment.

The Goal of the research is to be acquainted with the Circular Economy, determine strategic framework for stimulating the switch from linear to new circular economy model.

The purpose of the research is to determine the current stage of performance of different EU countries on the way to the circular economy, its importance, define main economic trends and to see how they are affected by circular economy indicators, to study the actions and measures that the different EU countries making to adapt the CE and compare it between each other and to feather implement achieved experience on Ukrainian economy.

The following scientific methods were used in the research: the historical method (processing of available literature and internet sources), the method of comparison, analysis and synthesis (empirical research of practical possibilities), and the method of induction and deduction (conclusion).

Overall, this study adopts a quantitative informative approach with practical implementation of the research analysis. The paper gathers statistical information and makes it accessible to the non-specialists.

The research process is based on the already familiar knowledge which was published in the literature used to produce this thesis. This topic was created by use of academic papers, professional reports, news articles, blogs, and websites, as demonstrated in this paper references. This information was afterwards analyzed to generate the

hypothesis and answer research questions. During the development of master's degree thesis efforts were made to meet the basic features of the scientific methods such as objectivity, reliability precision and generality. By reviewing, organizing, and collating information of various sources, the paper hopes to provide a better perception on the sustainable development of countries in the future.

The research paper is divided on 3 main chapters. Starting from Introduction which leads reader into the research problem by first providing a general overview of the research topic.

Theoretical part presents detail information about circular economy, its background, concept, basic principles, importance and benefits of CE for EU and economies as a whole. This part also gives more focus on EU strategic policy framework, its key challenges and priorities for the development of the circular economy in Member States.

Analytical part starts with establishing baselines of the EU with use of monitoring framework for the circular economy in the EU and then it comes to comparative analysis which covered all indicators for circular economy analysis in the EU.

Practical part reflects the problem of waste management and one of the methods to support it’s solving on the way to sustainable development in the sphere of circular economy, on the example of Ukraine.

The research part finishing with the practical recommendations that should reflect to problems that exist in economies, especially in the EU and Ukraine. At the end, this paper provides conclusion which present a synthesis of research results.

1 FUNDAMENTALS OF THE CIRCULAR ECONOMY AND IT'S IMPLEMENTATION IN THE EU

To get the initial understanding of the matter, this chapter covers general information about concept of CE, its origins, basic principles, benefits and barriers of its implementation. Besides that, it specifies the overall EU and individual countries strategic frameworks that describe their policy actions regarding development towards CE. Also, it indicates the way the CE financed and as well, presents monitoring framework created by the EU.

1.1 Definition and origins of the circular economy

For the last 150 years, the world industrial economy has been dominated by a linear take-make-use-dispose model. It was originated in the second industrial revolution, and generated considerable prosperity growth in the years after World War II. However, the population has risen dramatically, to the point when human needs have exceeded the Earth's renewable capacities and potentials. Adding to that, way of production and consumption in the linear approach started to be more and more unsustainable and to generate a huge amount of toxic waste, which is disposed and creates an ecological problem. Along with a growing global population, depletion of finite resources, the increasing amounts of waste, and the rise of greenhouse gas emissions (GHGs), it is becoming increasingly apparent that such practices are not an option for a sustainable future. That is why the concept of circular economy is getting attention worldwide.

The circular economy is an industrial system which is based on regeneration promoted by use of renewable: products, materials and energy sources. Underpinned by controlling and minimizing waste generation and other negative environmental impacts in the system, the circular economy entails gradually separating economic growth from the consumption of finite resources. As a result, this system can bring not just environmental but also economic and social benefits. One of the most-commonly used

definitions has been provided by the Ellen MacArthur Foundation (2013, p.7) which describes the circular economy as “an industrial system that is restorative or regenerative by intention and design. It replaces the ‘end-of-life’ concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models’’. At the EU level, the circular economy is defined as an economy “where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimized” (European Commission, 2015, p. 2).

Concept of the circular economy started to develop in the late '70s of the last century based on the synergy of opinions of scientists and experts from different fields, that shared the idea of closed loops. The bearer of the idea was K. E. Boulding, who introduced it in his work “The Economics of the Coming Spaceship” (Earth as a spaceship) in 1966. For the first time formally, in an economic model, this term was able to be used by Pearce & Turner (1990).

The term circular economy is generated from several authors from different time periods, by contribution of specific schools of thought like:

- “Cradle to cradle” principle - where the end of one usage cycle opens up the possibility of new technological processing or production, taking as an example nature’s ‘biological metabolism’ (Braungart & McDonough, 2002);
- Performance economy - is a concept that sketched a vision of an economy in loops and its impact on job creation, economic competitiveness, resource savings, and waste prevention (Stahel & Reday-Mulvey, 1981);
- Regenerative design - is a concept which describes that all systems, beyond agriculture, for which the concept had already been formulated earlier, could be orchestrated in a regenerative manner (Lyle, 1994);
- Industrial ecology or industrial symbiosis - is the concept of avoiding the unusable surpluses in industrial production and developing of parallel production based on by-

products. It is perhaps the most related to the concept of CE, focuses on the flow of energy and materials through industrial systems (Tibbs H. 1993);

- Biomimicry – is the approach which imitates nature's processes and use the applied knowledge for solving the socio-economic problems;
- Systems thinking – is the ability to understand how every actor in the economy influence one another, and as a result form a network.
- Blue economy – is the economic model that encourages renewal, maintains ecosystems' evolutionary path so that everyone benefits from the endless natural flow of creativity, adaptation, and abundance. Through its innovative business models shows that environmental sustainability and business profitability do not have to be mutually exclusive. According to the World Bank, the blue economy is the "sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystem."

While the performance economy and the blue economy mainly concentrate on the business model, others are more concerned with the impact of systems and products on the environment (Industrial Ecology and Cradle to Cradle) or product design efforts. The concept of circular economy refers to each above mentioned school of thought up to a certain point and therefore it can be considered as a holistic framework.

The first country to formally adopt the concept of a circular economy and incorporate its ideas into national legislation was Germany, which in 1996 passed the Act of indefinite waste management cycle (German Law Archive,1996). Japan came up with this example and already in 2000 adopted the Law on the Establishment of a Recycling Company (Environment Agency, 2000). The biggest progress in the transition to the circular economy has so far been achieved by the Republic of China and the European Union.

1.2 Basic principles of the circular economy

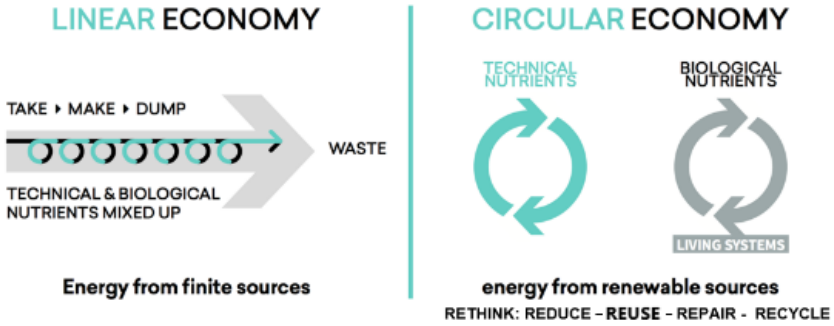
The circular economy should be considered as a holistic framework, which relies on several specific approaches that gravitate around a set of basic principles:

- Circular economy is the economy of **zero waste**. The produce is designed on such a way that all its components can be repaired, disassembled and reused, without creation of extra waste.
- Concept of closed loops, consist of **technical and biological cycles**. Biological can be decomposed and brought back to the nature, such as paper or textile, and technical material can be used again in the economy, such as metal or plastics. The complex products which include both kinds, should be designed on a way that allows efficient recycling of resources without losing of their value in the end of the product life cycle. In another words, should be used at the highest utility.
- To secure the reliance of the system and decrease resource dependency, it should be fueled by renewable energy sources. That is why, this principle is about **designing out negative externalities**.
- **Industrial symbiosis** is the principle which is based on the idea that all by-products from one industry can be used like a raw material, without being thrown away, by another industry.
- Customers are no longer consumers, but users. That principle promotes new **consumption patterns** like, leasing, renting or sharing and fosters consumer awareness.

According to the previously explained principles, the circular economy is actually a strategy of transition from the existing linear economy to the circular one. Linear economy creates value by maximizing the amount of produce goods with mixed up technical and biological nutrients, and result is inseparable, huge amounts of hazardous waste. Unlike the circular economy, which is based on a new economic concept of

sustainable resource management, extending the life of the product for creating its added value with closed material flows.

Figure 1. Linear economy versus circular economy.



Source: Sustainability guide https://sustainabilityguide.eu/sustainability/circular-economy/, 10.08.2020

Although the circular economy is often mistakenly identified as a waste collection and recycling plan, the concept is actually much more complex and moves in the direction of developing new technologies, innovations, designs and modular products that can be continuously supplemented and transformed in this new way.

Figure 2. Phases of the circular economy.

Source: SRIP - Circular Economy https://srip-circular-economy.eu , 10.08.2020

The Figure 2 represents value chains according to the economic principles of closed material flows. The circle starts with efficient use of natural resources and primary raw materials, with minimization of natural resources dependence and waste accumulation on each step of the model. All of that can be achieved by putting special attention on

industrial processes and design of the product, which tries to create the most durable and lasting produce, that can be easily divided into parts and that does not contain hazardous substances with future possibility of disassembling, repairing, adjustment, rebuilding and reuse. Filling the single market with greener and eco-friendly produce and making people more aware about importance of sustainable behavior, can stimulate the new consumption patterns, such as service as a product, digitization, renting instead of ownership and sharing economy.

The next stage introduced across whole value chain is efficient waste management, which includes, availability of appropriate infrastructure for waste collection, recycling and elimination of toxic elements from products and its parts. And to close the loop, the raw materials and resources which can be reused or repaired are injected in production process again and materials or products which reached their end-of-life period are firstly processed/recycled and then applied back into the economy as a secondary raw material. The EU works to make this easier, and to realize the full potential of these materials. It also promotes the fair and sustainable exploitation and sourcing of primary raw materials globally, with reduced import reliance and as a result increased competitiveness of the economies.

1.3 Benefits and barriers of the circular economy

The circular economy has benefits that are operational as well as strategic and brings together a huge potential for value creation within the economical, business, environmental and societal spheres.

Environmental benefits are (Ellen MacArthur Foundation, 2015):

- **Fewer greenhouse gas emissions** by implementing renewable energy that in the long run is less polluting than fossil fuels, as well as reusing and dematerializing can support carbon dioxide minimization, because fewer materials and production processes are needed as residues are seen as a valuable source that can be reused.

According to Circle Economy calculations, 62% of global greenhouse gas emissions (excluding those from land use and forestry) come from the extraction, processing and production of goods to meet society's needs; only 38% are emitted in the supply and use of products and services (Circle Economy, 2019).

- **Healthy and resilient soil** achieved by returning of important nutrients to the soil through anaerobic processes or composting and this benefit can provide essential cost savings as soil degradation has hidden costs such as the increase of fertilizer use, loss of biodiversity and loss of unique landscapes, which estimates for US$40 billion annually worldwide (WE Forum, 2017).
- **Conservation of nature reserves** - protecting nature from excessive extraction and dumping of raw materials and waste.
- **Fewer negative externalities** (excessive land use, soil, water and air pollution, emission of toxic substances, climate change, etc.).

Economic benefits are (WE Forum, 2017):

- **Boosting economic growth** (increase EU's GDP by an additional 0.5% by 2030 (Cambridge Econometrics, Trinomics, and ICF 2018)) - through implementation of decoupling concept and more efficient use of raw materials and resources. By getting products and materials more functional and easily disassembled and reused the cheaper production can be realized;
- **Substantial net material cost savings –** can be achieved by optimization of waste management through industrial chain that boosts recycling, reduces landfill with more resources saved and promises production cost savings with less resource dependence.
- **Innovation stimulus** – means optimization for the new system, include higher rates of technological development, improved materials, labor, energy efficiency, and more profit opportunities for companies.
- **Employment growth** – due to increase in recycling and repairing practices together with higher skilled jobs in remanufacturing, in new businesses (and niches) through

development of local reverse logistics, with innovation processes and new business models in a new service-based economy;

- **Changing demand** – change the way companies deal with their consumers and the role they play all through leads to less use of raw materials, less waste generation and changing production.

Business benefits are (Vermunt, 2019):

- **Increase in competitiveness** – by reuse, increase of efficiency and prolong the productive use of materials.
- **New profit opportunities -** from playing in new markets, cutting costs off with waste and energy reductions and with increased security of supply;
- **Protection against price volatility and scarcity of resources -** protect companies from geopolitical imbalances or natural disasters and increase resilience to ever more volatile raw materials;
- **The demand for new services** – such as reversed logistics companies, new marketers and sales platforms, and experts in remanufacturing and product repair.
- **Getting to know clients better** – gain unique insights into usage patterns by implementing a new business models such as rentals or leasing contracts. That models provide a longer-term relationship with consumers, because the number of touch points increase over the lifetime of a product.

Social benefits are (Ellen MacArthur Foundation, 2015):

- **Increased disposable income** – the cost of products and services would be reduced and there would be less unproductive time, as example time stuck in traffic;
- **Greater utility** – increase in variety and quality of products and services to better meet customer's needs;

- **Health** – lower the healthcare costs associated with pesticide use by USD 550 billion globally. There would also be reductions in air pollution, water contamination, and foodborne diseases.

There are also some barriers that make implementation of circular economy more difficult and complicated:

- **Lack of a coherent and complete understanding of the circular economy concept**. From the one side, strategies do not always address all circular economy aspects and often overrepresent some topics (typically, waste management). From the other side, strategies often do not effectively include all actors involved in implementing a circular economy model.
- **Lack of political backing**. Most strategies have more or less direct involvement of public authorities, and the concern is visible if to look on it in dynamics. In first case, the bottleneck appears with the lack of deeper cross-level links and cooperation between policy makers for implementation of strategies at different government layers. For example, when city strategies are not coherent with the strategies at the European level but with respect to regional and national ones. In another situation, some strategies are not proceeded forward by successors. This can be partially counteracted by ensuring some autonomy in the implementing bodies, so they can bring work forward in the absence of a strong political lead.
- **Lack of public awareness.** Public awareness is a driver for shift to a circular economy. For this reason, grassroots initiatives and partnering with civil society organizations should be ensured. However, this approach is rarely seen in existing strategies.
- **Risk aversion.** This barrier is related to the overall social and business attitude. The inertness of business models together with sustainability strategies are indicating that the disruptive transition towards CE is definitely impossible.
- **Lack of provisions for scalability and transferability.** Most strategies do not describe in detail the coherent ways of transferring and scaling up of initiatives to

other sectors or territories. On this regard, the forward-looking approach and quantitative estimates, should be provided while setting the initiatives.

- **Lack of tailoring to the specific territorial context.** In most cases, strategies appear as a collection of examples, good practices and general principles, but have a lack of comprehensive understanding of the current state of affairs and can have a little connection to the local economic, social, and environmental context. That is why, it is important to focus on elements that are relevant for the specific territory, with complete review of existing circular economy initiatives and ensuring the broadest possible inclusion of stakeholders.
- **Lack of economic incentives**. Circular models may need to be attractive for economic actors to enable the transition. Without specific interventions, sustainable practices are often not economically viable (Post and Altma, 1994). Strategies often focus on constraining methods such as Extended Producer Responsibility, circular public procurement and taxation, without too much focus putted on positive tools involving financial or other incentives. Moreover, incentives should collaborate with main strategies to ensure the effective implementation on the broad scope.
- **Operating in a linear system.** An enterprise can only deliver a circular product if its entire supply chain is circular. But as circular economy model is quite recent, it is enough difficult to find firms that are also endeavoring to adopt CE.
- **Low virgin material prices.** Not all consumers will want to buy secondary raw materials, because due to the fact that prices of primary raw materials are volatile, the law price alternative is winning against even good quality secondary resources.
- **High upfront investment costs.** Market readiness is not completely realized and that is why leading to extra costs for pioneers, that trying to implement new circular strategies in that specific, not still adapted, market sectors.

1.4 Strategic framework in the EU

The European Union has shown leadership by creating the first foundations for this new economic framework.

In 2010 the European Union introduced the “Europe 2020” strategy, with emphasis on the smart, sustainable and inclusive growth (European Commission, 2010). By implementing this strategy, EU for the first time officially stressed the need for economic transition to more efficient, sustainable, competitive and green economy.

Direction of EU to the circular economy was firstly officially introduced within the Roadmap to a resource efficient Europe in 2012 (Eurostat, 2020). On 11 December 2019, the EU Commission sets out a new European Green Deal roadmap, to make the EU's economy more sustainable by simply decoupling economic growth from resource consumption with no net emissions of greenhouse gases, while ensuring its competitiveness and with goal to achieve climate neutrality by 2050. One of its main pillars has become new Circular Economy Action Plan of 2020, which summarizes main achievements and analyzes future challenges towards a carbon neutral, resource-efficient and competitive economy. The Plan covers all relevant aspects of the value chain, with special attention on eco-design, production, sustainable consumption from side of both private and public consumers. It also strives to retain valuable resources and materials within the EU economy for as long as possible, while bringing real added value for sectors which are using resources the most (electronics and ICT, batteries and vehicles, packaging, plastics, textiles, construction and buildings, food, water and nutrients). The main focus is on creation of strategic approaches to improve plastics management and potential of more efficient and circular use of critical raw materials and leading global efforts on the circular economy. Finally, horizontal measures like innovation and investment are also observed to stimulate the transition to a circular economy. (European Investment Bank, 2020).

Also were implemented revised legislative proposals on waste within the Circular Economy Package in July 2018. That proposals include set of clear recycling and reduction targets and activities for the period to 2030. The Commission proposes to:

- Boost the recycling of 65% of municipal waste by 2030;
- Increase the packaging waste recycling rate to 75% by 2030, with interim target of 65% by 2020, including recycling targets for specific materials;

- Ban the landfilling by a maximum of 10% of total waste by 2030;
- Prohibit the disposal of waste that is separately collected;
- Promote economic instruments to discourage waste disposal;
- Develop the common EU definitions that are coherent and simplified;
- Provide a clear and harmonized calculation method in order to ensure the high-quality recycling rates;
- Introduce the concrete measures to foster recovery, reuse and to stimulate industrial symbiosis;
- Further economic instruments for producers such as, disposal, incineration and not separately collected waste taxes, 'pay-as-you-throw' (PAYT) and deposit-return schemes as well as Extended Producer Responsibility (EPR) schemes, to place greener products on the market and various other incentives for recovery and recycling of materials and products;
- Ensure the application of the Structural Funds to support the implementation of the EU's waste management objectives based on the waste management hierarchy;
- Implement special rules for Member States that facing the biggest implementation challenges (European Commission 2019).

The successful implementation of these measures would be possible if collected savings will amount 630 billion euros per year by the end of 2030 (Europe INNOVA, 2012).

In 2018, EU Member States together with institutions agreed on a comprehensive set of laws aimed at preventing household waste and boosting recycling. The new laws are part of four EU Directives: The Waste Framework Directive (WFD), the Landfill Directive (LD), the Packaging and Packaging Waste Directive (PPWD) and the Single-Use Plastics Directive (SUP). All MS have been expected to reflect the agreed EU laws in their national legislation by July 2020 (EEB, 2020).

In addition, the circular economy has strong commitments to support EU's targets to reach Sustainable Development Goals (SDGs) by 2030, in particular SDG 12 'Responsible Consumption and Production' (Eurostat, 2020).

Among other things it is envisaged the better use of EMAS and the EU Ecolabel instruments. The key elements of EMAS or Eco-Management and Audit Scheme are efficiency, transparency and credibility of companies and other entities to analyze, report and improve their environmental performances (European Commission, 2018). The ultimate goal of the eco-label is to reduce the negative impact of consumption and production on the environment, health, climate, as well as on the consumption of resources and energy, and to encourage responsible behavior towards the environment (Ministry of Environment and Energy, 2020). In general, these two instruments show the public authorities' engagement to policies that support the circular economy. As a result, action on the circular economy ties in closely with key EU policy priorities and with global efforts on sustainable development.

Meanwhile, it remains true that the pace of change is largely determined by initiatives within and differences between the Member States.

Regarding the national level, for now only 13 out of 28 countries have their own circular economy strategies. The list of adopted national strategies and roadmaps that is shown below, are from all parts of Europe, with slightly higher intensity in northern and western Europe: (European Circular Economy Stakeholder Platform, 2020)

1. Belgium - "Belgium as pioneer of the circular economy";
2. Denmark – "Strategy for circular economy";
3. Finland – "Leading the cycle: Finnish road map to a circular economy 2016- 2025";
4. France – "Roadmap for the Circular economy - 50 measures for a 100% circular economy", "A French act of law against waste and for a circular economy";
5. Germany – "Germany Resource Efficient Programme II: Programme for the sustainable use and conservation of natural resources";
6. Greece – "Transition to a circular economy model for sustainable production and consumption patterns";
7. Italy – "Towards a Circular Economy Model for Italy";
8. Luxembourg – "National Waste and Resource Management Plan";
9. Poland – "Road map - transformation towards a circular economy";

10. Portugal – “Leading the transition: a circular economy action plan for Portugal 2017-2020”;
11. Slovenia – “Roadmap towards Circular Economy in Slovenia”;
12. Spain – Circular Spain 2030. Spanish strategy for circular economy. Draft for public consultation;
13. The Netherlands - A Circular Economy in the Netherlands by 2050;

A number of new strategies are under development particularly in central and eastern Europe, as well as in Spain.

Therefore, the half of the EU countries established their roadmaps towards circular economy transition, while another half are active by establishing of proposals and initiatives, but for now without overarching strategies that can take into the account overall value-chain. This can be done, by focusing on the circular economy in other strategies such as for waste or smart specialization, or by supporting studies and sharing knowledge on the circular economy. In some cases, circular economy initiatives evolve into strategies that are umbrella frameworks for set of different initiatives and activities.

The ongoing national activities for circular economy strategies in Europe were observed:

- Italy’s national strategy aims to maintain the country’s position in manufacturing in global value chains and limit the risks of increased environmental pressures in the country;
- the local strategy of Maribor, Slovenia aims at economic gains through resource efficiency;
- the Dutch national strategy aims at reducing the use of primary raw materials by 50% in 2030 by working together with a variety of stakeholders (including public authorities, university and research centers, businesses, civil society organizations, and citizens);
- the Danish national strategy aims at supporting economic growth and employment by taking more care of natural resources in production and consumption;

- the strategy for the city of Glasgow, Scotland, aims at improving material flows and stimulating innovation; and
- he strategies for Luxembourg and Germany perceive the circular economy from the perspective of resource efficiency and waste management.

1.5 Financing the circular economy in the EU

The transition to circular economy is financed by the European Structural and Investment Funds (ESIFs), which are managed by EU Commission and EU countries jointly. The main purpose of these funds is to invest in job creation and a sustainable and healthy European economy and environment. For the support and spread of good practices can be also presented other funding programmes such as:

- **Program Horizon 2020** is the EU Framework Program for Research and Innovation for period from 2014 to 2020. The main focus is putted on research projects for creation of new concept of circularity in the field of textile and chemical industries. Horizon has a budget in the amount of 80 billion euros.
- **Cohesion fund** is part of ESIFs and it representing support for countries with low gross national income per inhabitant in spheres of transport and environment projects funding.
- **Program LIFE 2014-2020** is the EU's financial instrument for the environment and climate. Starting from 1992, EU has funded more than 670 waste reduction, recycling and reuse projects in total with more than 1 billion euros.
- **Program COSME** is the EU program for the competitiveness of enterprises and small and medium-sized enterprises (SMEs), running from 2014 - 2020 with a planned budget of 2.3 billion euros. It aims to make it easier for SMEs in the EU to access finance in all phases of their lifecycle – creation, expansion, or business transfer (European Commission, 2020).

- "**InnovFin – EU Finance for Innovators**" – is the European Investment Fund (EIF) guarantee scheme, financially supported by the European Commission under the Horizon 2020 financial instrument, for 2014-2020. InnovFin aims to facilitate and accelerate access to finance for innovative entities and SMEs which are focused on research, development and innovation in Europe.
- **European Investment Bank (EIB)** which provides funding for projects that help to achieve EU's goals, both within and outside the EU. It sets specific priorities for lending between member states, encourages EU development and cooperation policies around the world. By the end of 2016, the European Commission, together with the European Investment Bank (EIB), had invested 164 billion euros in the circular economy (European Investment Bank, 2020).

Member States on their own are also making the noticeable contribution, investing in the transition to the circular economy.

1.6 Measurement of the circular economy in the EU

With a single measure, or score, it would not be possible to appropriately capture the complexity and the many dimensions of the transition to the circular economy and its development. For this reason, a set of relevant indicators and monitoring framework are used.

In order to assess the degree of transition towards CE, quantitative indicators can be useful. However, they need to be correlated into well devised sets to account for their combined effects and the intricacies of the system's dynamics. Finally, data interpretation should be contextualized to evaluate impacts in each member state.

The CE is a composite objective and therefore a single indicator does not explain the complexity of a whole transition process. Such a process needs to be investigated bearing in mind the impact of economic variables such as GDP in PPS in each country in order to understand their potential correlation with quantitative indicators (Awasthi et al., 2018).

From our research perspective it is essential to outline the European context and analyze the performance of each Member State.

The EU has established circular economy monitoring framework that aims at measuring progress towards a circular economy in a way that encompasses its various dimensions at all stages of the lifecycle of resources, products and services. This is why the monitoring framework has a set of ten indicators grouped into four stages and aspects of the circular economy: (1) production and consumption, (2) waste management, (3) secondary raw materials and (4) competitiveness and innovation, related to the priorities pointed out by the Commission in the CE action plan.

Figure 3. Circular economy monitoring framework

Source: European Commission, 2018.

Monitoring the production and consumption phase is essential for understanding progress towards the circular economy, as more sustainable models of production with improved manufacturing methods in all sectors and a responsible, greener consumption with less demand for packaging are needed. In the long term, this may contribute to a higher self-sufficiency of selected raw materials used in production processes. As well as

statistical indicators of waste generation can help to evaluate the production and consumption impact on the EU.

The next phase of the monitoring framework is the waste management. This stage includes set of indicators and sub-indicators that analyze recycling rates of different raw materials and products. The idea is to monitor the amount of recycled waste which is returned to the economic cycle. This indication can introduce the quality of the overall waste management system in the specific country.

One of the main goals of the circular economy is to preserve natural resources from excessive extraction by focusing on the use of the recycled materials. That is why, statistical indicators under the group of secondary raw materials can help to evaluate the performance level in the EU. The material use rates and trade of recyclable raw materials are indicators that are used in this dimension.

'Competitiveness and innovation' is another important stage that represents horizontal development towards circular economy. For assessing the competitiveness under the circular economy, the investments, employment and company's value added are considered. The innovation is a booster of circular economy implementation, that is shown in the amount of publications of patents approved, that are related to recycling and secondary raw materials.

2 COMPARATIVE ANALYSIS OF THE CIRCULAR ECONOMY INDICATORS FOR THE EU COUNTRIES

The present analysis will be of interest for researchers, policy makers and government planners, who can acquire information for the development of CE strategies in long term plans.

The comparability of available country data and indicators is limited in some cases. There are differences in municipal waste definitions, reported waste types and data processing. For example, some countries include only waste from households, whereas others include similar wastes from commercial activities and offices.

Some countries have changed their definition of municipal waste over time, and recycled amounts can also be calculated differently, depending on whether they include the weight of materials collected but discarded during the recycling process. The information for some years is not available for specific countries. However, the data used in this assessment are currently the best available.

2.1 Production and consumption

For the support of circularity, the quantity of material waste should be reduced with improved quality that promotes value maintenance of products, materials and resources in the economy for as long as possible and makes economies more self-sufficient for selected raw materials.

In the chapter of production and consumption, the main focus will be on indicators related to generation of waste, especially municipal waste in per capita valuation and all waste excluding major mineral wastes per GDP unit valuation.

Generation of municipal waste per capita indicator measures the waste generated by households, commerce, offices and public institutions and processed through the waste management system. Although municipal waste amounts for just 10%

of total waste generated (around 2.5 billion tonnes per year) in the EU, its mixed composition makes problem for its proper management (Eurostat, 2020). With the good indication of municipal waste prevention, it can be possible to assume the changes in consumer patterns and importance of citizens' involvement in different MS. That is why monitoring of that indicator is of high importance for the circular economy analysis.

However, the different interpretations of the definition, reported waste types and data processing currently limit to some extent the comparability among countries. For example, some countries include only waste from households, whereas others include similar wastes from commercial activities and offices.

Table 1. Generation of municipal waste kg per capita, 2008-2018.

EU-28 countries	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Index 2018/2008
EU28	521	511	504	498	486	479	478	481	488	488	489	0,94
EU15 (members before 2004)												
Luxembourg	697	679	679	666	652	616	626	607	609	615	610	0,88
Ireland	718	651	624	616	585	/	562	/	581	576	/	0,80
Austria	600	590	562	573	579	578	565	560	564	570	579	0,97
Netherlands	600	589	571	568	549	526	527	523	520	513	511	0,85
Denmark	830	762	/	862	806	813	808	822	830	820	814	0,98
Germany	589	592	602	626	619	615	631	632	633	627	615	1,04
Sweden	485	472	441	453	454	455	443	451	447	452	434	0,89
Belgium	480	467	456	455	445	436	425	412	419	411	411	0,86
Finland	521	480	470	505	506	493	482	500	504	510	551	1,06
United Kingdom	541	522	509	491	477	482	482	483	483	468	463	0,86
France	538	534	534	534	527	520	517	516	521	526	527	0,98
Italy	552	543	547	529	504	491	488	486	497	488	499	0,90
Spain	551	542	510	485	468	454	448	456	463	473	475	0,86
Portugal	518	520	516	490	453	440	453	460	474	487	508	0,98
Greece	458	464	532	503	495	482	488	488	498	504	/	1,10
EU10 (members of 2004)												
Malta	674	649	601	589	590	579	591	606	593	631	640	0,95
Czechia	306	317	318	320	308	307	310	316	339	344	351	1,15
Slovenia	542	524	490	415	362	414	432	449	457	471	486	0,90
Cyprus	728	729	689	672	657	618	614	638	640	637	/	0,88
Slovakia	313	307	319	311	306	304	320	329	348	378	414	1,32
Lithuania	428	381	404	442	445	433	433	448	444	455	464	1,08
Estonia	392	339	305	301	280	293	357	359	376	390	405	1,03

Poland	320	316	316	319	317	297	272	286	307	315	329	1,03
Hungary	454	430	403	382	402	378	385	377	379	385	381	0,84
Latvia	345	352	324	350	323	350	364	404	410	411	407	1,18
EU3 (members after 2007)												
Romania	411	381	313	259	251	254	249	247	261	272	272	0,66
Bulgaria	599	598	554	508	460	432	442	419	404	435	407	0,68
Croatia	415	405	379	384	391	404	387	393	403	416	432	1,04

Note: 2017 data for index calculation for Cyprus, Ireland and Greece are used.

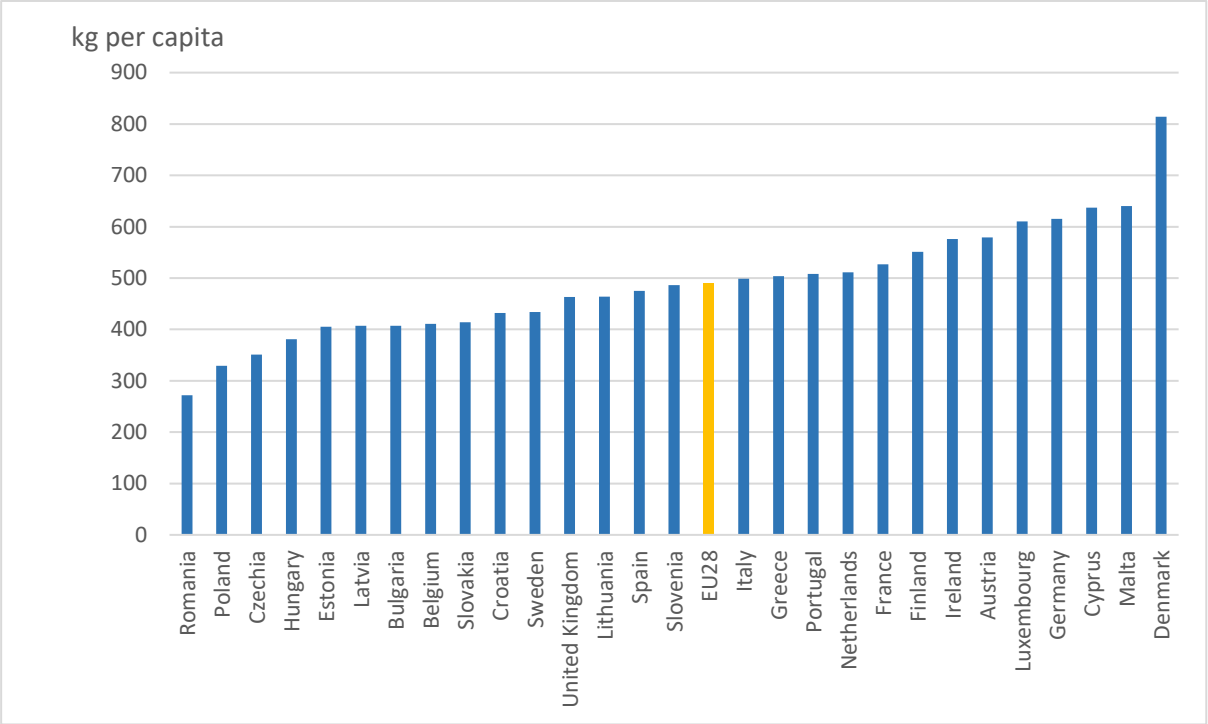
Source: Eurostat, https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=cei_pc031&plugin=1, 01.12.2020.

The average generation of municipal waste by EU citizens has decreased from 521 kg in 2008, down to 489 kg in 2018 (-6.1%). In 2014 it reached the lowest point of 478 kg per capita and after that the figure was steadily increasing. This is due to the fact that there are more than a half of countries that reduced municipal waste generation, what can be a good sign for circular economy development.

However, the drop in municipal waste generation could be caused by recently happed financial crises that provoke a fall in household consumption duting 2008-2013 period, rather than from improvement of social awareness towards sustainable use of resources. Accordingly, after 2013 amounts have increased again in all MS.

The best performers during the period from 2008 to 2018 are: Romania (0,66), Bulgaria (0,68), Ireland (0,80), Hungary (0,84) and Netherlands (0,85). But some countries showing the opposite trend and the highest indeces represent by Slovakia (1,32), Latvia (1,18) and Czechia (1,15).

Graph 1. Generation of municipal waste per capita, 2018.



Note: 2017 data for index calculation for Cyprus, Ireland and Greece are used.

Source: Eurostat, https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=cei_pc031&plugin=1, 01.12.2020.

The Graph 1 representing generation of municipal waste per capita in all EU countries in 2018. The results show a wide variation among EU members, from 272 kg per capita in Romania to 814 kg per capita in Denmark. These results can be proved by positive correlation to GDP per capita, as wealthier people tend to higher municipal waste generation per capita. Another reason for such a result is economic structure of a countries. For example, countries with well-developed tourism sector also contribute to the higher rates in municipal waste generation, like Cyprus and Malta.

The EU average level in 2018 is equal 489 kg per capita. Two countries generate less than 400 kg of municipal waste per capita, while five countries generate more than 600 kg per capita.

Such a variation of indicator could be caused by differences in methods applied for measuring, collection and management of municipal waste as well as differences in consumption patterns in different countries.

Generation of waste excluding major mineral wastes per GDP unit indicator measures overall waste generated in a country, excluding major mineral wastes. Since the biggest share in weight (almost two thirds) of total waste is represented by mineral waste from construction, demolition and mining sectors and its value has a significant difference between Member States, it is decided to divide it from overall waste calculation to get more meaningful comparison of results between EU countries. The transition to a circular economy envisages decoupling of waste generation from increase in economic output. Based on the principle "do more with less", this indicator helps to identify waste intensity of the economy thus measuring "eco-efficiency".

Table 2. Generation of waste excluding major mineral wastes per GDP unit, 2008-2018.

EU-28 countries	2008	2010	2012	2014	2016	2018	Index 2018/2008
EU28	69	67	66	66	65	65	0,94
EU15 (members before 2004)							
Luxembourg	28	38	31	20	32	27	0,96
Ireland	16	74	48	42	35	28	1,75
Austria	76	54	48	51	52	50	0,66
Netherlands	65	68	66	66	64	63	0,97
Denmark	37	44	40	40	35	37	1,00
Germany	50	55	54	56	55	52	1,04
Sweden	63	49	48	46	50	49	0,78
Belgium	72	109	85	92	98	99	1,38
Finland	117	129	111	73	73	70	0,60
United Kingdom	75	56	56	55	57	58	0,77
France	47	49	48	46	46	46	0,98
Italy	56	62	65	69	69	69	1,23
Spain	64	58	62	64	62	64	1,00
Portugal	79	64	68	69	67	72	0,91
Greece	93	99	119	113	78	85	0,91

EU10 (members of 2004)							
Malta	61	49	55	51	63	50	0,82
Czechia	77	78	79	72	73	71	0,92
Slovenia	87	105	98	91	79	73	0,84
Cyprus	43	45	35	37	38	39	0,91
Slovakia	130	97	95	86	100	102	0,78
Lithuania	172	109	96	99	102	105	0,61
Estonia	651	772	690	728	653	646	0,99
Poland	176	184	183	186	183	168	0,95
Hungary	114	117	114	113	98	87	0,76
Latvia	63	74	92	97	97	58	0,92
EU3 (members after 2007)							
Romania	341	188	178	150	140	127	0,37
Bulgaria	440	389	459	447	418	473	1,08
Croatia	65	68	60	70	75	77	1,18

Source: Eurostat, https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=cei_pc032&plugin=1, 01.12.2020.

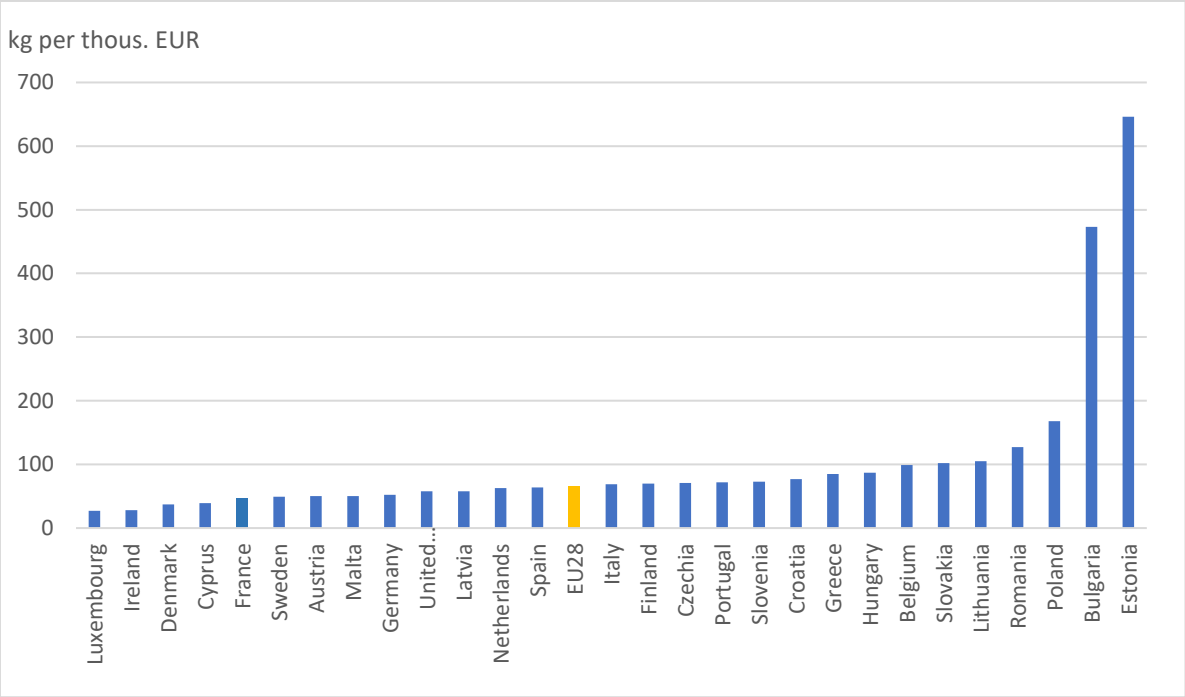
The average generation of waste excluding major mineral wastes per GDP unit in EU has decreased from 69 kg of waste (excluding mineral waste) per EUR GDP in 2008, down to 65 kg/ thousand EUR GDP in 2018 (-5.7%), thanks to the positive development by almost all EU countries, thus making economies more eco-efficient.

The best performance was reached by: Romania (0,37), Finland (0,60) and Lithuania (0,61), their indicators decreased by more than 40% between 2008-2018.

On another side, Ireland has the highest index of waste generation in comparison with another MS. Despite of this fact, after the significant increase in 2010 the value was constuntly going down, riching 62% of decline between 2010 and 2018, what can be a sign of eco-efficiency improvement in economic activities. The next worsest index has Belgium with 1,38 and this index is rising.

One of the factors to these trends can be result of the financial crisis.

Graph 2. Generation of waste excluding major mineral wastes per GDP unit, 2018.



Source: Eurostat, https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=cei_pc032&plugin=1, 01.12.2020.

The Graph 2 representing the cross-country comparison in waste generation excluding major mineral wastes per GDP unit in 2018. The EU average is stable during last years and amounts for 65 kg/ thousand EUR GDP. Six countries generated less than 50 kg of waste per GDP unit, while two countries generated more than 400 kg per GDP unit. The waste generated per GDP varies widely between countries, from 27 kg/ thousand EUR GDP in Luxembourg, to 646 kg/ thousand EUR GDP in Estonia.

The indicator not representing the propriate comparison between countries as it not considering the differences in GDP per capita. As a result, it could penalize the countries with lower GDP per capita, like Bulgaria, Romania, Poland etc.

Moreover, depends on the specificities in economic activities between MS, they tend to include different types of waste, thus resulting in partial noncomparability. For example, high value for Estonia is due to waste derived from extraction of shale oil for

energy production. Bulgaria is also strong representative in industrial sectors, like metallurgical and machinery industries.

The high variation of metric can be related to the difference in national economic structures, such as material- intensive or more service oriented, like IT or finance sectors.

Also, the currency purchasing power cannot be represented properly just through exchange rates, that lowers the adequate countries comparison.

Beyond the above mentioned, can be made conclusion about the results achieved from production and consumption phase. There are a lot of external factors that prevent from getting a true picture of countries performances. Nevertheless, major leaders and outsiders are visible. Thereby, Romania is the best performer in both indicators, with only deviation regarding eco-efficiency level caused by quite strong industrial sector. The factors that bring this economy on such a good level are: one of the lowest GDP per capita among EU countries, high service oriented and it is leading destination for foreign direct investments. Noteworthy the situation with Luxembourg, Denmark, Ireland and Cyprus as their results are the same. They had the worst levels in households waste generation while the eco-efficiency level was the best in these countries. The economic overview of these countries confirms the above-mentioned clarifications.

Overall situation in EU represent an improvement in reduction of both municipal waste and generated waste from economic activities.

2.2 Waste management

In order to look after the environment, waste either needs to be avoided or treated to reduce its impact. If the prevention and re-use are not possible then the recycling (including composting and digestion) and energy recovering activities should be preferred over the simple landfilling or incineration.

In phase of waste management, the main focus will be on the share of recycled waste that is reintroduced into the system with the purpose of continuous value creation and waste minimization. This area comprises indicators measuring recycling rates, especially of municipal waste and all waste excluding major mineral wastes, that are the most appropriate for tracking the EU targets implemented by legislation.

Recycling rate of municipal waste indicator helps to track the share of municipal waste produced by final consumers, that is fed back to the circular economy as a new resource, related to the total municipal waste generation. Due to its heterogeneous composition the management of that waste is more complex. That is why analysis of recycling rate of this kind of waste helps to understand the quality of the overall waste management system. The recycling process involves material recycling, composting and anaerobic digestion avoiding energy recovery and backfilling.

This indicator supports monitoring progress towards the target of 50% of municipal waste recycled by 2020 admitted in the Waste Framework Directive and to the 65% recycling target for 2030 proposed in the legislative proposal on waste (European Parliament, 2018). There are some other Directives, such as: The Landfill Directive, the Packaging and Packaging Waste Directive, that in particular should have led to improvement of municipal waste recycling levels.

Table 3. Recycling rate of municipal waste, (%), 2008-2018.

EU-28 countries	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Index 2018/2008
EU28	36,5	37,4	38,3	39,3	41,1	41,7	43,4	44,7	46	46,5	47	1,29
EU15 (members before 2004)												
Luxembourg	46	46,2	46,5	46,4	47,4	46,6	47,7	47,4	48,2	50,4	50,1	1,09
Ireland	33,6	33,5	35,7	36,1	36,6	/	39,8	/	40,7	40,4	/	1,20
Austria	63,2	61,9	59,4	56,7	57,7	57,7	56,3	56,9	57,6	57,7	57,7	0,91
Netherlands	48,4	49,1	49,2	49,1	49,4	49,8	50,9	51,8	53,5	54,6	55,9	1,15
Denmark	47,9	48,8	/	42,4	42,5	43,3	45,4	47,4	48,3	47,6	49,9	1,04
Germany	63,8	63,1	62,5	63	65,2	63,8	65,6	66,7	67,1	67,2	67,3	1,05

Sweden	45,6	49,2	47,8	47	46,9	48,2	49,3	47,5	48,4	46,8	45,8	1,00
Belgium	52,7	53,9	54,8	54,4	53,4	52,8	53,8	53,5	53,5	53,9	54,6	1,04
Finland	34,3	35,9	32,8	34,8	33,3	32,5	32,5	40,6	42	40,5	42,3	1,23
United Kingdom	36,4	38,3	40,2	42	42,6	43,2	43,4	43,3	44	43,8	44,1	1,21
France	33,8	35,3	36	36,8	37,7	38,7	39,7	40,7	41,9	43	44	1,30
Italy	23,8	29,7	31	35,5	38,4	39,4	41,6	44,3	45,9	47,8	49,8	2,09
Spain	39,7	33,2	29,2	26,7	29,8	32,5	30,8	30	33,9	36,1	36	0,91
Portugal	17,3	19,5	18,7	20,1	26,1	25,8	30,4	29,8	30,9	28,4	28,9	1,67
Greece	17,7	18,9	17,1	17,8	17	15,8	15,4	15,8	17,2	18,9	/	1,07
EU10 (members of 2004)												
Malta	3,6	3,7	5,2	9	9,7	8,5	7,4	6,7	7	7,1	6,5	1,81
Czechia	10,4	12,4	15,8	17	23,2	24,2	25,4	29,7	33,6	34,1	34,5	3,32
Slovenia	18,9	19,6	22,4	35,6	41,9	34,8	36	54,1	55,6	57,8	58,9	3,12
Cyprus	7,3	8,3	10,7	12,6	13,6	14,6	16,8	17,9	17,2	16,1	/	2,21
Slovakia	7,4	8,2	9,1	10,8	13,4	10,8	10,3	14,9	23	29,8	36,3	4,91
Lithuania	8,5	8,5	4,9	19,9	23,5	27,8	30,5	33,1	48	48,1	52,5	6,18
Estonia	20,2	21	18,2	23,3	19,1	17,9	31,3	28,3	28,1	28,4	28	1,39
Poland	10,5	13,2	16,3	11,4	12	15,1	26,5	32,5	34,8	33,8	34,3	3,27
Hungary	15,2	15,4	19,6	22	25,5	26,4	30,5	32,2	34,7	35	37,4	2,46
Latvia	6,4	7,7	9,4	9,7	14,7	25,9	27	28,7	25,2	24,8	25,2	3,94
EU3 (members after 2007)												
Romania	0,9	1,1	12,8	11,7	14,8	13,2	13,1	13,2	13,3	14	11,1	12,33
Bulgaria	19,4	19,9	24,5	26,2	25	28,5	23,1	29,4	31,8	34,6	31,5	1,62
Croatia	2,8	2,3	4	8,3	14,7	14,9	16,5	18	21	23,6	25,3	9,04

Note: 2017 data for index calculation for Cyprus, Ireland and Greece are used.

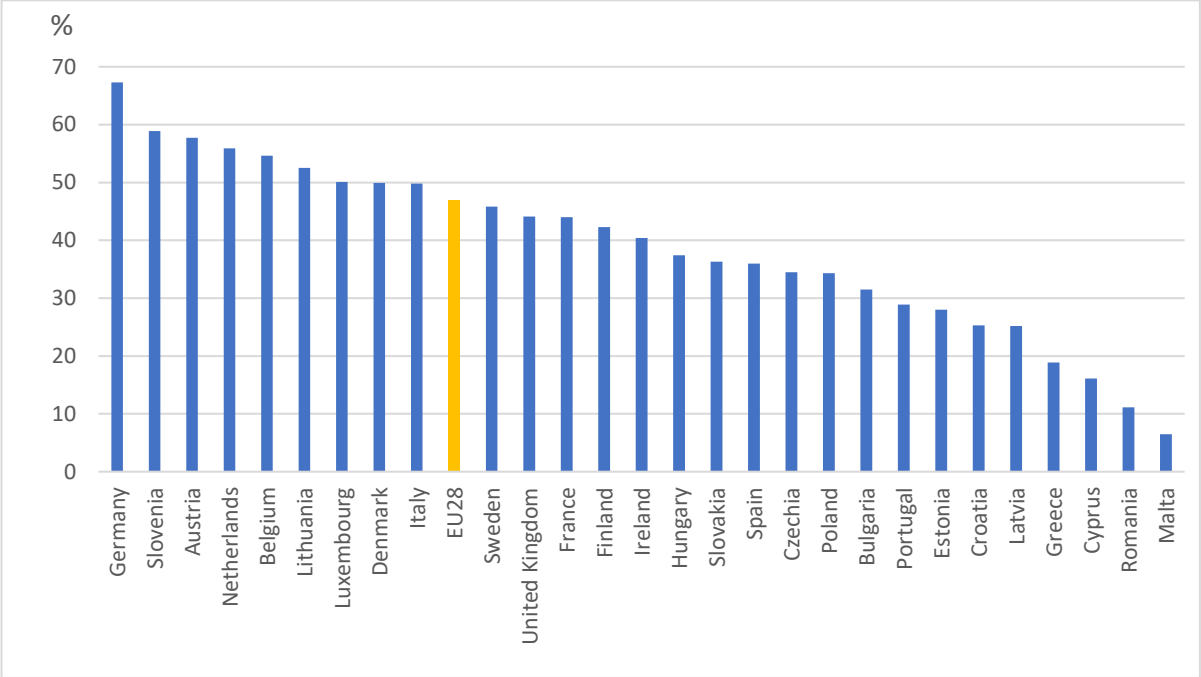
Source: Eurostat, https://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=cei_wm011&language=en, 01.12.2020.

Table 3 representing performances of EU countries in recycling rates of municipal waste between the period 2008-2018. Regarding that table, almost all countries have enhanced their recycling capacities of municipal waste, except of Austria and Spain that have around 9% decrease during provided period. The significant growth rate can be noticed by group of countries that accessed the EU more recently, like Slovakia, Lithuania

and Croatia for which the change is higher than 80%. Besides that, the main leader is Romania with more than 90% increase in recycling rate of municipal waste.

The average EU recycling rate have increased steadily from 36,5% in 2008 to 47% in 2018.

Graph 3. Recycling rate of municipal waste, (%) 2018.



Note: 2017 data for index calculation for Cyprus, Ireland and Greece are used.

Source: Eurostat, https://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=cei_wm011&language=en, 01.12.2020.

The Graph 3 representing the EU cross-country comparison of recycling rate of municipal waste in 2018. The enormous differences in municipal waste recycling levels can be observed between MS, ranging from 67,3% in Germany to 6,5% in Malta in 2018. In 2018, only seven countries accomplished the 50% recycling target, besides that, Germany went beyond and has already achieved the 65% recycling rate target planned for 2030 by the revised legislative proposal. From another side, there are four countries that didn't reach even the 20% municipal waste recycling level in 2018, there are: Malta, Romania, Cyprus and Greece.

The EU average level in 2018 came to 47% of household waste recycling.

In large part, these differences can be explained by the varying initial municipal waste recycling rates in different countries; the fact that many countries joined the EU (and became subject to its waste management provisions) in 2004 or later (an ongoing catch-up process); the existence of derogation periods for some countries; and the fact that some frontrunner countries started increasing municipal waste recycling before the introduction of EU policies or went beyond the minimum requirements.

Recycling rate of all waste excluding major mineral waste indicator includes all types of waste from all economic sectors, as well covering secondary waste from waste treatment but excluding most mineral waste, as it takes the biggest share in overall waste generation for some countries that have major mining and construction sectors. The metric is calculated by dividing recycled waste by total waste generated excluding major mineral waste. This indicator encompasses both production and consumption waste recycled trends.

In order to get the correct understanding of the waste recycled data it is important to adjust it for the net export of waste sent to another country for recycling.

The recycling rate indicates the amount of waste reintroduced back to the economy, with the goal of value conservation of the materials for as long as possible thereby reducing losses. The increase in recycling rate gives indication of possible product and waste management improvement together with sound institutional involvement towards higher circularity.

Table 4. Recycling rate of all waste excluding major mineral waste, (%), 2010-2016.

EU-28 countries	2010	2012	2014	2016	Index 2016/2010
EU28	55	55	56	57	1,04
EU15 (members before 2004)					
Luxembourg	87	77	62	64	0,74
Ireland	36	37	44	41	1,14
Austria	60	65	62	66	1,1

Netherlands	71	71	72	72	1,01
Denmark	56	59	60	61	1,09
Germany	55	54	53	/	0,96
Sweden	51	53	51	49	0,96
Belgium	75	80	81	78	1,04
Finland	33	41	41	37	1,12
United Kingdom	55	56	57	58	1,05
France	50	51	53	54	1,08
Italy	60	64	67	68	1,13
Spain	44	46	46	46	1,05
Portugal	47	49	54	52	1,11
Greece	/	/	/	/	/
EU10 (members of 2004)					
Malta	24	28	27	43	1,79
Czechia	50	58	60	60	1,2
Slovenia	52	74	75	80	1,54
Cyprus	46	34	31	31	0,67
Slovakia	38	40	40	44	1,16
Lithuania	50	51	57	68	1,36
Estonia	22	25	19	10	0,45
Poland	58	55	60	56	0,97
Hungary	36	35	40	43	1,19
Latvia	/	/	/	/	/
EU3 (members after 2007)					
Romania	26	28	27	30	1,15
Bulgaria	27	14	17	27	1
Croatia	26	35	47	52	2

Note: Data are presented for all EU Member States except Latvia and Greece(confidential data).2014 data for index calculation for Germany is used (confidential data).

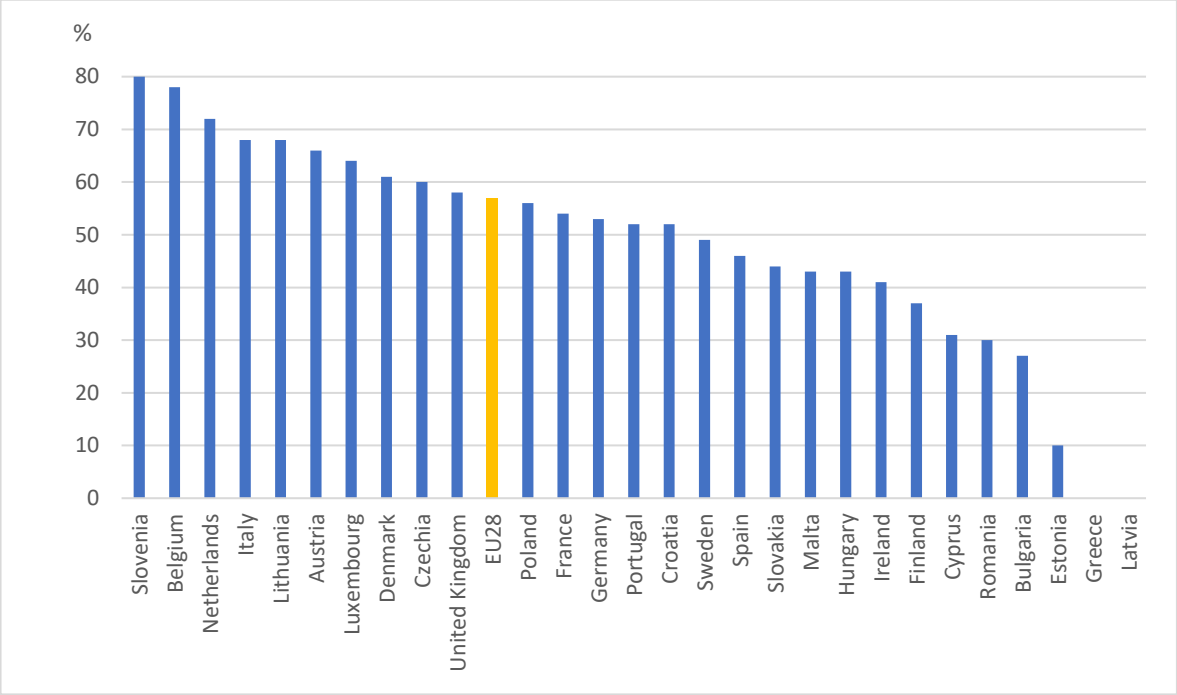
Source: Eurostat, https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=cei_wm010&plugin=1, 01.12.2020.

Table 4 representing performances of EU countries in recycling rates of all waste excluding major mineral waste between the period 2010-2016. Concerning that table, majority of countries have improved recycling capacities of waste, except of Estonia,

Cyprus, Luxembourg, Germany, Sweden and Poland. The highest growth rate were demonstrated by Croatia, which doubled its results from 26 % to 56 % within six years, also Malta and Slovenia.

Thus, some group of countries that entered EU from 2004 are showing proccess of cathing-up the introduced levels. The overall results in EU-28 is continuously increasing.

Graph 4. Recycling rate of all waste excluding major mineral waste, (%), 2016.



Note: Data are presented for all EU Member States except Latvia and Greece (confidential data). 2014 data for index calculation for Germany is used.

Source: Eurostat, https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=cei_wm010&plugin=1, 01.12.2020.

The Graph 4 representing cross-country comparison of recycling rate of all waste excluding major mineral waste in 2016. The best result in this year showed Slovenia with 80% of recycling level, Belgium with 78% and Netherlands with 72%, and with only 10% recycling level had Estonia, placed in the bottom of the rating. The EU average level in 2016 reached 57% of recycling.

In fact, the wide variation can be observed, caused by differences in initial amounts of waste recycling rates, insufficient use of economic instruments, lack of investments in waste management infrastructure and lack of administrative capacities.

Altogether, results indicate that, many countries have improved their municipal and overall waste recycling rates between 2008 and 2018, including many countries that entered the EU in 2004 or later that demonstrate the process of catching-up other countries. Even though indicator clearly demonstrates that for the most countries the extent of the challenge requiring outstanding effort in order to achieve at least the target of 50 % recycling.

Many countries use ‘pay-as-you-throw’ schemes (i.e. fees based on the weight or volume of the waste as an economic incentive for households to recycle their waste). Their level of implementation varies greatly by country and within countries. However, all countries with recycling rates above 45 % employ a similar system of sorts, while most countries with recycling rates below 20 % do not use them, indicating that pay-as-you-throw schemes are an effective instrument that drives recycling up.

Although not analyzed here, other factors can be expected to contribute to high recycling rates, such as the level of wealth (there is a correlation factor of 0.65 between gross domestic product per person and the recycling rate), environmental awareness in the country, waste management tariffs and stringent implementation of waste management legislation. All countries with recycling rates below 30 % (with one exception) entered the EU in 2004 or later, indicating that these countries started to implement recycling policies later.

Improvements in waste data and harmonization of national reporting methodologies are required, as uncertainties relating to the comparability of national data are a barrier to assessment of progress and the effectiveness of policy measures.

2.3 Secondary raw materials

Although the price volatility of some materials is already high, change for the better seems possible. The primary raw materials can be saved from excessive extraction by

returning used materials back into the economy as secondary raw materials. In this regard, the current chapter includes circular material use rate and trade in recyclable raw materials indicators, in order to obtain perception about current situation of secondary raw materials management.

Thus, for measuring the percentage of reintroduced materials or so called secondary raw materials, from overall material use, the circular material use (CMU) rate indicator is recommended. This indicator is defined as the ratio of the circular use of materials to the overall material use. To evaluate the overall material use, the sum of total domestic material consumption (DMC) and the circular use of materials are needed. The circular use of materials includes the amount of waste recycled within the country plus net export of waste destined for recovery. A higher CMU rate value represent the case when use of recovered raw materials prevail over extraction of primary ones. This indicator is relevant as it helps to circular economy to measure the contribution of materials recycled and reintroduced into the economy to the overall materials demand. Since this in turn, can reduce the generation of waste and minimize the extraction of primary raw materials.

Thus, the higher CMU rate opens the possibility for new markets, creates benefits for businesses both in their production processes, through reduction of production costs by making them less energy intensive and more resource efficient, and by increasing their competitiveness, as well as fosters new product development and innovation, improves employment thereby promotes economic growth. According to the European Commission's Circular Economy package (European Commission, 2015b)

Table 5. EU-28 CMU rate, % of total material use (2010-2019).

EU-28 countries	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Index 2019/2010
EU28	11,2	10,7	11,4	11,7	11,6	11,7	12	12	12,2	12,4	1,11
EU15 (members before 2004)											
Luxembourg	24,1	20,7	18,5	15,3	11,2	9,7	7	10,6	10,8	11,9	0,49
Ireland	1,7	2,1	1,8	1,7	2	1,9	1,7	1,7	1,6	1,6	0,94
Austria	6,6	6,8	7,6	8,9	9,9	11	11,4	11,6	11,4	11,5	1,74

Netherlands	25,3	25	26,5	27,1	26,6	25,8	28,5	29,7	29	28,5	1,13
Denmark	8	7,1	6,5	7,8	9,1	8,4	8,1	8	8,2	7,8	0,98
Germany	11	10,4	10,7	10,9	10,8	11,6	11,7	11,5	12	12,2	1,11
Sweden	7,2	7,5	8,2	7,3	6,5	6,8	7	6,8	6,7	7	0,97
Belgium	12,6	13,5	16,7	17,1	18,2	18,4	18,3	20,4	21,8	24	1,90
Finland	13,5	14	15,3	10,1	7,3	6,5	5,3	5,6	5,9	6,2	0,46
United Kingdom	14	13,7	14	14,2	14	15,1	15,7	15,7	16,3	16,6	1,19
France	17,5	16,8	16,9	17,3	17,8	18,7	19,4	18,8	19,6	20,1	1,15
Italy	11,5	11,6	13,9	16,1	16,1	17,3	17,8	18,4	18,7	19,3	1,68
Spain	10,4	9,8	9,8	8,9	7,7	7,5	8,2	8,9	9,6	10,2	0,98
Portugal	1,8	1,7	2	2,5	2,5	2,1	2,1	2	2,1	2,2	1,22
Greece	2,7	2,2	1,9	1,8	1,4	1,9	2,3	2,8	3,3	4,2	1,56
EU10 (members of 2004)											
Malta	5,3	4,5	3,9	6,3	6,4	4,6	4,2	6,5	8,1	7,1	1,34
Czechia	5,3	5,4	6,3	6,7	6,9	6,9	7,6	7,9	8	8,3	1,57
Slovenia	5,9	7,6	9,3	9,2	8,4	8,4	8,5	9,7	10	10,4	1,76
Cyprus	2	1,9	2	2,4	2,2	2,4	2,4	2,4	2,7	2,9	1,45
Slovakia	5,1	4,8	4,1	4,6	4,8	5	5,2	5,1	5	6,1	1,20
Lithuania	3,9	3,6	3,8	3,2	3,8	4,1	4,6	4,5	4,3	4	1,03
Estonia	9,1	14,6	19,3	14,8	11,4	11,8	12,2	12,6	13,8	15,1	1,66
Poland	10,8	9,2	10,6	11,8	12,5	11,6	10,2	9,9	9,7	9,8	0,91
Hungary	5,3	5,4	6,1	6,2	5,4	5,8	6,5	6,9	7	6,8	1,28
Latvia	1,2	2,9	1,3	3,8	5,3	5,4	6,5	5,5	4,8	4,7	3,92
EU3 (members after 2007)											
Romania	3,5	2,5	2,6	2,5	2,1	1,7	1,7	1,7	1,5	1,5	0,43
Bulgaria	2,1	1,8	1,9	2,5	2,7	3,1	4,4	3,5	2,5	2,4	1,14
Croatia	1,6	2,4	3,6	3,7	4,6	4,3	4,4	5	4,9	4,9	3,06

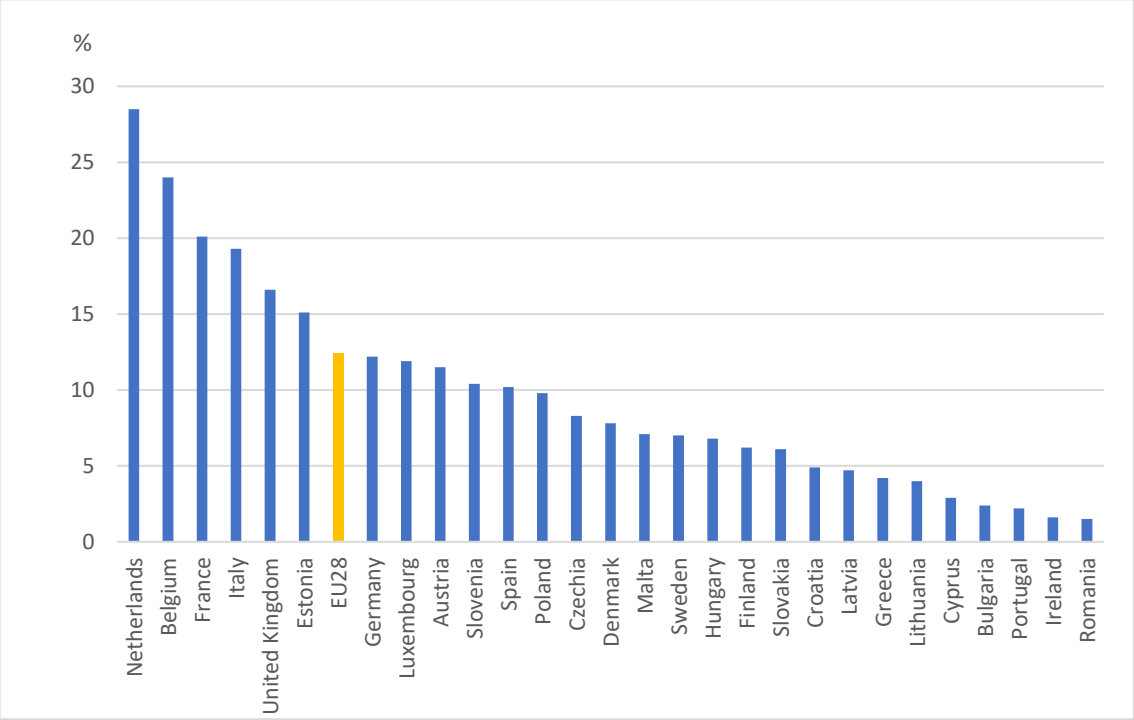
Source: Eurostat, https://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=cei_srm030&language=en, 01.12.2020.

Table 5 displays contribution of recycled raw materials to overall material use in percentage, among all Member States and EU aggregate, during the period from 2010 to 2019.

The incomparable leaders in contribution of secondary raw materials use, are Latvia with 3,92 index, followed by Croatia – 3,06. This progress they got through high recycling rates. The negative trend was represented by: Romania – 0,43, Finland – 0,46 and Luxembourg – 0,49, due to decrease in recycling amounts and rice in DMC. The majority of EU countries representing progress towards bigger use of secondary raw materials in their production processes.

The overall situation in EU has steady upward trend from 11,2 % in 2010 to 12.4 % in 2019, with insufficient drop in 2011. The positive trend during this period is primarily due to the enhancement of the amount of waste recycled rather than decrease of the DMC.

Graph 5. EU-28 CMU rate, % of total material use, 2019.



Source: Eurostat, https://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=cei_srm030&language=en, 01.12.2020.

As presented in the Graph 5, in 2019 the best was Netherlands with 28,5 % of secondary material use while the worst was Romania with 1,5 %.

Most of the countries are under EU average of 12,4 %, only six countries have higher share of circular material use rate in their production sectors. There are:

Netherlands (28,5 %), Belgium (24 %), France (20,1 %), Italy (19,3 %), United Kingdom (16,6 %) and Estonia (15,1 %).

To better understand these wide variations between countries, the CMU rate values (domestic material consumption and circular use of materials per capita) should be analyzed separately. For example, low DMC in Italy, Spain, United Kingdom (as they more oriented on services like tourism and don't have strong industrial sector) and high recovery capacities in The Netherlands, Estonia or Belgium (as they have better technologies, high GDP rate and oriented on trade, market oriented). From that perspective becomes visible the importance and strong influence of economic structures on the CMU rate performance in different countries.

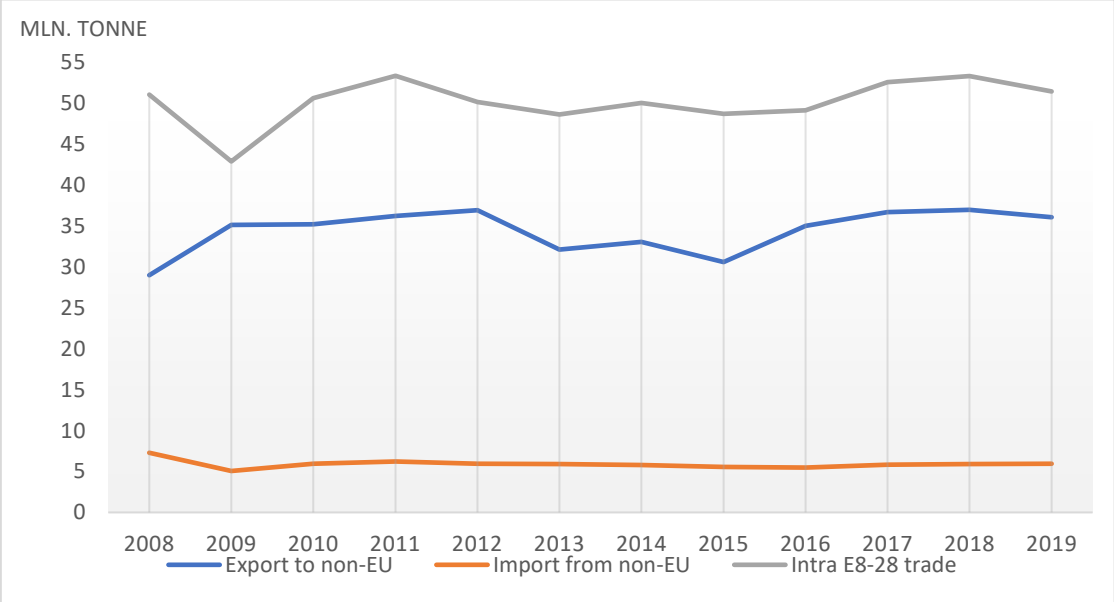
Another important indicator that helps to understand level of efficiency in the use of the EU's recycling capabilities is trade in secondary raw materials. This indicator measures the amounts of residual recyclable materials or by-products that are traded within the EU (intra-EU) and across the EU boundaries (extra-EU) through imports and exports.

According the classification of the Joint Research Center (JRC), this indicator includes the next classes of recyclable raw material: paper and carboard; plastic; precious metals; iron and steel; copper, aluminum and nickel.

Evaluation of this indicator is highly important for getting a complete picture of countries' performances in the field of secondary raw materials management. Also, the trade in recyclable raw materials has several benefits, for example to reduce net wastes for countries with lack of recycling capacities or to improve the security of raw materials supply for countries that are not self-sufficient with several raw materials. As many non-hazardous wastes are considered as valuable resources, they can be an important source of raw materials for countries in need. In general, cross-border trade of recyclable waste becomes more and more popular among nations and that is a good sign in the context of CE implementation.

From the overall trade perspective, presented in Figure 4, the intra-EU trade always prevailed over extra-EU trade in the period 2008-2019. Furthermore, extra-EU trade characterized by much higher levels of export to non-EU countries rather than imports from them.

Figure 4. Extra- and intra-trade of secondary raw materials in EU-28, 2008-2019 (tons).



Source: Eurostat, https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=cei_srm020&plugin=1, 01.12.2020.

Intra-EU trade prevail over extra-EU trade and that can be explained by existence of common market among EU Member States, that gives them possibility to trade freely and to use recycling capacities on more optimal way.

In order to get more detail information about EU countries performances, it is needed to divide analysis on intra-EU trade and extra-EU trade.

In the Table 6 presented import flows of recyclable materials between MS in the period 2008-2019.

Table 6. Trade in recyclable raw materials, intra- EU trade (tonne), 2008-2019.

EU-28 countries	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Index 2019/2008
EU28	51098275	42918927	50675411	53389653	50171871	48659189	50066087	48729842	49169116	52600019	53339628	51470034	1,01
EU15 (members before 2004)													
Luxembourg	2911788	2148001	2859631	2791203	2392097	2405070	2333853	2276302	2390539	2410053	2518449	2322917	0,80
Ireland	87870	89349	96376	87024	78224	78696	78956	81275	83446	94547	87095	71524	0,81
Austria	3050834	2493689	2493289	2634998	2518957	2554020	2911280	2900332	2752643	2806230	3042531	3107008	1,02
Netherlands	4629557	5742488	5133237	5124718	5101960	4444323	4292304	4432298	5814263	6724991	6230011	6407060	1,38

Denmark	653438	373190	317270	383690	380734	275152	253403	136737	129230	194689	274001	321531	0,49
Germany	10104683	7608261	10074619	11240278	10317728	10062310	10078296	9583353	9623256	10141419	9858757	9791420	0,97
Sweden	844956	850868	973797	941183	921530	749178	880265	790354	820575	813148	897379	720101	0,85
Belgium	6172425	5958441	6703508	6671651	6304432	6104802	6445778	5894009	6141470	6120357	6268813	6159882	1,00
Finland	466804	422695	709785	657320	94631	105361	156419	95457	99575	99219	129368	140656	0,30
United Kingdom	465358	426002	516942	727036	602124	659799	577477	645473	496931	617779	646238	511790	1,10
France	4073620	3258476	3547830	3732022	3626698	3264269	3559316	3522616	3036360	3181705	3051670	2719260	0,67
Italy	6098404	3711653	4989039	6105201	5801006	5347940	5772543	5290595	5184414	5918018	6374405	6100958	1,00
Spain	6544280	5272818	6490529	5875999	5538464	6072531	5842459	6324024	5435180	5697294	5504534	5476071	0,84
Portugal	1058275	989292	948595	1270751	1144615	1331833	1563709	1671966	1531619	1621452	1746976	1453408	1,37
Greece	757716	719724	697552	689998	331896	290886	408981	342634	413356	522295	525394	326141	0,43
EU10 (members of 2004)													
Malta	125	40	615	443	612	506	226	904	737	212	250	218	1,74
Czechia	670123	546745	629376	749099	774858	797663	851392	761803	783385	804759	884525	892170	1,33
Slovenia	649355	581780	779813	799129	811479	810239	912662	861068	911100	922841	913732	926875	1,43
Cyprus	16	358	795	339	312	392	320	343	637	660	999	796	49,75
Slovakia	274613	230188	364283	362422	533052	573560	377069	297147	322413	415475	490709	252914	0,92
Lithuania	118908	96347	139905	197964	172538	125426	147644	137891	152915	221557	315360	314376	2,64
Estonia	41412	15154	19642	17398	233546	168084	110424	66788	90536	121275	160346	164486	3,97
Poland	654691	768622	886832	932176	976740	1194564	1355807	1515948	1664851	1729823	1832204	1634466	2,50
Hungary	222385	186348	466793	528835	515927	520721	521794	511494	592456	641902	613945	643447	2,89
Latvia	218450	165911	382971	453396	727138	409363	248494	201541	143537	164103	165090	127364	0,58
EU3 (members after 2007)													
Romania	29323	11777	103353	96633	111602	128229	119811	125578	243264	332253	393378	380732	12,98
Bulgaria	261456	220769	271081	233664	124921	117002	137879	133244	105720	89743	180659	274682	1,05
Croatia	37411	29942	77953	85083	34050	67271	127530	128670	204709	192217	232811	227783	6,09

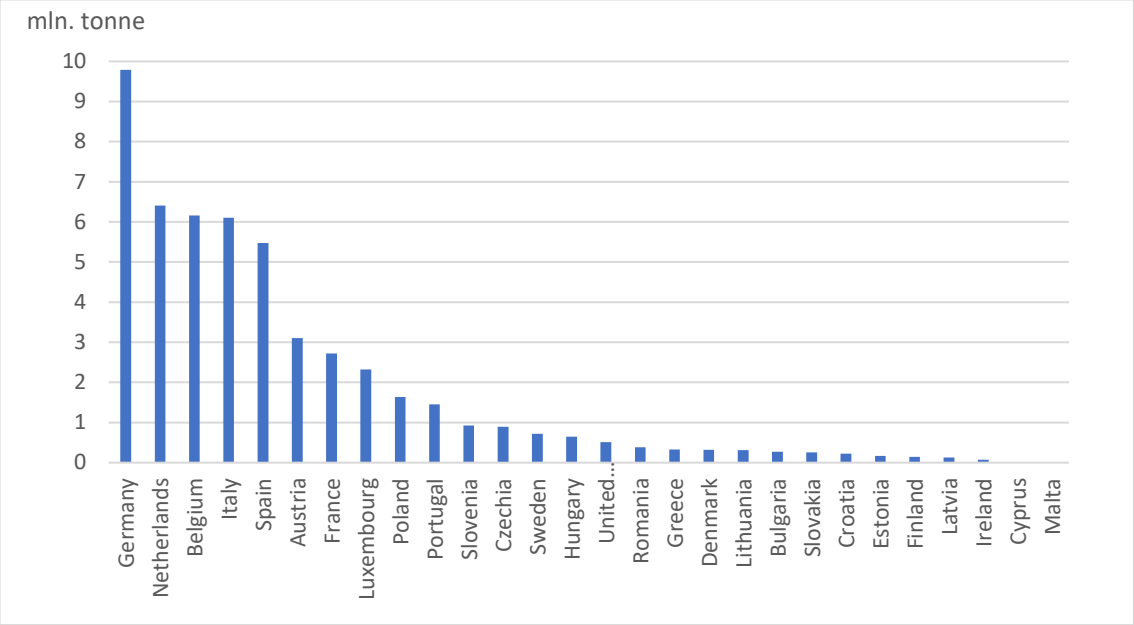
Source: Eurostat, https://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=cei_srm020&language=en, 09.09.2020.

Cyprus represented tramendous increase in amounts of imports from another MS, as it increased for almost 50 times from 16 tonnes to 796 tonnes in given period. Other examples of high growth rates are in Romania and Croatia that have 12,98 and 6,09 indices of increase respectively. In general, the group of countries that had accessed the EU in 2004 and later has increased their imports of secondary raw materials from other EU countries.

The intra- EU trade decreased for Sweden, Spain, Ireland, Luxembourg, France, Latvia, but the biggest decrease in trade was presented by Denmark, Greece and Finland that in 2019 traded less than in 2008 on 50% or more.

Across the EU the biggest drop was in 2009, due to economic crises that limited the trade. After that the situation with overall EU intra-trade comparatively stabilized with insufficient fluctuations in the range between 53 million tonnes and 48,6 million tonnes.

Graph 6. Trade in recyclable raw materials, intra- EU trade, million tonne, 2019.



Source: Eurostat, https://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=cei_srm020&language=en, 09.09.2020.

The Graph 6 introduces the intra-EU trade of recyclables for all EU countries in 2019.

According the Graph 6, Germany acts as a main importer of recyclables from other EU countries and its intra-trade accounts for almost 10 million tonnes imported in 2019. The following countries with quite less amounts of imported tonnes are: Netherlands, Belgium, Italy and Spain, all in a range between 5,5 million tonnes and 6,5 million tonnes.

The eighteen countries, form the majority in EU, had less than 1 million tonnes of imported secondary raw materials in 2019. In the end of the rating are Malta and Cyprus with 218 and 796 tonnes respectively.

In addition, the significant differences in value of the materials processed in each Member State appear to reproduce, in some cases, the existing disparities in terms of development and complexity of their productive structure.

From the other side it is important to represent extra-EU trade, that will detail interconnections between different countries.

Table 7. Trade balance in extra-EU28, tonne, 2008-2019.

EU-28 countries	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Difference 2019-2008
EU28	21713616	30102709	29267870	30041945	30998829	26229847	27276966	25084552	29552468	30881761	31099598	30167292	8 453 676
EU15 (members before 2004)													
Luxemburg	-66118	-17078	-29352	-37325	-39853	-30178	-17590	-18955	-13037	-13146	-26997	-13063	53 055
Ireland	349126	388272	320099	344359	393700	367193	379336	386769	376025	374110	371935	365796	16 670
Austria	-174689	-127731	-42463	-106643	-103973	-81162	-114719	-88862	-93695	-101141	-107742	-64574	110 115
Netherlands	4487760	6101148	5451045	4942720	5072258	3669181	3371778	3441110	4751074	4840194	4902378	4672307	184 547
Denmark	415800	465132	497718	404212	506229	478970	729704	425451	597537	692990	844363	848788	432 988
Germany	2283062	3413926	2944323	2929285	2826943	2062740	2140690	1558009	1833453	1693483	1535501	1536897	-746 165
Sweden	105963	471571	29066	210949	365300	226689	455890	297645	581156	662611	660011	763057	657 094
Belgium	2716437	3555682	3629179	3637561	3556281	3158081	3848407	3183909	3472331	3509600	3484069	3364005	647 568
Finland	13622	87997	23637	-16577	88462	98799	156567	147937	161054	99925	183195	265974	252 352
United Kingdom	8913022	9086402	9898801	10445820	10306222	9469486	10106547	10355569	11967104	12200445	12076173	11408160	2 495 138
France	573257	1408149	1299185	1470831	1659460	1290024	1260200	1264108	1451157	1625084	1624215	1571659	998 402
Italy	420167	1404780	807626	802340	1333438	933405	1034494	1231560	1351654	1351380	1342349	1350574	930 407
Spain	-740905	277452	121666	342614	682040	210140	84976	330477	648179	718340	682488	368348	1 109 253
Portugal	-84833	32389	93747	66313	-10878	-61977	-17965	-8295	43879	-12427	-23435	14807	99 640
Greece	-599942	-69898	4354	21202	184489	233939	208174	165070	-122730	-81000	-116649	-315046	284 896
EU10 (members of 2004)													
Malta	28403	32876	42696	58259	56403	45994	72874	54130	67339	69710	169538	62518	34 115
Czechia	22898	64975	74183	118837	115439	107875	134770	141853	58638	60089	44239	42064	19 166
Slovenia	-71907	43676	-58595	-44041	80275	60198	91925	93562	62856	32744	-15185	41248	113 155
Cyprus	33056	42102	59616	69167	70686	64676	61617	58198	61737	58121	57807	53925	20 869
Slovakia	4574	-2021	24536	38555	29346	24210	24887	20849	19282	19323	40356	46504	41 930
Lithuania	276513	187820	178503	269069	157023	206480	369896	371724	481352	759571	738184	688346	411 833
Estonia	493386	313431	326897	380515	479517	464463	387728	278177	347522	475580	432241	350771	-142 615
Poland	216959	187648	234778	271101	347870	309436	340809	161874	295028	288391	544787	873646	656 687
Hungary	93848	74986	135112	108206	141804	173571	178137	102746	113799	105322	107428	114770	20 922
Latvia	-118355	70205	103723	368402	121551	341825	404955	378490	321844	373972	437230	331598	449 953
EU3 (members after 2007)													
Romania	1513153	2184464	2294398	2094694	1740660	1748105	1165545	540972	471621	679363	706257	885864	-627 289
Bulgaria	573594	369705	761325	705381	669215	564938	355796	185660	203447	299210	310821	356619	-216 975
Croatia	35765	54649	42067	146141	168922	92744	61552	24816	42864	99916	94038	181731	145 966

Source: Eurostat, https://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=cei_srm020&language=en, 01.12.2020.

The overall EU has positive trade balance that is increasing mostly due to increase in exports in almost all EU countries.

Countries that have negative trade balance since 2008: Luxembourg (decreased both imports and exports, but exports almost eliminated by 2019 (22 tonnes)), Austria and Greece (decrease in imports and quite strong increase in exports). Countries that

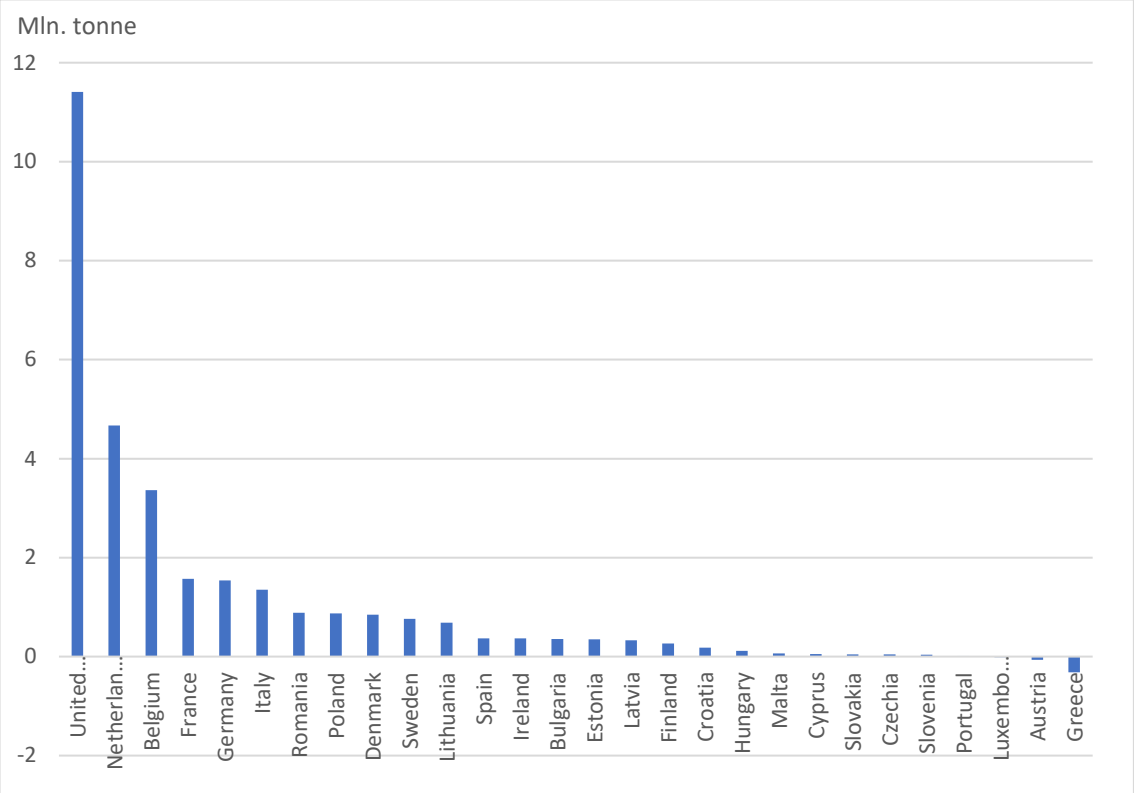
Countries that had transition from negative to positive trade balance: Spain (strong decreased in imports and increased exports), Latvia (strong decrease in imports and strong increase in exports), Slovenia (decreased imports and increased exports), Portugal (not significant decrease in imports and quite strong increase in exports).

Countries with highest increase in positive trade balance: Finland (drastic fall in imports and insignificant increase in exports), Slovakia (increase in imports and one of the strongest growth rates in exports), Sweden (decreased imports and increased exports), Croatia (decreased imports and increased exports).

Countries which positive trade balance has decreased: Romania (slight increase in imports and strong decrease in exports), Bulgaria (higher increase in imports than decrease in exports), Germany (increase in import and quite strong decrease in exports), Estonia (one of the strongest increases in imports and strong decrease in exports). This is only countries that had a decrease in exports from all EU28.

The biggest changes in the trade balance were represented by countries that entered the EU in 2004 or later.

Graph 7. Trade balance in extra-EU28, tonne, 2019.



Source: Eurostat, https://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=cei_srm020&language=en , 01.12.2020.

The Graph 7 introduces the trade balance in secondary raw materials with non-EU countries in 2019.

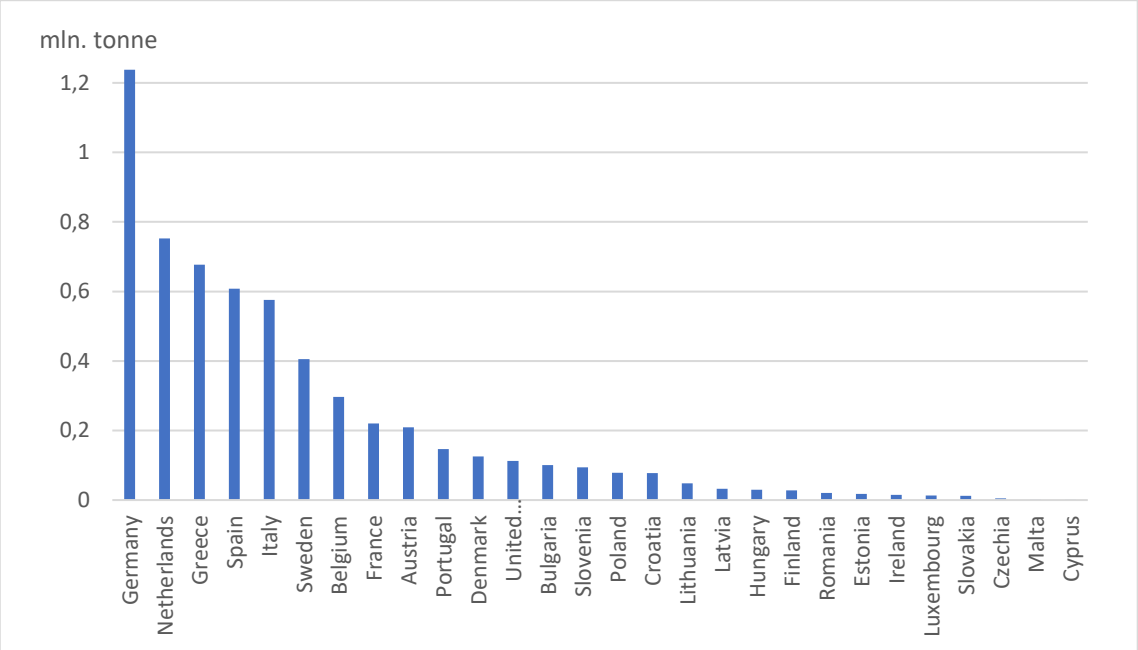
The noticeable leader is United Kingdom with 11,4 million tonnes of surplus followed by Netherlands and Belgium with quite less amounts of 4,6 million tonnes and 3,4 million tonnes respectively. The countries that have surplus which is lower than 100 thousand are: Portugal, Slovenia, Czechia, Slovakia, Cyprus and Malta. Also, three countries have a trade deficit, there are: Greece, Austria and Luxembourg.

Countries that are on the bottom of rating with the lowest surpluses or insignificant deficits are countries with low import and export volumes in general, as the trade in secondary raw materials is not their primary activity, like: Cyprus, Malta, Czechia, Luxembourg and Slovakia.

The prices of imports have been three times higher from prices of exports since 2013. This can be partially explained by differences in the types of the materials traded.

According to the data from Eurostat, the overall EU import has decreased for 20% during the period 2008-2019. The possible result of that can be an increase in recycling volumes in EU countries thus improved self-sufficiency. The countries that decreased their foreign imports the most, are: Cyprus, Finland, Latvia, Luxembourg, Spain, France and Malta. Nevertheless, the biggest increase is made by countries that entered the EU in 2004 and later, some of them are: Poland, Estonia and Hungary.

Graph 8. Imports extra-EU28, tonne, 2019.



Source: Eurostat, https://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=cei_srm020&language=en, 01.12.2020.

The Graph 7 introduces the imports of secondary raw materials from non-EU countries in 2019.

Germany has showed the highest imports of about 1,2 mln. tons, followed by Netherlands and Greece with 752 thousand tons and 677 thousand tons respectively. The least amount of trade was represented by Czechia – 4,4 thousand tons, Malta - 1,1 thousand tons and Cyprus - 25 tons.

Imports from non-EU countries vary considerably across EU countries in 2019, ranging from 1,2 mln. tons in Germany to 25 tons in Cyprus.

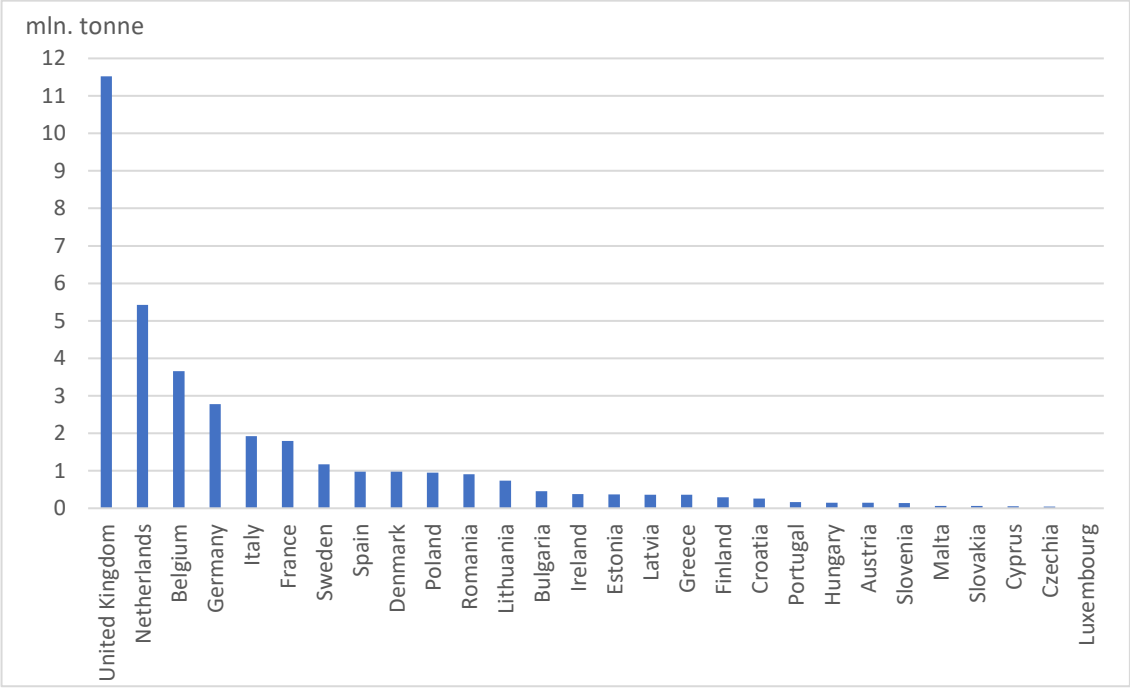
Regarding the indicator of export to non-EU countries, the data presented in Table 8 counts only amount of legal shipments of waste materials. There is however information about huge amounts of illegally transported waste, for some categories like end-of-life vehicles or electronics, amount of which is even higher than the legal exports.

The total export of EU has increased for 24% during the period 2008-2019.

The highest export growth rate had Poland, Slovakia, Slovenia and Latvia with 3 or more times increase from 2008. On the other side, countries with the biggest decrease, they are: Luxembourg, Romania, Bulgaria, Estonia and Germany. Majority of countries that had the biggest changes are countries that accessed the EU in 2004 or later.

Almost all EU countries demonstrated the increase in exports of secondary raw materials to non-EU countries, except of five.

Graph 8. Exports extra-EU28, tonne, 2019.



Source: Eurostat, https://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=cei_srm020&language=en, 09.09.2020.

The Graph 8 introduces the amount of export of secondary raw materials to non-EU countries in 2019.

United Kingdom has showed the highest export activity of 11,5 mln. tons, followed by Netherlands and Belgium with 5,4 mln. tons and 3,6 mln. tons respectively. The least amount of trade was represented by Luxembourg – 22 tons.

Export to non-EU countries vary considerably across countries in 2019, ranging from 11,5 mln. tons in United Kingdom to 22 tons in Luxembourg. In particular, six Member States proceed more than 6 mln. tons, while nine countries proceed less than 200 thousand tons per year.

According to above mentioned, the general EU performance is progressing on the proper way, taking into account that the EU has positive trade balance with the much more valuable imports than exports. From the CE perspective, it is a positive outcome for economies, as it means that countries trying to prevent leakage of most valuable secondary raw materials and in its turn, relocating low value materials to non-EU countries for processing and reduction of negative environmental impact within the EU.

However, there are still countries with low levels of retention of valuable raw materials.

As well huge amounts of exports and imports in some countries indicate the lack of capabilities to close the cycle of many material flows.

To get better understanding of the results, the market value of the different types of secondary raw materials traded should be taken into account.

2.4 Competitiveness and innovation

The CE is able to facilitate employment and economic growth by implementing recycling, repair and reuse activities that are especially job intensive, and contribute to generation of employment, investment, value added and innovation that in its turn, will lead to overall economies' competitiveness. The CE activities have potential to contribute

in innovation and investments in different spheres like, eco-design, recycling processes and industrial symbiosis.

In this analysis the main attention is going to be on value added at factor costs related to CE sectors. This is the share of companies' contribution to GDP from circular activities, like recycling, repair, reuse, renting and leasing. It is calculated as the amount of profit realized, based on the cost of factors of production with adjusted production subsidies and indirect taxes. The higher the indicator, the more efficient operating models, reduced operating costs and increased inherent value in products and secondary products are implemented in economy.

Table 9. Value added at factor cost (% of GDP), 2008-2017.

EU-28 countries	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Index 2017/2008
EU28	/	/	/	1	0,98	0,97	1	0,98	0,98	1	1
EU15 (members before 2004)											
Luxembourg	/	/	/	/	/	/	/	/	/	/	/
Ireland	/	/	/	/	/	/	/	/	/	/	/
Austria	0,93	0,93	0,96	0,94	0,94	0,98	1,04	1,03	1,04	1,12	1,2
Netherlands	/	0,83	0,84	0,92	0,87	0,79	0,8	0,75	0,79	0,84	1,01
Denmark	0,89	0,82	0,82	0,86	0,84	0,78	0,83	0,84	0,82	/	0,92
Germany	/	/	/	1,01	0,97	0,94	0,97	0,94	1	0,99	0,98
Sweden	1,01	0,94	0,93	0,96	0,95	1,12	0,93	0,9	0,88	0,88	0,87
Belgium	/	0,66	0,71	/	0,72	0,69	0,67	0,68	0,68	0,68	1,03
Finland	0,85	0,85	0,94	/	/	/	0,94	0,96	0,93	0,88	1,04
United Kingdom	1,07	1,02	1,03	1,12	1,13	1,14	1,18	1,17	1,19	/	1,11
France	/	0,98	1,03	1,03	0,99	1	1	0,97	0,87	0,98	1
Italy	1,06	0,92	1,06	1,05	1,07	1,05	1,08	1,07	1,06	1,07	1,01
Spain	0,97	0,88	0,96	0,9	0,9	1,06	1,03	1,02	1,03	1,06	1,09
Portugal	0,77	0,78	0,78	0,73	0,71	0,69	0,73	0,75	0,76	0,79	1,03
Greece	/	/	/	0,47	/	0,39	0,35	0,36	0,35	0,36	0,77
EU10 (members of 2004)											
Malta	/	/	/	/	/	/	/	/	/	/	/
Czechia	/	/	/	/	/	/	/	/	/	/	/
Slovenia	1,09	0,99	1,22	1,24	1,31	1,26	1,31	1,3	1,31	1,3	1,19
Cyprus	0,77	0,8	0,8	0,74	0,73	/	/	0,81	0,86	0,99	1,29
Slovakia	0,72	0,56	1,02	1,11	1,13	0,79	0,66	0,74	0,77	0,79	1,1
Lithuania	0,97	0,76	0,8	0,93	0,95	0,93	0,95	0,95	1,05	1,12	1,15
Estonia	1,13	/	/	1,04	/	/	/	/	1,11	/	0,98
Poland	1,3	1,1	1,12	1,13	1,09	1,07	1,13	1,1	1,13	1,11	0,85
Hungary	0,74	0,79	0,83	0,84	0,78	0,75	0,83	0,76	0,9	0,98	1,32
Latvia	1,19	1,21	1,21	0,98	1,14	1,01	1,02	0,98	1	1,09	0,92

EU3 (members after 2007)											
Romania	0,97	0,81	0,81	0,81	0,74	0,68	0,68	0,71	0,75	0,79	0,81
Bulgaria	1,35	0,94	1,16	1,1	1,09	1,05	1,14	1,14	1,11	1,22	0,9
Croatia	/	/	1,33	1,18	1,14	1,19	1,21	1,24	1,22	1,27	0,95

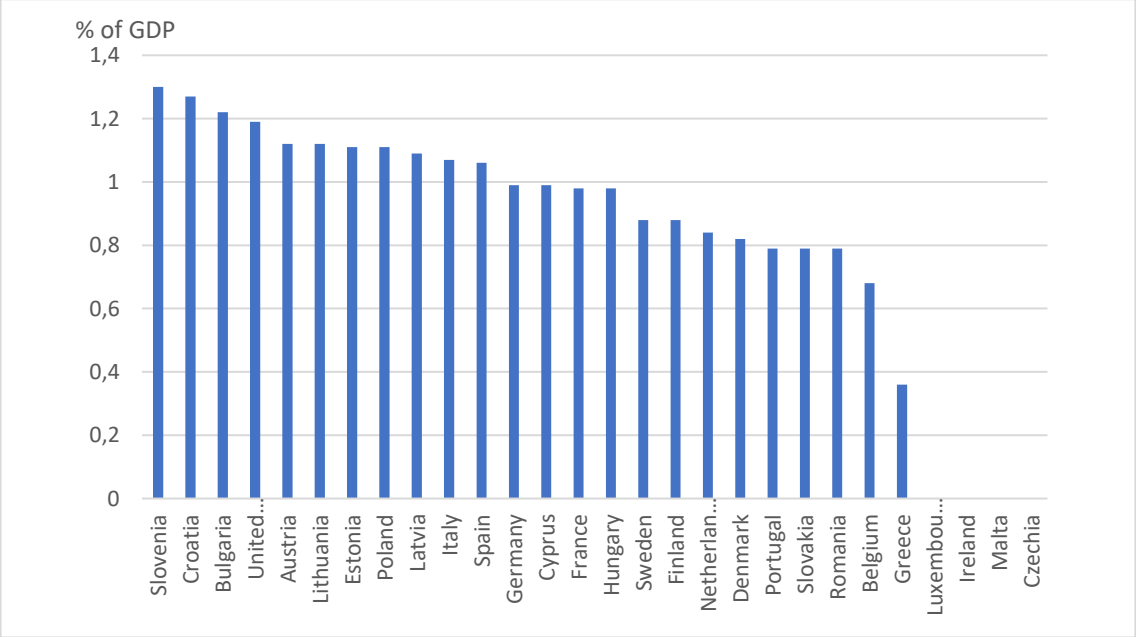
Note: Data are presented for all EU Member States except Czechia, Ireland, Luxembourg and Malta (confidential data). 2008 data for calculation of index for Netherlands, Germany, Belgium, France, Greece, Croatia and EU-28 are not available and the following data are used: (2009) Netherlands, Belgium, France, (2010) Croatia, (2011) Germany, Greece and EU-28. 2017 data for calculation of index for Denmark, United Kingdom and Estonia are not available and 2016 value is reported instead.

Source: Eurostat, https://ec.europa.eu/eurostat/tgm/table.do?tab=table&tableSelection=2&labeling=labels&footnotes=yes&layout=time,geo,cat&language=en&pcode=cei_cie010&plugin=1, 01.12.2020

The biggest growth rate in contribution of sectors that implementing circular activity to the overall economy of country is represented by Hungary with 32% increase, and it is followed by Cyprus and Austria with increase of share more 20% and more. The decreased share is represented by Greece, Romania, Poland and Sweden.

By 2017 the CE sectors generated 155 billion EUR of gross value added in EU, this is around 1% of the EU GDP. In the monetary terms during the period from 2011 to 2017 the indicator increased by 17% for overall EU.

Graph 9. Value added at factor cost (% of GDP), 2017.



Note: Data are presented for all EU Member States except Czechia, Ireland, Luxembourg and Malta (confidential data). 2017 data for calculation of index for Denmark, United Kingdom and Estonia are not available and 2016 value is reported instead.

Source: Eurostat, https://ec.europa.eu/eurostat/tgm/table.do?tab=table&tableSelection=2&labeling=labels&footnotes=yes&layout=time,geo,cat&language=en&pcode=cei_cie010&plugin=1, 01.12.2020

From the Graph 9 that demonstrates the gross added value of the CE sectors as a share of GDP for the 2017, can be seen that the contribution between countries vary drastically from 1,3% of GDP in Slovenia to 0,36% of GDP in Greece.

The last indicator that presented in this analysis, considers the number of patents linked to recycling and secondary raw materials. An important aspect of CE implementation is boosting an innovation that is why, the relation between the number of new

patents and innovation in CE is straightforward. This indicator can be used to assess technological progress in the analyzed sectors. The development of innovative processes, technologies, services and business models help to improve waste management and recycling of materials, thus leading to EU self-sufficiency (reduce the EU dependence on critical commodities), reliance to possible supply disruptions and competitiveness of domestic industries.

Table 10. Number of patents related to recycling and secondary raw materials, 2008-2016.

EU-28 countries	2008	2009	2010	2011	2012	2013	2014	2015	2016	Difference 2016-2008
EU28	287,38	300,4	337,93	343,72	368,17	341,18	331,32	355,62	290,47	3,1
EU15 (members before 2004)										
Luxembourg	1,11	5,04	1,82	1,17	2,81	3,54	6,49	2	1,5	0,4
Ireland	3,24	3,12	1,98	3,42	1,44	2,37	2,89	1,5	1,14	-2,1
Austria	10,71	8,88	11,7	14,95	6,21	10,15	9,84	8,22	3,86	-6,9
Netherlands	10,44	13,66	10,05	14,32	17,65	15,14	17,57	20,9	15,69	5,3
Denmark	2,71	1,03	0,29	1,2	4,05	6,74	7	4,65	5,5	2,8
Germany	105,76	106,75	91,03	100,04	93,4	89,48	76,85	89,87	66,53	-39,2
Sweden	3,7	1,1	1,83	6,46	4,32	5,84	3,62	9,81	5,01	1,3
Belgium	7,15	6,02	13,04	10,14	4,75	13,69	10,29	8,91	14,65	7,5

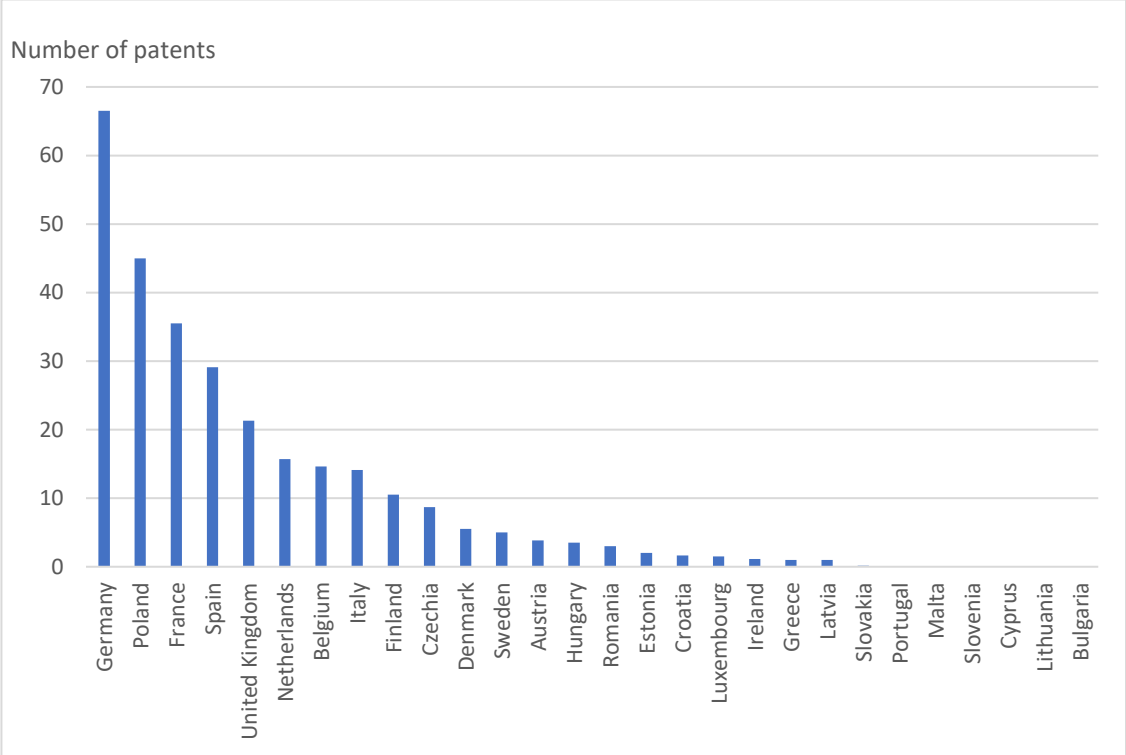
Finland	5,75	7,39	15,32	8,3	10,91	12,26	13,63	16,46	10,5	4,8
United Kingdom	17,21	17,31	22,94	23,29	24,11	20,92	19,5	17,88	21,33	4,1
France	36,81	35,02	43,97	34,99	44,07	36,53	65,25	36,68	35,53	-1,3
Italy	22,46	29,33	25,18	23,91	24,74	26,31	13,57	18,91	14,12	-8,3
Spain	22,19	22,95	23,8	25,85	21,8	32,17	24,53	19,82	29,09	6,9
Portugal	1,71	0	2,5	6,25	3,67	1	0	5	0	-1,7
Greece	0	0	1	0	0	0	0,5	1	1	1
EU10 (members of 2004)										
Malta	0	0	0	0	0	0	0,75	1	0	0
Czechia	6	10,38	19,3	15,46	35,38	13,8	14,99	9,58	8,72	2,7
Slovenia	1	1	0	0,2	0	2	2,25	0	0	-1
Cyprus	0	0,04	0	1,67	0	0	0	1,5	0	0
Slovakia	0,67	1,5	0,5	0	1,22	3	1,5	6,2	0,13	-0,5
Lithuania	1	0	2	1,5	1,14	1	0	0	0	-1
Estonia	0	1	0,25	0	0	0	2,17	0	2	2
Poland	20,8	18,73	33,67	41,08	55,65	37,66	28,17	67,4	45,01	24,2
Hungary	3,4	1,04	6,1	3,85	3,33	1,25	2,96	1,33	3,5	0,1
Latvia	0,06	2,17	1,5	0	2,33	3	0	2,5	1	0,9
EU3 (members after 2007)										
Romania	2,5	5,44	4,83	4	4,99	2,33	5	4,5	3	0,5
Bulgaria	1	1,5	2,33	1	0	1	2	0	0	-1
Croatia	0	0	1	0,67	0,2	0	0	0	1,66	1,7

Source:Eurostat,https://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=cei_cie020&language=en, 01.12.2020.

Regarding the Table 10, an increase in patents has been observed, from 287 in 2008 to 355 patents in 2015. However, the significant drop in the last represented year can be noticed, that lead to the almost same amounts of patents implemented in 2016 and in 2008.

The best contribution was made by Polish economy that generated on 24 patents more in 2016 than in 2008. At the same time Germany approved on 39 patents less during that period.

Chart 10. Patents related to recycling and secondary raw materials, 2016, (numbers).



Source: Eurostat, https://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=cei_cie020&language=en, 01.12.2020.

Germany is the most innovative and productive in regards to the number of approved patents, which amounts for almost 70 patents in 2016. Seven countries didn't invent anything in 2016.

But there are around 9 countries that have just one or two or none of patents every year, what indicates that probably these countries have no investments in R&D as well as in innovation and skills development for CE sectors that can strongly slow down the transition towards circular economy.

The above indicator still clearly indicates the extent of the challenge ahead for many.

There is a need for fast innovations and investments which creates a hard challenge for a lot of countries, especially developing one. Taking into account that concept of circular economy is global and will not have sense without all actors involved.

2.5 Results discussion

The largest developments towards CE so far have been made in waste management, especially recycling activities. A more recent press release highlights that record recycling rates were achieved in 2018, with the highest ratios observed in construction materials and packaging.

However, the use of secondary (recycled) raw materials is reported to be low, as they only account for 12,4% of the overall materials demand.

There is high degree of dependency of the EU on imports of key raw materials.

A -6% fall in the generation of both municipal waste and total waste between 2008 and 2018 is presented as a sign of general progress towards CE. Nevertheless, it was also observed a great difference between Member States and a certain correlation with per capita GDP.

Regarding extra-EU trade in secondary raw materials, data for the period 2008–2019 show a large surplus, both in value and volume, while intra-EU trade experienced a remarkable increase in the same time frame. These results are presumed to be positive, as the description of the indicator made in the Commission's Staff Working Document (SWD) suggests that higher levels of trade of secondary raw materials could signal the presence of a dynamic internal market and an optimal use of the EU's recycling capacities.

Finally, the contribution of CE to overall competitiveness and innovation is measured based on the added value and number of patents developed in companies of economic sectors that are considered especially relevant to the CE. These involve recycling, repairing, reuse, activities renting and leasing activities. In this sense, it is outlined that the level of circularity of European economies is very low.

Currently available data shows that value added did not change between 2011 and 2017. The number of patents related to recycling and secondary raw materials grew

steadily between 2008 and 2015, with 44% of the total global amount of glass recycling patents occurring in the EU.

Based on the examples from European countries strategies, which are focused on the economic shift towards circular economy, can be noticed that every strategy on their beginning starts with methods of waste management. That is why in practical part of this work, the main focus is going to be on the representation of economic efficiency of separate municipal solid waste collection as one of the foundation actions to promote circular economy development.

3 MUNICIPAL SOLID WASTE MANAGEMENT AS A BEGINNING FOR THE TRANSITION TOWARDS CIRCULAR ECONOMY IN UKRAINE

This section presents the practical part of this paper. It reflects the problem of waste management and one of the methods to support it's solving on the way to sustainable development in the sphere of circular economy, on the example of Ukraine.

3.1 Analysis of the municipal solid waste management problem

Every day, a huge amount of unnecessary materials goes to waste. Besides that, this mixed composition also includes valuable components such as plastic, glass, paper, and metals. When the waste is transferred to landfills, these specific fractions cannot be recovered again. According to the Cabinet of ministers of Ukraine, Ukraine sending in the form of waste from 0,5 to 0,6 mln. tons of paper and carboard, 1 mln. tons of glass, 0,6 mln. tons of polymeric materials each year. In addition, this mixture contains a considerable number of hazardous components: mercury from household thermometers and fluorescent lamps, acid from batteries, etc. The regularly increasing volume of waste generation and the lack of funds for their management create a problem in most Ukrainian cities, as places for its landfilling are constantly decreasing. Despite the fact that over the last 20 years the population of Ukraine has been constantly declining, the volume of household waste is increasing. The increase in waste generation can be also partly explained with an increase in living standards, taking into account the positive correlation between the dynamics of GDP per capita and the levels of specific waste generation.

According to the Minregion, in 2018 (excluding data from the Autonomous Republic of Crimea and the city of Sevastopol) was generated almost 54 million m3 of household waste, or more than 9 million tons, which are disposed on the 6 thousand landfills with a total area of over 9 thousand hectares. The annual amount of waste per capita is about 300 kg (IFC, 2015).

Although the share of solid waste in the total amount of waste generated in Ukraine may seem insignificant - 2-3% (IFC, 2015), the effective functioning of this industry is very important because it directly affects the state of the environment near residential areas.

The problem of waste generation is distinguished by its particular scale and significance, both due to the fact that national economy of Ukraine mostly dominated by resource-intensive technologies that produce a lot of waste, and due to the lack of an adequate response to the emerging challenges for a long time.

Such circumstances lead to a deepening environmental crisis and aggravation of the socio-economic situation in society and necessitates reform and development taking into account domestic and international experience of the entire legal and economic system governing the use of natural resources and in particular waste management. The problem of waste is one of the key environmental problems and it is even more important in terms of resources.

The waste has a significant resource potential in the form of secondary raw material, that is residues of final consumption products (waste paper, polymers, cullet, worn tires, etc.). The high level of waste generation and low rates of their use as secondary raw materials have led to the fact that in Ukraine every year in both industrial and municipal sectors accumulate significant amounts of solid waste, of which only a small part is used as secondary material resources and the rest end up in landfills.

According to various data, the level of solid waste recycled in Ukraine ranges from 3 to 8%, including 2.71 percent (1.3 million m3) - recovered (burned), 3.09 percent (1.53 million m3) - sent to other recycling complexes and about 0.003 percent (2000 m3) - composted, while for the European Union the level of recycling is up to 60% of solid waste (IFC, 2015).

At the same time, more than 90% of solid waste is sent to landfills and unauthorized landfills. According to official data obtained from the Cabinet of ministers of Ukraine, 10.000 hectares of land are occupied by about 6,700 landfills and dumps, which occupy

7% of the territory, of which 256 (5.5 percent) are overloaded, and 1,347 units (26 percent) do not meet environmental safety standards. According to expert estimates, more than 99 percent of existing landfills do not meet European requirements (Council Directive 1999/31 / EU of 26 April 1999 On the landfill of waste).

However, according to the Ministry of Communities and Territories Development of Ukraine, there is a need for at least 626 new landfills for solid waste.

The lack of a system for recycling (including a system for separate collection) of household waste leads to the loss of millions of tons of resource-rich materials contained in waste that can potentially be used in economic circulation. According to the experience of developed countries, the introduction of waste into economic circulation ensures the formation of a significant part of gross domestic product and the creation of jobs. Until recently, the economic component was not a decisive factor in determining the government strategy for waste management. However, the lost economic benefits from the lack of sustainable waste management are quite significant. According to the UNDP estimates, in 2011 the potential profit from the disposal of paper was UAH 180 million, metals - UAH 225 million, and plastics - UAH 740 million per year. In total, taking into account the production of heat and electricity, the economic effect can reach 1.3 billion UAH (130 million euros as of 2011).

This situation necessitates the establishment and proper functioning of a national system for waste prevention, collection, recycling and recovery, decontamination and environmentally sound disposal. This should be an urgent task even in conditions of relatively limited economic opportunities for both the state and the main waste generators. Thus, the only possible way to resolve the situation is to create a comprehensive waste management system. Solving this problem is a key in addressing the issues of energy and resource independence of the state, saving natural and energy resources from excessive extraction, and an urgent strategic task (priority) of public policy.

Thanks to the introduction of separate collection of household waste in 1181 settlements, the operation of 26 waste sorting lines, 1 incinerator factory and 3 incinerator

equipment, was recycled and disposed about 6.2% of household waste, of which: 2% was incinerated and 4.2% transferred to the procurement points for secondary raw materials and to the waste processing plants (Minregion, 2019).

Excessive dependence on municipal waste disposal can no longer be the basis for household waste management in Ukraine. In addition, the Association Agreement signed in 2014 between Ukraine, on the one side, and the European Union, the European Atomic Energy Community and their Member States, from the other side, requires Ukraine to take immediate and decisive steps to implement European standards in the regarding area.

The main directions of state regulation of Ukraine in the field of waste management in the coming decades, are based on the European provisions:

- Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 On waste and repealing certain Directives.
- Council Directive 1999/31/EC of 26 April 1999 On the landfill of waste.
- Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006 on the management of waste from extractive industries.
- European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste.
- Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment.
- Directive 2006/66/EC of the European Parliament and of the Council of 6 September 2006 on batteries and accumulators and waste batteries and accumulators.

3.2 Calculation of the implementation of selective waste collection method on the example of residential complex “Geneva” in Dnipro city

The implementation goal of selective waste collection method reduce the volume of household waste disposal by introducing new modern highly efficient methods of their

collection. As a result of reducing the harmful effects on the environment and human health.

The introduction of selective waste collection is a long-term process that involves a gradual increase in the amount of waste collected selectively and sent for recycling. To calculate the economic efficiency of separate collection, it should be assumed that at the first stage this value will be 6–10% of the volume of all waste, followed by an increase to 70–75% in volume. To calculate the economic effect of selective waste collection, it is necessary to take into account the following income and expense items presented in Table 11.

Table 11. Income and expense items for calculating the economic effect of selective waste collection.

Possible items of income (savings)	**Possible expense items**
Income from the sale of secondary raw materials (taking into account its delivery to the consumer)	Purchase of specialized containers and equipment.
Reducing the cost of transporting waste to the sorting site (associated with the optimization of the scheme: the use of containers of a larger volume, a lower frequency of removal)	Increased costs of transporting waste to the sorting site (associated with the use of smaller containers and, therefore, a higher frequency of removal).
Avoiding the costs of transporting waste from the sorting site to the landfill.	Selective waste container maintenance costs.
Growth in production at existing facilities for sorting waste, without increasing it, compared to sorting mixed MSW (due to increased labor productivity of workers - sorters)	Reconstruction of container yards.
Avoiding the cost of waste disposal services or processing (other disposal) of mixed waste.	Waste sorting costs (including return on investment and loan servicing)
Avoiding environmental charges for waste disposal	Public awareness costs.

The most important problem for the Dnipropetrovsk region and in particular for the city of Dnipro is the organization of rational management of MSW, the volume of its creation, which is growing every year. Currently used municipal schemes for MSW management are economically, technologically, sanitary-epidemiological and environmentally ineffective. All this leads to the congestion of operating landfills and an increase in the number of unauthorized dumps in the suburban area. That is why, for solving these challenges in Dnipro was proposed the economically advantageous solution of separate waste collection.

According to the methodology of separate collection of household waste that was approved by the Order of the Ministry of Communities and Territories Development Components, SMW are determined by the following classification of:

- organic component of household waste that easily rots;
- paper and cardboard;
- polymers;
- glass;
- household scrap metal;
- textile;
- wood;
- hazardous waste as part of household waste;
- bones, skin, rubber.

The use of separate waste collection from the population can be more successfully applied in those houses where there is no garbage pipe, because the use of the garbage pipe leads to the dumping of all waste into one pile.

The Figure 3 below shows part of the city for which the method of separate collection of municipal waste will be applied. The new residential complex “Geneve” is being built in the Central district of Dnipro at the intersection of Korolenko and Kostomarivska streets. Within walking distance of Heroes' Square, Dnipro-Arena Stadium, Megaron Tennis

Club, Trinity Market. Proximity to the main thoroughfares of the city allows to be in the center of business and cultural life. The total area of the plot is 1.73 hectares.

The location of the quarter is shown in Figure 3.

Figure 3. Residential complex “Geneve”

Source: https://lun.ua/ru/%D0%B6%D0%BA-geneve-%D0%B4%D0%BD%D0%B5%D0%BF%D1%80, 10.01.2021.

Using the residential complex “Geneve” as an example, the calculation of proceeds from the sale of recyclable materials received in the process of sorting SMW by the population will be carried out, which will give an understanding of the efficiency of the processes of sorting SMW and their recycling in order to reduce environmental pollution.

At the moment, three houses have been commissioned in this residential complex (2 houses in the process): section 1 - 89 apartments, section 2 - 94 apartments, section 3 - 91 apartments, section 4 - 62 apartments, section 5 - 71 apartments, section 6 - 94 apartments, section 7 - 86 apartments, section 8 - 78 apartments and they are equal the total of 665 apartments. The living area is 45,000 sq.m.

It is determined that today the norm of living space for one person according to the Housing Code of Ukraine, art. 47 is equal 13.65 sq.m in average. Thus, the average population of the residential complex “Geneve” equals **P= 45000 / 13.65 = 3296 people**.

The total area **(Stotal) equals 60 000 sq.m**.

Density of the population (Dp) is calculated by the formula:

Dp = P/Stotal,

where **P-** population

Stotal- total area, sq,m.

Dp = 3296 / 60000 = 0,06 person/sq.m.

In accordance with the State Sanitary Norms and Rules, clause 2.8. to reduce the territory of the population of the city (approved by the Order of the Ministry of Health of Ukraine 17.03.2011 No. 145) container sites must be at a distance of at least 20m from the walls of residential buildings. Considering this, the maximum area of the residential sector **(Srs)** provided with one platform is 15,000 sq.m.

The number of people **(Q)** that will be served by one container platform is calculated by the formula:

Q = Dp × Srs ,

where **Q** - number of people that will be served by one container platform, people;

Dp - Density of the population, person;

Srs - area of the residential sector provided with one platform, m2;

Q = 0,06 × 15000 = 900 person;

The total number of waste accumulation platforms (**Nplat.**) for the GENEVE residential complex is equals - **4 pcs**.

According to the Decision of the Executive Committee of the City Council dated 31.08.2011 №1147 "On the establishment of tariffs for services for the removal (collection, transportation), recycling or disposal of solid and bulky household waste for all consumer groups" the general accumulation rate of SMW **(N)** for comfortable residential and public buildings is equals **2.01 m3 per person per year**.

The volume of SMW generated at one platform per day is calculated by the formula:

Vplat = (Q × N) / 365,

where **Vplat** - The volume of SMW generated at one platform per day, m3;

Q - number of people that will be served by one container platform, people;

N - the general accumulation rate of SMW among comfortable residential and public buildings in cities;

Vplat = (900 × 2,01) / 365 = 4,96 м3.

According to the Sixth National Communication of Ukraine on Climate Change, the structure of SMW includes food waste - 35-50%, paper and cardboard - 10-15%, secondary polymers - 9-13%, glass - 8-10%, metals - 2%, textiles - 4-6%, construction waste - 5%, wood - 1% and other waste - 10%.

Knowing the approximate morphological composition of the waste that enters the selection process, it is possible to get percentage of recovery of secondary raw materials by the following formula:

Rsrm = ksort × Σ (ri × Pi),

where **Rsrm** - share of recovered secondary raw materials (the ratio of the total mass of recovered secondary raw materials to the mass of sorted waste), in percentage;

ksort - the coefficient of the sorting process efficiency assumed to be equal 1, since the waste that goes into sorting is conditionally clean, "dry";

ri — recovery ratio of the extractable component;

Pi — Share of extractable component that consist in separately collected waste, in percentage.

The calculation of the possible percentage recovered of secondary raw materials is made in Table 12.

Table 12. The calculation of the possible percentage recovered of secondary raw materials.

Extractable component	Recovery ratio of the extractable component, **(ri)**	Share of component in waste, % **(Pi)**	Recovery of secondary raw materials, % **(Rsrm)**	Volume of secondary raw materials per day, m3
Paper waste	0,5	15	7,5	0,38
Polymers	0,8	13	10,4	0,52
Glass	0,8	10	8	0,4
Metals	0,8	2	1,6	0,08
TOTAL		40	27,5	1,38

Recovery ratio of the extractable component **ri**, depends on several factors: (Scientific journal Successes of modern natural science, 2018):

1) the nature of the component (whether or not it gets wet, decay, etc.);

2) characteristics of SMW (initial moisture content, fractional composition, etc.);

3) seasons of the year and weather conditions (wetting, freezing, etc.);

4) Waste collection and removal systems (general or separate waste collection, degree of waste compaction during transportation, overload, etc.).

According to the Table 12 the volume of collected secondary raw materials per day should be equal 1.38m3.

Based on the achieved volumes of collected secondary raw materials per day, the acceptable volume of container should be not less than 0.52 m3 to prevent its overloading. After market research of the possible options of containers, the optimal variant is a plastic euro-container with a volume of 700l (0.7 m3), which costs UAH 4960 **(Pc)** (Ltd. "Techmashinocomplect"). Regarding the analysed number of extractable component types of MSW presented in the Table 12, the 4 containers **(Ncont.)** per each platform should be implemented.

The costs of buying containers are calculated using the next formula:

Ccont. = Nplat × Nc × Pc.

Where **Ccont**. – costs of purchasing containers, UAH;

Nplat – number of container platforms;

Nc – number of containers;

Pc – price per one container;

Ccont. = 4 × 4 × 4960 = 79360 UAH.

Based on the amount of the recoverable component and its cost per 1 kg, it is possible to calculate the revenue from the separate collection of waste. Calculations are summarized in Table 13.

Table 13. Revenue from separate waste collection

Extractable component	Prices for receiving recyclable materials, UAH per 1 kg	Waste receiving organization	Volume of secondary raw materials per day, m3	Density of MSW in a heap, kg / m3	The amount of recyclable materials kg / day	Costs, UAH per day
Paper waste	1,5	EcoVtorGroup	0,38	60	22,8	34,20
Polymers	7	Ltd. Advans & Co	0,52	38	19,76	138,32

Glass	0,5	Ltd. Steklogroup	0,4	300	120	60,0
Metals	3,5	TransMetalDnepr	0,08	37	2,96	10,36
TOTAL			**1,38**		**165,52**	**242,88**

The income from the sale of recyclable materials will amount to 242.88 UAH per day from one container platform. Since the complex Geneva should be equipped by 4 platforms, the total income will be 971.52 UAH. The removal of separately collected waste is carried out as the containers are filled. That is why, removal of waste is going to be 15 times a month/ ones per 2 days.

Thus, monthly proceeds **(E)** will amount to 971.52 * 2 * 15 = 29145.60 UAH or 349747.20 UAH per year.

The payback period for installing euro containers for separate collection of SMW, can be calculated with formula:

PP = **Ccont/E**(per year),

PP = 79360/349747,20=0,23 of the year.

Thus, the installation of containers for separate collection of waste for residents of the GENEVE residential complex should pay off in 0.23 years or 2.76 months.

Based on the calculations made with use of the real example of the GENEVE residential complex, the volume of secondary raw materials recovered can be predicted for the whole Dnipro city. If 900 people account for 1.38 m3 of secondary raw materials per day, then for one person this will be 0.0016 m3 per day.

In 2017 the volume of MSW in the city was 1,912,989 m3. The population of Dnipro in 2017 was 9,664,00 people. Therefore, the volume of secondary raw materials obtained will be 966,400 x 0.0016 x 365 = 564,377.60 m3 per year, which is 29.5% of the total volume of MSW produced by the city in 2017. In monetary terms, the proceeds from the sale of recyclable materials separately collected throughout the city of Dnipro

will amount to 966 400 x 165.52 / 900 x 242.88 / 900 x 365 = 17 523 924.48 UAH per year.

Also, if to consider that the tariff for the utilization or disposal (placement at the city dump) of solid waste for the population is 13.08 UAH / m3 according with Decision of the Executive Committee of the City Council No. 1192 dated 12/04/2018, then additional savings from garbage that did not end up in the city dump will be 564 377.60 m3 x 13.08 UAH / m3 = 7 382 059.00 UAH per year. The total benefit from the introduction of selective waste collection in the city of Dnipro will be equal 17 523 924.48 + 7 382 059.00 = 24 905 983.48 UAH per year.

Based on the above calculations, the following conclusions can be made.

The implementation of the method of separate MSW collection will allow to increase the share of extraction of secondary raw materials, which in turn will reduce the environmental burden due to the return to economic circulation of resources that previously had a negative impact on the environmental situation in the city. There are also another positive arguments:

1. Environmental arguments

- decrease in the finite natural resource consumption, in particular forests;
- decrease in the amount of plastic waste that does not decompose naturally;
- prevention of pollution of the atmosphere, soil and groundwater;
- moral satisfaction from living in harmony with nature;

2. Hygienic arguments

- decrease in the incidence rate;
- decrease in the number of dumps and landfills;

3. Economic arguments

- introduction of low-waste technologies and saving of resources;

- creation of new jobs and reduction of unemployment;

- additional income for processing plants;

- replenishment of the city's budget due to higher volumes of processing;

- decrease in the size of territory allocated for landfills;

6. Social arguments

- raise of public awareness;

- education of careful attitude to nature;

- natural resources will last for future generations.

Regarding the existing problems the following recommendations can be proposed.

1. Since, the population is the main determinant towards the successful implementation of the separate MSW method, it is necessary to conduct targeted and continuous work with people to increase their interest in selective MSW collection in order to get the highest quality secondary raw materials.

There are five main informative and educational methods that determine the success of MSW management programs:

- Raising general awareness of the impact of waste on the environment and human health through social advertising, courses and seminars;
- Promoting economic attitude to the use of resources, explaining the feasibility of sorting and recycling waste;
- Providing information on types of MSW suitable for recycling, as well as, advantages, features and disadvantages of certain methods of waste management;
- Informing the population about solid waste legislation, relevant programs and initiatives, funding opportunities and compliance procedures;
- Development of appropriate models of consumer behavior in the market.

2. It is necessary to create an economic interest to improve the system of MSW management in terms of separate collection.

For example, to introduce the differentiated fees for selected and solid waste collection. Set a lower tariff for the removal of household waste with a multi-container collection system rather than with a mixed flow. Actually, in the perfect waste management system, the population should pay for the removal of only the non-recyclable part of the waste.

3. It is necessary to ensure the provision of high-efficient multi-container garbage trucks, that will collect different categories of waste without mixing it.

4. To create a system of two-stage transportation of household waste (with the construction of waste transshipment stations);

5. Application of composting of the organic part of household waste, pyrolysis, incineration and other methods of utilization or removal of the components in places of waste generation;

6. To ensure the localization of the negative impact on the environment from the decommissioned landfills;

7. To create modern landfills for household waste with neutralization of leachate and utilization of biogas.

Considering all above mentioned, significant amounts of waste accumulated in Ukraine and the lack of effective measures to prevent their formation, recycling, decontamination and disposal, deepening the environmental crisis and become an inhibitory factor in the development of the national economy.

CONCLUSION

The strategy for the successful transition towards CE is unique for each country, as they have their own specificities, and a simple copping of someone's methods will not bring to the great results, though it is possible to learn from the various examples of good implementation. That is why, based on the previously obtained experience the adoption of the CE concept should be a matter of complex involvement of all economic actors such as, individuals or households, firms and the state. Individuals and firms can contribute to the transition through the waste minimization by sorting and recycling waste, saving energy, as well as adopting new business models (encouraging consumers to adopt renting instead of owning). The state can facilitate the shift by adopting the new perspective initiatives, policy measures and incentives.

The CE concept can generate income and create new jobs, can help companies get ahead of potential limitations such as a lack of resources, taxation, externalities, and more. By using waste as a resource and applying the principles of a CE, it is possible to reach new milestones in economic development and competitiveness.

Taking into account the amounts of waste that Ukraine is accumulating every day, it is just starting to take some measures to address this problem. One of the great steps towards waste management was adoption of the law "About waste". However, implementation of this law faced with several crucial obstacles like, lack of proper infrastructure and decision-making on the municipalities and communities' levels.

Besides that, the new concept requires far stronger social involvement, collaboration on both the local and national levels, supporting industry clusters to trade in by-products, and a new urban management system that will require time to fully complete the transition. Also, it is necessary to continuously stimulate citizens both financially and in terms of education, as transitioning to a circular economy cannot be boiled down to a matter of infrastructure and technological advancement.

Regarding the EU legislative initiatives that focused on the CE development, it is important to put attention to the next problems that should be solved in the near future.

At first, it is necessary to bring economic instruments to a common denominator. Since the expansion of enterprises to other countries is especially common in the EU, the introduction of coordinated taxes on non-recyclable products, incineration and disposal of waste are of high priority, especially for countries with lower taxes on waste.

Secondly, it is necessary to assess the effectiveness of public policy initiatives influence, on the development of processing and recycling sectors. The problem with assessing is mostly due to the lack of the necessary statistics, imperfect assessment methods, and the conflict of interests between state and business.

In the third place, it is necessary to remove barriers to the introduction of a circular economy. Among the barriers that come in contradiction with the formation of incentives for the development of a circular economy, are:

• Countries that shift towards CE, at the same time continue to support waste incineration, leaving enterprises without valuable secondary resources.

• Some countries do not switch to purchase renewable resources, but paying suppliers of mineral resources, thereby subsidizing their further extraction;

• Countries that have problems with waste placement and logistics, focusing their investments to manage these problems rather than tackling waste generation problem.

That is why, due to the presence of barriers, the implementation of the CE needs to be stimulated.

At fourth, it is important to increase decision-makers awareness about CE models, as low level of informing slows down the development of legislative initiatives and the provision of incentives for the CE projects.

Considering the experience of the world’s leading countries, can be concluded that the legal obligation of proper utilization of waste to the economic circulation is economically and environmentally feasible.

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