RAPID ASSESSMENT REPORT ON THE BENEFITS OF CIRCULAR ECONOMY ON MITIGATION OF GHGs EMISSION IN THE WASTE SECTOR

Republic of North Macedonia

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Abbreviations and acronyms

CE	Circular Economy
CO_2-eq	Carbon Dioxide equivalents
C&D	Construction and demolition
EC	European Commission
ELVs	End of Life Vehicles
EPR	Extended producer responsibility
EU	European Union
GHG	Greenhouse gas
GWP	Global Warming Potential
IND4.0	Fourth industrial revolution
IPCC	International Panel on Climate Change
LCI	Life cycle inventory
MBT	Mechanical and biological treatment
MS	Member states
NDCs	Nationally Determined Contributions
NMWP	National Waste Management Plan
SRF	Solid Recovered Fuel
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
WFD	Waste Framework Directive
WtE	Waste to Energy

Units and Metric Symbols

UNIT	Name	Unit for
g	gram	mass
W	watt	power
J	joule	energy
m	meter	length
Wh	watt hour	energy
toe	ton of oil equivalent	energy
Mass Unit Conversion		
1g		
1kg	= 1 000 g	
1t	= 1 000 kg	= 1 Mg
1kt	= 1 000 t	= 1 Gg
1Mt	= 1 000 000 t	= 1 Tg

Metric Symbol	Prefix	Factor
P	peta	10^{15}
T	tera	10^{12}
G	giga	10^{9}
M	mega	10^{6}
k	kilo	10^{3}
h	hecto	10^{2}
da	deca	10^{1}
d	deci	10^{-1}
c	centi	10^{-2}
m	milli	10^{-3}
µ	micro	10^{-6}
n	nano	10^{-9}
p	pico	10^{-12}

EXECUTIVE SUMMARY

The project “Rapid Assessment Report on the Benefits of Circular Economy on Mitigation of GHGs emission in the Waste Sector” includes the following tasks:

- A desk review of current policies and laws related to the waste sector and an assessment if they create an enabling environment for promotion of circular economy, and how much are they in line with the relevant EU Directives and policies and plans, particularly with the Circular Economy Action Plan of the EU Green Deal;
- An assessment of the potential benefits of employing circular systems that will minimize the use of resources input, foster sustainable consumption, and decrease the waste, pollution and carbon emissions;
- The identification of both Opportunities and Challenges for the introduction of Circular Economy focused on mitigation of GHG emission in the Waste Sector on policy and implementation level. The focus should be put on the sectors that use most resources and where the potential for circularity is high such as: electronics and ICT; batteries and vehicles; packaging; plastics; textiles; construction and buildings; food; water and nutrients;
- Propose ways to empower consumers and public buyers and to make circularity work for people, regions and cities;
- Prepare a rapid assessment report of the benefits of Circular Economy focused on Waste Sector and provide recommendations for the way forward;
- Present the final rapid assessment report and roadmap to relevant stakeholders (on-line, using zoom or other relevant tools)
- Prepare a Policy Brief on the main findings and recommendations for the policymakers.

Based on the previous, the report of the project is structured in eight chapters that demonstrate the whole spectrum of circular economy, its potential and the challenges involved.

The first chapter is an introductory one regarding the project beneficiaries and the scope of work.

Chapter 2 explains the interconnections between Circular Economy, Waste Management and Climate Change and it includes the definitions and indicators relevant to Circular Economy. The main outcome of this chapter is that the potential of CE to mitigate GHGs is enormous and goes far beyond traditional waste management.

Chapter 3 presents an overview of the EU policies and framework regarding circular economy, as well as the CE monitoring framework. **A major conclusion from this chapter is that Circular Economy (CE), together with Climate Change policies, is one of the main two pillars of the EU policies for the next 15-20 years**, thus CE principles and concepts have to be incorporated to all the different levels of governance and governmental operations.

Two brief chapters (chapter 4 and 5) present the key-considerations from the Macedonian National Waste Management Plan and the 3rd Biennial Update Report and the Enhanced Nationally Determined Contribution.

Chapter 6 is the core of the report as it includes a systematic approach to quantify the economic and environmental benefits from the shift to CE on a national level for North Macedonia. **Six case studies were selected**, in accordance the priorities of the National Waste Management plan, **to demonstrate the benefits from the shift to CE** and a relevant methodological approach was developed. The case studies concern the **End of Life Vehicles, Biowaste, Construction & Demolition Waste, the use of Solid Recovered Fuel, Waste from Electric & Electronic Equipment and Plastic waste**.

Overall, it was assessed that **applying circular practices** to the selected case studies and waste streams **can deliver, by 2030**:

- 951 Gg CO2eq/year **GHGs savings** comparing to 2016
- 2,740 **new jobs**
- 47.17 million EUR of **economic benefits**

The total emission savings is equivalent to 201% of the solid waste disposal emissions and reached up to 156% and 111% of the emissions from the Waste and Industrial Processes and Product Use sectors, respectively. **That means that the shift to circular practices, even if it is restricted to those six case studies, is enough to counterbalance the emissions from solid waste disposal (almost double savings), and the emissions from the Waste and Industrial Processes and Product Use sectors**.

Chapter 7 sheds light to governance issues, a rather underestimated component of the shift to CE. As it is explained, **the shift to CE requires a serious transformation in governance issues and patterns**. The important role that governments can play is highlighted and three overarching goals for a governmental agenda are proposed for North Macedonia, namely, a. **Goal 1:** To reduce dependence on the import of raw materials b. **Goal 2:** To achieve economic prosperity c. **Goal 3:** To reduce environmental impact and/or increase economic added value of raw materials. The importance of developing proper information systems is discussed as a condition for managing and stimulating circular practices.

The development of proper Extended Producer Responsibility schemes for several waste streams is proposed and new legislative measures to promote the use of SRF and composting are required. The role of **economic incentives** in promoting reuse, repair and recycling practices is discussed and a tax reform that shifts the burden to resources rather than labor is outlined, in accordance with the discussions held in many EU countries. Last but not least, **a Recycling Agency**, as a separate department of the Environmental Agency, is proposed.

Finally, Chapter 8 presents and **prioritize the main steps for the way ahead**. The recommendations are the following ones:

1. Develop a horizontal government agenda on CE.
2. Proper EPR systems should be developed for C&D waste, E-waste, ELVs

3. Prepare a Recycling Agency as a part of the Environmental Agency
4. Invest in Information Systems to monitor and stimulate circular practices
5. Start to pilot reuse initiatives in different levels.
6. New legislation and certification procedures should be developed for compost and composting.
7. New legislation and standardization procedures should be developed for SRF.
8. A serious upgrade and new initiatives are required in plastic waste management.
9. Think of economic incentives for repair & reuse and test different approaches.

Overall, the **report concludes that Circular Economy becomes a condition to achieve the targets of Paris Agreement and to mitigate GHGs**. Thus, Circular Economy should not be considered an option for policy making but a main pillar of each and every policy option available. **The question is not if we need Circular Economy but how and how fast we can implement it**.

Another important element that was outlined through all the report regards the role of waste management in this context. Although circular practices concern the major industrial and manufacturing supply chains in rich countries, in countries like North Macedonia where the rate of industrialization is currently rather low and imports of manufactured materials are the main way to acquire them, the starting point for a shift to circular practices should be the waste management sector. By shifting the management of specific waste streams to circular practices, not only substantial environmental and economic benefits are achieved but **the waste management sector can act as a catalyst for the whole economy of the country**.

1. Introduction

The Ministry of Environment and Physical Planning (MoEPP) is revising the Macedonian Nationally Determined Contributions (NDCs) under the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC), supported by the United Nations Framework Convention on Climate Change (UNDP) Climate Promise Initiative (UNFCCC, 2015). The waste sector is the second largest source of greenhouse gases in North Macedonia, encompassing the following categories: Solid Waste Disposal, Biological Treatment of Solid Waste, Incineration and Open Burning of Waste, and Wastewater Treatment and Discharge. Uncertainly levels in the greenhouse gas (GHG) inventory for the waste sector are high due to difficulties in obtaining accurate data on waste generation and disposal.

Solid waste disposal is the category with the highest share of GHG emissions in this sector. In 2016, approximately 384 kg per capita per year of municipal waste was generated, and most of the collected residual municipal waste (99.4%) is disposed of in landfills. The Drisla Landfill, which serves the Skopje region, is the only sanitary landfill in Macedonia. Composting is still at a very early stage, the composting plant in Resen is not currently operational, and 2 other operational composting units in Probistip with volume of 60 tonnes/year biowaste per unit. Finally, many Macedonian mining and processing industries that generated hazardous waste have closed down, abandoning their on-site waste dumps with little or no information on the history of these dumpsites. Other key issues include a lack of implementation of existing legislation (new legislation developed, but not yet adopted) and the absence of waste separation and recycling facilities, including an absence of facilities for vehicle recycling and automotive waste management.

During the preparation of its Second and Third Biennial Update Report (BUR) to the UNFCCC, the country explored the impact of ongoing, planned, and potential measures for climate change mitigation. Waste sector measures include landfill gas flaring, Mechanical and biological treatment (MBT) in new landfills with composting, waste selection and improved waste and materials management at industrial facilities.

The Republic of Macedonia is a party of the United Nation Framework Convention on Climate Change (UNFCCC) (Official Gazette of RM – 61/97), has ratified the Kyoto Protocol (Official Gazette of Republic of Macedonia - 49/04) and has associated itself with the Copenhagen Accord (2009). The country has also signed (in 2015) and ratified (in 2017) the Paris Agreement. Under the Paris Agreement, the country became the twenty-third in the world to submit its Intended Nationally Determined Contributions for Climate Change (INDC) as per the Decision of the Government No. 42-17/91 of 28 July 2015.

The Ministry of Environment and Physical Planning (MOEPP) has been designated as the National Focal Point to the UNFCCC and as a Designated National Authority (DNA) for the implementation of the Kyoto Protocol. Other ministries that have responsibilities related to climate change aspects are the Ministry of Agriculture, Forestry and Water Economy, the Ministry of Economy, the Ministry of Transport and Communication, the Ministry of Health and the Ministry of Finance. The Office of the Deputy Prime Minister for Economic Affairs is responsible for the achievement of the Sustainable Development Goals (SDGs), and it is also a National Designated Entity for the Green Climate Fund. The Office of the Prime Minister for Economic Affairs also supports the implementation of climate and energy-related projects in the country.

As an EU candidate country, North Macedonia is in the process of transposing the acquis and will be obligated to comply with the Waste Directive and with EU requirements in the area of circular economy.

In summary, **policies and measures for the waste sector must meet three requirements: 1) They must address urgent economic, social, and environmental issues in the waste sector; 2) They must support the move to a low-carbon society and international commitments to the UNFCCC and the Paris Agreement; and 3) They must support the bilateral process of EU accession.**

1.1 Scope of Work

According the Terms of Reference of the project, the consultant will undertake the following tasks:

- Conduct a desk review of current policies and laws related to the waste sector and assess if they create an enabling environment for promotion of circular economy, and how much are they in line with the relevant EU Directives and policies and plans, particularly with the Circular Economy Action Plan of the EU Green Deal; ;
- Familiarize with the proposed mitigation measures within the 3rd Biennial Update Report and Revised Nationally Determined Contribution under the Paris Agreement
- Assess the potential benefits of employing circular system that will minimize the use of resources input, foster sustainable consumption, and decrease the waste, pollution and carbon emissions;
- Identify both Opportunities and Challenges for introduction on Circular Economy focused on mitigation of GHG emission in the Waste Sector on policy and implementation level, based on one of the key actions - less waste more value, applied in three building circular blocks: rethinking product design, innovative business models and reverse logistics; The focus should be put on the sectors that use most resources and where the potential for circularity is high such as: electronics and ICT; batteries and vehicles; packaging; plastics; textiles; construction and buildings; food; water and nutrients;
- Propose ways to empower consumers and public buyers and to make circularity work for people, regions and cities;
- Prepare a rapid assessment report of the benefits of Circular Economy focused on Waste Sector and provide recommendations for the way forward;
- Present the final rapid assessment report and roadmap to relevant stakeholders (on-line, using zoom or other relevant tools)
- Prepare a Policy Brief on the main findings and recommendations for the policymakers.

2. Circular Economy, Waste Management and Climate Change

2.1. Circular Economy and Climate Change

The European Green Deal provides a roadmap with actions to a. boost the efficient use of resources by moving to a clean, Circular Economy (CE), and b. to restore biodiversity and cut pollution. The core of the EU Green Deal is to turn climate and environmental challenges into opportunities across all policy areas and making the transition just and inclusive for all. **It is important to notice that the shift to circular economy is a condition for achieving the Paris Agreement targets regarding climate change**. This is because the required reduction of CO_2 emissions can only be possible under two main conditions a. massive investments in renewable energy projects, in different forms, and b. electrification of the urban mobility and transportation networks, which will only be possible with the use of new and more efficient batteries in a massive scale. The International Resource Panel has assessed (Suh et al., 2017) that there is a need for almost 1.5 billion tonnes of metals are required to implement the shift towards a less carbon-intensive economy. Such a demand for metals will certainly outweigh the availability of the supply chains and it will be impossible to be met without substantial circular loops. ***This means that the shift to circular economy becomes a condition for the substantial reduction of GHGs.***

In addition, **circular economy has to be considered not as an environmental policy *but as a new economic model*** (Korhonen, 2018) constructed from societal production-consumption systems that maximizes the service produced from the linear nature-society-nature material and energy throughput flow. This is done by using cyclical materials flows, renewable energy sources and cascading-type energy flows. Successful circular economy contributes to all the three dimensions of sustainable development. Circular economy limits the throughput flow to a level that nature tolerates and utilizes ecosystem cycles in economic cycles by respecting their natural reproduction rates. Considering circular economy as a new way of economic development creates serious implications for developing countries like North Macedonia as they have to balance between a certain economic growth that will allow them to cover the needs of their societies and economic initiatives that will integrate any growth in a circular economy model, without substantial and irreversible pollution, health and environmental impacts. *Thus, the conclusion is that the European Green Deal and the new Circular Economy Action Plan provide the guidelines but not the roadmap to circular economy for North Macedonia. This roadmap will be outlined by the adoption of the guidelines and their adaptation to the local culture and the domestic social, economic, and environmental conditions.*

2.2. Waste Management and Circular Economy

Waste management is reshaped by the interaction of five global trends (Mavropoulos and Anders, 2020). These five trends made their influence obvious during the period 2015–2020, and their combined effect stimulates a systemic change in waste management theory, practices, business, and legal instruments.

- Global warming increases the importance of waste management as a way to achieve immediate reductions in CO_2 emissions while reducing pollution and improving health and environmental protection. The incorporation of waste management practices in resilience and adaptation plans is an urgency for existing and historical infrastructure.

- Circular economy became a mainstream narrative for the last five years. Although there is no concrete definition and theory behind it, **circular economy pushes waste management towards a better integration with resource management and integrates waste management practices in each and every supply chain**. Circular economy concerns a much broader change than waste management practices. The concept should be further adapted to the needs and practices in low- and middle-income countries in which informal activities are already shaping circular practices.
- Marine litter and plastic pollution have also become top priorities on a global scale due to the massive evidence regarding their leakages and impacts in marine ecosystems. Plastic pollution in oceans and water is considered as a failure of the plastic industry and our modern waste management systems. As plastic has a central role in human societies, marine litter and plastic pollution have triggered a global wave of new regulations and measures to reduce plastics (starting from single use ones), advance their recycling, and redesign them for recyclability.
- The rise of the fourth industrial revolution (IND4.0) redefines the terms "resources" and "waste" through the new technological advances that reshape manufacturing, raw materials, and products. A new massive e-waste stream is expected as a result of the growing impact of IND4.0, while IND4.0 is already transforming the waste management industry delivering new solutions and data driven business models.
- Starting with China, many countries that were receiving recyclables from the United States, EU, and Australia raised quality standards to avoid pollution related to "dirty recyclables" imports. These moves, supported by a recent Basel Convention resolution, create a new global landscape especially in plastic recycling and oblige the exporting countries to find new domestic solutions. As a result, governments, local authorities, and the recycling industry in many countries have to face the end of recycling as we know it and deliver innovative business models for sustainable recycling programs.

The obvious impact of the five trends is that they push waste management closer to resource management and integrating more the waste management systems in the broader resource management. However, the circular economy as well as the zero waste approaches require much more and not less waste management. Their implementation requires advanced management of multiple streams of materials, before they become waste but after they have been discarded from the main production. Those streams must be as clean as possible in order to have high added value, so advanced treatment for removal of residuals will be required, in one or another way (Mavropoulos, 2015). And of course, there will be always residuals looking for appropriate final sinks, including energy recovery where this is possible. For that reason, the road to circular economy passes through substantial improvements of the waste management sector and IND4.0 advances can deliver the required shifts.

2.3. The role of final sinks

Final sinks are becoming a central element of the shift to circular economy as a result of the combined interaction of circular economy, IND4.0, and the core mission of waste management. Both landfills and waste to Energy (WtE) plants have a crucial role for the transition to a circular economy, as it will be explained below.

What makes final sinks so important? The answer is time. How much time do we need for a shift to circular economy? Based on historical experiences a 30–50years' time for the shift of the majority of the world population to more circular practices would be a huge achievement, although there is no evidence that this is possible. But let's assume that it can be done by 2050. In these 30 years, between 2020 and 2050, we need to advance the technologies, the governance, and the business models required to deliver closed loops at least for the most scarce and hazardous materials. In these 30 years there will be at least 650 billion tonnes of total waste produced worldwide (Kraussman et al, 2017). How we will manage them without proper financial sinks? What is clear is that the transition to a circular economy will not happen automatically and that for a long period, for all the different waste streams and substances, there will be a growing need to ensure proper final sinks, with minimum health and environmental impacts. This will allow the world to develop the technologies, the governance, and the business models required for advanced circularities. In addition, this is the good case – the bad case is that, no matter how good we will become in circularities, there are global limits, the laws of thermodynamics, and the problem that energy is not recycled that restrict the impact of circular loops that is so often overestimated.

What we need is to develop integrated sustainable waste management systems that will allow us to advance circular loops and ensure safe final disposal for the most harmful waste and the nonrecyclable (for technical or financial reasons) part. In these systems, Waste to Energy (WtE) plants and simple incinerators for hazardous waste as well as sanitary landfills have a crucial role to play. The safe disposal of waste is of equal (if not higher) importance with recycling activities. Modern incinerators are the only long-term solution that wipes out hazardous pollutants and chemical pollution, and sanitary landfills can provide the proper final (although not in the long term) storage for materials that can't be recycled or incinerated for technical or economic reasons.

2.4. GHGs and the Waste Sector

The waste sector is considered as a small contributor to the overall GHGs emissions, contributing almost 3% of worldwide GHG emissions in 2010 (Blanco et al., 2014). However, it can be a major contributor to GHGs savings at a country level through selected technologies and systems. Especially in low and middle - income economies, emissions from the waste sector can reach up to 15% of total country emissions (Maalouf and El-Fadel, 2018). This point is further strengthened by a broader understanding of the linkages between waste management – circular economy and climate change. The primary sector, covering the extraction of raw materials including mining, mineral extraction, agriculture, fishing, and forestry, is probably the most wasteful sector, at least in terms of quantities. It has been assessed (Circle Economy, 2016) that **worldwide almost 50% of the GHGs are related to primary materials**; thus **if we were able to reduce the emissions related to materials about**

20–30% with circular economy strategies, we would be able closing half of the emission gap between existing commitments and the 1.5 °C pathway in 2030. Consequently, any potential circularity or resource recovery improvement in the primary sector will have huge effects in the overall system by activating the domino effects.

For the case of **Macedonia, the Waste Sector accounted for 6% of the total country emissions in 2016**. The overall emissions from this sector are estimated at 610.2 Gg CO2-eq in 2016 (UNDP, 2019). Interestingly, the trend assessment for 1990 and 2016 conducted in the Macedonia's third Biennial Update Report on climate change (UNDP, 2019) showed that the Waste sector is one of the sectors with an increasing trend of GHG emissions achieving 610 Gg CO_2-eq in 2016, which is doubled compared to 1990 or 6.3% more compared to 2014. This highlights the importance of potential carbon credit from this sector in comparison of other sectors under the UNFCCC.

The growth of voluntary mechanisms for GHG emissions estimation and reduction can thus stimulate actions for mitigating climate change and enabling new openings for initiatives and public administrations (Gentil et al., 2009; Friedrich and Trois, 2010). Despite many voluntary and carbon market driven initiatives in higher income economies, low and middle - income countries did not have mandatory obligations for reducing emissions under the Kyoto Protocol. The situation has changed following the Paris agreement (United Nation, 2015) whereby it became mandatory for all parties to report regularly on their emissions and implementation efforts through NDCs that incorporate attempts by each country to decrease national emissions and adapt to climate change impacts. In this respect, MSW management has emerged as a potential to reduce GHGs in developing economies in particular.

2.5. CE definitions and indicators

Definitions of CE have been extensively reviewed by academics and scholars. CEPS scholars (Rizos et al., 2017) have found that there is a wide range of interpretations and definitions of CE that represent the diverse goals and opinions of the various stakeholders concerned. Definitions start by relying entirely on material flows and resources, heading to a massive restructuring of the economic system that extends well beyond waste and resource management. They concluded that "The circular economy is a complex concept and it is unlikely that in the short term there can be an international consensus on its meaning." Sacchi Homrich et al. (2018) analyzed 327 academic papers and concluded that there is a lack of agreement on the use of various definitions and terms for the CE among academics, policymakers and practitioners examining the patterns, trends, differences, gaps, and convergence of the CE literature. Two different clusters are also shown in the literature analyzed. One cluster focuses on eco-parks and industrial symbiosis, mostly in China. The second class includes supply chains, material closed loops and business models. Similarly, Kirchherr et al. (2017) reviewed 114 circular economy definitions which were coded on 17 dimensions. In this paper, within addition to acknowledging the conceptual blurriness, the writers have established a unifying and synthesized definition that aims to resolve the differences they have found. According to this definition, "circular economy is an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes. It operates at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, thus simultaneously creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations. It is enabled by novel business models and responsible consumers." A similar definition has been proposed by Korhonen et al. (2018): "Circular economy is an economy constructed from societal production-consumption systems that maximizes the service produced from the linear nature-society-nature material and energy throughput flow. This is done by using cyclical materials flows, renewable energy sources and cascading-type energy flows. Successful circular economy contributes to all the three dimensions of sustainable development. Circular economy limits the throughput flow to a level that nature tolerates and utilizes ecosystem cycles in economic cycles by respecting their natural reproduction rates."

According to the EU definition (European Commission, 2015), "The transition to a more circular economy, where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimized, is an essential contribution to the EU's efforts to develop a sustainable, low carbon, resource efficient and competitive economy. Such transition is the opportunity to transform our economy and generate new and sustainable competitive advantages for Europe." A research report by CEPS (Rizos et al., 2017) refers to three problems in the EU definition, namely, (i) the lack of importance in energy resources, (ii) the absence of the social dimension of sustainability, and (iii) the missing emphasis to the quality of materials and resources.

To summarize, there is no generally agreed definition of the term 'circular economy,' but various interpretations reflect the general principle of decoupling natural resource extraction and utilization from economic output, with improved resource productivity as a primary outcome. Many scientists believe that there is an urgent need to develop a commonly accepted and internationally recognized definition of the circular economy that will allow academics, practitioners and policy makers to communicate in a common language, as needed to make the implementation of the circular economy more pragmatic. It appears that the definitions set out above by Kirchherr et al. (2017) and Korhonen et al. (2018) are more appropriate, since they include all aspects of sustainable development (economy, environment, and society). However, it should be necessary to provide a variety of coexisting narratives (Schröder et al., 2019), each representing separate and sometimes overlapping social, economic and environmental contexts and, thus, separate iterations of the circular economy. This will lead to diversified policy strategies and different country-specific pathways, especially for the developing world, since there is certainly no one-size-fits-all approach to the circular economy as well. (Scoones, 2015).
We recognize that we potentially exclude possible meanings by including only one CE definition. Nevertheless, in order to identify the indicators, we need to specify the boundaries of the various CE approaches (Moraga et al., 2019).

It is possible to tell a similar story when defining indicators. In fact, the word "indicator" has been defined in the literature in different ways (Park and Kremer, 2017; OECD, 2014; Joung et al., 2012; Singh et al., 2012; EEA, 2003; Saidani et al., 2019) and there is no generally accepted definition of an indicator. We adopt the global view of the OECD (2014) where an indicator is defined as "a quantitative or qualitative factor or variable that provides a simple and reliable means to measure achievement, to reflect changes connected to an intervention, or to help assess the performance of a development actor".

An indicator framework involves a set of indicators that "conveys a broader purpose and significance to the individual indicator and provides a comprehensive picture of some entity" (Wisse, 2016). Indicators thus summarize knowledge, can help to expose complex phenomena and provide an important tool for measuring change and performance.

It is also important to note that other terminology is used to define assessment tools, such as "Measures," "Metrics," "Index" or "Indices". In reality, the use of adequate synonyms during the research process is crucial to maintain a thorough identification of existing Circular-indicators. Even if there are minor semantic variations between these words, most scholars use them interchangeably. In order to cope with and better handle a large number of indicators, it may be helpful to identify the classification (i.e. taxonomy or typology) of indicators in order to improve their selection process (Lützkendorf and Balouktsi, 2017).

There must be a clear distinction between methodology, method, model and indicator. The CE assessment includes methodologies (e.g. LCA) that are a series of methods (e.g. LCA impact categories). A method integrates models, tools, and indicators that are significant to show information on circularity (technological cycles or its cause-and-effect modelling). A model is a mathematical description of the calculation of an indicator that can be derived from a tool. The indicator is a variable (parameter) or function variable providing information on circularity (technological cycles) or causes (cause-and - effect modelling). Moreover, the composite information on quantitative and qualitative data may result in an indicator (Moraga et al., 2019).

3. Overview of EU Directives and policies and plans on CE

The European Green Deal (**Figure 1**) provides a roadmap with actions to a. boost the efficient use of resources by moving to a clean, circular economy, and b. to restore biodiversity and cut pollution. It outlines investments needed and financing tools available and explains how to ensure a just and inclusive transition. The core of the EU Green Deal is to turn climate and environmental challenges into opportunities across all policy areas and making the transition just and inclusive for all.

Late 2015, the European Union (EU) approved an action plan to implement CE across the union and member states (European Commission, 2015). The new Circular Economy Action Plan is one of the main blocks of the European Green Deal, presenting measures to:

- Make sustainable products the norm in the EU;
- Empower consumers and public buyers;
- Focus on the sectors that use most resources and where the potential for circularity is high such as: electronics and ICT; batteries and vehicles; packaging; plastics; textiles; construction and buildings; food; water and nutrients;
- Ensure less waste;
- Make circularity work for people, regions and cities,
- Lead global efforts on circular economy.

The new Action Plan announces initiatives along the entire life cycle of products, targeting for example their design, promoting circular economy processes, fostering sustainable consumption, and aiming to ensure that the resources used are kept in the EU economy for as long as possible.

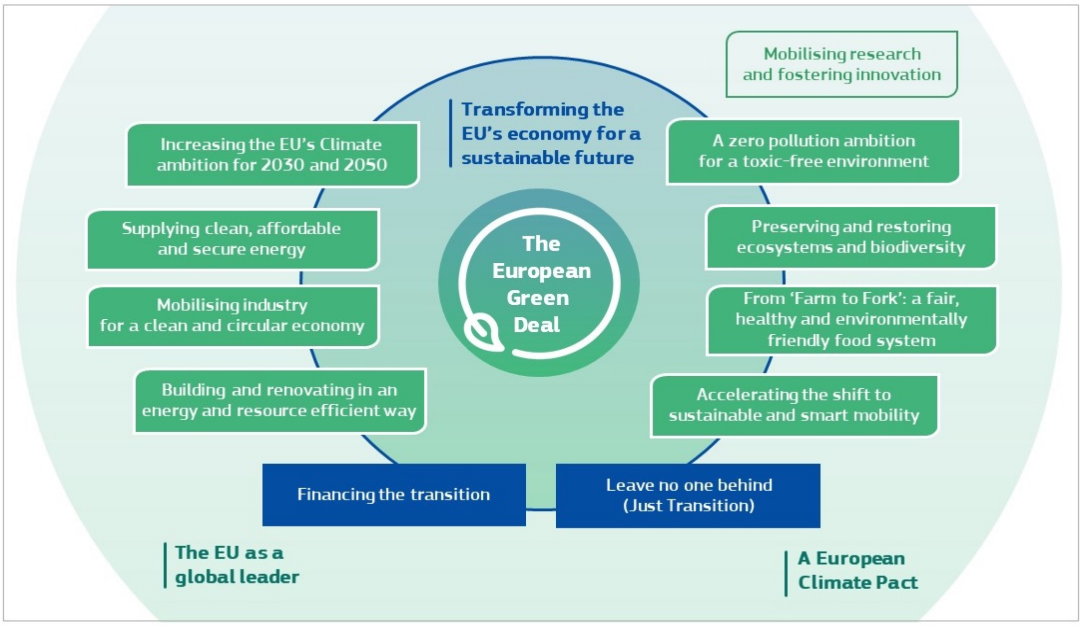


Figure 1. The European Green Deal (Source: European Commission, 2019a)

However, elements of CE have already been present in other EU policies, for example resource efficiency (European Commission, 2011) and waste-related legislation developed since the 1970s (CEC, 1975). In 2018, EU adopted its Circular Economy Package (European Commission, 2016) that includes a strategy for plastics in circular economy; a proposal for port reception facilities; a communication on how to address the interface between chemical, product, and waste legislation; a monitoring framework on CE (European Commission, 2018); and a report on critical raw materials and the circular economy. In March 2019, the European Commission issued a comprehensive report on the implementation of the Circular Economy Action Plan (European Commission, 2019b), which was adopted in 2015. The report presents the main achievements under the action plan and sketches out future challenges to shaping EU economy and paving the way towards a climate-neutral circular economy where pressure on natural and freshwater resources as well as ecosystems is minimized In addition, EU has created the Circular Economy Stakeholder Platform (European Union, 2018), a virtual open space that aims at promoting Europe's transition to a circular economy by facilitating policy dialogue among stakeholders. There is no doubt that the most important impacts by the adoption of circular economy have been to the waste sector. A serious revision of the waste legislation has entered into force by July 2018.
The main elements are the following:

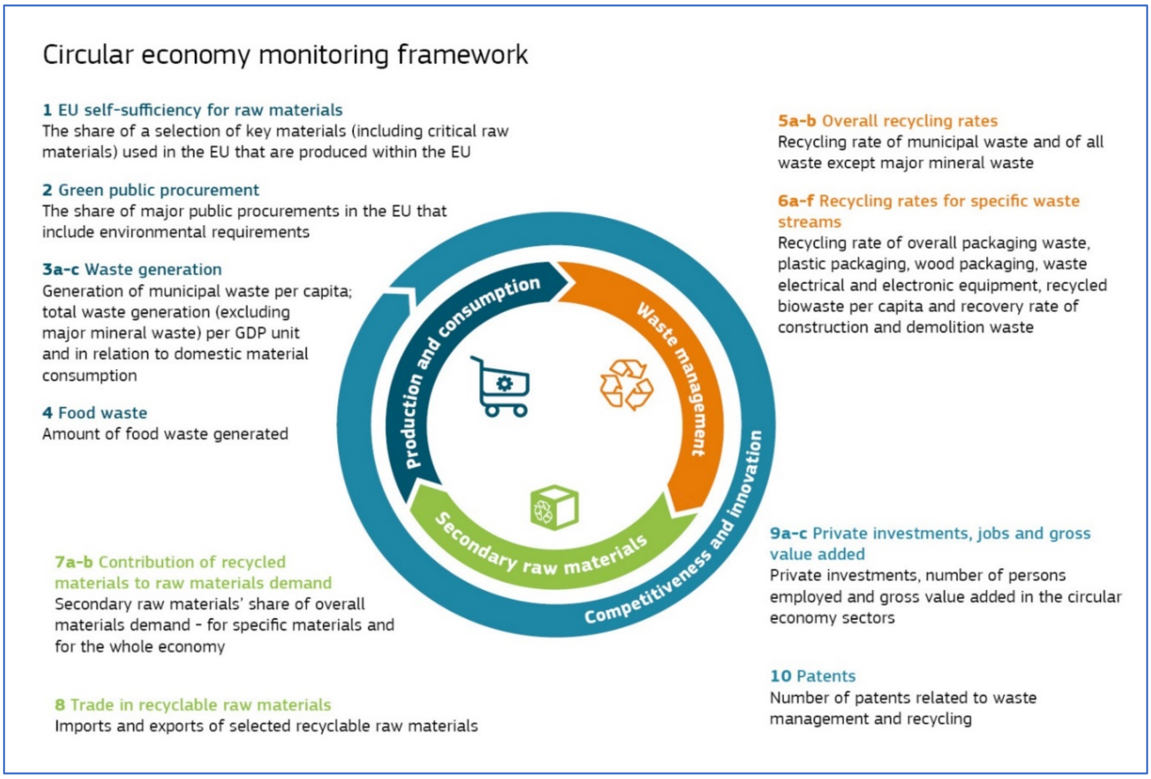
- A common EU target for recycling 65% of municipal waste by 2035.
- A common EU target for recycling 70% of packaging waste by 2030 (plus targets for each material).
- A binding landfill target to reduce landfill to maximum of 10% of municipal waste by 2035.
- Separate collection obligations are strengthened and extended to hazardous household waste (by end of 2022), biowaste (by end of 2023), and textiles (by end of 2025).
- Minimum requirements are established for Extended Producer Responsibility (EPR) schemes to improve their governance and cost efficiency.
- Prevention objectives are significantly reinforced, in particular, requiring member states to take specific measures to tackle food waste and marine litter as a contribution to achieve EU commitments to the UN SDGs.

It is important to notice that according to the agenda set by the new European Commission President Ursula von der Leyen, EU aims to become the world leader in circular economy. A new circular economy action plan focusing on resource-intensive and high-impact sectors such as textiles and construction is expected. Austria, Germany, France, Netherlands, and Belgium are playing a central role to push the whole EU towards circular economy.

3.1. CE monitoring framework' in the European Union

In this initiative, the indicators recently proposed by the European Commission (EC) (European Commission, 2018) were selected to explain the framework for macro-scale (regional / country) indicators for the case of Macedonia. The EC proposal is one possible example of macro-scale CE indicators; other examples might include proposals from the Netherlands (Potting et al . , 2018), France (Magnier et al., 2017), or China (Geng et al . , 2012) with recent attempts to provide indicators based on emergencies (Geng et al., 2013).

We present an overview and analysis of 'CE monitoring framework' illustration and we provide an overview of the CE indicators classification.



(Source: European Commission, 2018)

3.1.1. Classification of the 'CE monitoring framework' and CE indicators: overview and analysis

The CE monitoring framework is the EC proposal for measuring CE progress in the EU and Member States (European Commission, 2018). The 'CE monitoring framework' divides indicators into four topics: production and consumption, waste management, secondary raw materials, and competitiveness and innovation (see Table 1). Those are closely related with the priority areas from the CE Action Plan in Europe: plastics, food waste, critical raw materials, construction and demolition, and biomass and bio-based products (European Commission, 2015). The EC proposal contains ten indicators, but six of them do have so-called 'sub-indicators.' In total, the proposal uses twenty-four measuring guides. The indicators are based on Eurostat' existing data from, the Raw Materials scoreboard, and the Resource Efficiency scoreboard (European Commission, 2018).

Table 1. Indicators on the circular economy included in the monitoring framework

No	Indicator	Sub-indicator
Production and consumption		
1	EU self-sufficiency for raw materials	
2	Green public procurement*	
3	Waste generation	3a Generation of municipal waste per capita
		3b Generation of waste excluding major mineral waste per GDP unit
		3c Generation of waste excluding major mineral waste per domestic material consumption unit
4	Food waste*	
Waste management		
5	Recycling rates	5a Recycling rate of municipal waste
		5b Recycling rate of all waste excluding major mineral waste
6	Recycling /recovery rates for specific waste streams	6a Recycling rate of overall packaging waste
		6b Recycling rate of plastic packaging waste
		6c Recycling rate of wooden packaging
		6d Recycling rate of electrical and electronic waste (e-waste)
		6e Recycling of biowaste per capita
		6f Recovery rate of construction and demolition waste
Secondary raw materials		
7	Contribution of recycled materials to raw materials demand	7a End-of-life recycling input rates
		7b Circular material use rate
8	Trade in recyclable raw materials	
Competitiveness and innovation		
9	Private investments, jobs and gross value added related to circular economy sectors	9a Gross investment in tangible goods
		9b Number of persons employed
		9c Value added at factor cost
10	Number of patents related to recycling and secondary raw materials	

** Indicator under development*

Eight indicators from the ‘CE monitoring framework’ are available in other European frameworks and are not unique to CE (**Figure 2**). The other indicators are under development: ‘Food Waste’ and ‘Green Public Procurement’ (GPP). In any case, the first measurement was foreseen when revising the EU Waste Directive (European Commission, 2015). For the GPP, data are still unavailable. The importance of GPP for CE may rely on the incorporation of public contracts and procurement of relevant requirements (e.g. reparability, durability and recyclability) (European Commission, 2018). The Sustainable Development Goals also cover both indicators for responsible consumption and production (European Commission, 2018).

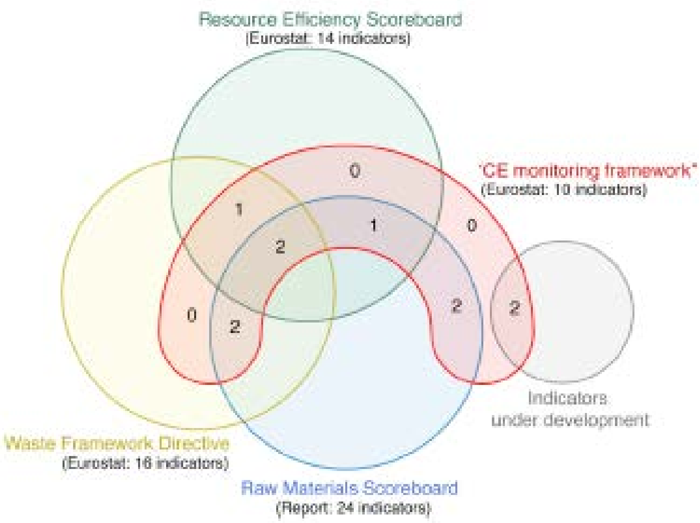


Figure 2. The interaction of the indicators from the 'CE monitoring framework' and other European directives shows that the indicators are not unique to the 'CE monitoring framework'. (Source: Moraga et al., 2019)

The 'CE monitoring framework' also makes use of material flow analysis (MFA) with Sankey diagrams (Figure 3) to provide a description of material flows in the EU. The diagrams provide aggregated details on metallic and non-metallic materials, fossil energy and biomass as an introductory guide to a more detailed MFA. The diagrams can be used to identify the CE indicators, but at this stage the 'CE monitoring framework' does not define such particular indicators.

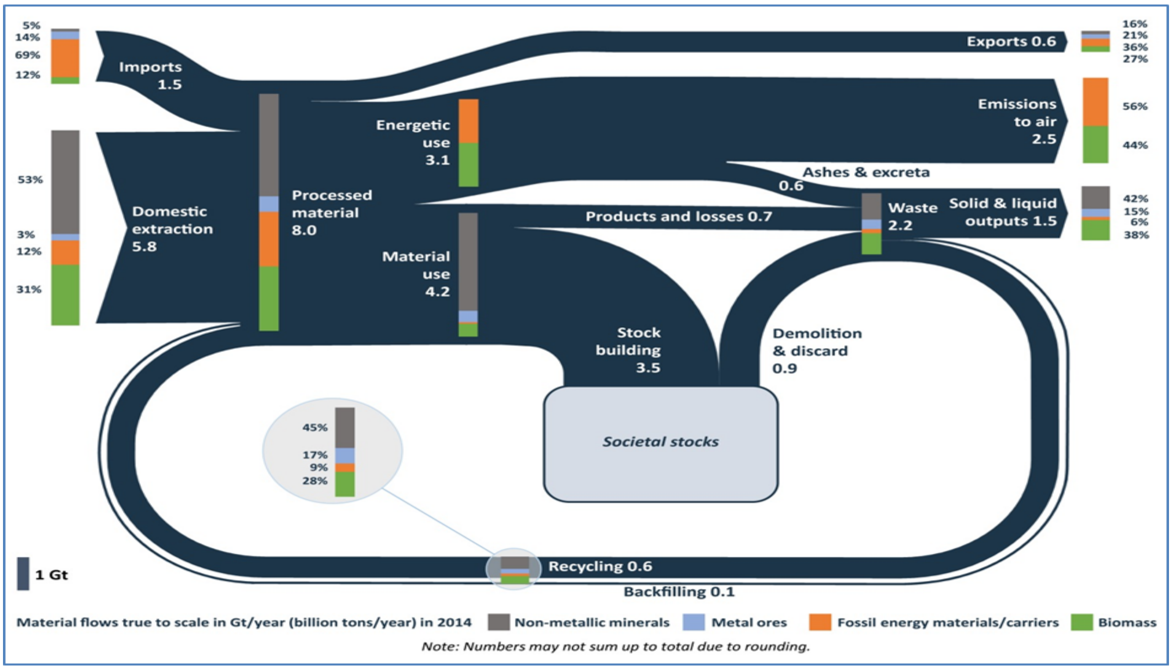


Figure 3. Material flows in the economy (EU-28, 2014) (Source: European Commission, 2018)

3.1.2. CE in developing countries

Optimism over the CE 's potential as a new model for sustainable growth in developing countries is growing. A CE is one in which products are recycled, repaired or reused rather than disposed of and in which waste from one process is an entry into other processes. CE-related activities have been taking place in countries as varied as Laos, Rwanda and Colombia in recent months. key issue here is that in developing countries there are several activities that are resource efficient and can be considered as circular economy initiatives, but most of them are implemented by the informal sector. A recent report by Preston and Lehne (2017) describes the situation like this: “Although developing countries are often more ‘circular’ than wealthier countries – in the sense that few things left on the street are not retrieved for recycling or repairs – this is largely out of economic necessity. A key question is how the Circular Economy will affect people employed in informal sectors who play significant roles in waste-management processes; whether or how to ‘formalize’ such jobs is a well-known development challenge. Looking to the future, developing countries also need to address rapidly rising consumption among the middle classes.”

The applicability of circular economy in developing countries is also another important aspect. It is true that developing countries are facing a growing waste crisis, which has major consequences for environmental and health outcomes. In this view, a circular economy strategy could help developing countries to follow a more sustainable pathway for their development, avoiding the resource-intensive Western paradigm. As Preston and Lehne (2017) noticed, “Lower-income countries are in many ways more ‘circular’ than their developed- economy counterparts – the question is how to turn this into a development opportunity. Much economic activity in lower-income countries revolves around sorting and reusing waste. However, higher-value, employment-generating opportunities for reuse and remanufacturing are yet to be captured.”

4. Key-considerations regarding the Macedonian National Waste Management Plan 2020-2030

The aim of this paragraph is to **highlight the linkages between the National Waste Management Plan 2020-2030** (further simply “the plan”) **and the shift to circular economy policies and practices**. Here are some relevant key considerations.

The plan aims to unlock the system so that integrated waste management can develop in line with the waste hierarchy and EU law and ensure environmentally safe recovery and disposal in the manner best adapted for Macedonia’s circumstances. The plan focuses on a number of key enablers - clear and effective legislation, strong institutional capacity and infrastructure delivery, high quality waste data and extended producer responsibility. Success in these areas will provide a platform on which the ambitions of a circular economy can be realized.

Importantly, the plan refers also to a National Waste Prevention Plan proposing as a **key-indicator the quantity of total waste and generation per unit of GDP/GVA (kg/€)**. In addition, the plan proposes several progress indicators that refer to recycling as:

- Total separately collected recyclable waste
- Overall quantity of Waste Electrical & Electronic Equipment (WEEE) separately collected
- Recycling rate for WEEE
- Overall quantity of waste batteries separately collected
- Recycling rate for batteries
- Overall quantity of end of life vehicles collected for treatment
- Recycling rate for End of Life Vehicles (ELVs)
- Recycling rate for waste oils
- Recycling rates for waste tires
- Recycling rates for textile waste
- Overall quantity of construction and demolition waste collected
- Recycling rate for construction and demolition waste

Two things are important about the above indicators. First, obviously, the separately collected recyclable streams do not match with the recycling rates because they always involve impurities and problematic waste. Second, it is important to clarify what is the denominator for the measurement of the recycling rates. Usually, in most of the cases, the denominator of the recycling rates is the quantity of recyclables in the waste stream, however, from a circular economy perspective the indicators required should reflect the level of substitution of primary resources rather than the level of recycling.

In terms of waste streams, the plan prioritizes the following streams:

- Municipal waste
- Commercial & Industrial wastes
- Construction & Demolition waste

- Hazardous waste
- Clinical & Healthcare waste
- Sewage sludge

A very interesting part of the plan regards the interventions to the legal framework. A serious structural improvement is proposed and described in detail. **From a circular economy perspective, the proposals for a law on Extended Producer Responsibility and the Law on Producer Balancing Body are very crucial**. According the plan, a review of the EPR experiences in the country highlighted a range of issues as follows:

- The relevant laws require modification to provide a clearer and more concise approach.
- A clear implementation plan is needed, clearly establishing the obligations of each party, appropriate financial measures and the sanctions for non-compliance.
- There is an unacceptably high 'free-rider' rate and a need to improve implementation, strengthen capacity and develop a strong regime of sanctions and enforcement.
- It is necessary to address the issue of the informal sector who reportedly 'cherry-pick' the most valuable materials.
- The Extended Producer Responsibility (EPR) system for WEEE needs to transpose the 2012 Recast WEEE Directive.
- There is no EPR system in place for End-of-Life Vehicles as required by the EU.
- In addition to the EU mandated schemes, there is a need in Macedonia to develop EPR schemes for oils, tires, end-of-life vehicles and textiles.
- There is a need for a 'Clearing House' or 'Producer Balancing Body' to manage EPR.

The creation of a "**Producer Balancing Body**" or "Clearing House" will have a pivotal role to play, making a significant contribution to the overall administrative capacity in the system and help limit and focus the role of the Ministry. The operation of it will enable the government to focus on the critical role of regulation and enforcement to improve produce participation in the system and to drive the investment of funding into the system to deliver a compliant recycling sector. It will be an independent organization and its main activities will include to check the compliance of recycling and EPR schemes, to set up minimum prices, to report to the state, to publish information and to communicate.

The plan considers packaging, batteries and accumulators and waste electrical & electronic equipment (WEEE) as key-streams for the development of the Extended Producer Responsibility while new schemes for End-of-Life Vehicles, spent tires, textiles, oils & lubricants are proposed.

The linkage between waste generation and the economic growth of the country is presented in **Figure 4**, where the Municipal Waste Generation per Capita (as presented in the plan) is correlated with the Gross Domestic Product per Capita (based on the World Bank's data sets) for the years 2009 – 2017.

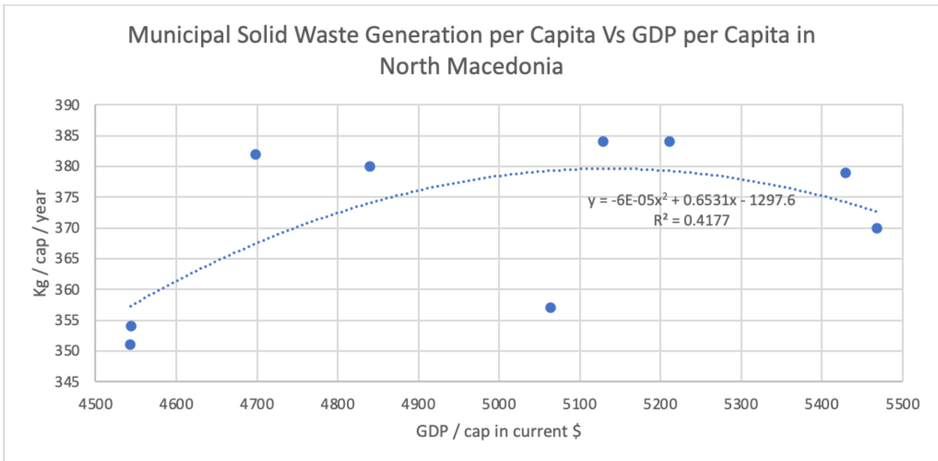


Figure 4: Municipal Waste Generation per Capita Vs Gross Domestic Product per Capita 2009 - 2017

It seems that, for the years the data is available, the growth of the GDP/cap results in the increase of the municipal waste generated per capita, although the correlation between the two parameters is rather weak. As a proxy of this relationship, between 2009-2017 the GDP/cap was increased by 19.5% and the municipal waste generated per capita was increased by 7%, or for every 1% increase of the GDP/cap, the waste generated per capita is increasing by 0.36%.

To complete this paragraph, it is important to present the total waste generated in the country divided in its different categories, based on the data sets of the pan for the year 2016, as shown in **Figure 5.** As it is shown, municipal waste has the largest share (35.71%) which justifies its priority in management, and the second one is mining and quarrying waste (big volume – low risk) with 31.39%. The total waste generated per capita is 1,076 kg/cap/year, much lower than the EU average which is around 2,500 kg/cap/year.

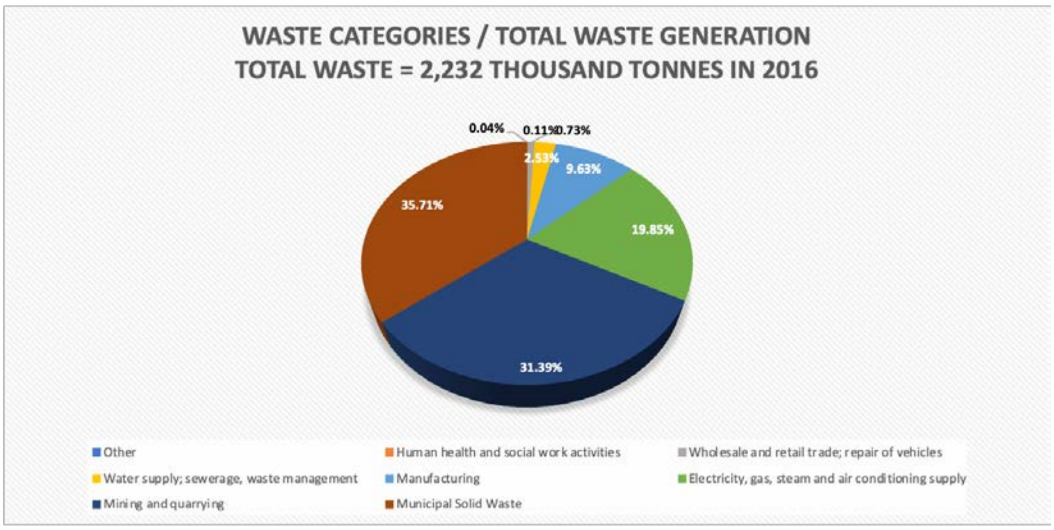


Figure 5: Total waste generated divided by different streams in 2016

5. Key-considerations regarding the Macedonian 3rd Biennial Update Report and the Enhanced Nationally Determined Contribution

This report considers the existing proposed mitigation measures within the Macdonian 3rd BUR and the Enhanced Nationally Determined Contribution under the Paris Agreement of the UNFCCC. The report then identifies both opportunities and challenges for introducing Circular Economy measures focusing on mitigation of GHG emission in the Waste Sector.

It should be noted that the methods and tools that link the evaluation of circularity and carbon footprint of the waste sector are available only to a limited extend, most of them may only be applicable for thematic or country-specific contexts and/or not be publicly available or not be recognized by agencies and organizations that lead the NDC process on international level. Therefore, countries reporting on their NDCs have to follow the methods and approaches published by UNFCCC in order to serve international negotiations. These methods such as the IPCC 2006 Guidelines for National Greenhouse Gas Inventories (Volume 5: Waste) do not include effects for GHG emission reduction due to enhanced circularity, but rather focus on individual municipal solid waste (MSW) technologies/options (e.g. composting, waste incineration or landfilling). They basically allow to evaluate activities that fall under the waste sector[1], but do not cover the whole value chain or production process prior to waste generation of materials and products. With the limited waste sector approach, climate benefits related to activities and project enhancements that follow a Life-Cycle-Approach and include relevant actions prior to waste generation remain largely invisible.
The International Panel on Climate Change (IPCC) has since 1995 released guidelines setting the methodological foundation for carbon accounting in all sectors. However, their implementation, can be hampered by uncertainties, such as the interlinkage between various sectors, creating complex life cycles of emissions that are difficult to represent and assess (Maalouf and El-Fadel, 2020). **The IPCC methods only account for direct emissions from the waste sector and does not include emissions or avoided emissions from electricity imports, upstream and downstream waste processes, recycling, or other waste streams** (e.g. electronic waste, end of life vehicles, construction and demolition wastes etc.). **This can be of particular interest with recent trends to shift the waste sector towards a circular economy.** Emissions and other environmental impacts occur mostly in processes of raw material extraction, production, transport, logistics, and distribution –outside of the direct processes from waste degradation or combustion (only accounted for in the IPCC methods), thus, important for reporting on the NDCs.

According to the Macedonian 3rd Biennial Report on climate change, the greatest share of emissions is from the Energy sector, accounting for 73.7% in 2016, followed by the Agriculture (excluding FOLU) with 11.8% and IPPU sector with 8.5% and Waste sector with 6% share. The total direct emissions from the waste sector amounted to 610 Gg CO_2-eq in 2016. The latter considers the following categories that act as contributors to the GHG emissions from the

[1] Solid Waste Disposal, Biological Treatment of Solid Waste, Incineration and Open Burning of Waste, and Wastewater Treatment and Discharge

waste sector: Solid Waste Disposal (473.2 Gg CO_2-eq in 2016), Biological Treatment of Solid Waste (1 Gg CO_2-eq in 2016), Incineration and Open Burning of Waste (22.7 Gg CO_2-eq in 2016), and Wastewater Treatment and Discharge (113.4 Gg CO_2-eq in 2016). The Solid Waste Disposal[2] is the category with the highest share (77.5%) of GHG emissions in the waste sector in 2016.

In the 3rd BUR on climate change mitigation, four measures are modelled and analyzed for the waste sector: (1) **Landfill gas flaring** (with 489.7 Gg CO_2-eq of emissions reduction in 2030), (2) **Mechanical and biological treatment (MBT) of waste in new landfills with composting** (with 108 Gg CO_2-eq of emissions reduction in 2030) , (3) **Selection of waste – paper[3]** (with 62.5 Gg CO_2-eq of emissions reduction in 2030), (4) **Improved waste and materials management at industrial facilities** (with 3.3 Gg CO_2-eq of emissions reduction in 2030). The total emissions reduction was reported around 663.5 Gg CO_2-eq in 2030. The **Landfill gas flaring** measure was reported as the **most significant** potential for greenhouse gas emissions reduction. These mitigation measures and associated reductions in emissions were added to the Macedonian enhanced NDC, since the latest submitted NDC by the Republic of North Macedonia in August 2015 did not consider the waste sector within the target sectors.

Following the assessment of direct emissions from the waste sector in 2016 and the reported mitigation measures with associate emission reductions in 2030, the report assessed additional savings in emissions from adopting circular approaches to enhance existing baseline conditions of the MSW management system and other waste streams.

[2] The Solid Waste Disposal emissions are estimated in accordance with the IPCC 2006 Guidelines using the IPCC Inventory Software, which impose the First Order Decay (FOD) methodology. All of them have been assumed to be equal to the default values provided in the IPCC 2006 Guidelines.

[3] Installation of containers for collection of selected waste, mainly paper

6. Circular Economy benefits

6.1. General approach: Circular Economy economic and environmental benefits

According to the EU Monitoring Framework for the Circular Economy (European Commission, 2019b), the transition to Circular Economy has helped put the EU back on a path of job creation. In 2016, sectors relevant to the circular economy employed more than four million workers , a 6% increase compared to 2012. Additional jobs are bound to be created in the coming years in order to meet the expected demand generated by fully functioning markets for secondary raw materials .

Circularity has also opened up new business opportunities, given rise to new business models and developed new markets, domestically and outside the EU. In 2016, circular activities such as repair, reuse or recycling generated almost €147 billion in value added while standing for around €17.5 billion worth of investments.

In Europe, recycling of municipal waste during the period 2008-2016 has increased and the contribution of recycled materials to the overall materials demand shows continuous improvement. However, on average, recycled materials only meet less than 12 % of the EU demand for materials.

The following assessment seeks to present an overview of the current situation of the waste sector and the relevant waste streams, consider developments towards circular economy by identifying challenges and opportunities, and study the environmental and economic implications as well as employment creation.

6.2. General methodology developed

6.2.1. Objective of the rapid assessment

The objective of this report is to provide a rapid assessment of both opportunities and challenges of circular economy on mitigation of greenhouse gas (GHG) emission in the waste sector, reflecting on policy and implementation level in the Republic of North Macedonia (RNM). The rapid assessment considers the benefits of circular economy in minimizing the use of resource inputs and the creation of waste and carbon emissions and improving the current situation. **The assessment focused on growing waste streams such as the end of life vehicles (ELVs), refused derived fuels (RDF), biowaste, waste electrical and electronic equipment (WEEE) , construction and demolition (C&D) waste, and plastics**. These waste streams were selected because they were prioritized in accordance with the priorities of the Macedonian National Waste Management Plan 2020-2030. The waste streams were assessed alongside a **set of evaluation criteria**, including (1) **financial or economic benefits** (e.g. value of recovered resources, reduction of consumption, carbon credits cost savings etc.), (2) **new employment and jobs created and benefits to operators** (e.g. producers and the treatment industries), government and society generally, and (3) **net savings in GHG emissions** (**Figure 6**).

The assessment methodology was based on the following requirements:

- Definition of the waste streams
- Current management and challenges involved
- Circular solutions and practices
- Evaluation of economic and environmental benefits as well as new job employments from adopting circular economy

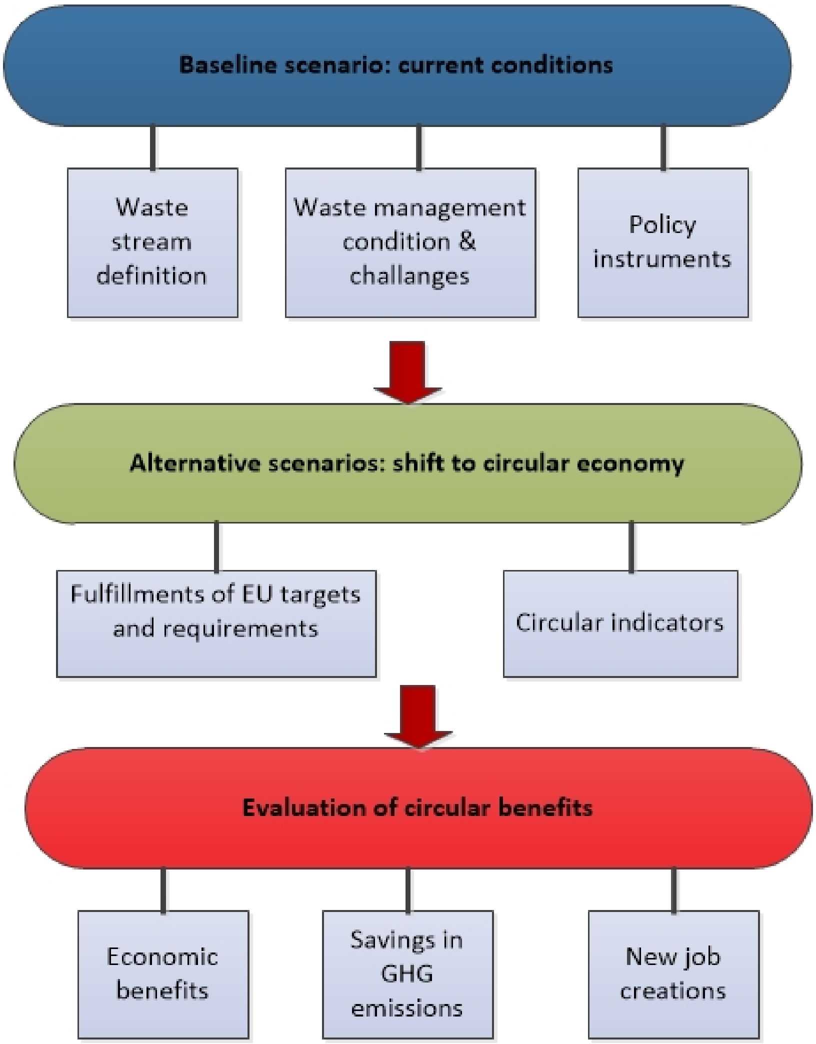


Figure 6. Structure of the overall assessment of circular benefits

For each waste stream under assessment a detailed evaluation was prepared, which includes the following:

6.2.2. Scenarios analyzed

Baseline scenario: current conditions

The baseline scenario reflects the current conditions (for the year 2016) of the studied waste stream. In order to focus on the changes in behavior that can be attributed to the implementation of circular targets, a baseline scenario was defined corresponding to the practices which would occur if the circular targets would not exist and it is used as a reference to calculate avoided GHG emissions. The assessment also considers the current challenges involved in the management of the waste stream while taking into account the existing legal requirements, the self-declared targets (e.g. related to GHG emissions or waste reduction/recycling rates), existing NDCs, and compliance with set national targets for preparing the discussion on alternative scenarios. The report will considers current policies and laws related to the waste sector and relevant waste streams to assess if they enable an environment for promoting circular economy, and how much are they in line with the relevant EU Directives and policies, targets and plans, particularly with the Circular Economy Action Plan of the EU Green Deal.

Data sources: Collection of baseline data was conducted through a desk review of previous studies, including the national waste management plan (NWMP), and available data, as well as through interviews with experts and practitioners in the waste field, and various strategies and reports from relevant institutions, such as Ministry of Environment and Physical Planning (MOEPP), and various international databases such as UN projections for population and GDP. This data of the relevant waste streams is needed to establish a suitable baseline against which the impacts of future targets considering circular economy can be evaluated.

Data requirements on waste streams: type and source of waste generated / waste amounts / trends of waste generation over the last years / existing waste collection schemes / information on treatment options / associated costs /policies, regulations, and targets. Data was collected for the year 2016 whereby this report is in line with the 3rd BUR.

Alternative scenarios: Shift to circular economy

As previously explained, there is not a commonly accepted set of indicators to assess the shift to circular economy at the macro level. In this initiative, the indicators recently proposed by the European Commission (EC) (European Commission, 2018) were selected to explain the framework for macro-scale (regional / country) indicators for the case of RNM and to assess circularity. The alternative scenarios are based on setting targets to shift to circular economy. Each alternative scenario describes a different route for a specific waste stream taking into account different circular targets. These scenarios allow to estimate the change in treatment for each material type with higher recycling and recovery rates and provides the basis for the calculation of the associated GHG savings of higher targets and the illustrative economic benefits. Following that recommendation and incentives was proposed to framework what is needed at national level with relevance to each waste stream and to fill existing gaps or/and unachievable measures/targets.

6.2.3. Evaluation of circular benefits

Environmental benefits: The analysis of environmental benefits from shifting to circular economy mainly focused on the global warming potential (GWP) and savings in GHG emissions. In order to provide a comprehensive response to the question considered:

- We build on the baseline scenario, which reflects the current practices on ground (prior to the shift to the circular economy, implementation of EU directives and targets, national targets, or other possible drivers such as legislation pieces or existing evolution trends, voluntary agreements etc.). Total GHG emissions from the waste sector for 2016, was used as a basis for comparison to calculate avoided GHG emissions and to reflect on the baseline condition.

- We focus on the changes in behavior that can be attributed to the shift to circular economy (alternative scenarios) by considering the net GHG savings that will be defined for each waste stream. The net GHG savings will consider the direct benefits of the avoided pollution corresponding to the previous practice (e.g. increased reuse and recycling targets, recovery of materials and energy, various treatment options compared to landfill etc.) while integrating the environmental impacts of the new practice or the remaining that goes for landfilling. Studying GHG savings projections, will be within the time frame of EU targets and specific policy strategies for each waste stream.

Following the estimation of the overall avoided GHG emissions from the relevant waste streams, savings in carbon emissions will be compared to existing proposed mitigation measures within the Macedonian enhanced NDC under the Paris Agreement and the reported GHG emissions from the different sectors under the 3rd BUR.

Method for quantification of GHG emissions:

We built-up of a database of GWP factors for 1 kg of each concerned fraction and its different end-of-life options. A large literature review was conducted to select the best available LCI database or LCA studies from which data were extracted (such as the U.S. Environmental Protection Agency Office of Resource Conservation and Recovery, 2019) and to account for the IPCC methodology constraint which do not consider emissions from different waste streams such as ELVs, WEEE, plastics, C&D, and SRF processes under the Volume 5 waste[4].The database was built while taking several decisions and assumptions (system boundaries, substituted material / products etc.). For each scenario, multiplication of these values by the quantities of each flow (fraction / end-of-life option) to quantify the total GWP associated.

- Step 1: Identify the total GHG emissions from baseline condition for each waste stream in 2016 (this mainly reflected the total emission from landfilling as it is the mostly commonly adopted method in Macedonia).
- Step 2: Examine the total net savings for each alternative scenario when meeting circular targets (increased in the recovery and recycling targets and diversion from landfilling).
- Step 3: Calculate avoided GHG emissions from each alternative scenario when meeting circular targets in comparison to baseline conditions.
- Step 4: Assess other changes in GHG savings assumptions (reflecting possible changes in other periods beyond 2016).

Avoided GHG emissions thus includes avoided emissions from landfilling + savings due to recycling/ recovery of materials or energy.

Employment benefits: In assessing new job creations in the waste sector, the report firstly studied currently practiced activities within the relevant waste streams and estimate the employment numbers involved in these. Furthermore, the report considered future developments and estimate the potential increase in jobs in this sector by the year 2030. This was done by studying current growth projections, recent and planned constructions of new

[4] https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol5.html

facilities, as well as waste stream-specific policy strategies. The assessment was based on available case literature data and a review of case studies for each studied waste stream.

Economic benefits:
The economic benefits to reach the circular targets compared to the baseline conditions are considered for each waste stream. The economic benefits include avoided costs from recovered materials or energy in addition to the avoided carbon prices (external costs) which were calculated based on GHG savings. The average carbon price of 21 EUR /tonne of CO_2-eq (100 years) was adopted in this study from Ramstein et al. (2019), given that the European Union Allowance (EUA) carbon price reached the level of 20–25 EUR / tonne of CO_2-eq (US$22-28/ tonne of CO_2-eq). This approach could be of interest for the private sector, as the carbon pricing is being included as an in many Tendring for waste projects in some European countries. Innovative approaches to use carbon pricing to identify greater prospects for GHG reduction and to reduce climate-related financial threats are being found by the private sector. Traditionally, in their procurement choices, companies use internal carbon pricing to determine risks from mandatory carbon pricing policies. Nevertheless, companies are finding innovative ways to use internal carbon pricing in order to mitigate long-term climate risks and match their investments with business targets. International carbon pricing collaboration can play an important role in reducing the cost of introducing mitigation policies and increasing the utilization of finance through crowding of public and private capital. In achieving the mitigation goals of the NDCs, collaboration will lead to significant cost savings.

6.3. Circular economy benefits for each waste stream

All circular economy benefits used in the alternative scenarios are presented in this chapter and are providing information on:

a. Current management and problems involved: waste stream definition; current management practices (waste generation, collection, treatment, and disposal); waste composition; main challenges; main environmental & health problems, main resources lost and corresponding economic value; relevant laws, regulations, national targets and EU directives and targets;
b. Circular solutions and practices;
c. Circular benefits: timeframe; estimated GHG emission savings; economic savings; job creations; and other contribution to the achievement of the EU directives and targets.

The effect of the circular measures regarding emissions reduction and costs are presented in relation to the baseline scenario for each waste stream.
In the waste sector six waste streams are modelled and analyzed. The most relevant information for the circular measures/policies are given below.

6.3.1. End of Life Vehicles (ELVs)

a. Current management and problems involved

ELVs definition
Vehicles reach the end of their life either because they become old and worn out and cease to be roadworthy ("natural" end of life vehicles or NELVs) or because they are written off following involvement in an accident ("premature" end of life vehicles or PELVs). Vehicles may be sold for export either before reaching the end of their life as secondhand vehicles, or at the point of deregistration as waste.

Current management practices and challenges involved
The NWMP identifies this as a priority for Macedonia.
Management of ELVs is an issue of discussion but of limited action (till now) in North Macedonia policy and decision makers. Although this waste stream is identified as a priority in the NWMP strategy 2020-2030, there is no serious and organized on-going ELVs management system in place. Currently, it is estimated that the total number of ELVs requiring treatment is around 10,411[5] in 2016 (equivalent to 10,411 tonnes of ELVs requiring treatment in 2016). The average age of ELVs is estimated at 18 years in Macedonia, 5 years higher than the average age of 13 years estimated for EU (GHK, 2006).
There are only four authorized treatment facilities (ATFs) in Macedonia, treating 215 ELVs in 2016 (or 326.924 tonnes in 2016). According to the NWMP, the reality is that all other scrap yards will store and treat ELVs. It is unlikely that the Directive provisions on de-pollution are well established. Opportunities to recover waste oil as fuel exist if collections can be established.

The main problems and challenges involved can be described as following:

- The national targets are **not defined for ELVs**, yet, it will be negotiated as part of accession process according to EU targets.
- The EU End of Life Vehicles Directive (2000/53/EC) requires an increase in the recycling of ELVs and their components and the improved environmental performance of all the economic operators involved in the life cycle of vehicles. The ELV Directive requires member states (MS) to achieve a reuse and recycling rate of at least 80% (by weight) and a reuse, recycling and recovery rate of at least 85% by 2006. From 2015 onwards, each producer must achieve 95% reuse, recycling and recovery of ELVs (85% to be achieved by reuse and recycling). The EU recommends EPR for ELVs. By 2006, it requires that vehicle producers must establish a network of ATFs and collection points to take back their own vehicles; and from 1st January 2007, producers must provide free take back of their own ELVs when the owner presents a vehicle at designated collection points. However, the EU targets are not achievable and longer timescales will be negotiated as part of accession

[5] Number of deregistered vehicles is 10,411 (under category of EURO 1 or without of EURO produced before EURO standardization). It is 2.39% from the total number of vehicles registered in 2015.

talks. Specific details will be developed with stakeholders to inform new laws and regulations as mentioned in the NWMP.
- The current total reuse & recycling rate is around 2.71% of ELVs generated in 2016 and the total reuse, recycling & recovery rate is about 2.73% of ELVs generated in 2016 at a remaining landfilling rate of 97% of ELVs generated in 2016. This shows that the current ELVs management in North Macedonia is far behind of the EU targets, which is very hard to reach with only 4 operating ATFs. According to the EU ELVs directive, vehicle manufacturers should provide ATFs with all requisite dismantling information, in particular for hazardous materials in order to facilitate the dismantling and recovery, in particular recycling of end-of life vehicles.

b. Circular solutions and practices

The EU End of Life Vehicles Directive (2000/53/EC) requires an increase in the recycling of ELVs and their components and the improved environmental performance of all the economic operators involved in the life cycle of vehicles.

The Directive has brought benefits to public authorities in the EU by:
- Promoting cost savings and reducing the costs of dealing with abandoned vehicles (through free take-back) and addressing the problem of vehicle crime and fraud (through an enhanced system of deregistration)
- The requirement to issue Certificates of Destruction as a condition for deregistration should improve information about the vehicle stock in those countries where such a system did not previously exist
- Promotion of resource efficiency – potentially reducing raw material and energy costs by promoting recovery and reuse of valuable materials and components

Benefits to operators:
- Enhancing the efficiency and sustainability of the treatment sector, by raising professional and environmental standards and promoting modernization of operations.
- Reducing the costs of landfill to firms and the public, by increasing rates of reuse, recycling and recovery

According to the implementation of the ELVs report (European Commission, 2020), in 2016, 25 Member States had met the minimum reuse and recycling target of 85% by average weight per vehicle and year, 2 Member States had not reached the targets. The average reuse and recycling rate for the EU27 as a whole was 88%, three percentage points above the target. As of 2016, 15 Member States had met the minimum reuse and recovery target of 95% by an average weight per vehicle and year. The average reuse and recovery rate for the EU27 as a whole was 93%, just below the target (see **Figure 7**).
During the period 2015-2017, EU Member States were required to establish a network of ATFs and collection points. 18 Member States reported that within their borders there are treatment establishments with a certified environmental management system (EMS).

Throughout the EU28, the proportion of treatment establishments with an EMS has increased from 1.9% in 2012–2014 to 3.73% in 2015–2017 (see Figure 8).

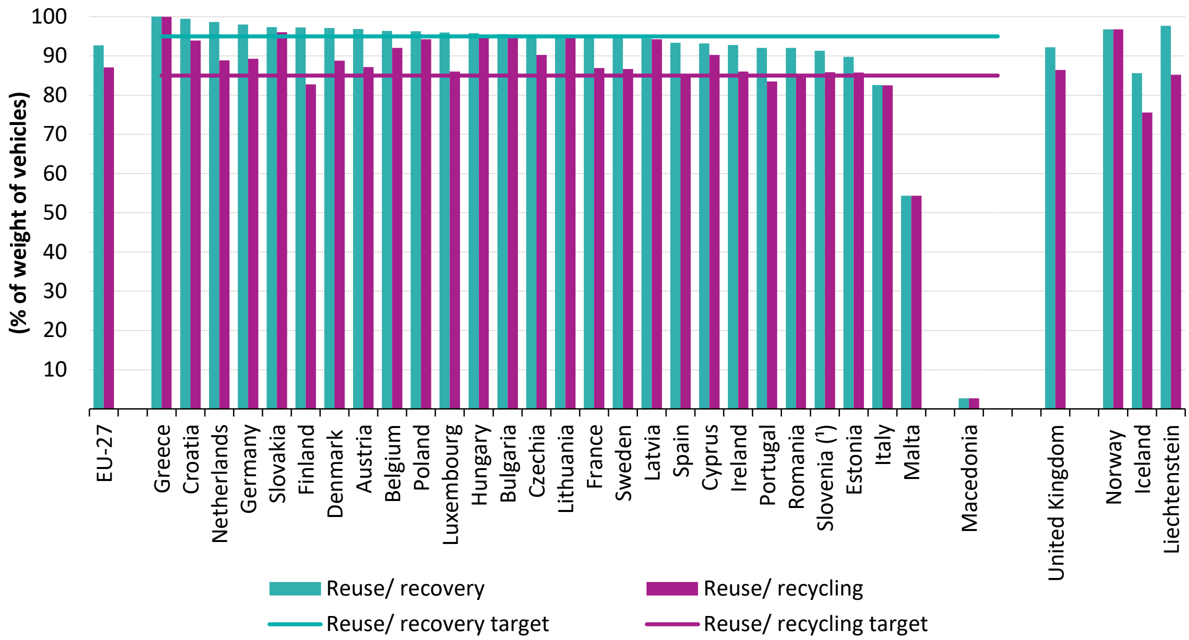


Figure 7. Reuse/recovery and reuse/recycling rate for end-of-life vehicles, 2016

Note: Countries are ranked in decreasing order by reuse/recovery.

(¹) 2014 data.

Source: Eurostat, 2020 (online data code: env_waselvt)

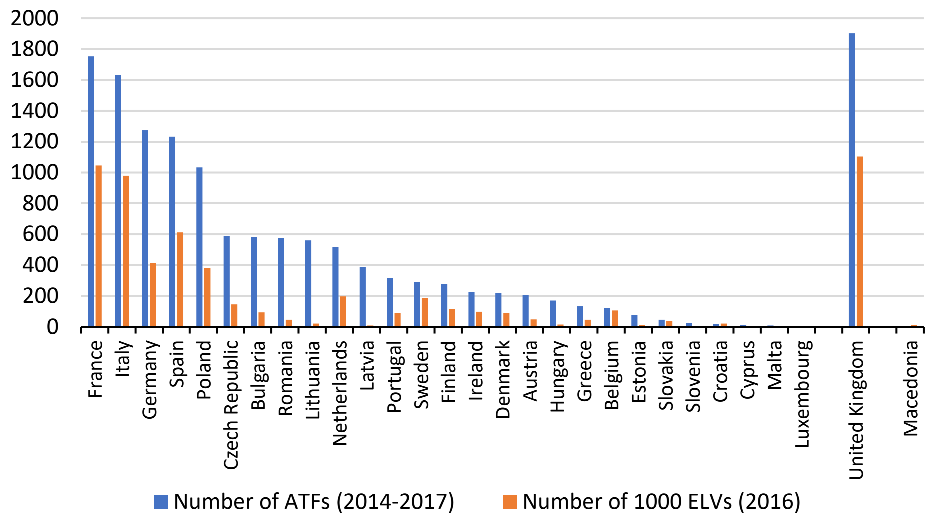


Figure 8. Total number of ELVs generated in 2006 and number of Treatment Facilities Authorized or Registered in Accordance with Article 6 (2014-2017)

c. Circular benefits

In this section of the report the benefits for North Macedonia from the application of basic CE activities (reuse, recycling and recovery) of ELVs are presented:

- The total quantity of ELVs requiring treatment is 10,411 tonnes, and around 326 tonnes are collected and sent to ATFs. It was assumed that all quantities of remaining materials (not collected and not treated in ATFs) go for landfilling (10,126 tonnes of ELVs).
- Total average weight of an ELV is approximately one tonne (or one thousand kg) was assumed constant over years, taking into account an average vehicle life of 18 years. A typical composition of an ELV was considered in the calculations (See Table **2**). These figures present an estimated breakdown of the materials and components arising in a typical ELV. Changes in vehicle composition and weight are driven by a range of factors including safety, fuel efficiency, and consumer preferences. The possibility of future vehicle design changes as a circular target should be taken into account in future assessment.

Table 2. Typical Composition of an ELV, % by Weight

Material/Component	% by weight
Ferrous Metal	68
Non Ferrous Metal	8
Plastics and Process Polymers	10
Tyres	3
Glass	3
Batteries	1.3
Fluids	1.7
Textiles	1
Rubber	2
Other	2
Total	100

Source: GHK (2006)

- The approach to the calculation of the costs and avoided emissions of meeting circular measures and targets is based on meeting higher EU directive rates (2015 target and beyond). The target consists of achieving a higher reuse and recycling rate of 95% (by weight) and a reuse, recycling and recovery rate of 95% through mechanical separation. Given the current limitation and challenges in the context of North Macedonia and the limited number of available ATFs, this target was assumed to be attained by 2030. The EU 2015 target used to calculate benefits for 2030(see **Error! Reference source not found.**).

Table 3. Alternative management scenario considering the EU-2015 target

Management option	Amount of ELVs (tonnes)	Percentage by weight of total ELVs generated
Reuse	619	6%
Recycle	9,273	89%
Landfilling	518	5%
Total amount of ELVs generated	10,411	100%

Quantification of benefits for North Macedonia

The estimated GHG emissions for baseline scenario are about -0.079 to 0.259 Gg CO_2-eq in 2016 (or about -7.7 to +24.9 kg CO_2-eq per ELV in 2016)[6]. Savings in GHG emissions with respect to the alternative scenario for attaining the EU2015 target in comparison to baseline condition in 2016[7] varied in a range about 9.02 to 19.49 Gg CO_2-eq in 2016 (or about 867 to 1,872 kg CO_2-eq per ELV in 2016). ELV recycling is environmentally beneficial for GWP whatever the recycling, reuse, and recovery target between 85% and 95%. This is mainly due to the positive contribution of ferrous and non-ferrous metals recycling. These benefits are even (a little bit) higher when the avoided impacts of landfill are added. The higher the recycling rate, the lower the environmental benefits. This is due to the fact that plastics have to be recycled and among those plastics, not all of them have a beneficial GWP for recycling. Thus, if high recycling targets were to be set up, then the environmental benefits of metal recycling would largely compensate the potential environmental disbenefits of some plastics recycling.

Data from the Greek Organization for Recycling shows that for the period 2014 – 2018 a total of 170,889 tons of ELVs were recycled creating 900 new jobs, saving 660,000 m^3/year from disposal, and saving up to 6,000,000 EUR/year. These indicators were used to calculate the circular benfits.

Table 4 presents a summary of the benefits from the introduction of the reuse, recovery and recycling activities in the ELVs' waste stream.

[6] The min value is negative (i.e. environmental benefit) and the max value is positive (i.e. environmental impact). The current situation is environmentally beneficial for GWP. This is mainly due to the positive contribution of ferrous and non-ferrous metals recycling. When considering the diversion from landfill, these benefits are even higher (because of the avoided impacts from landfill).

[7] It is not possible to conclude because the additional GWP vary in a range where the min value is negative (i.e. environmental benefit) and the max value is positive (i.e. environmental impact). Also, note that the higher the quantity of plastics recycled in a scenario, the larger the range of additional environmental impacts and benefits. The impact linked to the plastic fraction is the only determining parameter of the results in terms of GWP (the other materials do not influence significantly the results). Note that no data are available for glass and rubber recycling.

Table 4: Summary of benefits from circular activities for ELVs waste stream by 2030

	QUANTITY	UNIT	REMARKS
2030 *TARGET*	95	%	Considering recycling, reuse & recovery
RECYCLING & REUSE QUANTITIES OF ELVs	9,893	tonnes/year	
ECONOMIC BENEFITS			
SAVINGS FROM RECOVERED MATERIALS	690,711	EUR/year	
CARBON PRICE SAVINGS OR CARBON CREDITS	409,289	*EUR/year*	
TOTAL ECONOMIC BENEFIT BY 2030	*1.10*	Million EUR /year	
EMPLOYMENT BENEFITS			
TOTAL NEW JOBS CREATED BY 2030	*488*	*Jobs*	
REDUCTION OF GHGS EMISSIONS			
BASELINE CONDITION IN 2016	-13.548	Gg CO_2-eq/year	Considering 3% reuse, recycling and 97% landfilling of ELVs
2030 TARGET	-19.569	Gg CO_2-eq/year	Considering 95% reuse, recycling
TOTAL SAVINGS IN GHG EMISSIONS EXPECTED *BY 2030*[(1)]	19.49	Gg CO_2-eq/year	
OTHER BENEFITS			
INCREASE IN LANDFILLS *CAPACITY*	35,815	m^3/year	

[(1)]The savings in GHG emissions are calculated by subtracting the total GHG emissions of the baseline scenario from the alternative scenario that considers meeting the 2030 target.

6.3.2. Biowaste

a. Current management and problems involved

Biowaste definition

According the EU Directive 2018/851 "bio-waste" means "biodegradable garden and park waste, food and kitchen waste from households, offices, restaurants, wholesale, canteens, caterers and retail premises and comparable waste from food processing plants". A relevant term is the term "biodegradable" which means the capability of being degraded by biological activity or, in other terms, the capability of compostable material to be converted into carbon dioxide under the action of micro-organisms.

Current management practices and challenges involved

The distinct management of biowaste is an issue of discussion but of limited action (till now) in North Macedonia policy and decision makers. Although composting of the organic fraction is highlighted as a main measure in the Waste Management Strategy 2020-2030, there is no serious and organized on-going biowaste management system in place. There are no separate collections of either garden or other biodegradable waste. There are home composting initiatives in some rural municipalities. Composting plant in Resen (not working at the moment, but can capture lessons learnt), and 2 composting units in Probistip with volume of 60 t/y biowaste per unit. All organic waste that is collected is currently disposed of to landfill.

According the waste composition in the National Waste Management Plan, organics are around 45% of the total municipal waste in North Macedonia, which means it is by far the most important element of the municipal waste stream.

Here are the main problems and challenges involved:

- Dumping and landfilling of biowaste creates serious environmental and health impacts. Biowaste degrades in landfill conditions creating biogas and leachate pollutants. The main odor problems related to landfilling are related to the biowaste content of the waste. Either through aerobic or anaerobic degradation, landfilling of biowaste contributes to global warming. Especially in the case of anaerobic degradation, landfilling of biowaste generates methane which is a substantial contributor to GHGs emissions.
- The recycling targets set by the Waste Framework Directive (50% recycling rate by 2020 and 65% by 2030) are impossible to be achieved without substantial recovery and recycling of biowaste.
- The landfill diversion targets set by the EU Circular Economy Package (landfilling should not exceed 10% of the waste generated by 2035) are also impossible to be achieved without substantial recovery and recycling of biowaste.
- According the EU Directive 2018/851, which amends the Waste Framework Directive 2008/98, Member States shall ensure that, by 31 December 2023, and subject to

Article 10 (2) and (3), bio-waste is either separated and recycled at source, or is collected separately and is not mixed with other types of waste.

- To promote the separate management of biowaste it is important to set minimum quality standards for the product of composting – such minimum quality standards are defined in the regulation 2019/1009 of the European parliament that lays down the rules on EU fertilizing products.
- Landfilling of the organic fraction is also a lost opportunity to close a resource loop by returning nutrients and organic matter to agricultural land.

b. Circular solutions and practices

Before anything else, it is important to stress that closing the loop for the organic fraction of waste is probably the best available way to make citizens aware of the circular economy concept and how it creates benefits for their lives. Therefore, closing the loop of the organic fraction, either through aerobic composting or anaerobic digestion and energy recovery practices, provides the opportunity:

- to divert a big waste fraction from landfills,
- to produce a product (compost or digestate) that can be returned back to citizens in one or another way and in a visible manner,
- to close the loop of the organic fraction on a local scale, making the concept of circular loops a tangible reality and not an abstract policy.

In principle, the biological cycle of a circular economy is shown in **Figure 9**.

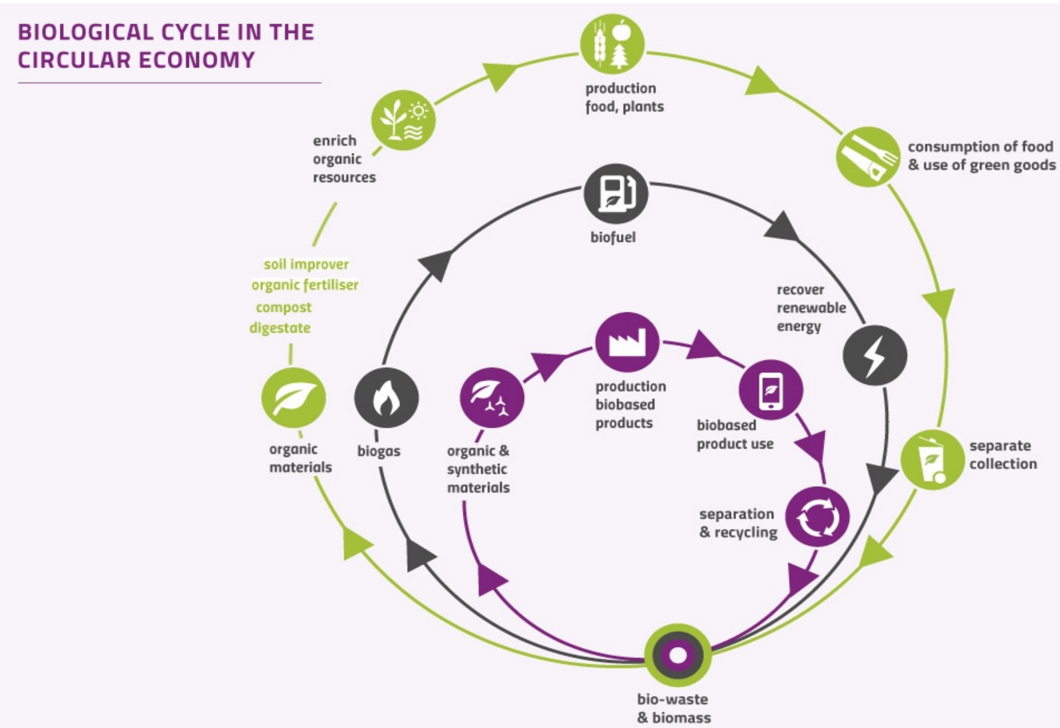


Figure 9: The Biological Cycle in a Circular Economy. Source: (Lystad, 2017)

In this report we will focus on the outer circle, as organics are the most important stream of the municipal waste stream.

The most effective first step, in terms of volume and ease of implementation is to concentrate on composting green / garden waste in open windrow systems. This can be implemented in rural areas at small and medium scales, providing local solutions and employment. Approaches for biowaste which includes food waste are In-Vessel Composting (IVC) and Anaerobic Digestion (AD). These facilities are more complex but have the advantage of being able to treat a wider range of material types.

According a survey (European Compost Network, 2017) in 19 countries of the EU, more than 33 million tonnes of municipal biowaste are biologically treated. There are more than 1,300 composting plants for biowaste (capacity around 13 million tonnes per year) and more than 1,500 for green waste (capacity over 10 million tonnes per year). The anaerobic digestion plants are almost 2,150, with a total input of 24 million tonnes of biowaste per year. **Figure 10** provides the overall picture.

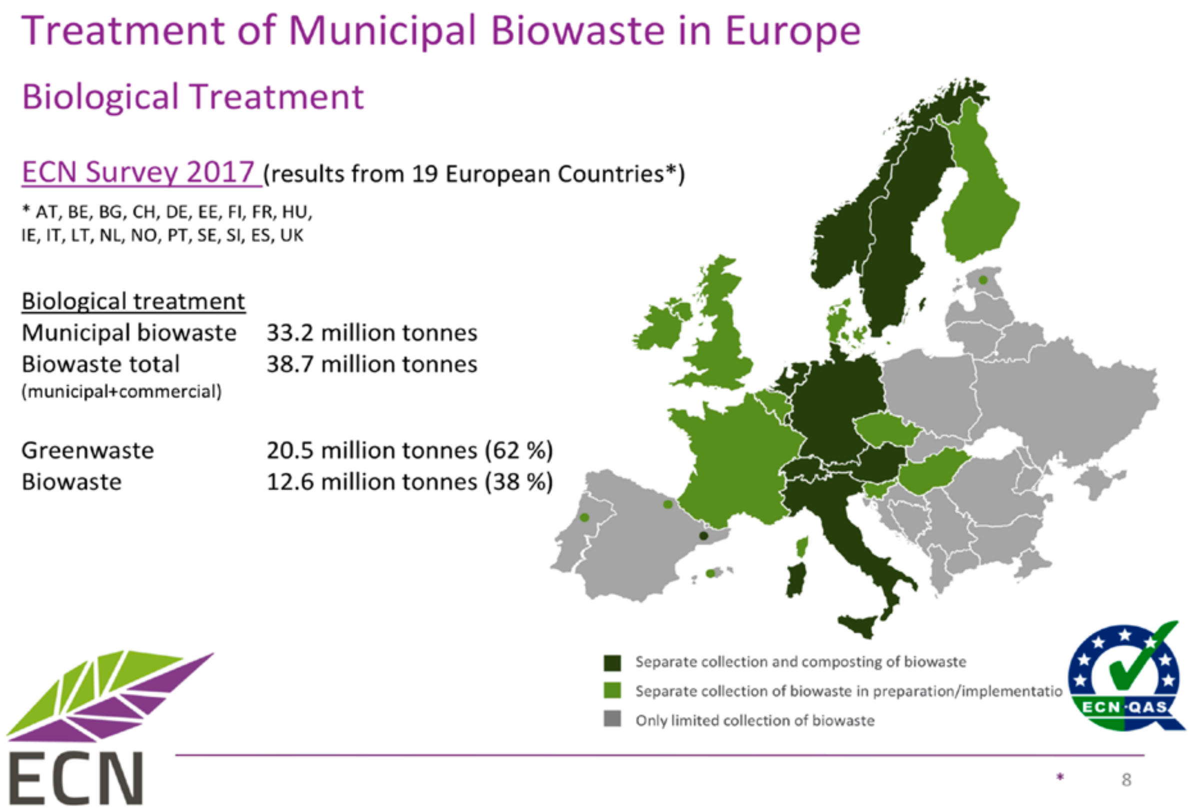


Figure 10: Treatment of Municipal Biowaste in EU. Source: (European Compost Network, 2017)

It is obvious that both composting and anaerobic digestion of biowaste is an extensively applied practice all around Europe and it represents a practical circular solution.

c. Circular benefits

Anaerobic Digestion

Although the practice of composting is widely discussed and it represents by far the easiest way to divert biowaste from landfills, it is important to stress that energy recovery from biowaste, through anaerobic digestion is another available, although more complex solution. Anaerobic digestion may be applied to a range of organic materials which are bio-degradable by methane producing micro-organisms. Most types of organic materials will be partly biodegradable, so that some matter is degraded and other remains in the digestate (residue/compost from the digestion process).

Source separated organic household waste contains both highly and less degradable organic matter together with some foreign matter. The pre-treatment step will remove foreign matter and other components that may impact the digestion process by causing sedimentation, flotation, blockages, increased wear and tear etc. These include materials such as plastic bags from the waste collection, packaging, bones, grit, metal pieces etc. The so called 'reject' is removed and sent to landfills or a Waste to Energy facility. Depending on the collection and pre-treatment systems the reject share may be significant, i.e. 25-40%, but in source segregation from single family houses the reject share may be down to a few percent. The energy efficiency of electricity output is about 18% and 41% for both electricity and heat Hulgaard (2015).

The net GWP for anaerobic digestion that was assumed to calculate the savings in GHG emissions from anaerobic digestion of mixed organic waste is estimated at -0.21 tonnes of CO2-eq per tonne of mixed organics adopted from (U.S. Environmental Protection Agency Office of Resource Conservation and Recovery, 2019). The following processes contributed to the GWP factor of anaerobic digestion:

- Transport of materials
- Preprocessing and digester operations
- Biogas collection and utilization
- Curing and land application
- Fugitive CH4 and N2O emissions
- Carbon storage
- Avoided fertilizer offsets
- Net electricity offsets

Composting

Composting considers the aerobic microbial decomposition, which transforms organic substrates into a stable, humus-like material. The following processes contributed to the GWP factor of composting:

- Collecting and transporting the organic materials to the central composting site.
- Mechanical turning of the compost pile.
- Non-CO2 GHG emissions during composting (primarily CH_4 and N_2O).
- Carbon storage after compost application to soils.

Composting also results in biogenic CO_2 emissions associated with decomposition, both during the composting process and after the compost is added to the soil.
Therefore, the net resulting GWP for compositing that was assumed to calculate the savings in GHG emissions from compositing of organic waste is estimated at -0.16 tonnes of CO2-eq per tonne of mixed organics composted (adopted from U.S. Environmental Protection Agency Office of Resource Conservation and Recovery, 2019).

An economic evaluation of the role of compost with regard to its potential to sequester carbon in soil and its total plant macro-nutrient content, suggests that it has significant monetary value ranging from 21.2 – 28.2 Euros / tonne. This is just its carbon and nutrient value and not the price that can be achieved, as this price is a matter of commercialization and it is determined by the competition with similar products in many countries quality compost from municipal waste has a price between 50-90 euros/ tonne.
In addition, according studies made by the European Compost Network (Lystad, 2017), the management of biowaste through source separation and composting, has a substantial potential for new employment creation. On average, through proper management of all the biowaste in EU, there is a potential of 230,000 new jobs or 2.4 new jobs per thousand tonnes of biowaste treated separately (Lystad, 2017). The potential is higher to rural areas (1 job per 1,380 tonnes) and lower to urban areas (1 job per 4,500 tonnes).

Table 5 summarizes the benefits of proper biowaste management through source separation and composting or anaerobic digestion.

Table 5. Qualitative benefits of proper biowaste management

CATEGORY	BENEFITS
Job creation	On average, through proper management of all the biowaste in EU, there is a potential of 230,000 new jobs or 2.4 new jobs per thousand tonnes of biowaste treated separately
Soil protection and improvement	Compost improves soil quality (biological activity, physical characteristics). It also enhances plant growth - value adding through organic farming and it reduces substantially erosion.
Resource management	Using compost and digestate save virgin resources in terms of phosphorus and peatland, while the source separation of the organics enables recycling of dry residual waste resources
GHGs savings	Biowaste recycling contributes to GHGs savings through: • Reduced methane emissions from landfilling • Replacement of fossil fuels in transportation, heat and power • production • Replacement of mineral fertilisers and peat • Carbon sequestration in soil
Renewable energy	Producing renewable energy through Anaerobic Digestion contributes to: • Safe and 24/7 reliable renewable energy for transportation, heat and electricity purposes • Balancing a future renewable energy mix

Quantification of benefits for North Macedonia

For the quantification of the benefits of a proper biowaste management, through source separation, in North Macedonia, the following steps were considered:

1. According the National Waste Management Plan 2020 – 2030, the total municipal waste generated for 2016 was 796,585 tonnes and 45.3% out if it regards organics. Thus, the quantity of organics in 2016 is 360,853 tonnes.
2. According the National Waste Management Plan 2020 – 2030 (page 39), in 2030, the total amount of biodegradable waste that goes to landfills should not exceed 168,000 tonnes.
3. We assume that:
    a. The targets set by the National Waste Management Plan 2020 – 2030 (page 39) will be achieved.
    b. All the biodegradable fraction reduction in landfills will be realized through source separation and composting of organics from municipal waste (anaerobic digestion is considered more complex and difficult, so we choose the easiest and cheaper way for biowaste management).
    c. The waste quantities remain stable at the level of 2016.
4. In this case, the quantity of organics that should be diverted from landfills in 2030 is calculated at 192,853 tonnes per year.

Thus, we assume that in 2030, 192,853 tonnes of biowaste are separately collected at source and composted in several decentralized facilities around the country. This means that roughly 94,000 tonnes of quality compost are produced. **Table 6** presents the quantification of the benefits involved for the year 2030.

Table 6. Summary of benefits from circular activities for biowaste stream by 2030

	QUANTITY	UNIT	REMARKS
***2030* TARGET**	168,000	tonnes/year	Max biodegradable to landfills in 2030
COMPOST PRODUCED	94,000	tonnes/year	
ECONOMIC BENEFITS			
CARBON & NUTRIENTS VALUE	2,350,000	EUR/year	Assuming an average of 25 EUR / tonne according (Gilbert, 2020)
MARKET VALUE OF COMPOST	3,760,000	EUR/year	Assuming 40 EUR/ tonne based on the market conditions
CARBON PRICE SAVINGS OR CARBON CREDITS	6,378,613	EUR/year	Assuming a carbon price of 21 EUR/ tonne CO_2-eq (Ramstein et al., 2019)
TOTAL ECONOMIC BENEFIT BY 2030	*12.49*	Million EUR /year	
EMPLOYMENT BENEFITS			
TOTAL NEW JOBS CREATED BY 2030	*488*	*Jobs*	Based on ECN's approach (2.4 jobs per 1000 tonnes of biowaste managed)
REDUCTION OF GHGS EMISSIONS			
AVOIDED LANDFILL EMISSIONS	268	Gg CO_2-eq/year	Assuming that the 100-year GWP for biowaste landfilling is 1.39
SAVINGS FROM COMPOSTING	36	Gg CO_2-eq/year	
TOTAL SAVINGS IN GHG EMISSIONS EXPECTED BY 2030[(1)]	303.74	Gg CO_2-eq/year	

[(1)] The savings in GHG emissions are calculated by subtracting the total GHG emissions of the baseline scenario from the alternative scenario that considers meeting the 2030 target.

6.3.3. Construction and Demolition waste (C&D)

a. Current management and problems involved

Construction and Demolition waste (C&DW) definition

Construction and demolition waste (C&DW) refer to the waste generated from the construction of buildings and infrastructure as well as the maintenance and the partial or complete demolition of existing facilities. EU Directive 2018/851 refers to this definition and incorporates the waste arising from minor do-it-yourself construction and demolition activities within private households. C&DW correspond to the types of waste included in Chapter 17 of the list of waste established by Decision 2014/955/EU in the version in force on 4 July 2018.

This waste stream constitutes one of the largest both by weight and volume waste fraction in the EU. Due to the high potential for recycling and reuse of the C&DW and the existence of a re-use market for different C&D materials and components, it has been identified as a priority waste stream by the EU.

Current C&DW management practices

In North Macedonia, local authorities are the responsible bodies for the management of the C&DW. According to the NWMP, despite the authorization of municipalities to coordinate and organize the management of this waste stream, current practices show that is mainly implemented informally, i.e. C&DW quantities are mostly collected by the informal sector and are illegally dumped. Moreover, there are a lot of questions about the amounts of the waste generated in construction and demolition activities, since there is a serious lack of data. In the NWMP the C&DW quantities generated in the country are estimated using the average per capita generation as an indicator from other countries and the results were:

- C&D waste (without excavation waste): around 1.95 million tons per year
- C&D waste (including excavation waste): around 8.5 million tons per year

It must be pointed out that the State Statistics Office (SSO) in 2018 officially reported only 35,617 tons of C&DW generated, where this number in 2016 was only 1,235 tones. These numbers show the enormous gap of information existing in the country regarding the management of this waste stream.

Understanding the significance and the problematic situation regarding this waste stream, North Macedonia sets proper C&DW management as a priority which is translated in formalizing collection activities and promote recovery and proper disposal activities. The NWMP shows that the country competent authorities will follow a phased approach to improve the C&DW management. In this framework the following measure and actions are required:

- To negotiate an extension of 10 years to achieve the waste framework directive (WFD) of 70% recovery of C&D. This extension is necessary for the country to improve management practices and to develop the necessary infrastructure

- To improve data on C&D waste by enforcing construction firms to take part in surveys regarding the waste generated in their activities
- To promote selective demolition and removal of the hazardous part from the C&D waste stream in order to facilitate reuse and high-quality recycling
- To introduce mandatory Site Waste Management Plans for large scale projects where the construction companies will be obliged to provide information about the waste amounts generated and their management during construction and demolition activities
- To develop C&DW sorting facilities for every region of the country for at least the following materials: wood, mineral fractions (concrete, bricks, tiles and ceramics, stones), metal, glass, plastics and plaster
- To provide market development support to the operators of the sorting facilities to enable them to promote and sell secondary materials to the market
- To develop an effective legislative framework that includes all these activities and to discourage illegal dumping through proper enforcement

In the meantime, until the implementation above mentioned measures and actions, the sanitary landfills will accept the C&D waste stream in order to decrease the rates of illegal dumping.

b. Circular solutions and practices

C&DW management shows a big potential to become circular in practice. It shows a high a potential for recycling and re-use and, probably most importantly, a secondary materials market exists ready to absorb materials resulted from C&D waste recovery activities. Data from EU show that C&D waste recovery rates are very high. According to Eurostat[8] the EU average recovery rate of C&D waste in 2018 was 90% (*Figure* 11) and the majority of Member States achieved the recovery requirement of the WFD that requires 70% of the C&D waste quantities to be recovered. It must be noted that in both WFD and EU Member States reports, recovery rates refer to the non-hazardous, mineral C&D waste.

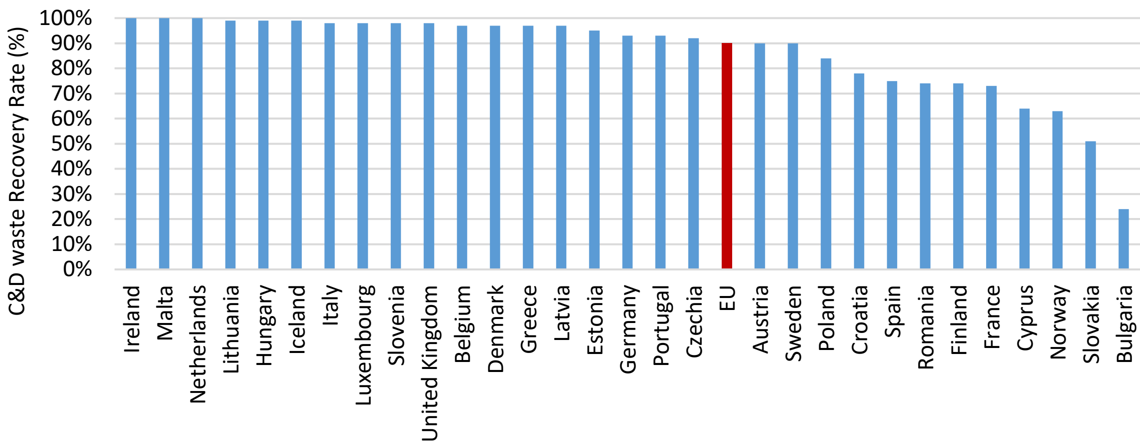


Figure 11. C&DW recovery rate in EU – 2018 (source Eurostat)

[8] https://ec.europa.eu/eurostat/tgm/table.do?tab=table&plugin=1&language=en&pcode=cei_wm040

The C&DW treatment methods followed in different Member States are presented in Figure 12 (reference year: 2016).

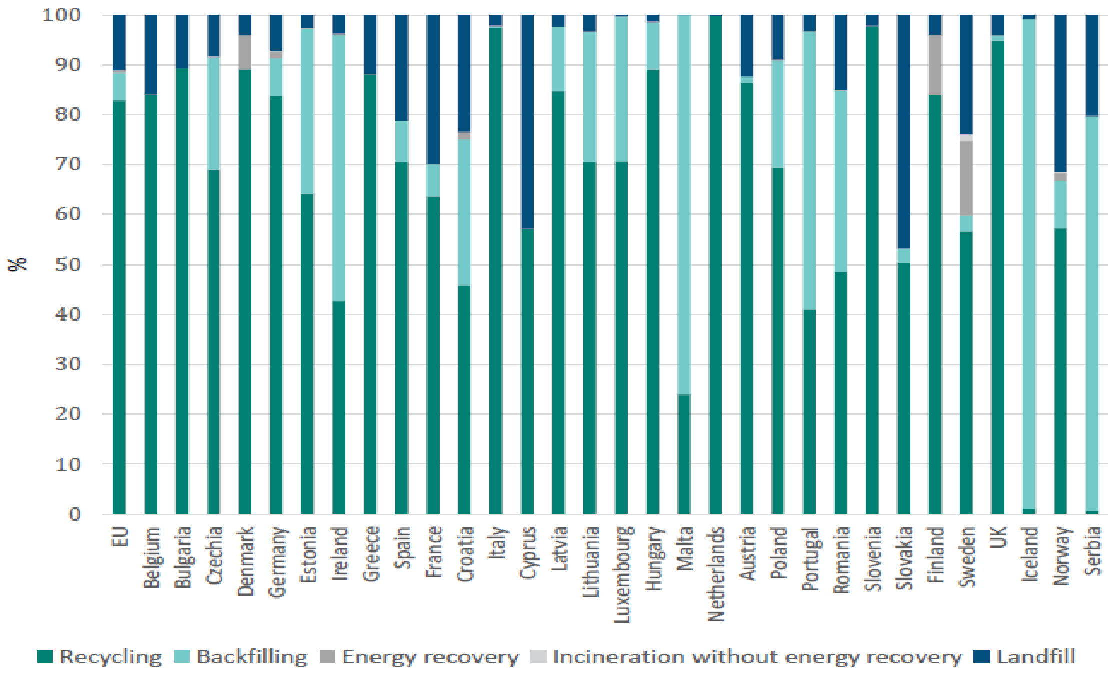


Figure 12: Treatment of mineral C&DW, per cent (Spurce: Margareta Wahlström et al., 2020)

These data confirm the realistic opportunity for applying CE initiatives effectively in this waste stream. EU has made some important steps towards CE in C&D waste management. Recycling and reuse practices show that secondary materials are rarely used in the building sector and materials from demolished buildings are commonly used in backfilling works and in the construction of infrastructure projects, e.g. as base material in road construction. In these low-grade applications, secondary materials do not keep their value high and the circular economy loops do not close properly.

In C&D waste management, CE initiatives must not focus only to increase recycling rates but also on:

- Increasing materials economic lifetime as long as possible;
- Keeping the materials value as high as possible;
- Reducing hazardousness in secondary materials.

There are some significant barriers in the adoption of CE in the C&D waste management. The most important of them are the following (European Environmental Agency, 2020):

- Price competition with virgin alternatives: Stakeholders tend to favor cheaper and credible solutions, and virgin minerals are in many cases cheaper than secondary materials due to the latter's processing costs
- Confidence in quality and structural properties of secondary materials (traceability): Stakeholders tend to choose virgin materials that are quality assured through warranties and standards

- Hazardous substances content: Polluted materials are not suitable for recycling, and removal of the hazardous content is costly
- Lack of sufficient and reliable data on (historical) buildings: The composition of material streams from demolition activities cannot always be predicted
- Time delay: The time delay between implementing a circular action and its benefits due to the long life
- Spans of buildings may discourage stakeholders

In order to overcome these barriers, changes in building and demolition practices are necessary for the generation of high purity materials, suitable for closed-loop recycling practices. These changes can focus on the following (European Environmental Agency, 2020):

- High-grade products with high-recycled content: use of high durability materials in building activities
- Design for disassembly: construction elements must be designed in such way to be easily separated into components that can be reused, recycled
- Materials passports: materials used in construction activities must be accompanied with sets of data regarding materials' characteristics
- Extension of construction service life: renovate, improve maintenance, upgrade repair and adapt constructions
- Selective demolition: removal of hazardous materials and increase source separation into high-value and pure materials fractions

The above five concepts/changes in construction and demolition activities are presented in **Figure 13**.

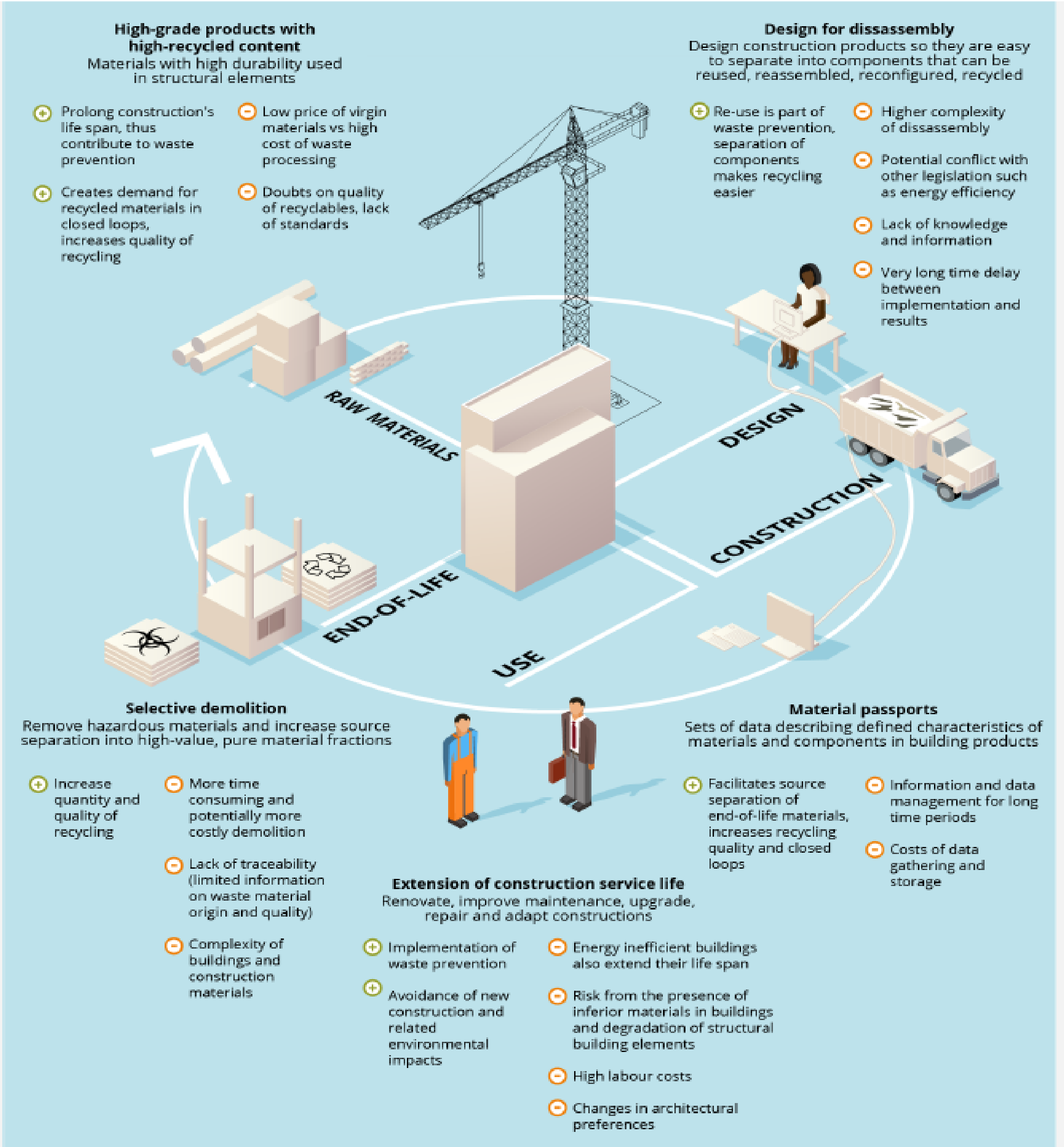


Figure 13. Changes in construction and demolition activities to improve C&DW management (Source: European Environmental Agency, 2020)

c. Circular benefits

In this section of the report the benefits for North Macedonia from the application of basic CE activities (recycling and reuse) of C&D waste are presented. In order to quantify the benefits, the following assumptions were considered in the calculations:

- Quantity of C&D waste generated in country level equal to 1.95 million tons based on the NWMP 2020 – 2030
- The typical composition of C&D waste adopted is the following:

Table 7. Typical C&D waste composition

Material	% by weight
Concrete	65
Bricks	2
Reclaimed asphalt pavement	14
Fines	3
Cardboard	3
Glass	3
Organics	1
Plastic	2
Carpet	3
Asphalt shingles	2
Gypsum drywalls	2
Metal	1

Source : CDRA - Construction & Demolition Recycling Association (2017)

The calculations presented show the benefits from the achievement of the WFD target of 70% recovery for the C&D waste generated in the country. Taking into consideration the C&D composition, the amounts for every material recycled and landfilled is presented in **Table 8**.

Table 8. C&D waste quantities recovered and landfilled applying the WFD target

Material	Quantities recovered (tonnes)	Quantities to landfill (tonnes)
Concrete	887,250	380,250
Bricks	27,300	11,700
Reclaimed asphalt pavement	191,100	81,900
Fines	40,950	17,550
Cardboard	40,950	17,550
Glass	34,125	14,625
Organics	13,650	5,850
Plastic	27,300	11,700
Carpet	34,125	14,625
Asphalt shingles	27,300	11,700
Gypsum drywalls	27,300	11,700
Metal	13,650	5,850
TOTAL	**1,365,000**	**585,000**

Reduction of raw materials extraction

CE applications in C&D waste management provide a source of materials that would otherwise have to be mined from the earth. Construction industry is the biggest consumer of virgin materials extracted from earth representing around 50% of the overall extracted materials. These resource savings have a direct connection with savings in GHGs and energy from avoiding mining of materials.

Reduction of landfilled quantities

Landfilling of C&D waste has a major impact on sanitary landfills' available capacity resulting in significant decrease of available lifetime of the facilities and the need to find new areas to expand existing landfills become more urgent since the C&D waste volumes are usually much bigger than the municipal waste, consuming quicker the available landfill capacity and lifetime.

According to the Construction and Demolition Recycling Association (CDRA - Construction & Demolition Recycling Association, 2017), recycling 430 million tons of C&D waste, the landfill area saved is about 5,534 acres (22.4 million m^2) of landfills or 336 million m^3 of landfill capacity. By applying these indicators, from the diversion of 1,365 million tons of C&D waste the country's available landfill capacity is increased by 1.1 million m^3 and the corresponding landfill area savings are almost 71 thousand m^2 for the case of Macedonia in 2016.

Reduction of GHGs emissions

Recycling and recovering activities in C&D waste in addition to the above-mentioned benefits, can decrease significantly the GHG emissions. The U.S. Environmental Protection Agency Office of Resource Conservation and Recovery, reported (U.S. Environmental Protection Agency Office of Resource Conservation and Recovery, 2019) has reported GWP factors from the different management options for different materials. Using these GWP factors, the total estimated GHG emissions for the baseline scenario is around 46.6 Gg CO_2-eq / year, considering landfilling of all C&D waste generated in North Macedonia in 2016 (see **Table 9)**.

Table 9. Total GHG emissions for the baseline scenario in Macedonia in 2016

Material	Quantities to landfills (tonnes)	Landfill emission factor (tonnes of CO2-eq/tonne of material)[(1)]	Total emissions (tonnes of CO_2-eq)
Concrete	1,267,500	0.02	25,350
Bricks	39,000	0.02	780
Reclaimed asphalt pavement	273,000	0.02	5,460
Fines	58,500	0.02	1,170
Cardboard	58,500	0.14	8,190
Glass	48,750	0.02	975
Organics	19,500	0.21	4,095
Plastic	39,000	0.02	780
Carpet	48,750	0.02	975
Asphalt shingles	39,000	0.02	780
Gypsum drywalls	39,000	-0.06	(2,340)
Metal	19,500	0.02	390
Total	**1,950,000**		**46,605**

[(1)] The landfill emission factors for each material are adopted from U.S. Environmental Protection Agency Office of Resource Conservation and Recovery, 2019

By achieving the WFD recovery target, the net GHGs emissions generated from the management of C&D waste is estimated at -340,509 tonnes of CO_2-eq/ year as presented in **Table 10**.

Table 10. Total GHG emissions from adopting the WFD recovery as an alternative to the baseline scenario in Macedonia for the year 2016

	Quantities recycled (tonnes / year)	Net recycling emission factor (tonnes of CO2-eq/tonne of material)	Recycling/ composting emissions (tonnes of CO2-eq/year)	Quantity landfilled (tonnes/ year)	Landfilling emission factor (tonnes of CO2-eq/ year)	Landfilling emissions (tonnes of CO2-eq/ year)
Concrete	887,250	-0.01	-8,872	380,250	0.02	7,605
Bricks	27,300	NA	-	11,700	0.02	234
Reclaimed asphalt pavement	191,100	-0.09	-17,199	81,900	0.02	1,638
Fines	40,950	-0.01	-409.50	17,550	0.02	351
Cardboard	40,950	-3.55	-145,372	17,550	0.14	2,457
Glass	34,125	-0.28	-9,555	14,625	0.02	293
Organics	13,650	-0.16[(1)]	-2,184	5,850	0.21	1,229
Plastic	27,300	-1.03	-28,119	11,700	0.02	234
Carpet	34,125	-2.38	-81,217	14,625	0.02	293
Asphalt shingles	27,300	-0.09	-2,457	11,700	0.02	234
Gypsum drywalls	27,300	0.03	819	11,700	-0.06	-702
Metal	13,650	-4.39	-59,923	5,850	0.02	117
TOTAL	**1,365,000**		**-354,490**	**585,000**		**13,981**

[(1)] Net composting emission factor expressed in tonnes CO2-eq/tonne of material, adopted from U.S. Environmental Protection Agency Office of Resource Conservation and Recovery, 2019

The avoided GHG emissions[9] with respect to the alternative scenario for attaining the WFD (target of 70% recovery) is estimated at 387.11 Gg CO_2-eq/ year in comparison to baseline condition in Macedonia for 2016.
The external costs of the reduction of GHGs can be also calculated considering the following factor of 21 Euros /tonne of CO_2-eq (100 yrs) (Ramstein et al. 2019). By applying this factor to the amount of avoided GHG emissions for the given scenario the overall savings in costs is almost 8.1 million Euros/ year.

<u>Job creation</u>

CE activities in C&D waste requires more employees per amount of material processed as compared to other management options and mainly landfill disposal. The Construction and Demolition Recycling Association (CDRA - Construction & Demolition Recycling Association, 2017) conducted a survey in the construction materials recycling industry and issued two indicators regarding the new jobs created per million of construction materials recycled. These indicators refer to both mixed C&D recycling facilities and bulk aggregate facilities and they are the following:

- 233 jobs per million tons of mixed C&D waste recycled

[9] The avoided GHG emissions is calculated by subtracting the total GHG emissions of the baseline scenario from the alternative scenario that considers meeting the WFD target.

- 45 jobs per million tons of bulk aggregate recycled

In North Macedonia according to the NWMP, the C&D waste generation is around 1.95 million tonnes per year. Assuming that almost 90% of the concrete quantities refer to bulk aggregates the overall C&D waste generated in North Macedonia consists of 794,040 tonnes of mixed C&D waste and 1,155,960 tonnes of bulk aggregate. Applying the WFD targets (70% recovery) and the relevant new jobs indicators, presented above, the total new jobs created are about 168 (see **Table 10**).

Table 11. New jobs creation from recycling and recovering activities for the C&D waste stream

Type	C&DW amounts generated	WFD target	Amounts recovered	New jobs per million tons recycled	Total new jobs
Mixed C&DW	809,250	70%	566,475	233	132
Bulk aggregates	1,140,750	70%	798,525	45	36
				Total	**168**

Table 12 presents a summary of the benefits from the introduction of recovery and recycling activities in the C&D waste stream in comparison to the baseline scenario.

Table 12: Summary of benefits from recycling and recovery activities in C&D waste stream by 2030

	QUANTITY	UNIT	REMARKS
2030 TARGET	70	%	WFD target of 70% recovery for the C&D waste generated
RECYCLING QUANTITIES OF C&D	1,365,000	tonnes/year	
ECONOMIC BENEFITS			
TOTAL ECONOMIC BENEFIT BY 2030	*8.13*	Million EUR /year	
EMPLOYMENT BENEFITS			
TOTAL NEW JOBS CREATED BY 2030	*168*	*Jobs*	
REDUCTION OF GHGS EMISSIONS			
BASELINE CONDITION IN 2016	46.6	Gg CO_2-eq/year	Considering landfilling all C&D
2030 TARGET	- 340.5	Gg CO_2-eq/year	Considering 70% recovery of C&D
TOTAL SAVINGS IN GHG EMISSIONS EXPECTED *BY 2030*[(1)]	*387.11*	Gg CO_2-eq/year	
OTHER BENEFITS			
INCREASE IN LANDFILLS *CAPACITY*	1,100,000	m^3/year	
REDUCTION OF LANDFILL AREA	71,000	m^2/year	

[(1)] The savings in GHG emissions are calculated by subtracting the total GHG emissions of the baseline scenario from the alternative scenario that considers meeting the 2030 target.

6.3.4. Solid Recovered Fuel (SRF)

a. Current management and problems involved

Residual Derived Fuel (RDF) or Solid Recovered Fuel (SRF) is the solid fuel prepared from high calorific fractions of non-hazardous waste materials to be utilized for energy recovery in incineration or co-incineration plants and meet the classification and specification

requirements laid down in European Standards (EN 15359). There is no experience in. North Macedonia regarding the production and use of SRF from municipal waste, so this paragraph will serve as an introductory one and aims to familiarize the reader with the main concepts regarding SRF.
The National Waste Management Plan 2020-2030 mentions (page 45) that: "Opportunities exist to make better use of residual municipal waste. The production of Refuse Derived Fuel (RDF) and Solid Recovered Fuel (SRF) for energy recovery will be explored including the use of existing co-incineration capacity. There are two cement kilns within 20-30 miles of Skopje. This approach would require development of treatment facilities to prepare the waste but not investment in dedicated EfW infrastructure."

The economies of the OECD countries have been dominated by the **linear economy** of extract, make, use, dispose since the early industrial revolution. In this economy **between 80- 90% of what is used by consumers becomes waste within 6 months. Almost one fifth of global material extraction becomes waste each year.**

The G7 Leaders' at their summit, 7-8th June 2015 established a G7 Alliance on Resource Efficiency. It has been set up to tackle the urgent global challenge of a rising population driving demands for raw materials. They recognized this demand "translates into increasing business risks through higher material costs, as well as supply uncertainties and disruptions". The declaration further highlighted the need for ambitious action to build on "existing national and regional initiatives, including the Kobe 3R Action Plan (Reduce, Reuse, Recycle)". This is where the role of Circular Economy is becoming mainstream.

The CE approach considers raw materials in a different way whereby products and materials are designed for recovery and re-use. Goods are either a source for raw materials that can be recovered and re-used or energy to displace primary fossil fuels. Raw materials can be recovered from both organic and inorganic materials that have previously been used.

The waste hierarchy is both a guide to sustainable waste management and a legal requirement of the revised EU Waste Framework Directive. It lays down a priority order of what constitutes the best overall environmental option for managing waste. The hierarchy is applied in the planning system through almost all the EU national members waste planning policy. The hierarchy's order (prevention, preparation for reuse, recycling, energy recovery and disposal) means that energy from waste is generally considered to have an environmental performance inferior to recycling but superior to disposal through landfill or combustion without energy recovery. In a perfect world all waste would be prevented, and the hierarchy would be unnecessary. However, in reality a range of social, economic, practical and technological reasons mean that different waste streams are currently best dealt with at different levels of the hierarchy – including energy recovery. Also, for specific wastes sometimes it is better to depart from the hierarchy altogether.

In most EU countries it is readily acknowledged that many waste materials that could theoretically be recycled are not currently and go to energy recovery or landfill. It is important that the presence of energy recovery as an option does not diminish efforts to overcome the range of barriers to capturing and recycling these. However, it is equally important that while those barriers do exist, energy from waste is used effectively to ensure those materials do not go to a worse environmental fate in landfill. In this context energy from waste needs to support, not compete with, both increased diversion from landfill and increased recycling whilst also ensuring waste reduction and reuse is not compromised.

To put it in a different context, **the challenge is to generate value from waste in terms of saved natural resources.** Material recovery is better than energy recovery in this respect when it comes to sorted, pure and homogenous high-value materials that are easily recovered such as plastic from industry, newsprint and where energy processes add no value such as pure glass and metals. Energy recovery has, however, its place when it comes to materials that are not easily recycled such as soiled or contaminated materials, composite materials and materials with a quality not suited for recovery for instance due to deterioration of quality through cascading in the course of several recycling sequences. Energy recovery may also be the better choice for low-value materials such as wood and materials that require disproportionate resources to collect, handle, and recover in a separate process system.

It is obvious that the energy recovery through the production of SRF has its own contribution to Circular Economy. Whenever waste is thermally converted with energy recovery, it generates primarily electricity and heat. A common benefit of energy and fuels, like SRF, from waste is that these outputs replace other energy resources, particularly fossil fuels and thereby their emissions of carbon dioxide. Plants for energy recovery from waste are thus dual purpose; replacing other energy resources and being part of the waste management system.

Energy recovery serves the same high-level objective as many material-recycling activities. For instance, one objective of recycling plastic is saving oil or natural gas, which are normally used for energy purposes. In similar manner oil, gas, or other primary energy resources are saved through energy recovery of plastics in SRF facilities producing electricity. Therefore, the process system used depends on the outputs, processing efficiencies and local circumstances.

SRF is a major option for recovering energy from solid wastes and can potentially contribute to the sustainable resource management and towards energy efficiency and security.
The role of SRF in circular economy is important since SRF production is complementary to recycling. There is a common misunderstanding regarding the competition between the increase - optimization of recycling and the use of high calorific value fractions for energy recovery and SRF production. However, full recycling is not possible since optimized sorting facilities can typically recover no more 35 - 55% of input recyclable material, leaving, therefore, space for SRF production. In addition, another benefit of SRF is the potential incorporation of the biogenic content of the initial waste stream; in this case the resulted fuel becomes a carbon dioxide (CO_2)-neutral and alternative renewable energy source, into the fuel.

b. Circular solutions and practices

SRF can be thermally recovered using a series of different end-user technologies as follows:

- Co-combustion in cement or lime kilns
- Dedicated mono combustion in purposely built Energy from Waste plants
- Co-combustion in power plants
- Industrial boilers
- Metallurgical plants for substitution of reducing agents

The main process of SRF production is the mechanical-biological treatment (MBT) of solid waste, which might be employed in facilities that typically are divided into two categories:

- Separation facilities, splitting residual waste into "biodegradable" (that may be dried and used as fuel) and "high calorific" fractions, and
- Dry stabilization processes facilities, which are less concerned with the splitting into fractions, and aim more at using the heat from a degradation process to dry the residual waste and increase its calorific value, therefore making it suitable for use as a fuel as well as to improve the separation of fractions.

SRF production can be divided into several steps, which are listed below. However, this list only presents an overview of possible techniques; usual process lines combine several of the below listed techniques, but not necessarily each one of them:

- Receiving area / bunker
- Presorting / contaminants selection
- Size reduction - comminution
- Metal separation
- Classification
- Air classification
- Near infrared spectroscopy
- Automatic picking
- Compacting / pelletizing
- Storage / storage area / hopper
- Biological degradation / thermal drying
- Exhaust gas collection and cleaning
- Wastewater treatment
- Loading and transportation

In some cases, additional processing steps (e.g., further compacting or further size reduction) may be required to design SRF according to the consumers' needs.

Figure 14 shows schematically the SRF production processes from Municipal Solid Waste (MSW), Industrial - Commercial Waste (I&CW), and Construction – Demolition Waste (C&DW). SRF is the final product of a long waste processing procedure where recycling (material recovery), organic recovery, incineration and even landfill for residuals might also be employed for different sort of waste (Glorius, 2014). Therefore, as mentioned above, the role of SRF in circular economy is important since it provides a renewable energy source for the materials that are not recycled either due to inefficient recycling systems or due to their physical – chemical properties.

The marketability of SRF strongly depends on several parameters. The most important are the stability, the adequacy and the high quality of the fuels, according the end-users needs. Standardization is the key for effective SRF markets.

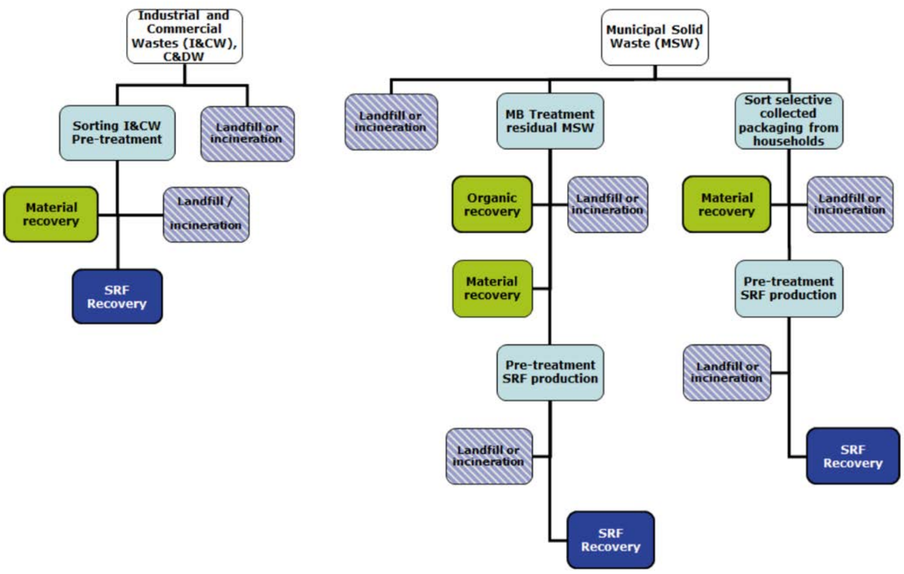


Figure 14. Schematic representation of two processes that can be used for SRF production

For the production of high quality SRF standardization and classification has been determined as the key-tool. The performance of the plant where SRF is used is depending on the properties of the SRF, as well as on the design and operating conditions of such a plant. SRF standardization aims at:

- Describing the fuels;
- Establishing a "common language";
- Distinguishing between SRF and RDF; and
- Helping to develop the SRF markets.

In order to meet the aforementioned aims, a series of standards have been issued so far by CEN/TC343, a technical body working on SRF standards publishing several technical documents so far, comprising five working groups, each of which is working on different issues of SRF standardization (terminology and quality assurance, fuel specifications and classes, sampling and supplementary test methods, physical/mechanical tests and chemical tests). **Figure 15** illustrates a simplified flow chain for SRF, from input of waste to the end-use of SRF.

According to the EN standards, SRF shall comply with the following requirements:

* SRF shall be classified;
* SRF shall meet quality requirements according to specific rules; and
* SRF properties shall be specified according specific procedure.

The classification system for SRF is based on limit values for three important fuel characteristics. These are:

* The mean value for net calorific value (NCV), as received;
* The mean value for chlorine content on dry basis (d); and
* The median and 80th percentile values for mercury content as received

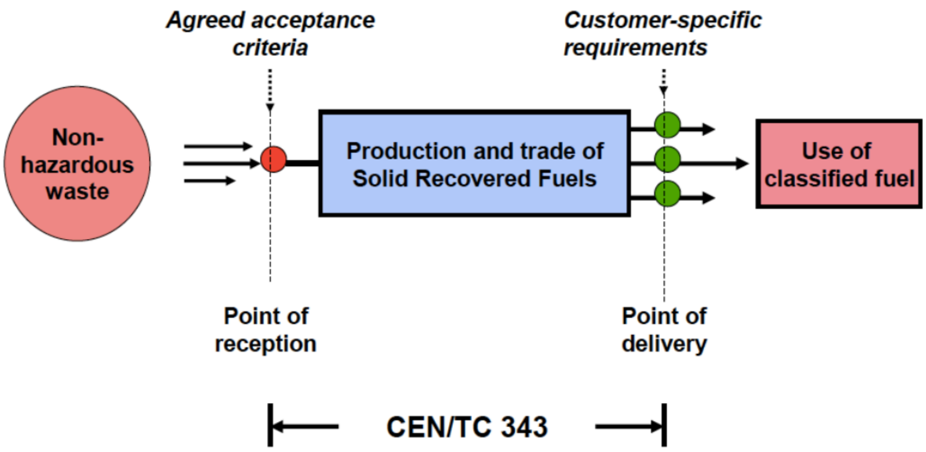


Figure 15. The EN Standard and its role in SRF supply chain

Each characteristic is divided into 5 classes. SRF shall be assigned a class number from 1 to 5 for each characteristic. A combination of the class numbers makes up the class code. Thus, based on these standards, there are 125 SRF different classes, based on limit values for three fuel properties. The characteristics are of equal importance and thus no single class number determines the code. Table 13 presents the classes, the descriptors and values in accordance to CEN TC/343 for SRF.

Table 13. Classes, descriptors and values, according to CEN TC/343 for SRF classification

Property Category	Classification Property	Unit	Statistical Measure	Classes				
				1	2	3	4	5
Economy	Net calorific Value (NCV)	MJ/kg (ar)	Mean	≥25	≥20	≥15	≥10	≥3
				1	2	3	4	5
Technology	Chlorine	%w/w (d)	Mean	≤0.2	≤0.6	≤1.0	≤1.5	≤3.0
				1	2	3	4	5
Environment	Mercury	mg/MJ (ar)	Median[3] 80th percentile[3]	≤0.02 ≤0.04	≤0.03 ≤0.06	≤0.08 ≤0.16	≤0.15 ≤0.30	≤0.5 ≤1.0

For example, the class code of a SRF having a mean NCV of 19 MJ/kg, a mean chlorine content of 0.5 % and a median mercury content of 0.016 mg/MJ with a 80th percentile value of 0.05

mg/MJ (ar) is designated as: Class code NCV 3; Cl 2; Hg 2. Not all kinds of SRF are suited for all types of installation. For example, if 100% SRF is used as fuel and an emission limit for Hg is defined at 0,05 mg/m3, for cement and lime kilns as well as for power plants, class Hg 1 fuels would fit to all types of these, while class Hg 5 fuels could only be used in these processes, if this class of fuel is just a part of the fuel mix. For other classes, the specific transfer factor of a given process and the proportion of SRF will determine, which classes can be used without improvement of the transfer conditions.
Besides the major standardization that is presented above, there is a plethora of sampling and preparation standards.

However, standardization in isolation cannot guarantee increased market share of SRF, since SRF marketability depends largely on its quality and quantity. Therefore, the implementation of a comprehensive Quality Management System (QMS), including appropriate QA/QC procedures, especially in the light of the wider technical, financial, policy and legal challenges involved, is imperative. QMS for SRF production should cover the whole process from the point of waste reception to the point of delivery of SRF to the customer. Generally speaking, a QMS suitable for SRF production, should have several important features, such as:

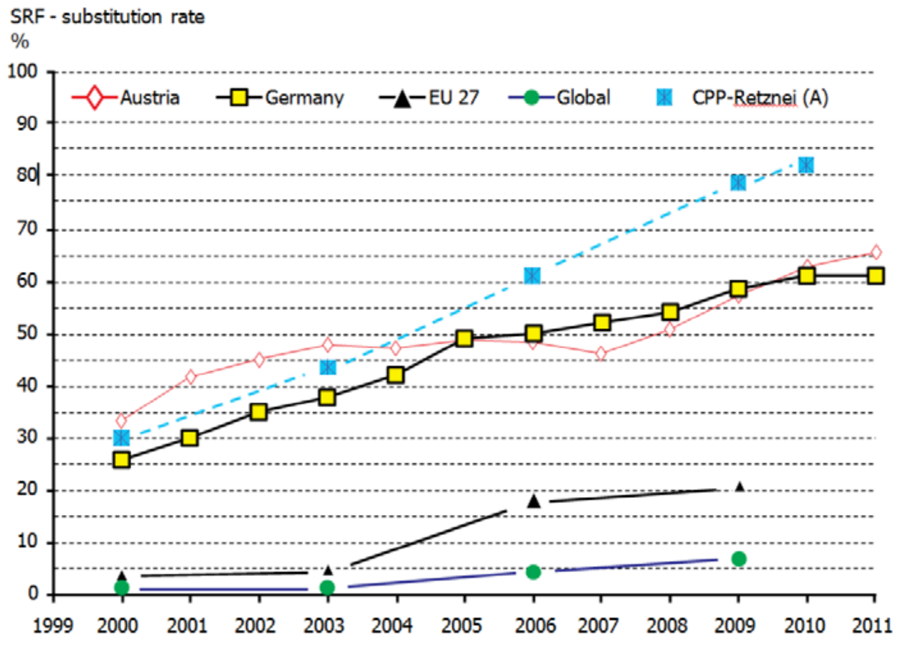
- The key steps in the process;
- The person(s) who is/are responsible for each step of the process, and for the overall co-ordination of quality-management;
- Training – policies and procedures for execution;
- Procedures for production;
- Procedures for record-keeping, to provide full traceability;
- Procedures for dealing with failures, and self-improvement; and
- Procedures for the development of the processing.

Such a QMS, which typically is based on the principles of ISO-9001, is fully described in the European Standard on “Solid recovered fuels - Quality management systems - Particular requirements for their application to the production of solid recovered fuels” (EN 15358:2011).

Currently available data indicate that approximately 13.5 Mt of SRF are used in the EU, 12 Mt of which are used in cement plants and dedicated EfW plants and 1.5 Mt in other applications, mainly to coal power plants. In total, it is estimated that more than 5,000 million m3 of Russian gas is replaced with SRF. A first attempt assuming very moderate substitution rates shows that, in Europe, 63 Mt of SRF could be produced from mixed wastes such as Municipal Solid Waste, Commercial & Industrial Waste and Construction & Demolition Waste and the market for SRF could amount to at least some 53 Mt which would replace at least 20,000 million m3 of natural gas.

The most important end user to SRF is still the cement industry. Fuels derived from waste have been used in the EU cement kilns for over 30 years. But there is also a huge unused potential in many other industries like paper industry, chemical industry etc. SRF market expansion has different drivers among European countries. A common factor, in all the countries involved, is that SRF is considered a renewable energy source and its use improves the GHGs emissions profile, as well as the relevant carbon economics. In Germany the most important drivers were landfill ban and resource strategy, the energy crisis and energy price development, and the wide recognition of the necessity to substitute expensive fossil fuels. In UK, SRF was rather a political choice, due to the difficulties to obtain a permit for EfW plants and it was substantially pushed by the high landfill taxes. In Belgium there was increasing demand of cement plants and in Spain the main drivers were the political choice, the demand of cement plants, and difficulties on the promotion of EfW plants. On the other hand, Italy promoted in early times a legislation that was allowing a product status to SRF. There were also common economic factors promoting SRF use such as the price of primary fuels and availability or lack of alternatives. During the last years, another driver has been also identified and this is the observed overcapacity of EfW plants in northern EU countries, creating additional quantities to be thermally utilized. This has resulted in increase of SRF export (e.g., from UK and Germany).

There is a large potential both for EfW and co-combustion in cement production plants in southern Europe, where both of these alternatives have very limited presence. The above conclusion is also implied by **Figure 16**, in which the substitution rate and trends in utilization of SRF in cement production plants in EU and worldwide is shown. In particular, as shown in Figure 16, the SRF substitution rate in Germany and Austria is continuously much higher than the rate in EU and globally (ERFO, 2015).



Note: CPP: Retznei Cement Production Plant, Austria

Figure 16. SRF substitution rate (the denominator is total fuel needs) in selected EU countries cement industries

During the last 10 years, the evolution and development of SRF technologies and standardization has created a very promising and challenging market due to the following factors:

- Large and homogeneous SRF amounts
- Reliable quality standards about chemical, physical and thermal characteristics
- Long-term availability
- Product- and environment-neutrality during valorization
- Suitability for storage and conveying
- Social acceptance (employees, authorities and public)
- Economic efficiency

SRF co-firing in existing utility boilers will play a key role for the next years. Partial substitution of coal by SRFs in large-scale power plants can effectively assist in covering the capacity limitations to a certain extent and will, furthermore, result in savings of valuable fossil fuel sources and reduction of carbon dioxide (CO2) emissions. SRF co-utilization in existing thermal plants usually requires low additional investments, and in this way reduced electricity generation costs are expected compared with the generation costs from other renewable energy sources, such as wind energy or photovoltaics.

Last but not least, co-processing in cement kilns has the advantage that the clinker reactions at 1450°C allow a complete incorporation of ashes and in particular the chemical binding of metals into the clinker material. Toxic organic compounds are completely destroyed in the flame at higher temperatures of >2000°C. *Direct substitution of primary fuel in the production process represents a significantly more efficient energy recovery than other WtE technologies, typically achieving 85-95% depending on waste characteristics* (GIZ, 2017).

c. Circular benefits

To assess the benefits from the use of SRF, the following assumptions are made:

- We assume that till 2030 a fraction of 50% of the country's municipal waste will be treated to Mechanical Biological Treatment (MBT) plants, capable to produce SRF. This means (based on the National Plan's quantities) that the waste input to MBT plants will be around 400,000 tonnes per year.
- The calorific value of the SRF will be 15 MJ/kg or 3,600 Kcal/kg and its quality will be at least according to class 3 as presented in **Table 13**.
- Based on the composition of the waste stream, as presented in the National Waste Management Plan 2020-2030, it is calculated that 15% of the input can be transformed to a good quality SRF. This means that the annual SRF production will be around 60,000 tonnes of SRF.
- The SRF will substitute a fuel similar to Colombian coal that is very popular to cement plants. The calorific value of the Colombian coal is 24.81 MJ/kg or 5,955 Kcal/kg.
- SRF emission factor = 1,780 kg CO_2/tonne (Psomopoulos et al, 2013 – Hilber et al, 2007), with renewable content of 60%. The renewable content is assessed according to a report

from the US Energy Administration (Energy Information Administration, 2007), which assigns a 56-65% of biogenic content to the heating value of fuels coming from municipal waste.

- Coal emission factor = 2,382 kg CO_2/tonne (emission factor in accordance with IPCC guidelines and the WBCSD Cement Sustainability Initiative

  CO_2 Emissions Inventory Protocol, Version 2.0 for coal price = 85 $/tonne (current price in accordance with Index Mundi[10])

Table 14 presents a summary of benefits from the use of SRF for North Macedonia in 2030.

Table 14. Summary of benefits from the use of SRF in North Macedonia by 2030

	QUANTITY	UNIT	REMARKS
2030 TARGET	50	%	Fraction of waste generated to MBT plants
AMOUNT TO MBT PLANTS	400,000	tonnes/year	
AMOUNT OF SRF PRODUCED	60,000	tonnes/year	Considering that 15 % of MBT input can be transformed to dry SRF
ENERGY PRODUCED	216	Million Gcal	Considering a calorific value of 3,600 Gcal/tonne
COAL QUANTITIES SUBSTITUTED	36,272	tonnes/year	Considering a coal calorific value of 5,955 Gcal/tonne
ECONOMIC BENEFITS			
SAVINGS FROM COAL SUBSTITUTION	*2.65*	Million EUR /year	Considering a coal price of 73.1 EUR/tonne
CARBON CREDIT OR SAVINGS FROM CARBON PRICING	3.92	Million EUR /year	Based on the forecast of 21 EUR / CO2 tonne for 2030
TOTAL ECONOMIC BENEFIT BY 2030	*6.56*	Million EUR /year	In reality the cost savings will be a little bit less due to the logistics involved to transfer the SRF to the cement plants, but this is considered a minor reduction. In addition, the cement plants have to make some investments that will make them capable to receive the SRF
EMPLOYMENT BENEFITS			
TOTAL NEW JOBS CREATED BY 2030	*80*	*Jobs*	
REDUCTION OF GHGS EMISSIONS			
SRF EMISSIONS	42.538	Gg CO_2-eq/year	Considering an SRF emission factor 1,780 kg of CO_2/tonne
SAVINGS FROM COAL SUBTSITUTION	86.031	Gg CO_2-eq/year	Considering an SRF emission factor 2,382 kg of CO2/tonne and a renewable content of 60%
AVOIDED LANDFILL EMISSIONS	143.385	Gg CO_2-eq/year	
TOTAL SAVINGS IN GHG EMISSIONS EXPECTED BY 2030[(1)]	*186.88*	Gg CO_2-eq/year	In reality the savings will be a little bit less due to the logistics involved to transfer the SRF to the cement plants, but this is considered a minor reduction
OTHER BENEFITS			
INCREASE IN LANDFILLS CAPACITY	130,000	m^3/year	This is the minimum expected based on the assumption of two MBT treatment plants of 200,000 capacity each. (60,000 / 0.7) x 1.5

[(1)] The savings in GHG emissions are calculated by subtracting the total GHG emissions of the baseline scenario from the alternative scenario that considers meeting the 2030 target.

Besides the savings related to the fuel cost, another category of economic benefit is related to carbon pricing. The pivotal role of carbon pricing in supporting efforts to decarbonize is also reflected in the Paris Agreement. Article 6 of the Agreement provides a basis for

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[10] https://www.indexmundi.com/commodities/?commodity=colombian-coal&months=180

facilitating international recognition of cooperative carbon pricing approaches and identifies new concepts that may pave the way for this cooperation to be pursued. The EU carbon price is expected to reach 32 EUR/tonne by 2030[11]. Thus, we will calculate the benefits using the price of 21 euros/tonne, which means benefits from the carbon pricing are more than 3.9 million EUR/year.

Regarding the expected new employment, a typical modern MBT plant that produces SRF, with a 200,000 tonnes per year capacity has 35-45 workers. For the treatment of 400,000 tonnes per year, two relevant plants are required, thus the expected new employment is roughly 70-90 labor jobs.

Besides the previous, another benefit will be from the diversion of the SRF from landfills. The volume that will be saved per year is calculated at minimum with the average density of a landfill (around 0.7 tonnes/m^3). However, it has to be considered that the recyclables involved in SRF (plastic and paper non-suitable for recycling) occupy much more volume and are not easily compacted, so the volume savings should be multiplied by 1.5. Thus, the annual volume savings are about 128,600 m3/year.

[11] see https://www.edie.net/news/6/EU-carbon-price-set-to-rise-to-EUR32-by-2030--but-experts-say-EUR81-necessary-to-achieve-net-zero-in-the-UK/

6.3.5. Electrical and electronic equipment (WEEE)

a. Current management and problems involved

Definition of Waste of electrical and electronic equipment (WEEE)

According to the new WEEE Directive (2012/19/EU), means “electrical or electronic equipment which is waste within the meaning of Article 3(1) of Directive 2008/98/EC, including all components, sub-assemblies and consumables which are part of the product at the time of discarding;”. The term of electrical and electronic equipment (EEE) according to the above mentioned directive includes the “equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields and designed for use with a voltage rating not exceeding 1,000 volts for alternating current and 1,500 volts for direct current”.

The current way of living and consumption in combination with the human dependence on EEE and technological progress sets WEEE as one of the fastest growing waste streams worldwide. It is estimated (Forti V., Baldé C.P., Kuehr R., Bel G, 2020) that the global WEEE generation is going to reach 74.7 million tons in 2030, where in 2019 the global WEEE generation was 53.6 million tons.

WEEE consists of a complex mixture of different materials and components that can create serious environmental and health problems because of their hazardousness. At the same time WEEE includes high value scarce materials which are critical for economies worldwide as they are necessary components for the production of new EEE and viable substitutes do not exist, due to their unique characteristics. These reasons determine WEEE as a high priority stream for separate collection, treatment and recycling contributing to the application of CE principles.

Current management practices and challenges involved

North Macedonia presents a continuous increasing market for WEEE which consequently will present significantly high generation of WEEE. According to the NWMP, reliable data regarding the WEEE generation are very limited. However, the NWMP presents details about the WEEE imported and put on the market are presented from 2014 to 2017. In the Global E-waste Monitor 2020 (Forti V., Baldé C.P., Kuehr R., Bel G, 2020), there is an estimation of 15,000 tons of WEEE generated in North Macedonia in 2016 with a per capita production of 7.2 kg of WEEE per capita per year. The total WEEE generated is expected to reach about 20,060 tonnes of WEEE per year by 2030 in North Macedonia, following the global trends.

The most important measures that are taken in the country for the management of some special waste streams was the introduction of EPR systems for packaging waste, WEEE and Waste Batteries and Accumulators. The system for WEEE is in operation since 2013. According to the NWMP, despite the EPR system, the WEEE management is not operating properly and it does not reach its potential.

In 2016, four collective systems for WEEE were operating. These systems collected 1,050 tonnes of WEEE in total, which represents almost 7% of the WEEE generation.
Despite the willingness to meet the EU targets for recycling, reuse and recovery of WEEE, it is considered unrealistic for the country to achieve them. For this reason, the NWMP introduces the WEEE separate collection targets that are presented in **Table 15**.

Table 15. WEEE separate collection targets

	Year						
	2019	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
WEEE	25%	30%	35%	40%	45%	55%	65%

In order to improve WEEE management and to encourage separate collection, the NWMP proposes a set of measures and actions that are listed under 3 major categories:

- Measures to prevent waste, which suggests to the EEE market to import and put on the market products that follow the WEEE EU Directive, that are compliant with the new Rulebook regarding the restriction of the use of certain hazardous substances in EEE, that can easily repaired, dismantled and remanufactured and encourage the citizens to repair and reuse EEE
- Measures to encourage collection of WEEE, which set rules regarding the development of a WEEE collection network that will accept WEEE from citizens free of charge. According to these measures, the municipalities will provide take-back sites and special information and capacity building programs will be implemented regarding WEEE recovery and take-back to the staff of EEE shops
- Measures to improve reuse, treatment technologies, treatment standards, recycling, recovery for all types of WEEE

b. Circular solutions and practices

Separate collection of WEEE, process and production of secondary raw materials is necessary for both financial/economic and environmental reasons. The high value and the continuous increasing demand for secondary materials create favorable market conditions for this type of businesses. But despite of these advantageous circumstances, the WEEE recycling rates are relatively low.

In 2019, the overall amount of WEEE generated worldwide, was 53.6 million tonnes (Forti V., Baldé C.P., Kuehr R., Bel G, 2020). From this amount only 17.4% or 9.3 million tonnes of WEEE were documented to be collected and properly recycled and for the rest of 82.6% or 44.3 million tonnes of WEEE no information about their fate is available. This deviation from the official WEEE collection system results a serious loss of materials and it is connected with important environmental risks for the environment and human health. The overall picture of WEEE management and its impact in the environment and economy is presented in **Figure 17**. From the quantities formally separately collected and recycled, the estimated raw material value was $10bn USD and the secondary materials that can be available for recycling was 4 million tonnes. By reusing only, the iron, aluminum and copper as substitute of virgin materials, saved up to 15 million tonnes of CO_2-eq emissions in 2019. Taking into consideration that the overall value of raw materials in global WEEE generated in 2019 was about $57bn USD the overall economic loss from the non-documented WEEE flow was $47bn USD. The emissions created from their improper management (landfill disposal, shipping to other countries, informal recovery activities etc.) is estimated about 98 million tonnes CO2-eq.

Globally, the challenges for WEEE management in the future will be more severe due to the continuous growing demand of WEEE and the increase of WEEE amounts generated. Current (2019 numbers) per capita WEEE generation is 7.3 kg/cap, almost 1 kg/cap more in relation to 2014 (**Figure 18**). This global WEEE generation rate is expected to reach the 9 kg/cap in 2030, showing a yearly increase of 2.1%.

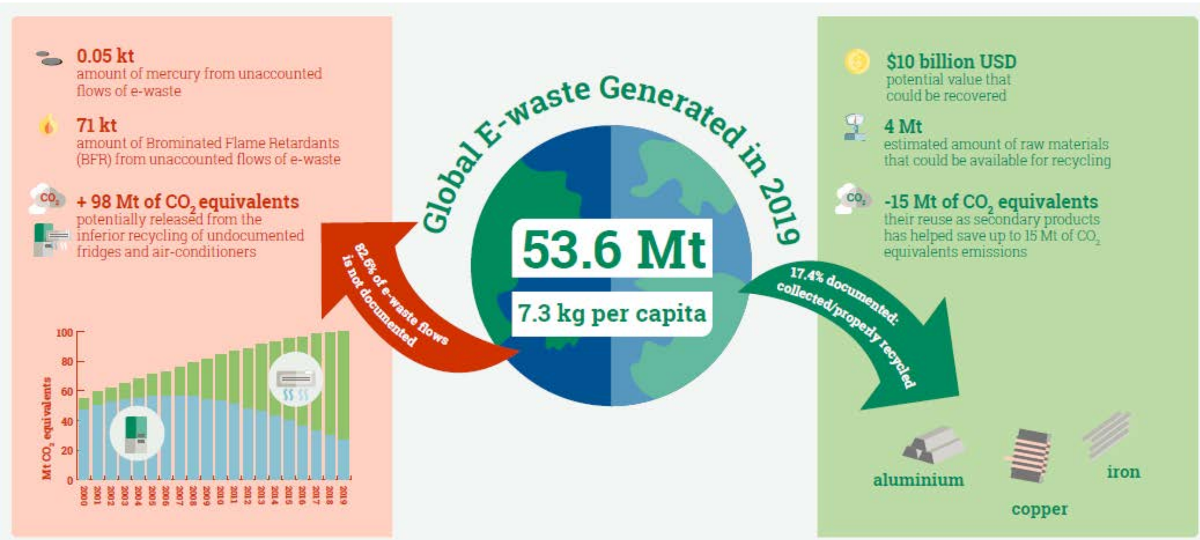

Figure 17: The global picture of WEEE management in 2019 (Forti V., Baldé C.P., Kuehr R., Bel G, 2020)

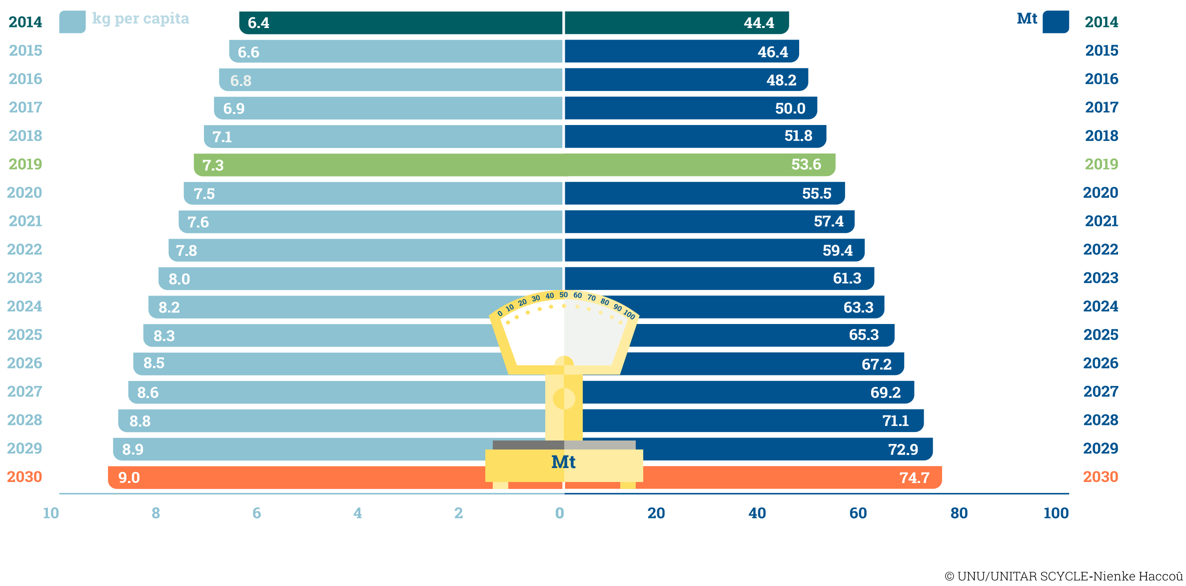

Figure 18: WEEE total and per capita generation 2014-2030 (Forti V., Baldé C.P., Kuehr R., Bel G, 2020)

From the analysis above, we can deduce that proper WEEE management, which includes separate collection, recycling, reuse and recovery of useful materials are necessary for both economic and environmental reasons. But besides these impacts, improper management of WEEE can have serious effects in human health. WEEE components are toxic and human are particularly vulnerable to the health risks of WEEE exposure. Informal recycling techniques of valuable elements from WEEE in the informal sector, include burning of plastic from electronic products, melting down lead in open pots, dissolve of circuit boards in acid etc., resulting recyclers to come in contact with many toxic substances (The Platform for Accelerating the Circular Economy (PACE, 2019).
In developing countries, women and children constitute an important part (almost 30%) of the informal WEEE recyclers' workforce and therefore are mostly vulnerable. Data show that increases in spontaneous miscarriages, premature births, and reduced birthweights are linked to women exposure to WEEE.

Moreover, we can deduce that an upgrade of current WEEE management practices worldwide is necessary. The adoption of new CE approaches and development of new business models is necessary. These practices need to focus on increasing EEEs' and their components lifetime as long as possible, to keep the materials value as high as possible and to reduce hazardousness and risks for the environment and human health in both WEEE management techniques and secondary materials.

It is equally important to highlight that considering the CE approach with an ideal assumption of 100% WEEE recycling rate, there will still be an extra need for raw materials to enter in the global economy to meet the consumption needs. **Figure 19** visualizes this gap. Even in the conditions of 100% recycling, the raw materials (in terms of iron, aluminum and copper which represent the majority of the total weight of raw materials found in WEEE) that will be economically viable or even feasible with the existing recycling technologies will not exceed the 25 million tonnes. The demand iron, aluminum and copper for the production of new WEEE is 39 million tonnes in total, representing a gap of 14 million tonnes that must be covered from virgin raw materials.

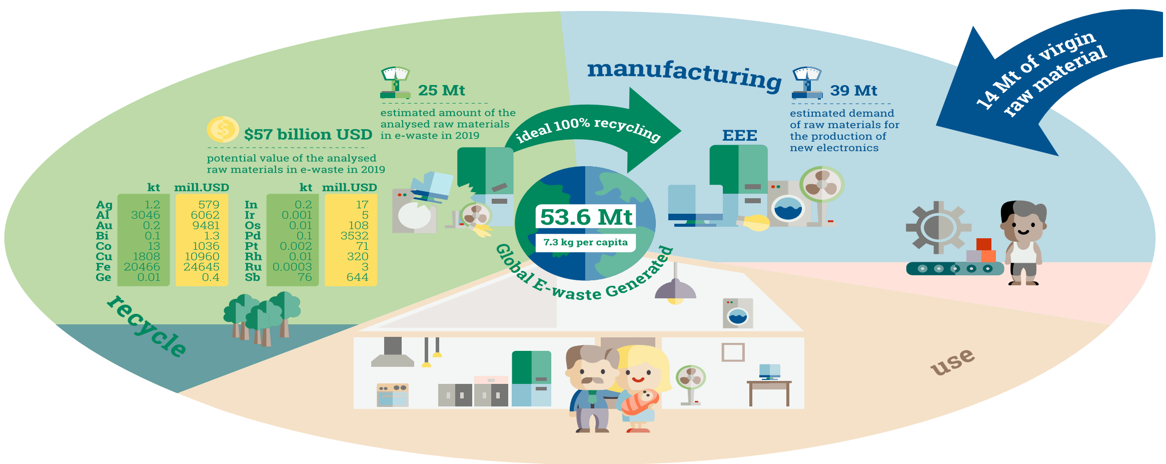

Figure 19: The gap between raw materials demand and recycling (Forti V., Baldé C.P., Kuehr R., Bel G, 2020)

Therefore, except the economic and environmental dimension of CE in WEEE, another parameter that must be taken into consideration in the development of the new CE approaches is how they can meet the raw materials demand for the production of new EEE. Solutions may be found in changing EEE design and manufacturing process, in substituting traditionally used raw materials with other materials that are not scarce and can be easily recovered, changing the consumption patterns and trends and surely by extending EEE's useful lifetime.

The Platform for Accelerating the Circular Economy (PACE) issued a new circular vision for electronics (The Platform for Accelerating the Circular Economy (PACE), 2019) which targets to intervene in the whole electronics value chain in order to serve the scope for circularity (**Figure 20**).

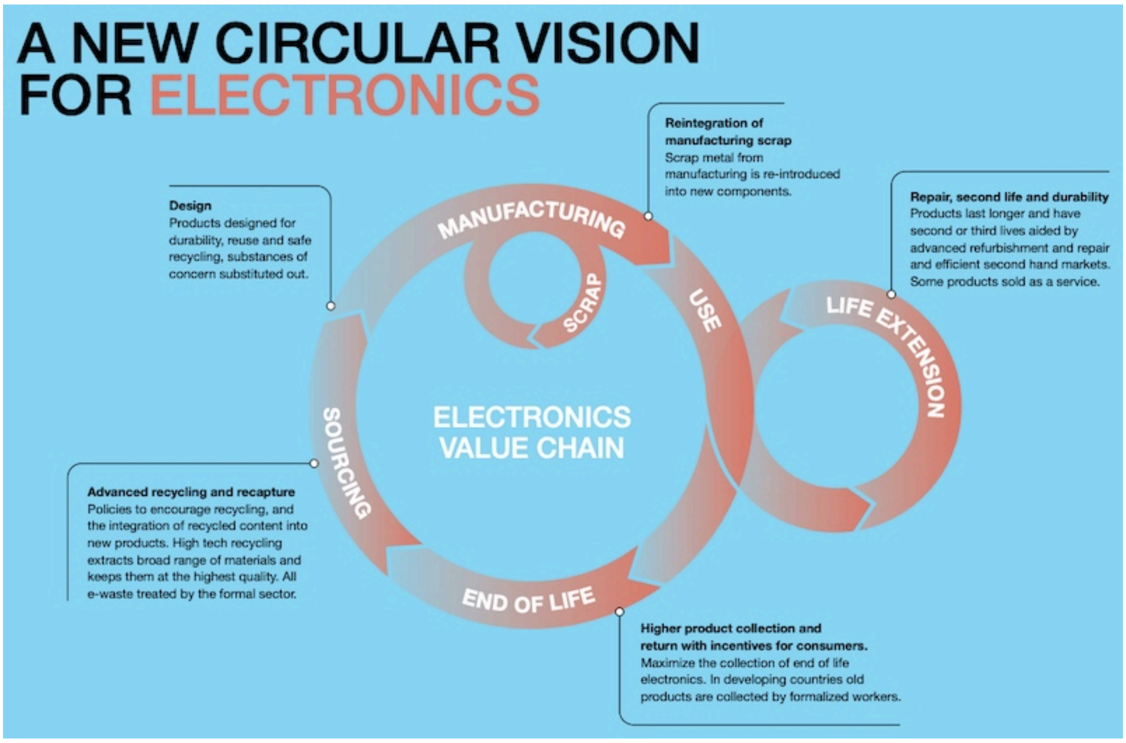

Figure 20. CE considerations in WEEE management (The Platform for Accelerating the Circular Economy (PACE), 2019)

In this approach, the following aspects must be considered:

- Design: Products must be designed for reuse, durability and eventually safe recycling. Durable design ensures that EEE are kept in circulation for longer. Design for reuse and safe recycling target to facilitate the dismantling and reuse process with recovery of pure secondary materials without complicated recycling techniques.
- Buy-back or return systems: In the framework of EPR, EEE producers can develop buy-back or return systems for old equipment. Incentives for the consumers, like discount in next EEE purchase, guarantee that data will be properly handled etc are necessary for the success implementation of these systems.

- Advanced recycling and recapturing: Private sector can effectively cooperate with authorities to introduce a WEEE recycling system that all old products are collected properly, and their components are incorporated in the new EEE products. Again, incentives for the consumers similar to the ones applied in the return systems must be applied.
- Durability and repair: Well-designed, durable and long-living EEE products are necessary to successfully implement CE approach in WEEE. Producers and/or electronics resellers must develop repair lines in their operating mechanism that will repair, maintain and refurbish the goods. This process must be done in significantly lower prices in order for consumers to prefer to repair their broken EEE instead of buying a new one. In these conditions, the development of a second-hand market for EEE can be proved as a viable business opportunity.
- Urban mining: according to PACE, it is time for companies to start investing heavily around the world in development and spread of technologies that can help metals and minerals extraction from WEEE. The target of maximizing the amount of valuable WEEE that returns into the production of new EEE (so-called reverse logistics), must be achieved and the companies' role on this is crucial.

c. Circular benefits

The benefits from the application of CE activities are very important for both the environment and the economy because of the hazardousness of the WEEE components and the scarcity of the virgin materials. In order to quantify the benefits, the following assumptions have been taken into consideration:

- The amount of WEEE generated in 2016 in the country was 15,000 tones (Forti V., Baldé C.P., Kuehr R., Bel G, 2020)
- The separate collection rate from the existing system is 7% as it was in 2016 (Source: NWMP)
- The average yearly increase of WEEE generated follows the global trends of 2.1%
- The NWMP target for separate collection of WEEE of 65% in 2025 is achieved
- The WFD target of 85% separate collection of WEEE is achieved in 2030

Taking into consideration the assumptions above, **Table 16** presents the current and the future (for 2025 and 2030) WEEE generation and separately collected quantities.

Table 16. WEEE generation and separately collected quantities

	Baseline (2016)	2025	2030
WEEE generation (tonnes)	15,000	18,085	20,066
WEEE separately collected (tons)	1,050	11,755	17,056

Reduction in GHG emissions

Separate at source and WEEE processing activities will be able to provide useful and valuable materials in order for EEE to be able to meet the high and continue growing demand for its products. These activities will reduce significantly the need for new virgin materials extraction and to decrease environmental impacts of these activities. For the quantification of the benefits from the reduction of raw materials, avoided landfilling and recycling of collected WEEE, the following emission factor were used (U.S. Environmental Protection Agency Office of Resource Conservation and Recovery, 2019):

- Recycling of mixed electronics: 0.79 tonnes of CO_2-eq/tonne
- Landfilling of mixed electronics: 0.02 tonnes of CO_2-eq/tonne

Applying the above indicators in the WEEE separated collection rates of North Macedonia for 2025 and 2030, the GHGs savings are presented in **Table 17**.

Table 17: Total GHGs savings from recycling WEEE for 2025 and 2030 targets

Benefits	Baseline (2016) (tonnes of CO2-eq)	2025 Target (tonnes of CO2-eq)	2030 Target (tonnes of CO2-eq)
GHGs avoided from sep. collection and recycling of WEEE	830	9,287	13,474
GHGs emissions from landfilling of WEEE	279	127	60
Total net GHG emissions	551	9,160	13,414
Total GHGs savings in relation to 2016		8,610	12,863

<u>Economic benefits from savings in raw materials extractions</u>

CE activities in WEEE provide also important financial savings due to the value of the materials that were recycled and entered in the economy for the manufacturing of new EEE products. It is estimated (Forti V., Baldé C.P., Kuehr R., Bel G, 2020) that the value of the materials extracted from the WEEE recycling activities in 2019, was $10bn USD. Therefore, the raw materials savings in 2019 were almost $1,072.20 USD per ton of WEEE recycled. Applying this, in the WEEE separated collection rates of North Macedonia for 2025 and 2030, the raw material savings are EUR 9,756,781 and EUR 14,587,493 respectively (equivalent to US$11,478,566 and US$17,161,756).

<u>Savings in landfill capacity and lifetime</u>

Applying separate source collection of WEEE and recycling activities, a significant amount of waste is diverted from being disposed of in the sanitary landfills. This decrease in the disposed amounts increases landfill lifetime and decreases the areas needed to be used for landfilling. Data from the Greek Organization for Recycling shows that for the period 2014 – 2018 a total of 262.013 tons of WEEE were collected separately, saving 280,000 m^3 every year from disposal, which corresponds that for every tonne of WEEE recycled, 5.34 m^3 of landfill capacity is gained. Using these data in North Macedonia WEEE separate collection rates for 2025 and 2030 the overall capacity gained is 57,201 m^3 and 85,523 m^3 of landfill capacity respectively. By assuming that an average landfill volume height is 15m, the landfill areas saved from the WEEE CE activities are 3,813m^2 for 2025 and 5,702m^2 for 2030.

<u>New jobs creation</u>

WEEE recycling and processing activities require the involvement of new employees with certain skills and potentials. In 2013, the International Labour Conference identified waste management and recycling as one of three economic sectors (alongside agriculture and construction) in which there is significant opportunity and a necessity to improve the quality of work (INTERNATIONAL LABOUR ORGANIZATION, 2019). A study in the UK (Friends of Earth,

2010) reports that for every 1,000 tons of WEEE processed in the UK, 40 additional jobs are created in collection and sorting. Using these numbers, in North Macedonia, the new jobs created in WEEE recycling and process were estimated at 428 for 2025 and will reach the 640 in 2030. It must be noted that in another study ("How Ewaste Recycling Is Creating A Lot Of Jobs," n.d.) estimated that from every 1,000 tons of WEEE recycled additional 200 jobs are created in repairing, which multiplies the benefits.

Summary of benefits

The following table presents the benefits from the development of WEEE separate collection activities for the year 2030.

Table 18. Summary of benefits from the development of WEEE separate collection and recycling schemes for 2030

	QUANTITY	UNIT	REMARKS
2030 TARGET	85	%	WFD target of 85% separate collection of WEEE
RECYCLING QUANTITIES OF WEEE	17,056	tonnes/year	
ECONOMIC BENEFITS			
SAVINGS FROM RAWM MATERIAL EXTRACTIONS	14.59	Million EUR /year	
CARBON CREDIT OR SAVINGS FROM CARBON PRICING	270,130	EUR /year	
TOTAL ECONOMIC BENEFIT BY 2030	*14.86*	Million EUR /year	
EMPLOYMENT BENEFITS			
TOTAL NEW JOBS CREATED BY 2030	*640*	*Jobs*	
REDUCTION OF GHGS EMISSIONS			
BASELINE CONDITION IN 2016	551	tonnes of CO_2-eq/year	Considering 7% collection and recycling of WEEE with the landfilling all remaining
2030 TARGET	13,414	tonnes of CO_2-eq/year	Considering 85% recovery of WEEE
TOTAL SAVINGS IN GHG EMISSIONS EXPECTED BY 2030(1)	*12.86*	Gg CO_2-eq/year	
OTHER BENEFITS			
INCREASE IN LANDFILLS CAPACITY	*85,523*	m^3/year	
REDUCTION OF LANDFILL AREA	*5,702*	m^2/year	

(1) The savings in GHG emissions are calculated by subtracting the total GHG emissions of the baseline scenario from the alternative scenario that considers meeting the 2030 target.

6.3.6. Plastics

a. Current management and problems involved

The current management of plastics in North Macedonia can't be considered environmentally safe and efficient in terms of recycling and recovery rates. The National Waste Management Plan 2020-2030 refers to plastics from industrial and commercial activities explaining that commercial collections (over 150 tonnes per annum) and industrial collections by the private sector are based on the quantity of waste produced (volume of weight) which is a fairer system. More than 150 registered companies exist for collecting, storing and treating non-hazardous waste (paper, plastic, scrap metals). There are three companies registered for managing the recovery of polyethylene terephthalate (PET) and one for plastic from WEEE. Plastics are simply prepared and then exported to Turkey for recycling.

Annex 6 of the National Waste Management Plan 2020-2030 refers also to plastics from packaging, mentioning that while an increasing amount of packaging waste is recycled in Macedonia, the majority is not. Collective schemes for packaging are established and represent large producers such as shopping centers, retailers and manufacturers but free rider rates are unacceptable high, and they are estimated to make up around 30-40% of the market. Furthermore, an inspection regime implemented in 2013 identified that 60% of companies visited did not meet their obligations. Companies have permits for storage and treatment of plastic packaging. Four are making new products and the others are selling or exporting.

There is great uncertainty in the quantities of packaging and plastics, thus the overall performance of the packaging recycling and more specifically of plastic recycling is impossible to be effectively assessed.

The National Waste Management Plan 2020-2030 refers to several measures to support packaging waste management that should be combined with the proposed measures for EPR improvements in legislation, supervision and communication. Besides the measures for business and citizens and measures to improve collection of packaging waste, the measures to improve reuse, recycling and recovery of packaging waste are very important from a circular economy point of view. The proposed measures include:

- The administration should promote awareness of the need for separate collections to enable high levels of reuse and recovery recycling of captured materials. New higher collection levels will create economies of scale consistent with development of technologies and new business opportunities.
- The administration should promote the use of containers designed to be reused or recycled, in accordance with the order in the hierarchy of waste management.
- The administration, together with the producers, collective schemes and the waste industry should support research into packaging waste collection, transport, reuse and recovery technologies to assist with greater efficiency of outputs and compliance.

- Producers, collectives, industry, retailers and government require comprehensive operational guidance and advice, so the packaging waste system runs smoothly and realizes the obligations in the Law. Key stakeholders will be involved in developing guidance to provide the required operational perspective. The following guidelines and standards will be developed:

    - Packaging waste treatment standards for the key material streams – including for collection, sorting, storage, transportation, preparation for re-use, treatment, processing and disposal of all kinds of packaging waste.
    - Packaging waste evidence and protocols guidance – standard documentation and reporting on collection transport reuse, recovery and recycling – an agreed evidence standard providing proof that treatment has taken place to the required standards. Once protocols are established and agreed after trials this will avoid repeated weighing and measuring to prove compliance and performance.
    - Auditing, monitoring and compliance guidance for key actors. Guidance on what will be audited and by whom and details of the evidence required.
    - Technical competence standards. Operations must be operated by skilled and technically competent persons – qualifications and standards to be agreed.
    - Packaging waste export procedures and guidance. Good practice for packaging waste exports will ensure valid high-quality overseas treatment routes are used. Evidence will be required for materials exported and details of treatment standards will be required to demonstrate compliance. Independent audits to certify the evidence and overseas treatment standards must be established.
    - Facilities carrying out packaging waste treatment operations must apply minimum technical requirements. Examples of key areas are:
        - storage areas,
        - treatment areas,
        - weatherproof coverings
        - weighing Equipment
        - impermeable surfaces
        - data collection, reporting and audit
        - fire prevention and management
        - transport handling and storage
        - contamination of materials
        - packaging waste stream targets

- The administration should carry out or support research that validates the operational performance of these materials should any doubt arise.

According to the NWMP (Annex 6), the national target in the Republic of Macedonia by the 31 December 2020 for recycling specific packaging wastes includes 40 % of plastic, while the EU Directive 2018/852 amending Directive (94/62/EC) on packaging waste consists of recycling 50 % of plastic by 2025 and 55% by 2030. In addition, Directive (2008/98/EC) consists of separate collection of plastics.

For a better idea regarding the problems that are generated by the current management of plastic waste, it is important to refer to the document "A European Strategy for plastics in a circular economy" (European Commission, 2019c). The figures below refer the EU level and it is considered that they are also representative, in one or another way, of the situation in North Macedonia too.

Global production of plastics has increased twenty-fold since the 1960s, reaching 322 million tonnes in 2015. It is expected to double again over the next 20 years. In the EU, the plastics sector employs 1.5 million people and generated a turnover of EUR 340 billion in 2015. Although plastics production in the EU has been stable in recent years, the EU's share of the global market is falling as production grows in other parts of the world. In the EU, the potential for recycling plastic waste remains largely unexploited.

Around 25.8 million tonnes of plastic waste are generated in Europe every year. Less than 30% of such waste is collected for recycling. Of this amount, a significant share leaves the EU to be treated in third countries, where different environmental standards may apply. At the same time, landfilling and incineration rates of plastic waste remain high - 31 % and 39 %, respectively - and while landfill has decreased over the past decade, incineration has grown. According to estimates, 95 % of the value of plastic packaging material, i.e. between EUR 70 and 105 billion annually, is lost to the economy after a very short first-use cycle. Figure 21 shows the EU plastic generation and demand for 2015.

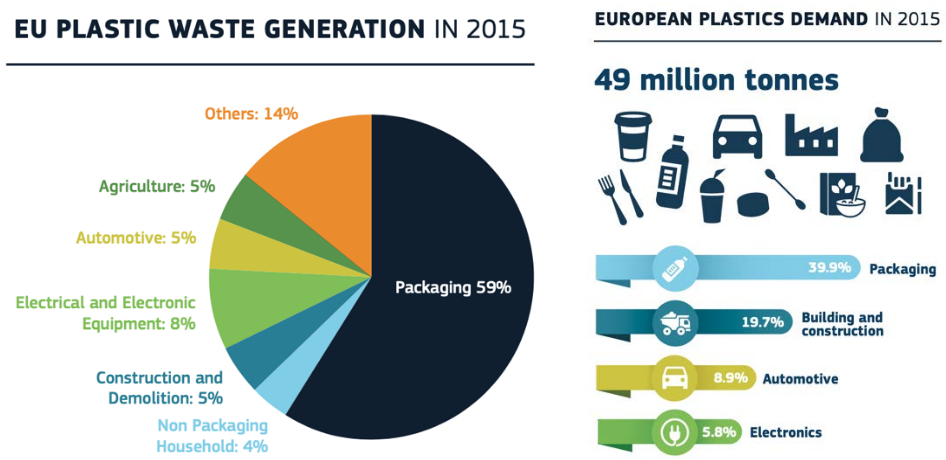

Figure 21: EU plastic generation and demand for 2015

Reuse and recycling of end-of-life plastics remains very low, particularly in comparison with other materials such as paper, glass or metals. Demand for recycled plastics today accounts for only around 6 % of plastics demand in Europe. In recent years, the EU plastic recycling sector has suffered from low commodity prices and uncertainties about market outlets. Investments in new plastic recycling capacity have been held back by the sector's prospects of low profitability. It was estimated that plastics production and the incineration of plastic waste give rise globally to approximately 400 million tonnes of CO_2 a year.

Very large quantities of plastic waste leak into the environment from sources both on land and at sea, generating significant economic and environmental damage. Globally, 5 to 13 million tonnes of plastics — 1.5 to 4 % of global plastics production — end up in the oceans every year. It is estimated that plastic accounts for over 80 % of marine litter. Plastic debris is then transported by marine currents, sometimes over very long distances. They can be washed up on land, degrade into microplastics or form dense areas of marine litter trapped in ocean gyres. UNEP estimates that damage to marine environments is at least USD 8 billion per year globally.

In the EU, 150,000 to 500,000 tonnes of plastic waste enter the oceans every year. This represents a small proportion of global marine litter. Yet, plastic waste from European sources ends up in particularly vulnerable marine areas, such as the Mediterranean Sea and parts of the Arctic Ocean. Recent studies show plastics accumulate in the Mediterranean at a density comparable to the areas of highest plastic accumulation in the oceans. Plastic pollution also affects areas of the European Exclusive Economic Zone, in the outermost regions along the Caribbean Sea, the Indian, Pacific and Atlantic Oceans. In addition to harming the environment, marine litter causes economic damage to activities such as tourism, fisheries and shipping. For instance, the cost of litter to EU fisheries was estimated at about 1 % of total revenues from catches by the EU fleet. **Figure 22** shows the sources, the pathways and the transport mechanisms for marine litter (JRC, 2016)

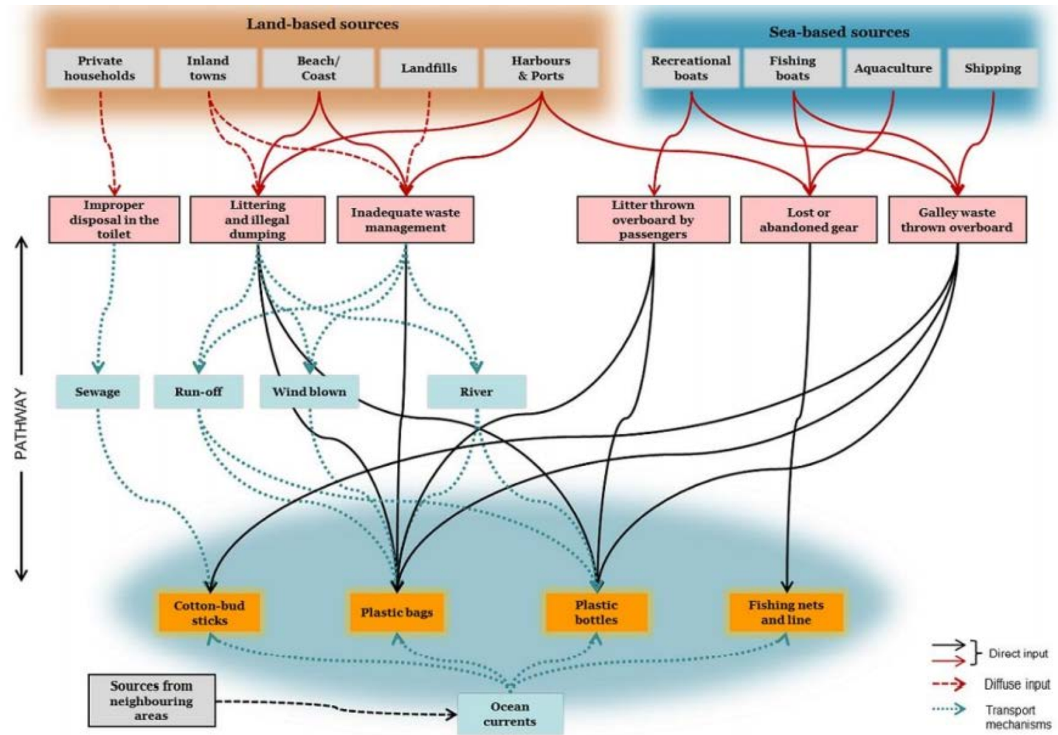

Figure 22: Sources, pathways and transport mechanisms for marine litter (JRC, 2016)

New sources of plastic leakage are also on the rise, posing additional potential threats to both the environment and human health. Microplastics, tiny fragments of plastic below 5mm in size, accumulate in the sea, where their small size makes it easy for marine life to ingest them. They can also enter the food chain. Recent studies also found microplastics in air, drinking water and other foods like salt or honey, with yet unknown impacts on human health. In total, it is estimated that between 75 000 and 300 000 tonnes of microplastics are released into the environment each year in the EU. While a large amount of microplastics result from the fragmentation of larger pieces of plastic waste, significant quantities also enter the environment directly, making it more challenging to track and prevent them.

b. Circular solutions and practices

Using more recycled plastics can reduce dependence on the extraction of fossil fuels for plastics production and curb CO_2 emissions. According to estimates, the potential annual energy savings that could be achieved from recycling all global plastic waste is equivalent to 3.5 billion barrels of oil per year (European Commission, 2019c).

As plastic value chains are increasingly cross- border, problems and opportunities associated with plastics should be seen in light of international developments, including China's recent decision to restrict imports of certain types of plastics waste (Mavropoulos, 2018). There is a growing awareness of the global nature of these challenges, as shown by international initiatives on marine litter, like the UN Global Partnership on Marine Litter and the action plans put forward by the G7 and G20. Plastic pollution was also identified as one of the main pressures on healthy oceans at the international ‘Our Ocean Conference’, hosted by the EU in October 2017. A resolution on marine litter and microplastics was adopted at the United Nation Environment Assembly in December 2017.
Based on the previous, EU has developed a vision for a New Plastic Economy, as shown in **Figure 23**.

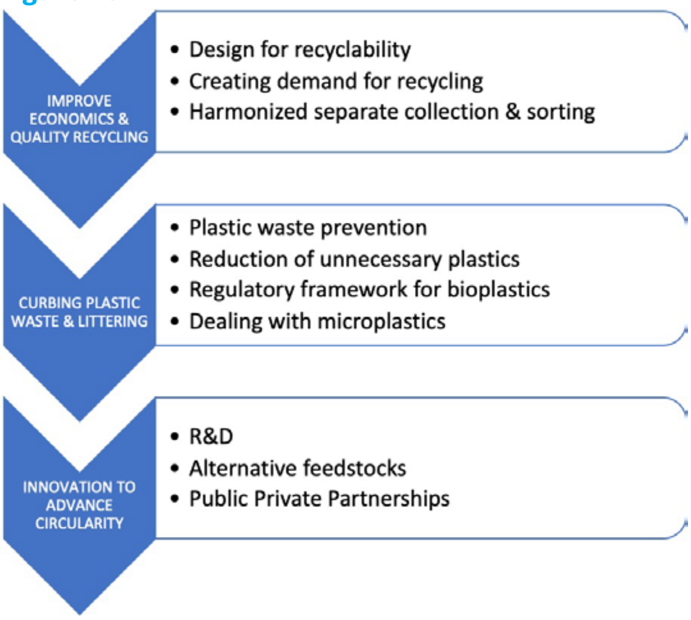

Figure 23: Elements of the EU vision for a New Plastic Economy

The core of this vision is a smart, innovative and sustainable plastics industry, where design and production fully respect the needs of reuse, repair, and recycling, brings growth and jobs to Europe and helps cut EU's greenhouse gas emissions and dependence on imported fossil fuels. Citizens, government and industry should support more sustainable and safer consumption and production patterns for plastics. This provides a fertile ground for social innovation and entrepreneurship, creating a wealth of opportunities for all Europeans.

The main elements of this vision are the following:

- **Improving the economics and quality of plastics recycling:** Stepping up the recycling of plastics can bring significant environmental and economic benefits. Higher levels of plastic recycling, comparable with those of other materials, will only be achieved by improving the way plastics and plastics articles are produced and designed. It will also require increased cooperation across the value chain: from industry, plastics manufacturers and converters to public and private waste management companies.]

    - **Design for recyclability:** Today, producers of plastic articles and packaging have little or no incentive to take into account the needs of recycling or reuse when they design their products. Plastics are made from a range of polymers and are highly customized, with specific additives to meet each manufacturer's functional and/or aesthetic requirements. This diversity can complicate the recycling process, make it more costly, and affect the quality and value of recycled plastic. Specific design choices, some of which are driven by marketing considerations (e.g. the use of very dark colors) can also negatively affect the value of recyclates. It is estimated that a better product design that improves recyclability can save 77-120 euros for each tonne of plastic waste collected (EMF, 2017). Plastics packaging is a priority area when it comes to design for recyclability. Today it accounts for about 60 % of post-consumer plastic waste.
    - **Boosting demand for recycled plastics:** Weak demand for recycled plastics is another major obstacle to transforming the plastics value chain. In the EU, uptake of recycled plastics in new products is low and often remains limited to low-value or niche applications. Uncertainties concerning market outlets and profitability are holding back the investment necessary to scale up and modernize EU plastics recycling capacity and boost innovation. Recent developments in international trade, restricting key export routes for plastics waste collected for recycling, make it more urgent to develop a European market for recycled plastics.
    - **Better and more harmonized separate collection and sorting:** More and better plastic recycling is also held back by insufficient volumes and quality of separate collection and sorting. The latter is also essential to avoid introducing contaminants in the recycling streams and retain high safety standards for recycled materials. National, regional and local authorities, in cooperation with waste management operators, have a key role to play in raising public awareness and ensure high-quality separate collection. Financial resources collected through the Extended Producer Responsibility schemes can do much to boost such efforts. Similarly, deposits systems can contribute to achieving very high levels of recycling. Reducing fragmentation and disparities in

collection and sorting systems could significantly improve the economics of plastics recycling, saving around a hundred euros per tonne collected. To encourage more standardized and effective practices across the EU, the Commission will issue new guidance on separate collection and sorting of waste. More importantly, the Commission strongly supports the European Parliament and the Council in their current effort to amend waste rules to ensure better implementation of existing obligations on separate collection of plastics.

- **Curbing plastic waste and littering:** Growing plastic waste generation and its leakage into our environment must be tackled if we are to achieve a truly circular lifecycle for plastics. Today, littering and leakage of plastic waste harm the environment, cause economic damage to activities such as tourism, fisheries and shipping, and may affect human health through the food chain.

    - **Preventing plastic waste in our environment:** Growing use of plastics for a wide range of short- lived applications gives rise to large quantities of plastic waste. Single-use plastics items are a major source of plastic leakage into the environment, as they can be difficult to recycle, are often used away from home and littered. They are among the items most commonly found on beaches and represent an estimated 50% of marine litter. Increasing on-the-go consumption of food and drink is fueling the growth of 'single use plastics' and the problem is therefore expected to grow. Where waste management is sub-optimal, even plastic waste that has been collected can find its way into the environment. More recycling of plastics used in agriculture (such as plastic mulching films or greenhouses) can contribute to reduce leakages in the environment. To achieve this, Extended Producer Responsibility schemes have proven effective in several countries. Curbing plastic waste and pollution is a complex problem, given its diffuse nature and the link with social trends and individual behavior. There is no clear incentive for consumers and producers to switch to solutions that would generate less waste or litter. The EU has already taken steps by setting requirements for Member States to adopt measures to cut the consumption of plastic bags and to monitor and reduce marine litter. EU funding is also being deployed to understand and combat the rise of marine litter, supporting global, national and regional action. EU rules supporting higher recycling rates and better waste collection systems are also important in helping to prevent leakage. In addition, through its upcoming legislative proposal for a revision of the Drinking Water Directive, the Commission will promote access to tap water for EU citizens, therefore reducing packaging needs for bottled water. The criteria for the Ecolabel and Green Public Procurement also promote reusable items and packaging.
    - **Reducing unnecessary plastics:** Additional measures at EU and national levels are under development to reduce the unnecessary generation of plastic waste, especially waste from single-use items or over-packaging, and to encourage the reuse of packaging. Analytical work, including the launch of a public consultation, has already been done to determine and finalize the scope of a legislative initiative on single-use plastics at EU level to be tabled by this Commission, following the approach used for

light-weight plastic bags and examining relevant evidence from behavioral science. Furthermore, the Commission is exploring he feasibility of introducing measures of a fiscal nature at the EU level. Finally, the Commission is also looking into the issue of over-packaging as part of the future review of the essential requirements for packaging.

- **Clear regulatory framework for biodegradable plastics:** In response to the high level of plastic leakage into our environment and its harmful effects, solutions have been sought to design biodegradable and compostable plastics. Targeted applications, such as using compostable plastic bags to collect organic waste separately, have shown positive results; and standards exist or are being developed for specific applications. However, most currently available plastics labelled as biodegradable generally degrade under specific conditions which may not always be easy to find in the natural environment and can thus still cause harm to ecosystems. Biodegradation in the marine environment is particularly challenging. In addition, plastics that are labelled 'compostable' are not necessarily suitable for home composting. If compostable and conventional plastics are mixed in the recycling process, it may affect the quality of the resulting recyclates. For consumer applications, the existence of a well-functioning separate collection system for organic waste is essential.
- **About microplastics:** Microplastics are intentionally added to certain product categories (such as cosmetics, detergents, paints), dispersed during the production, transport and use of plastic pellets, or generated through wear and tear of products such as tyres, paints and synthetic clothes. Microplastics intentionally added to products represent a relatively small proportion of all those in the sea. However, since they are relatively easy to prevent and in response to public concern, several countries have already taken action to restrict their use, while the cosmetic industry has also taken voluntary action. Bans are under consideration or planned in several Member States and this may lead to fragmentation in the single market. In line with the REACH procedures for restricting substances that pose a risk to the environment or health, the Commission has therefore started the process to restrict the use of intentionally added microplastics, by requesting the European Chemicals Agency to review the scientific basis for taking regulatory action at EU level.

- **Innovation and investment towards plastic circularity:** Achieving the objectives laid out in this strategy will require major investments in both infrastructure and innovation. Meeting ambitious goals on plastics recycling alone will require an estimated additional investment of between EUR 8.4 and 16.6 billion. Therefore, creating an enabling framework for investment and innovation is central to implementing this strategy. Innovation is a key enabler for the transformation of the plastics value chain: it can help reduce the costs of existing solutions, provide new ones and amplify potential benefits beyond Europe’s borders. While the EU can play an enabling role, European businesses need to invest in the future and affirm their leadership in the modernization of the plastics value chain. Alternative feedstocks, including bio-based feedstocks and gaseous effluents (e.g. carbon dioxide or methane) can also be developed to avoid using fossil resources. Finally, the Commission will develop a Strategic Research and Innovation Agenda on plastics to provide guidance for future research and innovation funding after 2020. To meet the objectives of this strategy, the scale of private and public investment must significantly increase, not only as regards innovation. At present, private investment in sorting and recycling plants is held back by uncertainties about profitability (given low oil prices, lack of outlets, etc.). For instance, only about two-thirds of the plastics recycling businesses in France today are profitable (French Environment and Energy Management Agency, 2015). As the situation in other EU countries shows, it is important to modernize and scale up recycling plants if plastic recycling is to be economically viable.

A crucial part of the EU strategy for a New Plastics Economy regards the new rules on Single Use Plastics. The single-use plastics legislation will address 70 percent of marine litters items, avoiding environmental damage that would otherwise cost €22 billion by 2030. The new rules are proportionate and tailored to get the best results. This means different measures will be applied to different products. The new rules are introducing:

- A ban on selected single-use products made of plastic for which alternatives exist on the market: cotton bud sticks, cutlery, plates, straws, stirrers, sticks for balloons, as well as cups, food and beverage containers made of expanded polystyrene and on all products made of oxo- degradable plastic (see .
- Measures to reduce consumption of food containers and beverage cups made of plastic and specific marking and labelling of certain products.
- Extended Producer Responsibility schemes covering the cost to clean-up litter, applied to products such as tobacco filters and fishing gear.
- A 90% separate collection target for plastic bottles by 2029 (77% by 2025) and the introduction of design requirements to connect caps to bottles, as well as target to incorporate 25% of recycled plastic in PET bottles as from 2025 and 30% in all plastic bottles as from 2030.

Figure 24. EU is tackling the 10 most usual items found in Beach Litter

c. Circular benefits

To calculate the benefits from adopting circular practices for plastic waste, the following assumptions are made.

- Based on the National Waste Management Plan 2020-2030, the total amount of plastics in municipal solid waste are estimated to roughly 110,725 tonnes in 2016. The latter is calculated in accordance with the detailed composition of the municipal solid waste, as presented in the NWMP.
- The updated recycling target for municipal solid waste (Table 5, page 38 of the NWMP) is 25% for 2025 and 45% for 2035, thus we assume reasonably a 35% for 2030.
- This means that the plastics diverted for recycling in 2030 is estimated around 38,754 tonnes per year.
- The Global Warming Potential (GWP) for each plastic fraction was calculated considering the quantitative Life Cycle Inventory (LCI) data available from the literature (U.S. Environmental Protection Agency Office of Resource Conservation and Recovery, 2019) for each fraction and its different end-of-life options, and also the IPCC methodology constraint, also the IPCC methodology constraint which do not consider emissions from the plastic processes under the Volume 5 waste.
- The approach to the calculation of avoided emissions of meeting circular measures is based on avoided emissions when complying with 2030 minimum target for recycling of plastics. Avoided emissions from achieving 2030 target consists of net GHG emissions reductions from recycling each materials and additional savings in GHG emissions from diverting materials from landfilling. The net GHG emission from recycling represent the GHG emissions associated with recycling each material into a new product for use, minus a GHG emission offset for avoiding the manufacture of an equivalent amount of the product from virgin inputs.
- Based on the previous, it was assessed that for each 1 tonne of plastic that is recycled there are net savings of 1.05 tonne of CO_2-eq / tonne of plastics (1.03 from substitution of virgin plastics plus 0.02 avoided landfill emissions).
- For the employment benefits, we used the approach described in the report "From Waste to Jobs: what achieving 75% recycling means for California" (NRDC, 2014).
- For the economic benefits, we used the current prices of mixed plastics increased by 50% due to the quality recycling that is expected in a circular business models – in addition, we assumed a serious reduction in recycling collection costs, as expected in accordance with the EU strategy.

Based on the above assumptions, the following table presents the expected benefits from advancing the recycling of plastics in 2030.

Table 19. Summary of benefits from advancing the recycling of plastics by 2030

	QUANTITY	UNIT	REMARKS
2030 TARGET	35	%	Fraction of waste plastic recycled of total waste generated
AMOUNT OF PLASTICS RECYCLED	38,754	tonnes/year	
Plastic Packaging	5,576	tonnes/year	
LDPE	19,238	tonnes/year	
PET Bottles	8,922	tonnes/year	
Other plastics	5,018	tonnes/year	
ECONOMIC BENEFITS			
GROSS REVENUES FROM PLASTICS	6.2	Million EUR /year	Considering a price for mixed plastics of 160 EUR/tonne
GROSS EXPENDITURE FOR COLLECTION & TREATMENT	3.023	Million EUR /year	Considering a collection cost for mixed plastics of 60 EUR/tonne and a treatment cost for mixed plastics of 18 EUR/tonne
CARBON CREDIT OR SAVINGS FROM CARBON PRICING	854,523	EUR /year	Based on the forecast of 21 EUR / CO2 tonne for 2030
TOTAL ECONOMIC BENEFIT BY 2030	*4.03*	Million EUR /year	
EMPLOYMENT BENEFITS			
TOTAL NEW JOBS CREATED BY 2030	*900*	*Jobs*	*Based on:* - Job creation in plastic recyclable collection of 1.23 jobs/1000 tonnes - Job creation in plastic recyclable manufacturing & reuse of 2jobs/1000 tonnes - Job creation in plastic recyclable processing of 20 jobs/1000 tonnes Accordingly, the total jobs created is 23.23 jobs/1000 tonnes
REDUCTION OF GHGS EMISSIONS			
SAVINGS FROM RECYCLING	39.916	Gg CO_2-eq/year	
AVOIDED LANDFILL EMISSIONS	775	tonnes of CO_2-eq/year	
TOTAL SAVINGS IN GHG EMISSIONS EXPECTED BY 2030[(1)]	*40.69*	Gg CO_2-eq/year	
OTHER BENEFITS			
INCREASE IN LANDFILLS CAPACITY	130,000	m^3/year	This is the minimum expected based on the assumption of two MBT treatment plants of 200,000 capacity each. (60,000 / 0.7) x 1.5

6.3.7. Summary of the benefits

Table 20 presents the environmental, economic and employment benefits from the shift to circular economy, as described above for each the waste streams we examined. The waste streams are ranked in accordance with their contribution to emission savings.

Table 20. Estimated benefits from the shift to circular economy for 2030

	Tonnes generated in 2016	GHG EMISSIONS SAVINGS (Gg CO2 eq)	EMPLOYMENT BENEFITS (NEW JOBS)	ECONOMIC BENEFITS (million EUR)
C&D	1,950,000	387.11	168	8.13
BIOWASTE	796,585	303.74	463	12.49
SRF	360,853	186.88	80	6.56
PLASTICS	110,725	40.69	900	4.03
ELVs	15,000	19.49	488	1.10
WEEE	10,411	12.86	640	14.86
Total	3,243,574	**950.78**	**2,740**	**47.17**

As it is shown above the shift for C&D and biowaste provides more than 70% of the emission savings, almost 20 million EUR per year of economic benefits (about 45% of the total benefits) and almost ¼ of the new jobs expected. Thus, the measures relevant to those two streams should be clearly prioritized.

On the other hand, in terms of new employment circular practices in plastics and WEEE are expected to create almost 56% of the total new jobs generated.

Finally, the economic benefits from the circular practices in biowaste and WEEE are expected to create about 60% of the total economic benefits.

To get a better idea regarding the practical importance of the expected savings in GHG emissions, **Figure 25** presents the percentage of the expected savings against the emissions of solid waste disposal as reported in the 3rd Biennial Report on climate change of the republic of North Macedonia (given that the total emission from the solid waste disposal is 473.2 Gg CO_2-eq in 2016).

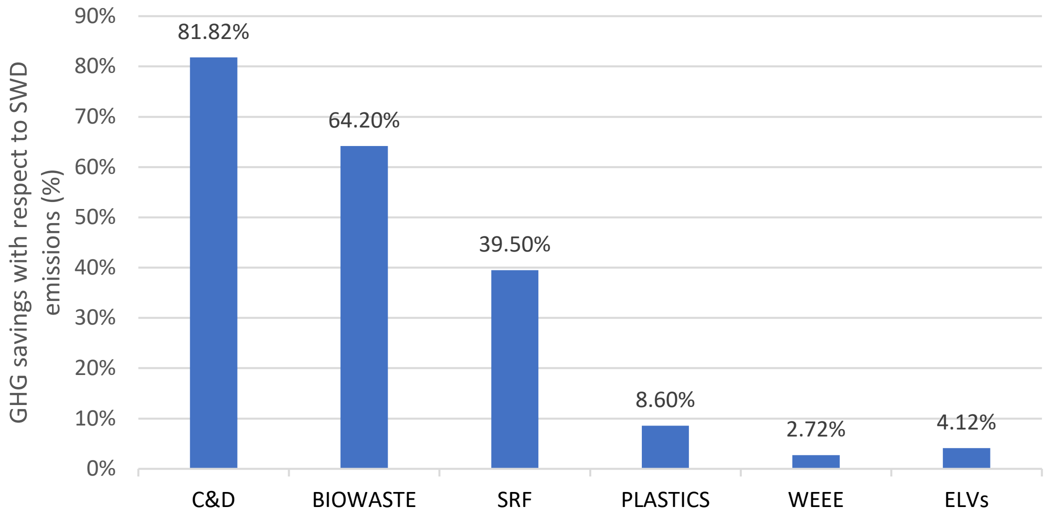

Figure 25. Emission savings from circular practices as a percentage of the solid waste disposal emissions (given that the total emission from the solid waste disposal is 473.2 Gg CO2-eq in 2016)

The total emission savings from the shift to circular practices from the studied waste streams is estimated at 951 Gg of CO_2-eq, equivalent to 201% of the solid waste disposal emissions and reached up to 156% and 111% of the emissions from the Waste and Industrial Processes and Product Use sectors, respectively (**Table 21**).

Table 21. Percentage of CE benefits with respect to sectoral emissions

	GHG emissions in Gg CO_2-eq in 2016	% of CE benefits to sectoral emissions
Benefits from shifting to CE	951	
Energy	7,449	12.76%
Industrial Processes and Product Use	858	110.81%
Agriculture (without FOLU)	1,193	79.68%
Waste	610	155.81%
Total (excl. FOLU)	10,111	9.40%

Source: 3rd Biennial Report on climate change of the republic of North Macedonia

7. The shift to Circular Economy requires new governance

It is clear that circular economy is challenging not only the business models worldwide but also the governance patterns. The implementation of the circular economy cannot be limited to simple procedures of reduction, reuse, and recycling. And the urgency to implement circular economy as the primary way to reduce carbon dioxide emissions and mitigate global warming does not allow us to wait until business interests and markets will decide to develop a bottom-up circular economy system that will gradually become global after 100-200 years. Several authors have noticed that the actual circular economy transition should lead to closing cycles at the level of individual products, i.e. in the related product chains. The transition process may differ across products and between circularity strategies, where lower circularity strategies are still closer to a linear economy and higher circularity strategies are closer to the circular economy (Mavropoulos and Anders, 2020).

Technological innovation is mainly relevant for lower circularity strategies, whereas "socio-institutional changes become more important for higher circularity strategies increasingly involve transforming the whole product chain (i.e. systemic changes). Socio-institutional changes refer to differences in how consumers relate to products, how all actors in a product chain cooperate to achieve circularity, and all institutional arrangements needed to facilitate this.

This brings the aspect of governance as a major challenge. The implementation of a circular economy requires serious changes on institutional levels that will allow us to overcome barriers like the internalization of externalities such as carbon emissions, regulations to overcome imperfect information on circular economy alternatives, and education and incentives to overcome cultural lock-in to linear economy business models and user practices. Attention to social dimensions is also important to avoid potential unintended consequences and to ensure that the social benefits of circular economy solutions are spread widely.

The report "Governance for the Circular Economy" (Stuebing and Vries, 2018) describes the building blocks of governance for a circular economy. It stresses the central role of governance for circular economy, and it highlights the importance of building relationships with value and supply chains and between producers and customers. In addition, it demonstrates the need to follow circularities in every step of the supply chain and to utilize authentic experiences and in situ observations for a circular economy governance. Next figure shows the governance framework for regenerative systems. And it's a good example of the serious, complex, and nonlinear changes required to address the challenges of circular economy.

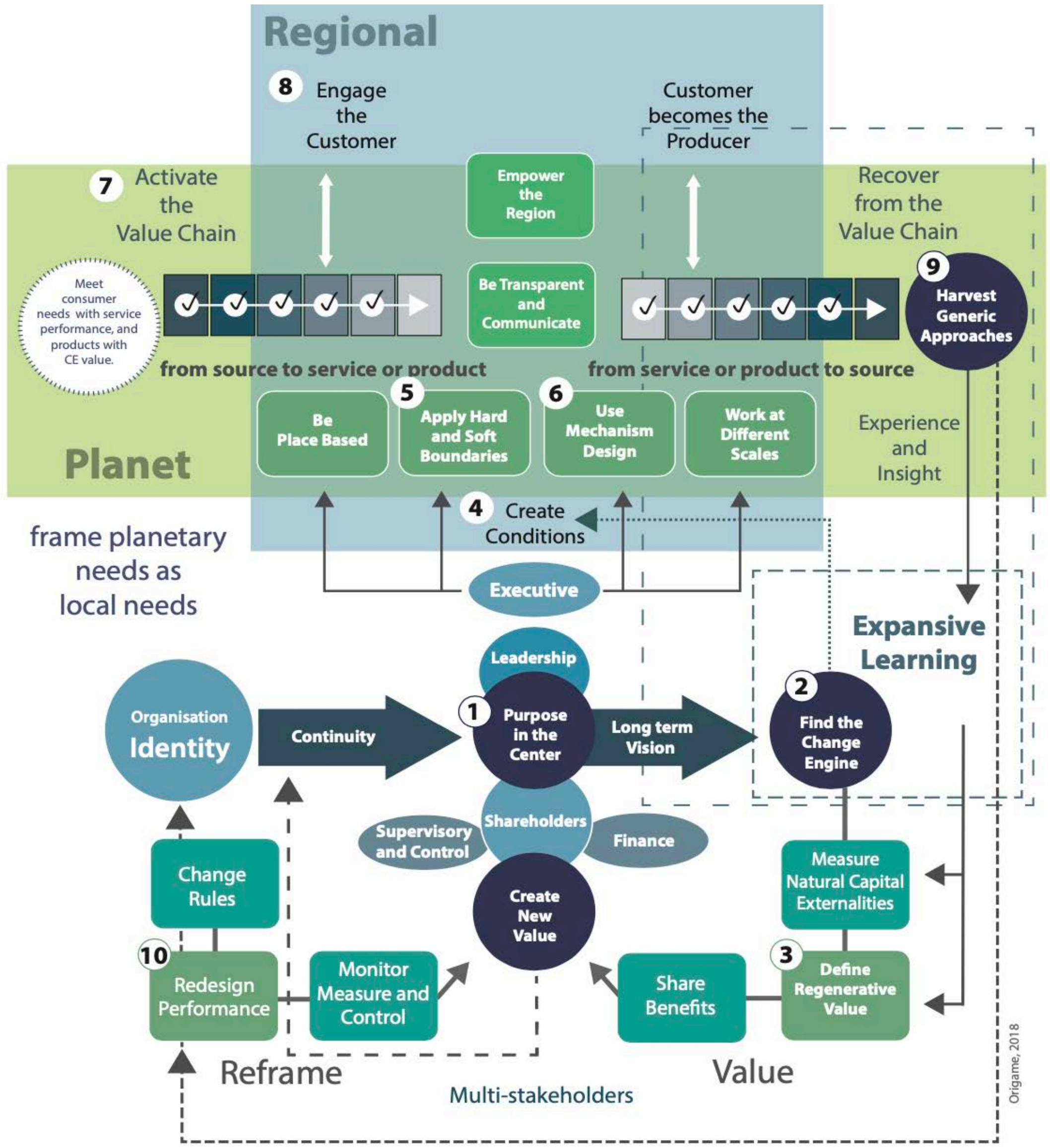

Figure 26: Governance framework for regenerative systems (Stuebing and Vries, 2018)

Ten principles have been proposed for driving a better governance adapted to Circular Economy needs, as shown in **Table 22**.

Table 22. Ten principles for a better governance towards Circular Economy

PRINCIPLES	REMARKS
Put purpose in the centre	Governance of organizations, business and government need to identify the purpose that drives decision-making, business strategy and communication in all forms (with a CE agenda). The purpose identifies a 'bigger picture' and defines strategic objectives precisely. Governance with a purpose as a central focus will support collaboration across the network. The philosophy 'we cannot do it alone' is accepted as a condition for success rather than a weakness in the organization. By putting purpose in the centre, multiple stakeholders and shareholders can participate and join in building on their own possibilities and opportunities.
Find the CE driving motor	Create governance that is self-seeding and self-generating to develop your mission. Develop an ecosystem, a generating motor will support new ideas to grow and to succeed. Recognize 'middle doesn't hold' environments, multi-level and multi-stakeholder, as infrastructures for collective learning.
Develop regenerative wealth definitions	Redefine value to focus on environmental integrity, across finance, stakeholder and shareholder systems. See time as an asset, continuity as a value. Explore how 'temporal space' can be communicated as a global value.
Identify, use and create conditions	Be local. Relate your operations and decisions to the quality of places. Apply direct feedback and physical consequence. Avoid trying to 'win' solutions, but engage solutions that work. By sharing and adapting, the learning will accelerate and expand.
Apply hard and soft boundaries. **Identify boundaries for collaboration and control.**	Be bold and tough on what you do not want, such as toxicity. To achieve what you do want, facilitate a soft environment for collaboration. Include participation of all actors in services and products including labour and customers. Develop an agenda that will facilitate what you want to achieve.
Accelerate collective performance with Mechanism Design	Make systems and market adjustments when necessary to achieve the purpose through mechanism design. Create conditions to help people and organizations to behave as if they were sustainable. Control and adjust based on new learning and new possibilities.
Activate the value chain	Identify and connect the value chain actors. Pay attention to a common language, enhance reciprocity, create meaning and share profits across the value chain. Employ new technology to bring parties together. Make community approach count. Define 'buy-in' (product, shareholders, leadership) a value-based result, not a short-term return.
Engage the customer	Re-frame consumption as a service and production as a value chain of good practice. Regarding product and pricing, act multi-layered, be transparent and make reporting available. Educate customers to increase understanding of value and performance. Promote dialogue with consumers, labour and communities to build understanding in multiple directions.
Harvest generic approaches from regional success	Develop regional sets of incentives, collaboration and legislation. Embrace local conditions and reinforce natural capital as well as human capital. Recognise identity and the regional biography. Make use of proximity to develop smart solutions. Observe working solutions to develop generic lessons and make them available to other regions.
Redesign and monitor performance	Find new value in environmental integrity through redesign and reconsidering the possibilities. New technologies and science can open new approaches and new business

	models (for example service systems versus products to control material use). Communicate performance.

Source: (Stuebing and Vries, 2018)

7.1 The role of government

There is a need to rethink and redefine the role of governments in a Circular Economy. There are several ways that governments can support the shift to a Circular Economy. An easy way is to support, financially and legally, circular innovation by covering completely or subsidizing initial costs. Other supports through subsidies are activities governments are known to provide. However, subsidies have in many cases been perverse, resulting in a negative effect or perpetuating activities which are not helping the CE agenda.

Funding alone was not enough, and governments should initiate very important activities to support CE other than direct funding. Government has a role to contribute by facilitating collaboration between industries, and within value chains. Developing methodologies particularly with regard to transparency is also an important activity that can impact market value through growth in sales, and also will contribute to broad value, important to investment. Governmental purchase power and procurement are powerful mechanisms that could activate the market, at least as important as the purchase power of consumers.

Several scientists (Bourgon, 2017) and promoters of Circular Economy are suggesting a serious tax reform that will shift taxes to a resource-based system rather than the existing labor based one, as an important vehicle to reinforce Circular Economy. Value Added Tax (VAT) differentiation is also a mechanism to nudge consumer behavior. Given the choice between two (otherwise) equal goods or services, even a moderate VAT difference can effectively nudge consumers to purchase circular products over products offered without a regenerative business strategy (Ecopreneur, 2019).

Other scientists suggest that government could do more to create 'a level playing field' for industries making their best effort with regard to the environment. This is especially important in a 'connected' world, with many interdependencies, where common standards should be set. Governments must play a role to negotiate clear standards. They also must play a role in supporting the generation of one common agenda, directed at the common purpose. Finally, they can help set the boundary conditions that will help drive developments into the right direction.

In general terms, it is obvious that everyone in the public sector has an important role in this agenda. Building awareness, aligning the public will, providing the public with support and boosting the capacity of the public to action, are all activities the government could undertake within its mission.

The Dutch Council for the Environment and Infrastructure (Council for the Environment and Infrastructure, 2015) has made very practical and cohesive suggestions regarding the role of the agenda setting by governments. Here are, in brief, the main recommendations:

- Make the transition to a circular economy one of the essential pillars of government policy and develop a joint, government-wide agenda 'circular economy' to this end.
- Develop a joint vision and incorporate this in the annual national Budget Memorandum.
- Formulate overarching objectives based on the joint vision.
- Using the overarching goals as a starting point, develop an approach for each ministry based on the inherent strengths of that ministry and the strengths of the country.

Below we propose the overarching objectives that could be used for North Macedonia, is shown below.

Goal 1: Reduce dependence on the import of raw materials

To develop a stronger economy, the control on essential resources must be maintained and increased. This can be achieved by reducing the dependence on imported raw materials. Reduced dependence can for example be achieved by:

- encouraging companies to organize their chains in such a manner that residual flows can be used in the processes of a similar or different chain (for example through the requirement that by 2030, every product launched in the domestic market must consist of recycled materials for X% in 2030 and y% in 2050).
- developing a circular 'ladder' with the nine levels of circularity: refuse, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle and, in conclusion, recover. The use of primary raw materials for example is allowed, provided that these materials have been assessed against the nine levels of circularity in a demonstrable manner.

Goal 2: Achieve economic prosperity

North Macedonia has a lot of distance to cover in order to approach the EU average standards in resource consumption and economic prosperity – thus by incorporating the Circular Economy as a way of the forthcoming economic growth, it can deliver prosperity in different ways like:

- encouraging companies to aim for increasing the economic profits in business processes by setting targets for eco-efficiency. Because of these goals, companies may (even more than before) ascertain where the use of resources can be prevented and reduced, so that more product of service can be delivered per unit of raw materials.
- improving the investment climate by facilitating let's say 20 'circular' start-ups per year in the country. This contributes to the development of the country into a circular hub in the Balkan Region.
- facilitating and stimulating new economic activities through innovative revenue models (such as X pilots in 2020 for sharing, leasing and dematerializing).
- stimulating the creation of new jobs related to the circular economy (for example, 5,000 direct jobs in 2030 and 30,000 in 2050).

Goal 3: Reduce environmental impact and/or increase economic added value of raw materials
The environmental impact in chains can be reduced by using fewer resources and reducing the generation of waste. Thus, the supplied economic value is increased, for example by:

- encouraging companies to create more functionality per unit of raw material and become more eco-effective.
- Think about making use of the same resources multiple times, for example through reuse, repair and recycling (among other things by increasing the number of jobs in the repair and recycling sector with X in 2030 or by less CO_2 emissions and less energy and water consumption by X in 2030).
- encouraging the consumer to adopt sustainable behavior.

Finally, we believe it is useful to list the roles that different ministries can play in the shift towards circular economy, as a tangible indication of the importance to have Circular Economy as a horizontal cross-cutting pillar of the government's program. Here are some examples from the relevant roles of the Dutch government.

Minister of Economic Affairs: Make choices in the promotion of and investments in sectors and promising chains that can serve as a figurehead for the domestic circular economy

Minister of Foreign Affairs: Develop a trade policy focused on a circular economy by instigating a so-called raw materials union package and by exporting circularity-related knowledge

Ministry of Environment and Physical Planning: Ensure the right conditions for a circular economy in terms of infrastructure, logistics, health and environment

Minister of the Interior Set a good example through circular procurement and sourcing policy, oversight on circular building (public housing and government buildings) and use the theme of circular economy to further flesh out the Urban Agenda.

Minister and State Secretary of Finance: Incorporate the circular economy in the annual national Budget Memorandum, stimulate the financial sector to finance the transition, prevent lock-ins that impede a greening of the tax system.

Minister and State Secretary of Educationand Science: Ensure continuous attention for the circular economy in various academic agendas and in the education curriculum

Minister of Social Affairs and Employment: Study potential employment development in a circular economy, stimulate training programmes to make this development possible.

7.2 The role of economic incentives

The Commission's Circular Economy Action Plan encourages the use of economic instruments to help ensure the extension of a products lifespan through re-use and repair. One such instrument is the use of Value Added Tax (VAT), currently governed by the EU Directive on a common system of value added tax (Directive/112/EC) which could be revised in the near future.

Repair activities in particular need to be made cheaper. In Europe 77% (RReuse, 2017) of citizens would be willing to have their goods repaired but hardly ever do because it is too expensive for them to do so.

Below we outline some recommendations on how VAT can be differentiated in order to boost jobs in re-use and repair activities, based on current examples from around Europe and the views of social enterprises working in this field.

A number of EU Member States have already made efforts to reduce VAT on both second-hand goods as well as repair services. There also exist a number of examples, both within and outside of Europe, whereby tax reductions are also being used to incentivise donations of used goods to social enterprise as well as encouraging citizens to have their goods repaired.

Here are some examples on VAT reduction on repair services and second-hand sales:

- Ireland, Luxembourg, Malta, Netherlands, Poland, Slovenia, Finland and Sweden apply VAT reduction on minor repair services (including mending and alteration) of bicycles, shoes and leather goods.
- In France, collection and sales of used goods carried out by social enterprises are exempt from VAT because their activities are linked to the employment of disadvantaged and disabled persons.
- In Belgium, social enterprises active in the area of reuse and preparing for reuse have a reduced VAT rate of 6% under certain conditions, because they combine their reuse and preparing for reuse activities with training, rehabilitation and integration of disadvantaged groups. This is a reduced VAT rate relating to the sales of goods and services provided by such social enterprises.
- In UK, currently donated items that are re-sold are VAT exempt only if sold by a registered charity or by a person (or company) who has agreed in writing to give all profits to a charity. This means that any organization that is not a charity (either registered or exempt) has to charge VAT at the prevailing rate on all donated items.

Other examples concern the use of tax reductions to advance repair practices, as follows:

- In Sweden 50% labor costs for repairs of large household appliances are tax deductible up to a maximum of 25000 Kr / year or 50000 Kr for persons over the age of 65. This is for repairs performed by professionals at the owner's home.
- In Austria, there is a proposal to make repair cheaper by reimbursement of 50% of the labor costs of repair. The maximum amount would be 600 EUR per year per private

person and year and it will be applicable for bikes, shoes, clothes, leather goods, electric household appliances. The city of Graz already introduced this system in November 2016 with maximum support of 100 EUR per household and year.
- In Spain, there is the Patronage law that allows tax reductions to companies and individuals who donate money from assets to charities. It also includes the donation of used goods, without differentiating them from new ones.

Several NGOs and policy makers are suggesting that:
- a 0% VAT should be applied on the cost of the labor of repair, maintenance, upgrade services on products such as furniture, electronic and electrical equipment, construction materials, bicycles, shoes and leather goods offer tax rebates to citizens after having had their goods repaired.
- a 0% VAT rate should apply on the sale of second-hand goods as VAT was already paid once during the purchase of a new product.
- governments should offer incentives to citizens by providing partial reimbursement for the cost of labor of repair, such as the case of Sweden.
- governments should allow retailers to recoup VAT through donation of unsold new products to social enterprise re-use operators
- governments should offer tax breaks to citizens following the donation of used goods to social enterprise re-use operators

A relevant study (Ecopreneur, 2019) suggests to:
- Improve and extend the extended producer responsibility (EPR) to cover eco-modulation of fees
- Introduce low VAT rates for repair services, resold goods and transactions with clearly defined social reasons
- Create a "Green New Deal" to shift taxes from labour to resources
- Initiate and fund a massive free training programme on Circular Procurement in all member states and lead by example with circular procurement across the board
- Ensure alignment of national EPR schemes by strong guidelines and reconsider the introduction of harmonized, mandatory schemes
- Prepare the VAT rate proposal in the context of its potential for the circular economy, table it when adoption by all member states can be reached, and continue investigating majority voting on tax matters
- Keep trying to introduce a tax shift from labor to resources and set up pilots to demonstrate its potential, including VAT differentiation

7.3 Time for a Recycling Unit?

There is a serious proposal that will create new governance patterns in the National Waste Management Plan 2020 – 2030. More specifically, a new implementation model is proposed (page 31 of the plan) based on the stakeholders' engagement and interaction. The proposed model includes:
- Clear roles and responsibilities for all stakeholders for all EPR waste streams

- Creation of an independent Clearing House (Producer Balancing Body)
- All producers to have obligations, including small producers (e.g. through a flat fee)
- Producers and schemes pay full net cost of treatment in a compliant recycling sector;
- Minimum fees paid for waste equipment & materials recycled.
- Payment based on acceptable, auditable evidence provided by compliant recyclers.
- Minimum length of contracts between the actors (at least one year)
- Regular meeting of stakeholders to feedback on practical operation of the system.

The proposal for a Producer Balancing Body (or Clearing House) is a central one that will reshape the recycling landscape in the country.

The Producer Balancing Body (PBB) will have a pivotal role to play, making a significant contribution to the overall administrative capacity in the system and help limit and focus the role of the Ministry. The operation of the PBB will enable the government to focus on the critical role of regulation and enforcement to improve produce participation in the system and to drive the investment of funding into the system to deliver a compliant recycling sector, as shown in Figure 27.

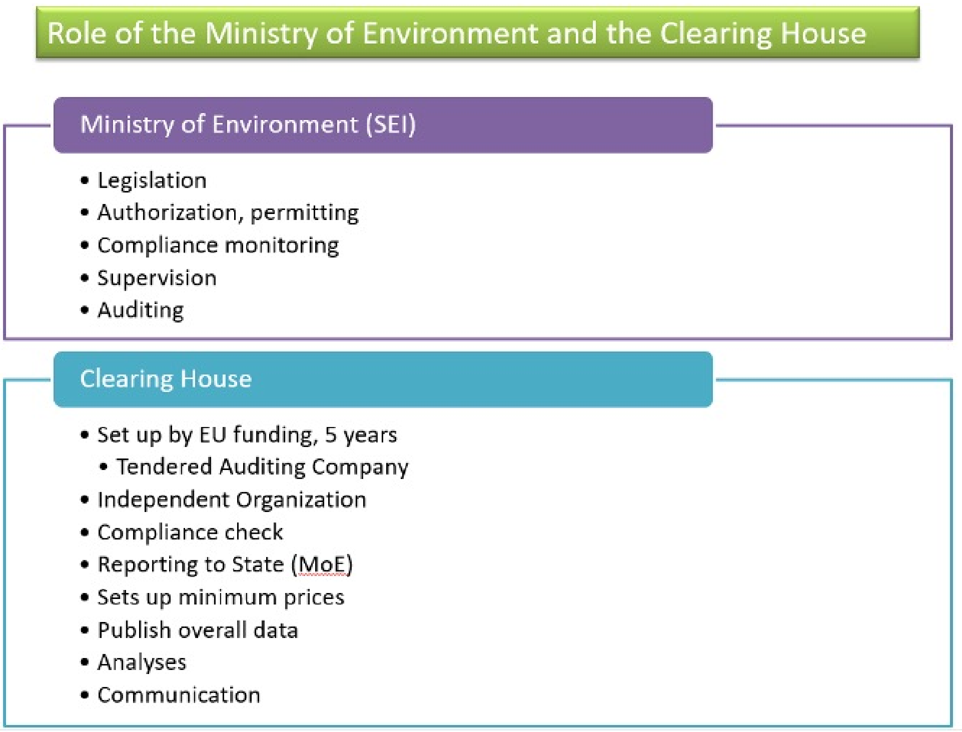

Figure 27: Roles of the Producer Balancing Body and the Ministry of Environment

We believe that this proposal is in the right direction and it can help the shift towards circular economy.

We also consider that it will be even better if a separate Recycling Unit will be created within the proposed Environmental Agency, with the following objectives:

- To prevent and reduce waste generation through the development and supervision of proper waste prevention programs for selected waste streams, especially in the field of eco-design and final consumption, stimulating public-private partnerships about it.
- To promote recycling and recovery activities through advancing and expanding Extended Producer Responsibility schemes.
- To ensure that the best available techniques for waste prevention, recovery and recycling will be applied through proper and systematic audits to all the different levels of the recovery – recycling supply chains.
- To make all the stakeholders aware of the circular economy advances and needs and promote R&D activities on recovery and circular Economy in regional and national levels.
- To act as a catalyst for the radical redesign of selected supply chains in the framework of a Circular Economy by coordinating the necessary cooperation between government, local authorities, industries and consumers.

8. Conclusions and the way forward

The report started by outlining the relationship between climate change, circular economy and waste management. In chapter 2, we already discussed that the shift to renewable energy requires a nearly 500% increase in the production and use of minerals, such as graphite, lithium and cobalt (World Bank, 2020). These minerals are required to deploy wind, solar and geothermal power, as well as energy storage, required for achieving a below 2°C future. In the same report report (World Bank, 2020), it is mentioned the important role that recycling and reuse of minerals will play in meeting increasing mineral demand. It is also noted that even if we scale up recycling rates for minerals like copper and aluminum by 100%, recycling and reuse would still not be enough to meet the demand for renewable energy technologies and energy storage. So, starting the conclusions, through this example we want to emphasize a major outcome of several studies and scientific reports and of this study too:

Circular Economy becomes a condition to achieve the targets of Paris Agreement and to mitigate GHGs. Thus, Circular Economy should not be considered an option for policy making but a main pillar of each and every policy option available. Thus, **the question is not if we need Circular Economy but how and how fast we can implement it**.

Another important element that was outlined through all the report regards the role of waste management in this context. Although circular practices concern the major industrial and manufacturing supply chains in rich countries, in countries like North Macedonia where the rate of industrialization is currently rather low and imports of manufactured materials are the main way to acquire them, the starting point for a shift to circular practices should be the waste management sector. By shifting the management of specific waste streams to circular practices, not only substantial environmental and economic benefits are achieved but the waste management sector can act as a catalyst for the whole economy of the country.

This report examined potential benefits due to the development of circular economy initiatives and practices on selected waste streams for the year 2030. More specifically, the report after considering the National Waste Management Plan and the 3rd Biennial Update Report and the Enhanced Nationally Determined Contribution, the authors assessed the economic, employment and emission benefits from circular practices in the following waste streams:

- End of Life Vehicles (ELVs)
- Biowaste
- Construction & Demolition Waste
- Electrical and electronic equipment (WEEE)
- Plastics
- Secondary Residual Fuels (SRF)

The overall conclusion from the assessment was that the total potential about emission savings from the shift to circular practices, for the specific waste streams mentioned above, is 951 Gg of CO_2-eq, similar to 201% of the solid waste disposal emissions. Thus, a shift to circular economy provides substantial savings in carbon emissions and can help the country to achieve its mitigation goals.

Circular practices for C&D and biowaste provide more than 70% of the emission savings, almost 20 million EUR per year of economic benefits (about 45% of the total benefits) and almost ¼ of the new jobs expected. Thus, the measures relevant to those two streams should be clearly prioritized. Moreover, in terms of new employment circular practices in plastics and waste electrical and electronic equipment (WEEE) are expected to create almost 56% of the total new jobs generated. Finally, the economic benefits from the circular practices in biowaste and e-waste are expected to create more than 60% of the total economic benefits.

To realize these potential benefits the following is required:

- Proper EPR systems should be developed for C&D waste, WEEE, ELVs
- New legislation and standardization procedures should be developed for SRF
- New legislation and certification procedures should be developed for compost and composting
- A serious upgrade is required in plastic packaging management and new initiatives for plastic waste streams are required.

In the next paragraphs some more specific proposals are developed in brief.

8.1 C&D Waste

The potential from circular practices on C&D waste is by far the bigger one because of the domino effects it introduces to building materials.

To realize this potential, we propose the following immediate measures:

- Apply the Extended Producer Responsibility (EPR) principle to C&D Waste and setup proper national and regional systems that will realize the EPR. A proper feasibility study should be the first step.
- Regulate new construction permits in order to include an integrated C&D waste management plan for every new construction that a. it will refer to the quantities and composition of the generated waste, and b. it will incorporate the contractual agreements with the relevant EPR systems.
- Prepare a Green Procurement Deal to advance C&D recovery and apply it to all public constructions and demolitions.
- Create a proper information system about C&D to reduce the high uncertainties involved.

8.2 Biowaste

Biowaste is the second stream that delivers substantial savings in GHGs emissions. In addition, diverting biowaste from landfills provides high environmental benefits (less biogas & leachate) and enables cost-savings in logistics through decentralized composting facilities.

To realize this potential, we propose the following immediate measures:

- Adopt the mandatory separate collection of biowaste by private sector companies for all major biowaste producers (restaurants, hotels, hospitals, schools, military camps etc.) as a measure that will immediately divert biowaste from landfills and stimulate the creation of composting facilities. The use of private companies to collect the biowaste from major biowaste generators will act as a push towards waste prevention as private collectors charge more than the public ones.
- Adopt the mandatory separate collection of biowaste for all the major urban centers of the country and develop a differentiation in gate fees for composting vs landfills.
- Prepare a decentralized network of 20-30 small biowaste composting facilities that will reduce substantially the logistics and transportation costs.
- Regulate compost certification rules and procedures in accordance with EU context. This will allow the commercialization of the produced compost.
- Prepare a Green Procurement Deal to advance compost uses in all public works, parks and reclamation projects.
- Prepare a food waste prevention guide for all the restaurants and hotels of the country and make a relevant campaign.

8.3 WEEE

There is a serious potential for improvements in electrical and electronic equipment waste management and the already existing system can be upgraded and deliver more. For that purpose, we propose:

- To implement the relevant proposals of the National Waste Management Plan 2020-2030.
- To proceed and implement repair-centers strategically located all around the country through the employment of currently unemployed and disabled people. A relevant business model and feasibility study is required as a first step.
- Use all the importers and retailers of e-waste as return points and regulate their relevant obligation.
- Provide economic incentives for electronic equipment repair and re-use.
- Provide a framework for the integration of informal sector in the formal system.

8.4 SRF

The production of SRF is linked with its potential to be used as substitute fuel for cement plant in the country. To develop the relevant opportunity and transform it to a tangible project the following steps should be made:

- Develop a feasibility study for the environmental and economic costs and benefits of using SRF to cement plants.
- Prepare the legal framework for the standardization of SRF in accordance with the EU standards.
- Examine the specific investments that are required by the cement plants to receive SRF and start by a low substitution rate no more than 10%. Based on the results of the first 1-2 years, substitution rates can go higher.
- Prepare a long-term agreement or an MoU between the cement plants and the potential SRF producers under the auspices of MoEPP that will allow relevant investments to flourish
- Prepare a communication campaign about the use of SRF in cement plants.

8.5 Plastic waste

Plastic waste management can be substantially improved if the relevant packaging EPR scheme gets better in accordance with the suggestions made by National Waste Management Plan 2020-2030. Besides that, the following measures are proposed:

- Calculate the costs and benefits of adopting the EU Single Use Plastics rules in North Macedonia and prepare a relevant roadmap for the next steps.
- Adopt a regulatory framework for the prevention of plastic pollution in water aquifers and bodies and develop plastic waste prevention plans for all the areas surrounding lake Ohrid, main rivers etc.
- Make a feasibility study for the implementation of a deposit-return system for bottled water and refreshments.
- Introduce measures to reduce plastic packaging and increase plastic recycling in the tourism industry

- Introduce measures to reduce plastic use and increase recycling in agricultural plastics.

8.6 ELVs

ELVs have a good potential for GHGs savings and their recycling will create serious new employment. In addition, a proper stimulation of ELVs recycling should address the issues of informal recyclers and practices as well as of their uncontrolled disposal. Some immediate measures:

- Create an EPR system for ELVs in accordance with the proposals of the National Waste Management Plan 2020-2030.Work with the main importers of cars in order to ensure their compliance with the proposed EPR scheme.
- From now on, the controlled disposal of ELVs should be put as a condition in order to buy any new car. So, every owner of a car that wants to change it must bring an invoice and a contract for the disposal of the old car before being able to buy a new one. Relevant measures are applied all around EU.
- Provide a framework for the integration of informal sector in the formal system. \

8.7 Governance and horizontal issues

In addition to the previous measures, we believe that special emphasis should be given to horizontal and governance issues as the following.

- <u>Setup a vision and a CE agenda on the government level</u>
  It is important to introduce Circular Economy as a main pillar for the state's policies in all levels. Consequently, there is a need for vision and an agenda about Circular Economy that will impact all the thematic policies and ministries, as we already described in the governance chapter.
- <u>Information system</u>
  In line with the suggestions made in the National Waste Management Plan 2020-2030, there is a need for a serious investment in proper information systems that will provide reliable and on-time data on waste streams. This is absolutely necessary for the shift to circular economy and it requires cross-cutting policies and obligations for all the ministries involved. More details in the next paragraph.
- <u>Green Procurement Deal</u>
  Launch a Green Deal Circular Procurement for both the public and the private sector, including a free training programme and commitments from both public sector and companies. The focus should be given to the most important waste streams as mentioned above.
- <u>Economic incentives</u>
  Start to examine the differentiation of VAT and tax regime for repair and reuse services in accordance with the practices in other EU countries.
- <u>Recycling Unit and EPR strengthening</u>
  Proceed with the feasibility study, the detailed design and creation of a Recycling Unit as described in Chapter 7 of this report.

8.8 The need for an information system

To better organize, supervise and monitor the waste flows within the country and through its borders, it is necessary to prepare and implement a Solid Waste Information system that will:

- Host all the relevant data in a digital - paperless way
- Cross-check different data sets to control compliance with the laws and regulation
- Be systematically updated with relevant data sets
- Be mandatory for all the waste generators (except households) and the companies that are active in waste management (collection, transfer, recycling, treatment, disposal)
- Cover all the waste streams, and
- Be linked with the operational and environmental licenses of the waste generators, the companies involved in waste management and the waste management facilities.

The main idea is to design, develop and implement three well-interconnected registries that will operate as one single information system as follows:

- A registry that will include all the big waste generators (for all types of waste, C&D, mining, municipal, hazardous, e-waste, healthcare etc.) and the way they manage their waste, including quantities and composition of waste streams and the companies that handle waste in one or another way.
- A registry that will include all the companies involved in waste management operations, in all the waste streams, including the clients they serve and the way they treat the waste from different clients.
- A registry that will include all the facilities that receive waste within the country, the way they manage it, their inputs and outputs and their environmental performance.

The Solid Waste Information system must ensure Administrative, Functional and Load scalability capabilities since at its final stage will incorporate data regarding all aspects of waste management activities e.g. waste generation, recycling/separation at source, transfer and transportation, waste treatment etc. Therefore, the scalability of the system must ensure (and focus on) the following:

- ability to increase the number of organizations and users
- ability to enhance the system by adding new functionality at minimal effort for future project phases
- ability to accept new type of data and to produce new output parameters
- ability to easily expand to accommodate heavier or lighter loads or number of inputs

8.9 Start pilot on reuse

It is necessary to start pilot programs on reuse and repair practices. An idea that can be a good starting point is to test and demonstrate a circular concept (reuse) to the waste stream of End of Life furniture.

End of life (EOL) furniture is a stream with special importance because in most of the cases the furniture's construction is a time-consuming, labor-intensive way using a multitude of components. The complexity of construction and difficulty in separating individual components makes this style of furniture impossible to recycle.

For furniture, the End of Life comes when the fabric wears, becomes soiled, or the owner follows the next fashion trend and the whole piece is then sent to landfill. It is generally more expensive to remove the cover to re-upholster than it is to start from new, because of the labor costs. As a result, every year there is more and more furniture on roadsides, put out for collection, to end up as landfill. There are three associated problems with the disposal of furniture in landfills.

First, we spent valuable space in landfills because the volume of furniture is big.

Second, by destructing furniture through compaction, we also destroy the embedded human labor and creativity.

Third, in many cases, putting furniture in landfills we lose a second chance to reuse them and, consequently, we lose the resources involved like wood, metal parts etc.

The scope of such a project should be to setup a reuse, upcycling and eco-design center for end of life furniture in the city of Skopje.

The project will be developed with the following elements:

1. Feasibility study: in this study the project's inputs and outputs will be defined and major decisions will be made like the partnerships required, the business model of the center, required skills and training of the personnel, the exact type of furniture that will be accepted, the exact way in which the end of life furniture will be collected and treated, as well as the way in which the treated furniture will be pushed back to new users, which type of users are targeted and what other attractive activities can be hosted in the reuse center (e.g. repair café, museum of furniture, kid garden et.) . Part of the feasibility study will be to assess the environmental, social and economic footprint of the project

2. Site allocation and development: in this phase, a proper site will be selected for the project, in a suitable area preferable with an existing building, electricity and water networks. Specific interventions will be implemented in accordance with the conditions of the specific site.

3. Operational phase: in this phase the reuse center will be operational, reuse and repair activities will take place and the treated furniture will be pushed to target users with a relevant pricing or for free, depending on the business model of the project.

Based on the project’s results and the experiences gained, the policy makers and stakeholders involved will identify:

- the critical parameters for the success of the project
- the most suitable financial and business model options
- the social benefits and environmental benefits that can be materialized

This deeper understanding will allow the policy makers and the stakeholders involved to develop a proper strategy a. to scale up the reuse concept geographically (on a national level) for EoL furniture, and b. to utilize the experiences gained in order to develop reuse concepts in other EoL streams.

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