Project funded by EUROPEAN UNION

Waste Free Rivers For A Clean Black Sea
GEORGIA MOLDOVA ROMANIA

Black Sea CROSS BORDER COOPERATION

# Guide to European Union Practices on Waste Recycling Technologies


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# Guide to European Union practices on waste recycling technologies

## Foreword

Appropriate waste management is one of the cornerstones of the circular economy and it helps to prevent a negative impact of waste on the environment and health.

Proper implementation of EU waste legislation will accelerate the transition to a circular economy. Local actors have a key crucial role to play in waste management and their involvement in policy development and implementation, as well as the support for their activities, are needed to ensure compliance with EU law.

All types of waste pose storage or aesthetic problems, but they are also a source of pollution that threatens human health and the environment. All waste degrades the environment, contaminating groundwater.

The development of the industry, of any kind, has led to an increase in the amount of waste, as well as in its variety.

To maintain a healthy living environment, waste must be disposed of by various methods or it should be recycled.

## EU legislation

The European Union environmental legislation has been developed over the past 30 years and today it includes approximately 300 legal acts, including directives, regulations, decisions and recommendations. In addition to these, a large number of bulletins are added and other policy documents, relevant to the EU environmental legislation. However, the entirety of EU environmental legislation, to which the associated countries of Central and Eastern Europe will have to align their national legislation and administrative practices, a condition for accession to the European Union - the so-called DTXLV GHPHGLX - is considerably less comprehensive. It mainly contains about 70 directives - some, however, have been amended several times and supplemented with "daughter" directives - and 21 regulations. About half of them - 36 directives and 11 regulations - are product-related and were included in the Commission's 1995 Report1.

The transformation of waste into a resource is supported by:

(i) the full implementation of Union waste legislation, which includes the waste hierarchy, the need to ensure separate waste collection, landfill reduction targets, etc ;

(ii) reduction of waste generation and per capita waste generation in absolute terms; and

(iii) limiting the energy recovery of non-recyclable materials and phasing out the storage of recyclable or recoverable waste.

The directive establishing a legislative framework for waste treatment in the EU is Directive 008/98 / EC on waste.

Its aim is to protect the environment and human health by emphasizing the importance of proper waste management and the use of recovery and recycling techniques to reduce pressure on resources and improve their use.

- The legislation establishes a hierarchy of waste: prevention, reuse, recycling, recovery for other purposes - such as energy - and disposal.
- It confirms the 'polluter pays' principle, on the basis of which the original waste producer has to bear the costs of waste management.

- The act also introduces the concept of "extended producer responsibility". This may include the task of the manufacturer to accept and dispose of the returned products after use.
- The directive distinguishes between waste and by-products.
- Waste management must be carried out without creating risks to water, air, soil, fauna or flora, without causing nuisance due to noise or odors and without damaging the landscape or areas of special interest.
- Producers or holders of waste must treat it themselves or ensure that it is treated by an officially recognized operator. They need a permit and are subject to periodic inspections.
- Competent national authorities should establish waste management plans and waste prevention programs.
- Special conditions apply to hazardous waste, waste oils and bio-waste.
- The Directive introduces recycling and recovery targets to be achieved by 2020 for household waste (50%) and for construction and demolition activities waste (70%).
- Certain types of waste, such as radioactive elements, unexploded ordinances, faeces, sewage and animal carcasses, are not covered by the legislation.

EU waste management policies aim to reduce the impact of waste on the environment and health and to improve resource efficiency in Europe. The long-term goal is to transform Europe into a recycling society, avoiding waste and using unavoidable waste as a resource, whenever possible. The aim is to achieve much higher levels of recycling and minimize the extraction of additional natural resources. Proper waste management is a key element in ensuring resource efficiency and sustainable growth of Europe's economies (the Europe 2020 strategy).

Consequently, the revised 2008 Waste Framework Directive introduces a five-tier hierarchy of waste, in which prevention is the best option, followed by reuse, recycling and other forms of recovery, disposal, for example in landfills. waste, being considered as a last resort. In line with this hierarchy, the 7th Environment Action Program sets the following priority objectives for waste policy in the EU:

- reducing the amount of generated waste;
- maximizing recycling and reuse;

•limiting incineration to non-recyclable materials;

• limiting the storage of waste in landfills to non-recyclable and non-recoverable waste;

• ensuring full implementation of waste policy objectives in all EU Member States.

This revised legislation addresses environmental issues with transnational implications, including the effects of mismanagement of waste on greenhouse gas emissions, air pollution and public waste disposal, including in the marine environment. It ensures that valuable waste materials are effectively reused, recycled and reintroduced into the European economy and therefore contributes to the transition to a circular economy, in which waste is progressively used as a resource and new economic opportunities are created. It aims to reduce the EU's dependence on the import of raw materials by promoting the cautious, efficient and rational use of natural resources.

Landfilling leads to pollution of surface water, groundwater, soil and air. Therefore, the legislation also includes a specific objective in terms of reducing landfills. Member States will endeavor to ensure that, starting 2030, all waste suitable for recycling or other form of recovery, in particular municipal waste, will not be accepted in landfills. The only exception is the type of waste for which storage provides the best environmental results. In addition, Member States shall ensure that, by 2035, the volume of municipal waste in landfills is reduced to 10% or less of the total volume of municipal waste generated.

At large, the Member States believe that these targets at EU level will create the minimum conditions for EU industry to invest in novel recycling techniques and technologies. Recent EU proposals aim at stimulating recycling targets, creating jobs in green industries and addressing food waste so as to turn the current linear economy into a circular economy and promote sustainable growth.

Among the mentioned objectives, increasing the recycling of packaging (60% by 2020, 70% by 2025, 80% by 2030) stands out as a priority.

Other targets include 90% recycling for paper and 60% for plastic packaging by 2025, as well as 80% for wooden packaging by 2030. Also for 2030: 90% recycling of all packaging in iron, aluminum or glass.

According to the proposals, recyclable waste will be banned from landfills until 2025 (plastics, metals, glass, paper, cardboard and biodegradable waste). This ban will also cover all municipal waste recoverable by 2030. Member States will set a 30% resource efficiency target by 2030, related to the consumption of raw materials and gross domestic product (GDP). It is intended to encourage and improve resource productivity. The focus is on those materials that promise the most economical environmental benefit.

New targets mean a fundamental transition from a linear to a more circular economy, in which reuse, repair and recycling become the norm, and waste would become a thing of the past. Of course, this requires innovation in the markets for recycled materials, new business models, ecological design and industrial symbiosis.

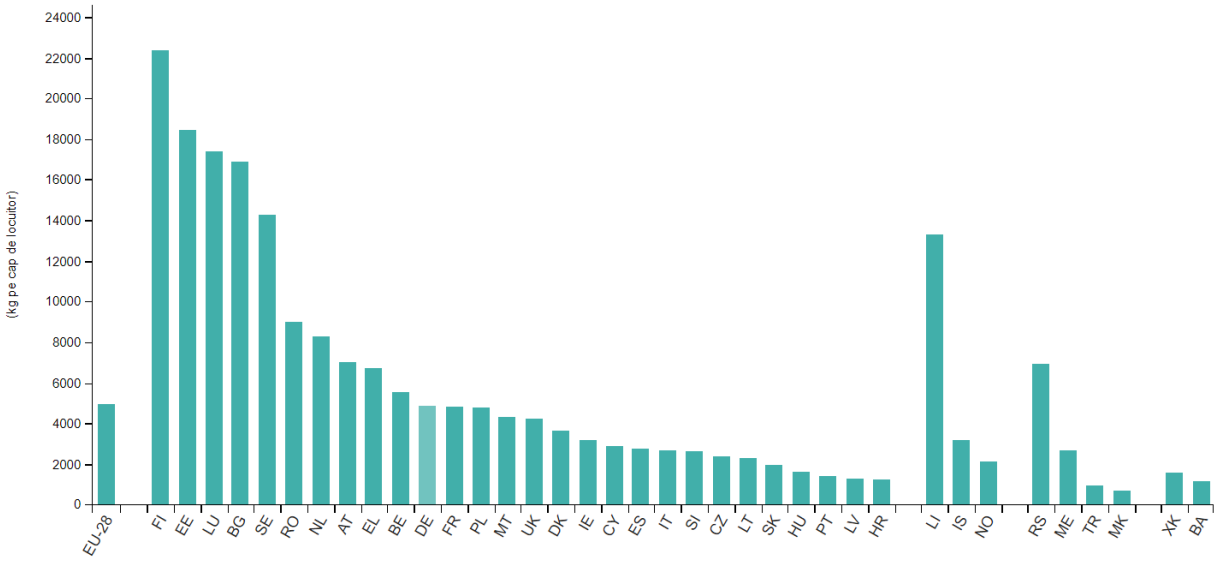
The proposed vision of a framework to help the circular economy become a reality calls for better interconnected policies, a smart regulation and an active support in the field research and innovation. According to the EU commission, this system would unblock investment and attract funding, while promoting a strong role for business and consumer participation. In addition, 580,000 new jobs could be created, and annual greenhouse gas emissions could be reduced by 62 million tonnes by 2030.

The EU is already expected to increase its resource productivity by 15% during 2014 - 2030, in a business scenario. Policies to promote the transition to a more circular economy could lead to a doubling rate, while stimulating job creation and generating additional growth. Legislative proposals will be forwarded to the Council and the European Parliament. Research and innovation efforts in the field of the circular economy will be intensified. The policy framework for promoting the circular economy will be further developed in the coming years. In addition, waste legislation will be simplified and cooperation between the Commission and the Member States will be intensified. Minimum operating conditions will be established for extended manufacturer liability schemes. Tailored deseuri

pproaches will be implemented for specific waste streams, such as marine litter, phosphorus, construction and demolition rubble, food, hazardous and plastic waste.

# Statistical data on EU waste

## Waste generation -2016




Overview of the evolution of waste generation and treatment in the European Union (EU) and in several non-member countries. It shall be based exclusively on data collected in accordance with Regulation (EC) No 2150/2002 of the European Parliament and of the Council on waste statistics.

Waste, defined in Article 3 (1) of the Directive 2008/98 / EC as "any substance or object which the holder discards or intends or is required to discard", can be a huge waste of resources, both in terms of materials as well as energy. In addition, waste management and disposal can have a serious impact on the environment. Landfills, for example, occupy land and can cause air, water or soil pollution, while incineration can generate emissions of air pollutants.

Therefore, EU waste management policies aim to reduce the environmental and health impact of waste and improve resource efficiency in the EU. The long-term objective of these policies is to reduce the amount of waste generated and, where waste generation cannot be avoided, to promote its use as a resource and to achieve higher levels of recycling and waste disposal in safe conditions.

Total volume of waste generated

In 2016, the total waste generated in the EU-28 by all economic and household activities amounted to 2,538 million tonnes.

As expected, the total amount of waste generated is linked to some extent to the size of the population and the economic size of a country.

In Table 1, the smallest EU Member States generally reported the lowest levels of waste generation, and the largest, the highest levels. However, relatively large amounts of waste have been generated in Bulgaria and Romania, and a relatively small amount in Italy.

**Waste generation by economic activities and households, 2016**
(%)

| | Mining and quarrying | Manufacturing | Energy | Construction and demolition | Other economic activities | Households |
|---|---|---|---|---|---|---|
| EU-28 | 25 | 10 | 3 | 36 | 16 | 8 |
| Belgium | 0 | 23 | 1 | 31 | 36 | 8 |
| Bulgaria | 82 | 3 | 8 | 2 | 3 | 2 |
| Czechia | 1 | 18 | 4 | 40 | 23 | 14 |
| Denmark | 0 | 5 | 4 | 58 | 16 | 17 |
| Germany | 2 | 14 | 3 | 55 | 17 | 9 |
| Estonia | 26 | 37 | 25 | 5 | 6 | 2 |
| Ireland | 16 | 35 | 2 | 10 | 28 | 10 |
| Greece | 78 | 6 | 4 | 1 | 4 | 7 |
| Spain | 16 | 11 | 3 | 28 | 26 | 17 |
| France | 1 | 7 | 0 | 69 | 14 | 9 |
| Croatia | 12 | 8 | 2 | 24 | 31 | 22 |
| Italy | 0 | 17 | 2 | 33 | 29 | 18 |
| Cyprus | 5 | 33 | 0 | 36 | 10 | 16 |
| Latvia | 0 | 19 | 11 | 4 | 30 | 34 |
| Lithuania | 1 | 41 | 2 | 8 | 32 | 17 |
| Luxembourg | 0 | 7 | 0 | 75 | 11 | 6 |
| Hungary | 1 | 17 | 16 | 23 | 25 | 18 |
| Malta | 8 | 1 | 0 | 69 | 13 | 8 |
| Netherlands | 0 | 10 | 1 | 70 | 13 | 6 |
| Austria | 0 | 9 | 1 | 73 | 10 | 7 |
| Poland | 39 | 17 | 11 | 10 | 18 | 5 |
| Portugal | 3 | 17 | 1 | 12 | 35 | 33 |
| Romania | 87 | 4 | 4 | 0 | 3 | 2 |
| Slovenia | 0 | 26 | 14 | 10 | 38 | 12 |
| Slovakia | 3 | 32 | 9 | 9 | 29 | 18 |
| Finland | 76 | 8 | 1 | 11 | 3 | 1 |
| Sweden | 77 | 4 | 1 | 7 | 7 | 3 |
| United Kingdom | 6 | 4 | 0 | 49 | 30 | 10 |
| Iceland | 0 | 25 | 0 | 4 | 31 | 40 |
| Liechtenstein | 3 | 2 | 0 | 88 | 1 | 5 |
| Norway | 3 | 14 | 2 | 27 | 32 | 22 |
| Montenegro | 19 | 2 | 18 | 37 | 10 | 13 |
| North Macedonia | 49 | 51 | 0 | 0 | 0 | 0 |
| Serbia | 79 | 3 | 12 | 1 | 2 | 3 |
| Turkey | 11 | : | 26 | : | : | 37 |
| Bosnia and Herzegovina (1) | 2 | 27 | 71 | 0 | 0 | 0 |
| Kosovo (2) | 14 | 20 | 40 | 6 | 10 | 11 |

(1) 2012.
(2) This designation is without prejudice to positions on status, and is in line with UNSCR 1244/1999 and the ICJ Opinion on the Kosovo declaration of independence.
*Source:* Eurostat (online data code: env_wasgen)

eurostat

Table 1: Waste generation by economic activities and households, 2016 (%) Source: Eurostat (env_wasgen)

Figure 1 shows the share of different economic activities and households in the total waste amount generated in 2016. At EU-28 level, in 2016, constructions contributed 36.4% of the total, followed by the extractive industry (25.3%), the manufacturing industry (10.3%), water and waste (10%) and households (8.5%); the remaining 9.5% was waste generated by other economic activities, especially services (4.6%) and energy (3.1%).

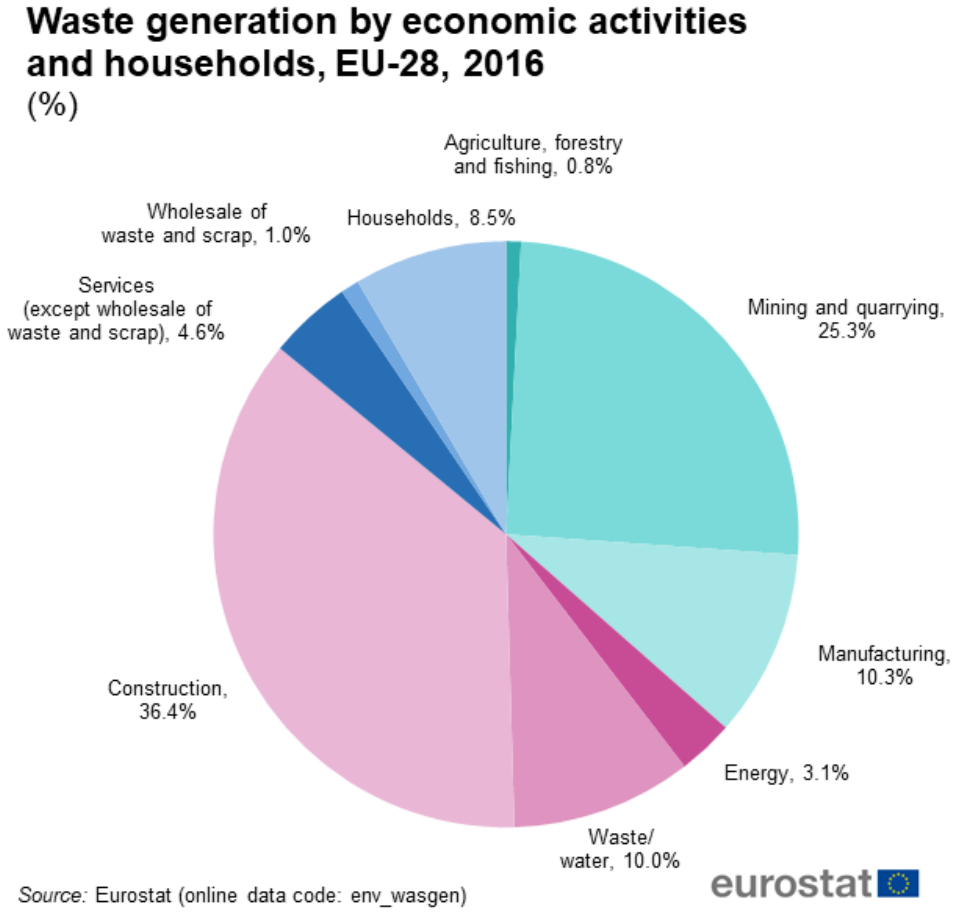



Figure 1: Waste generation by economic activities and households, EU-28, 2016 (%) Source: Eurostat (env_wasgen)

Figure 2 shows an analysis of the amount of waste generated in a standardized form, in relation to the size of population. The high levels of waste generated in some smaller EU Member States can be clearly seen, with a particularly high value being recorded in Finland, where, on average, 22.4 tonnes of waste per capita were generated in 2016, exceeding four times the average of 5.0 tonnes per capita registered at EU-28 level. Several Member States with a particularly high level of waste per capita reported very high shares

of waste from the extractive industry, while in other cases construction and demolition often contributed to a high share.

A large part of the waste from the extractive industry and from construction and demolition is classified as major mineral waste: the analysis presented in Figure 2 differentiates major mineral waste from other types of waste.

Almost two thirds (64% or 3.2 tonnes per capita) of the total waste generated in the EU-28 in 2016 was major mineral waste. The relative share of major mineral waste in the total amount of waste generated has varied considerably between EU Member States, which may reflect, at least to some extent, their different economic structures. In general, those EU Member States that had higher shares of major mineral waste were those that were characterized by relatively important activities in the extractive industry, such as Bulgaria, Sweden, Romania and Finland, and / or construction and demolition activities, such as Luxembourg; in these Member States, major mineral waste accounted for 85% or more of the total waste generated, as was the case for Liechtenstein (91%).

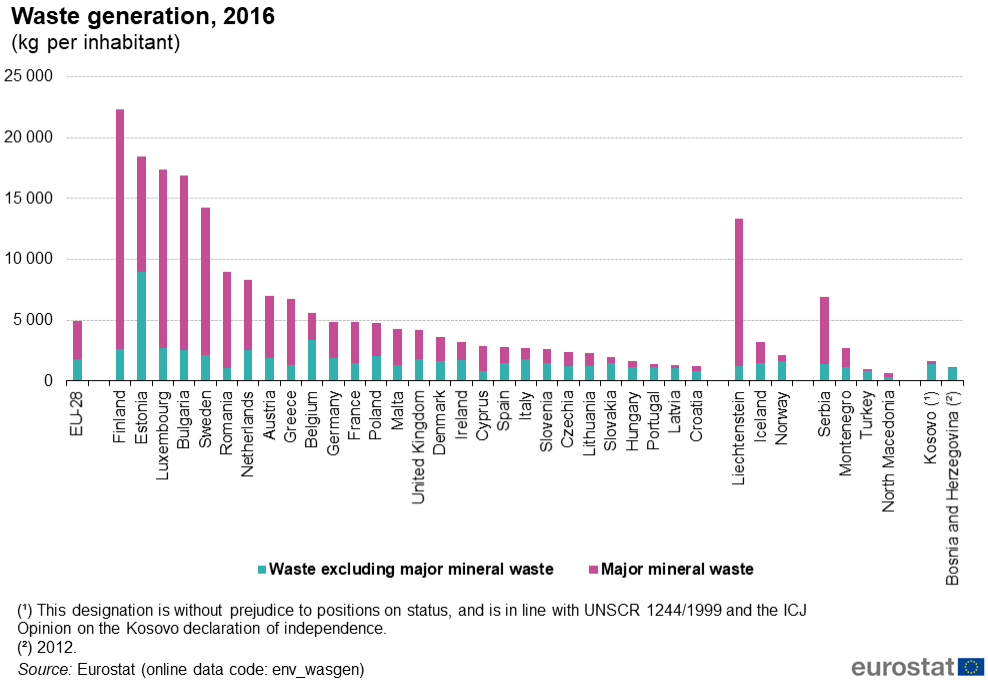



Figure 2: Waste generation, 2016 (kg per capita)
Source: Eurostat (env_wasgen)

*Hazardous waste generation*

If not managed and disposed of safely, hazardous waste can pose an increased risk to human health and the environment. Regarding waste generated in the EU-28 in 2016, 100.7 million tonnes (4.0% of the total) has been classified as hazardous waste.

Compared to 2010, 4.9% more hazardous waste was generated in 2016 in the EU-28, which is an increase in quantitative terms from 96.0 to 100.7 million tonnes. In 2016, the proportion of hazardous waste out of the total waste generated, was below 10.0% in all EU Member States except for Estonia and Bulgaria, these coutries accounting for 39.9% and 11.1% of the total, respectively. (see Figure 4). The very high proportion for Estonia was mainly due to the production of energy from bituminous shales. Of the third countries shown in Figure 3, Serbia recorded the highest proportion of hazardous waste from the total waste generated (35.2%) due to an intense activity in the extractive industry, followed by Montenegro (19.4%) and Norway ( 14.6%).

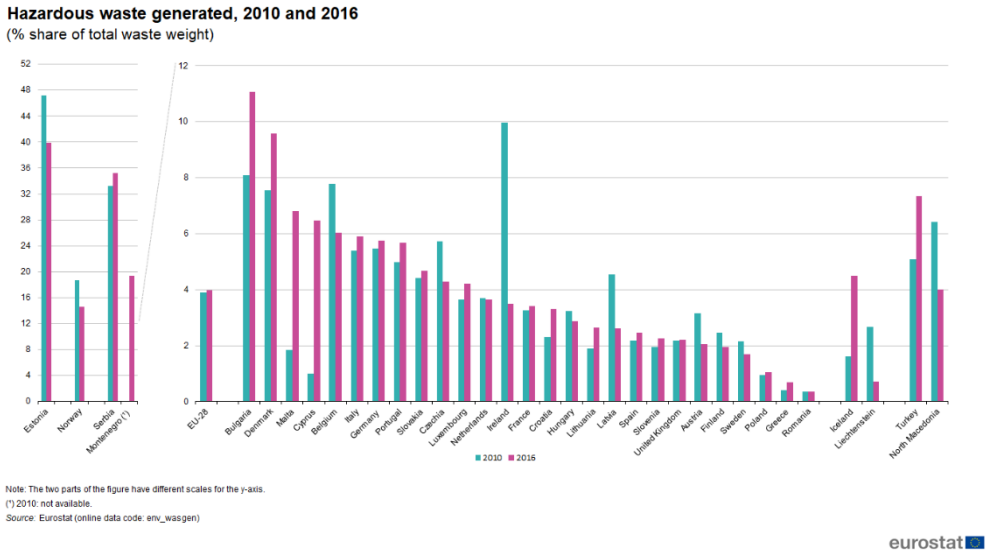



Figure 3: Hazardous waste generated, 2010 şi 2016 (% share of the total waste) Source: Eurostat (env_wasgen)

*Waste treatment*

In 2016, approximately 2,312 million tonnes of waste were treated in the EU-28. This excludes exported waste but includes the treatment of imported waste in the EU. Therefore, the reported quantities cannot be directly compared with those on waste generation.

Figure 4 shows the evolution of waste treatment in the EU-28 in total and according to the two main categories of treatment - recovery and disposal – during 2004-2016.

The amount of waste recovered, in other words recycled, used for backfill (use of waste in areas where excavations have been carried out to restore or consolidate slopes or for landscaping) or incinerated with energy recovery has increased by 28.2%, from 960 million tonnes in 2004 to 1,231 million tonnes in 2016; therefore, the share of recovered waste in the total amount of treated waste increased from 45.4% in 2004 to 53.2% in 2016. The amount of waste treated by disposal decreased from 1,154 million tonnes in 2004 to 1,081 million tons in 2016, which means a decrease of 6.3%. The share of waste disposed out of the total amount of treated waste increased from 54.6% in 2004 to 46.8% in 2016.

Figure 4: Evolution of waste treatment, UE-28, 2004-2016 (Index 2004 = 100)

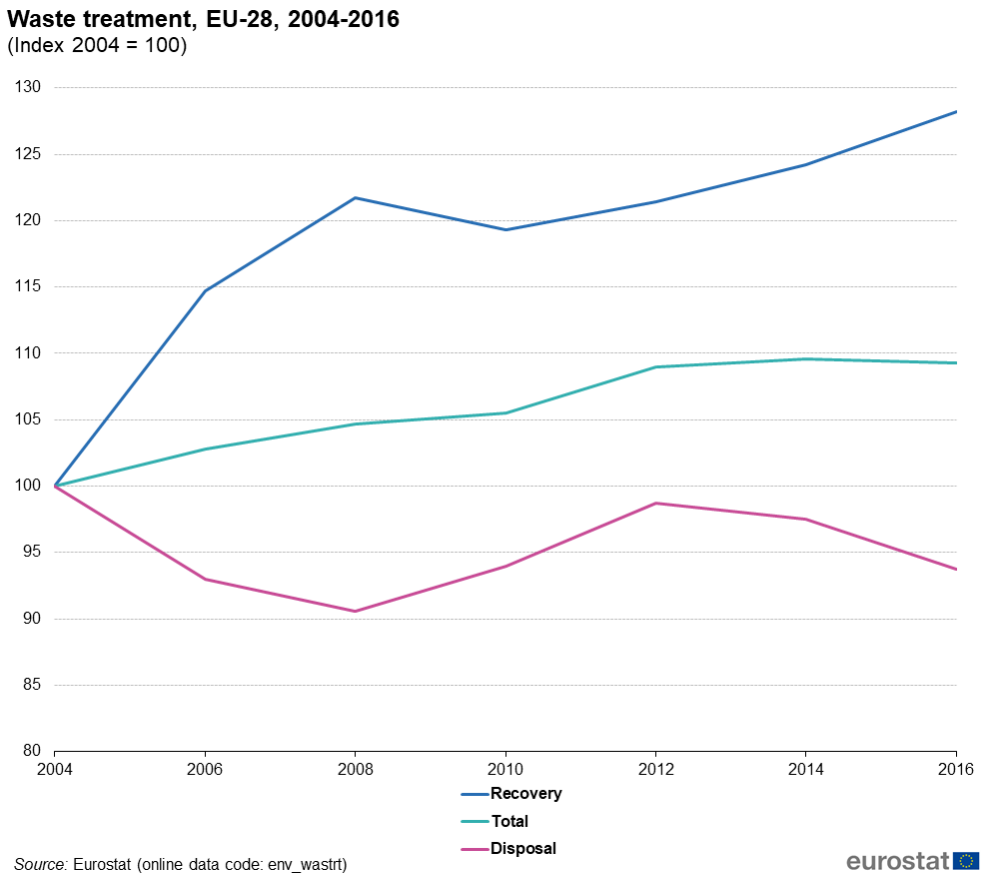



Figura 4: Evolution of waste treatment, UE-28, 2004-2016 (Index 2004 = 100)
Source: Eurostat (env_wastrt)

As mentioned above, in 2016, in the EU-28, slightly over half (53.2%) of the waste was treated through recovery operations: recycling (37.8% of the total treated waste), backfilling (9 , 9%) or energy recovery (5.6%). The remaining 46.8% were either deposited in landfills (38.8%) or incinerated without energy recovery (1.0%) or otherwise disposed of (7.0%). Significant differences have been observed among EU Member States regarding the use of different treatment methods. For example, some Member States had very high recycling rates (Italy and Belgium), while others promoted the use of landfills (Greece, Bulgaria, Romania, Greece, Finland and Sweden) (see Table 2).

**Waste treatment, 2016**
(% of total)

| | Recovery | | | Disposal | |
|---|---|---|---|---|---|
| | Recycling | Backfilling | Energy recovery | Landfill and other | Incineration without energy recovery |
| EU-28 | 37.8 | 9.9 | 5.6 | 45.7 | 1.0 |
| Belgium | 76.9 | 0.0 | 12.6 | 6.4 | 4.1 |
| Bulgaria | 5.2 | 0.0 | 0.4 | 94.4 | 0.0 |
| Czechia | 49.5 | 29.0 | 4.5 | 16.6 | 0.4 |
| Denmark | 51.4 | 0.0 | 19.5 | 29.1 | 0.0 |
| Germany | 42.7 | 26.6 | 11.3 | 18.1 | 1.2 |
| Estonia | 21.6 | 11.2 | 2.5 | 64.7 | 0.0 |
| Ireland | 10.6 | 46.0 | 4.8 | 38.4 | 0.3 |
| Greece | 4.8 | 0.0 | 0.3 | 94.8 | 0.0 |
| Spain | 37.1 | 5.7 | 3.6 | 53.6 | 0.0 |
| France | 55.0 | 10.3 | 5.4 | 27.6 | 1.6 |
| Croatia | 47.2 | 4.0 | 1.0 | 47.8 | 0.0 |
| Italy | 78.9 | 0.1 | 4.0 | 14.2 | 2.7 |
| Cyprus | 10.4 | 28.0 | 3.8 | 57.8 | 0.0 |
| Latvia | 71.7 | 1.1 | 6.8 | 20.3 | 0.0 |
| Lithuania | 33.4 | 4.1 | 5.8 | 56.6 | 0.0 |
| Luxembourg | 34.8 | 24.2 | 2.1 | 39.0 | 0.0 |
| Hungary | 54.1 | 3.7 | 7.4 | 34.2 | 0.6 |
| Malta | 19.1 | 63.4 | 0.0 | 17.2 | 0.4 |
| Netherlands | 45.6 | 0.0 | 7.6 | 46.0 | 0.9 |
| Austria | 37.0 | 11.0 | : | 45.9 | : |
| Poland | 46.2 | 22.2 | 3.3 | 28.0 | 0.4 |
| Portugal | 43.5 | 9.5 | 12.1 | 34.7 | 0.2 |
| Romania | 4.0 | 0.4 | 1.4 | 94.1 | 0.1 |
| Slovenia | 60.2 | 27.2 | 4.8 | 6.9 | 0.8 |
| Slovakia | 40.0 | 4.7 | 7.0 | 47.8 | 0.5 |
| Finland | 7.4 | 0.0 | 4.5 | 88.0 | 0.0 |
| Sweden | 12.0 | 4.9 | 6.6 | 76.3 | 0.2 |
| United Kingdom | 48.5 | 7.8 | 3.4 | 37.5 | 2.7 |
| Iceland | 25.0 | 51.0 | 0.4 | 22.3 | 1.3 |
| Norway | 43.5 | 2.6 | 34.0 | 19.5 | 0.5 |
| Montenegro | 0.8 | 0.0 | 0.2 | 98.9 | 0.0 |
| Serbia | 2.8 | 0.8 | 0.2 | 96.3 | 0.0 |
| Turkey | 33.0 | 0.0 | 0.8 | : | 0.2 |
| Kosovo (*) | 0.0 | 0.0 | 0.0 | 100.0 | 0.0 |

(*) This designation is without prejudice to positions on status, and is in line with UNSCR 1244/1999 and the ICJ Opinion on the Kosovo declaration of independence.

*Source:* Eurostat (online data code: env_wastrt)

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Table 2: Waste treatment, 2016 (% out of the total)
*Source:* Eurostat (env_wastrt)

*Treating hazardous waste*

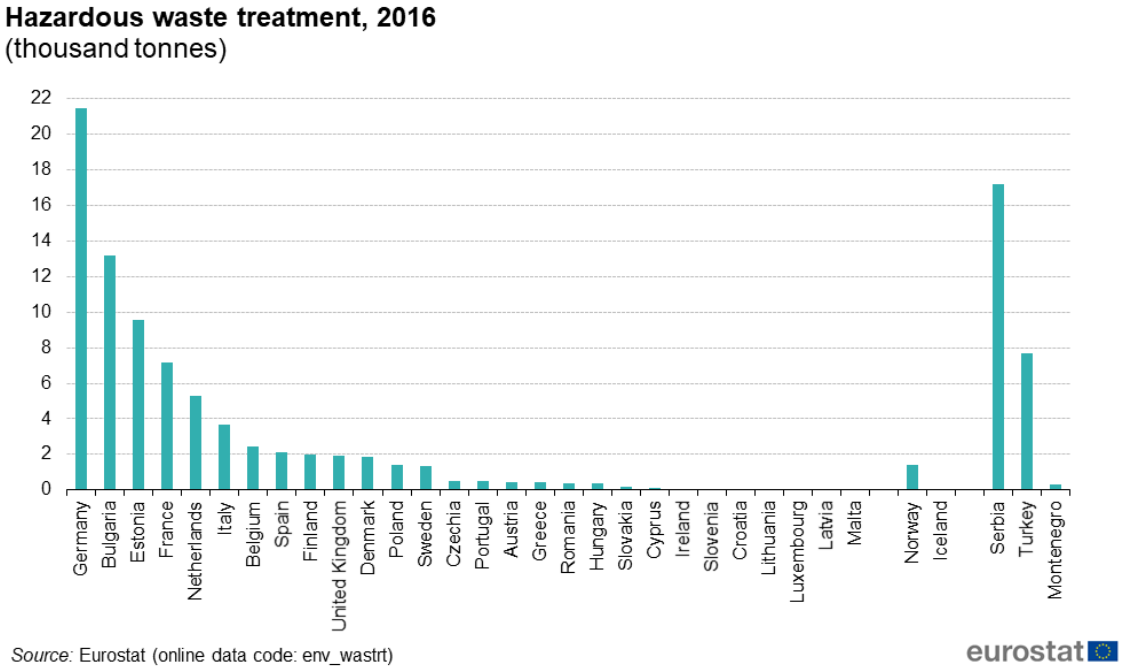


Figure 5 : Hazardous waste treatment, 2016 (thousand tonnes)
Source: Eurostat (env_wastrt)

All in all, 76.8 million tonnes of hazardous waste were treated in the EU-28 in 2016, more than half of which was treated in only three EU Member States, Germany (28.0%), Bulgaria (17 , 2%) and Estonia (12.5%) (Figure 5).

In 2016, 33.9% of hazardous waste treated in the EU-28 was landfilled, in other words, stored underground or on land or by soil treatment and discharged into the aquatic environment, which is equivalent to 51 kg per head of inhabitant (Figure 6). 5.9% of hazardous waste was incinerated without energy recovery (9 kg per capita). Energy recovery was used to treat 7.7% (12 kg per capita). More than a third (35.4%) of the hazardous waste in the EU-28 was recovered by recycling or used for backfill in 2016, which is the equivalent of 53 kg per capita.

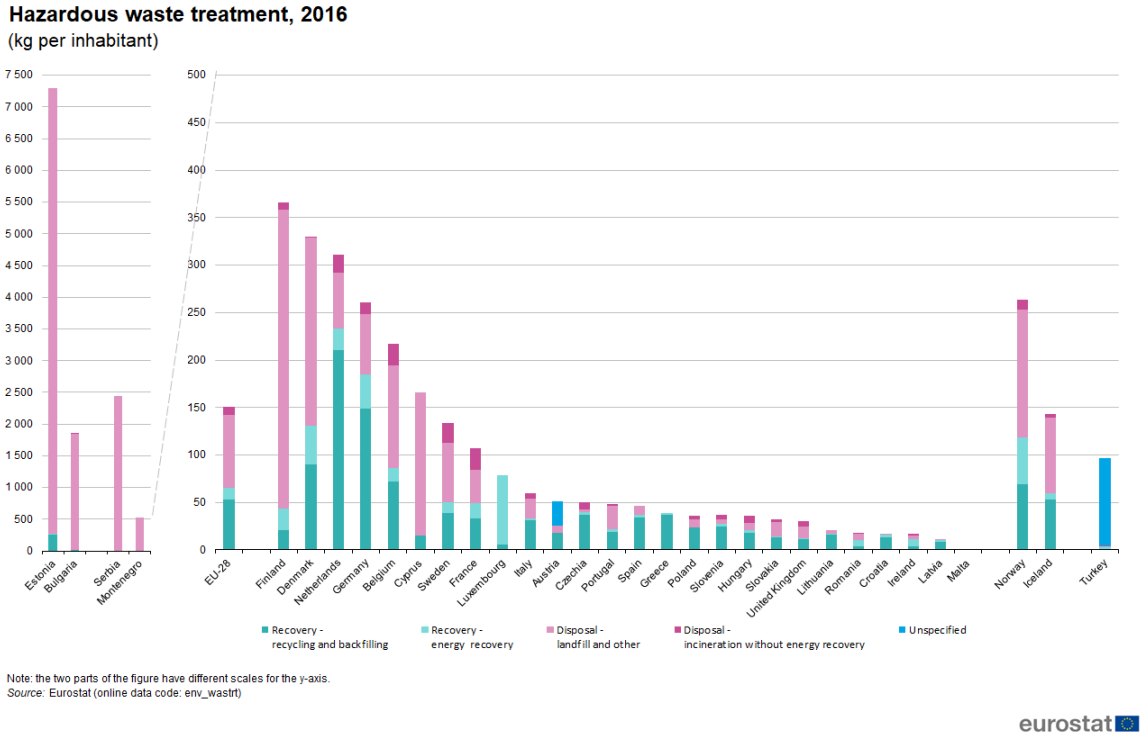


Figure 6: Hazardous waste treatment, 2016 (kg per inhabitant)
Source: Eurostat (env_wastrt)

## International recycling

Worldwide, municipal solid waste (MSW) recycling rates are widely reported - but different measurement methods make comparisons more difficult; some statements on the recycling rates should be treated with a certain caution.

- drawing up the reported figures on the recycling rate from sources including Eurostat and the OECD, the first 25 countries habe been identified;
- examining the data into detail and understanding what is and what is not included in the various new measurement methods, the top countries were compared to establish a "Top 10" league;
- these results have been updated as compared to the initial version published in March 2017.

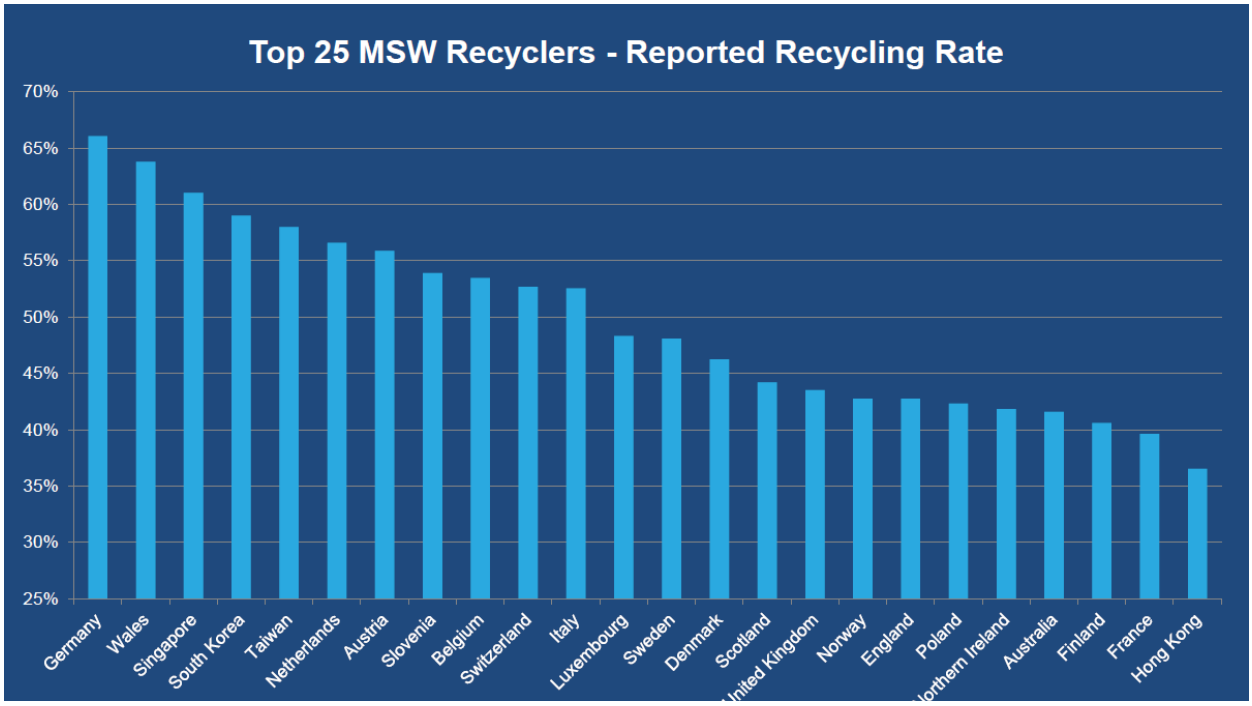


Figure 7 : Top 25 countries having reported the recycling rate

By further investigating the basic data and recycling practices in each country, it is possible to identify where the discrepancies may affect the way recycling is reported. The main differences are in the way they are accounted for (or not) in the reported figures:

- inclusion of construction and demolition waste (C&D)
- inclusion of commercial and industrial waste (C&I)
- incinerator ash (IBA) (and metals recovered from IBA).
- contamination in dry recycling and biotechnology
- inputs / outputs from mechanical and biological treatment
- recycling processing losses

By adjusting these discrepancies, we tried to solve a comparable set of recycling rates for both MSW and household waste that better reflect the amount of waste being actually recycled.

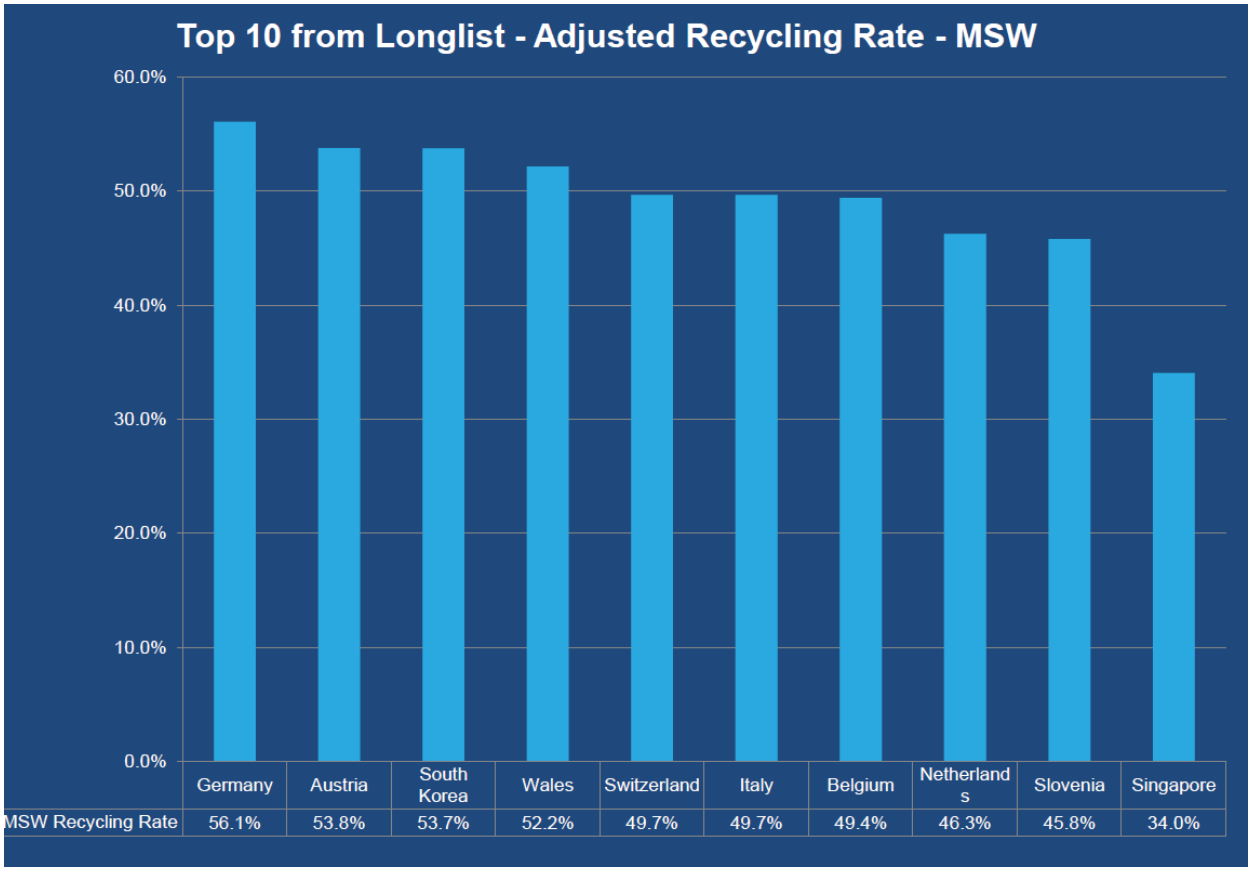


Figure 8 : Top 10 countries with the highest recycling rate

## Recycling in the EU countries

Household waste is a solid waste, collected from people's households and generally it consists of paper, plastic, textiles, ceramics, metals, glass, packaging, batteries, tires, oils and, last but not least, food waste.

Most of them are biodegradable, but metal, aluminum, plastic, and glass containers do not degrade at all or only after a very long time.

Therefore, it is necessary that this waste be collected, recovered, recycled and processed to make it possible for it to be reused. Taking into account the limited nature of natural resources, waste recycling has both ecological (eliminates environmental pollution) and economic (saving of raw materials and energy) advantages.

Wastes that are partially or fully recovered are ferrous, non-ferrous and precious metals, chemical waste (rubber waste), paper waste, textiles, glass.

In the last two decades, the European countries have increasingly focused their attention on municipal waste from disposal to prevention and recycling. Moving municipal waste management to the top of the "waste hierarchy" is essential to extract more value from resources by reducing environmental pressure and creating jobs.

Although municipal waste accounts for only about 10% of total waste generated in the EU (Eurostat, 2016a and 2016b), it is highly visible, and the prevention of this waste has the potential to reduce its impact on the environment not only during consumption and waste, but also and throughout the life cycle of the products consumed.

The European countries are improving their methods of preventing the dumping of household and other municipal waste in landfills. Recycling rates have risen sharply in Europe over the past decade, partly due to European environmental policies, according to a new assessment by the European Environment Agency.

The report of the European Environment Agency entitled "Municipal waste management in European countries" compiles the latest available data on waste management practices in EEA member countries (including the 28 European member countries, plus Iceland, Norway, Switzerland and Turkey, with partial information about the Western Balkan countries).

The percentage of municipal waste going to landfill in the 32 EEA member countries has

decreased from 49% in 2004 to 34% in 2014. Overall, the rate of landfilling has gone down in 27 of the 32 countries.

In Austria, Belgium, Denmark, Germany, the Netherlands, Norway, Sweden and Switzerland, basically no municipal waste was sent to the landfill. Overall, the amount of municipal waste generated in the 32 EEA Member States decreased by 3% and the average amount per person decreased by 7% from 2004 to 2014. However, the study showed that there was no steady trend in these countries. There has been an increase in per capita municipal waste generation in 16 countries and a decrease in other 19 countries.

One of the success stories of the European environmental policies is the increase in the rate of municipal waste recycling (which includes material recycling, composting and assimilation of bio-waste). EEA countries achieved an average total recycling rate of 33% in 2014, compared to 23% in 2004. (For EU Member States: from 37% to 44% over the same period, 2004-2014). Statistics show that Germany, Austria, Belgium, Switzerland, the Netherlands and Sweden have recycled at least half of the municipal waste generated. Altogether, in 15 of the 32 countries, the recycling rate increased by at least 10% during 2004-2014. Research shows that there is a correlation between the increasing recycling rate and the decreasing rate of landfilling. Landfilling rate usually decreases faster than the recycling rate increases, as waste management strategies change from landfilling to a combination of recycling and incineration. In some cases, these strategies also include pre-treatment measures, such as mechanichal and biological treatment, the results of which are then recycled, incinerated or disposed of.

Despite the progress made towards achieving the objectives imposed by the European waste management legislation, the prospect of meeting EU targets by recycling 50% of municipal waste generated by 2020 is mixed and many countries will have to step up their efforts, according to available data.

It is important to note, however, that the data used in the comparisons do not show progress against the targets imposed for all countries. Member States have a choice of the four different methods that monitor their progress, and the data use the same method for all countries. Moreover, data on waste generation and indicators are limited in some cases. Countries have different definitions of what municipal waste consists of or regarding the composition of recycled materials. For example, some countries include only household

waste, while others include similar waste from commercial or office activities. Improvements in waste generation data and further harmonization of national reporting methods would help the efficiency of the measurement process.

Municipal waste makes up about 10% of all waste generated in the European Union, but despite that, it remains a visible problem. Its prevention reduces the associated environmental pressure and recycling would help the waste generated to become valuable material sources for the economy. Last year, the European Commission proposed new targets for municipal waste - 65% recycling target of the municipal waste generated by 2030 and a target to reduce landfill waste by a maximum of 10% of the municipal waste by 2030. These proposals are part of the Commission's package of measures with view to the circular economy, in order to maintain the value of the products, materials and resources in the economy for as long as possible.

The countries that have efficiently developped their municipal waste management Systems, in general, have a better performance in terms of global waste management (EC, 2015). This information is a summary of the results of a country-by-country analysis, addressing 32 countries in the EU-28 Member States, Iceland, Norway, Switzerland and Turkey (ETC / WMGE, 2016), supplemented with some information from the countries of the Western Balkans.

*EU policies and targets*

Waste policies and targets set at EU level include minimum requirements for the management of certain types of waste.

The most relevant targets for municipal waste are the Landfill Directive (EC, 1999) on waste targets for biodegradable municipal waste; Recycling targets of the Packaging and Packaging Waste Directive (EC, 1994); and the objective of the Framework Directive on Waste (EC, 2008) targets for recycling and preparation for reuse (more specifically, the target applies to specific types of household and similar waste).

<u>Progress / Achievements</u>

Total municipal waste generation in EU countries has decreased by 3% in absolute terms and the average generation per person by 7% between 2004 and 2014. However, there was no consistent trend among countries, as there are some countries recording a 16% increase in the municipal waste production per person and a 19% drop in other countries.

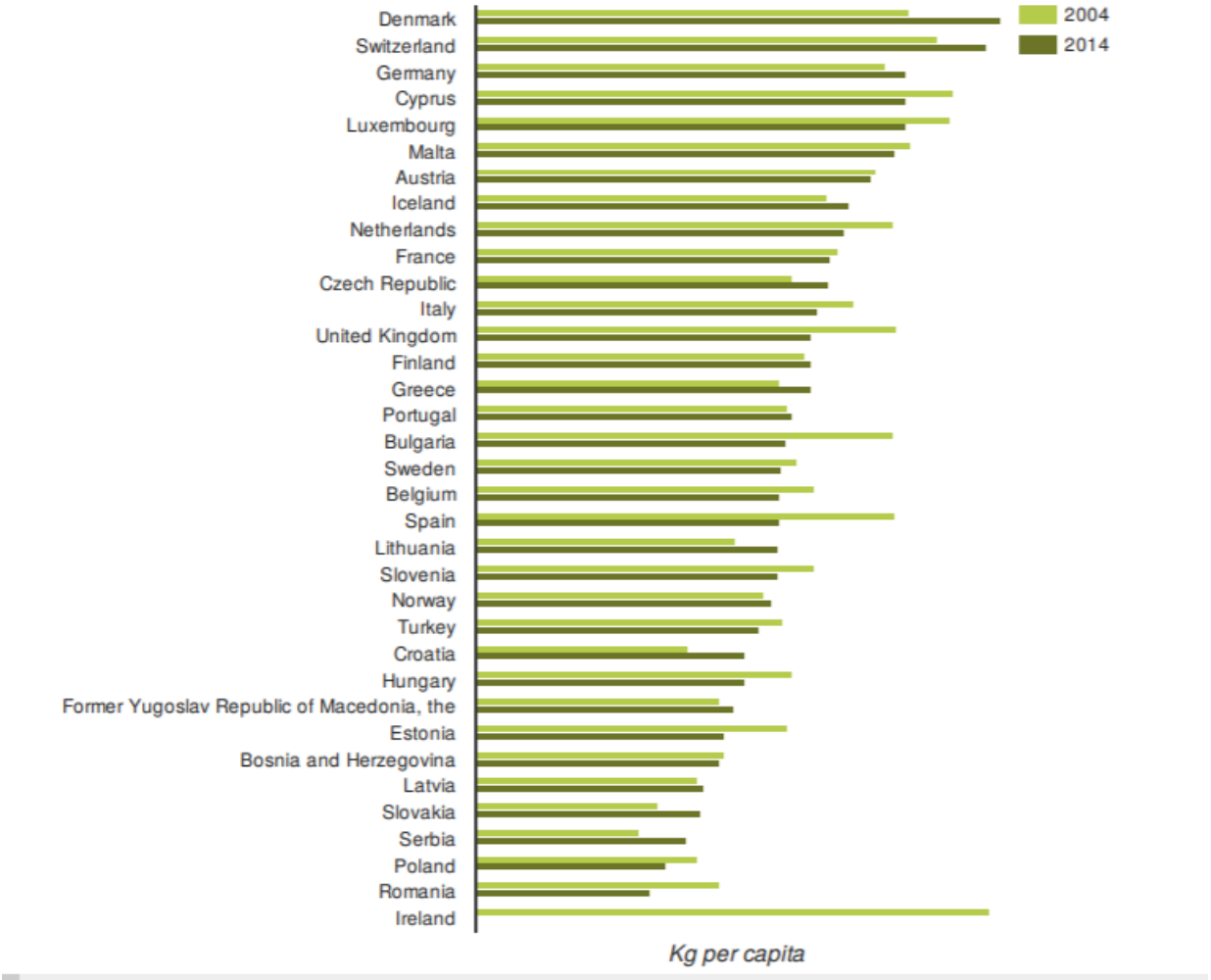


Figure 9: Municipal waste generated per capita in 35 European countries (2004 - 2014)

Europe has officially adopted new laws to prevent waste and stimulate recycling.

July 2018 - European leaders approve higher recycling targets and new waste reduction measures across Europe.

The laws were officially published in the Official Journal of the EU in June. As of July 4th, 2018, EU countries had a 24 months time to transpose these laws into their national law.

The news comes seven months after the laws and targets have been approved by the European Commission, the Parliament and governments as part of three-way negotiations known as trilogues.

EU countries will now be required to recycle at least 55% of municipal waste by 2025, 60% by 2030 and 65% by 2035.

Other approved measures include a 10% cap on landfills by 2035, mandatory separate collection of biowaste and stricter schemes to make producers pay for the collection of recyclable keys.

Recommendations also include economic incentives for reuse, refund schemes, food donations and the phasing out of subsidies promoting wastage.

In May 2017, government officials were questioned if they support the new, more ambitious proposals. Member States that did not disclose their position were shown in red on the map.

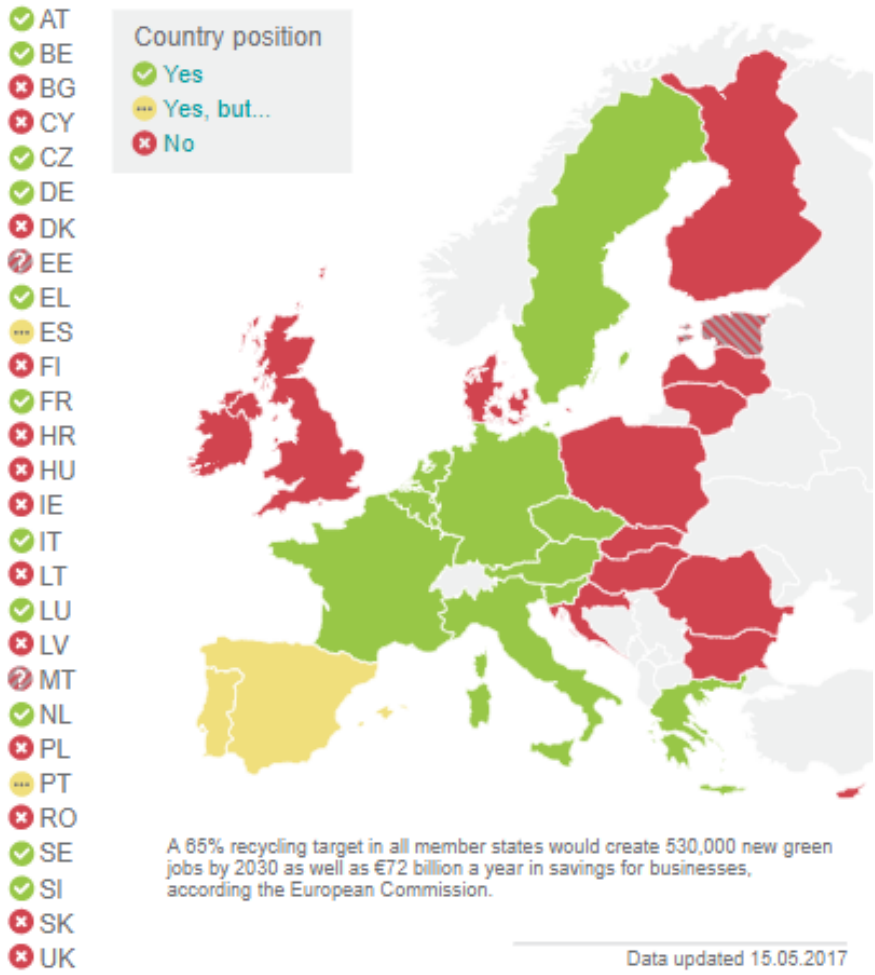


Figure 10: Position of member states against EC proposals

**Germany - an example of achievements in environmental policy**

Recycling has increased from 52% municipal waste (MSW) generated in 2001 to 64% in 2014.

Therefore, the EU's 50% recycling target by 2020 has already been met.

• The 2016 target for biodegradable municipal waste sent to landfills was met in 2006.

• There is a long tradition of national waste strategies and waste management plans in the federal states.

• The ban on the disposal of waste without pre-treatment, which is the responsibility of producers and the focus on separate collection have proved to be important policy initiatives.

• Among the latest initiatives, there is the introduction of the so-called recycling container - which will be adopted voluntarily by municipalities – aiming at increasing the recycling of plastics and metals in households and the mandatory separate collection of bio-waste since 2015.

Germany consists of 16 federal states (Bundesländer).

Responsibility for waste management and environmental protection is shared between the national government, the federal states and local authorities.

The National Ministry of Environment sets priorities, participates in the adoption of laws, supervises strategic planning, information and public relations and defines the requirements for waste facilities. The federal states and local authorities are responsible for enforcing the legal requirements set by the EU and the national law. Each federal state adopts its own waste management act which contains additional regulations to national law, for example on regional waste management concepts and rules on disposal requirements. There is no national waste management plan in Germany, instead, each federal state is developing its own waste management plan. (SEE, 2009).

For the household waste, the Recycling and Waste Management Act of 1996 gives the responsibility to the local public waste disposal authorities - in most federal states, these are districts and cities. Their responsibility covers waste collection and transport, measures to promote waste prevention and recovery and the planning, construction and operation of waste disposal facilities in accordance with national and regional legislation. Municipalities have more practical tasks, such as providing sites for the waste collection (Arcadis, 2014; EEA, 2009).

The Law on the German Circular Economy (Kreislaufwirtschaftsgesetz or KrWG) (Germany, 2012), adopted in 2012, incorporated the WFD requirements into the German law. The law was complemented by separate regulations, based on specific waste streams. (BiPro and CRI, 2015).

Germany was the first EU country to introduce producer responsibility with a regulation on packaging waste in 1991. According to this particularity, which is an essential element of the German waste legislation, the manufacturer of a product is generally responsible for the product once it becomes waste. The principle has been implemented for a number of product types, such as packaging, electrical and electronic equipment, vehicles, solvents, oil and batteries.

For the packaging waste, extended producer responsibility (EPR) applies only to household packaging waste, while in most other European countries, commercial and industrial packaging waste is included.

Nowadays, there are 10 organizations responsible for competing manufacturers for packaging in Germany, an organization representing about 50% of the market.

Generally, the system covers all costs for the collection and treatment of relevant waste streams and it achieves high recovery, recycling and reuse rates (EC, 2014).

German households benefir from door-to-door collection of residual waste services. In urban areas, recyclables are collected from door to door, while in rural areas, collection points are the main method of collecting recyclables, although there are many different collection systems. Door-to-door recyclable collection can be organized separately in special containers or bags or as a combined collection of several types of waste.

Since 2015, separate collection of bio-waste has been mandatory. Yellow baskets or bags are used for the collection of packaging waste - plastics and metals.

The federal government intends to provide a national expansion of the use of packaging containers to other products made from the same materials (recycling containers).

All households are served by formal waste collection systems.

Commercial waste that is similar to household waste is collected the same way as the household waste. (BiPro and CRI, 2015; Gibbs et al., 2014a).

There is also a deposit refund system in Germany for both disposable and refillable packaging. All beverage containers, except for wine, fruit juice, milk, sparkling wine or spirits have a storage fee (Gibbs et al., 2014a).

The collection of residual and bulky household waste services, as well as the biological waste are financed by a fee paid by the citizens and defined by each municipality. There is usually a flat fee as well as a variable rate. The collection of packaging waste, door to door or through collection points is free for the citizens and is funded by EPR schemes, although collection points are partially paid for by municipalities (Gibbs et al., 2014a).

In 2012, 94 waste incineration plants used to operate in Germany for the treatment of residual waste, not all of them for municipal waste incineration exclusively; several installations using waste-derived fuel and 60 mechanical biological treatment (MBT) installations of different types and configurations (Federal Statistical Office, 2015a).

MSW generation in Germany peaked in 2002, reaching 52.8 million tonnes. In the following years, its generation decreased, reaching 50.1 million tons in 2014. All waste generated reported to Eurostat is sent to treatment operations (Eurostat, 2016).

Municipal waste recycling, 2001–2014 Figure 2.1 shows the development of MSW recycling in Germany related to total recycling, material recycling and organic recycling - composting and other biological treatments.

Germany already had a high level of MSW recycling in 2001, and total recycling continued to rise steadily from 52% in 2001 to 64% in 2014. The reported quantities of MSW generated in Germany decreased by 12% during 2002 and 2006, and therefore the percentage increase in recycling over the same period is not due to the increase in the quantities recycled as such, but is due to the fact that the decrease in MSW production in is greater than the increase in recycling.

Nevertheless, the total and steady increase in MSW recycling covers various trends in materials and organic recycling. The amount of material recycling increased during the period from 19.6 million tons, 38%, in 2001 to 23.3 million tons, 47%, in 2014. However, this development was highly uneven. In 2001-2014, organic recycling increased very little, from 15% to 17%, the equivalent of an increase from 7.6 million tonnes to 8.6 million tonnes.

**Sweden**

Reloop Platform is the European organization that supports and develops implementations of the circular economy, where the Swedish system for collecting packaging waste on a guarantee basis was presented.

39 years after its inception, this system is the oldest in Europe and not only it has secured high collection rates for plastic waste and metal packaging for beverages but also managed to close the circle for recyclables in the local market, which means: garbage-free streets, clean air and the recycling of plastic bottles for food.

Highlights of the Swedish packaging waste collection system based on deposits:

· 84.9% recycling rate

· 3100 retailers - 94% of the collected volumes come from retailers

· 70 employees

· EUR 285.3 million in turnover (SEK 3.1 billion)

Low collection and recycling rates have led to the need for a complete guarantee system for beverage containers. The legislation was adopted in 2018 (GEO 74/2018 became Law 31/2019) and is expected to be implemented before 2022. The circular economy seems to be a difficult goal, but it can also be an opportunity for the country's development by the evolution local economies and green industry. All of these come with a nice bonus of cleaner streets and unpolluted air of hazardous gases from illegal (or legal) waste incineration", says Anna Larsson, Head of Reloop Platform.

Swedish packaging waste management legislation enforces that any legal person that produces and packs drinks in plastic bottles or cans, or imports them, has to ensure that the containers are integrated into an authorized return system. The answer is a centralized deposit system, coordinated by AB Svenska Returpack, which is also the owner of all the materials collected (bottles, cans, lids).

Thus, in Sweden, the implemented system ensures a 84.9% recycling rate while 10% is lost through cross-border trade (Sweden / Norway) and 3% is taken over by other plastic / metal collection systems. This means 19,870 tons of aluminum, 23244 tons of PET, 1377

tons of HDPW, 2.15 billion cans and bottles. Returpack collects 94% of the volumes from 3100 retailers, through 5,100 RVM (reverse vending machines), and through 50 Pantamera Express systems installed at the municipal recycling centers. The turnover amounts to SEK 3.1 billion, approximately EUR 285.3 million.

The way the Swedish guarantee system works:

The system is coordinated by AB Svenska Returpack and operated by partners. There are no claims on materials or their value on the part of the manufacturers or industry. Returpack sells the processed material (sorted, cleaned, packaged) to raw material purchasers based on the agreements between Returpack and them. Revenue from sales of materials covers for Returpack the costs of carrying out the return system, such as collection, processing and administration. To promote the circularity of materials, Returpack chooses to sell materials only to buyers who will support circularity. Buyers process the raw material and sell the products to customers - suppliers of can packaging, packaging for food or pre-forms. Returpack has absolutely no information on the agreements or prices charged at this level.

## Recycling in ROMANIA

The European Commission (EC) has proposed measures to help 14 Member States, including Romania, in order to meet municipal waste recycling targets.

The Commission's decision comes after the Community executive found that there are significant gaps that need to be addressed immediately so that Europeans can benefit from the economic and environmental advantages of the circular economy.

Along with Romania, on the list of the European Commission, there are also countries such as Bulgaria, Croatia, Finland, Greece, Hungary, Portugal or Spain, which risk not meeting their target for 2020, that is to recycle 50% of the municipal waste. Recent World Bank estimates show an annual increase in waste generation from 2.01 billion tonnes in 2016 to 3.40 billion tonnes in 2050. Although waste management and recycling is improving in Europe, one thing is clear: furthering the current system is not an option and much remains to be done, according to a statement issued by the European Commission.

In April 2017, the European Commission sued Romania to the Court of Justice of the European Union for failing to review and adopt the National Waste Management Plan and the Waste Prevention Program, in accordance with the European directives on waste and the circular economy. In December 2017, the government decision on the National Waste Management Plan was approved in the executive meeting held in Bucharest, this leading to the closure of an infringement procedure, which is in the litigation phase. The biggest problems are in Malta, Romania, Greece and Cyprus.

In 2016, all four recycled less than 20% of the total waste.

The recycling target set for 2020 at EU level, that of 50% of the total amount of waste, is far from being reached in these four countries and their 10 regions. The situation is worse in some regions than in others.

Malta is the weakest recycler in the EU: the recycling rate is only 7%, whereas 83% of its waste going to landfills. This state manages to merge the lowest waste recycling rate with the highest waste disposal rate. Thus, this state gets the crown for "Europe's dirtiest entity" in terms of waste recycling.

In the ranking, Malta is followed by **Romania** (recycling of waste - 13%, storage - 69%), Greece (recycling - 17% and storage as much as Malta, i.e. 83%) and Cyprus (17% waste recycling, storage - 75%).

Although Estonia does not have a good recycling rate (only 28%), it has an amazing 10% landfill rate - but it is still far from reaching the EU target, as waste here is incinerated much more than it is recycled. In 2013 and 2014, Estonia incinerated most of its waste. On the other hand, Poland is the "best" of troubled recyclers in Europe: it recycles 44% of its waste and "only" 36% goes to landfills. This recycling rate is just 6% below the EU target of 50%, with the lowest storage rate of the 14 countries. Finland, which recycles 42% of its waste, is also not far from reaching the target.

"Each country deals with municipal residual waste in different ways - it is either incinerated or sent to landfills, among other options."

Romania, Greece and Cyprus are struggling to meet their waste recycling target. "None of these countries will be able to meet the EU's 2020 recycling targets, as the current situation shows.

**Plastic**

EU member states need to improve the waste management, especially plastic and e-waste, while recycling more to limit the negative impact on the environment, the European Environment Agency (EEA) assessed in two reports published on Monday, transmits AFP, taken over by Agerpres.

"The European Union needs to find ways to treat its plastic waste in an environmentally friendly way, for example by increasing reuse and recycling," the European Environment Agency (EEA) said.

According to the report, the EU produces 30 million tonnes of plastic waste in just one year, and only 17% of it is reused or recycled. The situation is as such considering that the demand for plastic is greater than the supply anyway. In 2017, the demand for plastics in the 28 EU member states, plus Switzerland and Norway, amounted to 51 million tonnes, mainly used for packaging and constructions.

Statistics from the beginning of the year showed that the EU exported about 150,000 tonnes of plastic per month, twice as much as in 2016. The waste was mainly bound for China and Hong Kong.

However, the new bans and restrictions on Chinese imports, combined with a ban on a number of prohibited plastics added to a UN convention, are forcing the EU and the member states to improve their own waste management capabilities at home. These bans and restrictions and a declining international market for plastics are likely to increase waste storage and incineration in the short term, but should also trigger investment in capacities and systems to increase the recycling and reuse of plastic waste, the Agency stated.

The conclusions of the EEA report on exports of plastic waste show that there is huge potential for increasing reuse and recycling in the coming years. The reuse and recycling of plastic waste could provide a large amount of material resources for local producers. To this end, the EU has already taken steps to improve the management of plastic waste production and use, including the European Strategy for Circular Economy Plastics, the EU Disposable Plastics Directive and new, more ambitious targets for plastic recycling, including the updated EU waste guidelines for 2018.

Plastic pollution is a topic that has gained importance in recent years and is already seen as a global challenge. Our civilization is struggling to use this material efficiently and sustainably, with a quantity of 335 million tons of plastic produced in 2016 alone and which is expected to be substantially increased in the next decade.

The current plastic materials system has an estimated annual material loss of EUR 70-105 billion globally. From an environmental perspective, it is estimated that 75,000 to 300,000 tonnes of microplastics are introduced annually into EU countries.

Of the 8,300 million tons of plastics produced by mankind since the 1950s, it is estimated that 5,800 million tons of plastics, representing 70% of the total amount, have become waste, of which 84% or 4,900 million tons, have been disposed of in landfills or in the environment.

In the EU, the separate collection rate for plastic waste in 2014 was 37%, while the post-export recycling rate of 30% of the plastic waste outside the EU was estimated to be 13% (2.15 million tonnes).

From a systemic perspective, given the inefficient management of this resource, it is clear that much effort will be needed to think over how we use plastics today and many single-use applications will need to be reconsidered. Moreover, in a scenario where two-thirds of EU plastic waste is dumped or burned, there is a great opportunity to increase plastic recycling.

The low rate of plastic recycling in the EU leads to high losses for both the economy and the environment. It is estimated that 95% of the value of the plastic packaging material is lost after the short cycle of the first use.

Every year, the production and incineration of plastics gives off about 400 million tonnes of CO2 globally, some of which can be avoided through better recycling.

Plastic recycling issues

The main problems that complicate the recycling of plastic are the quality and price of the recycled product, compared to the original plastic.

Considering that plastics are easily adaptable to the functional or aesthetic needs of each manufacturer, the diversity of the raw material complicates the recycling process, making

it expensive and affecting the quality of the final product. As a result, the demand for recycled plastics represents only 6% of the demand for plastics in Europe.

Proposed solutions to increase the recycling rate:

MEPs backed an European strategy on plastics in September, which calls for all plastic packaging to be recyclable by 2030. However, measures are necessary to stimulate the market for recycled plastics.

These measures would include:

- creating quality standards for secondary plastics;
- encouraging certification to increase industry and consumer confidence;
- introduction of mandatory rules on the minimum recycled content in certain products;
- encouraging Member States to consider reducing VAT on recycled products.

Given the need to reduce the single use of plastic, the need to avoid landfilling and incineration and the focus on mechanical recycling, there is a legitimate question about what to do with those plastics that are too downgraded or too contaminated to be reintroduced into the production cycle. Currently, this fraction of plastic waste is exported, or disposed of, but in the recent years some technologies have been introduced with the claim that waste can be recycled by chemical recycling.

The type of technology included in what is commonly called **chemical recycling** can be divided into three different categories, depending on the level of decomposition to which the plastic waste will be subjected to:

- Solvent-based purification, which decomposes plastics back to the polymer stage.
- Chemical depolymerization, which converts plastics into monomers, through a chemical reaction.
- Thermal depolymerization (pyrolysis and gasification), which may be in some cases considered chemical recycling by cracking polymers back into monomers and beyond down in hydrocarbon.

Thermal depolymerisation technology can also produce fuels, although in this case, it can no longer be considered a form of recycling.

All these outputs (except for fuels) are then reprocessed to form new plastics.

Every year, Europeans generate 25 million tonnes of plastic waste, but less than 30% is collected for recycling.

World production of plastics in 2017 amounted to 348 million tons, the European share of this production representing 18.5%.

More than 80% of all marine waste is plastic and due to the low rate of decomposition, plastic accumulates in the seas, oceans and beaches, is ingested by certain marine species and reaches the human food chain.

In addition, a cigarette butt containing a plastic filter can pollute between 500 and 1000 liters of water, whereas once it is thrown on the road, it takes about 12 years to disintegrate.

The new EU strategy on plastics will address this issue directly. The European Parliament recently voted on a proposal for a directive of the European Parliament and of the Council on reducing the environmental impact of single-use plastic products. Romania will have to implement, together with the other European states, the measures adopted, respectively to reduce the use of plastic products and to promote the transition to a circular economy with innovative and sustainable business models, products and materials.

Achieving this objective will lead to increased obligations and extended liability for producers, which in the spirit of the Directive will include both the actual producers and the importers, exporters, distributors or traders of any kind, provided that they place the product on the market, that is, to make the product available on the market of a Member State for the first time.

Manufacturers will thus have to transform the manner their products are designed, manufactured, labeled, used and recycled, with the aim of protecting the environment and laying the foundations for a new plastics economy. This approach will bring new opportunities in terms of innovation, competitiveness and job creation, and only by way of sustained effort from all the parties involved will this transition be possible.

The directive will also affect restaurant, catering, public food services and other service providers, serving or packaging food sold in disposable plastic products, as well as wholesalers and / or retailers selling plastic or packaged plastic products.

They will have to modify or narrow the range of products or services offered to customers and adapt their internal processes for managing and marketing those products, bearing the costs thus generated.

The most important measures that Member States and manufacturers will have to implement depending on the type of plastic products considered are as follows:

1. For single-use plastic products, such as beverage cups or food containers intended for immediate consumption or used for fast food products, Member States will have to adopt and implement the necessary measures to achieve a measurable quantitative reduction of their consumption by 2026.

Traders will need to make reusable alternatives to those products available at the selling point to the final consumer and ensure that disposable plastic products are not provided free of charge at the sales point to the final consumer.

The Member States may also impose marketing restrictions, ensuring that such products will be replaced with alternatives that are reusable or do not contain plastic.

2. For plastic products such as ear sticks, cutlery (forks, knives, spoons, chopsticks), plates, drinking straws, sticks that attach to or support balloons, plastic bags that crumble over time, and Fast food packaging based on expanded polystyrene, restrictions have been imposed on the market, which will be banned.

As for the plastic beverage containers, manufacturers will be able to introduce on the market starting 2025, only PET bottles manufactured in a proportion of at least 25% recycled plastic.

3. Special labeling requirements have been imposed on plastic products such as sanitary pads and sanitary napkins, wet wipes, tobacco products with plastic filters, beverage glasses. Thus, manufacturers must ensure that these products bear a clear, legible and indelible marking, placed directly or on the packaging of the product, informing consumers of appropriate waste management options or means of disposal to be avoided for the respective products, the negative impact on the environment of the disposal or other unsuitable means of clearance, the presence of plastics in their composition.

4. For disposable plastic products such as food containers, flexible packs and foils, beverage cups, thin plastic carrying bags, tobacco products with filters and filters marketed for use in combination with tobacco products, wet wipes and balloons were placed under the extended responsibility of the producers.

Thus:

• producers will bear the costs of collecting the arising waste and the costs of transport and subsequent treatment, including the costs of cleaning up the waste and the costs of raising awareness regarding these products. The financial contributions incurred by producers to comply with these obligations shall not exceed the costs necessary for the provision of the services in question in an efficient manner and shall be agreed in a transparent manner between the parties concerned;

• as regards to filters for tobacco products containing plastics, producers must bear the costs of collecting the waste that is dumped in public collection systems, as well as the transport and subsequent treatment of this waste. Costs may include the creation of an infrastructure for the collection of used filters, such as the placement of appropriate containers in areas where a lot of waste is dumped;

• manufacturers of plastic-containing fishing gear will have to bear the costs of separate collection of waste that has been unloaded at port collection facilities or other collection systems, as well as the costs of transport and subsequent treatment, respectively the costs of awareness-raising measures. of the public regarding fishing gear containing plastic.

5. Separate collection measures have been put in place for single-use plastic bottles with a capacity of up to three liters, to the effect that Member States will have to take the necessary measures to collect separately for recycling, up to 2025, a quantity of plastic bottles equal to 77% of the weight of disposable plastic products placed on the market in a given year, the percentage to increase to 90% by 2029. This involves setting up container deposit schemes and setting separate collection targets. The measures will mainly affect producers, but possibly also companies that sell to the final consumer products packaged in disposable plastic bottles, the latter bearing along with the manufacturers, as it will be established at national level in each Member State, the costs of separate collection.

6. For most single-use plastic products, the directive enforces measures to raising awareness and informing the public. The obligation to inform consumers about the impact of plastic waste on the environment, to stimulate their responsible behavior and to raise public awareness on the damage caused to the environment are measures that may be in the scop eof both manufacturers of plastic products as well as of the final traders, depending on how by each Member State regulates it.

## RECYCLING TECHNIQUES – Municipal waste

Recycling plays an extremely important role in reducing the amount of existing waste, in preserving the natural resources of the planet and contributes to creating greater energy efficiency. More than 60,000 companies operate in the recycling industry, employing about 500,000 people, this segment producing $ 24 billion annually. The European Union has a share of around 50% of the world's waste recycling and management industry, and over the years, a number of legislative measures and directives have been imposed such as WEEE (electrical and electronic waste directive) or ELV (end of life cycle of vehicles).

**RECYCLING TECHNIQUES – Municipal waste**

The European Commission supports those technologies that yield the best recycling extent, such as the **MBO-Te** industrial recycling technology developed by Tehnix.

The new industrial waste recycling technology developed by **Tehnix** reaches to a circular economy.

The recycling facilities installed in the recycling centers carry out the complete recycling process. Complete municipal waste is sorted according to usable values and the market needs.

**MT** = **mechanical treatment** generating eight types of selected, packaged raw materials – namely plastic, cardboard, paper, PET, MET, textile, glass and metal. All raw materials are completely clean, packaged and sold on the world market for the production of new goods in industry.

**BT = biological treatment** of organic waste and green waste. The bioreactor composting process allows the production cycle of organic compost in a period of only two months. Composting is carried out in fully controlled technological conditions, without negative impact on the environment and without pollution of water, soil and air. The ecological compound enriched with minerals and phosphates is used for agricultural purposes.

**HT = heat treatment**. The rest of the combustible waste, which cannot be recycled due to the size of the material and the structure, dries and is crushed and then it is automatically baled without human interference.

The average value of RDF dry fuel energy in bales is four MW per tonne. The total percentage of waste recycling at the MBO-Te Tehnix plant is up to 100 percent. Such procedures achieve the objectives of sustainable development and the circular economy.

The construction of recycling centers takes less than a year from the issuance of the construction permit. The small size of the project allows the technological rationality and the recycling process flow. Solar panels are installed on the roof of built installations. By treating municipal waste, three general value systems are achieved:

- economy – all intake is loaded and everything that comes out is levied.
- the ecology of the recycling process allows the highest degree of recycling.
- a social advantage is the recruitment of people in the recycling process, especially those structures that are underestimated on the labor market.

Tehnix factories are very well adapted to the local conditions. They are designed to adapt to small and medium environments. They can simply be installed in old bays, thus improving abandoned buildings. Basically, they are industrial factories with low energy consumption, which guarantee efficient sorting by hiring local workers. The impact on the environment is extremely small, and the working area in the manual sorting room is ventilated and air-conditioned.

In large areas, Tehnix industrial sorting plants can be installed in two or more locations, thus reducing on-site traffic and ensuring the implementation of the proximity principle in the waste management system.

**The mechanical-biological recycling of pre-sorted or mixed municipal waste** is a technological concept developed by Tehnix. This technology is an important step forward in the economy of municipal waste management due to its technological flexibility, as it allows those technological innovations that achieve a high impact and low costs in recycling the municipal waste delivered.

**New Waste Recycling processes**

Under the group of new processes for the ecological waste dismantling, at least three methods may be included and these can be used both separately or jointly:

- electrostatic separation - corona effect;
- microwave separation;

- selective fragmentation with repetitive high voltage pulses.

The new methods have proven themselves lately due to the fact that the classic ones entail a series of drawbacks: either they are high energy consumers, or they have an impact on the environment by toxic emissions (liquids, gases). However, it is not excluded that the new processes will work in tandem with the classic processes for increasing productivity / yield.

**The selective fragmentation with high voltage repetitive pulses method** requires special characteristics of the pulse especially in terms of rise time. In order for the discharge to occur mainly through solid and not through dielectric medium (water or oil), it is necessary that the rise time be less than 500 ns. The value of the maximum voltage of the repetitive pulses is in the range of 150-500kV. Over this voltage, restrictive problems related to insulation start coming up.

The destruction of solid materials by pulsed electric discharges, sometimes called "electrodynamic fragmentation", was first investigated in the early 1960s in the former Soviet Union at the Polytechnic University of Tomsk. Mainly, the aim was to apply this technology to the disintegration of rocks to obtain a higher production of minerals and precious gems, keeping the original shape and dimensions. Also at the Polytechnic University of Tomsk, it was for the first time that the effect of increasing the breaking strength of water compared to that of solid material immersed in water in case of applying pulses with short growth times was discovered.

At AWE (Atomic Weapons Establishment) in Aldermaston, England, this effect was used to design high-power, low-impedance, water-based pulse dielectric lines [16]. In 1995, the German Karlsruhe Research Center (Forschungszentrum Karlsruhe, FZK) embarked on a large-scale research & development program to explore possible industrial applications of selective fragmentation. Since then, FZK has built several special pilot plants (FRANKA 0, FRANKA 1, FRANKA 2 also called FRANKAStein) and investigated the fragmentation of many materials in the field of mineralogy, raw materials and composites. FZK has demonstrated the advantages compared to the mechanical fragmentation and marketing potential of this technology. [15, 17] The Swiss Ammann Group now produces, under FZK's global license, this commercially available patented technology. The equipment made by Ammann-Group is known as SelFrag Lab and has the following fields of application:

academic research in the field of geoscience; exploration of mining settlements; analysis of the composition of raw materials; analysis and recovery of metals from waste as secondary raw materials.

**Heat Treatments**

More than a decade ago, Klean entered the waste energy sector using advanced **heat treatment** technologies (ACT), recognizing that waste energy is a key component in any efficient waste management system.

By using advanced **heat treatment** technologies, solid waste that could not be recycled by any other means, is transformed into green energy, providing more sustainable energy resources for the future and limiting climate change by reusing resources. Klean considers waste to be an unused and unappreciated item. Klean processes the waste using patented technologies that it owns or has under license with various partners. Its main activity is the applications of **carbonization and / or gasification technologies** that produce clean energy to meet the growing demand for energy.

A waste power plant can have uses in: electricity, heating / cooling in the region, steam for industrial processes or desalinated seawater, reusable goods such as steel and other recyclable materials.

Residual waste that is not economically or ecologically recycled becomes a valuable local source of energy raw material. In addition, the heat produced by a waste energy system is designed to power steam turbines, while synthetic gas produced by pyrolysis or gasification technology have a variety of potential uses, the most common being burning it in a boiler for steam generation.

Advanced heat treatment of solid waste reduces the volume of waste, thus reducing the storage space. The need to transport waste is reduced, cutting down the costs and labor involved, as well as environmental pollution due to long-distance waste transportion. It allows the recovery of energy from the solid waste flow, as well as the recovery of minerals and chemicals that can be reused or recycled. Effective waste management strategies can benefit greatly from waste energy technologies, and Klean can offer its

customers some of the most advanced technology systems available for applications around the globe.

**UBQ**, Quantis International has found the solution to transform unsorted household waste into a sustainable, bio-based and climate-positive thermoplastic material that can be used for commercial and industrial products instead of petroleum-based plastics. Named "the most positive climate material on the planet" by sustainability tacticians, the company receives significant international attention.

While the increased production of waste sent to landfills and the demand for plastics are both reasons for concern, the innovative technology of this Israeli company promises a solution for both trends simultaneously.

Produced from unsorted household waste, the globally patented biological product is a homogeneous composite material that can be mixed with plastic resins from the plastics industry of the final product.

Unlike the polluting plastics that dominate the market, (polyethylene, PVC and polypropylene), the production of 1 kg. of UBQ material means a 11.7 kg. reduction of equivalent carbon dioxide emissions.

In other words, producing a ton of UBQ is equivalent to halting the melting of 35 sqm. Arctic ice or keeping 540 trees over 10 years old.

What UBQ does is take all these valuable materials that are thrown away and bring them back to life in a cyclical way. It replaces a very expensive and limited resource approaching an actual circular economy.

The UBQ process is:

- worldwide patented
- observes the circular economy
- climate friendly
- energy efficient
- zero residual waste
- zero emissions
- zero water consumption

An industrially operational UBQ plant, having an 80,000 tons per year production capacity, is equivalent to reducing the pollution of 565,000 cars on the roads for a single year.

The heterogeneous mixture of waste (including organic fractions such as food waste, garden waste, paper, cardboard, diapers, dirty plastics, and packaging materials) is transformed into a completely homogeneous material that can be used in the plants processing existing plastic.

This solution allows the industry to reuse waste materials perpetually. By transforming waste into this marketing viable and valuable material, the missing link between a linear consumption system to a truly circular economy is provided.

It is estimated that the global plastics industry can implement UBQ material mixed with manufactured or recycled plastic at a 10% rate. A 10 ton / hour plant will produce about 70,000 tons of UBQ material per year. After having an industrial capacity of 20 tons / hour in 2020, a total capacity of at least 1.4 million tons per year to be reached in 8 years is envisaged.

In an age where efficient solutions are needed for all types of waste and the crucial need to prevent landfills, advanced technologies are vital, such as UBQ technology, a sustainable solution for waste treatment, offering not only efficient and sustainable recycling, but also a new and competitive raw material on the market.

UBQ is currently working with some of the world's leading food giants, DIY companies, automakers and construction companies to implement UBQ technology in their produts.

**Plastic waste recycling techniques**

In recent years, the concept of **chemical recycling** has been promoted by industry as a potential solution to help reduce plastic pollution and for waste management as a whole.

**Mechanical recycling** is a mature industrial process that is well established and spreading in Europe. However, plastics cannot be recycled indefinitely mechanically without losing their properties and quality. In addition, not all types of plastic can be mechanically recycled. These limits are challenges for plastics recycling and indicate a need for significant improvements in end-of-life management of plastics.

**Polyolefins** (PP - polypropylene, PE-LD - low-density polyethylene, PE-LLD -low-density linear polyethylene, PE-HD -high-density polyethylene- and PE-MD -medium-density polyethylene) are, according to the amount of plastic materials, the most used in Europe, together accounting for about half of the total consumption. If these are pure quality residues, they can be processed efficiently, so that there are numerous recycling centers for the reuse of polyolefins established.

The situation is more complicated when PE and PP are mixed, because they are very difficult to separate due to their similar density, and the NIR (near infrared radiation) sorting processes are state-of-the-art. However, PE and PP can also be processed together into high quality products.

**PET**, which is used for the production of most plastic containers (bottle type), accounts for almost 7% of total annual plastic consumption in Europe.

Although the original goal was to return plastic flakes to the bottle manufacturers, the industry sought and found customers in other fields. For foil producers, post-consumption plastic flakes have become increasingly interesting, and they have used most of the waste collected in their industry. Almost 30% of the flakes are used in blow molding applications, 26% in the fiber industry, and the rest for packing straps and other products.

Although post-consumer products made of pure polymers are well suited for reprocessing, the situation of composite products, consisting of two or more raw materials, is completely different.

Dr. Michael Scriba, CEO of MTMPlastics and a member of Plastics Recyclers Europe (PRE) and of Bundesverband Sekundärrohstoffe und Entsorgung, calls for friendly packaging recycling design that contributes to a large part of post-consumer waste.

In this case, it is particularly important to abandon fillers, such as chalk in PE and PP packaging, as far as possible, to avoid plastic-paper composites, to use pigmentation in moderation and to ensure that the density of all products is much higher than 1g / cm3, so that separation based on density can be achieved.

At the same time, efforts are being made in the industry to develop reuse strategies for mixed waste.

Trenntechnik Ulm GmbH is pursuing a very interesting approach in this regard, by developing a **chemical separation process** for PE / PA composite films and building am unique production unit with a 10 tonnes per day capacity.

Recycling allows materials from other single-use items to become something new and saves resources when providing new materials, but the downside of recycling is that it is water and energy consuming.

- Usually, plastic is washed with detergents and then ground into pieces or smaller bead-like particles. These pieces must then be dried to crystallize, which involves exposure to heat of 180 Celsius degrees and then water cooling.

- A new process developed by Ak Inovex in Mexico recycles plastics without water. It is also able to form plastic beads without excessive temperatures, which means that the technology not only saves water, but uses half the energy of conventional recycling methods.

The waterless method can process more than 90 percent of any type of plastic, including styrene foam, polystyrene, PET and ABS.

It is a simpler method, it requires less space and, according to Ak Inovex, the beads produced are of a higher quality.

- Gizmag reports that this technology uses special walls that, "once in contact with the material, they are able to shape both the plastic into the desired pellet shape and cool the pellets at the same time ", instead of high temperatures and water cooling, Ak Inovex has an ongoing patent on the three different technologies that make this possible.

The next step is replacing the detergent in use with a special biodetergent that would make the process even safer and cheaper. The company is already in partnership with the ALINSA group, a company specialized in the manufacture of environmentally friendly cleaning products using biodegradable chemicals.

**Chemical recycling** today often refers to technologies that can be classified according to the level that plastic waste decomposes. Specifically, technologies can be divided into 3 types:

- Solvent-based purification.

It includes technologies that go down to the polymer stage. They are able to decontaminate plastic, but it cannot address its degradation. They work only with monostreams (PVC, PS, PE, PP).

- Chemical depolymerization.

Chemical process that turns plastics back to monomers. It allows decontamination, but it does not address degradation. It works only with monostreams (PET, PU, PA, PLA, PC, PHA, PEF).

- **Thermal depolymerization** and fracturing (pyrolysis and gasification) consume energy processes that transform polymers into simpler molecules.

They are able to decontaminate polymers and, by returning the plastic to its original building blocks, addressing the degradation of the material. These technologies can treat more than one monomer at a time and are also capable of producing fuels. This increases the need for strict regulatory controls to prevent the conversion of plastic into fuel instead of recycling.

Gasification and pyrolysis have been tested for decades as alternatives to waste incineration energy with very limited results due to energy balance and environmental impact. Generally, the available information on the environmental performance of chemical recycling technologies as a whole is still extremely limited and requires further research.

Unlike mechanical recycling, chemical recycling is an industry in its early days and in the most factories on the market, it is in a pilot stage. The possibility of developing these technologies on an industrial scale can only be expected during 2025-2030 and this is an important factor when planning the transition to a circular economy and especially considering the decarbonisation agenda.

For reasons of policy coherence, it is essential to establish the appropriate policy framework to continue on the one hand, to include chemical recycling as a complement to mechanical recycling and, on the other hand, to ensure that the carbon remains in plastic and it is not released into the environment.

Therefore, accepting the production of plastic fuel as chemical recycling risks creating a gap within the EU Legislation regarding the climate and the circular economy.

**Plastic recycling for fuel production**

Greenfuels AG, a developer of Cleantech projects, has partnered with Klean Industries Inc. to propose a solution for **heat processing of mixed plastics** that are not currently recycled. Greenfuels has an area of eight acres in the industrial area of former East Germany and it produces a specific fuel with a low level of sulfur, which can be used as a generic fuel for the local heavy industry.

The first step is analyzing and testing a sample of plastics that they sent for liquefaction to one of his testing facilities. A series of tests were performed to find out the maximum oil yield obtained from the customer's specific waste stream and the ideal processing temperatures and subsistence time were established.

The proposed technology, already marketed and experienced in Japan, incorporates a continuous liquefaction process of 100 tons per day, which heats plastic waste in the presence of a catalyst to produce a hydrocarbon gas rich in naphtha. This gas is then cooled and condensed to produce a fuel comparable to natural fuel, but with cleaner combustion properties. Non-condensable gases are returned to the reactor to be used as process heat.

**Recycling construction and demolition waste**

Good planning of construction activities and related waste management activities on construction sites is a prerequisite for high recycling rates and high quality recycling products. A large part of the construction and demolition waste is recycled for economic reasons, but the recycling of materials such as concrete, glass, gypsum boards and asphalt chips brings some benefits that far exceed the financial ones: it results in a higher rate of job growth, reduced use of raw materials and reduced storage in landfills. Avoiding landfilling also contributes to environmental protection, smarter use of natural resources, energy savings, a net reduction in greenhouse gas emissions, and the avoidance of excavations in rural / forest regions.

Materials can be recycled either on site, being turned into new construction resources, or outside the site, in a recycling unit. The usual materials recycled from construction sites include metal, construction timber, asphalt, paving (from parking lots), concrete and other hard materials, ceramics (eg bricks, roofing tiles), roofing materials, corrugated cardboard, and wallpaper.

Recycling of construction and demolition waste should be promoted especially in densely populated areas, where demand and supply are geographically close, which results in shorter transport distances than those for the supply of raw materials, as in the case of aggregates.

A construction and demolition waste treatment plant, with view to its recycling, can be built according to simple or complex technological schemes taking into account the desired extent of recovery. Depending on the technological diagram adopted, the installation is designed and provided with the necessary equipment. The equipment being currently made by several specialized companies, the offer is higher on the international market, the installations being able to adapt both to the raw material that is subjected to processing and to the products to be obtained.

The concept can include the following stages: the primary sorting of waste using tilted or drum sieves, the selection of smaller fractions by densimetric separation, the selection of recyclable fractions in mobile sorting cabins, selection of metals using magnetic strips or magnetic drums and aggregates crushing by mobile or modulation crushers.

Construction and demolition waste treatment plants can be steady, in the sense of being adapted to a continuous operation, having a specific location or can be mobile, consequently, located at the waste generation point or where the products obtained are used (for example in the construction of roads and highways). Combined central station solutions with small movable stations can be created and applied.

**Recycling used tires**

Every year in the UK, 500,000 tonnes of used tires require a waste management solution. It is no longer allowed to be dumped or incinerated with other problematic waste, the tires must be subjected to some form of recycling or recovery. However, the properties that make tires so safe and durable during their lifetime make them so difficult to recycle in an environmentally friendly and cost-effective way.

Klean Industries, a specialist in tire waste recycling, has developed its position in the UK in recent years and proposes an unique advanced heat conversion technology as a solution to the problem of worn tires. Tertiary technology will use pyrolysis and gasification dynamics to recover the main materials used in the production of tires – respectively oil, carbon

black and steel. High quality final products will be comparable to virgin goods, but they will be less expensive and more environmentally friendly.

The technology developed in Japan in the early 1970s was the world's first thermal process specifically designed to recover oil from tires. Klean Industries now owns the intellectual property and patents associated with this technology and intends to replicate these installations, but with a customized, improved process to produce carbon black with a high value. Carbon black can be used again as a binder or filler in the manufacture of rubber or plastic or used in the asphalt industry.

The company will be able to recycle over 100 tons of tires per day. An unique feature of this technology is that the reactor is fed with whole tires continuously, thus avoiding the need for expensive pre-treatment, usually a two-stage bunch cutting operation. In addition to carbon black, oil and steel, the company will also generate electricity from the synthetic gas generated by the process, due to the extremely efficient design of the technology.

**Paper recycling methods**

Recycling paper waste into paper, cardboard and other products is produced in several stages. The number and purpose of these steps depend on:

- the type of waste paper;
- further use of the purified mass.

Therefore, it is possible to conditionally divide the processing into two stages.

The first phase

The first step includes the following steps:

- screening;
- grinding;
- primary dissolution;
- impurities removal.

The paper is divided into fragments of 1-5 cm, suitable for further processing. Mills and crushers are used for this operation, and not necessarily for used paper. Crushers may be used for wood or plastic chips.

The attempt to achieve the initial dissolution of the waste mass without crushing the raw materials will lead to excessive energy consumption, because large fragments are more difficult to turn into an aqueous solution.

This process is often excluded from the technological chain in the processing of small volumes of paper waste due to the high costs of mill purchasing. In this case, a more powerful sprayer with a vertically mounted rotor can be used.

The above step allows to obtain from waste paper a substance suitable for the production of cardboard and packaging of eggs.

The second stage

To obtain raw materials for paper production, a second step is required, which includes:

- secondary dissolution;
- fine cleaning;
- additional processing.

Secondary dissolution and fine cleaning are performed equally, regardless of the raw material and the final product.

Differences between these operations begin during further processing, when not only mechanical action but also chemical reagents are applied.

The composition of the reagents and the processing technology depends on both the type of waste paper and the purpose of the pulp.

After the completion of the second stage, a purified aqueous solution is obtained, out of which paper of different grades is made.

Sometimes this aqueous solution is mixed with unprocessed cellulose. During this operation, raw materials suitable for the production of quality paper are obtained from any waste paper.

**Glass recycling**

Like aluminum, glass can be recycled by melting indefinitely, without losing its properties; like aluminum, recycling costs are lower than those of producing glass from raw materials, thus saving energy.

Glass is the most resistant pollutant, and its recycling saves energy and money. Along with paper, glass has the largest share of waste stored in landfills, depending on the weight.

However, glass poses a big problem: it is practically indestructible to corrosion, because it decomposes in about... a million years! It is, by far, the most resistant waste produced by humanity (PET, with a lifespan of no more than 1,000 years comes secondly in this ranking).

The recycling process is relatively long, but essentially simple: the glass is washed, then sorted by color (the pigments that give the color to the glass do not "come out"), broken, crushed, then claned of impurities (labels, paper, metal, etc.) and the ground is melted and transformed into granules - the raw material for the various uses of recycled glass.

Only colored glass can be produced from colored glass, the colorless glass being thus more valuable, because it can be reused for several purposes.

Heat-resistant glass (Jena vessels) cannot be recycled with the usual material, because it affects the melting process.

In principle, glass is made of household glass, although there are some more "exotic" uses - for example the famous thermal insulation wool that covers hot water pipes, some concrete mixtures or sanitary products such as sinks.

**DEE recycling**

An Interpol report reveals that only 35%, that is about 3.5 million tonnes of waste electrical and electronic equipment (WEEE) ended up in official collection and recycling systems, the remaining 65%, about 6.2 million tonnes , being either exported, or recycled non-compliantly, or landfilled. This is one of the conclusions of the "Countering WEEE, Illegal trade" Project, a study conducted by INTERPOL in cooperation with Cross Border Research Association, Compliance & Risks Ltd, United Nations Interregional Crime and Justice Research Institute, United Nations University, WEEE Forum and Zanasi & Partners , a project co-financed by the European Commission.

Following this report, the implementation of an operational information management system at European level is desired, the formation of an environmental security group for each country, the prohibition of cash transactions at European Union level for trade in metals, the treatment of WEEE to be mandatory according to certain certified standards, such as WEEELABEX, and others as well, the implementation of the directive and the harmonization of definitions so that all things are clear, possibly with some clarifications in

the annexes where certain aspects, certain articles can be stipulated. This report identifies not only the ecological stake, but also the economic and social stake. Recyclers in Europe need to work and capitalize on raw materials for Europeans, and this means jobs for the European citizens and raw materials that are no longer taken to China. Indeed, electrical and electronic waste is a very high economic, ecological and social stake.

**Conclusions**

EU waste legislation leads to considerable improvements in waste management. However, the full implementation of this legislation is extremely important if the EU is to reap the economic and environmental benefits of the circular economy and compete in a world where resources are dwindling.

The early warning reports on municipal waste and the Commission's efforts to promote compliance described in this report indicate continuous progress in the Member States, but also serious gaps and challenges that need to be addressed quickly.

Significant progress is possible if the Member States concerned urgently take steps to implement the actions identified in this report and in the country-specific accompanying reports. A more effective separate collection, efficient extended producer responsibility systems, economic tools such as storage and incineration fees, as well as improving data quality are all essential to ensure compliance with the EU waste legislation, both now and in the future.

In the follow-up to this report, the Commission will carry out high-level visits on the circular economy / waste in Member States at risk of not meeting the municipal waste targets for 2020. To this end, the Commission will work with relevant stakeholders, including with associations of local and regional actors.

The Commission will continue to allocate significant resources to support the Member States in their implementation efforts, including by way of technical assistance [for

example, the regular assessment of the implementation of environmental[1] policies and the exchange of best practices[2]] and with EU funding. However, it is up to the national authorities to strenghten the necessary policy reform process and step up actions in the field.

[1] http://ec.europa.eu/environment/eir/index_en.htm
[2] TAIEX-EIR Peer2Peer - http://ec.europa.eu/environment/eir/p2p/index_en.htm