GREEN PARTICIPATION, GREEN EUROPE

A9: THE IMPORTANT OF RECYCLING

PROJECT NUMBER: 2023-2-TR01-KA154-YOU-000168735

Prof. Dr. Sevcan Aydın







Funded by
the European Union



GREEN PARTICIPATION
GREEN EUROPE

PROJECT NUMBER : 2023-2-TR01-KA154-YOU-000168735 Funded by the Erasmus+ Program of the European Union. Nevertheless, European Commission and Turkish National Agency cannot be held responsible for any use of the information contained herein.

INDEX

01 Definition of Recycling

02 Methods of Recycling

03 Types of Recycling

04 Re-usable Items over Single-Time Items

DEFINITION OF RECYCLING

Any recovery process that turns waste materials into materials, products, or substances for their original use or for other uses. The purpose of recycling is to increase environmental sustainability, decrease resource depletion, and prolong the lifecycle of materials.

- Importance of Recycling



Faster Capital, 2024, *Recycling: The Importance of Recycling in Meeting Clean Up Requirements*



Over 193 million metric tons of carbon dioxide equivalent in 2018 by recycling municipal solid waste.

In 2020, 681,000 jobs were accounted by recycling and reuse activities.

- 1.17 jobs per 1,000 tons of materials recycled

EPA, 2024, *Recycling Basics and Benefits*

METHODS OF RECYCLING

The recycling process can happen in three different ways, but they all have three steps in common:

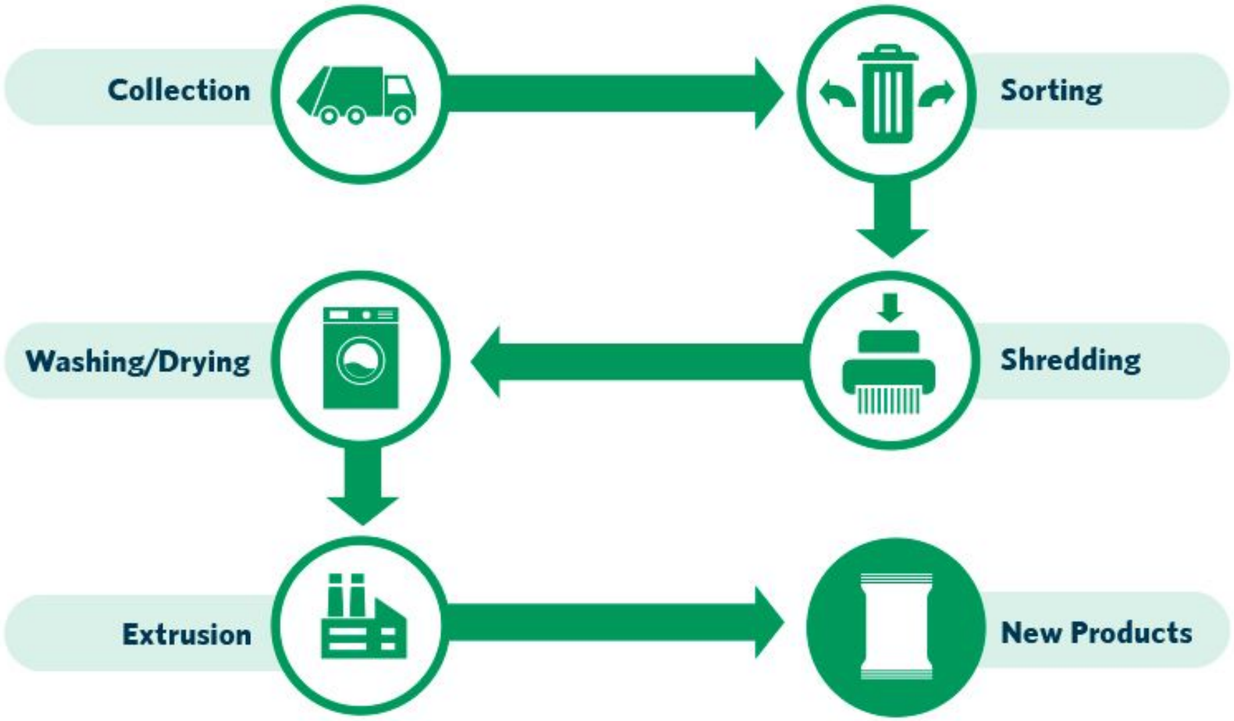
- Collect and separate recyclable materials from waste.

- Apply one of the three known procedures

- Turn the raw material into a finished product again

1. Mechanical Recycling

This technique can recycle glass, paper, and plastics. It is processing of waste into secondary raw materials or products without significantly changing the chemical structure of the material.

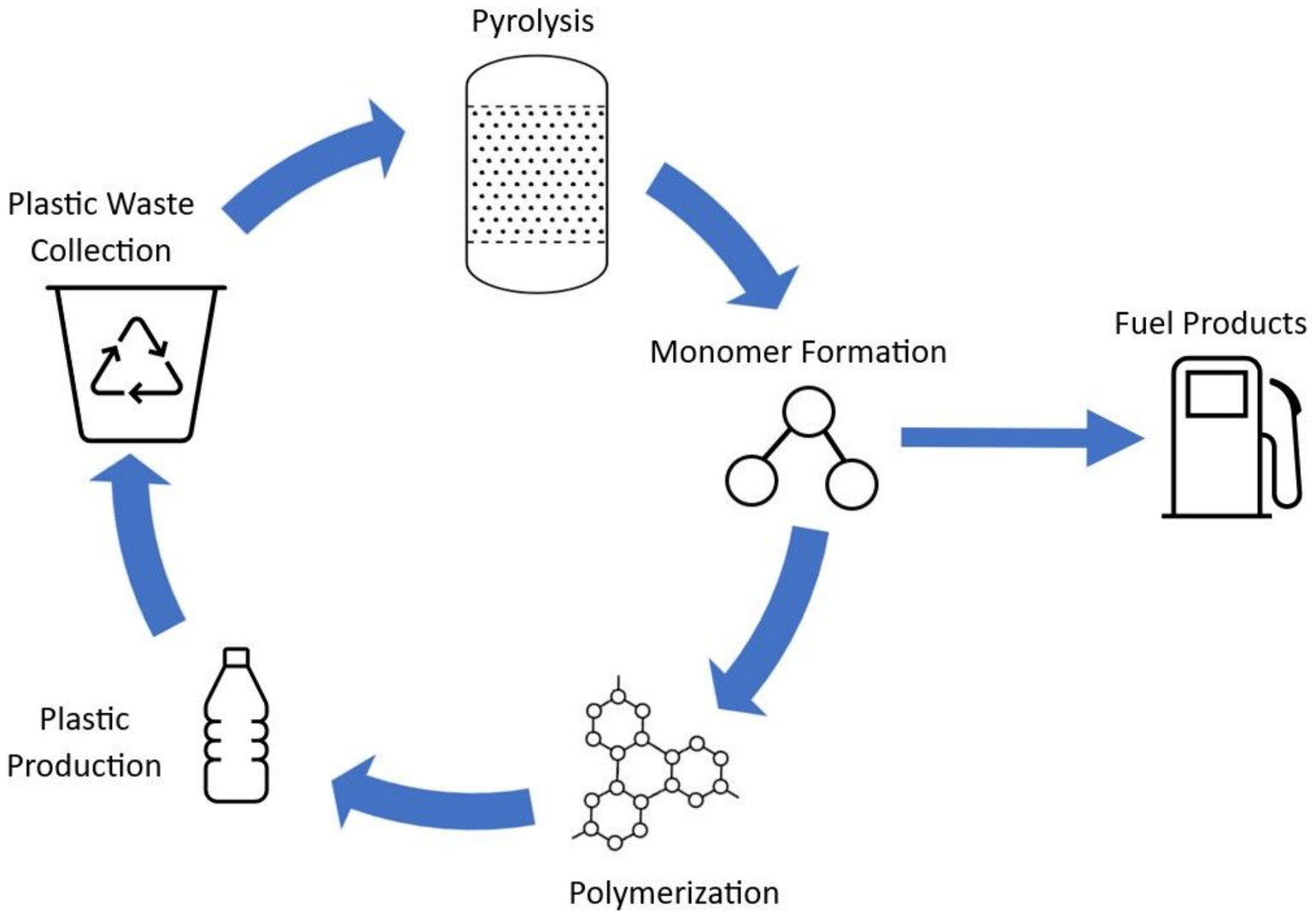


Rebittzer, G., & Cools, P., 2024, *Chemical recycling for flexible plastic packaging in Europe*

2. Chemical Recycling

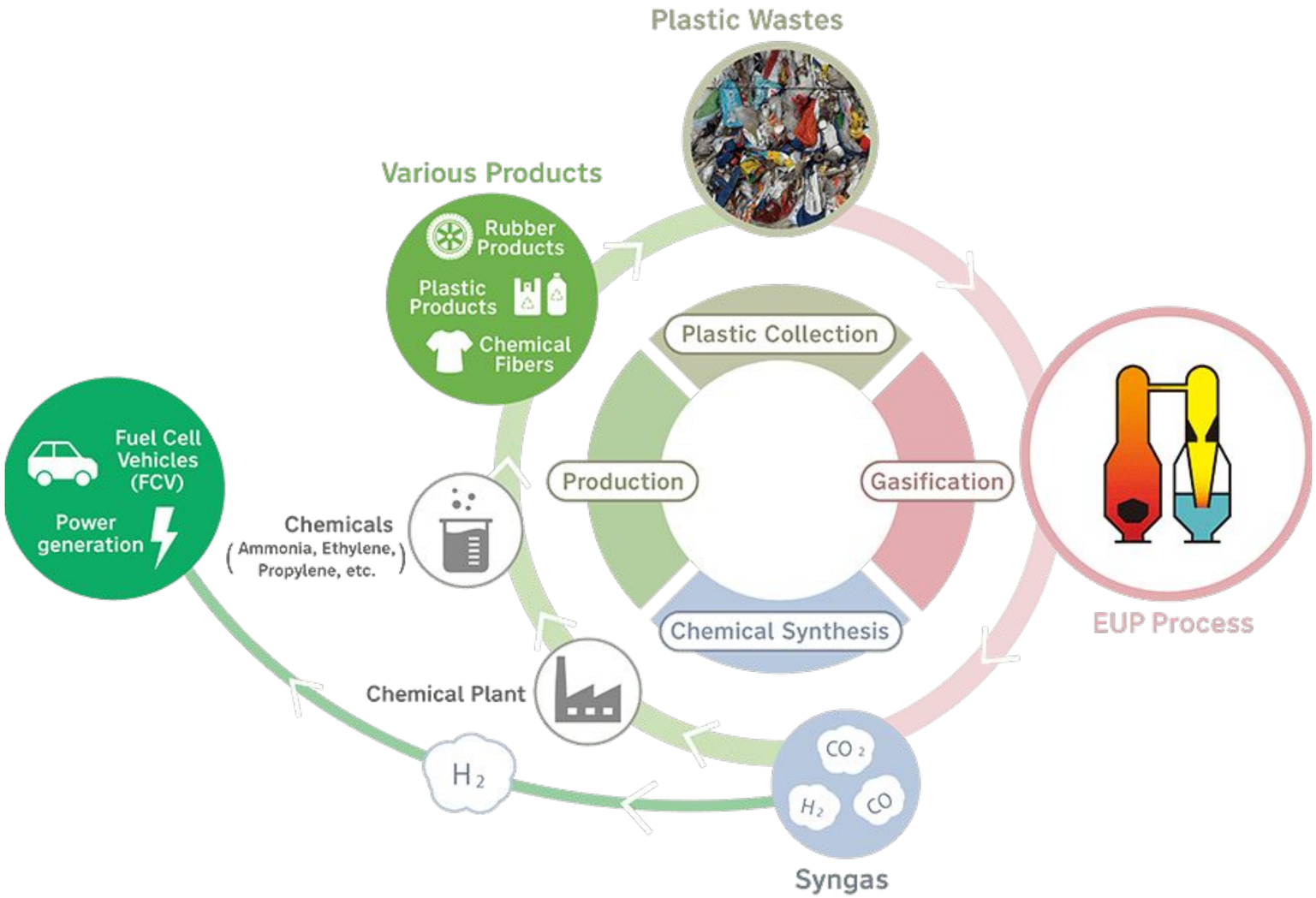
Chemical Recycling is a recently new technology that converts polymeric waste by changing its chemical structure and turning it back into substances that can be used as raw materials for the manufacturing of plastics or other products. There are different chemical recycling technologies.

- Pyrolysis



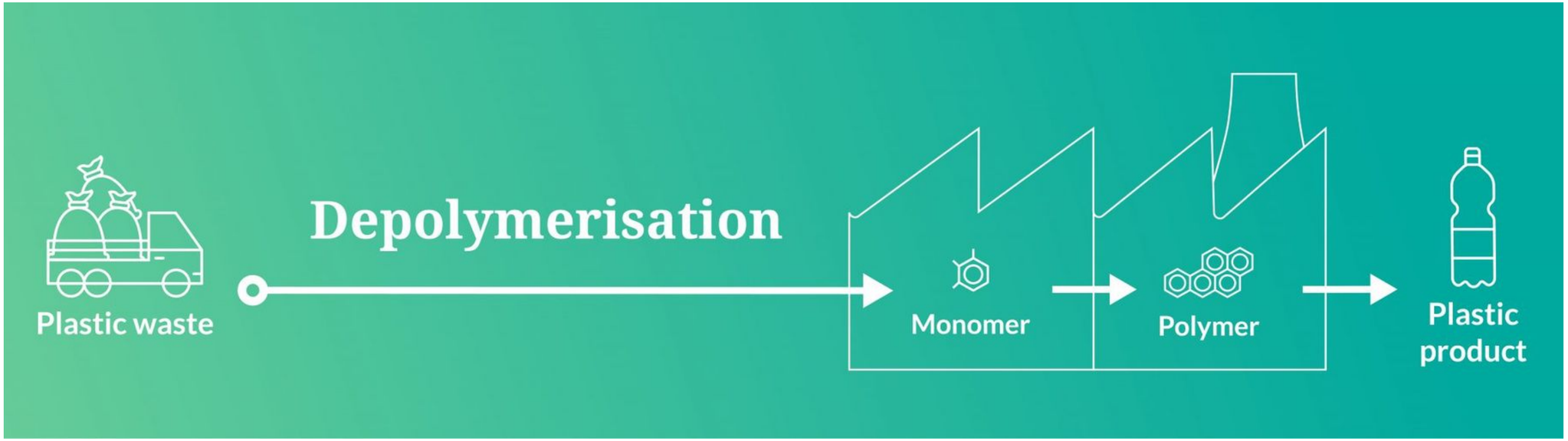
LaJoie ,D., 2023, *Pyrolysis of the World's Plastic Waste*

- Gasificiation



JGC, n.d., *Gasification*

- Depolymerization



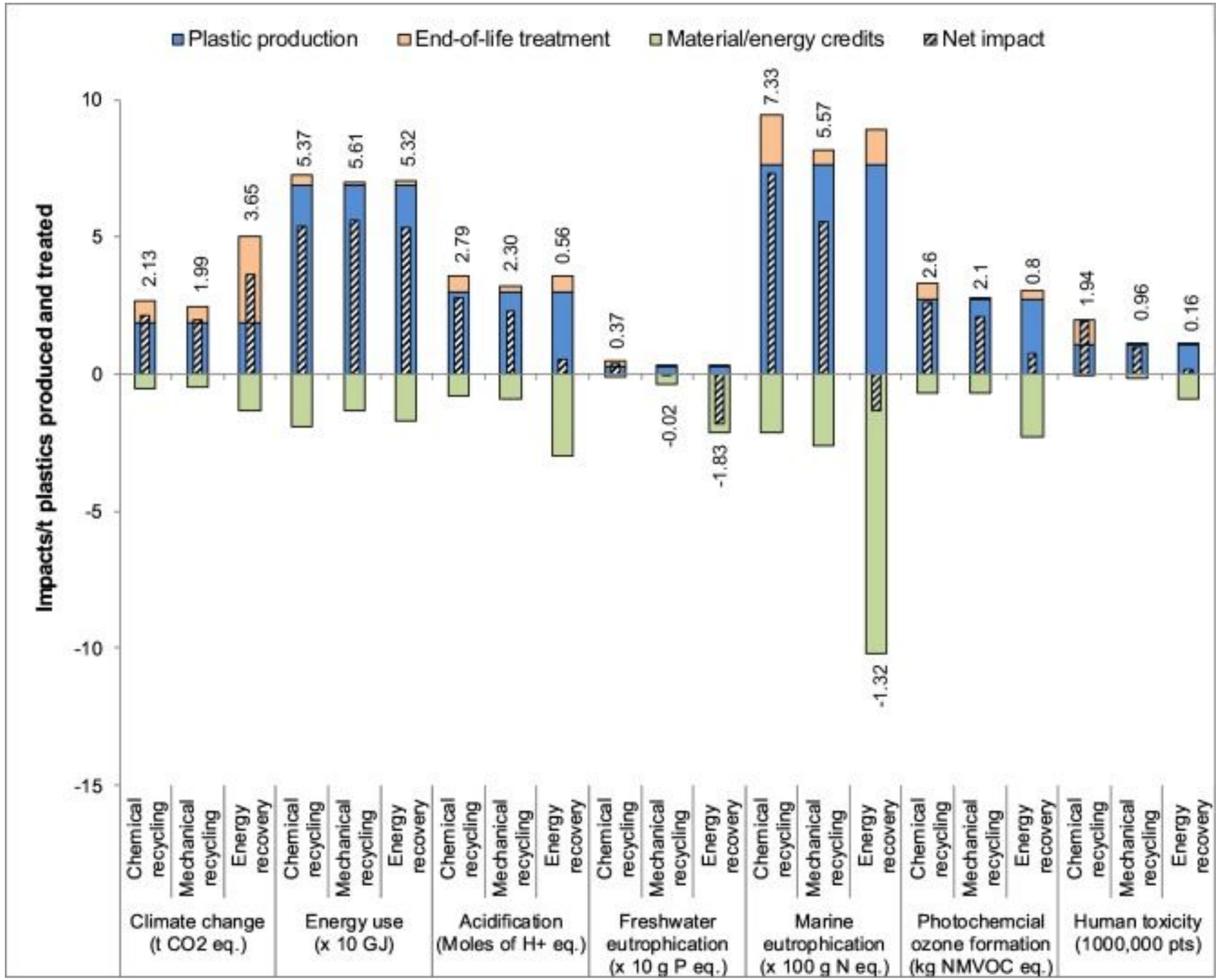
Cefic, n.d., *Depolymerisation: breaking it down to basic building blocks*

3. Energy Recycling

Energy recycling refers to the process of recovering energy from waste materials, such as PVC, through techniques like incineration to generate heat or electricity. It is common in Europe and Asia since it reduces the areas that are used as landfill.
There are two primary methods of energy recycling:

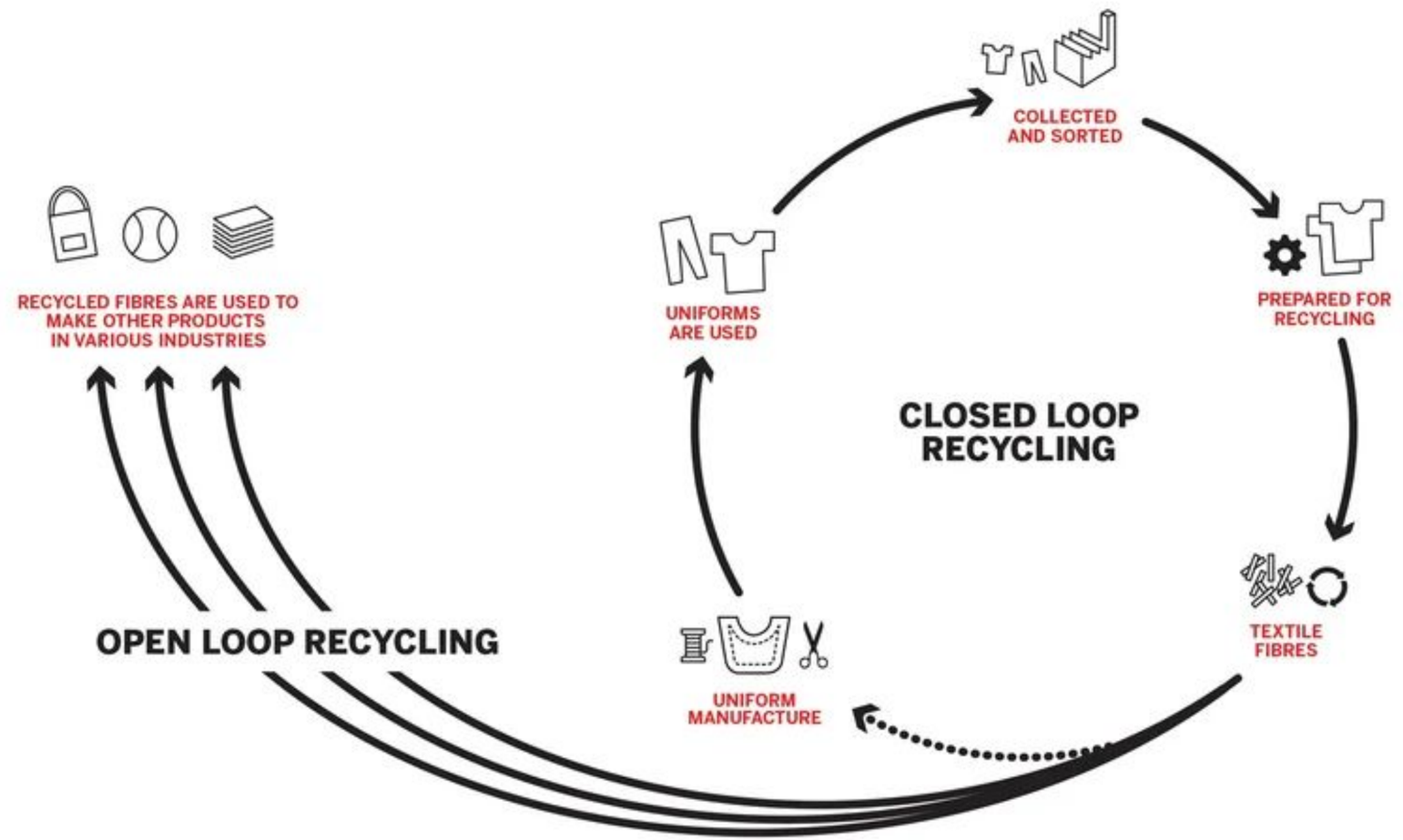
- Waste Heat Recovery: Waste heat from industrial processes is captured and converted into usable energy like electricity and steam.

- Combined heat and power (CHP): It involves producing both electricity and usable heat from a single energy source, like natural gas. This allows facilities to make full use of fuel by simultaneously generating power and capturing the heat produced during electricity generation.



Jeswani, H. et. al., 2021, *Life cycle environmental impacts of chemical recycling via pyrolysis of mixed plastic waste in comparison with mechanical recycling and energy recovery*

- Closed-loop recycling vs Open-loop recycling



Total Uniform Solutions, n.d., *The Future Lies in Closed-loop Textile Recycling*

TYPES OF RECYCLING

There are different types of recycling based on the materials involved and how they are processed. In order to manage waste effectively and advance a circular economy, it is necessary to understand these types.

1. PAPER WASTE RECYCLING

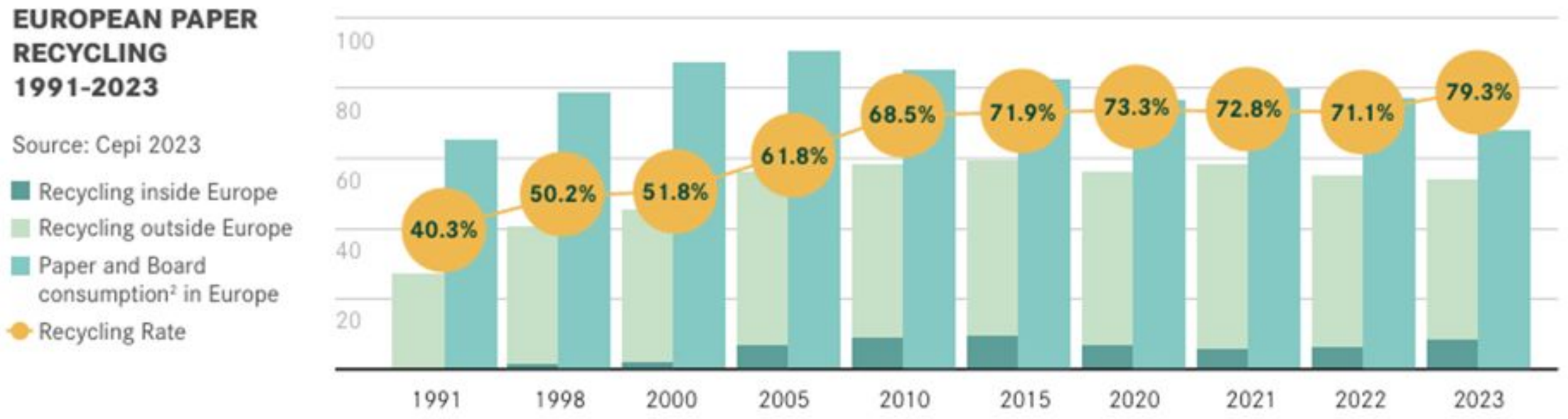
In Europe, paper and cardboard constitute approximately 25% of municipal solid waste (MSW) generated.

It makes up 23% of municipal solid waste generated in the USA, more than any other material.

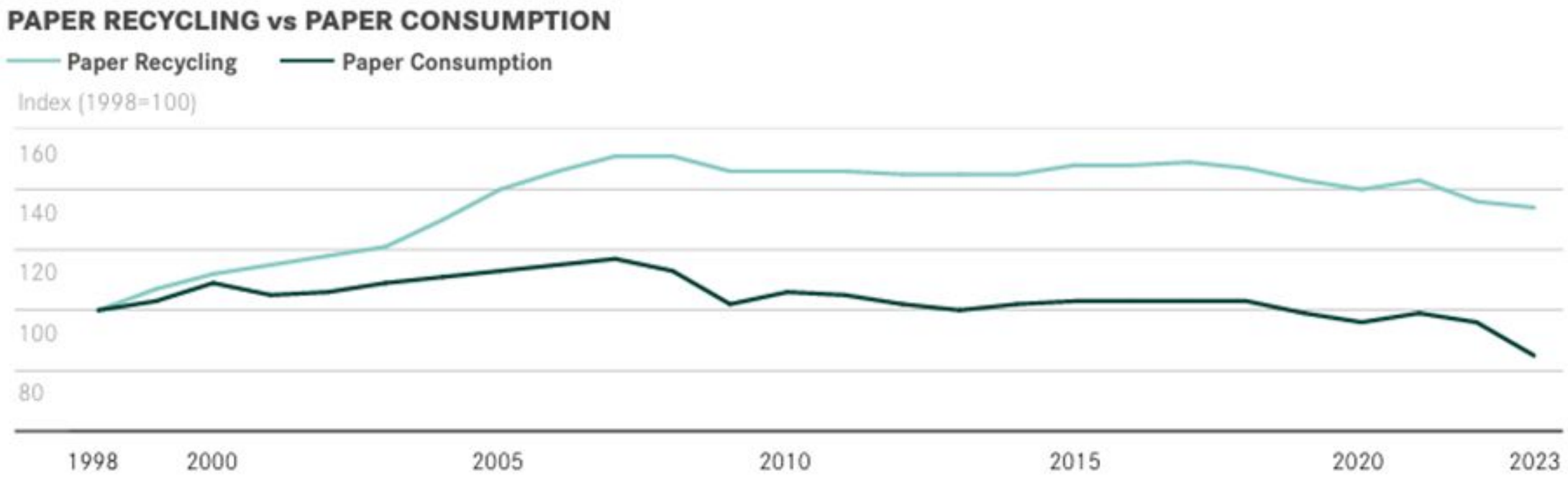
From 2001 to 2019, a total of 386 million hectares of forest were lost globally (in all forest types combined). This loss represents an almost 10 % decrease in tree cover since 2000.

- 93% of paper comes from trees

The recycling rate is defined as the ratio between the recycling of used paper, including the net trade of paper for recycling, and the consumption of new paper and board.



European Paper Recycling Council, 2024, *Monitoring Report 2023*



1998 - the base year for the first voluntary commitment set in the European Declaration on Paper Recycling

European Paper Recycling Council, 2024, *Monitoring Report 2023*

RECYCLING RATE IN WORLD REGIONS IN 2022

Cepi, Fastmarkets RISI – 2022

*EU-27+3 (The UK, Norway and Switzerland)



EUROPE IS THE PAPER RECYCLING CHAMPION!

At regional level, the number of countries with a recycling rate below 60% was 4 in 2023, down from 7 in 2022.

In 2023, the number of countries exceeding recycling rates of 70% was 19, from 15 in 2022.

In 2021, the signatories of the European Declaration on Paper Recycling declared their commitment to reach a 76% paper recycling rate by 2030.

If the recycling rate improves from 72.8% to 76%,

- the additional 3.7 million tons of paper will be diverted from landfills or incineration annually.
- Potential savings of around 5.55 million tons of CO_2 annually by 2030.
- Energy savings can be significant, as recycled paper production uses about 60% less energy than new paper (11.1 to 14.8 billion kWh)

2. Plastic Waste Recycling

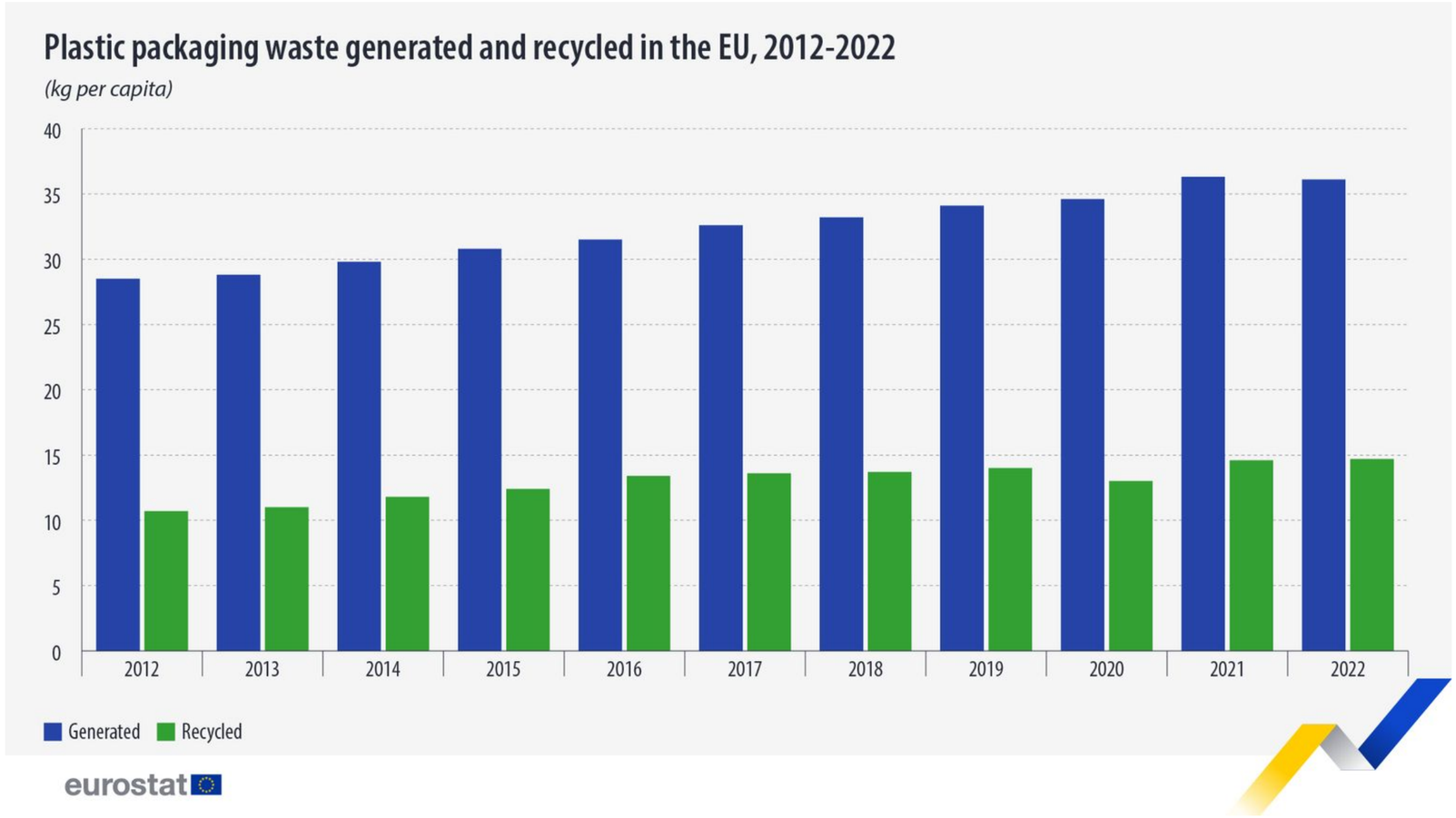
About 22 million tonnes of plastic found its way into soils, rivers and oceans in 2019, and plastic leakage is projected to double by 2060.

In 2019, plastics generated 1.8 billion tonnes of greenhouse gas (GHG) emissions – 3.4% of global emissions – with 90% of these emissions coming from their production and conversion from fossil fuels. By 2060, emissions from the plastics lifecycle are set to more than double, reaching 4.3 billion tonnes of GHG emissions.



Abdulraheem, M., n.d., *Plastic waste at the Thilafushi waste disposal site, Maldives*

In 2022, an average of 36.1 kg of plastic packaging waste was generated for each person living in the EU, and out of this, 14.7 kg were recycled.



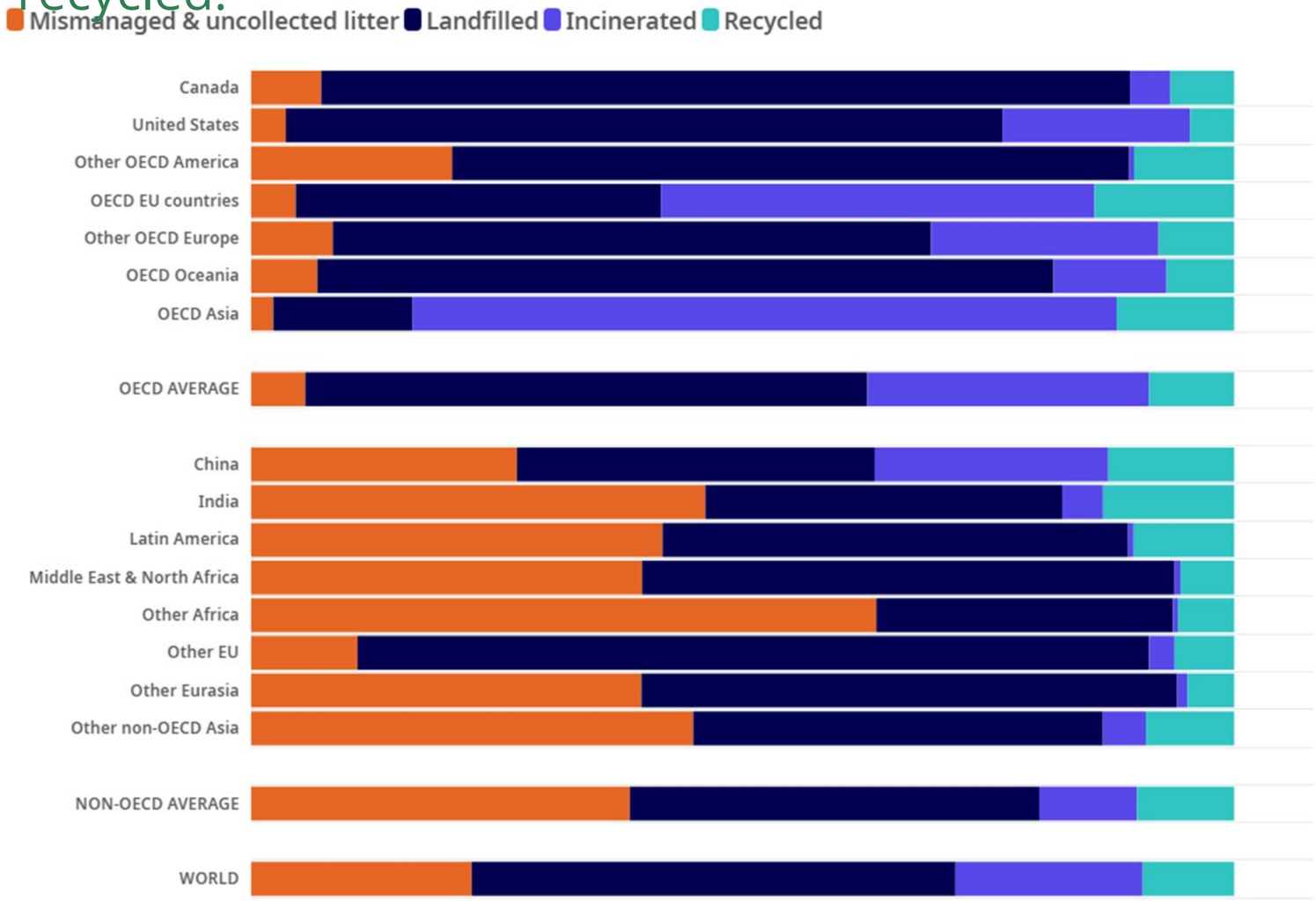
Eurostat, 2024, *41% of plastic packaging waste recycled in 2022*

Following stricter rules, implemented in 2020 for Member States to report their recycling, the recycling rate shifted from 41.1% in 2019 to 37.6% in 2020. In 2021, the recycling rate was back to an increasing path, marking 39.7%.

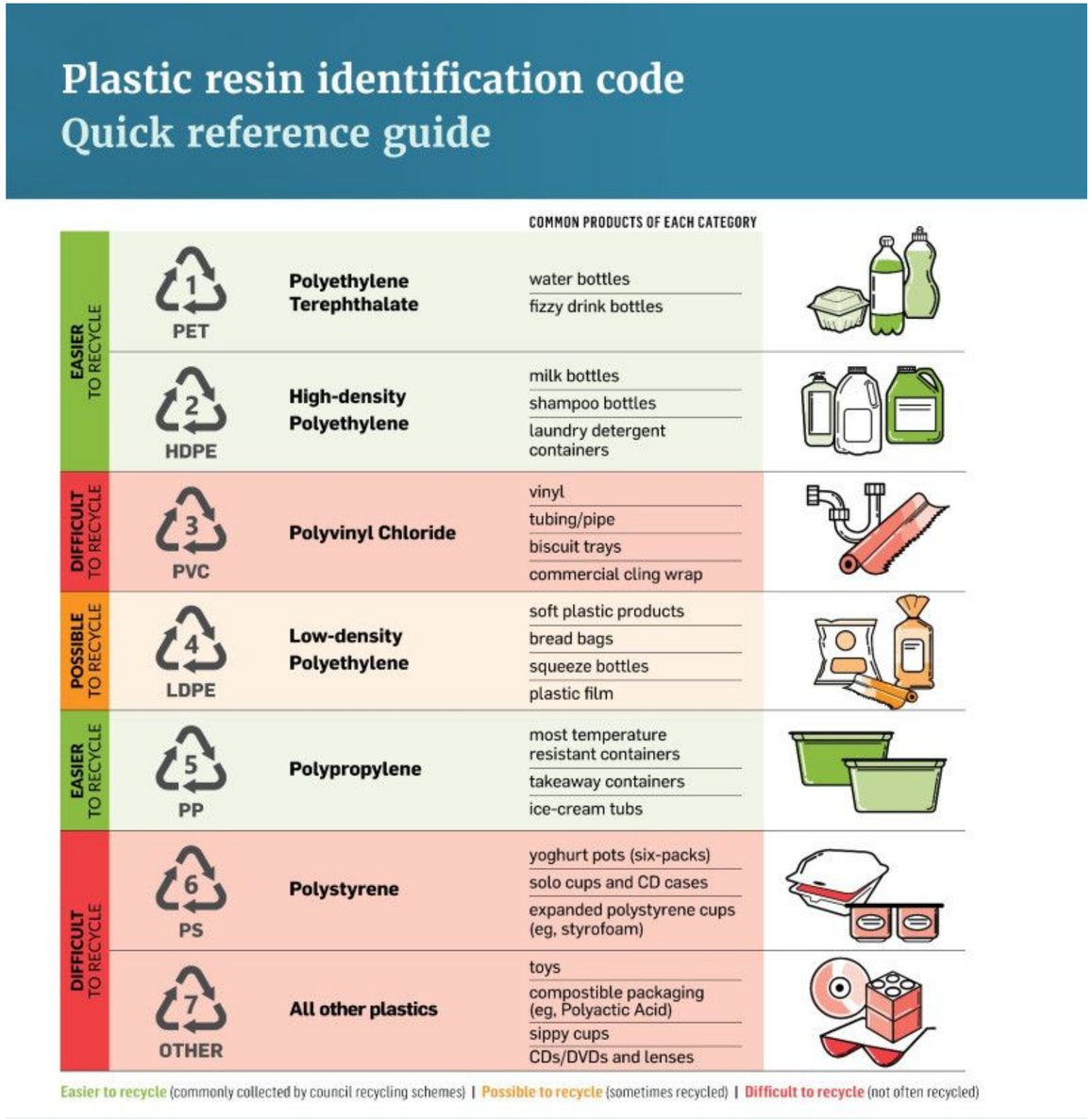


Eurostat, 2024, *41% of plastic packaging waste recycled in 2022*

The world is producing twice as much plastic waste as two decades ago, with the bulk of it ending up in landfill, incinerated or leaking into the environment, and only 9% successfully recycled.



OECD, 2022, *Global Plastics Outlook*



In 2019, 6.1 million tonnes (Mt) of plastic waste leaked into aquatic environments and 1.7 Mt flowed into oceans. There is now an estimated 30 Mt of plastic waste in seas and oceans, and a further 109 Mt has accumulated in rivers.

Global production of plastics from recycled – or secondary – plastics has more than quadrupled from 6.8 million tonnes (Mt) in 2000 to 29.1 Mt in 2019, but this is still only 6% of the size of total plastics production

New Zealand Ministry for the Environment, 2024, *Phasing out hard-to-recycle and single-use plastics*

As part of the Green Deal, 55% of plastic packaging waste should be recycled by 2030.

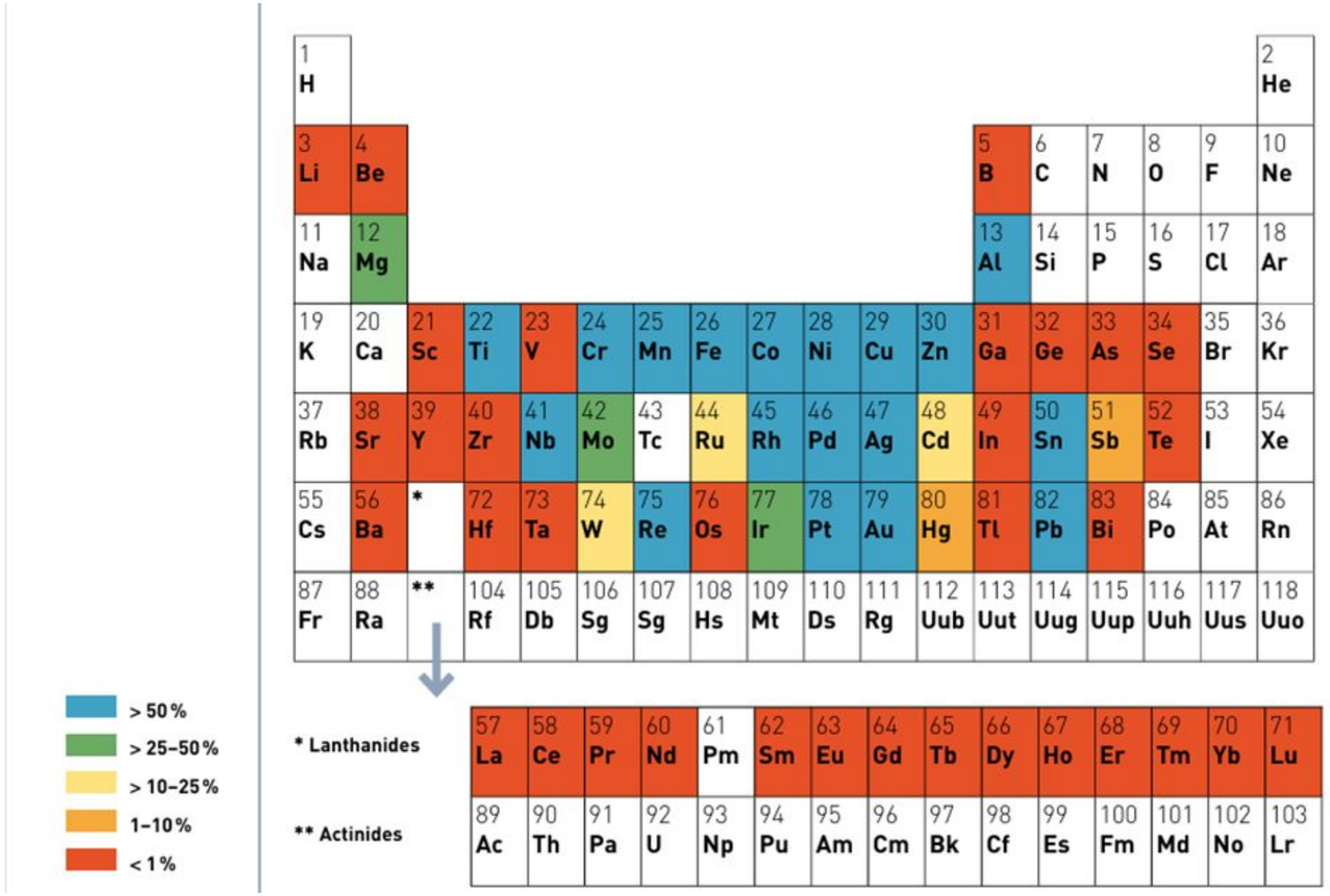
Parliament and the Council reached a deal and Members of the European Parliament approved it in April 2024. The rules require EU countries to reduce total packaging waste per capita compared to 2018 by 5% by 2030; 10% by 2035 and 15% by 2040.

- Ban on certain single-use plastics: from 1 January 2030, specific types of single-use plastic packaging will be banned
- Recyclable packaging: almost all packaging will have to be recyclable under the new rules. Any plastic packaging will have to include a minimum percentage of recycled content from plastic waste.
- By 2029, 90% of single-use plastic and metal beverage containers (up to three litres) will have to be collected separately.

3. Metal Waste Recycling

Metals are broadly present in a variety of goods with both short- and long-term use. EU economic growth is deeply linked to the use of metals with metal supply widely depending on metal scrap.

The EU produces only about 3% of the primary raw materials required to sustain a growing demand for metals.



The report estimated that about 40% of the global demand for metals could technically be met by recycling existing scrap if more efficient recycling systems were developed.

UNEP, 2011. *Recycling Rates of Metals – A Status report*

- STEEL

80.5%

SteelPackaging

recycling in Europe 2022

(EU 27 + Norway, Switzerland and UK)

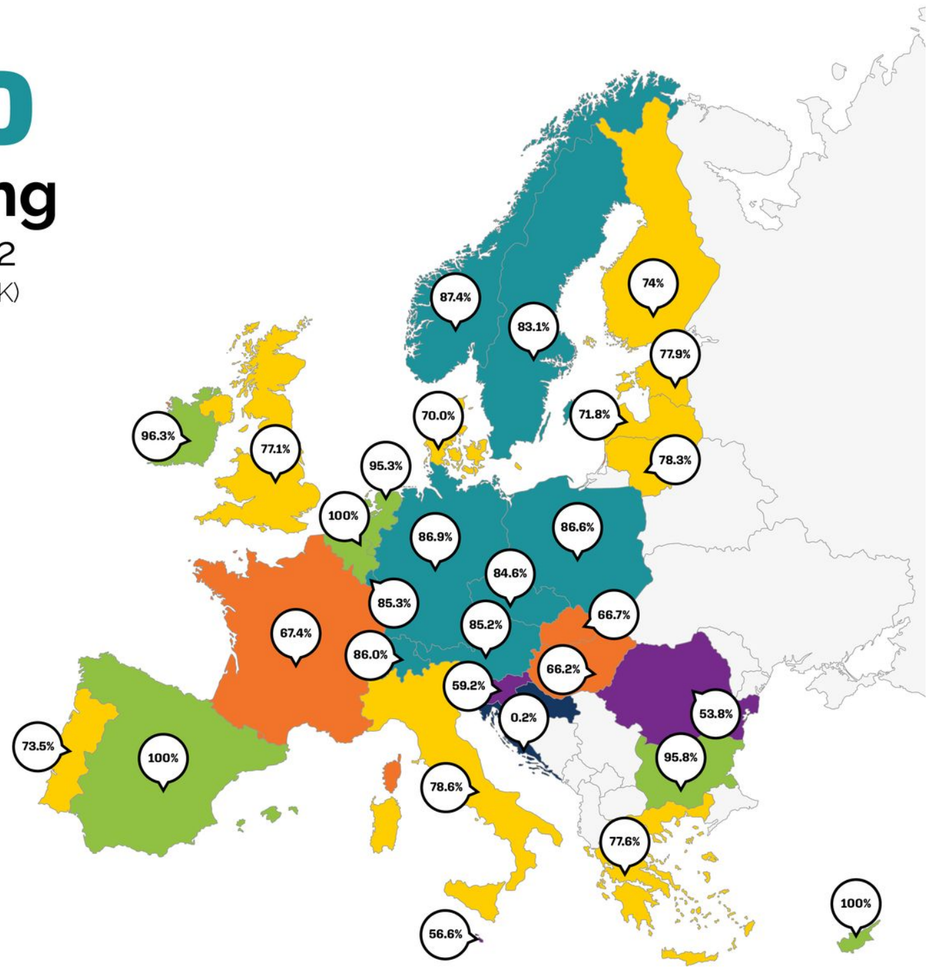
- 90 - 100%
- 80 - 90%
- 70 - 80%
- 60 - 70%
- 50 - 60%
- < 50%

Metal recycling data

Hungary

2021 latest official data

Austria, Denmark, France, Hungary, Malta, Portugal.



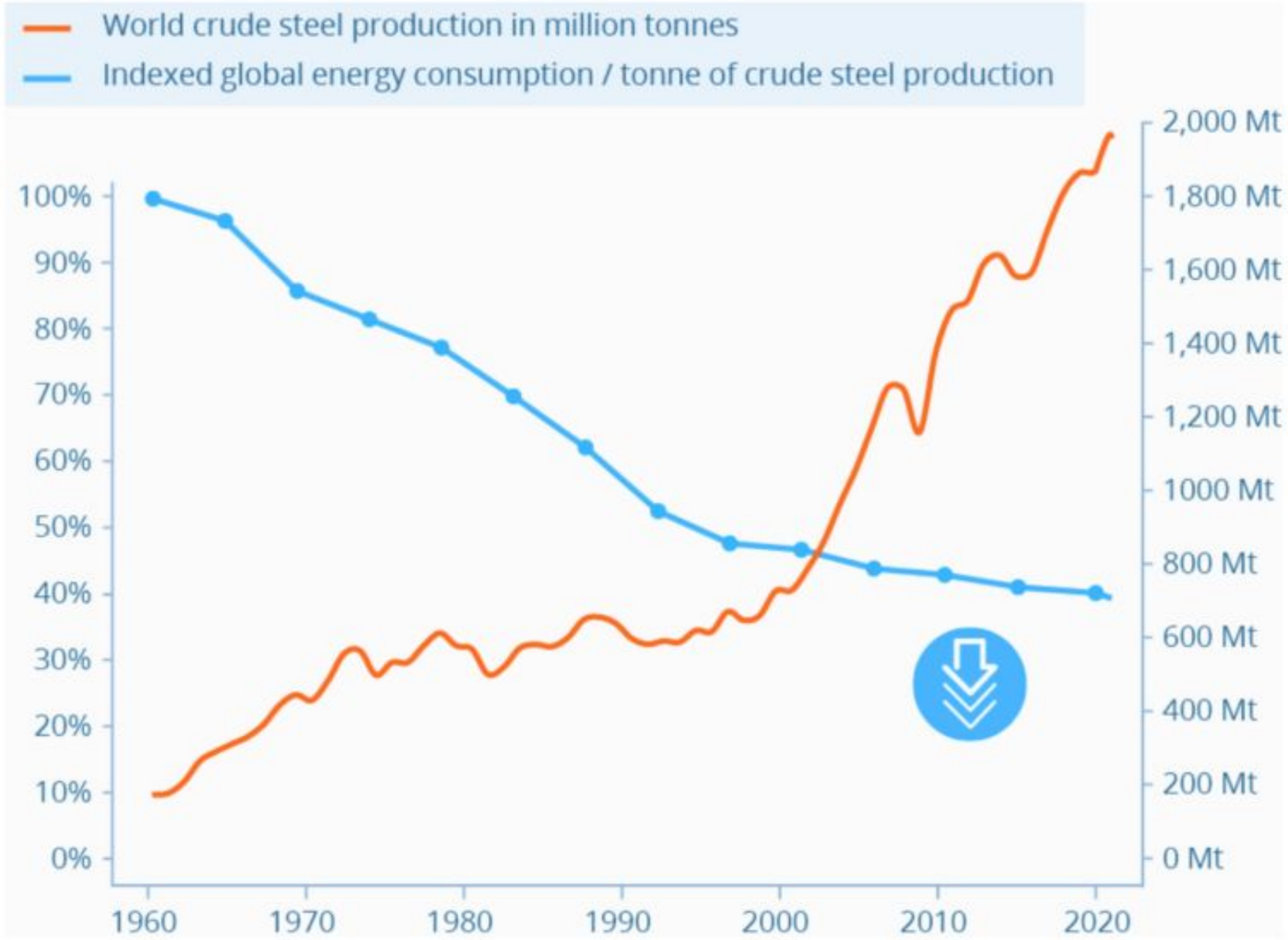
Source: Official member states and PRO`s

Critical Review: Eunomia Research & Consulting Ltd.

Over 90% of end-of-life stainless steel is currently collected and recycled into new products.

70% of the steel produced to date is still in use.

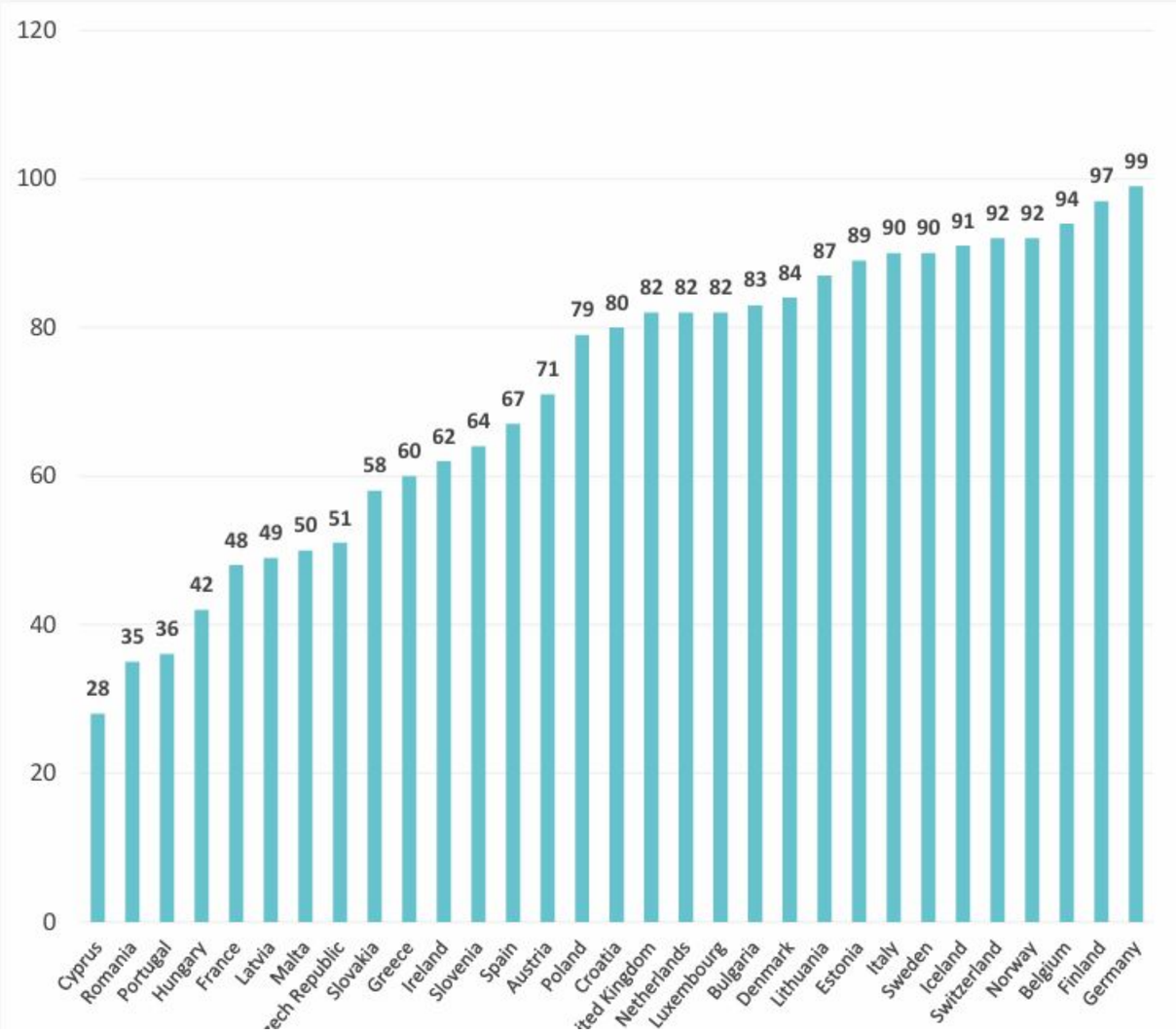
Steel for Packaging, 2024. *Steel for Packaging Europe confirms new recycling record*



- Using steel scrap in the production process reduces CO2 emissions by 58%.
- Recycling steel saves 72% of the energy needed for primary production.
- Using recycled steel to make new steel reduces air pollution by 86%, water use by 40%, and water pollution by 76%.

World Steel Association, n.d.. *Circular Economy*

• ALUMINIUM

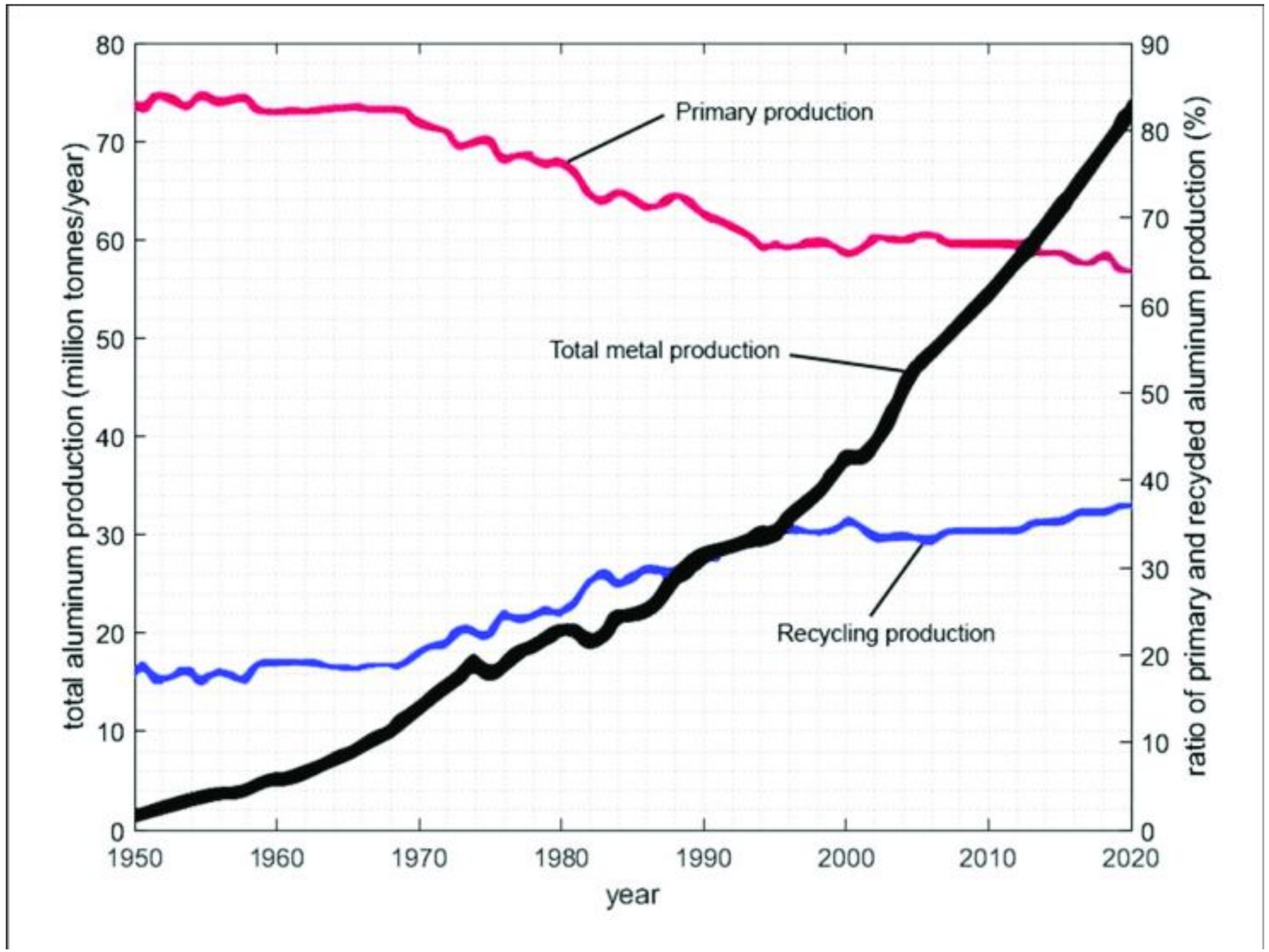


Aluminium beverage can recycling in 2021 at a new record level of 76% in Europe.

Of the total amount of aluminium scrap generated in the EU at end-of-life, a 69% recycling rate was obtained.

Thanks to its endless recyclability, 75% of all aluminium ever produced is still in use today.

European Aluminium, 2024. *Aluminium beverage can recycling in 2021 at a new record level of 76%*

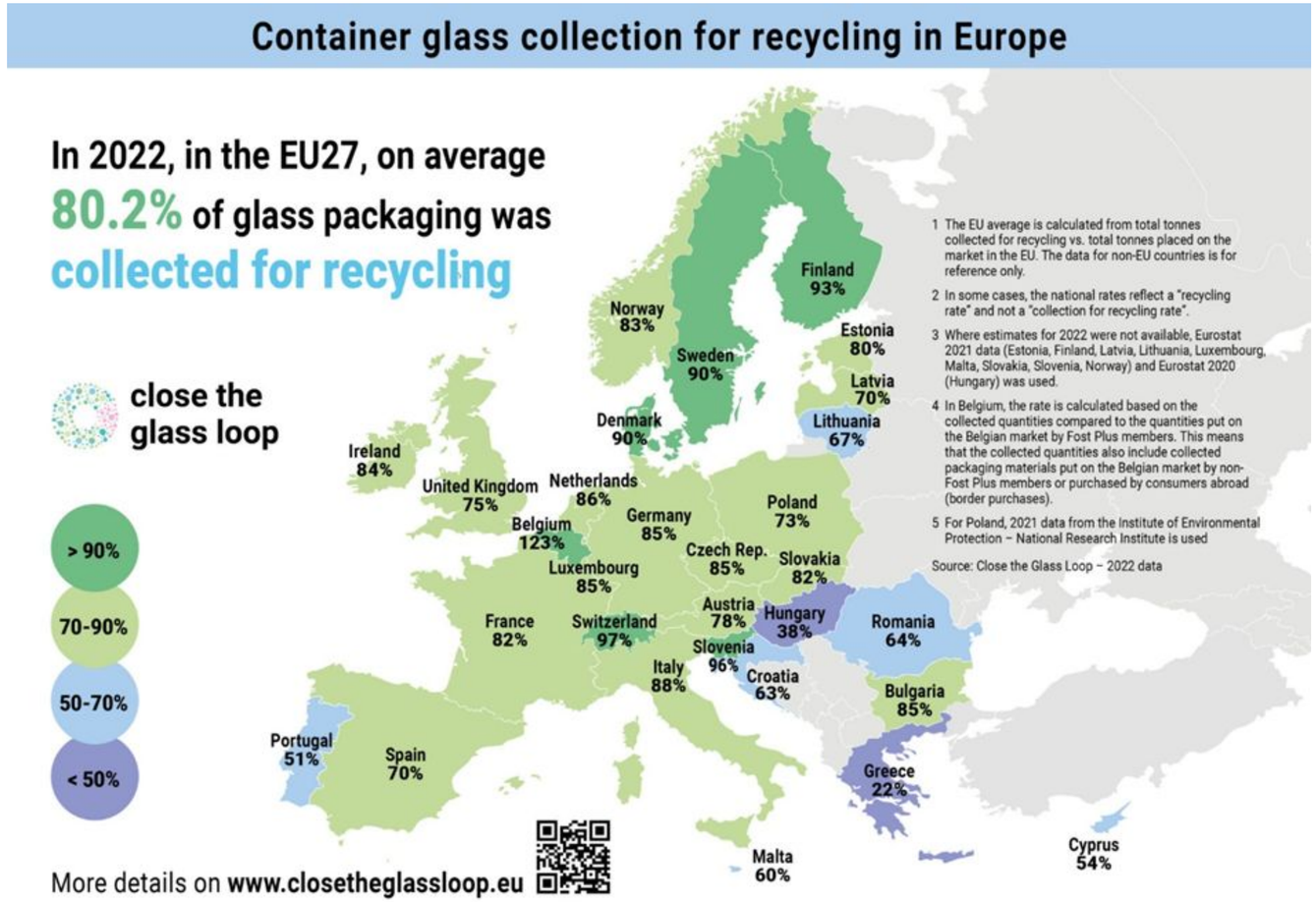


By using aluminium scrap, CO2 emissions can be reduced by 92% compared to raw aluminium.

Recycling aluminium saves 95% of the energy needed for primary production.

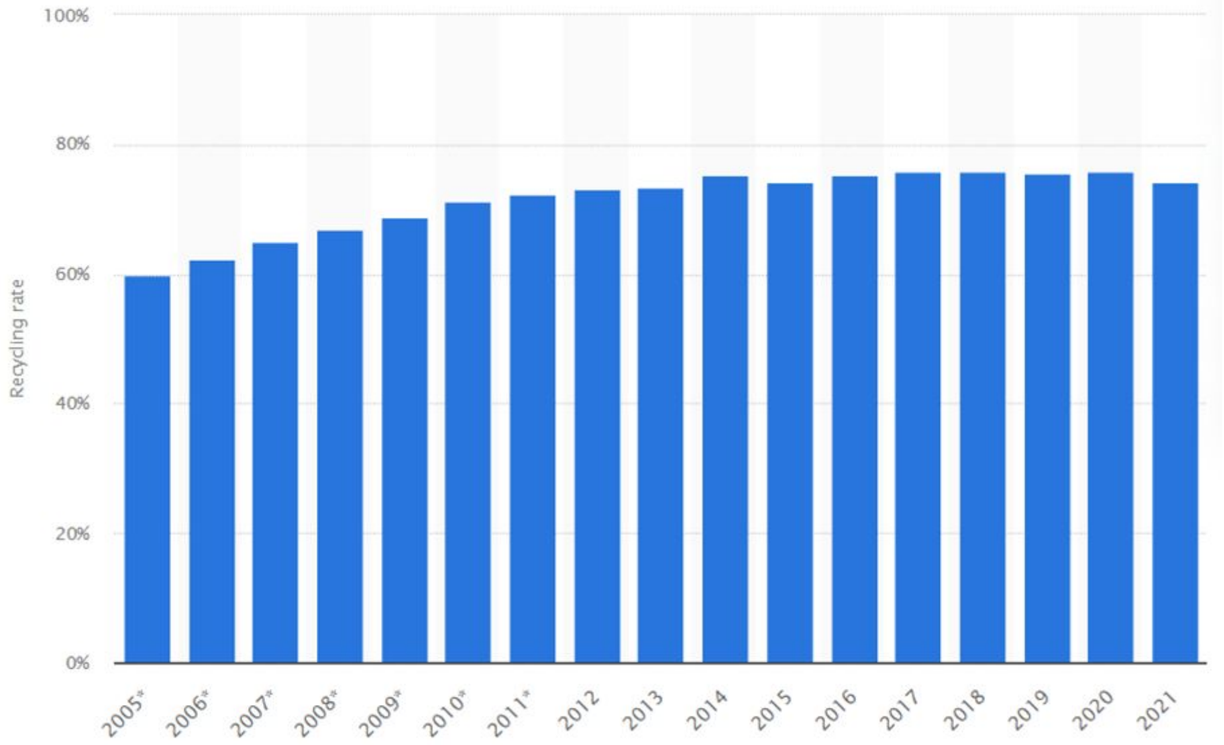
Rungskunroch, P., Kaewunruen, S., & Shen, ZJ., 2019. *An Improvement on the End-of-Life of High-Speed Rail Rolling Stock Considering CFRP Composite Material Replacement*

4. Glass Waste Recycling



As of 2022, Europe generated approximately 11 million tonnes of glass waste from municipal solid waste (MSW), which is close to 10% of the total MSW generated.

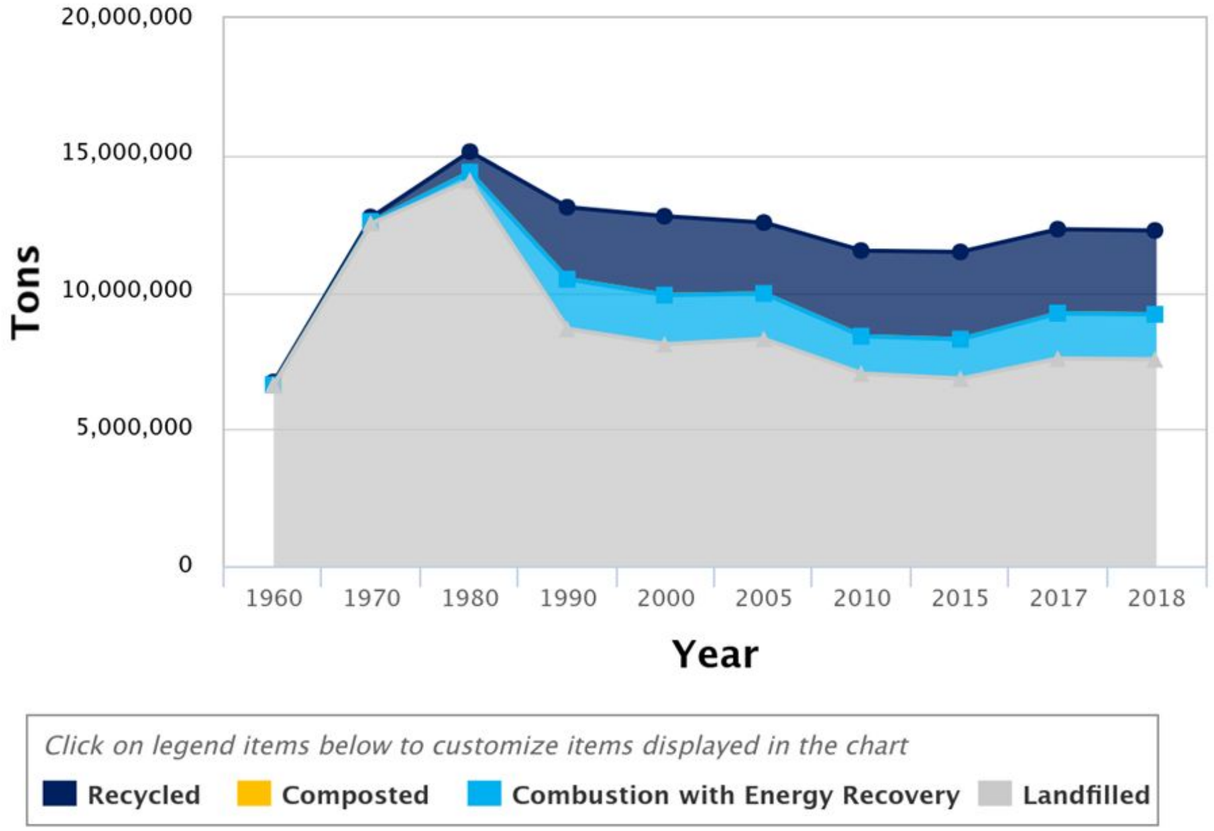
Close the Glass Loop, 2024. *The EU's glass value chain sustains a steady 80.2% glass packaging collection rate with record volume of collected glass*



According to the Close the Glass Loop study on the Performance of Packaging Glass Recycling in Europe in 2019

- 96% of the total tonnage effectively recycled in 2019 was recycled in a glass manufacturing process
- the closed loop glass recycling process represents 91% of the total tonnage of glass packaging recycled in 2019.

Alves, B., 2024. *Recycling rate of glass packaging in the European Union (EU-27) from 2005 to 2022*



In 2018, the glass recycling rate in the United States was approximately 31.3%. First time surpassing 30% in U.S.A history.

The Glass Packaging Institute has initiated plans to increase this rate to 50% by 2030 through various strategies, including enhancing collection systems and promoting public awareness

EPA, 2023. *Glass: Material-Specific Data*

The multi-stakeholder partnership Close the Glass Loop aims to reach a 90% post-consumer glass container collection target by 2030 and ensure that the collected glass is recycled back into the container glass production loop.

- This would mean an increase of about 5 million tonnes of glass being recycled annually compared to 2022 levels
- Recycling glass consumes about 30% less energy compared to producing new glass from raw materials
- Reduction of carbon emissions by around 3.35 million tonnes of CO_2 annually which is close to taking 1.4 million cars off the road for an entire year.
- Reduction of the need for approximately 6 million tonnes of raw materials.

5. Electronic Devices Waste Recycling

The amount of waste electrical and electronic equipment (widely known as WEEE or e-waste) generated every year in the EU is increasing rapidly. It is now one of the fastest-growing waste streams.

E-waste contains a complex mixture of materials, some of which are hazardous. These can cause major environmental and health problems if the discarded devices are not managed properly.

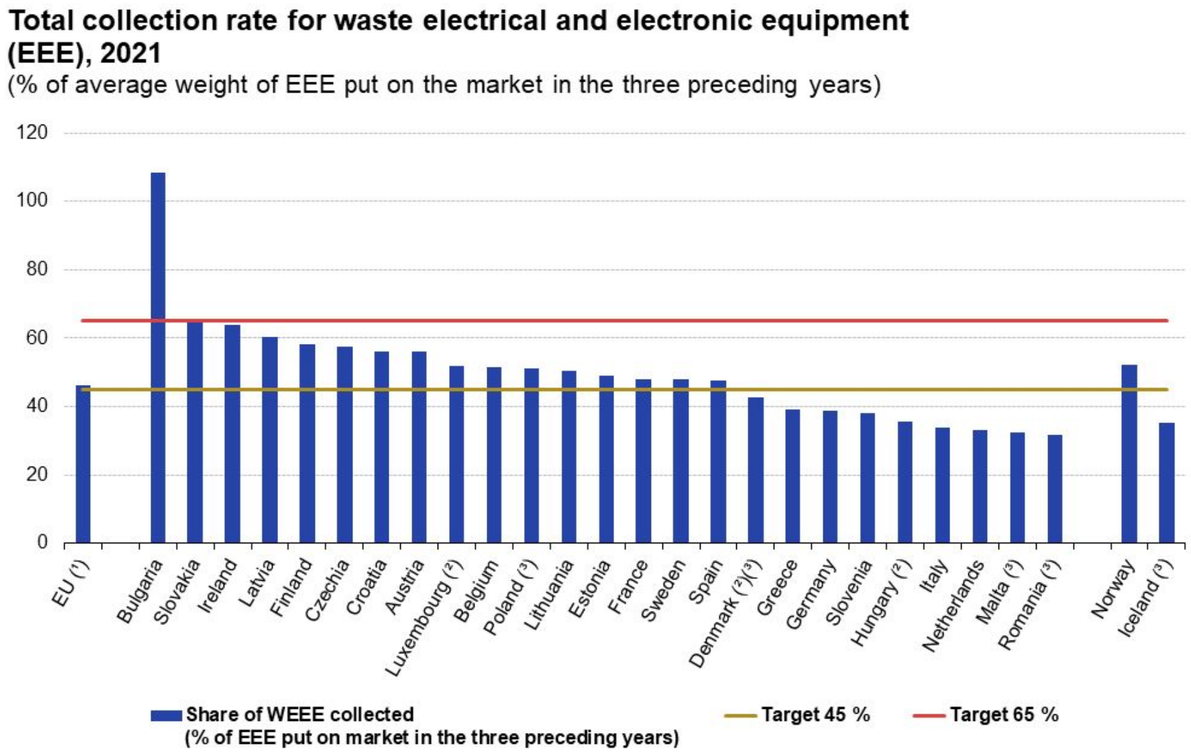
A record 62 million tonnes (Mt) of e-waste was produced in 2022, up 82% from 2010;

- On track to rise another 32%, to 82 million tonnes, in 2030

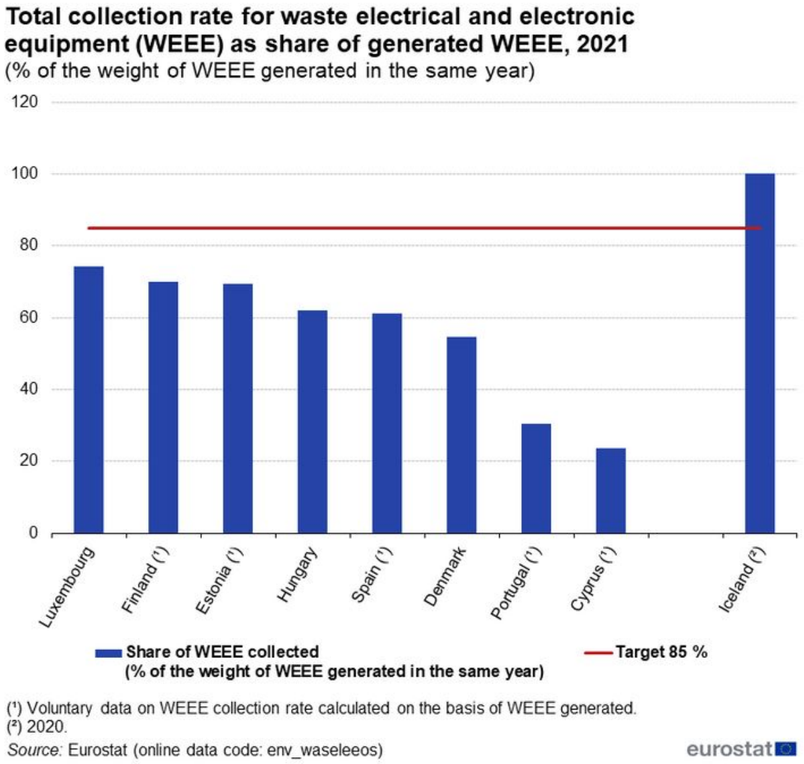
In 2021, the collection rate of WEEE in the European Union was 46.2 %.

From 2016 onwards, the annual collection target for WEEE is defined as the ratio between the amount of WEEE collected in the reference year and the average weight of EEE put on the market in the three preceding years.

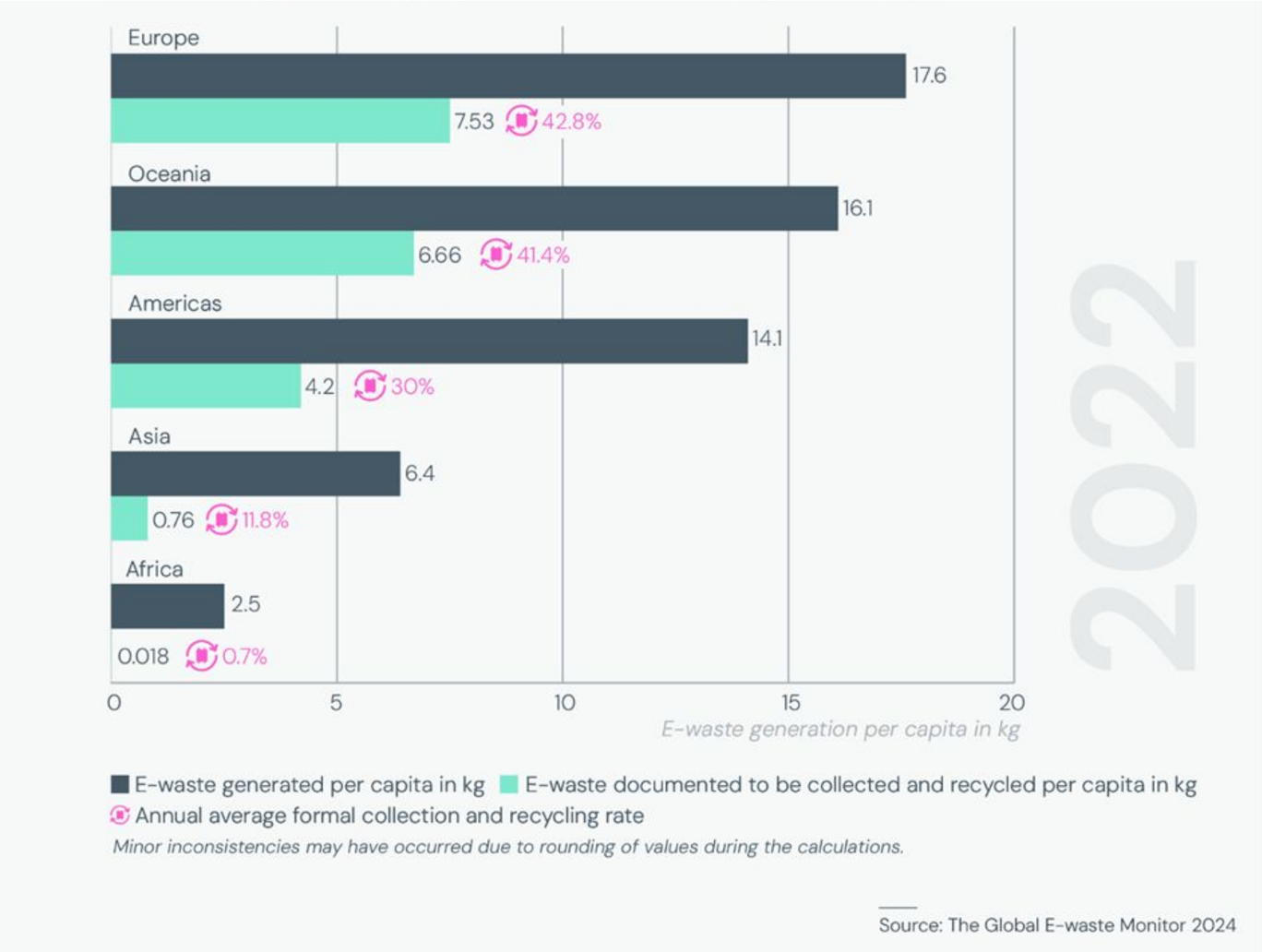
(A)



(B)



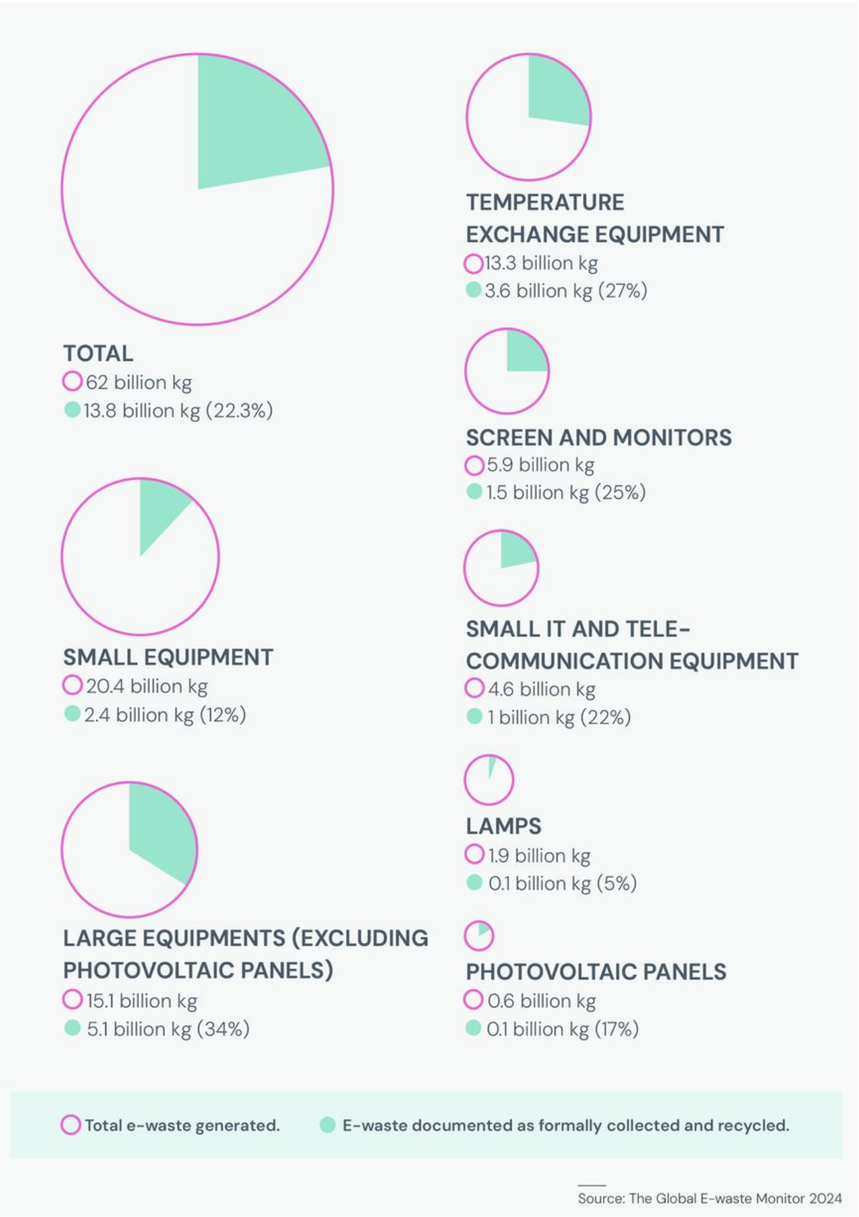
Eurostat, 2023. *Waste statistics - electrical and electronic equipment*



Less than one quarter (22.3%) of the year's e-waste mass was documented as having been properly collected and recycled in 2022.

The report foresees a drop in the documented collection and recycling rate from 22.3% in 2022 to 20% by 2030.

UNITAR, 2024. *Global E-waste Monitor 2024*



- 93 million tonnes: CO2-equivalent emissions avoided by formal e-waste management – recaptured refrigerants (41 million tonnes), avoided metals mining (52 million tonnes)

- Electronics contain hazardous materials such as lead, mercury, and cadmium. Improper disposal of these can lead to soil and water contamination

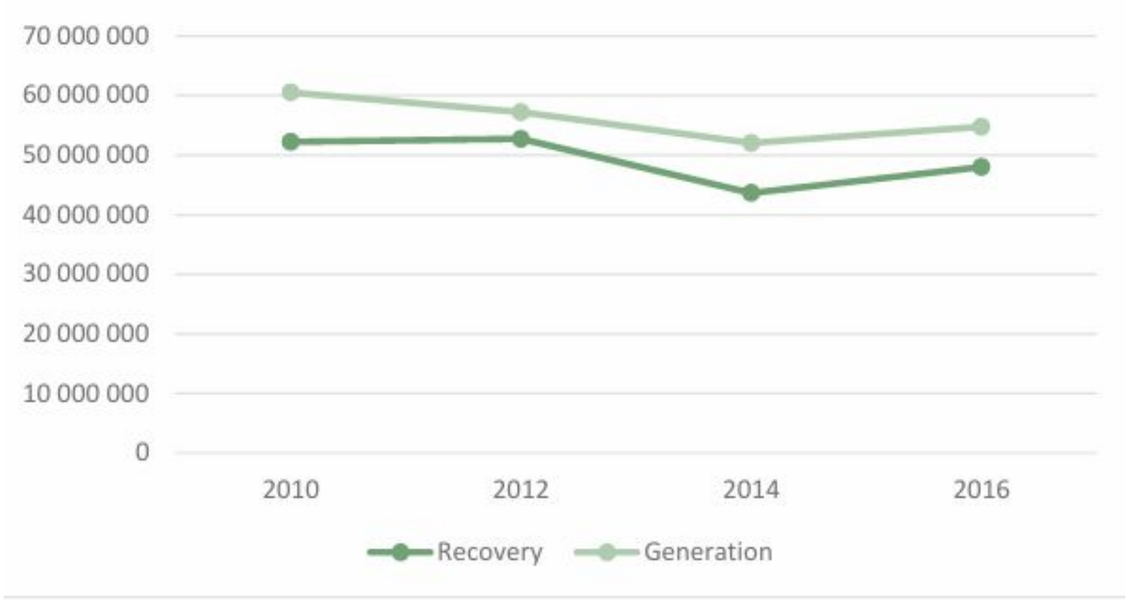
- Europe imports over 90% of certain critical raw materials used in electronics.

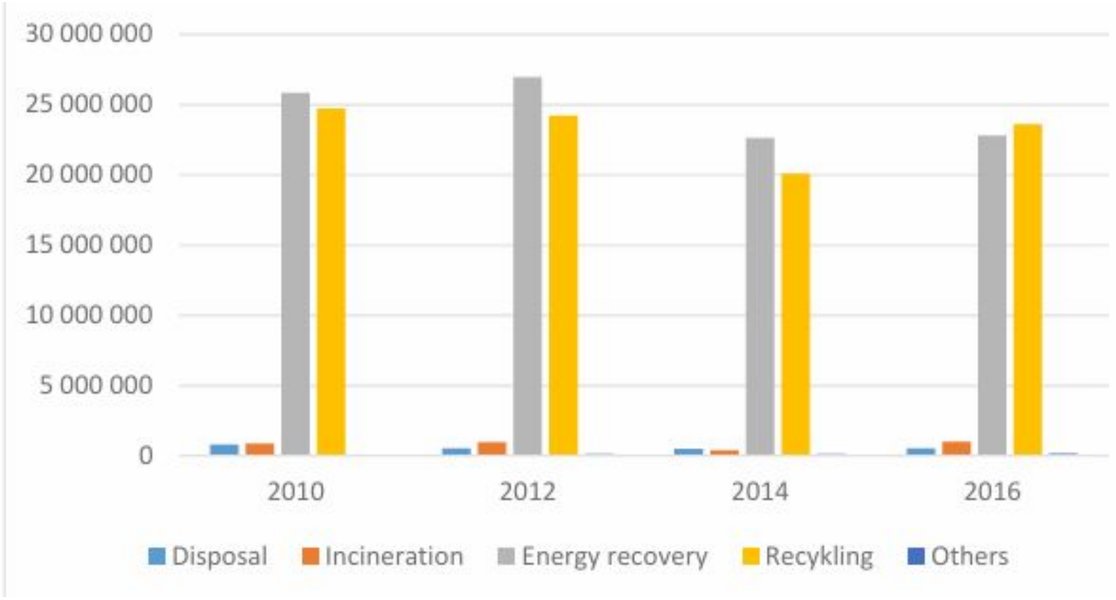
UNITAR, 2024. *Global E-waste Monitor 2024*

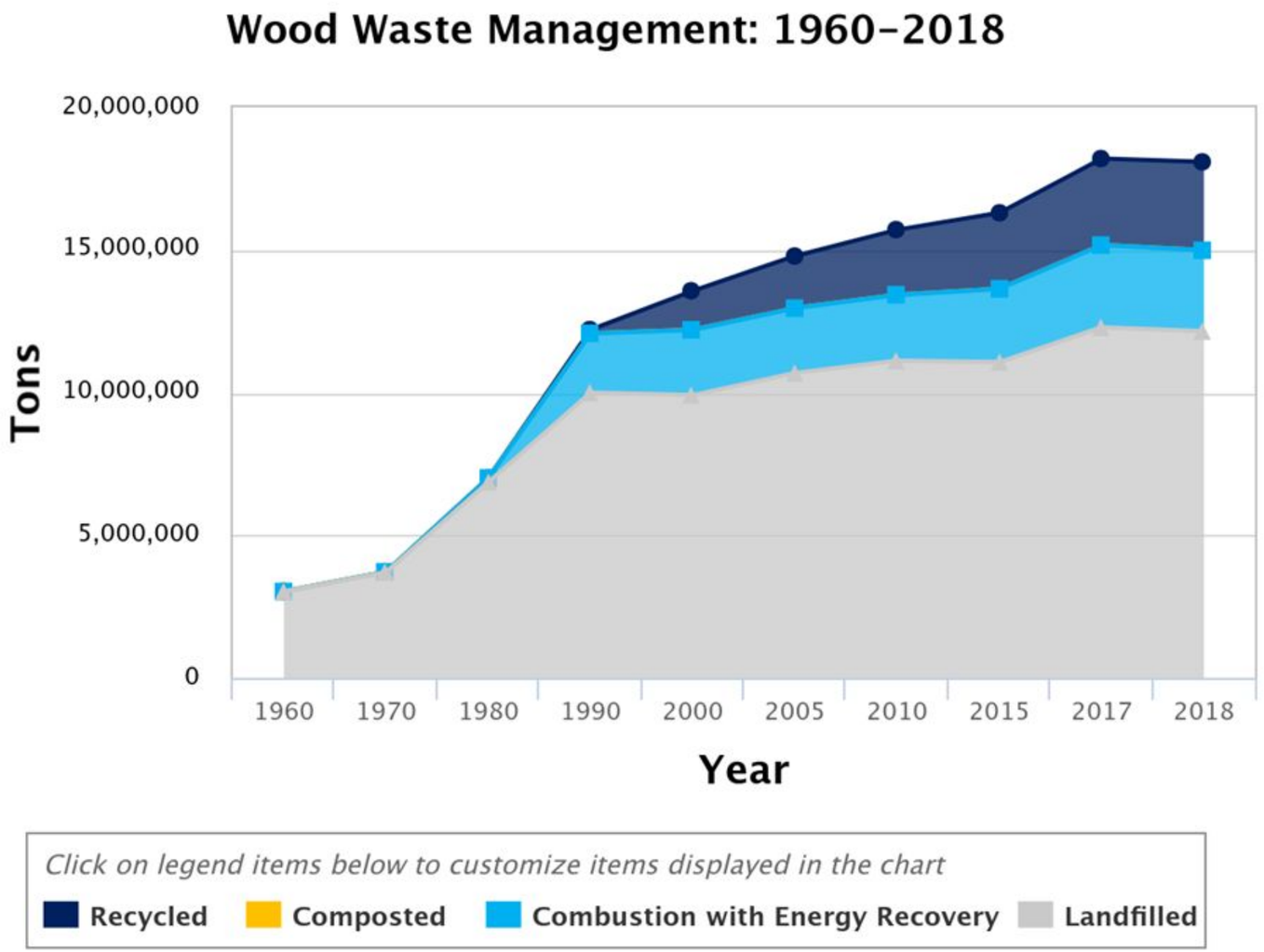
6. Wood Waste Recycling

In 2020, 40.20 Mt of wood waste was treated, accounting for 83.26% of the total, while 8.08 Mt was not treated (16.74%).

- Among the treated wood waste, 53.36% was used for energy recovery while 46.04% was used for recycling.







In 2018, wood in MSW generated 18.1 million tons, which equaled 6.2 percent of the total MSW generation in the USA that year.

In 2018, 17.1% was recycled while 15.7% was combusted with energy recovery. Rest of the wood waste was landfilled.

EPA, 2023. *Wood: Material-Specific Data*

7. Textile Waste Recycling

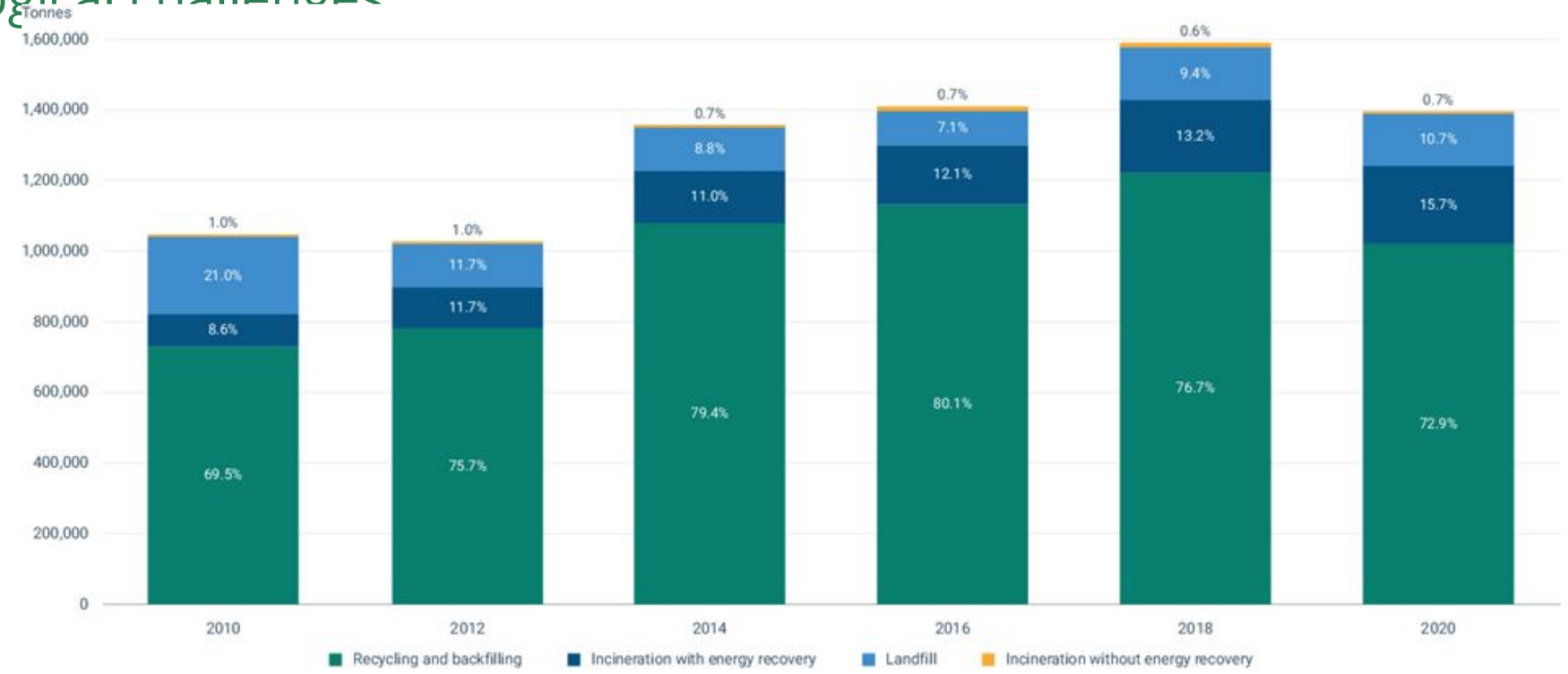
Fashion waste often refers to any items of clothing thrown away. However, the industry is responsible for waste in many other areas

- Old clothes – items of clothing that are damaged, no longer fit, or are unwanted
- Stock waste – unsold and out-of-season items from retailers
- Uniforms and workwear – worn out or old uniforms from schools and workplaces

Of all textile waste in Europe, 82% came from consumers and the rest was waste from manufacturing or textiles that were never sold.

The EU-27 generated an estimated total of 6.95 million tonnes of textile waste in 2020 — around 16kg per person. 4.4 kg per person of this were collected separately for reuse and recycling.

Less than 1% of textile waste was recycled back into new textiles, mainly due to technological challenges

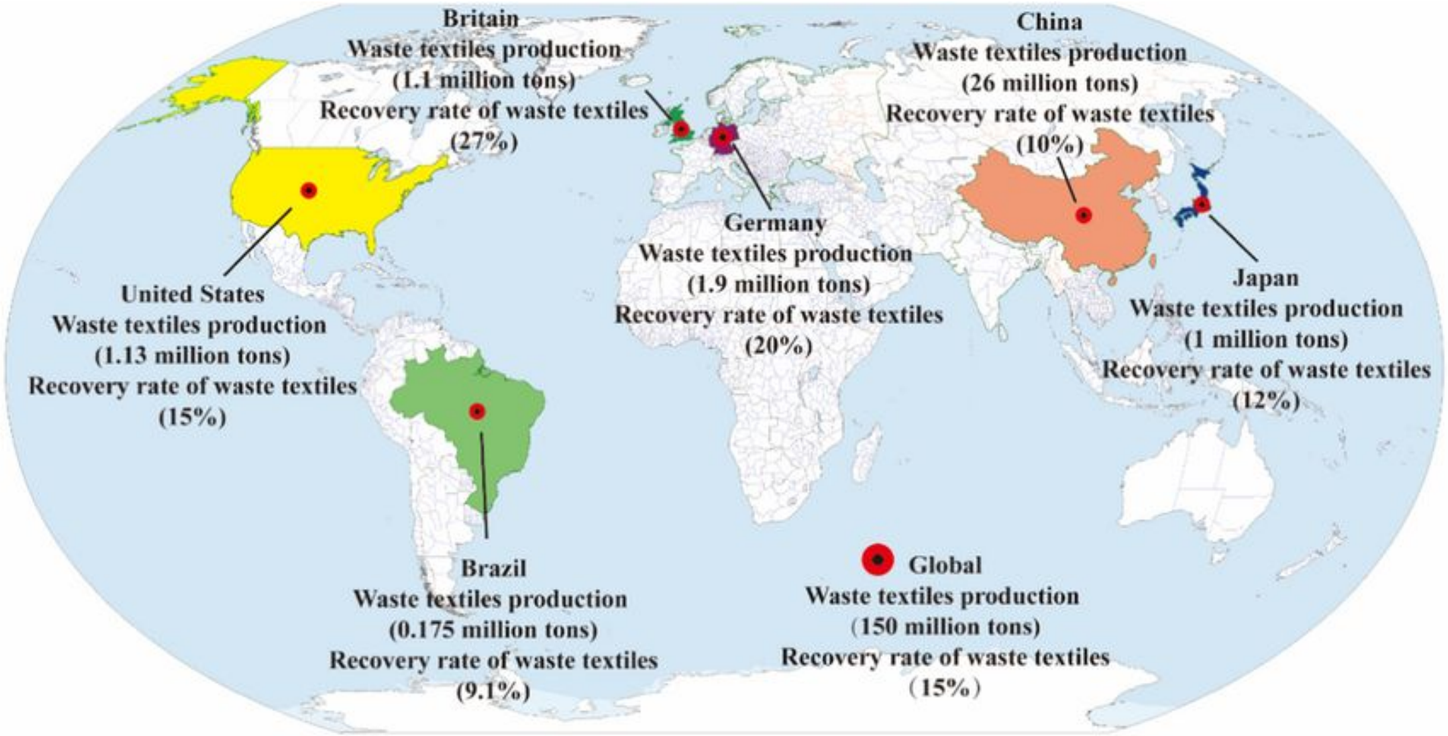


European Environment Agency, 2024. *Management of used and waste textiles in Europe's circular economy*

The worldwide fashion industry is responsible for 10% of all greenhouse gas emissions.

Of all the clothing thrown away across the world 57% is sent to landfill.

About 25% of cl



Liu, H., Fan, W., Miao, Y. et al., 2023. *Closed-loop recycling of colored regenerated cellulose fibers from the dyed cotton textile*

In more than half of the EU-27 Member States, it is already mandatory to collect textiles separately, but this is mostly to capture reusable textiles.

By 2025, all EU member states will be required to implement separate collection systems for textile waste, which is expected to drive up recycling rates.

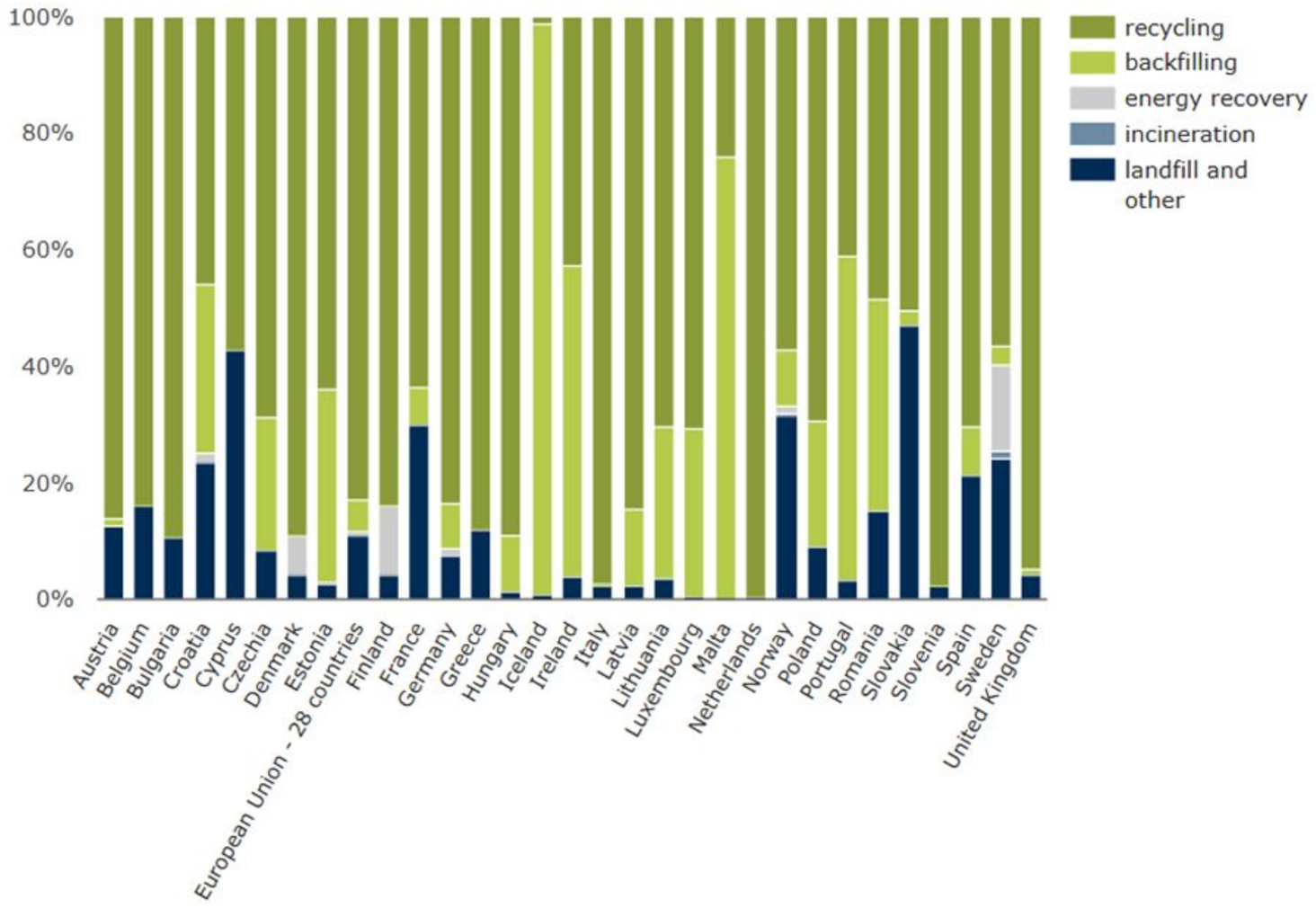
- This will also help to meet the broader EU target of reducing landfill use to less than 10% of municipal waste by 2035.

8. Construction and Demolition Waste Recycling

The construction industry contributes roughly 39 % of energy-related global carbon dioxide emissions and is responsible for 35 % of global waste disposed in landfills with related environmental consequences.

EPA estimated that 600 million tons of C&D debris were generated in the United States in 2018, which is more than twice the amount of generated MSW.

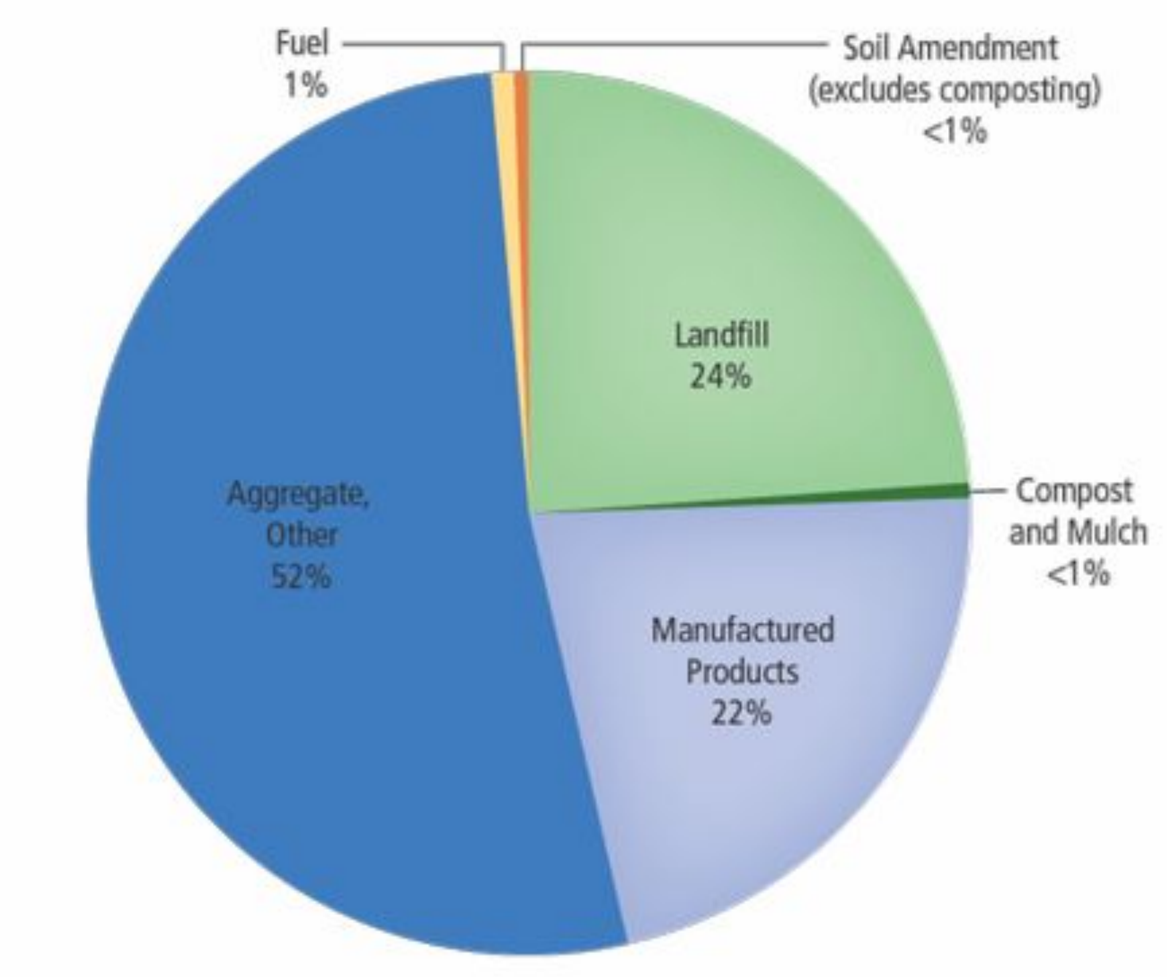
- Construction and demolition projects filled U.S. landfills with almost 145 million tons of waste in 2018.



EU countries are on track to fulfill the 70 % recovery target of 2020, with most countries already exceeding the target in 2016.

The high recovery rates of C&DW in Europe are mostly achieved by using recovered waste for practices such as backfilling and low-grade recovery applications

European Environment Agency, 2020. *Mineral waste from construction and demolition, waste treatment*



In 2018, 76% of all C&D waste in the U.S. was recovered or recycled.

- Over 95% of concrete and asphalt concrete waste, the largest contributors to total C&D waste, was recovered in 2018

EPA, 2020. *Advancing Sustainable Materials Management: 2018 Fact Sheet*

9. Rubber Waste Recycling

Tire industries, as the main application of rubbers (65% of the global production), generate the largest amounts of rubber waste materials. Therefore, rubber recycling is often defined as tire recycling.

Currently, 1.5 billion tires are discarded worldwide every year, containing up to 90% vulcanized rubber that cannot be easily recycled (reprocessed) due to its complex crosslinked structure.

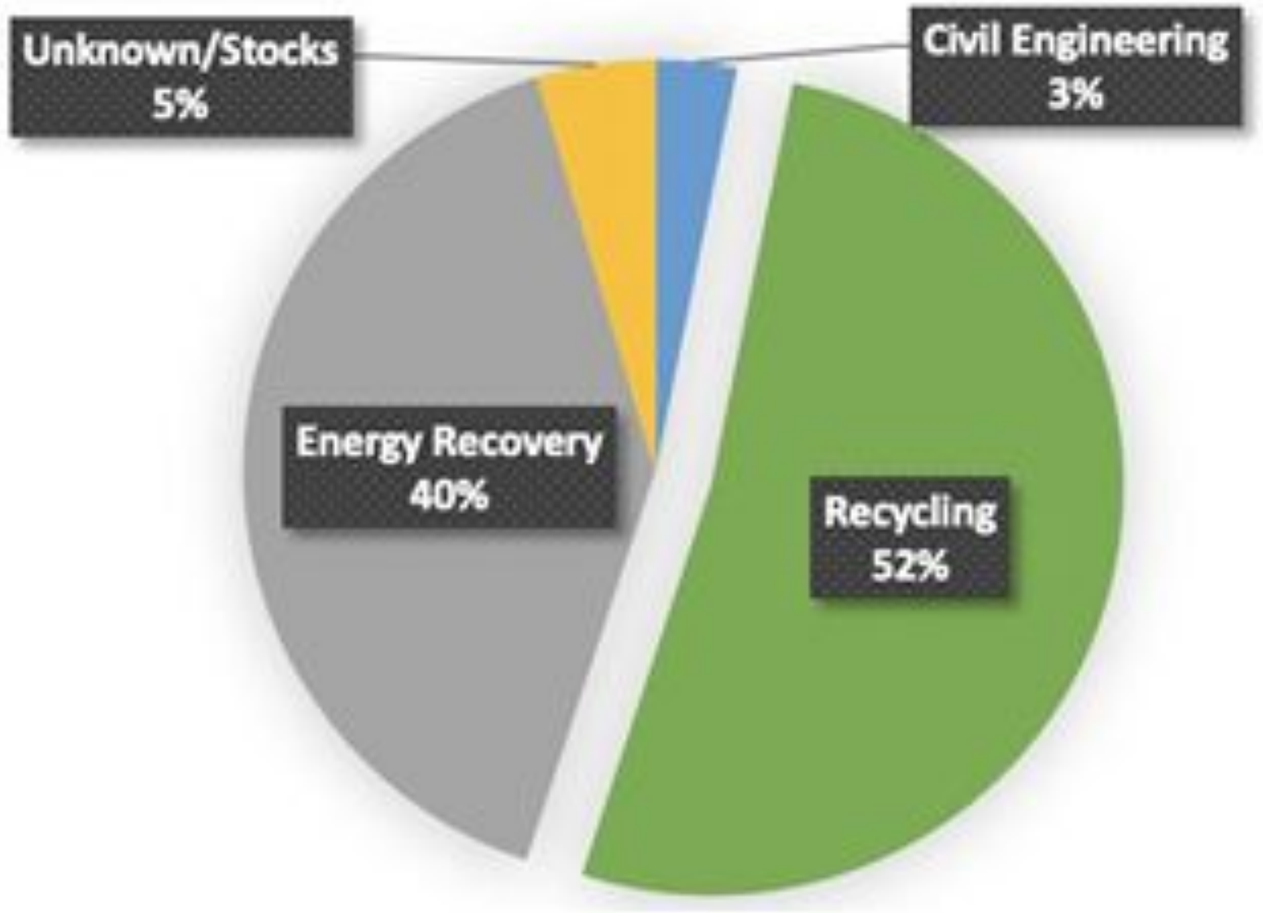
The global production of rubber materials in 2017 was about 26.7 Mtons divided into 12.31 Mtons of natural rubber and 14.46 Mtons of synthetic rubber.

The massive tire graveyard in Sulabiya, Kuwait, once containing over 42 million tires, was indeed a major environmental issue.

- In 2021 alone, authorities reported three different fires in Salmi: one on February 13, a second on March 30, and the third on April 29



Patowary, K., 2015. *World's Biggest Tire Graveyard in Sulabiya, Kuwait*



In 2019, data by the European Tyre and Rubber Manufacturers' Association covering 32 countries (EU27, Norway, Serbia, Switzerland, Turkey, and the UK) showed that 95% of ELTs in the 32 countries were collected and treated for material recycling and energy recovery.

European Tyre and Rubber Manufacturers' Association, 2021. In *Europe 95% of all End of Life Tyres were collected and treated in 2019*

Re-usable Items over Single-Time Items

One important step to implementing a low-waste lifestyle is reducing the amount of disposable items you use. By cutting back or eliminating single-use items, you can save the energy and materials that went into them AND prevent waste.

- GROCERY BAGS

	HDPE bag (No secondary reuse)	HDPE bag (40.3% reused as bin liners)	HDPE bag (100% reused as bin liners)	HDPE bag (Used 3 times)
Paper bag	3	4	7	9
LDPE bag	4	5	9	12
Non-woven PP bag	11	14	26	33
Cotton bag	131	173	327	393

Environment Agency, 2011. *Life cycle assessment of supermarket carrier bags: a review of the bags available in 2006*

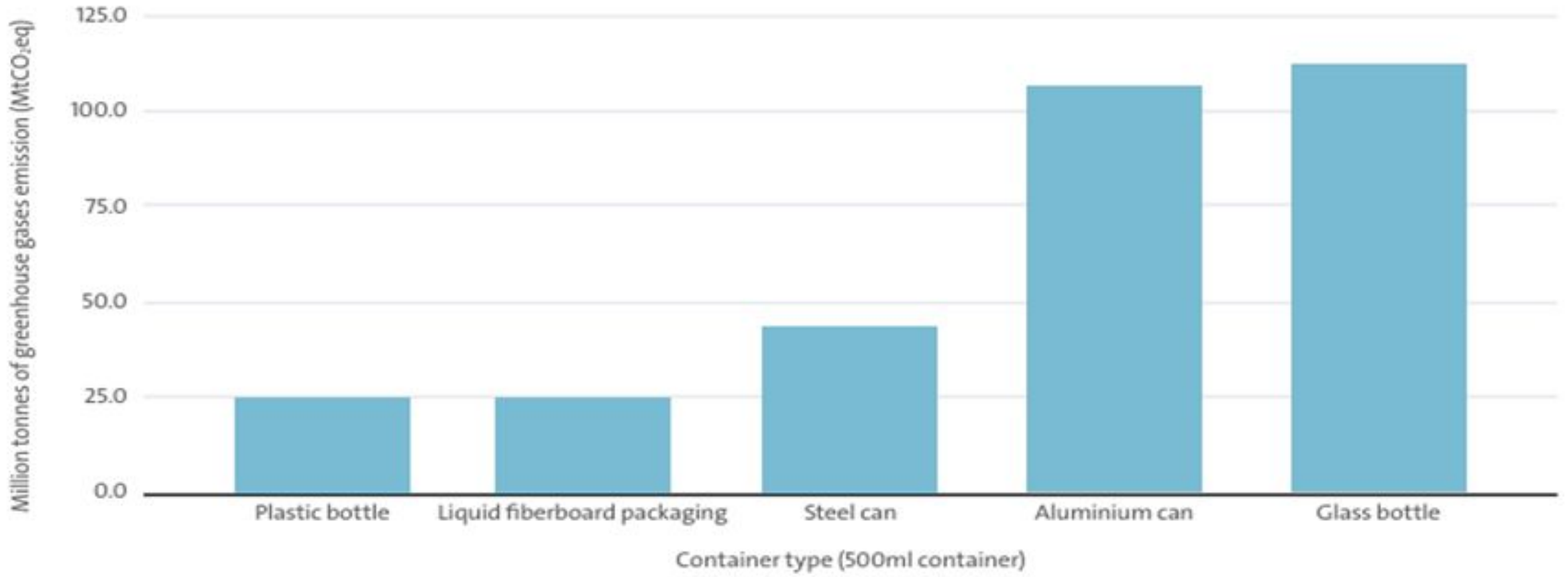
	LDPE average, reused as waste bin bag	
	Climate Change	**All indicators**
LDPE simple, reused as waste bag	0	1
LDPE rigid handle, reused as waste bag	0	0
Recycled LDPE, reused as waste bag	1	2
PP, non-woven, recycled	6	52
PP, woven, recycled	5	45
Recycled PET, recycled	8	84
Polyester PET, recycled	2	35
Biopolymer, reused as waste bag or incinerated	0	42
Unbleached paper, reused as waste bag or incinerated	0	43
Bleached paper, reused as waste bag or incinerated	1	43[4]
Organic cotton, reused as waste bag or incinerated	149	20000
Conventional cotton, reused as waste bag or incinerated	52	7100
Composite, reused as waste bag or incinerated	23	870

Danish Environmental Protection Agency, 2018. *Life Cycle Assessment of grocery carrier bags*

WATER BOTTLES

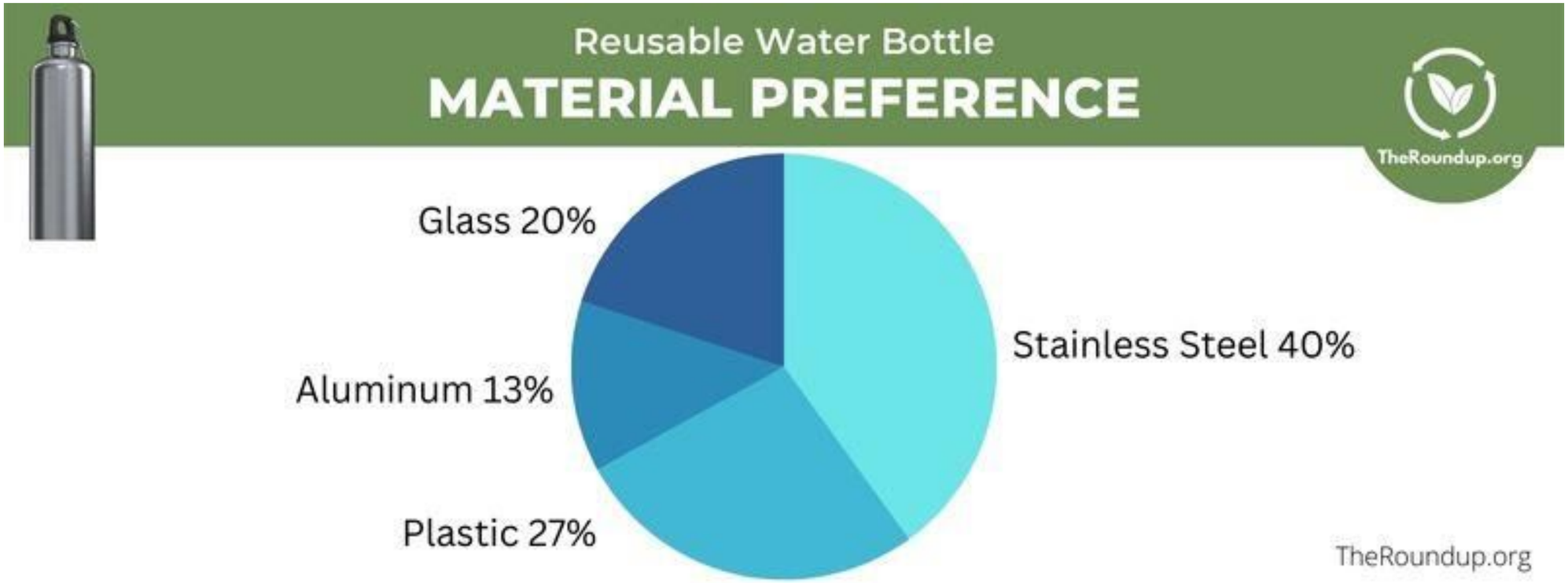
Six to seven times more water goes into manufacturing and filling bottles, filtering water, and cleaning the bottling facility than goes into the bottle itself.

It takes more than 17 million barrels of oil per year to produce the plastic for bottles. In the US alone, we're consuming 1.7 billion bottles of water each week, and the final kicker is that less than 30% of these bottles are recycled.



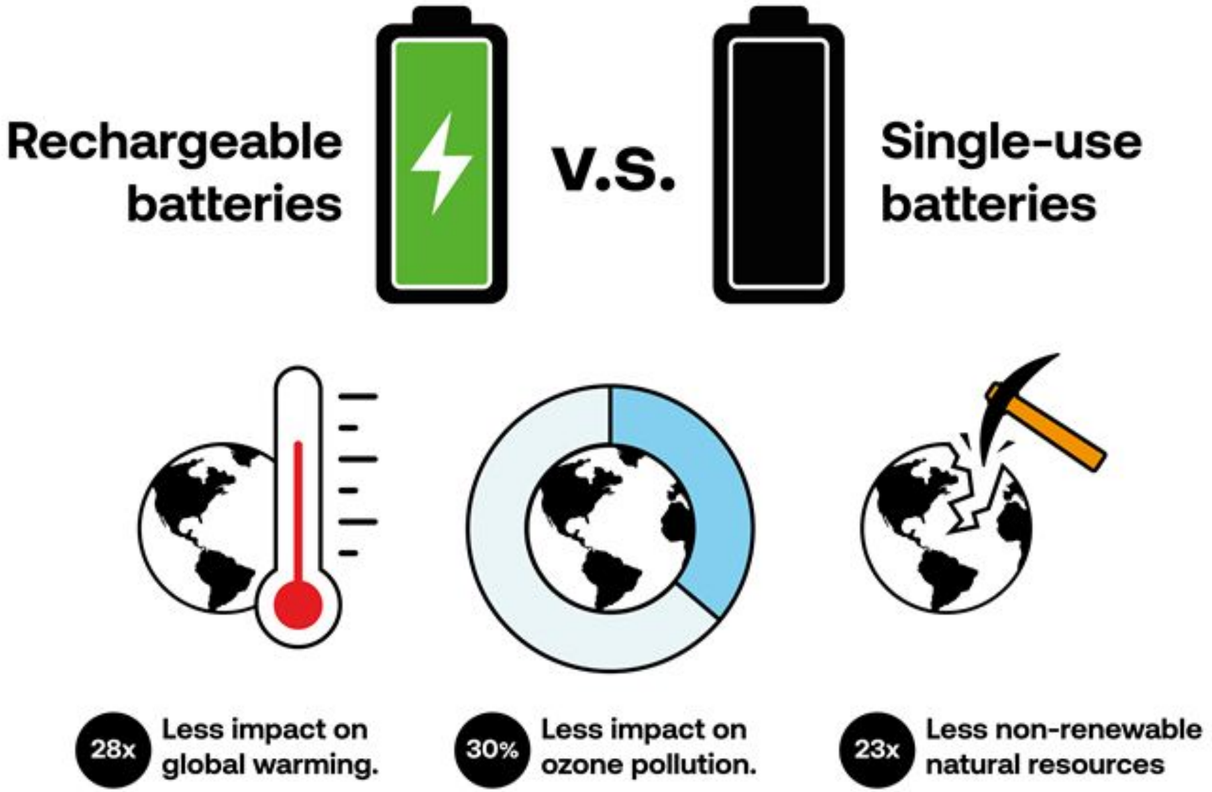
Imperial College London, 2019. *Examining Material Evidence the Carbon Fingerprint*

Reusable bottles become comparable somewhere between 10 and 30 uses, depending on the material, with plastic coming in as the lowest impact per use followed by steel and aluminium.



Ruiz, A., 2024. *15 Fascinating Reusable Water Bottle Statistics & Facts*

RECHARGABLE BATTERIES



Studies show that rechargeable batteries have about 30 times less environmental impact in terms of global warming potential compared to single-use batteries.

While rechargeable batteries are typically recycled at higher rates, it's still important to note that about 90% of all batteries (mostly single-use) are not recycled.

VRR, 2022. *Can rechargeable batteries really oust disposables in cool containers?*