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THE INVISIBLE THREAT

digital waste and digital pollution

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www. greenco-project.eu

Preface

According to research by the University of Surrey's Faculty of Engineering and Physical Sciences (2015), a single smartphone emits 95 kilograms of CO2 over its useful life, which is expected to be two years. Every text message, every phone conversation, and every video you upload or download is processed by a data centre. Telecommunications networks and data centres need a lot of energy to serve you, and most data centres are still fuelled by fossil-fuel electricity.

In total honesty, we are unaware of our energy use. Although technology helps to lower the carbon footprint of other businesses by making them more efficient, the global carbon footprint of the Information and Communication Industry (ICT), encompassing primary consumer gadgets, data centres, and communication networks, might reach 14 per cent of the 2016-level worldwide Greenhouse Gas Emissions (GHGE) by 2040.

Consequently, the Information Technology Industry would contaminate the environment more than automobiles or motorbikes, considerably increasing greenhouse gas emissions. Smartphones are now the most environmentally destructive gadgets, with 85 per cent of their emissions effect coming from production: natural resources utilized, energy usage, and transportation of components to factories as well as completed devices to places of sale.

This e-book aims to provide you with all the information you need, including practical tips, on digital pollution, energy consumption and electronic waste. We hope, through this book, to provide you with the tools you need to make better-informed decisions, improve the sustainability of your habits, and become more familiar with the European context and initiatives in support of ecological mindfulness and well-being.

The first chapter will introduce you to the challenges related to energy consumption, both from industry and the average household user, and examine the impact and the need for impact reduction. The first chapter will also provide some practical ideas and information on how to minimise your energy usage, decrease equipment and equipment management expenses, and provide additional valuable information.

The second chapter will provide an overview of the various categories of electronic waste, why recycling e-waste is essential, and how it can be done individually. Furthermore, in this chapter, you will find some tips and tricks for reducing and recycling electronic waste and helpful information about e-waste recycling.

Governments, companies, non-governmental organizations and citizens must join forces in initiatives through which they produce and consume responsibly, reducing emissions and making better use of resources. In this situation, it is essential to be creative and propose initiatives that have a multiplying effect on the rest of society**. In the third chapter**, we have compiled some initiatives successfully carried out by different actors that we hope will serve as an inspiration to others to apply in their small or large areas of action.

The fourth and final chapter analysed the EU legislation regarding environmental protection when this book was composed (2022). This chapter will provide an overview of the historical process for creating the first global policies on the environment, with all the steps taken, especially at the

United Nations level, from the 70s to 2000. Finally, the focus will be on the thematic core of the GreenCo project: laws on energy reduction and green energy, the connection between the environment and ICT production, and e-waste reduction.

Sustainability is a joint responsibility, and the future of our planet is in our hands. We sincerely hope you enjoy reading this book, but also that it inspires you to act sustainably, pilot your own initiatives and spread awareness in your circle of influence.

Feel free to contact us with questions, comments, or feedback on www. greenco-project.eu.

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1. Energy Consumption

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Organisation. CMQ Numérique

Chapter Summary.

In this area of the e-book, we will present challenges related to energy consumption, both from industry and the average household user, and examine the impact and the need for impact reduction. The chapter will give more insights and trends on current challenges and breakthroughs in energy-saving technology. The chapter will provide practical ideas and information on how to minimise your energy usage, decrease equipment and equipment management expenses, the benefits of reducing energy consumption, and additional valuable information.

Keywords.

Energy Consumption, Energy Reduction, Carbon Footprint, Green Energy.

1.1. Introduction

Digital pollution includes all sources of environmental pollution produced by digital tools. It is divided into two parts: the first is related to the manufacture of any digital device, and the second to the functioning of these tools.

REMEMBER!
Digital pollution is not negligible and increases incredibly quickly.

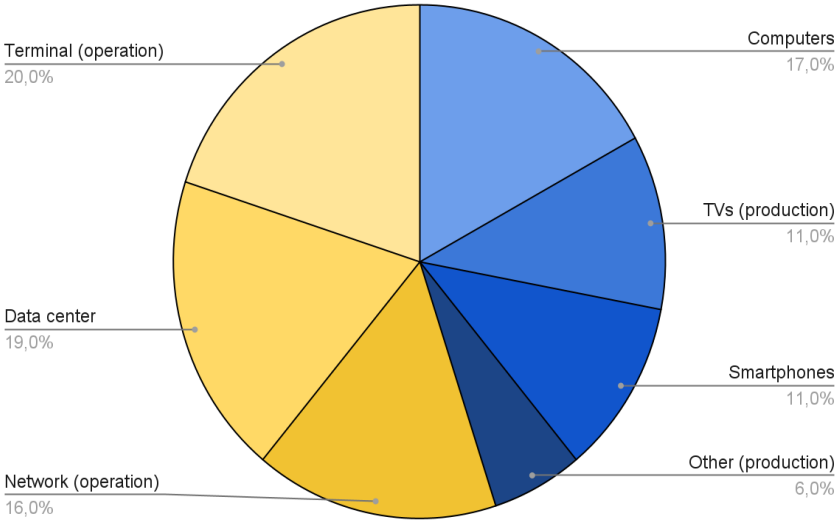

Figure 1 Distribution of Energy Consumption (Operation vs Production) in 2017 (The Shift Project 2018[1])

[1] The Shift Project – Juillet 2019."Climat, l'insoutenable usage de la vidéo en ligne. Le cas pratique de sobriété numérique". Available online at: https://theshiftproject.org/wp-content/uploads/2019/07/2019-01.pdf

Experts estimate that if the Internet were a country, it would be the 3rd largest electricity consumer globally, with 1500 TWh per year, behind China and the United States. In total, digital technology consumes 10 to 15% of the world's electricity, the equivalent of 100 nuclear reactors. And this consumption doubles every four years!

In 2017, 55% of the energy consumption of the digital sector was for operations and 45% for the construction of devices (computers, screens, smartphones)[2], as seen in Fig. 1. This chapter will explain how the Internet and the application usages induce electricity consumption. We will detail the infrastructure, that is, the machines' organisation. Then, we explain what happens when we surf the web, send an email or watch a movie online.

To understand the impact, we will use a carbon footprint measure that calculates the total climate change impact of something by a carbon dioxide equivalent (CO2e). It translates all different greenhouse gases into a comparable amount of CO2e. As a result, the effects can be compared under the same metric. Remember that those figures are estimations subject to change depending on the factors. For instance, the carbon footprint of streaming video depends first on the electricity usage and then on the CO2e emissions associated with each electricity generation unit.

REMEMBER!
When speaking about the environmental footprint, it is crucial to remember the orders of magnitude and not the precise figures.

1.2. Electronic Devices

The digital world starts with electronic devices. In 2021, the number of mobile devices operating worldwide stood at **almost 15 billion** (Statista[3]). This is the hidden side of the iceberg because we generate around 40 million tons of electronic waste yearly (The World Counts[4]). Take a few minutes to observe around you. What kind of electronic devices can you see? How many of them belong to you?

Beyond the energy required to build these devices, each requires electricity to be operated. Do you know how much power they consume?

Table 1 illustrates the power consumption difference between on-mode and stand-by. Keep in mind that those figures are average values, and there can be huge differences between two different models. Figures are given in Watt (W), a unit of power.

[2] The Shift Project – Juillet 2019."Climat, l'insoutenable usage de la vidéo en ligne. Le cas pratique de sobriété numérique". Available online at: https://theshiftproject.org/wp-content/uploads/2019/07/2019-01.pdf

[3] Statisa. "Forecast number of mobile devices worldwide from 2020 to 2025 (in billions)". Available online at: https://www.statista.com/statistics/245501/multiple-mobile-device-ownership-worldwide/

[4] The World Counts. "Electronic Revolution = E-Waste". Available online at: https://www.theworldcounts.com/stories/electronic-waste-facts

	DVD player	Printer	PC	Laptop	TV 100Hz, 96cm	Gaming station
On-Mode Power Consumption	17.9 W	7 W	60 W	40.3 W	110 W	150 W
Standby Power Consumption	13.9 W	5.3 W	4.1 W	1.1 W	0.3 W	0.3 W

Table 1 Power Consumption for Different Appliances in On-Mode and Stand-By.

To evaluate the impact of your energy consumption, you need to assess the energy amount used. It is expressed in kilowatt-hour (kWh), power sustained for one hour. An electric appliance consuming 1000 watts (1 kilowatt) operating for one hour uses one kilowatt-hour energy. Then, it would help if you converted it into Carbon dioxide equivalent CO2e, a metric for comparing the emissions of various greenhouse gases. The conversion of electrical power into CO2e strongly depends on how the electricity is produced: 1 kWh of hydropower produces only 4 grams of CO2 eq., compared to 1 kg of CO2 eq. for 1 kWh of coal. The average for Europe is estimated to be 0.45 kg CO2e. / kWh.

REMEMBER!
In Europe, a kilowatt-hour of energy represents 0.45 kg CO2e, but it varies a lot depending on the way the electricity is produced

A simple way to decrease energy consumption is to chase **vampire power**. Vampire power is also known as standby power and phantom load. It corresponds to the electricity wasted when devices are just by being plugged in (even if they're switched off). To chase the vampire power, you can:

- unplug or turn off appliances you do not use
- plug home electronics on power strips that can be switched off
- pay attention to the consumption when you buy a new appliance

REMEMBER!
Decreasing your energy consumption allows you to reduce your carbon footprint. Switch off your devices whenever you can.

1.3. The Hidden Cost of the Internet Infrastructure

The Internet is now part of our life. It is quite natural for us to connect to the Internet. To make this possible, many devices and equipment are installed everywhere. Most of them need electricity to run. As written previously, if the Internet were a country, it would be the 3rd largest electricity

consumer globally with 1500 TWh per year, behind China and the United States. In total, digital technology consumes 10 to 15% of the world's electricity, the equivalent of 100 nuclear reactors.

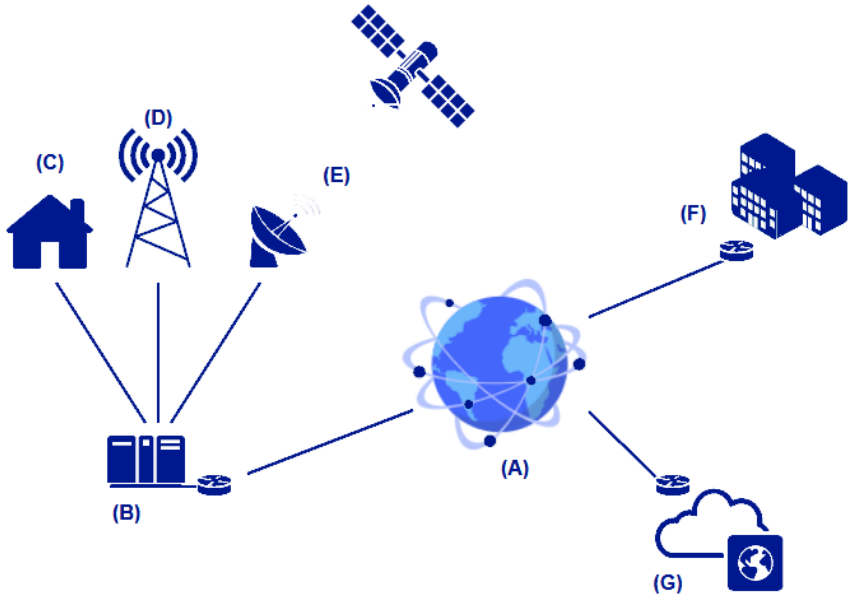

Figure 2 Infrastructure to Access the Internet

There are different ways to access the Internet, as illustrated in Fig. 2. To access the Internet (Fig. 2. A), an individual must sign a contract with an Internet Service Provider (Fig. 2. B). The provider will give you equipment to be installed in your home (Fig. 2. C.). This equipment creates a small Local Area Network (detailed Fig. 3). The provider can also propose you a 4G/5G contract. The 4G/5G connection to the Internet is possible through relay antennas (Fig. 2. D) or satellite connection (Fig. 2. E).

Organisations (Fig. 2. F), such as companies, schools, and universities, generally install dedicated networks to allow their members to access the Internet easily. Some companies offer cloud services (Fig. 2. G), i.e., services accessible from the Internet.

Each (local) network is connected to the others, mainly with cables. Those cables are similar to the roads that connect cities. They can be more or less "large". The main routes for the Internet are called the **Internet Backbone**. They are composed of fibre-optic cables. The continents are connected with fibre-optic submarine cables, allowing rapid data exchange. Similar to roads connected by junctions, the wires are connected one to the other with **routers**. They are responsible for the traffic directing functions on the Internet. A satellite connection is also possible but slower than a cable connection.

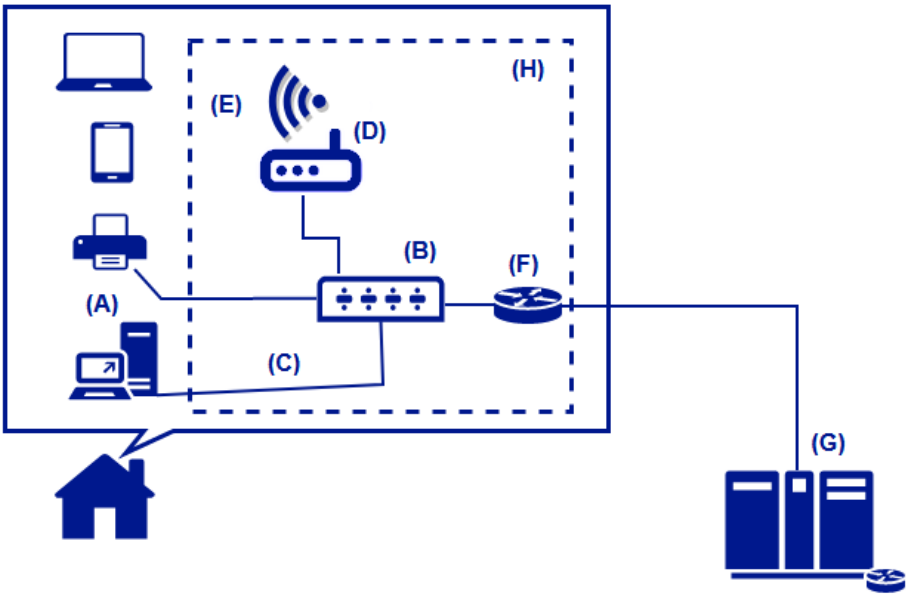

Figure 3 The Infrastructure at Home Based on a Local Area Network (LAN)

To allow you to access the Internet, your provider will give you one or several devices. You might physically connect your PCs or printer (with a cable) to the hub or switch device (Fig. 3. B). The cable is called “ethernet cable” (Fig. 3. C). A wireless connection (Fig. 3. E) is only possible if a Wi-Fi connector is installed (Fig. 3. D). All of these form a Local Area Network (LAN). The link between this network and the Internet (Fig. 3. G) is done thanks to an appliance called ‘router’ (Fig. 3. F).

Sometimes your provider proposes only one appliance, frequently called a set-top Box (Fig. 3. H), that combines the switch, the wireless router, and the router (Fig. 3. H). The set top boxes have a power consumption of 7 to 20 W in on-mode and 0.5 to 16 W in standby mode. Thus, a set-top box of 10Wh, used 24h a day and 365 days a year, consumes 24 x 365 x (10/1 000) = 88 kWh, 40 Kg of CO2e (considering the European average 0.45 kg CO2e. / kWh).

If we consider every home with a box, we are looking at a tremendous number which can be lowered with a bit of effort from everyone by switching off the box when it is not used (night, vacation, etc.).

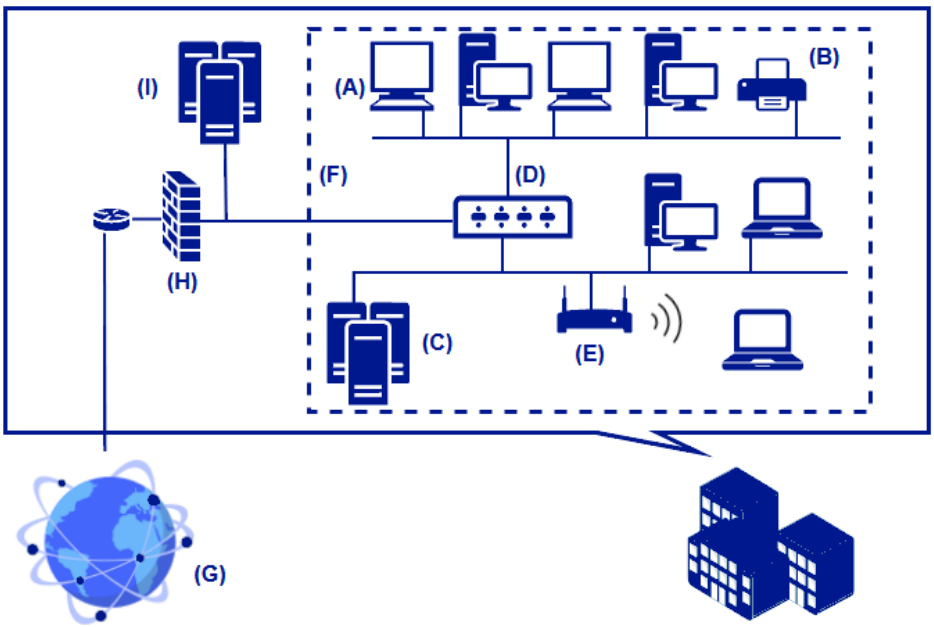

Figure 4 An Intranet

Organisations such as universities or companies may want to offer their members a way to communicate safely. They may propose an intranet (see Fig. 4). An **intranet** is a private network within an enterprise that uses the same technology as the Internet. Here, “private” means only the organisation’s members can access the intranet. Computers (Fig. 4. A) and other appliances such as printers (Fig. 4. B) are connected to a local server (Fig. 4. C) with a wired infrastructure (ethernet cable and switch - Fig. 4. D) or a wireless infrastructure (Wi-Fi - Fig. 4. E).

The infrastructure can be based on a Local Area Network (LAN) if it spreads out a small geographic area (e.g., a building) or on a **Wide Area Network** (WAN) if it is more prominent (Fig. 4. F). The intranet is usually isolated from the Internet (Fig. 4. G) by a firewall security system (Fig. 4. H). It monitors and controls the incoming and outgoing network traffic based on predetermined security rules. Additional servers (Fig. 4. I) can also be installed to provide public content (e.g., websites).

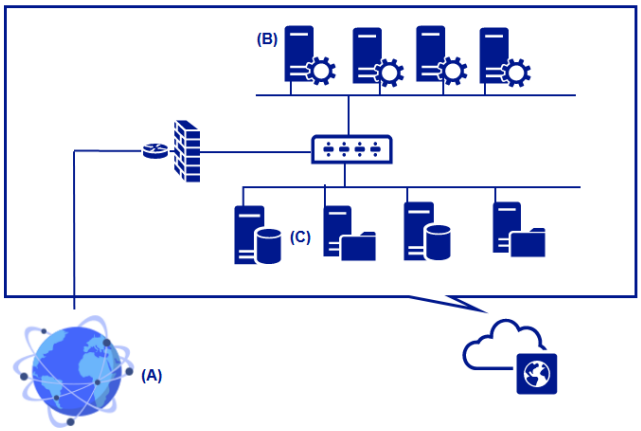

Figure 5 A Cloud Infrastructure

More and more companies and individuals use the cloud to store their data. The **cloud** refers to a group of networked elements providing services offered by different companies and not directly managed by the user (Fig. 5). Resources (data and/or computing power) are accessible globally from the Internet (Fig. 5. A). The cloud infrastructure relies on many interconnected servers dedicated to computation (Fig. 5. B) or data storage (Fig. 5. C). They are generally housed in data centres, (set of) building(s) in which the computers and storage systems are installed (Fig. 6).

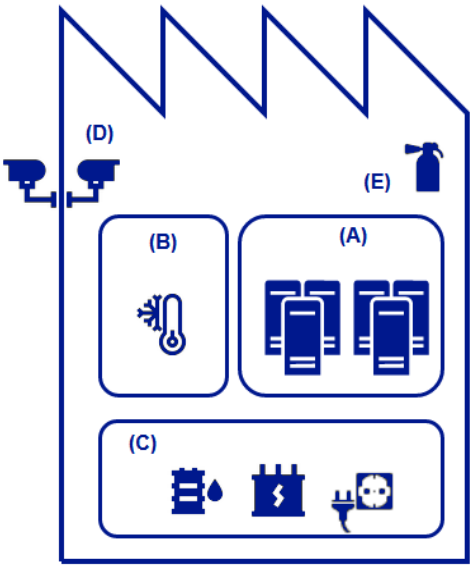

Figure 6 A Data Centre

A data centre machine room includes servers (Fig. 6. A) and a powerful air-conditioning system to maintain a low temperature (Fig. 6. B). It also integrates different means to provide energy (electrical connection, generator and battery - Fig. 6. C), a video-surveillance system (Fig. 6. D) and a fire protection system (Fig. 6. E).

A data centre is very energy-intensive. According to a report by the European Commission[5], between 2010 and 2018, the energy consumption of data centres rose from 53.9 TWh/year to 76.8 TWh/year. Global data centre electricity use in 2020 was 200-250 TWh[6]

Each device that makes the Internet (computer, server, router, switch, Wi-Fi connector) is electrically operated. They consume electricity even when they are not solicited, and their consumption increases when used (e.g., sending an email to its destination, downloading a document, etc.). More and more local networks, servers, routers, cables, clouds, and data centres are being installed to deal with increased Internet traffic. Internet development is so vast and rapid that electricity consumption doubles every four years.

[5] European Commission 2020. "Energy-efficient Cloud Computing Technologies and Policies for an Eco-friendly Cloud Market". Available online at: https://www.actu-environnement.com/media/pdf/news-36483-etude-UE-consommation-energie-centre-donnees-cloud.pdf

[6] IEA analysis based on Masanet et al. (2020). Available online at: https://www.iea.org/reports/data-centres-and-data-transmission-networks

REMEMBER!
By adopting good habits, each of us can reduce the electricity consumption of the Internet and thus slow down Internet development.

The following section explains what happens when we use the Internet to send an email, watch a movie online, etc. It will help you to understand the impact of changing your habits.

1.4. Internet Usage and Electricity Consumption

The Internet is a network of networks. It is a means to connect different devices (such as computers) and allow them to communicate. Various applications exist on the Internet infrastructure, such as the mail and the World Wide Web.

In 2021, for example, it was estimated[7] that in just one minute:

- 197,6 million emails were sent, 69 million messages on WhatsApp and Facebook Messenger, 200 000 on Twitter.
- 500 hours of content were uploaded to YouTube and 3,4 million on Snapchat.
- 28 000 subscribers were watching videos on Netflix.
- Over €1.3 million were spent online.

Each of those applications/usages induces some electricity consumption. In the following, we explain why and how.

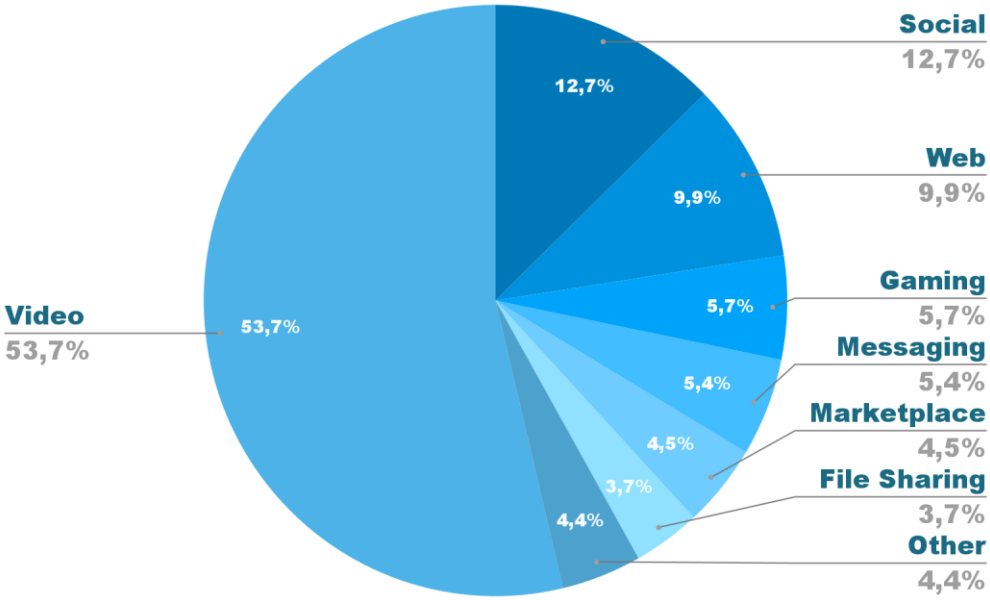

Figure 7 Internet Traffic Repartition (The Global Internet Phenomena Report[8])

[7] Lori Lewis 2021."Infographic: What Happens In An Internet Minute 2021". Available online at: https://www.allaccess.com/merge/archive/32972/infographic-what-happens-in-an-internet-minute

[8] The Global Internet Phenomena Report January 2022. Available online at: https://www.sandvine.com/phenomena

1.4.1. Messaging

Electronic mail (email or e-mail) is a method of exchanging messages between people using electronic devices. Basically, a user writes addressed to the email address of the recipient (Fig. 8. A). The message is first transmitted to the mail server of the email sender (Fig. 8. B). Then, it is relayed through the Internet (Fig. 8. C) until it reaches the mail server corresponding to the recipient address (Fig. 8. D). Finally, the message is picked up when the recipient wants to read it: it will thus be copied on the device on which it will be read (Fig. 8. E).

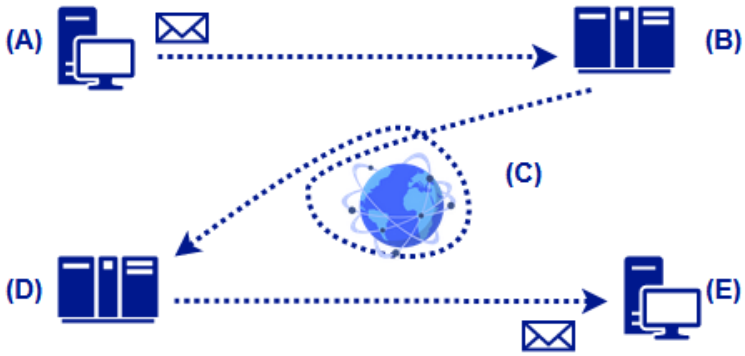

Figure 8 Transmission of an Email

When studying the carbon footprint, you should consider both the sending and storage of the email. The footprint is more significant if the email contains attached files and/or if the number of recipients is large. The carbon emissions of an email vary according to its content: from 0.3 grams of CO2e for a spam email to 4 g. of CO2e for a standard on and up to 50 g. of CO2e for an email containing a photo or a large attachment, as visible in Fig. 9[9].

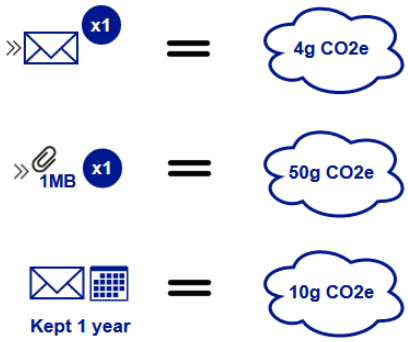

Figure 9 Email Impact

Those figures are average estimations. According to Basile Fighiera[10], the carbon impact of an email is highly variable depending on its use and the configuration in which the email is written by

[9] Mike Berners-Lee. "How bad are bananas? The Carbon Footprint of Everything". Green Profile; Main Edition (13 May 2010). ISBN-13: 978-1846688911

[10] Basile Fighiera LinkedIn page: https://www.linkedin.com/in/basile-fighiera-b05805163/

the sender and read by the recipients. It also depends if the mail is stored directly on the computer or a server (which is the case if you use a webmail application). The storage cost is more critical since emails are often stored for years on servers accessible seven days a week, 24 hours a day. Some estimations (ADEME[11]) indicate that an email stored on a server for one year corresponds to 10 grams of CO2e.

The carbon footprint of an email may seem negligible, but the number of emails that are exchanged must be considered. An estimated 306.4 billion emails were sent and received per day in 2020. Email statistics predict that by 2025, this number will reach 376.4 billion (Statista[12]). On average, a person sends and receives 121 business emails per day[13].

To evaluate the carbon footprint induced by your emails, you can use several websites, such as:

https://8billiontrees.com/carbon-offsets-credits/reduce-carbon-footprint/texts-emails/

REMEMBER!
You can act to decrease the digital pollution generated by emails.

You can:

- Make sure you're sending to the right people (limit the recipients to the ones that are needed)
- Unsubscribe from mailing lists that you do not read.
- Remove useless mails from your mailbox (including inbox, junk, sent).
- Stock your mail locally (on your computer) instead of on the server.
- Use temporary deposit sites to transmit a document and provide a link instead of attaching it to your email.
- Use text format (instead of HTML)
- Close your mailbox window as often as possible to prevent constant update
- Reduce the descriptive part of the email, narrowing it down to the essential.
- If you have one, pay attention to your signature (choose a textual version).

Instant messaging applications are similar in how users send messages to other users. They differ from email in that conversations over instant messaging happen in real time. Sending a message via a messaging app such as WhatsApp or Facebook Messenger is estimated to be slightly less polluting than sending an email. Anyway, this depends on the transmitted content: gifs, emojis and images have a larger footprint than plain text. A tweet is estimated to have 0.2 grams of CO2 footprint (Fig. 10).

[11] The French Agency for Ecological Transition. https://www.ademe.fr/en/frontpage/

[12] Statista. "Number of e-mail users worldwide from 2017 to 2025". Available online at: https://www.statista.com/statistics/255080/number-of-e-mail-users-worldwide/

[13] Campaign Monitor. (n.d.) *How Many Emails Does The Average Person Receive Per Day?.* Available online at: https://www.campaignmonitor.com/resources/knowledge-base/how-many-emails-does-the-average-person-receive-per-day/.

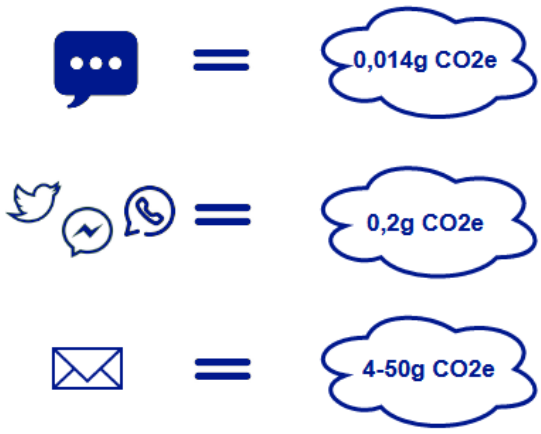

Figure 10 Footprint of Emails and Messages

Sending an SMS is estimated to be the most ecological alternative. Indeed, the SMSs are saved locally on your smartphone. The carbon emissions are reduced by almost 5 tonnes for every 100,000 messages sent. It is the equivalent of 26,000 km by car!

REMEMBER!
Sending SMSs instead of emails has a positive impact on digital pollution reduction.

1.4.2. Browsing for Information

It has become a reflex when we need information: we connect to the Internet and launch a search engine such as Google! According to Internet Live Stats, it is so natural that nearly 100,000 queries per second are made to Google. Since this engine represents approximately 92% of the world market share, daily internet searches can be estimated to be more than 9.5 billion daily.

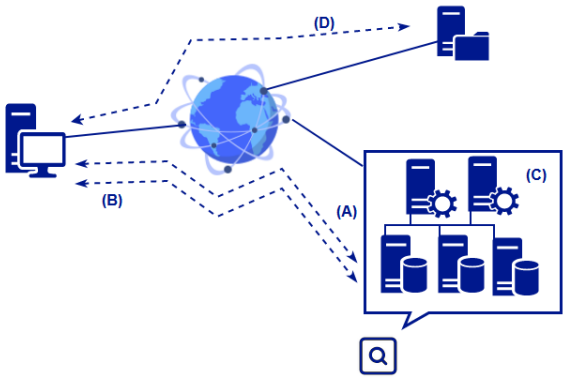

Figure 11 How Web Queries are Handled

A search on the Internet is performed in three steps. First, we ask for the web page of the search engine (Fig. 11 A). Once the web search engine's home page is displayed, we write our keywords and submit them (Fig. 11 B). The web engine server (Fig. 11. C) scours its databases to find a list of highly relevant website contents and sends back a page containing the list of the most pertinent website

addresses (also called URLs). When we click on one of those URLs, a query is relayed over the Internet until it reaches the website server, which will send back the page.

To be sure to propose the most relevant content, the web search engines constantly search for new pages on the web and unique content (the crawling phase) with dedicated servers. The new content is then memorised (also called *indexing*) in the databases.

When experts estimate the cost of a web search request, they generally consider the cost of the whole process: the energy necessary to send the messages with the request and its answer and the energy required by the engine to crawl and index the web pages. You will find many figures on the Internet that estimate the cost of an Internet query, mainly because it is challenging to estimate it precisely.

REMEMBER!
Keep in mind that if you reduce the number of Internet requests, you reduce the energy consumption of the Internet. Moreover, requesting by voice is more energy-expensive than typing it.

To reduce the cost of web search requests, you can:

- use the keyboard instead of your voice

To reduce the number of web search requests, you can:

- type the address of the web page directly if you know it
- use the bookmarks of your browser for sites you visit regularly

Each time you go on a website, the content of the website (i.e., the web pages you are browsing) is sent through the Internet. These pages include text, pictures, videos, advertisements, and interactive maps. The more data is on the pages and the more complex it is, the more significant its impact on the footprint. For instance, if you block ads, you get the same webpage, with the same content, without ads, fewer requests to random servers, and still with the stuff you want to see.

To evaluate the cost of your web surfing habits, you can install some ad-on on your web browser that evaluates the electricity consumption and greenhouse gas emissions that your Internet browsing leads to. For instance, you can find:

- https://theshiftproject.org/en/carbonalyser-browser-extension/ or
- https://microsoftedge.microsoft.com/addons/detail/wedeex/jbocoolinibenmobjadejejdbanalfee

To reduce the cost of surfing, you can:

- Block advertisements (you can use an ad blocker)
- When your web page contains a video, check the video quality, and change it from high-definition to standard-definition.

1.4.3. Internet Videos

In the Global Internet Phenomena Report[14], some experts indicate videos represent more than 53% of the Internet traffic in the first half of 2022. The most popular video websites were:

- YouTube with 14.61%,
- Netflix with 9.39%,
- Facebook Video at 4.20%, and
- TikTok at 4.00% of total app traffic.

The average European footprint of video streaming is estimated to be between 40 and 56 grams of CO2e per hour. Table 2 gives an overview of how the power consumption for streaming is distributed over the components. End-user devices (e.g. smartphones, personal computers, TVs) and peripherals (e.g. set-top boxes) are the elements that contribute the most to the energy and carbon impact of an hour of video streaming.

Moreover, the footprint of watching on a 50-inch TV is roughly 4.5 times that of watching on a laptop. Furthermore, watching a video on 50-inch TV results in an approximately 90 times higher footprint than watching on a smartphone. For this reason, the choice of the peripheral is essential when streaming. But since the construction of devices also has associated emissions (from raw materials to manufacturing and end-of-life), you should consider that increasing the period between device upgrades is essential for reducing your environmental impact.

Video streaming component stage	**% of total**
Data centre	1%
Transmission network	10%
Home router	38%
TV peripheral	5%
Screens	46%
Total	100%

Table 2 Emission Repartition for the Video Streaming Process for Europe in 2020 (Global Internet Phenomena Report)

The video traffic over mobile is growing at 55% per year. You can act to decrease the footprint of video on the Internet:

- Watch your videos on a low-consumption screen.

[14] The Global Internet Phenomena Report January 2022. Available online at: https://www.sandvine.com/phenomena

- Change your video quality to low definition (even if it is supposed to have a small impact on carbon emissions, it decreases the effective traffic on the Internet).
- During video conferences, turn off your camera if not needed.
- Download videos that you think you might watch several times.
- Choose a low-definition format when you upload videos or photos on your favourite social media.

1.5. Computer Science Trends

You may have heard about Artificial Intelligence, Bitcoin, Blockchains and NFTs (for Non-Fungible Tokens). They all have the common point of being very energy-hungry, thus impacting the carbon footprint. In the following, we give some elements to understand the different concepts and their environmental impact.

1.5.1. Artificial Intelligence

Artificial Intelligence (AI) is intelligence demonstrated by machines instead of the natural intelligence displayed by humans or animals. There are more and more applications/programmes that include Artificial Intelligence. For instance, Artificial Intelligence is used to interpret text (e.g., Chatbots) to allow a device to recognize voice (e.g. virtual assistant) or images (e.g. facial recognition or autonomous cars).

It is essential to understand that programs with Artificial Intelligence algorithms must be trained before being usable. Depending on the applications, the training can last for a long time and thus could significantly impact the environment. For instance, in 2019, researchers at the University of Massachusetts Amherst analysed various programs with Artificial Intelligence available online to estimate the energy cost required to train them. Converting this energy consumption into approximate carbon emissions and electricity costs, the authors estimated that the carbon footprint of training a single complex program is equal to around 300,000 kg of CO2e. For reference, this is equivalent to the order of 125 round-trip flights between New York and Beijing

Not everything is negative. As experts have shown, using an artificial intelligence program can significantly reduce greenhouse gas emissions [15]. Across sectors, Artificial Intelligence has helped organisations reduce greenhouse gas emissions by 13% across industries and improve power efficiency by 11% in two years. It also helped reduce waste and deadweight assets by improving their utilisation by 12%.

If you are working in the field of Artificial Intelligence or if you teach it, you can:

- Be aware of the negative impact of Artificial Intelligence on the climate.
- Educate Artificial Intelligence teams on the criticality of climate change.
- Lay down the technological foundations for Artificial Intelligence-powered climate change action.

[15] CapGemini Research Institute. “How Artificial Intelligence can power your climate action strategy”. Available online at https://www.capgemini.com/wp-content/uploads/2020/11/Climate-AI_Final.pdf

- Scale use cases based on impact for your sector and emissions intensity of particular functions.
- Collaborate with the climate action ecosystem.
- Harness the power of Artificial Intelligence to bring greater focus to reducing scope three emissions.

1.5.2. Cryptocurrency and Similar Technologies

Cryptocurrency is a digital currency, such as Bitcoin, Ethereum, Ripple, or Litecoin. They all follow the same paradigm, called blockchain technology. A blockchain is a decentralised system (called a database) shared among the nodes of a computer network. A blockchain is, by definition, "a chain of blocks" (see Fig. 12). Each block (Fig. 12 A) contains data protected by cryptographic processes and is connected to another to form a chain (Fig. 12 B).

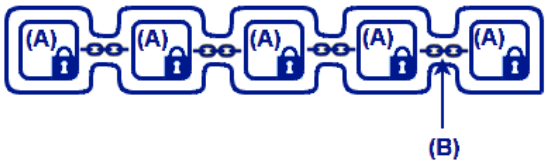

Figure 12 The Mechanics of Blockchain

In a blockchain, you can write some piece of data, but you cannot delete it. In essence, blockchain is decentralised. It means that it can be located all over the world. It makes them incredibly robust, as they can survive power outages and political turmoil.

There are probably over 10,000 blockchains today, either public or private. They are used for banking and payments, online data storage, and voting. Blockchains can be used to certify digital artworks. The idea is that a token is associated with a specific digital production to authenticate it. The tokens, which also indicate who possesses the product, are "Non-Fungible" (NFT): contrary to a coin, they cannot be replaced with another.

A process called mining is involved in safely verifying data blocks and adding them to a blockchain. During the mining, the data in the block are verified, the transactions on the block are recorded, and the new block is added to the blockchain. The verifications are based on complex calculations related to cryptographic algorithms. This is an energy-intensive process.

According to Digiconomist[16], "the carbon footprint of a single Ethereum transaction as of December 2021 was 102.38 kilograms of CO2e, which is equivalent to the carbon footprint of 226,910 VISA transactions or 17,063 hours of watching YouTube".

The expansion of cryptocurrency is extremely rapid. In 2019, the global market was estimated at $793 million. Between July 2020 and June 2021, the international adoption of cryptocurrency burst

[16] Robin Scher, 2022. "As cryptocurrency becomes mainstream, its carbon footprint cannot be ignored". Available online at https://www.downtoearth.org.in/blog/environment/as-cryptocurrency-becomes-mainstream-its-carbon-footprint-can-t-be-ignored-81118

by more than 880 per cent. And according to the market research organisation Facts and Factors report, it's expected to reach nearly $5.2 billion by 2026.

This increasing popularity of cryptocurrency has environmental consequences. The "mining" process requires a large amount of energy and thus creates a massive carbon footprint. According to a February 2021 CNBC article, based on data from the Bitcoin Energy Consumption Index from Digiconomist, an online tool designed by data scientist Alex de Vries, the carbon footprint of Bitcoin emits nearly 37 megatons of CO2e into the atmosphere every year, which represents New Zealand's CO2e emissions.

Thanks to energy-efficient consensus protocols, less popular and newer platforms supporting NFTs have also advertised their environmental credentials. Palm uses the Ethereum blockchain to trade NFTs, claiming to consume 99% less energy than the original blockchain, while Cardano and Flow offer alternative models for NFT trading.

1.6. Green Computing

Green computing, also known as Green Technology or Green IT, is the environmentally responsible and eco-friendly use of computers and their resources. It includes the study of designing, engineering, manufacturing, using and disposing of computing devices in a way that reduces their environmental impact. Actions aim at using less energy, reducing waste and promoting sustainability.

Green Design aims to create energy-efficient digital devices, such as computers, servers, printers, projectors, etc., and programs. ***Green manufacturing*** seeks to reduce waste while manufacturing computers and other subsystems to decrease the environmental impact of these activities. ***Green use*** aims at using computers and their peripheral devices in an eco-friendly manner to reduce energy consumption. And ***green disposal*** aims at repurposing existing equipment or appropriately disposing or recycling unwanted electronic equipment.

In terms of usage, manufacturing and disposal, the tips are the same as those given to individuals. Reduce consumption and use, avoid replacing appliances, and optimise travel. Green design requires dedicated skills. More initiatives, guides, and training courses are proposed to design hardware and software cheaper, more performant, and/or more resilient.

If you are a software or a hardware engineer, you can act to reduce numeric pollution. You can:

- Be aware of the problem.
- Learn about green computing and green design.
- Propose energy-efficient solution.
- Educate your teams.

1.7. How Your Footprint is Computed

As written previously, the carbon footprint is an indicator expressed in carbon dioxide equivalent (CO2e), standardising the reading of the impacts of our activities. You may ask why estimations for carbon footprint vary so much from one information source to another.

To compute the carbon footprint, a protocol was defined[17]. First, you should determine the scope of the activities you are considering. Scope 1 considers only emissions are direct emissions from owned or controlled sources. Scope 2 adds indirect emissions from the generation of purchased energy. Scope 3 includes all indirect emissions (not included in scope 2) (see Fig. 13). So, to compare the carbon footprint estimations, you should first check for which scope it has been computed.

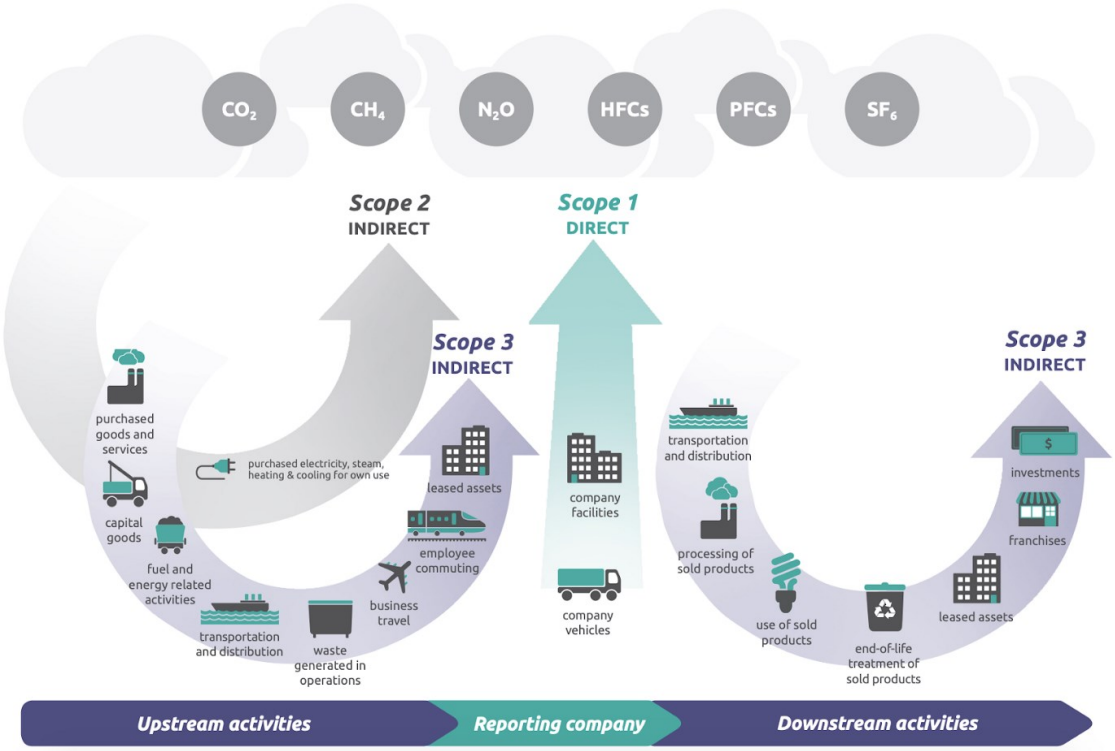

Figure 13 Overview of the Three Scopes for Carbon Footprint Computation. Source: GHG Protocol[18]

As soon as the scope includes the purchased electricity, the way the electricity is produced influences the results. In 2014, experts harmonised the carbon dioxide equivalent (CO2e) conversion of the electricity generating sources. As you can see in Fig. 14, coal is the worst CO2e emitter, followed by natural gas, with low-carbon solar, wind, and nuclear. Hydropower, biomass, geothermal, and ocean power may generally be low-carbon. Still, it depends on how the power stations were built (poor design or other factors may result in high CO2e emissions.

Since energy production varies from country to country, the carbon footprint will differ for the same action considering one country or another. Moreover, the intensity of emissions from electricity generation varies over time. These variations are significant enough to matter (sometimes

[17] GreenHouse Gas Protocol website: https://ghgprotocol.org/

[18] Diagram of Scopes and Emissions Across the Value Chain. Available online at: https://www.ghgprotocol.org/sites/default/files/ghgp/standards_supporting/Diagram of scopes and emissions across the value chain.pdf

more than an order of magnitude). As a result, it is challenging to compare independent estimates of ICT emissions directly[19].

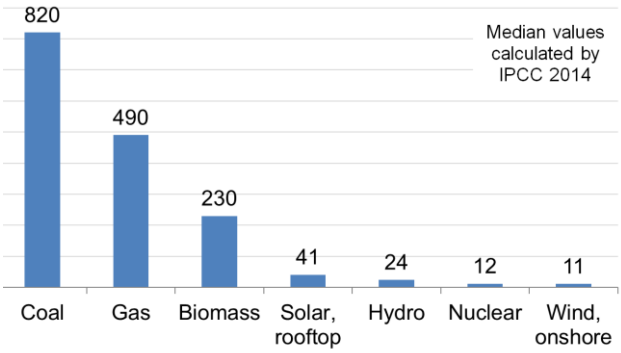

Figure 14 Lifecycle CO2e Emission (g/kWh), from Wikipedia[20]

REMEMBER!
CO2e emission estimations can vary depending on the scopes for carbon footprint computation and the source for electricity generation.

[19] The Global Internet Phenomena Report, January 2022. Available online at: https://www.sandvine.com/phenomena
[20] Wikipedia. Life-cycle greenhouse gas emission of energy source. Available online at: https://en.wikipedia.org/wiki/Life-cycle_greenhouse_gas_emissions_of_energy_sources

2. E-Waste Recycling

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Chapter Summary.

Electronic garbage, often known as e-waste, refers to wasted electrical or electronic gadgets. E-waste includes used electronics for reuse, resale, salvage, recycling, or disposal. With developments in the electronic world nearly occurring daily and increasing product availability to the general public, it is not unexpected to observe a phenomenal growth in the output of electronic trash over the last decade. The present chapter will define and examine what e-waste, or electronic garbage, is, how it has accumulated over time and the ongoing concerns and problems associated with recycling e-waste. The chapter will provide an overview of the various categories of electronic waste, why recycling e-waste is essential, and how it can be done individually. Furthermore, in this chapter, you will find some tips and tricks for reducing and recycling electronic waste and helpful information about e-waste recycling.

Keywords

Electronic waste, e-waste, e-waste reduction, e-waste recycling, e-waste optimization, recycling lifecycle

2.1. What is E-Waste?

Electronics are a necessity, source of joy and means of earning a living in modern life. Their broad availability and use have enabled a large portion of the world's population to enjoy greater living conditions.

Nevertheless, the way we generate, use, and dispose of electronics is not sustainable. Electronic dependence and the rapid obsolescence of devices have undoubtedly increased along with economic and technological development, resulting in a shorter product lifecycle and an increase in end-of-life (EOL) electronics[21].

REMEMBER!
From the vendor's perspective, EOL indicates that a product has reached the end of its useful life. As a result, unused electronic devices have become the fastest-growing domestic waste stream[22].

Technology has infiltrated every aspect of our existence, however, most of us rarely consider what happens to these devices when we discard or replace them. After the technology is disposed of, it becomes a source of many valuable materials. However, when recycled, some materials release

[21] Asante KA, Amoyaw-Osei Y, Agusa T (2019) E-waste recycling in Africa: risks and opportunities. Curr Opin Green Sustain Chem 18:109–117. Available online at: https://doi.org/10.1016/j.cogsc.2019.04.001

[22] Forti V, Balde CP, Kuehr R, Bel G (2020) The Global E-waste Monitor - 2020: Quantities, flows and the circular economy potential. United Nations University (UNU)/United Nations Institute for

hazardous compounds that negatively influence human health and the environment. Given the volume of electronics created and the presence of both harmful and valuable components, unwanted electronics are a growing concern. **The electronic devices discarded after their use are often referred to as "e-waste"**.

REMEMBER!
E-Waste, also known as Waste Electric and Electronic Equipment (WEEE), is made up of unwanted devices or gadgets that use electricity or their power is battery supplied. This term refers to a wide range of discarded items after usage. Some electronics are produced with sustainability in mind, allowing for their refurbishment. After being dumped, these electronics also fall into the category of electronic waste[23].

According to Eurostat[24], e-waste is the EU's fastest-increasing waste source, with less than 40% recycled. This also means a massive spike in EOL devices that must be recycled. This is a cause for significant concern, primarily due to the harmful and poisonous substances in e-waste, such as mercury, lead and cadmium.

- **Cadmium** is used to make nickel-cadmium (Ni-Cd) rechargeable batteries and preserve iron and steel against corrosion. Similarly to **Lithium**, a substance used to make Lithium-ion (Li-ion) batteries, for instance, Cadmium is highly toxic when disposed of improperly. Cadmium and its derivatives are hazardous, and exposure to this metal has been linked to cancer in the cardiovascular, renal, gastrointestinal, neurological, reproductive, and respiratory systems[25].
- **Lead** and **Mercury** are often used in the production of electronics. Lead is preferred for its malleability, durability, and conductive properties, while Mercury is used for liquid-crystal displays (LCD) devices. Unfortunately, these components are known to leak into the soil and contaminate water due to their overall extended degrading period.

Improper disposal of WEEE, including burning electronics or throwing them in the all-purpose recycle bins, can result in the emission of hazardous substances into the atmosphere, causing harm to our ecosystem and our health. On the other hand, contemporary electronics include rare and valuable materials that may be recycled and reused if WEEE is adequately controlled. This highlights the importance of proper disposal of electronic waste, which is most commonly conducted by recycling electronic waste. According to the European Union's WEEE Directive[26], improving the processes related to the overall treatment, including collection and recycling of electronic waste, can 1) improve sustainable production and consumption, 2) increase resource efficiency, and 3)

[23] Belgium: E-Waste in the EU: Facts and Figures (Infographic). MENA Report, Albawaba (London) Ltd., Dec. 2020.

[24] Eurostat. (2020) Recycling Rate of E-Waste. T2020_RT130. Available online at: https://ec.europa.eu/eurostat/databrowser/view/T2020_RT130/bookmark/table?lang=en&bookmarkId=a69be825-957e-473c-a81f-f02866dc9141

[25] UK Government Health and Safety Executive. (2010) Cadmium and You. Working with Cadmium. INDG391. Available online at: https://www.hse.gov.uk/pubns/indg391.pdf

[26] European Commission (2021). Directive 2012/19/EU Of The European Parliament and of the Council. Waste Electrical and Electronic Equipment (WEEE). Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02012L0019-20180704

contribute to the circular economy, meaning promoting the reuse, repair, refurbishment, and recycling of existing resources and goods for as long as feasible.

REMEMBER!
A circular economy is a production and consumption paradigm that promotes the reuse, repair, refurbishment, and recycling of existing resources and goods for as long as feasible. The life cycle of items is, therefore, prolonged.

However, properly disposing of electronic waste is highly dependent on the category under which the device falls. The types of WEEE will be discussed next.

2.1.1. E-Waste Categories

The composition of e-waste is quite complex and varies between product categories. It comprises about 1000 distinct compounds classified as “dangerous” and “non-hazardous”. These compounds contain ferrous and nonferrous metals, plastics, glass, wood and plywood, printed circuit boards (PCB), concrete and ceramics, rubber, and other materials. Iron and steel account for over half of all E-waste, followed by plastics (21%), nonferrous metals (13%), and other elements[27]. Nonferrous metals include copper (Cu), aluminium (Al), and precious metals such as silver (Ag), gold (Au), platinum, palladium, and others. Including metals such as lead, mercury, arsenic, cadmium, selenium, hexavalent chromium, and flame retardants over threshold amounts of e-waste defines it as hazardous waste.

According to the European Union’s WEEE Directive[28], we can broadly differentiate ten categories of electronic waste. Those categories are as follows:

- **Large Household Appliances.** This broad category includes temperature-controlling appliances, such as refrigerators, freezers, air conditioners, electric heating appliances, and fans. Cooking equipment, including microwaves, stoves, fanning and exhaust ventilation, also falls into large appliances. Large household appliances are dishwashers, washing machines and dryers, and more. These appliances are recycled by dedicated companies that can pick them up from your house and safely dismantle them for recycling and reuse. Services by such companies are usually free of charge. When possible, it is recommended to contact the vendor, as this could increase the chances of some waste being reused for spare parts.
- **Small Household Appliances.** We can put almost all household appliances that are meant to be frequently moved or lifted to use into this category. Vacuum cleaners, cleaning appliances and electronics for processing textiles comprise this category. Smaller kitchen appliances, such as toasters, coffee grinders, and hair and electronic

[27] Puckett, Jim & Byster, Leslie & Svtc, Sarah & Westervelt, & Ban, Richard & Gutierrez, Sheila & Davis, Mff & Hussain, Madhumitta & Dutta, Toxics & India,. (2002). Exporting Harm: The High-Tech Trashing of Asia.

[28] European Commission (2021). Directive 2012/19/EU Of The European Parliament and of the Council. Waste Electrical and Electronic Equipment (WEEE). Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02012L0019-20180704

beauty appliances, are considered small household devices. Dedicated companies can recycle those appliances, but some could be brought to recycle bins and facilities, targeting small household appliances. All batteries should be removed and recycled separately. This category, however, does not include electrical tools used in the home, which fit into a dedicated category.

- **IT and Telecommunications Equipment.** All types of telecommunication equipment fall into this category, including phones, fax machines, and pay telephones. IT equipment, including servers, computers (laptops and personal computers) and their periphery, are part of this category. Interestingly, printers and copy machines are part of this category as well, however, their toners and ink cartridges are usually recycled separately by dedicated companies. Because of the current spike in popularity of 3D printing, certain 3D printers (FDM variant) have been created to produce waste that can be readily recycled, reducing the number of dangerous pollutants in the atmosphere. Excess plastic produced by these printers as a by-product may also be utilised to construct new 3D printed objects.
- **Consumer Equipment and Photovoltaic Panels. Radio sets.** Television sets, video cameras, audio amplifiers, and electronic musical instruments are separate categories of appliances for recycling. All products or equipment to record or reproduce sound or images, including signals or other technologies for distributing sound and pictures than telecommunications, are considered consumer equipment. Photovoltaic panels also fall into this category.
- **Lighting Equipment**. Includes straight fluorescent lamps, compact fluorescent lamps, high-intensity discharge lamps - including pressure sodium lamps, metal halide lamps, low-pressure sodium lamps, and LED.
- **Electrical and Electronic Tools.** This category does not include large-scale stationary industrial tools, and is more focused on household appliances for turning, milling, sanding, grinding, sawing, cutting, shearing, drilling, making holes, punching, folding, bending or similar processing of wood, metal and other materials. This category also includes garden appliances such as mowing or water dissemination tools.
- **Toys, Leisure and Sports Equipment.** Apart from apparent appliances which fall into this category, including toys and games, including game consoles, this category also includes larger game appliances such as slot machines and casino equipment. Nevertheless, the class also comprises equipment not traditionally considered IT equipment, such as sports monitors, smart watches, GPS modules, etc.
- **Medical Devices.** All medical appliances powered by electricity or batteries fall into a separate category of medical devices, regardless of their size, from radiotherapy to cardiology equipment, pulmonary ventilators, laboratory equipment and more, to thermometers suitable for home use. Interestingly, freezers and cooling technology used for medical purposes are not recycled with large household appliances but are also under the medical devices category. Implanted products such as cardiovascular bypass pumps or other EEE devices implanted in the body are not recycled under this category. The same goes for infected devices or devices marked as biological hazards.

- **Monitoring and Control Instruments.** This category puts all detectors under one roof, such as smoke detectors, thermostats, and measuring and weighing appliances used in the home or the industry, such as control panels.
- **Automatic Dispensers.** This includes automatic dispensers for cold drinks, vending machines, solid products, money, or all appliances that automatically deliver all kinds of products and do not fall under the toys and gaming category.

Electronic appliances are marked with a special symbol consisting of a crossed-out wheeled bin, as shown below.

Figure 15 A marking, Used to Indicate EEE for Separate Collection

This symbol indicates that the device is a subject of separate waste collection and should not be thrown into a general-purpose recycle bin. The symbol is printed visibly and legibly on the appliance's packaging and is often embossed or engraved on the device itself. The embossing is where the power cable connects to the device, but it might be elsewhere.

As you see, however, **batteries are not included in any of these categories**.

REMEMBER!
A battery is generally considered a device that receives, stores, and delivers electric energy and comprises one or more electrically coupled electrochemical cells.

An electrochemical cell is a system composed of an anode, a cathode, an electrolyte, and any electrical and mechanical connections required to allow the cell to give or receive electrical energy.

Batteries exist in various forms and sizes, ranging from tiny cells used to power hearing aids and wristwatches to massive battery banks the size of rooms that supply standby or emergency power for phone exchanges and computer data centres. There are generally two types of batteries, namely:

- **Primary (Single-Use or "Disposable") Batteries**. Because the electrode materials are permanently modified after discharge, this battery is used once and discarded; an example is an alkaline battery used in flashlights and various portable electronic gadgets.
- **Secondary (Rechargeable) Batteries**. These batteries can be drained and recharged several times with an applied electric current; reverse current can restore the original composition of the electrodes. Two examples are lead-acid batteries used in automobiles and lithium-ion batteries used in portable gadgets such as laptops and mobile phones.

Waste batteries are generally classified as hazardous waste. This is due to their chemical composition, containing harmful chemicals such as lead, cadmium, lithium, etc. However, many can be collected under the streamlined collection standards for universal waste. These universal waste

standards were created to make it easier to manage the waste batteries and send them for recycling.

In the US, one such legislation established to streamline the collection of batteries is the Mercury-Containing and Rechargeable Battery Management Act of 1996[29]. It prohibits the sale of mercury-containing batteries, establishes universal labelling rules for rechargeable batteries, and mandates that they be readily detachable.

Furthermore, dumping rechargeable batteries in general-purpose trash is prohibited in some states. Similarly, manufacturers maintain countrywide recycling programs with drop-off locations at local merchants for rechargeable batteries.

The European Union's Battery Directive[30] contains similar rules and demands more battery recycling and fostering research on improved battery recycling processes. According to this law, all batteries sold within the EU must bear the crossed-out wheeled bin symbol discussed above.

These batteries are among the most used goods in household appliances and other battery-powered devices in our daily lives. The critical problem to investigate is how this battery trash is appropriately collected and recycled, which can potentially discharge harmful compounds into the environment and water supplies.

In Europe, batteries need to be dismantled and stored for recycling separately, in separate containers, before sending the remaining e-waste for recycling.

Many portions of these batteries and accumulators/capacitors may, in general, be recycled without releasing these dangerous compounds into our environment and damaging our natural resources. More about the recycling of batteries will follow further below.

2.1.2. Environmental Impact of E-Waste

Despite accounting for only 2% of rubbish in landfills[31], e-waste accounts for roughly 70% of harmful heavy metals in these landfills[32]. The repercussions of inappropriate e-waste disposal in landfills and other non-designated dumping locations are significant, ranging from causing public health issues to contaminating ecosystems for future generations.

REMEMBER!
The three main ways WEEE impacts the environment are soil, air and water.

[29] U.S. Environmental Protection Agency. Mercury-Containing and Rechargeable Battery Management Act - Public Law 104-142

[30] Regulation Of The European Parliament and of the Council Concerning Batteries and Waste Batteries, Repealing Directive 2006/66/EC and Amending Regulation (Eu) No 2019/1020. Com/2020/798 Final

[31] U.S. Environmental Protection Agency. "Wastes - Resource Conservation - Common Wastes & Materials - eCycling."

[32] Slade, Giles. "iWaste." Mother Jones, 2007.

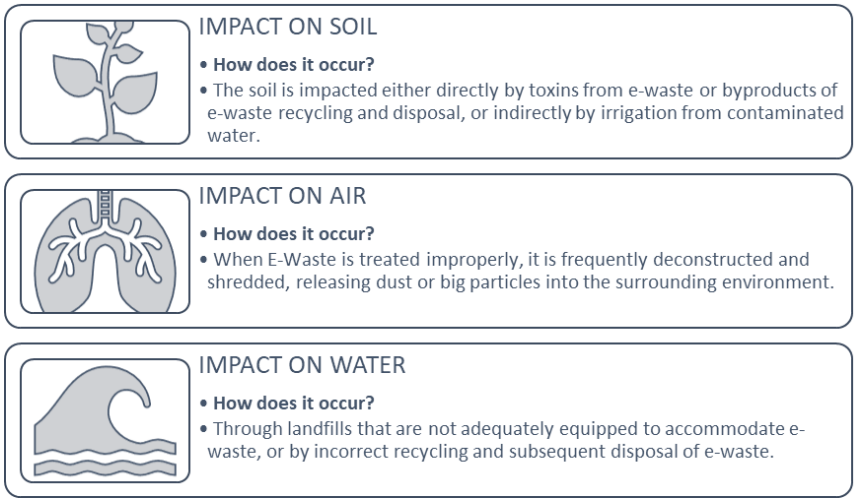

Figure 16 The Three Main Ways WEEE Impacts the Environment

When e-waste is not recycled correctly, as is the case in areas of the world where recycling practices for e-waste are not regulated or are only informally monitored, soil can become directly contaminated by:

- Waste products from recycling practices that extract precious metals and other valuable materials from e-waste.
- Large particles and bottom ash are generated from dismantling, shredding, or burning e-waste. Shredding or burning e-waste creates ash, which can be significantly polluted with heavy metals and flame retardants, which leak into the underlying soil.
- Heavy metals, such as mercury or cyanide, might discharge additional harmful compounds into the soil.

Much of the **soil pollution** is persistent, and the pollutants linger in the soil for a long time, some developing into much more hazardous species than in their initial form. The soil is also indirectly influenced by e-waste recycling due to interaction with polluted water

E-waste can have unforeseen and complicated effects on soil. Because many of these toxins bio-accumulate up the food chain, the larger the animal, the greater the impact, causing complex and upsetting alterations to biodiversity and ecological balance in polluted places. This implies that alterations can be highly damaging to soil and ecosystems that depend on these plants for subsistence.

- Plants frequently suffer compromised cell structure, altered metabolism, and limited growth in polluted soils.
- E-waste can impact some plant species due to pollution of the surrounding ground and direct contact with pollutants. For instance, lead can cover the leaves' surface, slowing photosynthesis and causing plant harm or death.

E-waste can pollute the air when deconstructed and shredded, releasing dust or big particles into nearby areas. Low-value WEEE is frequently burnt when good practices for e-waste recycling are not observed. Unregulated burning often occurs at lower temperatures and emits pollutants in the air, which are intense and harmful to humans and animals alike and can travel large distances by air. If not burned, higher-value elements like gold and silver are frequently removed from highly

integrated electronics and e-waste using acids, desoldering, and other chemicals and procedures that emit other harmful fumes into nearby areas when recycling is not adequately controlled.

Air pollution pollutes the soil and water as well. **Water can generally be contaminated by e-waste** through landfills that are not adequately equipped to accommodate e-waste or inappropriate recycling and subsequent disposal of e-waste.

Heavy metals and other persistent pollutants leak into underground waters from landfills and illegal dump sites. Water is also impacted by the chemical procedures used to extract valuable metals such as gold from electrical equipment. These operations often leach or strip precious elements away from materials of lesser value, such as plastic, using acids and other harmful chemicals discharged into local water sources, harming people and animal life for many miles.

2.1.3. Human Health and Safety

Toxic compounds may be released during electronic waste recycling operations such as scrap breakdown, shredding and separation, heating, or hydrometallurgical processes. Unfortunately, these dangerous substances can escape into the environment throughout the product's lifetime or destruction.

As a result of the possible hazard that these chemicals represent to human health, the breakdown of electronic trash may be a difficulty and must be carefully handled.

For The General Public

Residents living near e-waste recycling sites may face environmental exposure due to food, water, and environmental contamination caused by e-waste by three major exposure routes: inhalation, ingestion, and skin contact.

Prenatal e-waste exposure, on the other hand, has negative impacts on newborns, including developmental implications. Prenatal exposure to informal e-waste recycling can also result in several adverse delivery outcomes (stillbirth, low birth weight, poor Apgar scores, etc.) and long-term impacts such as behavioural and learning issues in neonates later in life[33].

According to studies, those near e-waste recycling operations have a greater daily intake of heavy metals and a more significant bodily load. Mental health, poor cognitive function, and general physical harm are potential health issues.

“Children and digital dumpsites: e-waste exposure and child health”, a first-ever report by the World Health Organization describing the magnitude of the e-waste impact on child health, was published in June 2021[34]. The report establishes that children are more vulnerable to e-waste exposure due to various factors, including their more diminutive stature, greater metabolic rate,

[33] Zeng, Z., Huo, X., Zhang, Y. et al. Lead exposure is associated with risk of impaired coagulation in preschool children from an e-waste recycling area. Environ Sci Pollut Res 25, 20670–20679 (2018). https://doi.org/10.1007/s11356-018-2206-9

[34] World Health Organization. (2021) Children and Digital Dumpsites: E-Waste Exposure And Child Health. Report. Available online at: https://www.who.int/publications/i/item/9789240023901

increased surface area in ratio to weight, and different exposure pathways (for example, dermal, hand-to-mouth, and transplacental exposure).

Children exposed to e-waste neurotoxins, such as those found in batteries, including lead, cadmium, etc., are at a higher risk of having a lower IQ, impaired cognitive function, exposure to known human carcinogens, and experiencing other adverse effects.

For Workers

Workers in the e-waste industry are exposed to toxins, including metals, particulates, persistent organic compounds, and flame retardants. Exposure varies by employment activity, with more significant implications recorded for e-waste recycling jobs, including dismantling and burning, where more particles are released into the air. Especially workers in informal e-waste recycling, which is common in developing countries, face additional risks and implications.

In one research[35], Soil samples from the ground, dust from the platform where recycling operations were done, and skin samples from employees were obtained. The soil and dust samples had high concentrations of barium, copper, lead, and zinc. Substantial amounts of chromium, lead, and zinc was found in dermal samples. These heavy metals may have significant health consequences. Human health risk assessment was also performed utilizing carcinogenic (cancer risk potency factor) and non-carcinogenic (health hazard index) risk assessment methods. The study was conducted in the e-waste recycling sectors of Chandigarh and Ludhiana, Punjab, India.

Physical, on-the-job factors, such as loud noises, bright light exposure, and stress dangers (such as noise), are also non-negligible, especially in e-waste recycling sites with poor monitoring. This might be due to the low quality or non-existent personal protective equipment.

High-quality personal protective equipment, including hearing protection, a visibility waistcoat, gloves, safety boots, a respirator and eye protection, and proper recycling process overview and monitoring, substantially mitigate the risk for workers in the field.

2.2. E-Waste Management. Recycling E-Waste.

A fundamental principle of EU waste policy is to move waste management up the "waste hierarchy" and adhere to a circular economy, specifically to maintain resource value in the economic cycle to prevent and reduce the adverse effects of using primary resources on the environment and society. Recycling is one of the essential techniques to minimize immediate resource use by substituting them with secondary products derived from recycled trash. This is the preferred method for attaining sustainability, material self-sufficiency, and the other advantages of a circular economy.

REMEMBER!
E-waste recycling is recovering valuable elements from outmoded equipment, such as plastics, glass, copper, and iron, for use in new goods. This lowers the demand for further manufacturing.

[35] Manmohit Singh, Parteek Singh Thind, Siby John. (2018) Health risk assessment of the workers exposed to the heavy metals in e-waste recycling sites of Chandigarh and Ludhiana, Punjab, India, Chemosphere, Volume 203, 426-433, https://doi.org/10.1016/j.chemosphere.2018.03.138.

EU waste management objectives are essential drivers of improving recycling rates or the amount of garbage recycled as a percentage of waste created. The WEEE Directive, for example, establishes targets for the separate collection and recycling of electrical and electronic waste.

The Waste Framework Directive includes targets for municipal waste recycling and preparation for reuse. The Packaging and Packaging Waste Directive, on the other hand, establish targets for recycling packaging waste.

Recycling rates for municipal garbage, packaging waste, and WEEE — all significant sources of secondary materials and vital raw materials — are gradually growing in Europe, utilising waste as a resource and attaining a circular economy. For the time for which statistics are available, the overall recycling rate – the ratio between total trash created excluding minerals and the amounts handled through recycling — remained below half of the entire waste creation, with a recycling rate of 48 per cent in 2016.

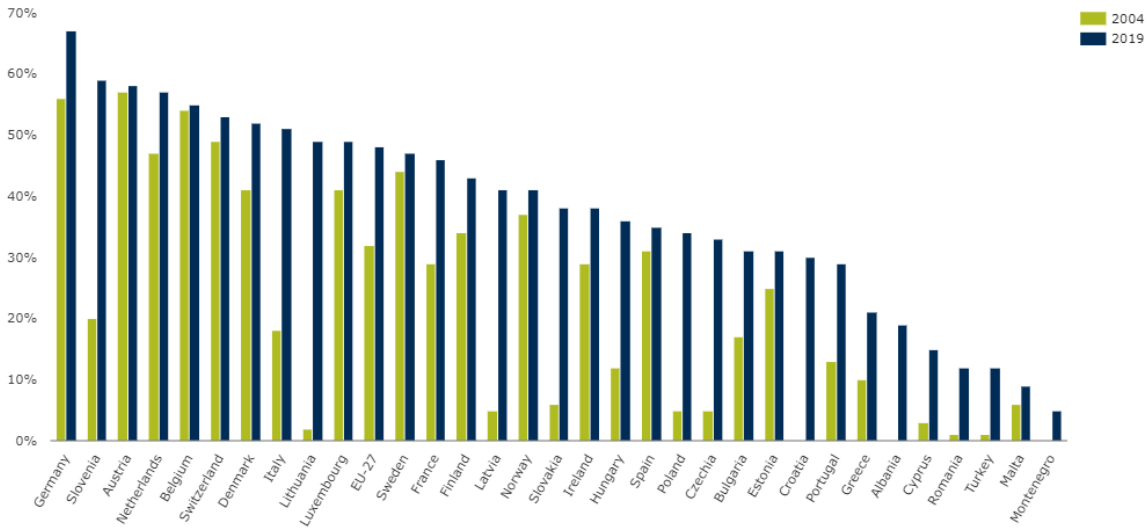

Figure 17 Municipal Waste Recycling Rates In Europe By Country. Source: European Environment Agency

Since 2004, most studied nations have dramatically boosted their municipal trash recycling rates, indicating improvements in waste management. However, the disparity in municipal trash recycling performance between the countries with the most outstanding and lowest recycling rates is significant. Rates in 2019 varied from 67 per cent in Germany to 5% in Montenegro. Germany, Slovenia, Austria, the Netherlands, Belgium, Switzerland, Denmark, and Italy achieved (in decreasing order) 50% or more excellent recycling rates. The remaining six nations recycled less than 20% of their municipal garbage[36].

Recycling raw materials from end-of-life gadgets is the most effective solution to the rising e-waste issue.

Most electronic gadgets include a range of components, including metals that may be recovered and reused in the future. By deconstructing and reusing, intact natural resources are preserved, and

[36] European Environment Agency. (2019) Waste Recycling in Europe. Available online at: https://www.eea.europa.eu/ims/waste-recycling-in-europe

air and water pollution caused by hazardous waste disposal is avoided. Furthermore, recycling minimizes greenhouse gas emissions produced by producing new items.

Another advantage of recycling e-waste is that many materials may be recovered and reused. Improper e-waste management is causing a significant loss of precious and critical raw resources, including gold, platinum, cobalt, and rare earth elements. When competent recycling practices are employed, the benefits of recycling are increased.

2.2.1. The Generic Lifecycle of E-Waste Recycling

Because e-waste management is falling behind our consumption, the need for large-scale recycling of e-waste cannot be overstated. Sustainable waste management mitigates the trash's adverse effects while simultaneously delivering various advantages, primarily by keeping materials in circulation. For the description of the generic lifecycle of WEEE recycling, we use the RTS process description[37].

The generic lifecycle of WEEE recycling could be narrowed down into four key steps, as follows:

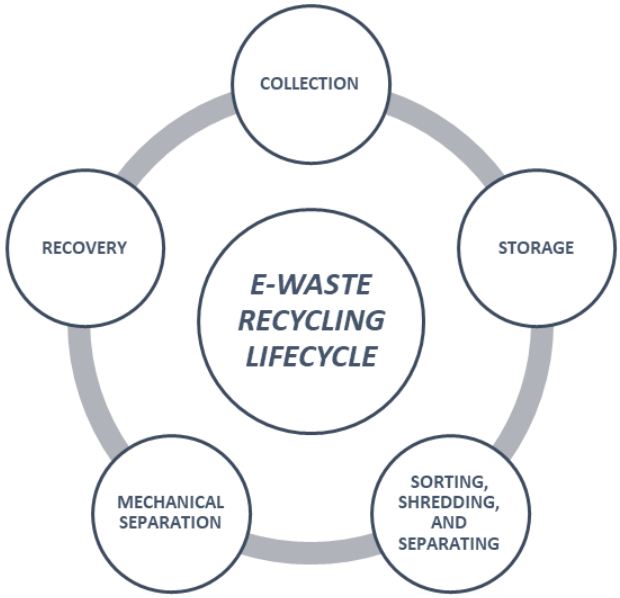

Figure 18 The Generic Process for E-Waste Recycling

The generic WEEE collection process will be described below in further detail.

Collection

Collecting electronic items through recycling bins, collection locations, take-back programs, or on-demand collection services begins the e-waste recycling lifecycle. The combined e-waste is then collected and sent to specialist electronics recyclers.

At this step, best practice demands that e-waste is divided by kind, so many collection locations will have multiple containers or boxes for different things. This is especially true for items, such as

[37] RTS. Recycle Track Systems. (2021) The Complete E-Waste Recycling Process. Article. Available online at: https://www.rts.com/blog/the-complete-e-waste-recycling-process/

batteries, which require specific treatment and can be extremely hazardous if mixed with other rubbish. More about the recycling of batteries will be included further below.

Storage

While safe storage may not appear to be vital, it might be, especially for items such as the glass screens of CRTs, which, as will be described further below, are coated with lead. Where there is a concern, storing e-waste on specially designed surfaces is required to prevent dust particles and runoff discharge.

Some items for which specific storage conditions apply are batteries, CRTs, LEDs, and photovoltaic panels, to name a few. Storage facilities should also be designed to support the prevention of additional damage, such as breakage of screens, etc.

An appropriate storage facility for collecting electronic waste also considers the storage period and purposes.

Sorting, Shredding, and Separating

Materials in the e-waste stream must be treated and segregated after collection and delivery to the e-waste recycling plant. The recycling procedure begins with the device's manual disassembly. Different products, such as light bulbs, are removed for processing. Some artefacts may also be physically demolished at this point for components, repurposing, or the recovery of precious materials.

Following this, e-waste is separated into its principal recyclable streams using automatic and semi-automatic sorting technologies. E-waste is shredded into little bits, allowing precise material sorting, an essential process element. Most electronics are made of various materials, and breaking them down into bits as small as a few millimetres allows them to be mechanically separated.

Mechanical Separation

Mechanical separation of various materials is essentially a series of operations that occur after each other. Magnetic separation and water separation are the two critical phases: water separation and mechanical separation.

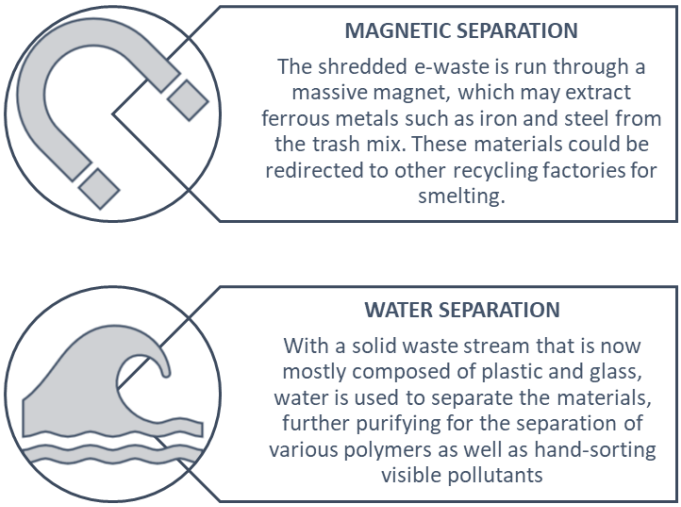

Figure 19 Two Types of Mechanical Separation. Water Separation and Magnet Separation

Recovery

The materials have now been sorted and are ready for sale and reuse. For certain materials, this requires them to enter another recycling stream. Others may be processed on-site and sold alongside useable components isolated early on.

2.2.2. The Differences in the Generic Recycling Lifecycle Among Common Items

While the previous chapter described a process representing the general e-waste management recycling process, many items have unique processes. Such items are batteries, cathode ray tubes, and computers or laptops.

For Batteries

When batteries arrive at the recycling facility, they are classified according to their chemical makeup into one of the following categories: lead-acid, nickel-cadmium, nickel-metal-hydride, and lithium-ion.

All combustible components, such as plastic casings and insulation, are burnt away and then collected with a scrubber to prevent harmful particles and fumes produced during the incineration process from polluting the air.

The emptied metal cells are then cut into pieces and heated until the metal liquefies, and non-metal components burn and collect on the surface as slag is scraped off. Some centres now deliver raw metal to specialist recycling factories. Other plants gather metals during the liquification process because they settle in layers based on density. Cadmium vaporizes and is collected by condensation during this procedure.

In Europe, the recycling of batteries must abide by the following requirements:

- All fluids and acids must be removed at a minimum throughout treatment.

- Treatment and any storage, including temporary storage, at treatment facilities, must take place in locations with impervious surfaces and appropriate weatherproof coverings or containers.
- Waste batteries in treatment facilities must be kept to not combine with waste from conductive or flammable products.
- Special precautions and safety procedures must be in place to manage waste lithium-ion batteries, which must be protected from excessive heat, water, crushing, or physical damage during handling, sorting, and storage.

Cathode Ray Tubes

Cathode Ray Tubes (CRTs) are regarded as one of the most challenging forms of e-waste to recycle. The cathode-ray tube is a vacuum tube that displays pictures and incorporates one or more electron guns and a phosphorescent screen. It modifies, accelerates, and deflects electron beams onto the screen to generate the visuals. CRTs were widely utilized in televisions and computer displays for a while. While this obsolete technology may not appear to be a concern in the future, recycling old products remains a significant challenge.

The two harmful elements present in electrical gadgets are lead and polybrominated flame retardants. CRTs, in particular, include leaded glasses. This poses a considerable risk because the lead so pollutes the glass that it cannot be recycled in a typical manner.

While many of their components may be separated, each monitor/TV can contain up to four pounds of lead. Over 98 per cent of the lead in a computer display is in the CRT. CRTs marked for disposal are classified as hazardous waste under the RCRA[38] because of lead's presence in the funnel glass. However, if specific requirements are satisfied, CRT glass and used CRTs, RCRA does not consider recycled or exported for recycling trash to be solid or hazardous waste.

Cathode Ray Tube glass may be recycled by crushing or pulverizing it to provide feedstock for lead smelters. The recovered material equals high-grade lead ore, and the glass component acts as a natural refining fluxing agent.

Computers and Laptops

The procedure for recycling laptops and PCs is relatively similar to the methods described above. However, because computer components from damaged machines may be integrated into new computers with no added resources, there will likely be more emphasis on human sorting and separation.

Furthermore, the e-waste recycling procedure is likely to entail data deletion. This will be done digitally by erasing reused hard drives, physically destroying them, or other data destruction methods. Businesses and people are becoming increasingly worried about data security, and destroying private paper documents is already standard procedure. Data destruction on hard drives is merely the 21st-century equivalent.

[38] Resource Conservation and Recovery Act (RCRA) 42 U.S.C. §6901 et seq. Available online at: https://www.law.cornell.edu/wex/resource_conservation_and_recovery_act_%28rcra%29

Your laptop most likely contains sensitive personal information such as your bank account details and social security number. Wipe your computer clean of personal information before sending it to a recycler to avoid identity theft or fraud. The easiest way is to follow this four-step process.

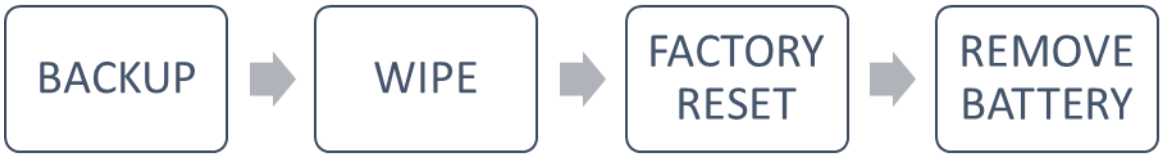

Figure 20 The Four-Step Process to Prepare your Laptop for Recycling

The steps could be described in more detail as follows:

- **Backup**. To begin recycling your laptop, make a backup of crucial data. Connect an external hard drive and save all of the files you wish to keep on it. You might also save this information to a flash drive or store it in the cloud. Consider encrypting your backups. The data may then be readily transferred to your new laptop and deleted from your old one.
- **Wipe**. Wipe up your old laptop's hard disk by manually removing files and then overwriting them using a shredding application. If your laptop does not power on so you can wipe it clean, you can remove or destroy the hard drive to safeguard the data. Drilling through it or breaking the circuit board is the best method to destroy it.
- **Factory Reset**. The machine can then be reset to factory settings.
- **Battery Removal**. Please remove the battery from your laptop to recycle it separately. Before submitting your computer to a recycler, flip it over and remove it.

You can also take another route to recycle your laptop: reuse your machine or some of its components.

- **Donation**. If your laptop is in proper condition and can be used by somebody else, you can consider donating it. Asking a local charitable organization if they need a computer is an approach to donation. You can also contact schools, refugee centres, kindergartens and more. Instead of donating, you may consider giving your machine to an older relative or someone in your circle of friends and family who does not require the latest model laptop.
- **Fix It**. If your machine is not working but has any chance for a second life, consider fixing it yourself or with the help of a company or a knowledgeable friend. You may then consider keeping it for yourself as a second machine or adding storage to your other devices by converting it into a network-attached storage system (NAS). You may still choose to donate it.
- **Reuse it**. You may reuse some parts of your laptop to fix other machines or repurpose them. For instance, you can turn your hard drive into an external hard drive, which you can use to store your backups.

2.2.3. Repairing and Reusing, Donation and Refurbishment

One practical action we can undertake to tackle the global problem of electronic waste at home is to consider repairing, reusing, donating and refurbishing electronic devices. This is one of the most ecologically sound acts we can consider to challenge environmental concerns.

Repairing Electronics to Reduce Waste

There are numerous approaches to reducing the environmental risks associated with electronic trash recycling. The decreasing lifetime of many electrical and electronic items is one of the elements exacerbating the e-waste problem. Consumer discontent with current affairs has fuelled a burgeoning repair movement.

Repair cafés are springing up worldwide to encourage customers to bring in their broken items. The volunteers' cafés assist with repairing and maintaining damaged or malfunctioning electronics.

Many nations now provide courses to teach the general public about electronics repair procedures. These educational initiatives offer a fantastic opportunity to learn about electronics and gain new skills while being environmentally responsible and giving your electrical items a second chance.

Reusing and Refurbishing Electronics

Every year, billions of electronic devices are made throughout the world. And the waste will be enormous if left to decay in landfills. It consequently makes a lot of sense to reuse or give obsolete electrical devices that are no longer functional or have lost their aesthetic appeal.

The most common complaints about obsolete electrical devices concern their performance and, more importantly, their appearance. Most gadgets include upgrade options, allowing older models to run on par with freshly launched versions. For example, laptops have built-in upgrades to boost processor speed and RAM or install a new operating system to improve performance. The aesthetics of the device, on the other hand, are radically different because prior versions will not look as attractive as the new one in terms of shape, size, weight, and appearance. However, several refurbishment processes are available to make aged electronics look brand new again.

Donation

Electronics are constructed from precious resources and materials such as metals, polymers, and glass, which all require energy to mine and manufacture. Instead of disposing of electronic devices, a straightforward way to reduce their environmental impact is by selling or giving them. Improperly dumped e-waste is getting increasingly dangerous, especially as the volume of e-waste grows. Donating or recycling consumer gadgets helps the environment by conserving natural resources while avoiding air and water pollution and greenhouse gas emissions produced by virgin materials.

Consider contacting nearby refugee centres, educational institutions, thrift stores, community centres, healthcare facilities, or senior social services. For suggestions on where to contribute, contact the local representatives of your gadget maker. Or just ask your closest friends for recommendations; perhaps one of them needs the equipment you wish to give away.

2.2.4. Urban Mining

Urban mining has become a high-value material per ton trend compared to traditional metal ore mines. As urban cultures continually generate WEEE, industrialized urban areas contribute 75 per cent of the world's waste[39]. These wastes have a higher concentration of minerals and metals than their sources. Sewage sludge, for example, has been shown to contain more gold and copper than several mines[40].

Urban mining is known to use less energy than collecting primary source minerals. It has been discovered that recovering significant amounts of gold and copper from garbage television is less expensive than removing the metal from the mining site.

Some significant social and health issues and technological challenges stand in the way of the complete expansion of urban mining. Other notable problems that urban mining faces are that:

- Metals cannot be recycled endlessly, which is one of these technical issues because losses are unavoidable.
- Another issue with urban mining is ore access. It is not stockpiled in a specific spot like a mine but in a broad section of our house that is hidden and difficult to access.

Because consumers are unaware of the need to collect and distribute old electronic devices, solving these challenges will be accomplished by educating the public.

2.3. Social Challenges for E-Waste Recycling

As more electronic gadgets are manufactured and discarded, the amount of e-waste produced increases. However, an increasing number of individuals are responsibly disposing of their e-waste.

Nonetheless, despite the amount of e-waste that is correctly recycled, electronic recycling has several ongoing obstacles. These concerns have become a big issue in the business, and swift action is required to stop them.

2.3.1. Exports to Developing Countries

Despite the amount of work promoting electronic recycling and the number of electronic recycling firms available to assist, most e-waste still ends up in landfills. The current rate or level of e-waste recycling is insufficient, implying that much e-waste is not properly disposed of.

Because of cheaper labour costs and fewer stringent restrictions, most of these landfills or e-waste recycling plants are currently in developing nations. It is common practice for first-world countries to illegally export their electronic garbage containing harmful and poisonous elements to underdeveloped countries. It's quickly becoming one of the most critical issues surrounding

[39] Statista. (2022) Global Waste Generation. Statistics and Facts. Available online at: https://www.statista.com/topics/4983/waste-generation-worldwide/#dossierContents__outerWrapper

[40] Paul Westerhoff, Sungyun Lee, Yu Yang, Gwyneth W. Gordon, Kiril Hristovski, Rolf U. Halden, and Pierre Herckes. (2015) Characterization, Recovery Opportunities, and Valuation of Metals in Municipal Sludges from U.S. Wastewater Treatment Plants Nationwide. Environmental Science and Technology. 49, 16, 9479–9488. 2015 American Chemical Society.

technological trash and debris. Governments are attempting to repeal a worldwide law to stop the issue.

There has to be greater attention and more information offered so that people realize the consequences of inappropriate e-waste disposal. Without the proper methods, techniques, and systems, these countries have suffered from garbage overflow, affecting their environment, economy, and health.

2.3.2. Declining Quantities of Precious Materials

Although the number of e-waste is continuously growing, the quality of e-waste is declining. It is logical, considering that fewer materials are utilized for their production as electronics become smaller and smaller. As a result, the value of these commodities has plummeted dramatically.

When combined with sinking worldwide pricing for recycled goods, it's easy to understand why enterprises may struggle to sell or make the most of their gadgets and materials. It may be more difficult to retain interest and investment in electronic recycling without consistent revenue.

2.3.3. Electronics Unfit for Recycling

A large portion of electronic equipment is increasingly not built to be readily recyclable, repairable, or reusable. It seems less expensive to produce new items rather than fix existing ones. Furthermore, we can generalize that nowadays, many people prefer to purchase new equipment rather than repairing or reusing old one. As consumers replace their outdated equipment, this leads to a rise in WEEE.

On the other hand, companies and manufacturers often produce EEE that are not readily recyclable for various reasons, including intellectual rights and cost savings. This practice negatively influences the environment, so governments and activists have advocated for regulations that enable corporations to repair and refurbish cell phones to minimize unnecessary destruction.

2.4. Sustainability and Circular Economy

The existing state of the environment leads to short-term consumption, creating an unsustainable condition for the world. The current situation is opposed to how nature operates in the long run. It is a system in which elements are reduced, reused, and recycled. These are also the main principles of a circular economy.

As defined already as part of this chapter of the current e-book, the circular economy is an ecosystem in which components, products, and by-products retain most of their value. The core idea of this system is not manufacturing, use, and disposal but instead reducing, reusing, and recycling, which is the foundation for action-based solutions for sustainability. As opposed to a standard linear economy, a circular economy approaches this process more thoroughly, from supply chain structure through material and product design, all the way to end-of-life materials recovery. A circular economy might enable extended product lives, reduced environmental concerns, and a potential value for manufacturers. Although manufacturers have begun to disclose their sustainability targets,

the industry is still far from being a fully circular economy. Some notable elements of the circular economy are still a long way from success:

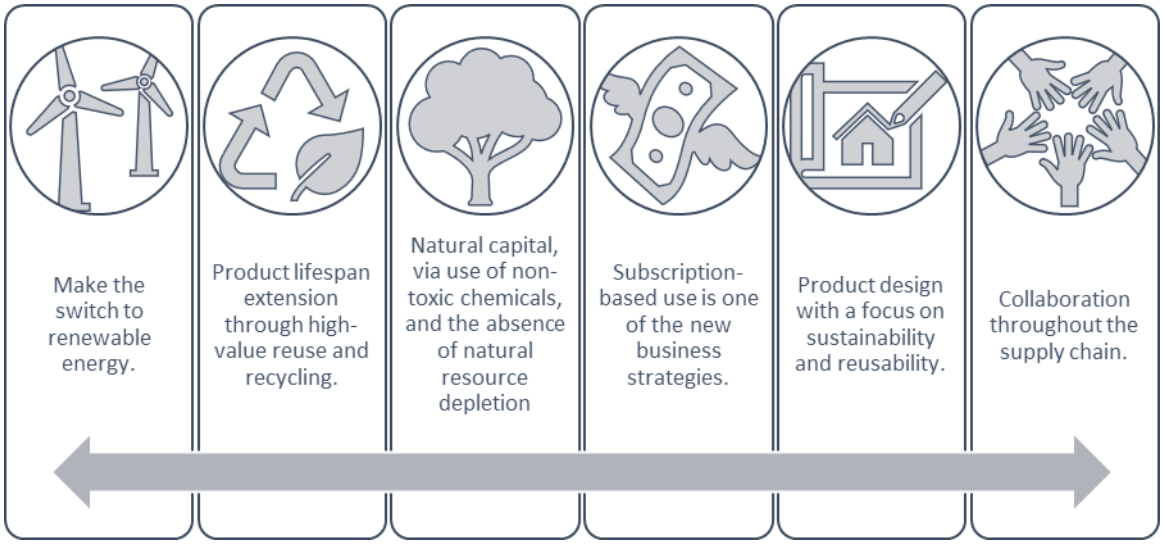

Figure 21 The Six Elements of Circular Economy. Adapted from Kenniskaarten

The elements of the circular economy rely heavily on three core principles.

- **Reduce, Recycle, Reuse**. Otherwise known as the three Rs, this principle could be broken into three core steps, as follows:
    - **Reduce**. This sub-principle relies on purchasing less, reducing unnecessary consumption, purchasing items that require less packing or fewer consumables or reducing the amount of garbage you produce. Fixing broken electronics, for instance, is a crucial component of reducing your purchases of devices and thus extending the lifecycle of the products you use.
    - **Reuse**. Reusing has already been discussed as part of this section of the e-book. The main principle of reusing, either by repurposing, donating or avoiding single-use items, is to prevent new resources from being used for an extended period and old resources from entering the trash stream.
    - **Recycle**. Electronics and other materials, such as paper, plastic, glass, magazines, and other materials, may be recycled to create new goods while using less natural resources and energy.
- **Valorisation**. Valorisation is harnessing or producing energy from materials that cannot be recycled. One core component of valorisation is the subscription or the pay-per-use economic models, otherwise put under the umbrella of functionality economy. The functionality economy seeks to replace the sale of commodities, especially those that cannot be recycled, with the renting of goods to improve the value and utilization of the items. After completing the primary purpose, the product is dismantled, repurposed, reused, and, if possible, recycled.
- **Sustainability by Design**. A technique for designing goods with environmental implications in mind and avoiding the use of as many fossil fuels as feasible in the production, reuse, or recycling of the items.

A linear model of production and consumption has been followed from the beginning of industrialization, with raw materials typically being converted into goods and value being added to the raw material. Once used, the residue becomes rubbish and is usually managed or disposed of accidentally. On the other hand, a circular economy is a model for an economic system that combines regenerative design concepts and approaches to improve the performance of previously discarded resources.

Among the many benefits of a circular economy are environmental and cost-effective, providing opportunities for economic growth, profit opportunities generated by new service demand, and resource-saving. However, one of the most significant benefits of a circular economy is considered sustainability.

REMEMBER!
Sustainability concerns safeguarding the world, stopping climate change, and encouraging social progress without jeopardizing life on Earth. This philosophy aims to meet our immediate demands without jeopardizing resources for future generations.

The industry has long recognized the importance of sustainability. This broad term, however, signifies various things to different parties. Typically, sustainability is examined along three major dimensions: environmental, social, and economic sustainability.

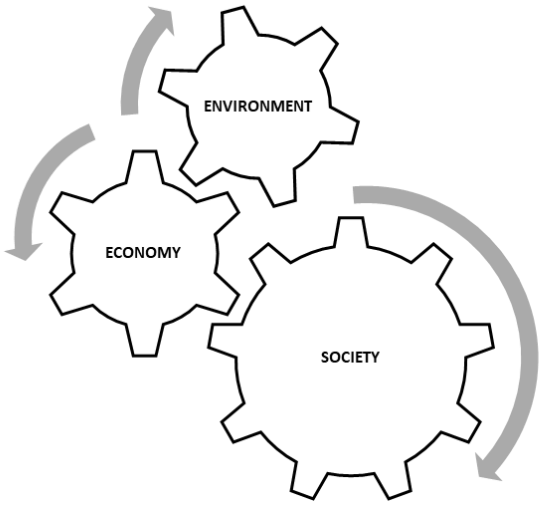

Figure 22 The Three Pillars of Sustainability

Environment. Sustainability requires accepting that nature and the environment are not an infinite supply of resources but must be protected and used wisely. Environmental conservation, a dedication to renewable energy, water conservation, encouraging mobility, sustainable fashion, building innovation, and sustainable design are all factors that contribute to environmental sustainability from many perspectives.

Society. Sustainability fosters social growth while seeking cohesiveness across communities and cultures to achieve acceptable levels of quality of life, healthcare, and education. Another factor influencing social sustainability initiatives in the following years is the battle for gender equality.

Economy. Sustainability fosters economic growth by creating equal riches for all while protecting the environment. This pillar encompasses various activities, from banking to agriculture, tourism to industry, etc. Investment and equitable distribution of economic resources will maximise development across the board under the other sustainability pillars.

The modern idea of sustainability was initially introduced in the **Brundtland Report in 1987,** with the first warnings on the effects of an unsustainable economy provided in the **Meadows Report** (see Chapter 4). The Brundtland Report, also known as Our Common Future and released by the United Nations, was the first to warn of the detrimental environmental repercussions of economic expansion and globalization. It sought to give solutions to issues caused by industrialization and population growth.

Nowadays, sustainability is considered a cornerstone and an end goal of the circular economy, intending to solidify worldwide peace and access to justice, favouring people, the earth, and prosperity. Changing how we produce, consume and dispose of devices is just one step towards sustainability. However, it might be among the most important ones to make. Interventions at the technical and policy levels, implementation and capacity building, and increased public awareness can turn the challenge of e-waste recycling into an opportunity to address future issues and set reasonable global standards for environmental and occupational health.

Recycling is the key to reducing E-waste because it has environmental advantages at every stage of a computer product's life cycle, from raw material to final disposal. Recycling decreases greenhouse gas emissions, which contribute to global warming, and minimizes air and water pollution associated with producing new goods from raw materials. We can help make recycling work by using discarded, unwanted, or obsolete resources as industrial feedstock or for new materials or products.

3. Initiatives

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Chapter Summary.

Governments, companies, non-governmental organizations and citizens must join forces in initiatives through which they produce and consume responsibly, reducing emissions and making better use of resources. In this situation, it is essential to be creative and propose initiatives that have a multiplying effect on the rest of society. We intend to do our bit for the community by compiling in this chapter initiatives successfully carried out by different actors that we hope will serve as an inspiration to others and apply them in their small or large areas of action. Everything adds up to benefit our planet, aid us all and help in this vast task.

Keywords.

Environmental action, Environment protection, Green initiatives, Reduce, Recycle, Reuse

3.1. Global Initiatives

The United Nations, the European Commission, the World Bank, the OECD and organisations such as C40 promote initiatives at the global level that serve as a reference for other organisations acting locally. They are the mirror in which they look to reduce pollution and energy consumption and make citizens aware of the importance of their actions to improve our world.

3.1.1. United Nations

Sustainable development and climate action are linked and crucial for humankind's present and future well-being. For this reason, the United Nations supports initiatives along these lines, acting as a leader and serving as a reference for other organizations, as shown below. The adoption in 2015 of the Agenda for Sustainable Development and the subsequent agreements and summits reflect the concern of the Member States and justify the search for a sustainable development model that helps improve people's lives worldwide. The following are the most relevant initiatives promoted by the United Nations.

The 2030 Agenda for Sustainable Development

On September 25, 2015, all United Nations member states ratified the 2030 Agenda for Sustainable Development, an occasion for countries and their societies to begin a new journey to improve their lives, with no one left behind. The Agenda has 17 Sustainable Development Goals (SDGs) and 169 integrated and indivisible targets spanning the economic, social and environmental spheres. The goals range from eradicating poverty to the fight against climate change, education, women's equality, environmental protection, and our cities' design.

This strategy will guide global development programmes for years to come. By adopting it, states have committed themselves to mobilise the means necessary for its implementation

REMEMBER!
In particular, Goal 13 (called Climate Action) consists of urgent action to fight climate change. To achieve this goal, policies, roadmaps, technologies and financing must be put in place to ensure that global emissions peak in the coming years, that deep decarbonization of the global economy is initiated and that climate neutrality is achieved in the second half of the century. Climate neutrality, also called carbon neutrality or net-zero emissions, means restoring the planet's balance, in terms of emissions and removals, to the state it was in a hundred and a half centuries ago.

Consequently, clean and renewable energies must be significantly increased and managed sustainably.

Figure 23 Sustainable Development Goals (Source: United Nations)[41]

Paris Agreement

On December 12, 2015, the Paris Agreement, a legally binding international climate change treaty, was adopted in Paris by 196 Parties. It aimed to limit the average global temperature increase to 2 degrees Celsius above pre-industrial levels, redouble efforts to not exceed 1.5 degrees Celsius by the end of this century, and achieve climate neutrality by 2050.

[41] https://www.un.org/sustainabledevelopment/blog/2015/09/why-should-you-care-about-the-sustainable-development-goals/

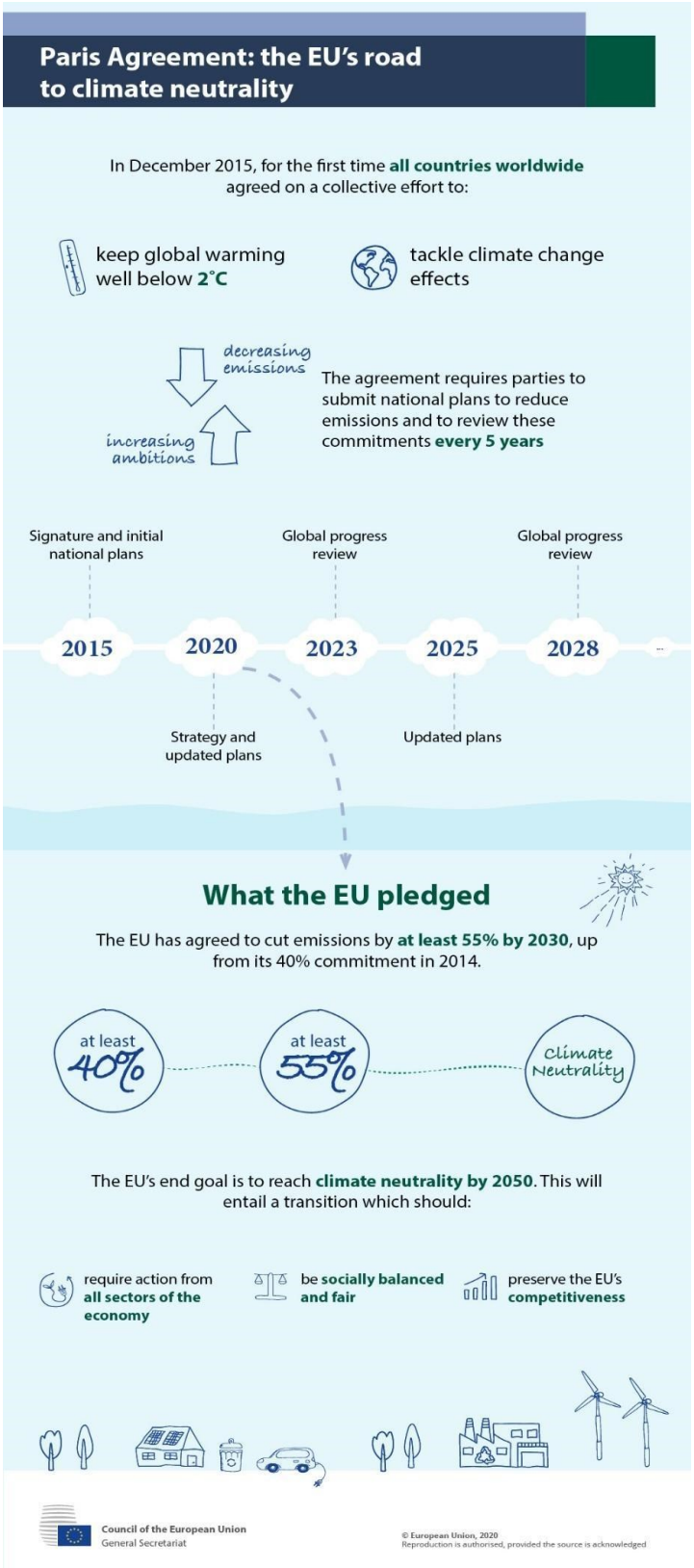

Figure 24 Infographic Published by the European Commission on the COP21 in Paris (Source: Council of the European Union – General Secretariat)[42]

The Agreement entered into force on 4 November 2016 and, since 2020, has replaced the Kyoto Protocol as the leading international climate regime.

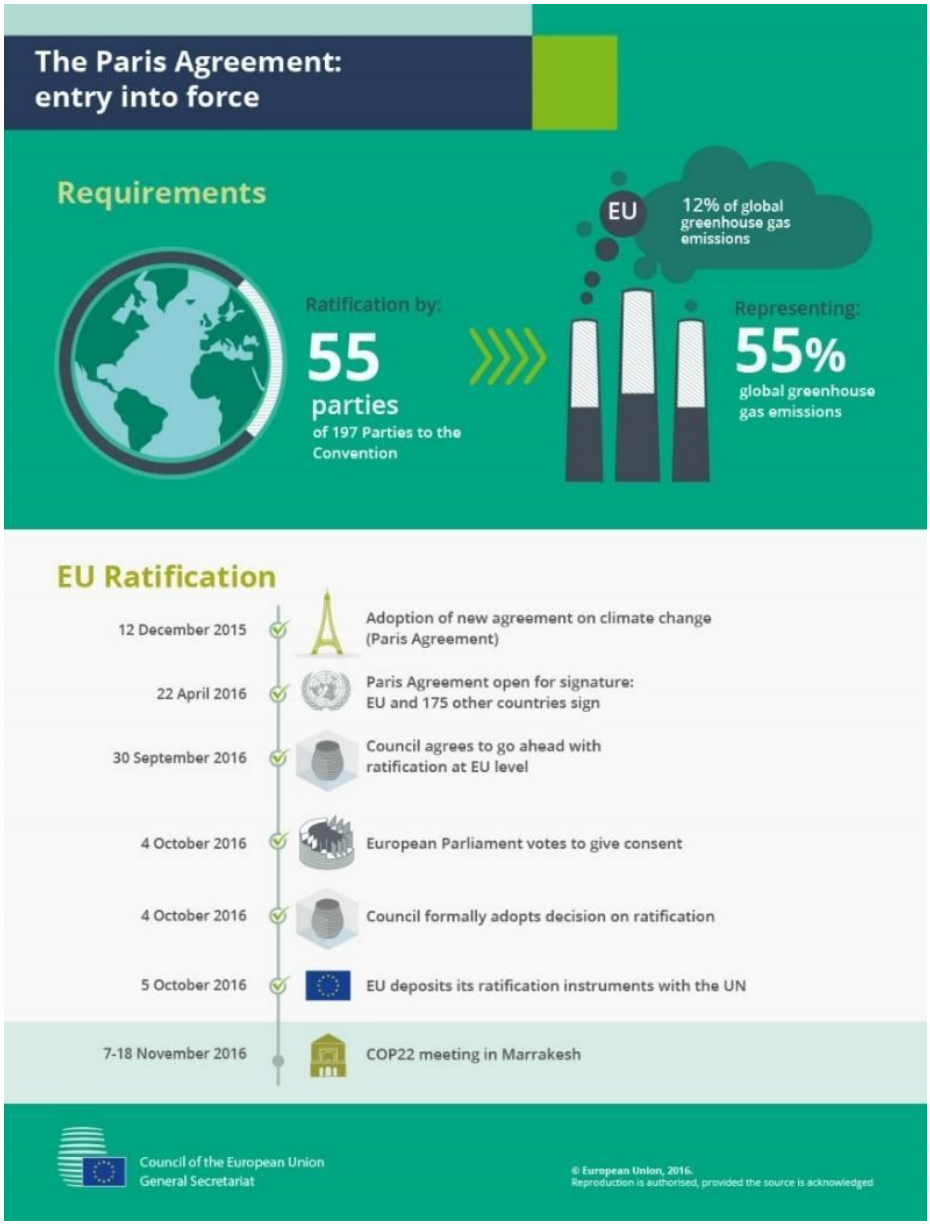

Figure 25 The Paris Agreement: Entry Into Force (Source: Council of the European Union - General Secretariat)[43]

REMEMBER!
The big difference between the two agreements is that in the first one, only developed countries were obliged to cut their emissions by 5% per year on average between 2008 and 2012, compared to the base year 1990.

[42] https://www.consilium.europa.eu/en/infographics/paris-agreement-eu/

[43] https://www.consilium.europa.eu/en/infographics/paris-agreement-ratification-v2/

Glasgow Climate Change Conference - COP 26

From 31 October to 12 November 2021, the United Nations Climate Change Conference (COP26) was held in Glasgow (Scotland), bringing together representatives of some 200 governments to accelerate climate action to comply with the Paris Agreement. COP26 emphasized the need and opportunities to move towards a carbon-neutral economy and called for transparent and rigorous climate action plans from both governments and companies.

The agreements keep the 1.5ºC scenario alive - with quantitative targets and explicit references to reducing subsidies to coal and fossil fuels - and recognize the need to comply to avoid devastating effects. To this end, it is imperative to reduce emissions by 45%, compared to 2010 levels, by 2030 and achieve net-zero emissions by 2050. In addition, countries are called upon to step up their climate action and reach their 2030 targets, in line with the Paris Agreement, by 2022.

Everyone must play their part: governments, companies and civil society to reach these targets.

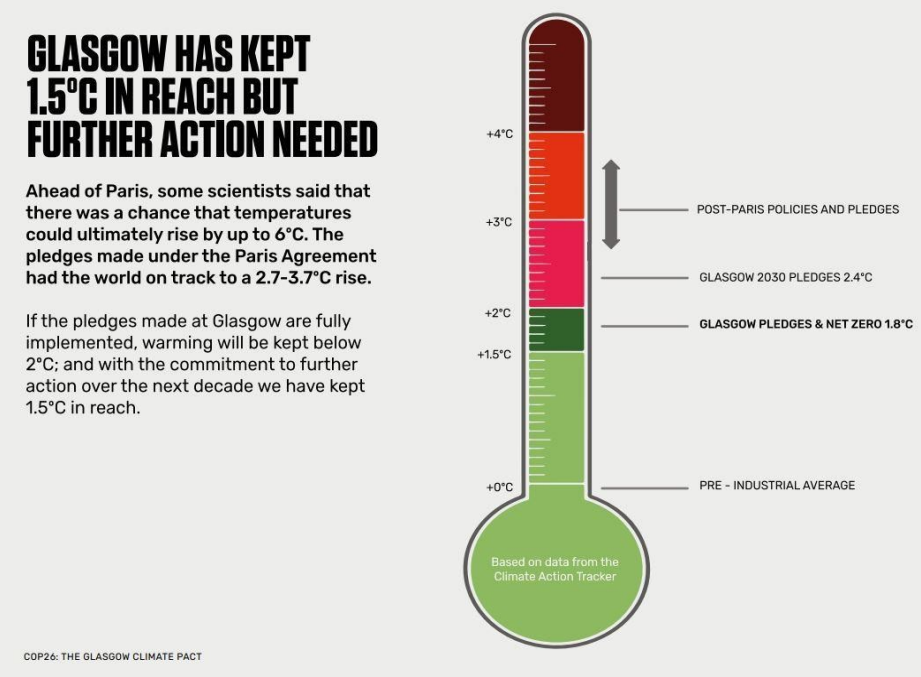

Figure 26 Pledges Made at Glasgow COP26 (Source: UK COP26)[44]

3.1.2. European Commission

The European Commission and the United Nations are partners in achieving a safer and better world. To this end, the EC supports a practical multilateral approach and a rules-based international order in which the UN is at the centre. One of the most important examples is that the SDGs are an excellent vehicle to project EU values and objectives globally and provide a shared framework for international partnerships. Therefore, the EC is ready to lead the implementation of the 2030 Agenda.

[44] https://ukcop26.org/wp-content/uploads/2021/11/COP26-Presidency-Outcomes-The-Climate-Pact.pdf

Figure 27 European Commission Priorities on Sustainable Development Goals (Source: European Commission)

In many high-level policy forums, the EU maintains that it will focus on using the United Nations Sustainable Development Goals as a compass for Europe's recovery and building a better future through a new growth model.

REMEMBER!
Many actions and initiatives are emerging from European authorities to implement the twin transitions: the green transition and the digital transition. The aim is for manufacturers to improve the durability and recycling of electronic devices. Public authorities have tools to determine the environmental impact of the products and services they intend to purchase or enhance efficiency in data centres.

On September 23, 2021, the European Commission took an important step against e-waste and the annoyance caused to consumers by many different and non-compatible chargers for electronic devices. Years of hard work and effort with manufacturers in a voluntary approach already reduced the number of cell phone chargers from 30 to 3 in the last decade but could not offer a complete solution. Therefore, the Commission is now presenting a legislative proposal to establish a standard charging solution for all relevant devices.

Figure 28 Presentation of the initiative by Commissioner Thierry Breton, responsible for the Internal Market (Source: European Commission)[45]

The following initiatives can be highlighted among the EU's actions to deliver on the Sustainable Development Goals.

Digital Product Passport

The European Commission plans to implement a Digital Product Passport that would include information on the disposition of products on the European market to increase their chances of reusing or recycling.

The idea is to distinguish crucial information about the composition of each product so that users in the supply chain can reuse it or treat it correctly in waste management plants.

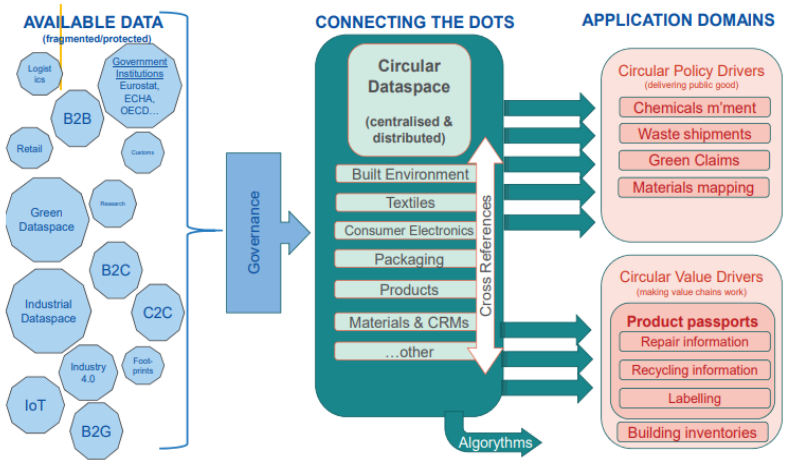

Figure 29 OSCE Considers Product Passports as Drivers of Circular Value (Source: Organization for Security and Cooperation in Europe)[46]

[45] https://ec.europa.eu/commission/presscorner/detail/es/ip_21_4613

[46] https://www.osce.org/files/f/documents/8/a/454966.pdf

REMEMBER!
The goal of such data collection on the composition of goods on the European market is to increase the possibility of products being reused at different times and recycled correctly at the end of their life. And on top of that, to give users more information about the supply chain of fabrics and products that may come in handy for possible reuse or proper routing to waste management facilities.

Eco-design and Energy Labelling

EU legislation on energy labelling and eco-design improve the products' energy efficiency in the EU market. There is a call for more efficient products to reduce energy and other natural resources to improve overall sustainability.

EU eco-design laws are an effective tool for improving the environmental efficiency of products by setting mandatory minimum standards for their energy performance. The worst-performing products are removed from the market, achieving the EU's energy and climate targets. Eco-design also supports industrial competitiveness and modernisation by promoting the products' better environmental performance throughout the internal market.

Eco-design sets common minimum standards at the EU level to remove poorer-performing products from the market. Energy labels provide a clear and straightforward indication of energy efficiency and other key product characteristics at the point of sale. It also makes it easier for consumers to save money on household energy bills while helping reduce greenhouse gas emissions across the European Union.

Climate Neutral Data Centre Operator Pact

European cloud infrastructure, data centres providers, and European trade associations have formed the Climate Neutral Data Centre Operator Pact and the Self-Regulatory Initiative. This agreement sets a historical precedent. It is the first time the industry has consolidated its commitment to ensuring that European data centres achieve carbon neutrality by 2030. The sector aims to play a leading role in Europe's transition to a climate-neutral economy, supporting the European Data Strategy and the European Green Pact, making Europe the world's first carbon-neutral continent by 2050.

The signatories of the agreement commit themselves to:

- Improve the efficient use of energy.
- Purchasing 100% zero-carbon energy.
- Conserve water by selecting efficient and appropriate refrigeration systems.
- Recycle servers, computers and devices.
- Reusing heat from data centres. It is convenient, eco-friendly and cost-effective.

The European Commission will monitor progress toward the Initiative's objectives twice a year.

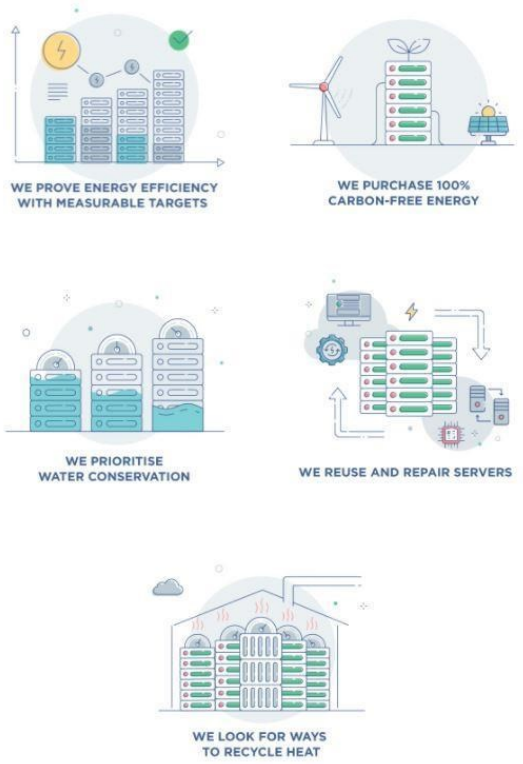

Figure 30 Actions by Climate Neutral Data Centre Operator Pact Partners (Source: Climate Neutral Data Centre Operator Pact Website)[47]

As for the topic of data centres, the European Commission wants to develop a modern approach to design and develop data centres in the ocean to keep them cool naturally. Examples for reference can be Kolos in Norway and the Natick project, implemented by Microsoft on the Orkney coast (Scotland). It was an underwater data centres experiment that proved a success.

Considering cooling, the energy benefit of underwater storage is clear. Servers usually produce a lot of heat, and cooling them requires energy. Therefore, placing servers underwater makes the need for artificial cooling redundant. However, underwater data storage seems to have few consequences; the heat produced only changes the temperature of the water a few centimetres from the tank.

[47] https://www.climateneutraldatacentre.net

Figure 31 The Container Where the 864 Servers of The Natick Project Were Hosted (Source: Microsoft)[48]

D4D Hub

The D4D Hub was launched at the end of 2020 by the President of the European Commission, Ursula von der Leyen, European Heads of State and the D4D Hub partners.

Figure 32 The launch of the D4D Hub in December 2020 by the President of the European Commission, Ursula von der Leyen (Source: European Commission)[49]

REMEMBER!
The D4D Hub serves as a strategic multi-stakeholder platform that promotes digital cooperation after the Coronavirus crisis (COVID-19), highlighting the need for increased coordination of international efforts to take advantage of the benefits of the digital age and manage its potential pitfalls.

[48] https://news.microsoft.com/innovation-stories/project-natick-underwater-datacenter/

[49] https://digital-skills-jobs.europa.eu/en/latest/news/eu-launches-digital-4-development-hub-latin-america-and-caribbean

The European Union has embarked on a path to embrace a fair, inclusive and green digital transformation worldwide - inaugurating a new era for global digital cooperation.

The challenge is to shape digital economies that put people at the centre, protect citizens' fundamental rights, and provide equal opportunities for all in the green and digital transition we are undergoing.

D4D aspires to be the human-centred innovation hub for sustainable digital transformation.

Digital Europe

Digital Europe is the European organization representing the digital technology industry, consisting of 59 leading IT companies and 35 national trade associations.

It aims to ensure industry participation in developing and implementing European Union policy. It has several working groups focused on technology, trade, technical and regulation, and the digital economy.

On 27 October 2021, the organization published the report "Digital action = Climate action: 8 ideas to accelerate the twin transition", a report on innovative solutions to well-known climate challenges.

Figure 33 8 Ideas to Accelerate the Twin Transition (Source: Digital Europe)[50]

[50] https://www.digitaleurope.org/resources/digital-action-climate-action-8-ideas-to-accelerate-the-twin-transition/

For example, the information refers to the smart city project of the city of Vienna. Through a combination of innovative digital solutions and data analytics, enabling, among other environmental benefits, a 71% reduction of CO2 emissions in a large residential building, the city of Vienna has made progress towards its goal of reducing its footprint.

In the port of Rotterdam, a combination of innovative digital technologies, including Artificial Intelligence, optimises route planning and berthing of ships, meaning they are on track to reduce their carbon emissions by 50% by 2030.

EU Missions

EU Missions are a new approach to providing specific solutions for our most critical challenges. They have ambitious objectives and will transfer tangible results by 2030. They will impact by putting research and innovation in a new role, blending with new forms of governance, working together and involving citizens.

On September 29, 2021, the Commission launched five EU Missions. One of these was the Climate Neutral and Smart Cities Mission to achieve 100 climate-neutral and smart cities by 2030 and ensure they are hubs of innovation to make all European cities climate-neutral by 2050.

Figure 34 EU Missions: Climate-Neutral and Smart Cities. Concrete Solutions for our Greatest Challenges (Source: European Commission)[51]

3.1.3. Other International Organizations

Beyond the United Nations and the European Commission, other organizations are also trying to help reduce the digital carbon footprint and make the world a more sustainable place.

The World Bank

The World Bank considers that the acceleration of today's digital revolution creates new challenges and opportunities for the green agenda. Digital innovations are enabling new forms for governments to optimize and deploy innovations for more meaningful climate change mitigation, adaptation, and control, but at the same time increasing greenhouse gas (GHG) emissions through higher energy use.

On 3 March 2022, the World Bank organised an exciting webinar called "Green and Digital: Accelerating Climate Action. Learning from the Korean Journey"[52].

[51] European Commission, Directorate-General for Research and Innovation, EU missions: 100 climate-neutral and smart cities, 2021, https://data.europa.eu/doi/10.2777/197915

[52] https://www.worldbank.org/en/events/2022/02/24/green-and-digital-accelerating-climate-action-learning-from-the-korean-journey

This event provided insight into Korea's ongoing practices and challenges in implementing decarbonization strategies in the information and communications technology (ICT) sector. In addition, it discussed options for reducing GHG emissions from the digital industry in long-term sustained growth in developing countries and common issues related to digital and data infrastructure that can contribute to climate change mitigation and adaptation.

This kind of action aims to disseminate good practices carried out by some countries to serve as a model for others to follow. In this case, the World Bank looked at Korea as a nation working well in the area of the twin transition (green and digital)[53]. Assess what policy choices are open to developing economies to assure that digital technologies provide the proper foundation for their national climate change strategies and how policies can enable decarbonization through digital technologies, data and analytics in critical social and economic sectors.

The Republic of Korea was one of the first to adopt a green policy initiative as part of the national development agenda. The Korean government early committed to climate-friendly technology policies by announcing "Low Carbon, Green Growth" in 2008 and, more recently, its Korea New Deal. Its two pillars - the Digital New Deal and the Green New Deal - serve as the driving force behind the recently announced Carbon Neutral 2050 Strategy, which focuses on carbon neutrality, economic growth and improved quality of life.

OECD

The Organisation for Economic Co-operation and Development (OECD) is an international organization whose mission is to design better policies for a better life, promoting prosperity, equality, opportunity and well-being.

As early as 2009, the OECD organized a high-level meeting in Denmark on "ICT, environment and climate change". The following year, it published a report on the same topic, significantly impacting management and business. This report examines how information and communication technologies can improve the environmental performance of the user and how they can be utilized to improve the environmental performance of the entire economy and community. The direct environmental impact of ICT is considerable in terms of energy use, fabrics production and end-of-life treatment. Government policies on "Green ICT" can be instrumental in promoting life-cycle approaches that improve the research, development, and design of ICT goods, services, and systems. Innovative ICT applications enable sustainable production and consumption across the economy. The potential for improved environmental performance targets specific products and entire industrial systems and sectors, such as construction, transport or energy.

It is surprising that already in 2009, the OECD addressed these issues:

[53] https://documents.worldbank.org/en/publication/documents-reports/documentdetail/152001645712665901/greening-digital-in-korea-korea-case-study-for-greening-the-ict-sector

ICTs, the environment and climate change: Key issues		
14:00 – 15:30	Session 1 **Reducing environmental impacts during the ICT life cycle**	Session 2 **Clean technologies for greener urban growth**
16:00 – 17:30	Session 3 **ICTs in pollution reduction and resource management**	Session 4 **Innovation and behavioural change**

Strategies to achieve environmental goals		
9:00 – 10:30	Session 5 **The ICT sector in focus**	Session 6 **Fostering sustainable consumption and use**
11:00 – 12:30	Session 7 **Cleaner technologies and smarter ICT applications**	Session 8 **Governments paving the way**

Figure 35 Part of the Agenda of the 2009 Green IT Conference In Denmark (Source: OECD)[54]

REMEMBER!
The OECD does a great job of disseminating information, organising conferences with experts and publishing guides on topical issues and best practices that serve as a reference for political and economic leaders worldwide.

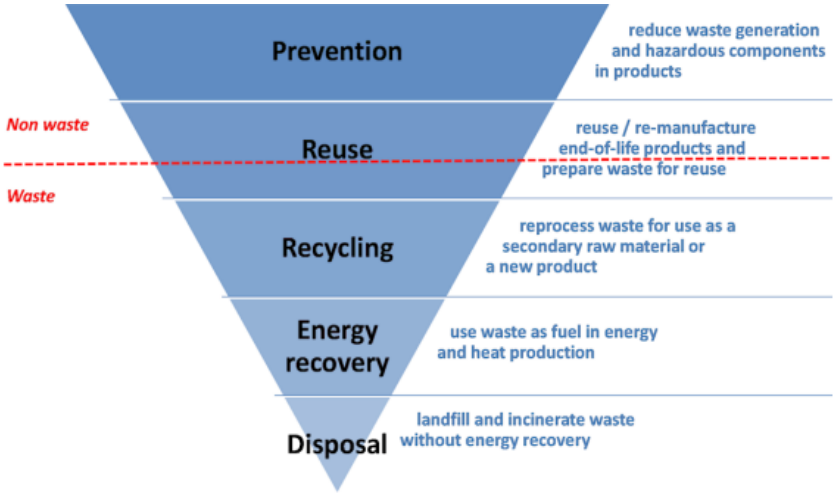

Figure 36 The Waste Hierarchy (Source: OECD)[55]

[54] https://www.oecd.org/digital/ieconomy/42788321.pdf

[55] https://www.oecd.org/environment/environment-at-a-glance/Circular-economy-waste-and-materials-May-2020.pdf

Through the link goingdigital.oecd.org, the OECD offers a tool to help countries assess their state of digital development and formulate policies. The exploration and visualisation of data are effortless, allowing comparisons between a country and the simple average of OECD countries.

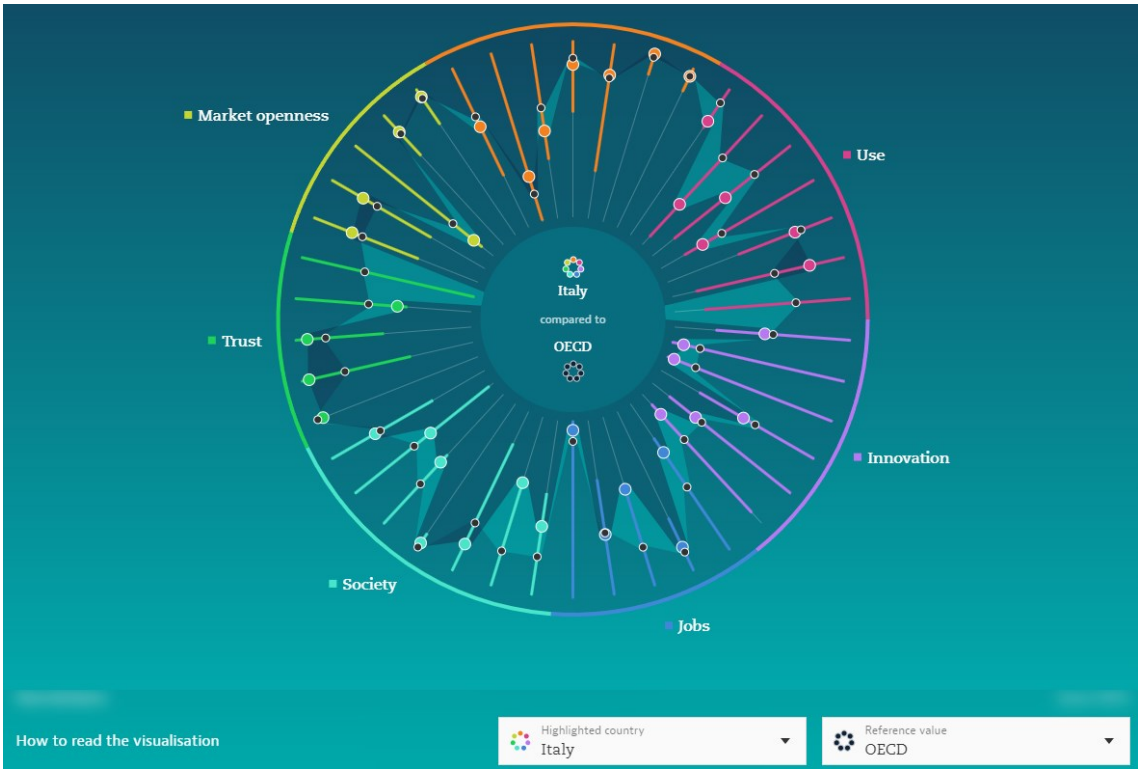

Figure 37 Visualization Obtained Through The OECD Online Tool Comparing Italy's Parameters With The Average Of OECD Countries

In the Growth & Well-being section, you can see how an indicator considers the e-waste generated by each inhabitant:

Figure 38 Visualization Obtained Through The OECD Online Tool Comparing The Amount Of E-Waste Generated By France And Spain

C40 Cities

C40 is a collaborative network of mayors from nearly 100 of the world's leading cities collaborating to deliver the urgent action needed right now to tackle the climate crisis. The mayors of C40 cities are at the forefront of climate action. They are deploying a science-based, partnership approach to support the global community in reducing global warming to 1.5°C and building healthier, more inclusive, and resilient cities. They are promoting a circular economy and zero waste programmes.

It has a C40 Cities Against Climate Change Leadership Group whose purpose is to develop initiatives that can be carried out in the cities of the organisation.

In February 2016, the C40 organisation published a best practice guide on Green IT based on the strategy implemented in Stockholm. Stockholm's Green IT Strategy intends to create "a standardized and modern citywide IT infrastructure" to minimize city operations' greenhouse gas (GHG) emissions. The city's goal is to cut its operational costs by 10% below 2006 levels by reducing energy usage. The strategy outlines the primary objectives, the necessary related actions, and the results the city expects to achieve. In addition, there are at least nine "action areas" in the Green IT Strategy that relate directly to building and office efficiency, including energy-efficient buildings (HVAC settings), visualization of energy and electricity use (including metering and individual charging), digital meetings, digital document processing, a greener IT sector (green and cost-effective IT procurement), green data centres and telecommunications, standardized energy-efficient worksites, and energy-efficient printing.

Another action that received a lot of media coverage was that the 5,000 medals awarded to athletes at the Tokyo 2020 Olympic Games were made entirely from recycled material from used electronic devices.

Figure 39 Tokyo Olympic games medals made with recycled material from used electronic devices (Source: International Olympic Committee ©)

3.2. Companies and NGO Initiatives

Initiatives do not always come from public organisations; companies and NGOs have a lot to say on this issue due to the originality and scope of their proposals. We have compiled some of them as a sample of their work to reduce emissions, promote recycling, change habits or make citizens aware of the importance of their actions.

3.2.1. Digital Pollution Awareness

Digital Clean-Up Day

Organiser / Sponsor: Let´s do it world NGO (Estonia)

Description: There is a lot of trash in the digital world and the environment. Unneeded emails, files, applications and duplicate photos and videos are digital garbage. This digital waste creates pollution that consumes energy even when we have forgotten about it. Annually, the Internet and its support services generate 900 million tons of CO2, which is more than the annual production of Germany.

Figure 40 Image of the Digital Clean-Up Day 2022 campaign (Source: Digitalcleanupday.org Pressroom)

Increasing concern about the ICT sector's energy usage and the CO2 emissions caused by wasteful digital practices led Let's Do It World to launch its first global digital clean-up initiative in 2020.

The project website can download resources and materials such as Guidelines for schools, Guidelines for individuals or Guides about how to clean your computer or mobile phone.

The last Digital Clean-up Day was organised on 19 March 2022.

Goals: The objective is to reduce digital waste and save our environment through simple actions such as:

- Clean your smartphone up

- Clean your personal computer or laptop up
- Clean your mailbox up
- Make new arrangements
- Share your results

Figure 41 Image Of The Digital Clean-Up Day 2022 Campaign (Source: Digitalcleanupday.Org Pressroom)

It is possible to register the effort of the participants through a form, and the sponsors give awards to those who have made the most significant effort to reduce the amount of digital waste.

Country: Worldwide project

Website: https://www.digitalcleanupday.org

Additional information:

Digital Clean-up Day 2022 involved individuals and communities in 124 countries checking their devices for unnecessary files and deleting them. 530.884 GB of data was deleted. While the Internet and its supporting systems produce 900.000.000 tonnes of CO2 annually, this will reduce the production of about 133 tonnes of CO2 annually and slow down global warming.

Solar Impulse Foundation

Organiser / Sponsor: Solar Impulse Foundation

Description: Although the Solar Impulse Foundation is dedicated to promoting solutions to combat climate change from a technical point of view, at the end of 2020, it surprised us with the publication of a video on the YouTube platform entitled "Digital Pollution - limiting your digital environmental footprint". It showed a man in sportswear exercising in his living room. The actor was exercising to reduce his "digital weight" in a comedic tone. We are surprised by the low number of

views because we believe it is a very appropriate format to connect with young audiences and the general public. Similar initiatives should be promoted in other applications such as TikTok.

Goals: Raise awareness of the digital pollution caused by everyday actions such as sending emails, searching the internet, changing equipment without completing its life cycle, making calls instead of video calls and the excessive consumption caused by abusing streaming.

Country: Switzerland

Website: https://solarimpulse.com

Zero Emission Digital

Organiser / Sponsor: IAB Italy

Description: ZED - ZERO EMISSION DIGITAL is a campaign promoted by the Italian interactive advertising association IAB, which aims to become the platform for sharing and acting on digital sustainability issues.

Goals: This initiative aims to raise awareness among users through:

- A manifesto on practices and behaviours companies/individuals should follow to reduce their digital carbon footprint.
- An online tool calculates websites, applications, or videos' digital carbon footprint.

Country: Italy

Websites: https://iab.it and https://zeroemission.digital

Universal Carbon (UPCO2) / Bitcoin Zero (BTC0)

Organiser / Sponsor: Universal Protocol Alliance

Description: If you are interested in cryptocurrencies, you will know that Bitcoin mining is highly polluting due to the enormous energy required for its development. However, Bitcoin's environmental footprint threatens the future of the currency. There is so much computing power focused on decrypting and mining Bitcoins on the network that the energy consumption for these practices has surpassed that of whole countries in its entire magnitude. For example, the energy consumption of cryptocurrency exceeds that of countries such as Argentina.

Each UPCO2 token (tradable asset) represents one tonne of CO2 pollution avoided by a certified REDD+ project, preventing tropical rainforests loss or degradation. REDD+ is a mechanism created by the United Nations to combat climate change by reducing CO2 emissions from deforestation and forest degradation.

Each token is backed by a digital certificate issued by Verra and other international agencies, allowing certified projects to convert their greenhouse gas (GHG) reductions into tradable carbon credits.

In the run-up to creating UPCO2 and BTC0 (a carbon-neutral ERC-20 bitcoin), the UP Alliance consulted with carbon experts worldwide and eventually formed the UP Carbon Foundation.

Goals: The founders of Universal Carbon believe it is the best way to achieve the purpose of protecting the world's rainforests.

The developers of Bitcoin Zero intended the new cryptocurrency to have the characteristics of Bitcoin and zero net emissions (carbon neutral).

To achieve carbon neutrality, developers:

- Prudently calculate the carbon footprint of Bitcoin, 2.5 tonnes per year, plus annual efficiency gains of 20% per year.
- Taking this into account, retire 10 Universal Carbon tokens at minting.
- Because each UPCO2 token is backed by 1 tonne of CO2 from REDD+ rainforest projects certified by Verra and other international standard-setting bodies, they offset the carbon footprint of each Bitcoin wrapped.

The process is audited by the renowned security firm CertiK to verify that there is no malpractice.

Country: Worldwide project

Website: https://www.universalprotocol.io

3.2.2. E-Waste Recycling

Recycle Your Mobile

Organiser / Sponsor: Oxfam Intermón and Movilbank

Description: Oxfam Intermón and Movilbank joined forces to make recycling a solidarity act.

The idea is elementary. The sponsors replace old mobile phones with seeds, books, water bottles, tools and other resources to improve people's lives in the poorest countries.

Goals: The objectives of this initiative include:

- Reuse devices.
- Recycle components respecting the environment.
- Reduce the demand for components such as coltan, a mineral that degrades ecosystems and causes armed conflicts in the Democratic Republic of Congo.
- Raise funds to support Oxfam Intermón's projects to help more and more people to have access to a dignified life.

Country: Spain

Website: https://www.oxfamintermon.org/es/recicla-tu-movil

Sustainable Digitalization

Organiser / Sponsor: CEOE Foundation

Description: This initiative is looking for citizens and companies involved in Sustainable Digitalization, participating in recycling unused devices or donating new equipment.

Organizing specific actions in universities and training centres is expected so young people can participate.

Goals: The primary purpose of this initiative is to contribute to the development of the circular economy by reusing electrical and electronic equipment at the end of its useful life, thus promoting universal access to technology. In addition, the initiative promotes a selective collection of computers and tablets throughout Spain and generates new opportunities for people at risk of exclusion.

This initiative achieves:

- Reduce waste
- Reduce the digital divide
- Extend the life of the devices
- Protect the environment

Country: Spain

Website: https://digitalysostenible.com

Get Moving for the Rainforest

Organiser / Sponsor: Jane Goodall Institute – Spain Chapter

Description: It is a mobile phone recycling initiative created by the Jane Goodall Institute Spain from its environmental education program Roots and Shoots, with the support of the primatologist and conservationist Jane Goodall, Messenger of Peace by the United Nations 2002, Prince of Asturias Award 2003 and International Prize Catalonia 2015.

Goals: The campaign proposes to extend the useful life of our cell phones and, at the same time, offers citizens a simple and free way to contribute unused cell phones (working or not), which will allow:

- Reuse terminals and reduce the unsustainable demand for their parts
- Recycle functional elements and properly dispose of toxic materials, avoiding environmental pollution
- Raise funds for projects to support the development of Congolese citizens and education and conservation programs in the Democratic Republic of Congo, such as the Chimpanzee Recovery Center in Tchimpounga. The Jane Goodall Institute cares for more than 150 rescued chimpanzees, most of whom arrived in terrible conditions after being confiscated from hunters, traffickers or private individuals. The funds are also used for reforestation and chimpanzee conservation projects in Senegal and educational projects for children in the Democratic Republic of Congo
- Education, development and conservation: by donating your mobile phones (working or not), you collaborate with the chimpanzee rehabilitation programs carried out by the IJG at the Tchimpounga Rescue Center. There, the more than 150 rescued chimpanzees are cared for by experienced caregivers, led by Spanish veterinarian Rebeca Atencia. They live in groups in a natural environment, with daily outings into the forest, having begun their gradual reintroduction into the wild. Part of their sustenance is obtained through

the Chimpamigos sponsorship program. You will also be collaborating with the IJG's wild chimpanzee research and conservation programs in Senegal, including reforestation projects and sustainable use of natural resources

- Coltan mining: Much of the world's reserves of coltan that are used in our everyday technology, as well as in the weapons manufacturing industry, are located in the east of the Democratic Republic of Congo, an area of permanent strife where millions of people have been killed and uprooted. Coltan mining employs semi-slave labour, and the location of the famous Kahuzi-Biega National Park also impacts the already endangered gorilla and chimpanzee communities.

Country: Spain

Websites: https://mobilitzatperlaselva.org/es/ and https://janegoodall.es/es/grupo.html

TA Recycling Service

Organiser / Sponsor: TA Education

Description: This training centre offers the Tech Recycling Service, which collects and deletes all information according to EU GDPR, recycles old or no longer used equipment, and provides TA Credit to purchase new devices in its STEM Shop.

Goals: This initiative seeks to reduce the carbon footprint and the number of devices in landfills without completing their useful life.

Country: United Kingdom

Website: https://ta.education/recycle/

Biodegradable and Recycled Credit Cards

Organiser / Sponsor: Caixabank

Description: As a customer, you may ask yourself what your bank can do for the environment to make our planet a better place. We have been looking for exciting initiatives and have found the following one from the Spanish bank Caixabank. The bank leads the payment sector in Spain, with more than 18,8 million cards issued.

In addition to replacing materials, the bank is implementing changes in the printing technique that reduce the carbon footprint and reinforces the internal recycling circuit for expired cards.

Goals: This initiative aims to reduce the impact of climate change. The bank believes that sustainability must be embedded in the business model of the organisations. Therefore, the Environmental Strategy is one of the five pillars of the Socially Responsible Banking Plan. The financial institution is also committed to complying with the Paris Agreement. With such actions, it aims to offset all the greenhouse gas emissions generated and calculated in its carbon footprint and become a "Carbon Neutral" entity.

Country: Spain

Web: https://www.caixabankpc.com/

3.2.3. Other Initiatives

ESCP Green Hackathon | Digital Carbon Footprint

Organiser / Sponsor: ESCP Business School

Description: The Career Service & Corporate Relations team at ESCP Business School in Turin proposed to its students a challenge focused on the digital carbon footprint that it called Green Hackathon.

Over 150 students assisted by 37 mentors challenged each other to design an innovative and sustainable solution to reduce a company's Digital Carbon Footprint by 50%.

The participants had just six hours to create a 15-second short video explaining their ideas and a one-page brief describing the requirements for turning the vision into implementation. A five-person jury evaluated the results.

Goals: The primary purpose of this initiative is to raise participants' awareness so that they can act now to reduce their digital carbon footprint.

Country: Italy (ESCP Turin Campus)

Web: https://escp.eu/events/escp-green-hackathon-digital-carbon-footprint

Additional information:

The most innovative ideas to reduce the digital carbon footprint were the following:

- **Greentopia:** project to restrict the storing of useless data in the cloud by implementing an expiry date system on data to limit energy consumption dramatically.
- **Rose:** design a monthly competition for the greenest employee based on evaluating energy efficiency versus productivity. To help companies reduce their digital carbon footprint, they need to raise awareness among employees by actively engaging them in this value change.
- **Susties:** a project to make data server accounts as "circular" as possible. They followed the seven R's of sustainability: rethink, reject, reduce, choose again, reuse, repair and recycle. For example, one of the suggestions for the R of recycling was to reuse the heat generated by data centres. Indeed, just like our computers and smartphones, data servers also heat up, and this heat, which is a form of energy, should not be wasted. For example, implement an air circulation system to recover the hot air created by the data centre to heat the office or heat the water used. This project was the winner, and the team members presented the idea at the ZED - Zero Emission Digital conference, part of the IAB Forum 2021.

Call for Solutions Tech & Climate

Organiser / Sponsor: Spanish Government **//** red.es // Mobile World Capital – Barcelona

Description: The digital transition offers many new opportunities for society. Still, it also implies, among other things, an increase in energy consumption due to the use of devices, distribution networks and data centres; the extraction of resources and the production of waste associated with the manufacture and disposal of electronic instruments; and the emissions and other environmental impacts created during the life cycle of technological solutions.

The contribution and co-responsibility of the technology sector in the climate emergency must be recognised; quantifying and reducing the environmental footprint of companies in the technology sector, both public and private (especially SMEs and start-ups), making their products, services and infrastructures carbon neutral and minimising their environmental impact.

The solutions must be technological, and their implementation must be technically feasible in less than one year.

Two prizes will be awarded, which each winner will use to set up their pilot project.

Goals: The primary purpose of this initiative is to seek solutions to decrease the impact of the environmental footprint of technology companies by launching a pilot project in the city of Barcelona.

The proposed solutions may be focused, for instance, on the following areas, among others:

- Measuring, reporting and reducing the environmental footprint (including reducing greenhouse gas emissions) of technology and ICT infrastructure services and products.
- Reducing the production of e-waste, promoting the circularity of technological products, and extending their useful life. A life-cycle approach can facilitate reuse, repair, refurbishment, remanufacturing and recycling.
- Improving energy efficiency, promoting renewable energies and incorporating sustainability criteria in using and managing data storage centres and fixed and mobile data networks.
- Optimising the consumption and transmission of data and the performance of software and hardware applications (e.g., use of green coding)

Country: Spain

Website: https://digitalfuturesociety.com/tech-climate/

Carnegie Cyber Academy

Organiser / Sponsor: Carnegie Mellon University

Description: This initiative tries to raise awareness among young people to make more intelligent and responsible choices to help make this world a better place.

Goals: Some of the purposes of this Carnegie Mellon University project include:

- Reduce the use of electricity when using computers and other electronic devices
- Consider how energy efficient and environmentally friendly an electronic device is when purchasing

- Warn about greenwashing by some companies

Country: United States

Website: http://www.carnegiecyberacademy.com/facultyPages/environment/green.html

Ecosia

Organiser / Sponsor: Ecosia GmbH

Description: Ecosia is an internet information search engine that promises to plant trees for searches done by its users (approximately 45 searches per tree).

Goals: Use the profits from the searches to plant trees where they are most needed, mainly in areas affected by deforestation, such as Brazil, Indonesia or Uganda. In Uganda, they have started a new project to protect chimpanzees.

Country: Germany

Website: https://www.ecosia.org

Figure 42 Ecosia plants trees in Kenya with the Green Belt Movement, founded by Nobel Prize laureate Wangari Maathai (Source: Ecosia Press Room)[56]

Clicking Clean

Organiser / Sponsor: Greenpeace

Description: This awareness campaign started in 2010 for big companies to move their data centres to renewable energy.

Goals: Greenpeace aims to ensure that the migration of services to the Cloud must benefit the climate. As a result of their campaign, an annual report measuring the percentage of renewable energy used by the big players in the technology sector, companies invested heavily in improving the efficiency of their data centres in the following areas:

- Operational efficiency
- Hardware Efficiency
- Infrastructure Efficiency

[56] https://www.dropbox.com/sh/qj75colsl86n5km/AADGnV7jm1s3BBQM3LBcVvbNa?dl=0

- Renewable Energy Exploitation

Country: International

Web: http://www.clickclean.org

Additional information: No continuity in the project since 2017. After seven years, Greenpeace considers that the campaign's objectives have been reached.

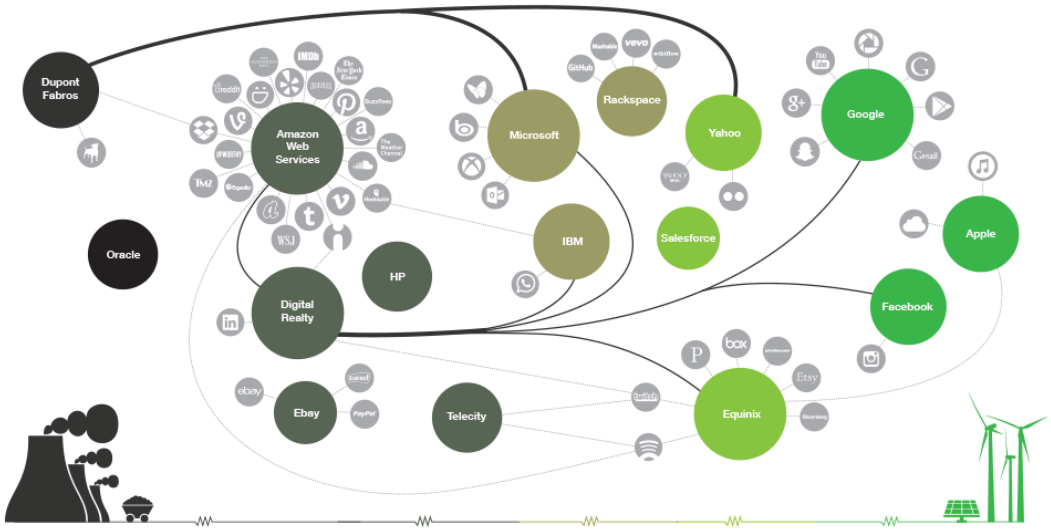

Figure 43 Graphic Resource that Appears in the Annual Reports of Greenpeace's Clicking Clean Campaign (Source: Greenpeace)[57]

ONCE – Green Makers

Organiser / Sponsor: ONCE Foundation

Description: The ONCE Foundation, part of the Spanish National Organisation for the Blind, committed to inclusion and diversity, launched the Green Makers initiative at the end of 2021. Fifty-two employees were selected to improve the organisation's environmental impact and work to make the culture change towards sustainability a cross-cutting one.

Goals: Promote sustainability within the organisation, underpinning the internal culture with environmental commitment.

Country: Spain

Web: https://www.fundacionONCE.es/es/comunicacion/noticias/fundacion-once-lanza-la-iniciativa-green-makers-para-promover-la

Additional information:

[57] https://www.greenpeace.org/usa/clicking-clean-report/

REMEMBER!
The importance of this initiative is that it could open the door for organisations and companies to have people on their staff responsible for recycling electronic devices or reducing electricity consumption. In the same way that there is vigilance to prevent accidents in the workplace, managers or teams could be appointed to be responsible for reducing the organisation's digital carbon footprint or promoting green computing.

The idea would also be feasible in educational institutions, colleges or universities. Incentives could be sought, financial or otherwise, for these people to carry out this activity with the necessary degree of commitment to do it as well as possible.

BackMarket Reconditioned Products

Organiser / Sponsor: BackMarket

Description: BackMarket is a French company that refurbishes electronic devices (mobile phones, computers, tablets, headsets) and offers them for sale at a much lower price than the initial price, emphasising the impact this purchase has on the carbon footprint.

Goals: the company intends that the customer buys reconditioned products to avoid the emission of CO2 into the atmosphere that would have occurred if the products, with minimal damage, had been thrown away and new ones had been manufactured.

Country: France

Website: https://www.backmarket.fr

Additional information:

It started offering its services in France in 2014 and now sells in 15 countries. After mobile phones, laptops and tablets are the most successful categories on its marketplace. BackMarket offers an additional discount to students.

The Initiative is the Person I: Joana Moll

Joana is an artist and researcher based between Barcelona and Berlin. Her performance critically explores how techno-capitalist narratives impact the literacy of machines, humans, and ecosystems. Her main research interests are internet materiality, surveillance, social profiles and interfaces. She has presented her work at renowned institutions, museums, universities and festivals worldwide.

We want to highlight two of their initiatives as highly original, significantly impacting citizens despite their technical complexity.

In 2014, she developed the CO2gle project[58], a real-time project that shows the quantity of CO2 emitted each second from global visits to Google.com, which according to her data, is about 5104.91 kg of emissions per second.

[58] http://www.janavirgin.com/CO2/

Figure 44 Information Provided When Accessing the CO2gle Project Website

In 2022, she developed the _carbolytics Project[59], an interactive web-based installation that measures the carbon costs of real-time cookie tracking.

Carbolytics is a project at the crossroads of art and research. It aims to raise awareness and call for action on the environmental impact of surveillance and tracking in the ad tech landscape. In addition, this work provides a new perspective on tackling the social and ecological costs of companies' non-transparent practices in collecting user data.

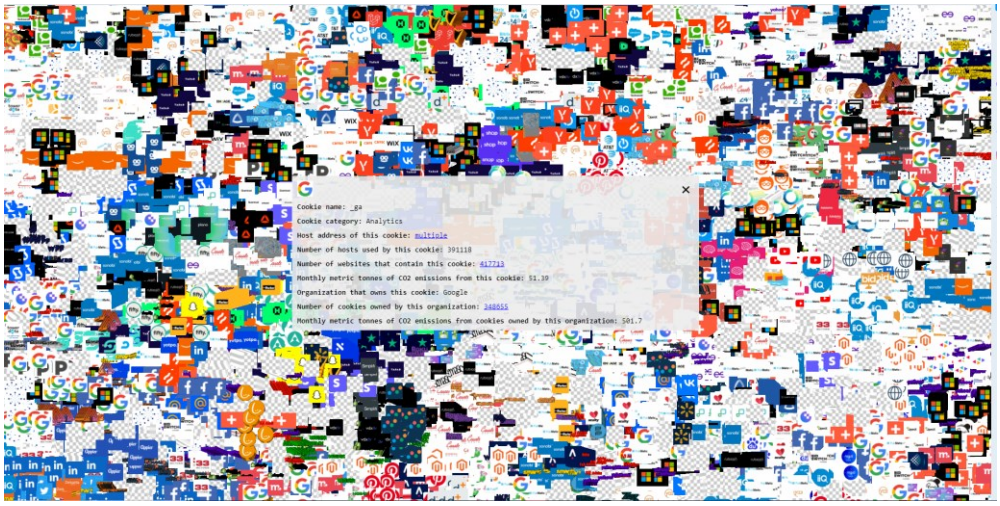

Figure 45 It Is Possible To Visualise The Energy Impact Of Internet Cookies Via The Project Website

The research has identified more than 21 million cookies per unique visit to all these sites from 1.200 different organisations, which means an average of 197 billion cookies per month, equivalent to approximately 11.440 metric tons of CO2 emissions per month, the equivalent of the monthly emissions of a Spanish city of about 28.000 inhabitants. However, this number only shows browser-based cookie traffic and does not include other application tracking activities, so this number is estimated to be much higher.

The Initiative is the Person II: Inès Leonarduzzi

Inès is the founder and CEO of Digital for the Planet[60]. She is one of France's most potent tech entrepreneurs and supports digital sustainability and the inclusive economy. She is setting up a movement to raise awareness of, among other things, digital pollution and the responsible use of technology. She refers to it as L'écologie numérique.

[59] https://carbolytics.org/web2x/

[60] https://digitalfortheplanet.com

In 2019, this specialist in sustainable development and digital strategy was named "Women 4 Climate" by C40 Cities. In 2021, after four years of research, she published the book Repairing the Future with Éditions de l'Observatoire. The book puts forward fascinating ideas:

- Today, more than 14 billion smartphones are used worldwide; 21 billion connected objects help us daily; 7 billion Google searches are performed or 80,000 per second, and 1 billion hours of videos are watched daily. These startling figures mask three types of digital pollution: environmental, intellectual and social. Disembodied digital technology affects our planet, our cognitive capacities, and certain fundamentals of our society, such as living together daily
- The challenge is not to condemn the digital, this fabulous tool, but to initiate a new future. Acquiring not "power" but acquisitive "knowledge".

These actions are already within our reach:

  - reducing the carbon footprint of our devices
  - educating our children who are already addicted to screens, learning to disconnect
  - tracking our data to one day benefit from it

You can see it in this TED Talk[61], in which she discusses the barriers to the advent of sustainable development and what ecology lacks to meet its greatest challenge: building an ideal future.

3.3. Individual Initiatives

Reducing e-waste emissions and energy consumption helps to conserve our planet's resources. It all adds up, and even if you think your contribution is irrelevant, the sum of it all is. So we encourage you to take the following actions to improve the place where we all live. As stated below, there is no Planet B!

3.3.1. Computers and Other Devices

Turning Off Your Electronic Devices When You Are Not Using Them

It's common to go to a class or a meeting and not remember turning off your electronics while away. Even if turning off your desktop or laptop is not an alternative, ensure that your screen is turned off and other things you are not using are unplugged, such as mobile phone chargers. Chargers without phones, laptops, and electrical appliances still draw power by plugging into the socket.

Intelligent Use For Ecological Effects

Computers and their peripherals enable incredible performance leaps and make workflows that were impossible before. But they are some of the world's biggest energy consumers. Consider this. A computer and its attached peripherals running for a month would use the energy generated by

[61] https://www.youtube.com/watch?v=nJksX2MZ80g

eighty kilograms of coal. The power a laptop and its peripherals use while idle for a weekend could run a compact fluorescent light bulb for twenty days at a time.

Turn Off Your Computer Regularly

Turn off all peripherals even if your computer is still on. For example, if your PC needs to be working after hours, you can save energy by turning off your monitor and peripherals. For example, turning off the monitor at night and not letting it suspend can save up to fifty per cent of the monitor's energy costs.

Give your electronics a much-needed rest. All this switching off, especially of monitors and computers, can increase the lifespan of your devices. Unfortunately, an old myth says that turning off computers wears them out. It does not.

Use a hibernation setting if slow boot time is your main reason for keeping your computer on. Save a snapshot of your desktop in memory before going into a deep sleep, and when it wakes up, it will return more quickly to the state it was in than waiting for a complete reboot. During hibernation, power consumption is minimal.

Also, consider installing a smart power strip to help you manage your power.

Overnight Charging

Charging electronic devices (computers, tablets, smartphones) is recommended only as long as necessary. Charging electronic devices during the night may add unnecessary wear and tear. Continuous charging can cause batteries to lose efficiency over time. Take note of the time your phone needs to charge and limit it to that time; you will save battery and energy!

3.3.2. Collaboration

Manage your Email Responsibly

According to an article published on the Guardian's Green Living blog, the average email user emits roughly 135 kg of carbon each year. While this may not sound like a lot when extended to 20000 email accounts, that adds up to 2700 tons of carbon emitted annually from email.

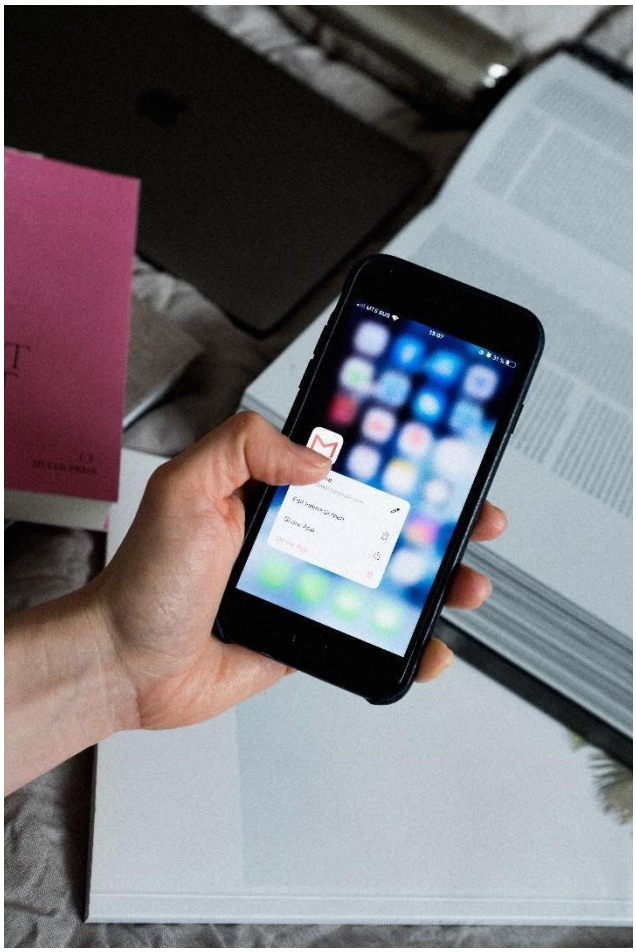

Figure 46 It Is Essential To Know How To Use E-Mail Responsibly To Pollute As Little As Possible[62]

We recommend that you follow these simple recommendations:

- Actively manage your email. Delete unneeded messages through the management of your inbox and sent mail folder.
- Optimize the file size of attachments. Save large Word (and PowerPoint) files as PDFs. This action can reduce the file size by up to 90%
- Reduce the size of images that are attached to emails.
- Compress files before sending them. Programs such as WinZip can reduce the size of large files and can be used to send groups of files as a single attachment

In 2019, UK company OVO Energy published a report saying that if every Briton sent one less thank-you mail a day, 16.433 tonnes of coal could be saved per year - the equivalent of 81,152 flights between London (Heathrow) and Madrid (Adolfo Suarez).

This report listed the top 10 most unnecessary emails sent:

[62] https://www.pexels.com/es-es/foto/telefono-inteligente-aplicacion-correo-telefono-movil-3850252/

Figure 47 The Top 10 Most Unnecessary Emails Sent

REMEMBER!
It is becoming increasingly common to include such messages in the signature/bottom of the email to warn of this action.

Examples of such email messages include:

- Think Before You Thank. There is no Planet B.
- Please consider this a "thanks" in advance. Every email has a carbon footprint. So if you do not hear back from me, it's not you; it's for our planet.

Collaboration Tools

Use online collaboration tools to save time and other resources.

Working with others via video conferencing or e-collaboration tools can help save on travelling and paper costs. Before travelling to a class or a business meeting, consider whether it is possible to do it online. It will save time, and the planet will thank you! For example, think of the thousands of cars on the streets each day, releasing vast amounts of toxic fumes into the atmosphere. Remote work helps you do your tasks comfortably at home using minimal energy.

REMEMBER!
Sometimes a quick online chat can avoid travelling to a meeting. Online collaboration tools reduce the need to store email attachments and decrease paper consumption.

Save Paper and Toner

To help reduce paper consumption, please make printing a conscious choice, not default behaviour. When printing is necessary, please change the default settings to make printing more efficient and, of course, once you're done with anything, ensure it goes to the recycle bin rather than the rubbish.

Change your Printing Habits

To use less paper and less ink or toner, follow these tips:

- Print as little as possible; edit documents on-screen instead of printing them out.

- Distribute documents and collaborate electronically instead of making hard copies.
- Remove unwanted items before printing from your web browser.
- Reduce font size and margin to reduce paper usage.
- Print on both sides of the page (double-sided or duplex) whenever possible
- Put the printer in draft/ink-save mode when high-quality printing is unnecessary.
- Use Eco-font to save ink/toner, designed to use 20% less ink/toner than typical fonts. Letters are perforated with small holes to save ink/toner.
- Print in black and white when you do not need colour.
- Put the message in your message! Include the following sentence at the end of each email you send "Please consider the environment before printing this email".

Reuse and Recycle Paper and Toner

REMEMBER!
Recycle paper and toners or cartridges by depositing them in the appropriate containers after their useful life is over. Many companies include a free return label for sending used cartridges to the supplier for recycling.

3.3.3. Recycle e-Waste

Because the Correct Disposal is Crucial

Recycling is the need of the hour. It helps mitigate environmental damage by reusing non-biodegradable materials such as plastic.

No matter how sophisticated they may be, all electronic devices have a lifecycle. Computers, monitors, tablets, mobile phones and other devices that are not disposed of properly are a real burden to the environment as they contain toxins and are non-biodegradable. Old CRT (cathode ray tube) displays, for example, include lead that can filter into the soil and contaminate our drinking water sources. The material from which such devices are manufactured may be recycled, conserving natural resources and cutting down plastic production. These substances can be safely contained, and most can be used again if disposed of appropriately.

You can also use the suppliers' recycling programmes. The programmes are available through their websites.

Figure 48 Electronic Devices Should Be Recycled Appropriately To Mitigate The Impact On The Environment.

Consider Donating

Donate old devices to give them a second life. We have already seen above that there are organisations that do this. Obsolete equipment that should not be donated should also be recycled.

Do Not Forget Your Data

Ensure that your data is erased securely from the hard drive before sending the computer(s) for donation or recycling.

3.3.4. Energy Saving

Leaving a tap open just because someone might wish to clean their hands later may seem brutal, but that is what we are already doing with our energy when we keep our computers and screens switched on for possible later use.

Thinking consciously about energy, combined with small behavioural changes, such as making an effort to switch off and unplug wherever possible, could go a long way to reducing our electricity consumption.

Follow the recommendations below if you want to save energy and reduce your digital carbon footprint:

- Set power management settings on your computer (Windows, OS X or Linux) to save energy.
- Whenever possible, turn off machines that are not in use.
- Whenever possible, turn off devices at the end of a work session.
- Even when computers cannot be turned off, disconnect monitors, printers and other peripheral equipment that are not in use.

- Group non-critical electrical devices, especially those requiring power adapters, to share a single power strip. When not used, many electrical devices keep consuming power in standby mode; a common phenomenon is known colloquially as "vampire power". Turning off a shared power strip manually will significantly reduce this passive power usage.
- Set your displays to enter into a power-saving "sleep" mode after a particular time of non-use
- Reduces the brightness of monitors and laptop displays. An added benefit for a laptop is that it will extend battery life when working without the power plugged in
- Do not use screensavers. Developed long ago to "save the screen" by preventing images from permanently burning out on older CRT monitors, their need has been rendered obsolete by today's LCD (Liquid Crystal Display) monitors. They only burn out energy

3.3.5. Purchasing

Only Buy As Much As You Need

REMEMBER!
Before purchasing a new device, consider extending its life by refurbishing or repairing it. One of the best methods of reducing waste is to be conscious of your purchases.

For example, do you need those new gadgets or a curved screen the size of a large TV? Make sure your tech purchases are the right size for your needs.

Buying Green

Today, there are many "green" options for ICT-related purchases, from recycled paper to Energy Star-rated laptops. Make sure you choose the technology that best suits your needs and is as environmentally friendly as possible.

Some tips on how to go green:

- When they reach the end of their lifespan, replace CRT displays with LCD monitors. LCD monitors consume much less energy (and therefore cost less), generate less heat, take up less space, cause minor damage to the environment when discarded, and weigh less (they are easier to transport and have a smaller carbon footprint when shipped)
- Buy from the same supplier simultaneously to reduce multiple shipments' costs and carbon footprint
- Consider solid-state drives instead of traditional hard disk technologies to reduce power consumption; as technology evolves, these drives will increase in size and decrease in price
- Consider purchasing small form factor or "all-in-one" desktops, when possible, as they consume significantly less power and consume far fewer materials than mini-towers or towers computers
- Do not choose a bigger monitor more than you need; a 19" monitor can consume 30% more energy than a 17" monitor
- Buy new monitors every two computer replacement cycles rather than every replacement cycle. If you choose this option, make sure the displays are of high quality and try to buy ones that support the connections that will become the standard

- Energy Star is a recognised programme of the U.S. Environmental Protection Agency and the U.S. Department of Energy that promotes efficiency. Look for Energy Star-compliant desktops or laptops. Monitors that have achieved the [ENERGY STAR] label are, on average, 7% more efficient than the standard choices

3.3.6. New Technologies

Virtualisation

Virtualisation is a technology that allows us to run several virtual machines on a physical device to make the most of a system's resources. Before acquiring a computer for academic or work purposes, we should ask ourselves if it is possible to virtualise it through software such as VirtualBox or VMWare[63].

Virtualisation makes it possible to use fewer servers in the data centres, reducing energy use and waste.

Cloud Computing Services

You had a computer on your office desk with certain specifications such as RAM, storage and processing power. When you turn on the computer to perform your daily tasks, it consumes energy, whether you use all the resources.

REMEMBER!
With new technology, such as cloud computing, multiple users can be hosted on a single physical server. However, it can do considerably more work on fewer servers because it optimises the server's resources.

In addition, because all hardware is in a remote data centre, the users have access to their data on their smartphones, notebooks and tablets. Therefore, it eliminates unnecessary bulky IT systems, reducing energy consumption.

[63] https://www.vmware.com/es/products/workstation-player.html

Figure 49 Amazon Web Services, Microsoft Azure, Google Cloud, and Alibaba Cloud are the most relevant cloud computing service providers.[64]

[64] https://www.pexels.com/es-es/foto/cerrar-foto-de-la-plataforma-minera-1148820/

4. Legislation

Authors: **Diego** Borsellino, **Veronica** Tanelli, **Lorenzo** Borsellino

Organization. Fondazione ITS INCOM per l'INformazione e la COMunicazione (ITS INCOM)

Chapter Summary.

The current chapter analyzes the legislation regarding environmental protection in force when composing this book and its security at the international and EU level. The process standing behind its development is described, as well, to understand the ongoing legislative activity on the topic. Both at the United Nations and a European level, the international community constantly develops new laws and updates the existing ones.

In this chapter, you will find an introduction to creating the first global policies on the environment, with all the steps taken, especially at the United Nations level, from the 70s to 2000 (section 4.1). We will then move to the European context to analyse the most critical milestones for introducing environmental protection in regional policies (4.2). After discovering the basis, we will see the current framework for developing laws on the environment, with the leading European Action Programme and strategies and the existing monitoring process (4.3). Finally, the focus will be on the thematic core of the GreenCo project: laws on energy reduction and green energy, the connection between the environment and ICT production, and e-waste reduction (4.4).

Keywords

Environmental law, Environment protection, Legislation, EU Law, Green Energy, Recycling, Waste reduction, Sustainable Development

4.1. Global environment policy: where and when it started

REMEMBER!
When we analyse the historical development of the international policy on the environment, we cannot disregard the concept of Sustainable Development, understood as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs"[65].

As emerging from this definition created in 1987 by the World Commission on Environment and Development, the use and safeguarding of the environment and its natural resources represent a precondition for human development.

[65] World Commission on Environment & Development, "Our Common Future", Geneva: Oxford University Press, 1987.

REMEMBER!
Thus, the environment and its development constitute one of the three vertices of the triangle of Sustainable Development, together with economic growth and social development (see Figure 50). When this correlation between development and the environment was understood, the international community first raised its interest in climate safeguarding and started legislating on this topic.

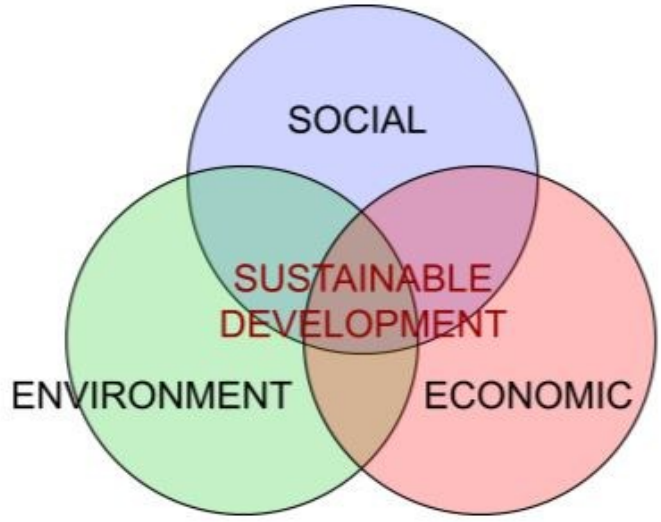

Figure 50 The Triangle of Sustainable Development

With this milestone set, we can now investigate the origin of international legislation and policy on the environment and its development over the years. This will help us understand and evaluate the current laws existing worldwide and in Europe. What we will see here are the steps that were taken internationally to reach the "2030 Agenda for Sustainable Development" and the "Paris Agreement" that we have described above (see section 3.1.1.).

4.1.1. United Nations Conference on the Human Environment (Stockholm 1972)

Some years before the Conference of 1987, which then originated the "Our Common Future" report[66], the international community had a first discussion on the environment. It happened in 1972 when Stockholm hosted the first international Conference on the Human Environment. During this Conference, the need to adopt environmentally compatible development took on the dimensions of a global debate.

The origin of this discussion was the report "The Limits to Growth (LTG)"[67], commissioned by the Club of Rome, which was a non-governmental, non-profit association of scientists, economists,

[66] See section 4.1.2.

[67] Donella H. Meadows, Dennis L. Meadows, Jørgen Randers, William W. Behrens III, "The Limits to Growth", Potomac Associates, 1972.

businessmen, civil rights activists, senior international public officials and heads of state on all five continents, formed in 1968 in Rome, Italy.

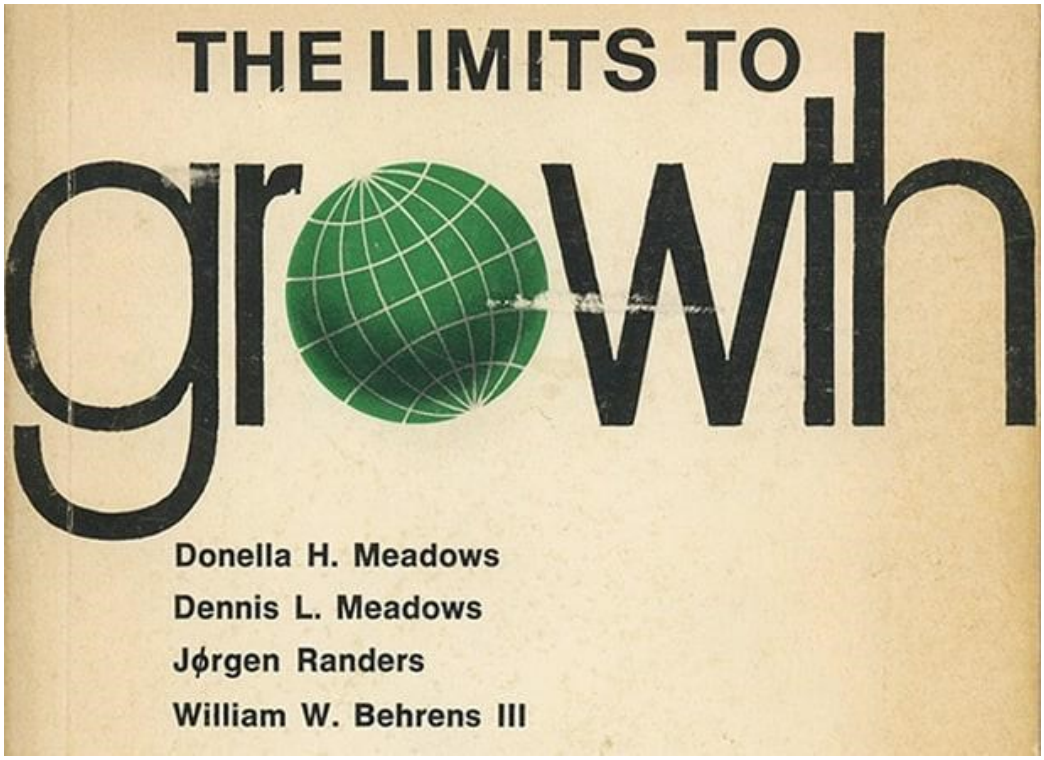

Figure 51 The Limits to Growth[68]

REMEMBER!
In the 1972 report "The Limits to Growth", also known as the Meadows Report from the names of the principal authors (Donella H. Meadows, Dennis L. Meadows, Jørgen Randers, and William W. Behrens III), the Club of Rome predicted that economic growth could not continue indefinitely due to the limited availability of natural resources, especially oil, and the planet's limited ability to absorb pollutants.

Suppose the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged. In that case, the limits to growth on this planet will be reached sometime within the next one hundred years. The most probable result will be a sudden and uncontrollable population and industrial capacity decline.[69]

However, it was considered possible to "alter these growth trends and establish a condition of ecological and economic stability that is sustainable far into the future"[70].

[68] https://www.listal.com/viewimage/21810563 [30/04/2022]

[69] Donella H. Meadows, Dennis L. Meadows, Jørgen Randers, William W. Behrens III, "The Limits to Growth", Potomac Associates, 1972.

[70] Ibidem.

REMEMBER!
After the publication of the 1972 report "The Limits to Growth," it started to crumble the assumption that the economic growth of 'developed' countries would have stimulated that of developing countries. On the contrary, it became clear how developing countries, and all countries in general, would soon suffer from the extensive and uncontrolled exploitation of natural resources.

4.1.2. Our Common Future: Environment and Development (1987)

In 1987 the World Commission on Environment and Development, chaired by Norwegian Prime Minister Gro Harlem Brundtland, drew up the report "Our Common Future"[71] (Brundtland Report), describing the close connection between economic development and environmental quality. The information defined the concept of sustainable development[72]. It explained how sustainable development is not a fixed state of harmony but rather a process of change in which the exploitation of resources, the orientation of technological development, and institutional change are consistent with future and present needs[73].

REMEMBER!
To preserve future needs, Brundtland, in its 1987 report "Our Common Future," declared that each country must ensure 'sustainable' use of natural resources, limiting the exploitation of non-renewable resources - in order not to cause their rapid depletion - and respecting renewable resources - by taking due account of their capacity for regeneration and thus avoiding causing their progressive deterioration.

The Brundtland Report's main merit was setting a process that created the context for much of the sustainability policy and legislative work on the environment that led to the United Nations Conference on Environment and Development in Rio in 1992.

4.1.3. Rio de Janeiro Earth Summit (1992)

The Rio de Janeiro Earth Summit (United Nations Conference on Environment and Development)[74], held in 1992, is perhaps one of the largest and most celebrated international events organised by the United Nations. The level of attendance at the conference was very high and unprecedented: heads of State (See Figure 52), 8,000 journalists and more than 30,000 people attended the official government summit and the parallel Global Forum of Non-Governmental Organisations.

[71] World Commission on Environment & Development, cit.

[72] See 4.1.

[73] World Commission on Environment & Development, cit.

[74] United Nations, United Nations Conference on Environment and Development, Rio de Janeiro, Brazil, 3-14 June 1992, https://www.un.org/en/conferences/environment/rio1992 [29/04/2022]

Figure 52 Group Photo Of World Leaders Meeting At The Earth Summit In Rio De Janeiro, Brazil, 13 June 1992. UN Photo/Michos Tzovaras[75]

During the conference, the connection and interdependence between social, economic, and environmental factors were highlighted, making it necessary to start an integrated approach to ensure sustainability for development. It produced a new blueprint for international action on environmental and development issues. Despite this, the general commitments made in Rio have no legal value, and the economic cover necessary to start the process of sustainable development (especially in developing countries) has not been found or provided by industrialised countries. Thus, these instruments have been severely undermined. However, after the Conference, some important documents were created.

REMEMBER!
Eventually, the United Nations Conference on Environment and Development resulted in five official documents that still constitute the main reference framework for sustainable development at the international level: "Rio Declaration on Environment and Development"; "Agenda 21"; "Non-legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forests"; "Convention on Biological Diversity"; "Framework Convention on Climate Change".

Rio Declaration on Environment and Development

The Declaration contains 27 principles defined for establishing a global partnership and "working towards international agreements which respect the interests of all and protect the integrity of the global environmental and developmental system"[76]. Among the principles, explicit reference is made to integrating environment and development, intergenerational equity, poverty reduction and the precautionary principle.

[75] Ibidem.

[76] United Nations, "Rio Declaration on Environment and Development", New York, United Nations publications, 1993, preamble.

Agenda 21

The Agenda[77] is a dynamic programme inviting the whole international community to work toward achieving overall sustainable development in the 21st century. For us, it is particularly relevant that in its Chapter 8, "Integrating environment and development in decision-making", contains indications on objectives, activities and means of implementation regarding "Integrating environment and development at the policy, planning and management levels" and "Providing an effective legal and regulatory framework"[78].

Non-legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forests[79]

Although not binding for signatory states, they constitute the first effort towards sustainable management, conservation and development of all types of forests[80].

Convention on Biological Diversity

The Convention[81] recognises the value and importance of biodiversity. Thus, it requires the development of national and international strategies for protecting biological diversity and identifying and monitoring the components of biodiversity and the activities that have the most significant impact on it. It promotes adopting protection programs, sustainable use of biological diversity components, and training on these issues.

Framework Convention on Climate Change (UNFCCC)

Adopted in New York in 1992, signed at the Earth Summit by 155 countries, and in force since 1994, the Convention[82] recognises the global problem of climate change and sets the goal of stabilising:

"greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within time to allow ecosystems to adapt to climate change, ensure food production is not threatened, and enable sustainable economic development"[83].

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[77] United Nations, "Agenda 21" as Annex I to "Rio Declaration on Environment and Development", New York, United Nations publications, 1993.

[78] Ivi, chapter 8, c. 8.1.

[79] United Nations, "Non-legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forests" as Annex III to "Rio Declaration on Environment and Development", New York, United Nations publications, 1993.

[80] Ivi, preamble, c. b.

[81] United Nations, "Convention on Biological Diversity", 1992.

[82] United Nations, "Framework Convention on Climate Change", 1992.

[83] Ivi, article 2.

REMEMBER!
The 1992 "Framework Convention on Climate Change", deriving from the Rio de Janeiro Earth Summit, set the goal of stabilising the greenhouse gas concentrations in the atmosphere. However, the Convention did not define the value of these concentrations. After Rio, several meetings and conferences of the Convention's signatory state to determine the exact quantitative emission targets.

All the conferences were characterised by a heated debate about differentiated responsibility, i.e. how to calculate each country's emission reduction allowances and thus on the commitments to be made, either differentiated according to their industrial history (as proposed by the developing countries) or undifferentiated concerning previous responsibilities for current pollution.

Like all UN conventions, the Climate Convention acquires legal force when several countries ratify it. This Convention came into force in 1994, and it is an international framework law that commits the countries that ratify it to implement it. Since it is a framework law, it needs enforcement laws, which in the UN are called protocols.

4.1.4. Kyoto Protocol (1997)

REMEMBER!
The 1997 Kyoto Protocol is the implementing law deriving from the UN "Framework Convention on Climate Change". The Protocol committed industrialised countries and countries with economies in transition to reduce their primary anthropogenic greenhouse gas emissions by 5% from 1990 levels in the period from 2008 to 2012.

The overall 5% reduction was distributed differently among countries: for EU countries, 8% overall, for the US, 7% and for Japan, 6%. The Russian Federation, New Zealand and Ukraine only needed to stabilise their emissions. Norway, Australia and Iceland could increase their emissions by 1%, 8% and 10%. No limitation of greenhouse gas emissions was envisaged for developing countries, as this would have slowed their path to socio-economic development. However, the risk was that the reduction efforts of industrialised and transitional economy countries were nullified by the contribution of developing countries' greenhouse gas.

Even if the Protocol was adopted in 1997, due to a complicated ratification process, it entered into force only in 2005. Today, there are 192 Parties to the Kyoto Protocol[84]: among the big absents, the US stands out[85].

[84] United Nations Climate Change, What is the Kyoto Protocol?, https://unfccc.int/kyoto_protocol [29/04/2022]

[85] United Nations Climate Change, Parties to the Kyoto Protocol, https://unfccc.int/process/parties-non-party-stakeholders/parties-convention-and-observer-states?field_partys_partyto_target_id%5B512%5D=512 [29/04/2022]

REMEMBER!
Between 1990 and 2010, the industrialised countries subject to reduction obligations (as defined in the 1997 Kyoto Protocol) reduced their emissions by almost 9%. Nevertheless, due to the unexpected and tumultuous growth of emerging countries, primarily China, the model of the Kyoto Protocol has proved inadequate concerning its primary objective. In fact, from 1990 to 2010, emissions rose from 37 to almost 50 GtCO2eq[86].

In 2012 the Parties to the Kyoto Protocol adopted an amendment to the Protocol, the Doha Amendment, which should have covered a second commitment period, starting in 2013 and lasting until 2020, but which entered into force in 2020 when three-fourths of the Parties to the Kyoto Protocol accepted it. With this amendment, Parties committed to reducing their global emissions by at least 18 per cent below 1990 levels[87].

4.1.5. UN Millennium Summit and the Millennium Development Goals (2000)

In September 2000, after a decade of conferences and summits, 149 heads of state and political representatives from 40 other countries gathered at UN headquarters in New York to adopt the United Nations Millennium Declaration. The stated objective was the commitment of their nations to a new global partnership to reduce extreme poverty and establish a set of goals, called Millennium Development Goals (MDG), to be achieved by 2015.

REMEMBER!
At the 2000 United Nations Millennium Summit, the United Nations Millennium Declaration was signed, and eight Millennium Development Goals were derived from this Declaration.

Those eight goals are as follows:

1. to eliminate extreme poverty and hunger;
2. to achieve global primary education;
3. to empower women and promote gender equality;
4. to reduce child mortality;
5. to promote maternal health;
6. to fight malaria, HIV/AIDS, and other diseases;
7. to promote environmental sustainability;
8. to develop a universal partnership for development.

[86] Fondazione per lo sviluppo sostenibile, "L'Italia ha centrato l'obiettivo del Protocollo di Kyoto – Dossier Kyoto 2013: prima stima delle emissioni nazionali di gas serra 2008-2012", 2013, p. 9.

"tCO2eq is a unit of measure of atmospheric pollution. One tCO2eq is equivalent to one tonne (1000 kilograms) of carbon dioxide", Answers, What is tCo2Eq?, https://www.answers.com/physics/What_is_tCo2Eq [30/04/2022].

[87] United Nations Climate Change, What is the Kyoto Protocol?, https://unfccc.int/kyoto_protocol and United Nations Climate Change, The Doha Amendment, https://unfccc.int/process/the-kyoto-protocol/the-doha-amendment [30/04/2022].

REMEMBER!
For each Millennium Development Goal, specific targets and indicators were set. The first target for the Goals on the environment (Goal 7) was, specifically, "To integrate the principles of sustainable development into every nation's policies and programmes, and also reverse the depletion of environmental resources"[88].

The introduction of the MDGs represented a further step toward acquiring environmental protection consciousness by the international community. In 2015 two other essential initiatives were taken, as we have seen before: all United Nations member states ratified the "2030 Agenda for Sustainable Development" and more than 190 countries adopted the "Paris Agreement"[89].

4.2. European Environment Policy: Milestones

Laws on the environment and its protection exist on different levels. The following regulations have been developed thanks to the continuous international discussion on the environment and its safeguard. In addition, the environment is included in the Fundamental Rights declared in the "Charter of Fundamental Rights of the European Union"[90] of 2000, which became binding in 2009 when the Lisbon Treaty came into force. Its article 37 says: "A high level of environmental protection and the improvement of the quality of the environment must be integrated into the policies of the Union and ensured following the principle of sustainable development"[91]. The Charter made the existing rights more visible without creating any new rights.

Environmental protection has then been included within the "Treaty on the Functioning of the European Union"[92] and in some legislative packages and plans that we will now analyse.

4.2.1. Treaty on the Functioning of the European Union (TFEU): its origins

REMEMBER!
The "Treaty on the Functioning of the European Union" (TFEU), alongside the "Treaty on the European Union" (TEU, or Treaty of Maastricht), represents the constitutional basis of the European Union. While the TEU identifies and describes the European Union's primary purpose, principles and institutions, the TFEU defines how it is organised and its functional details.

The TFEU derives from the "Treaty establishing the European Economic Community" (better known as Treaty of Rome), which was signed in 1957 by Belgium, France, Italy, Luxembourg, the Netherlands and West Germany. The Treaty of Rome represented the basis for the creation of the European Economic Committee. In 1987, it received its first significant revision with the Single

[88] MDG Monitor, Millennium Development Goals, https://www.mdgmonitor.org/millennium-development-goals/ [30/04/2022].

[89] See section 3.1.1.

[90] Charter of Fundamental Rights of the European Union, 2000.

[91] Ivi, art. 37.

[92] See sections 4.2.1. and 4.2.2.

European Act (SEA), which set a timetable and a deadline (1992) for the creation of a single market within the European Community and the introduction of a European currency, as well as standard foreign and domestic policies[93]. Furthermore, with a dedicated Title, it introduced policies designed to protect the environment[94].

In 1993 alongside the Treaty of Rome, the "Treaty on European Union" (TEU) was introduced, commonly known as the Treaty of Maastricht, from the city where the 12 Ministers signed it for Foreign Affairs and Finance of the Member States (see Figure 53).

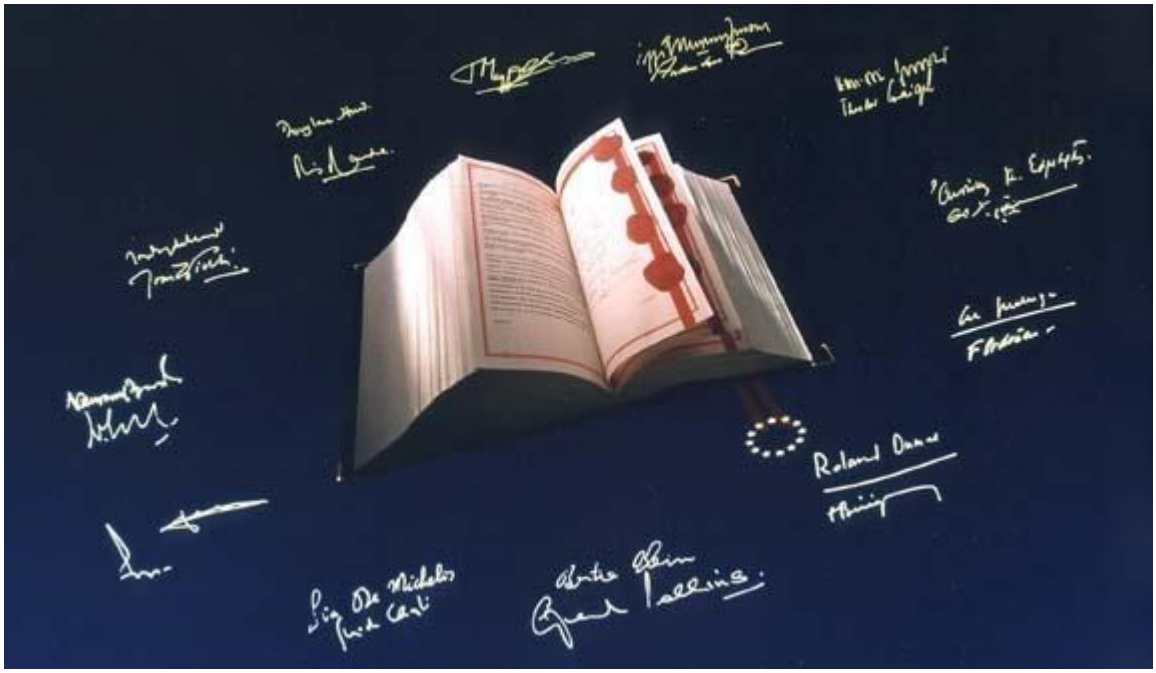

Figure 53 The Treaty of Maastricht with the signatures of the 12 Ministers[95]

With the entry of force of the Treaty of Maastricht, the European Economic Community was merged with the European Coal and Steel Community (ECSC) and the European Atomic Energy Community (Euratom) to become the European Community (EC), with the aim of "creating an ever closer union among the peoples of Europe"[96].

[93] Britannica, Single European Act, https://www.britannica.com/topic/Single-European-Act [30/04/2022].

[94] "Single European Act", 1987, Title VII.

[95] European Parliament, Treaty on European Union (TEU) / Maastricht Treaty, https://www.europarl.europa.eu/about-parliament/en/in-the-past/the-parliament-and-the-treaties/maastricht-treaty [30/04/2022]

[96] Council of European Communities, Commission of the European Communities, "Treaty on European Union", art. A.

REMEMBER!
In its preamble, the TEU already declared the determination of the European Union "to promote economic and social progress for their peoples, within the context of the accomplishment of the internal market and reinforced cohesion and environmental protection [...]"[97].

As in the previous SEA, a whole Title was also dedicated to revisions of the Treaty of Rome's articles regarding the environment (Title XVI). It also included, within its annexes, a Declaration on assessment of the environmental impact of Community measures, stating that "the Conference notes that the Commission undertakes in its proposals [...] to take full account of their environmental impact and the principle of sustainable growth"[98].

In 2009 with the Treaty of Lisbon, there was the last significant revision of the "Treaty establishing the European Economic Community", which eventually became the "Treaty on the Functioning of the European Union". This last Treaty aimed to make the European Union more democratic and with a better capacity for addressing global problems as a whole, including climate change[99]. From the Treaty of Lisbon arrived the final text of the "Treaty on the Functioning of the European Union", which we can now analyse.

4.2.2. TFEU Regulation on the Environment

The "Treaty on the Functioning of the European Union" (TFEU), signed by all the EU member states, consists of 358 articles, divided into seven parts, defining common principles and regulations on non-discrimination and citizenship of the Union, Union policies and internal actions, Association of the overseas countries and territories, External action by the Union, and Institutional and financial provisions.

REMEMBER!
Among the large number of articles defining the whole regulation of the European Union, the "Treaty on the Functioning of the European Union" (TFEU) contains four articles with a specific reference to the environment: articles 11, 191, 192 and 193.

REMEMBER!
The "Treaty on the Functioning of the European Union" (TFEU)'s article 11, included in the second title, "Provisions having a general application", states: "Environmental protection requirements must be integrated into the definition and implementation of the Union's policies and activities, particularly to promote sustainable development"[100].

[97] Ivi, preamble.

[98] Ivi, Declaration 20.

[99] European Union, Founding agreements, https://european-union.europa.eu/principles-countries-history/principles-and-values/founding-agreements_en [30/04/2022].

[100] "Treaty on the Functioning of the European Union", art. 11, 1957, last amend 2011.

This article acquires particular importance due to its location, which places it within the title on those provisions to be applied on any topic, at the same level as the activities to eliminate inequalities between men and women[101], guarantee social protection[102] and "combat discrimination based on sex, racial or ethnic origin, religion or belief, disability, age or sexual orientation"[103]. As in other global policies[104], Article 11 places environmental protection and sustainable development side by side.

Then, specific attention to the environment is dedicated by the tenth title ("Environment"), which consists of three articles detailing how the environment must be protected by the European Union and its Member States. Let's see them together.

Article 191:

1. Union policy on the environment shall contribute to the pursuit of the following objectives:

- preserving, protecting and improving the quality of the environment,
- protecting human health,
- prudent and rational utilisation of natural resources,
- promoting measures at the international level to deal with regional or worldwide environmental problems, particularly combating climate change.

2. Union policy on the environment shall aim at a high level of protection, taking into account the diversity of situations in the various regions of the Union. It shall be based on the precautionary principle and the principles that preventive action should be taken, that environmental damage should be rectified at the source and that the polluter should pay. […][105]

REMEMBER!
With the "Treaty on the Functioning of the European Union" (TFEU)'s Article 191, the European Union has defined the intention of introducing policies to protect the environment and link human health and natural resources. At the same time, it is specified how the modes of intervention must focus on prevention rather than aftercare, which means that immediate corrective actions must be taken in the case of risk of environmental damage, even if it is not sure. It is also established that in the possibility of actual damages, they will be repaired and, in any case, paid for by the polluter.

This specific point has been reiterated and furtherly defined in 2004 by Directive 2004/35/CE, which states that "The prevention and remedying of environmental damage should be implemented

[101] Ivi, art. 8

[102] Ivi, art. 9.

[103] Ivi, art. 10.

[104] See section 4.1

[105] Ivi, art. 191.

through the furtherance of the "polluter pays" principle, as indicated in the Treaty and line with the principle of sustainable development"[106].

The article then continues with subparagraphs 3 and 4, ensuring that all the objective data and elements will be considered when preparing the policy[107]. Also, it is guaranteed the possibility for the Member States to cooperate with third countries and "negotiate in international bodies and conclude international agreements"[108].

REMEMBER!
The "Treaty on the Functioning of the European Union" (TFEU)'s article 192 defines the modalities for the European Union to pursue the objectives described in article 191. In particular, it is indicated how the Union has the competencies to intervene in any topic related to environmental policy (such as air and water pollution, waste management and climate change), but with the need for unanimous consent from the European Council when it comes to topics such as fiscal issues, land use, choice of energy sources and structure of energy supply[109].

Article 193 maintains the possibility for the Member States to introduce more stringent protective measures as long as they are compatible with the European Treaties[110].

4.2.3. EU Climate and Energy (CARE) Package

After the end of the period covered by the Tokyo Protocol[111] (2008-2012), new proposals were made at a European level to define new targets by 2020. After two first propositions by the European Council and the European Commission, in December 2008, the European Council defined a "final compromise regarding the energy and climate change package"[112].

REMEMBER!
The 2008 Climate and Energy (CARE) Package included a set of binding legislation aimed at reaching, by 2020, the so-called "20-20-20" targets: "A 20% reduction in EU greenhouse gas emissions from 1990 levels; Raising the share of EU energy consumption produced from renewable resources to 20%; A 20% improvement in the EU's energy efficiency"[113]. The package defined several actions to be taken in different fields to reach this aim.

[106] Directive 2004/35/CE of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage

[107] E.g., scientific data, different environmental conditions of specific regions, development of each region.

[108] Ivi, subparagraph 4.

[109] Ivi, art. 192.

[110] Ivi, art. 193.

[111] See section 4.1.4.

[112] Council of the European Union, "Energy and climate change – Elements of the final compromise", Brussels, 2008, introduction. https://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/104672.pdf [01/05/2022].

[113] https://www.eea.europa.eu/policy-documents/the-eu-climate-and-energy-package [01/05/2022].

The package improved the EU Emissions Trading System, which had been created in 2003[114], defining it as a "system for greenhouse gas emission allowance trading within the Union [...]to promote reductions of greenhouse gas emissions in a cost-effective and economically efficient manner"[115]. This system aimed to cut greenhouse gas emissions produced by large-scale power, industry, and aviation facilities.

It committed States to a shared effort to reduce national greenhouse gas emissions and non-ETS industries (housing, agriculture, waste, and other transport). Decision No 406/2009/EC on the effort of Member States to reduce their greenhouse gas emissions[116] laid down the minimum contribution of each Member State[117], describing the annual reporting modalities[118] as well as the corrective actions to be taken, which included the deduction from the Member State's emission allocation of the following year, and the development of corrective action plans[119].

REMEMBER!
The 2008 Climate and Energy (CARE) package included binding national targets on the raised use of renewable energy. The global level of 20% to be reached by 2020 was diversified for each country based on their starting points for renewable energy production and their ability to increase it.

Everything was described in the Directive 2009/28/EC on the promotion of the use of energy from renewable sources[120], which, in its second article, specified how renewable energies included: "energy from renewable non-fossil sources, namely wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases"[121].

Each State was asked to adopt a national renewable energy action plan[122]. The Directive included cooperating with other countries on "joint projects relating to the production of electricity,

[114] "Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a system for greenhouse gas emission allowance trading within the Union and amending Council Directive 96/61/EC", 2003, see section 4.2.3.

[115] "Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003" as amended by "Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009", art. 1.

[116] "Decision No 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020", 2009.

[117] The targets vary according to national wealth, setting the limit in 2020 compared to 2005 greenhouse gas emissions levels between -20% (Denmark, Ireland, Luxembourg) and +20% (Bulgaria). Ivi, Annex II.

[118] Ivi, art. 6.

[119] Ivi, art. 7.

[120] "Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC", 2009.

[121] Ivi, art. 2, c. a.

[122] Ivi, art. 4.

heating or cooling from renewable energy sources"[123]. Here again, national reports were asked to each State, and the Commission would have monitored the actual origin of biofuels and bioliquids, the impact of their production and land use[124]. In 2018, after several amendments, the Directive was repealed by Directive (EU) 2018/2001 on promoting the use of energy from renewable sources[125]. We will describe this later in section 4.4.1.

4.2.4. Roadmap For Moving to a Competitive Low-Carbon Economy By 2050

REMEMBER!
The 2008 EU Climate and Energy (CARE) Package set three targets to be reached by 2020. It is also part of the following "Europe 2020 strategy for smart, sustainable and inclusive growth", specifically its Flagship Initiative: "Resource efficient Europe"[126]. With these initiatives as a basis, in 2011, the European Commission produced a new plan to meet the long-term target of reducing domestic emissions by 80 to 95% by 2050: the Roadmap for moving to a competitive low carbon economy in 2050[127].

To reach the final target of reducing European domestic emissions by 80% by 2050 compared to 1990, the Roadmap set intermediate milestones for 2020, 2030 and 2040. As visible in the figure below (Figure 54), the reduction should be 25% in 2020, 40% in 2030 and 60% in 2040. Additional European and national policies or modifications to the current ones should be implemented to reach the target.

[123] Ivi, artt. 7 and 9.

[124] Ivi, artt. 22 and 23.

[125] "Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources", 2018.

[126] European Commission, "Communication from the Commission. Europe 2020. A strategy for smart, sustainable and inclusive growth", Brussels, 2010, pp. 14-15.

[127] European Commission, "Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A Roadmap for moving to a competitive low carbon economy in 2050", Brussels, 2011.

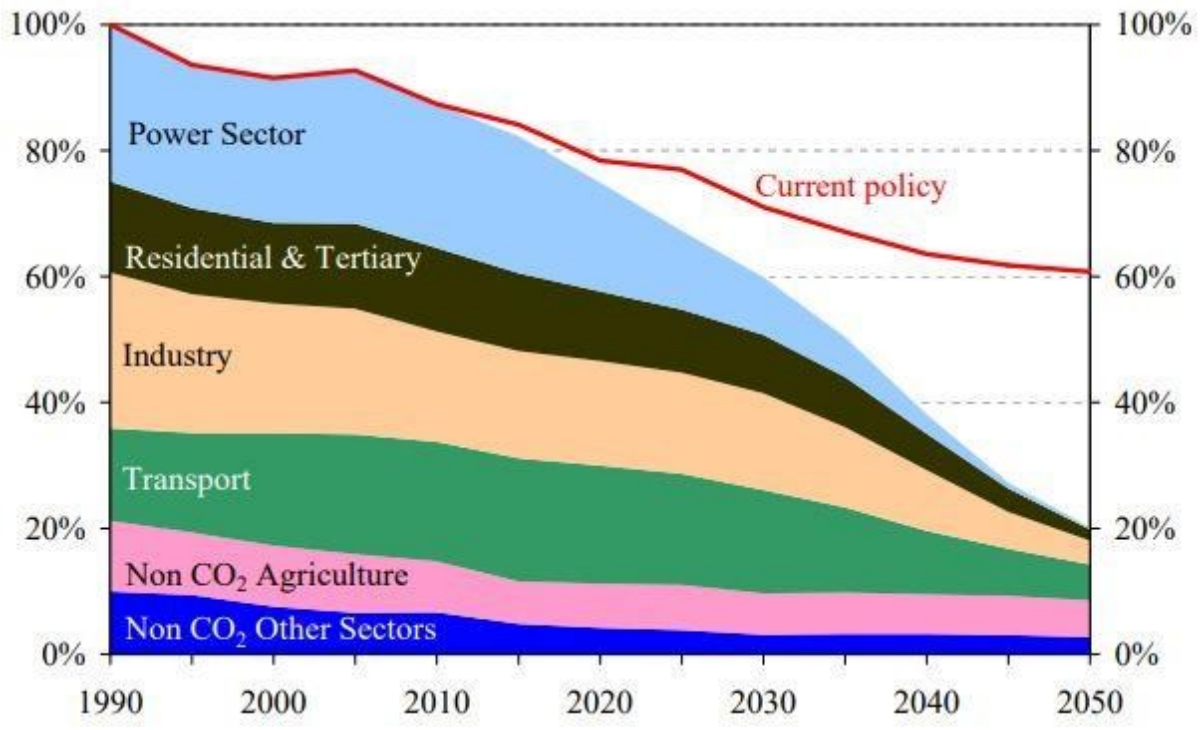

Figure 54 EU GHG Emissions Towards An 80% Domestic Reduction (100% = 1990)[128]

Reaching the goal of reducing European GHG emissions is linked to the commitment to get 20% renewable energy and achieve 20% energy efficiency. Resource efficiency should be increased, as well, e.g. through waste recycling, better waste management and behavioural change[129].

REMEMBER!
How can each key sector reduce the use of carbon and GHG emissions? The 2011 Roadmap for moving to a competitive low carbon economy in 2050 analyses this issue, suggesting some solutions based on an ongoing technological innovation process.

These solutions are as follows:

- Electricity plays a central role in the transport and heating sector, replacing fossil fuels. To allow this, investments in a continuous supply of renewables are necessary.
- Talking about the transport system, technological innovation can play a role in developing new hybrid engines, new biofuels and propulsion systems and safer operation through information and communication systems. The key to reducing GHG emissions is likely to remain improved fuel efficiency.
- The built environment is the sector where it is easier to reduce GHG emissions quickly. Here, it is enough to improve the energy performance of buildings. The possible solutions include heat pumps and storage heaters and energy from solar heating, biogas, and biomass to avoid fossil fuel use.

[128] Ivi, p. 5.

[129] Ivi, pp. 5-6.

- In the industrial sector, results can be obtained by applying energy-efficient industrial processes and equipment, recycling, and abatement technologies for non-CO2 emissions.
- For the agricultural industry, the proposed solutions include "efficient fertiliser use, bio-gasification of organic manure, improved manure management, better fodder, local diversification and commercialisation of production and improved livestock productivity, as well as maximising the benefits of extensive farming"[130].

Within its conclusions, the report underlines the benefits of the reductions in the EU's emissions for "savings on fossil fuel imports and improvements in air quality and public health"[131].

4.2.5. European Green Deal and the European Climate Law

In 2019 the European Commission described its plan to reduce emissions by at least 55% by 2030, compared to 1990 levels, and make the European Union the first climate-neutral continent by 2050. This plan is called the European Green Deal[132]and includes proposals to change the EU's climate, energy, transport and taxation policies.

REMEMBER!
To reach climate neutrality in 2020, a proposal for a European Climate Law was introduced so that the climate neutrality target could be written into binding legislation. In 2021 the European Climate Law[133] entered into force.

This Law recalls in its preamble the primary legislative references on the environment: from article 37 of the "Charter of Fundamental Rights of the European Union"[134] to the Paris Agreement[135], together with Directive 2003/87/EC on ETS[136], Regulation (EU) 2018/842 setting national targets for the reduction of greenhouse gas emissions by 2030, Regulation (EU) 2018/841 requiring to balance greenhouse gas emissions and removals from land use, land use change and forestry. It also refers to the "Clean Energy for All Europeans" package for the introduction of a decarbonisation agenda, with the 2030 goals for energy efficiency and deployment of renewable

[130] Ivi, p. 9.

[131] Ivi, p. 14.

[132] European Commission, A European Green Deal, https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en [05/05/2022].

[133] Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999, 2021.

[134] See 4.2.

[135] See 3.1.1.

[136] See 4.2.3.

energy of Directives 2012/27/EU[137] and 2018/2001[138], and Directive 2010/31/EU on the energy performance of buildings.

REMEMBER!
The scope of the 2021 European Climate Law is to establish "a framework for the irreversible and gradual reduction of anthropogenic greenhouse gas emissions by sources and enhancement of removals by sinks regulated in Union law"[139]. It is interesting that reducing GHG emissions and the transition towards climate neutrality want to be "irreversible".

Considering the collective interest, all EU policies must contribute to becoming climate-neutral by 2050[140], and all sectors of the economy and society must play their part. The Law also creates a monitoring system, with the European Commission assessing the collective progress made by all Member States every five years. The latest scientific, technical and socio-economic evidence on climate change will play a role in this evaluation. In particular, "the European Scientific Advisory Board on Climate Change established under Article 10a of Regulation (EC) No 401/2009 [ed: the article is introduced with this last law] shall serve as a point of reference"[141] on this.

REMEMBER!
The 2021 European Climate Law created a new European Scientific Advisory Board on Climate Change, "composed of 15 senior scientific experts covering many relevant disciplines"[142]. The Advisory Board should "serve as a reference point on scientific knowledge relating to climate change by virtue of its independence and scientific and technical expertise"[143].

4.3. European Environment Policy: Current Framework

In the previous sections, we have seen how environmental legislation has developed through the years and which milestones have been reached. We have seen how the protection of the environment has been present in international legislation and has acquired more and more importance through the years. We have analysed the packages of laws introduced on the topic, representing the starting point from where the laws on the issue originated.

[137] See 4.4.1.

[138] See 4.4.1.

[139] Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999, 2021, art. 1.

[140] Ivi, art. 2.

[141] Ivi, art. 3.

[142] Regulation (EC) No 401/2009 of the European Parliament and of the Council of 23 April 2009 on the European Environment Agency and the European Environment Information and Observation Network, 2009, art. 10a.

[143] Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999, 2021, preamble.

When it comes to nowadays and to the actual creation of laws, where defined targets and objectives are necessary, some additional programmes and strategies act as a reference. We will now analyse them.

4.3.1. Environment Action Programmes

REMEMBER!
In 1973 the European Commission started designing multiannual "Environment Action Programmes" (EAPs), representing a common framework for reaching targets and including legislative proposals. Since 1973, eight plans have been released, with the last one tabled in 2020 and entered into force on 2 May 2022, covering the period between 2021 and 2030.

This last plan, the 8th EAP, reiterated the general objective of ensuring well-being for everyone while staying "within the planet's ecological limits"[144], as had already been stated in the 7th EAP. The new EAP stands on the environmental and climate objectives introduced with the Green Deal[145].

REMEMBER!
The 2020 8th "Environment Action Programme" (EAP), "based on the precautionary principle, the principles of preventive action and rectification of pollution at source and the polluter pays principle"[146], defines six priority objectives.

The objectives are:

- attaining the 2030 greenhouse gas emission reduction target (as defined in the 2021 European Climate Law[147]);
- enhancing adaptive capacity, strengthening resilience and reducing the vulnerability of the environment;
- advancing towards a well-being, non-toxic circular economy;
- pursuing zero pollution to achieve a toxic-free environment;
- protecting, preserving and restoring biodiversity;
- reducing environmental and climate pressures related to production and consumption[148].

To reach this final list of priorities for the 8th EAP, an open public consultation was organised with "a targeted Member States' consultation, a targeted stakeholder consultation, and two public

[144] "Decision No 1386/2013/EU of the European Parliament and of the Council of 20 November 2013 on a General Union Environment Action Programme to 2020 'Living well, within the limits of our planet'", 2013, Annex 1.

[145] European Commission, Environment action programme to 2030, https://ec.europa.eu/environment/strategy/environment-action-programme-2030_en [06/05/2022].

[146] Decision (EU) 2022/591 of the European Parliament and of the Council of 6 April 2022 on a General Union Environment Action Programme to 2030, 2022, art. 1.

[147] See 4.2.5.

[148] Decision (EU) 2022/591 of the European Parliament and of the Council of 6 April 2022 on a General Union Environment Action Programme to 2030, 2022, art. 2.

workshops[149]. In particular, a Stakeholder Workshop was organised to define a new Monitoring Framework with headline indicators. It was finally decided that "the Commission shall present a monitoring framework by 2 May 2022"[150], which should soon be available[151].

The 8th EAP represents the EU's basis for achieving the United Nations' 2030 Agenda and its Sustainable Development Goals[152].

4.3.2. Horizontal Strategies

In the framework of environmental protection, in the last 20 years, the European Union has introduced some strategies on different topics.

In 2001 the EU tabled its first "Sustainable Development Strategy" (SDS), introducing the environmental aspect of the Lisbon strategy. This strategy included both objectives and policy measures to contrast unsustainable trends and a call for introducing a new approach to policy-making, ensuring more coordination between the EU's economic, social, and environmental policies. This approach committed the European Commission to submit any new policy proposal to an Impact Assessment[153].

In 2016, as a response to the introduction of the Sustainable Development Goals (SDGs), the European Commission published a communication describing "how the EU [would] take forward the implementation of the 2030 Agenda"[154].

REMEMBER!
To integrate the SDGs into the EU policy priorities, the European Commission declared it necessary to work on governance, financing and measuring progress at the national, UN, regional, EU and global levels, with shared responsibility for implementation and rewarding excellence[155].

The SDGs were also the main topic of the 2019 paper "Towards a Sustainable Europe by 2030"[156]. In the paper, the European Commission described three possible scenarios for the future:

- An overarching EU SDG strategy to guide all the actions of the EU and its Member States;

[149] European Commission, "Proposal for a Decision of the European Parliament and of the Council on a General Union Environment Action Programme to 2030", 2020, p. 2.

[150] Decision (EU) 2022/591 of the European Parliament and of the Council of 6 April 2022 on a General Union Environment Action Programme to 2030, 2022, art. 4.

[151] The framework is not available yet at the time of writing (10/05/2022) - Ed.

[152] See 3.1.1.

[153] European Commission, Sustainable Development, https://ec.europa.eu/environment/archives/eussd/index.htm [10/05/2022].

[154] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Next steps for a sustainable European future - European action for sustainability, 2016, section 3.

[155] Ibidem.

[156] European Commission, "Reflection Paper - Towards A Sustainable Europe by 2030", Brussels, 2019.

- Continued mainstreaming of the SDGs in all relevant EU policies by the Commission, but not enforcing Member States' action;
- Putting an enhanced focus on external action while consolidating current sustainability ambition at the EU level[157].

REMEMBER!
The European Parliament supported the most ambitious future scenario described in the 2019 paper "Towards a Sustainable Europe by 2030": an overarching EU SDG strategy to guide all the actions of the EU and its Member States. Here, all EU and Member State actions are guided by defining specific SDG implementation targets, with a reporting mechanism to monitor SDG progress. This scenario, therefore, influences the production of European laws.

In 2011 the EU adopted its "Biodiversity Strategy to 2020", which in 2020 was updated to the "Biodiversity Strategy to 2030"[158], for protecting nature and reversing the degradation of ecosystems. The strategy is based on four pillars: protecting nature in the EU, restoring nature in the EU, enabling transformative change, and including EU actions to support biodiversity globally.

Finally, in 2020 the Commission tabled a strategy on the food sector: "Farm to Fork strategy for a fair, healthy and environmentally-friendly food system"[159]. This foresaw a proposal for a legislative framework for sustainable food systems by 2030 and various revisions of existing Directives and Regulations for: ensuring sustainable food production; stimulating sustainable food processing, wholesale, retail, hospitality and food services practices; promoting sustainable food consumption, facilitating the shift towards healthy, sustainable diets; reducing food loss and waste[160].

4.3.3. Monitoring of the National Applications

As we have seen until now, many directives and regulations on the environment have been produced on an international and European level, covering different aspects and thematic. There is a process of constant updating to have laws aligned with the latest scientific findings and with the current needs.

REMEMBER!
However, the introduction of directives and regulations on the environment loses relevance if the single States do not implement this legislation at a national and local level. Thus, activities to monitor both the environment and the application of the EU environmental laws are required.

[157] Ivi, pp. 34, 36, 38.

[158] European Commission, Directorate-General for Environment, "EU biodiversity strategy for 2030: bringing nature back into our lives", 2021.

[159] European Commission, "Farm to Fork strategy for a fair, healthy and environmentally-friendly food system", 2021.

[160] Ivi, pp. 21-22.

Pursuing this objective, in 2001, the European Parliament and the Council adopted minimum criteria for environmental inspections in the Member States[161]. Even if it is not binding, this Recommendation sets "minimum criteria to be applied in the organising, carrying out, following up and publicising the results" of environmental inspections[162]. These inspections apply to "all industrial installations and other enterprises and facilities, whose air emissions and/or water discharges and/or waste disposal or recovery activities are subject to authorisation, permit or licensing requirements under Community law"[163]. According to the Recommendations, the environmental inspections may be routine or non-routine (part of a programme or deriving from complaints or incidents). Public authorities may carry them out at national, regional or local levels[164]. To verify the effectiveness of this monitoring plan, Member States were asked to publicly report to the Commission on their experience two years after the publication of the Recommendation[165]. All Member States produced a report, but from them, only a few States had fully implemented the recommendation. Thus, the Commission started considering the necessity of legally-binding sectoral requirements, at least for certain activities[166].

REMEMBER!
In 2008, Directive 2008/99/EC was introduced to protect the environment through criminal law[167]. In article 3, the most severe environmental offences which require criminal sanctions are listed. They include, for instance: "the illegal emission or discharge of substances into the air, water or soil; illegal wildlife trade; illegal trade in ozone-depleting substances; and illegal shipment or dumping of waste"[168].

In 2016 the Commission created a new dedicated tool for helping reach full implementation of EU environmental legislation: the "Environmental Implementation Review" (EIR)[169]. Its objective is "to support the delivery of the objectives of existing environmental policies and legislation while

[161] Recommendation of the European Parliament and of the Council of 4 April 2001 providing for minimum criteria for environmental inspections in the Member States, 2001.

[162] Ivi, art. 1.

[163] Ivi, art. 2.

[164] Ibidem.

[165] Ivi, art. 8.

[166] Communication from the Commission of 14 November 2007 on the review of Recommendation 2001/331/EC providing for minimum criteria for environmental inspections in the Member States, 2007.

[167] Directive 2008/99/EC of the European Parliament and of the Council of 19 November 2008 on the protection of the environment through criminal law, 2008.

[168] European Parliament, Environment policy: general principles and basic framework, https://www.europarl.europa.eu/factsheets/en/sheet/71/politica-ambientale-principi-generali-e-quadro-di-riferimento [11/05/2022].

[169] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Delivering the benefits of EU environmental policies through a regular Environmental Implementation Review, 2016.

scrupulously securing the equal treatment of the Member States"[170]. It collects information on the position of each Member State for implementing the central environmental policies, and it provides them with tailored support.

4.4. European Policy on the Environment and the Erasmus+ GreenCo Project

In the previous sections, we have seen how the legislation on the environment has been developed and how normative references have been introduced to provide a common framework for the European Member States. This section will analyse the primary laws - mostly European Directives - that have been introduced to regulate the specific topics of this e-book: energy reduction and green energy, environment and ICT production, and e-waste reduction.

You will find that there are no laws regarding (personal) digital pollution. This aspect is still relatively recent in general awareness, and no laws have yet been introduced to regulate it. However, even if it is not legally mandatory to do so, we invite you to learn and try to introduce some little tricks to reduce pollution in your daily life!

4.4.1. Energy Reduction and Green Energy

Introducing a robust environmental policy has always been a critical target for the European Union. For this reason, the Commission produced two kinds of directives: the Energy Efficiency Directives (EED directives) and the Renewable Energy Sources Directives (RES directives).

Traditionally, the primary reference on energy was the EED "Directive 2006/32/EC Energy end-use efficiency and energy services" (which was repealed by Directive 2012/27/EU and amended by Directive (EU) 2018/2002).

REMEMBER!
The EED "Directive 2006/32/EC Energy end-use efficiency and energy services" and its recasts (Directive 2012/27/EU and Directive (EU) 2018/2002) were based on the premise that the European Union can consume less by using technology more efficiently.

For this reason, in 2007, the EU leaders established a key target: improving by 20% the energy efficiency in the European Union[171]. The repealing Directive 2012/27/EU set a series of methods to ensure that the target was enacted. Member States were required to establish a national-level energy efficiency target and publish a "national energy efficiency action plan" every three years[172].

[170] Ivi, sez. 3.

[171] Commission Staff Working Document - Accompanying document to the Proposal for a Council Regulation on the protection of vulnerable marine ecosystems in the high seas from the adverse impacts of bottom fishing gears - Impact Assessment, 2007, section 3.4.

[172] Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC, 2012, art. 24.2.

In addition, it included obligations for the Member States to adopt policy measures to reduce energy usage by at least 1.5% per year between 2014 and 2020[173].

In 2018, the 2012 EED Directive was amended by Directive (EU) 2018/2002, establishing a new EU energy efficiency target for 2030 of at least 32.5%[174]. Moreover, it extended the obligation for every Member State to adopt policies to reduce energy usage, but it reduced the target to 0.8% per year from 2021 to 2030[175].

REMEMBER!
In the meantime, in 2009 it had been introduced the Renewable Energy Sources Directive (RES Directive), or "Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources"[176], which is now an essential European directive on the use of renewable energy sources. This had established an EU target of 20% final energy consumption of renewable sources by 2020[177]. In 2018 a new RES Directive was introduced on the use of renewable sources, thus revising the Directive 2009/28/EC to meet the ambitious environmental standards set by the Paris Agreement in 2015[178]. The RES Directive revised and upgraded the critical target, setting a new target of 32% renewables by 2030[179].

In addition, the new RES Directive did not just establish a new target but also provided different actions to ensure that the Member States could implement targets. It provided Guiding principles on financial support schemes for RES, a mechanism for cross-border cooperation and simplified administrative processes. Also, it set the target to mainstream the use of RES in the transport sector[180].

In 2020, a RES progress report assessed the share of renewable energy sources of each Member State in 2017 and 2018 (see Figure 55), showing that all but Ireland, France, the Netherlands, Poland and Slovenia reached the RES directive and national trajectories set for 2018, according to data from Eurostat[181].

[173] Ivi, art. 7.1.

[174] Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency, 2018, art. 1.1.

[175] Ivi, art. 7.1.b.

[176] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, 2009.

[177] Ivi, art. 3.1.

[178] See section 3.1.1.

[179] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources, 2018, art. 3.1.

[180] European Parliament, Briefing EU Legislation in Progress - Promoting renewable energy sources in the EU after 2020, BRI (2017) 599278.

[181] Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Renewable Energy Progress Report, 2020, section 3.1.

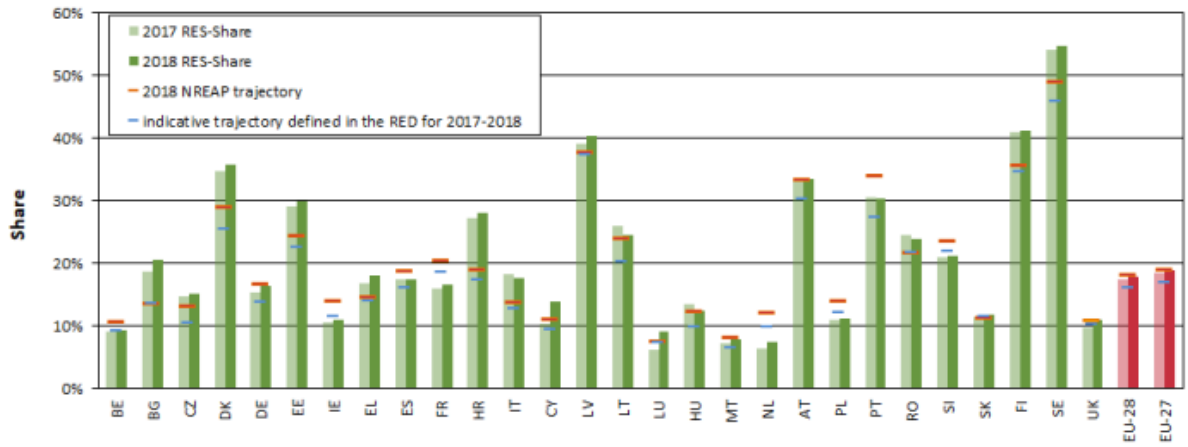

Figure 55 Member State Renewable Energy Shares in 2017-2018 and Their EU and National Trajectories[182]

REMEMBER!
In 2021, the European Environment Agency report estimated that the European Union achieved a 21.3% share of renewables and reached the 2020 energy efficiency target[183]**. However, it warned that the Covid-19 pandemic plays a significant role, while the strength of climate policies is uncertain**[184]**.**

Thus, in 2021 the European Commission presented a new proposal to revise the RES Directive, asking to raise the 2030 renewable target to 40% as part of the package to deliver on the European Green Deal and become the first climate-neutral continent by 2050[185].

4.4.2. Environment and ICT Production

REMEMBER!
The European Union has regulated and restricted the usage of hazardous substances for ICT production with the "Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment (EEE)" and its recast from 2011.

The purpose of Directive 2002/95/EC was to harmonise the policies of Member States on the restriction of the usage of such substances. They threaten the health and the environment even when disposed of and treated correctly. For this reason, from July 2006, Member States had to ensure that no EEE put on the market contained lead, mercury, cadmium, chromium, PBB and PBDE.

[182] European Commission, COM (2020) 952 final, Renewable Energy Progress report, 3.1, Figure 2.

[183] European Environment Agency, "Trends and projections in Europe 2021", Report No 13/2021, Copenhagen, 2021, Executive Summary, p. 10.

[184] Ivi, p. 9.

[185] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions 'Fit for 55': delivering the EU's 2030 Climate Target on the way to climate neutrality, 2021, section 2.2.3.

However, each Member State could legislate on a maximum concentration value to be tolerated[186]. While receiving this Directive, each Member State created a different environmental standard for the concentration of hazardous substances, potentially threatening the EU internal market. Consequently, recast directive 2011/65/EU[187] later set a common maximum concentration value tolerated. In particular, no more than 0,1% concentration rate of lead, mercury, cadmium, chromium, PBB and PBDE is permitted in the European Union[188].

REMEMBER!
In 2005 the European Commission started the regulation of Eco-Design, with the "Directive 2005/32/EC establishing a framework for setting eco-design requirements for energy-using products (EuPs)", every product that needs any kind of energy while in use. This Directive, also called the "Energy using Product Directive" (or EuP), sets generic eco-design requirements at every phase of the product's life cycle: raw materials selection and use, manufacturing, packaging and transport, installation, maintenance, use and disposal.

Moreover, it set a methodology to implement this generic eco-design requirement to a specific EuP. First of all, this Directive only applied to:

- EuPs which had a volume of sales higher than 200.000 units a year
- EuPs with a significant environmental impact
- EuPs with significant potential for environmental impact prevention improvement without negatively affecting the product's economic competitiveness.

If an EuP meets these criteria, the European Commission and Member States and Stakeholders' representatives should implement a measure to specify the best technical options for improving the environmental performance considering every stage of the product's life-cycle[189]. Once the best-specialised opportunities had been identified, every EuP covered by the implementing measure had to be affixed with a "CE marking" before being put into the market, whereby the producer declared that the product complied with all implementing standards[190].

[186] Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, 2002, artt. 4.1, 5.1.a.

[187] Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, 2011.

[188] Ivi, art. 4.2 and annex II.

[189] Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 establishing a framework for the setting of ecodesign requirements for energy-using products and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC of the European Parliament and of the Council, 2005, art. 15 and annex II.

[190] Ivi, art. 5.

Directive 2005/32/EC was then recast with Directive 2009/125/EC[191] to extend the previous Directive's scope and methodologies to energy-related products (ErPs), namely any good that impacts energy consumption during use[192].

In 2010, the past regulation on energy labelling[193] was recast with the new Directive 2010/30/EU, later repealed by the Regulation (EU) 2017/1369 of July 2017, setting a framework for energy labelling.

REMEMBER!
The Regulation (EU) 2017/1369 of July 2017 lays down an energy labelling for energy-related products (ErPs) to encourage consumers to buy more efficient products and reduce their energy consumption[194]. In particular, the European Commission must label ErPs in a ranking from A (most efficient) to G (less efficient), according to their energy efficiency and energy consumption while in use, and taking into account the possibility of fast-developing technology and, so, a rescaling of energy labelling[195]. Moreover, the regulation calls on the Member States to take appropriate steps to make the legislation effective, both with economic incentives and sanctions[196].

As we have seen before[197], in 2019, the European Union took a more ambitious step toward a more sustainable economy with the European Green Deal, a treaty aiming to turn Europe into the first climate-neutral continent by 2050. The EU committed to rethinking every European environmental and climate change law to achieve this goal, creating a solid and green circular economy.

REMEMBER!
Thus, the European Union adopted the new Circular Economy Action Plan in 2021, and in particular, it introduced the "Circular Electronic Initiative", which promotes some regulatory measures for electronics and ICT.

Examples include:

[191] Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products, 2009.

[192] Ivi, art. 2.1.

[193] Council Directive 92/75/EEC of 22 September 1992 on the indication by labelling and standard product information of the consumption of energy and other resources by household appliances, 1992.

[194] Regulation (EU) 2017/1369 of the European Parliament and of the Council of 4 July 2017 setting a framework for energy labelling and repealing Directive 2010/30/EU, 2017, art. 1.

[195] Ivi, art. 11.

[196] Ivi, art. 7.

[197] See section 4.1.5.

- Improving and implementing the eco-design and energy-labelling directives for mobile phones, tablets and laptops, which are not explicitly covered by the current directives[198], by the second half of 2022.
- Developing a common charger for small and medium-sized electronic gadgets. The European Commission already proposed the usage of a USB Type-C charger[199].
- Improving the collection of WEEE.
- Reviewing the EU policy on restricting hazardous substances in EEE by the last quarter of 2022.
- Improving the "right to repair" for ICT products. Consumers have a right to have products repaired free of charge within two years of purchase. The commission now wants to extend the legal guarantee period for reparation by the third quarter of 2022 to tackle planned obsolescence[200].

Within this Plan, there are some legislative proposals where the population has been involved, too, to share their feedback. For example, in 2020, the European Commission spoke in favour of harmonising the existing Product and Organisation Environmental Footprint methods (PEF and OEF methods). In the EU, more than 100 methods exist to label a product's environmental impact. Private individuals, NGOs and public bodies were asked to give feedback on the proposal, and many criticised the harmonisation of PEF and OEF and the PEF itself. Some claimed that PEF methods could not consider the long-term environmental impact of a product, such as micro-plastic pollution. Others pointed out that this kind of policy does not sufficiently keep up with scientific progress, ending with encouraging the usage of obsolete technology. The need to be aware of the topic became evident.

REMEMBER!
The EU policy activities on the environment and ICT production are supported by preliminary and complementary ICT standardisation activities collected in the Rolling Plan for ICT standardisation[201], an annual document released by the European Commission.

In particular, the last thematic area of the rolling plan, namely "Sustainable growth", lends itself to an overview of ICT environmental standardisation, underlining the lack of a consistent methodological framework to assess the actual ICT ecological impact. To solve this issue, it calls for the work of international standardisation organisations, such as the International

[198] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - A new Circular Economy Action Plan For a cleaner and more competitive Europe, 2020, section 3.1.

[199] European Commission, Inception impact assessment - Ares (2020)7893117, 2020 and Proposal for a Directive of the European Parliament and of the Council amending Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment, 2021.

[200] European Commission, Call for evidence for an impact assessment - Ares (2022)175084, 2022, section B.

[201] European Commission, Rolling plan for ICT standardisation, https://digital-strategy.ec.europa.eu/en/policies/rolling-plan-ict-standardisation [12/05/2022].

Telecommunication Union (or ITU), to be implemented in a broader range to find the global key performance indicators (KPIs) for ICT design and usage worldwide[202].

4.4.3. E-Waste Reduction

Electrical and electronic waste keep being created even with specific attention to the environment when producing ICT equipment. Thus, the European Union has introduced some specific laws on managing and reducing e-waste.

The European States started producing a common policy to harmonise their legislation on waste in 1975, with the Council Directive 75/442/EEC. For the first time, it included a common definition of waste as "any substance or object which the holder disposes of or is required to dispose of pursuant to the provisions of national law in force"[203], demonstrating the willingness of the European Countries to develop a shared terminology and strategy to manage it.

REMEMBER!
The Council Directive 75/442/EEC encourages all Member States to take actions to prevent, process, recycle and reuse waste without endangering human health and the environment[204]. It also binds the Member States to designate a competent authority responsible for planning, organising and supervising waste disposal operations[205]. Moreover, it introduced the principle of "the polluter pays", which means that all costs of the waste's disposal must be covered by the producer of the product from which the waste came[206].

The "polluter pays" principle was later reinforced with the Directive 2004/35/CE, which established a framework of environmental liability based on the principle, considering that an operator whose activity has caused ecological damage or the imminent threat of such harm is to be held financially liable, to induce operators to adopt measures and develop practices to minimise the risks of environmental damage so that their exposure to financial liabilities is reduced[207].

[202] European Commission, Rolling plan for ICT standardisation, ICT ENVIRONMENTAL IMPACT, https://joinup.ec.europa.eu/collection/rolling-plan-ict-standardisation/ict-environmental-impact [12/05/2022].

[203] Council of the European Communities, "Council Directive of 15 July 1975 on waste", 1975, art. 1.

[204] Ivi, artt. 3-4.

[205] Ivi, art. 5.

[206] Ivi, art. 11.

[207] Directive 2004/35/CE of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage, 2004, Preamble c. 2.

REMEMBER!
In 2002 EU also started regulating the management of electrical waste with the "Directive 2002/96/EC on waste electrical and electronic equipment (WEEE)" (also called WEEE Directive). This directive introduced a separate collection for e-waste, requiring all Member States to adopt appropriate measures to achieve a high level of separate collection[208]. It also needed them to create a system for final holders - but paid by producers (following the principle "the polluter pays") - to return WEEE free of charge to treat, reuse, recycle, or dispose of waste[209].

The general E-waste collection target was set to 4kg of WEEE per EU citizen every year[210].

In 2008, Directive 2008/98/EC (also called Waste Framework Directive) was introduced, which repealed Directive 75/442/EEC.

REMEMBER!
The Directive 2008/98/EC (also called Waste Framework Directive) introduced a new waste hierarchy (see Figure 56) which laid down a priority order of the best overall environmental options in waste and e-waste disposal policy: prevention, preparing for reuse, recycling, another recovery (e.g. energy recovery), and finally, disposal[211].

[208] Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE), 2002, art. 5.

[209] Ivi, art. 5.2.

[210] Ivi, art. 5.5.

[211] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives, 2008, art. 4, with all the definitions available in article 3.

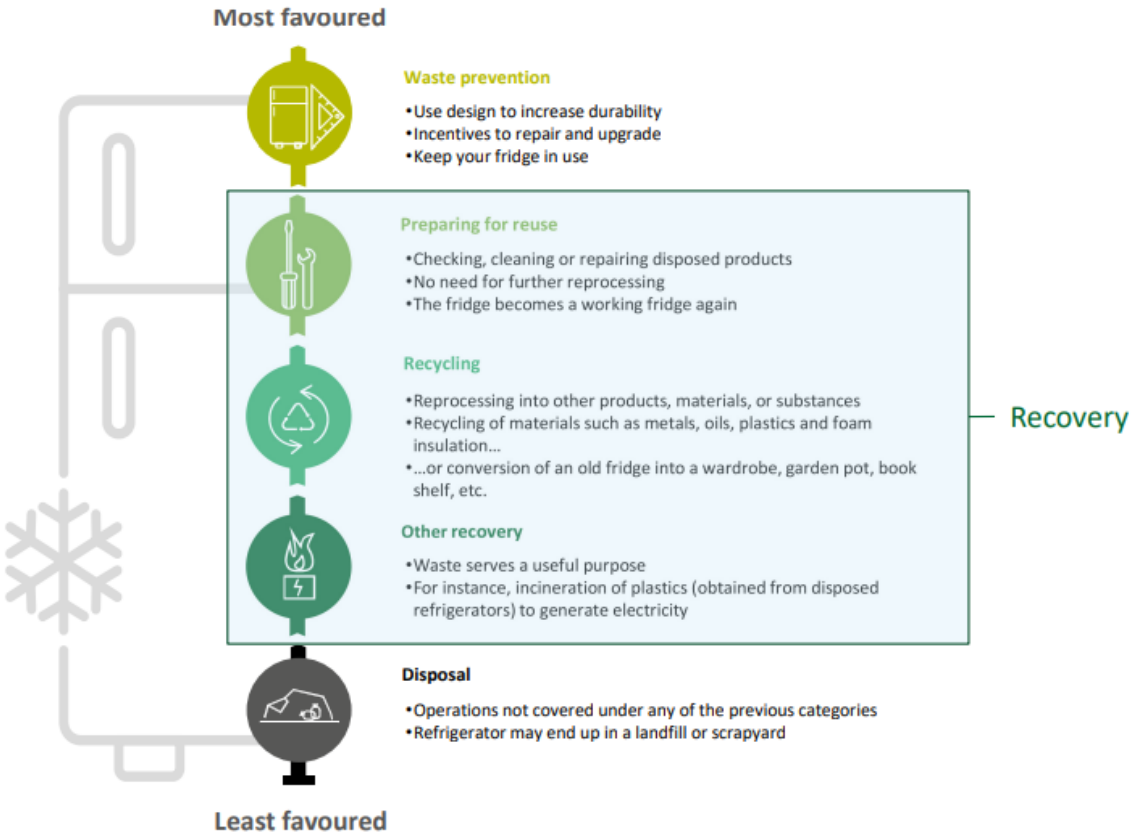

Figure 56 Application of the Waste Hierarchy to a Refrigerator[212]

It also introduced, in article 8, the "extended producer responsibility", a concrete application of the "polluter pays" principle. According to this principle, Member States must ensure that producers are responsible for their products' production, waste, and e-waste disposal. This should encourage the development of products that can be used multiple times, are durable, or are suitable for safe recovery or green disposal[213].

However, due to the different interpretations of Member States in implementing this article, the EU could not harmonise Member States' waste policies until Directive 2018/851[214] was introduced in 2018, adding new articles. The Directive aimed to coordinate Member States' policies by establishing general minimum requirements for the "extended producer responsibility". According to the recent article 8a, equal treatment of both big and small producers must be ensured[215], and the availability of waste collection systems in any area[216]. Also, in the case of collective responsibility, the product's

[212] European Court of Auditors, Review n° 04, EU actions and existing challenges on electronic, 2021, p. 9, figure 2,

[213] Ivi, art. 8.

[214] Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste, 2018.

[215] Ivi, art.8a.1. d.

[216] Ivi, art.8a.3.a, b.

durability, reparability, reusability, recyclability, and hazardous substances should modulate each producer's financing obligations for waste disposal[217].

After introducing the 2008 Waste Framework Directive, in 2012, the Directive 2002/96/EC was repealed by the new "Directive 2012/19/EU on waste electrical and electronic equipment (WEEE)". This sets new targets for the collection rate, now expressed as a percentage of the average weight of EEE placed on the market in the three preceding years in a Member State. From 2016, the minimum WEEE collection rate had to be 45%, reaching 65% by 2019 (or 85% of WEEE generated on the territory of the Member State[218])[219].

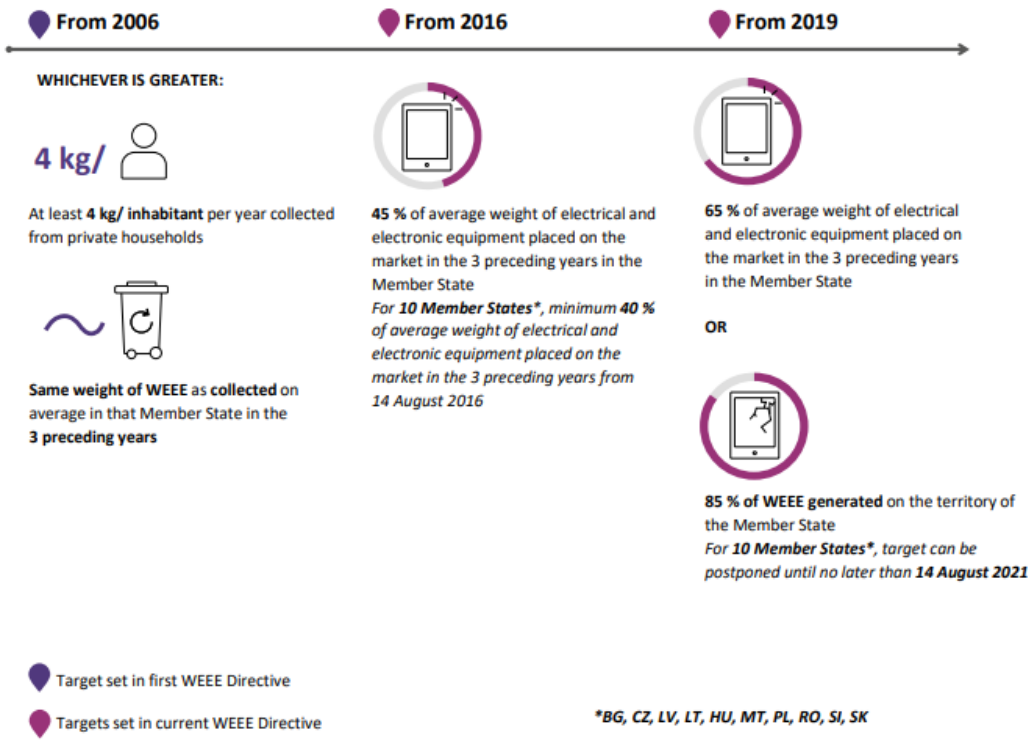

Figure 57 E-Waste Collection Targets Based On The WEEE Directives[220]

The Directive also introduced the possibility for producers to cooperate to establish and finance a "producer responsibility organisation" that took charge of waste management. Each producer had

[217] Ivi, art.8a.4. b.

[218] Ten European States (Bulgaria, the Czech Republic, Latvia, Lithuania, Hungary, Malta, Poland, Romania, Slovenia and Slovakia) were set lower targets due to their lack of infrastructure: 40% by 2016, and to reach the 85% collection rate of WEEE generated on the territory they had up to 2021 (art. 7.3).

[219] Ivi, art. 7.1.

[220] European Court of Auditors, Review n° 04, EU actions and existing challenges on electronic waste, 2021, p. 10, figure 3.

to fund it according to its share of the product's market and following the Member State legislation[221].

REMEMBER!
To avoid different approaches to the implementation of the 2012 e-waste regulation, the European Union introduced 2017 the Commission Implementing Regulation 2017/699[222], which established a common methodology for calculating the quantity of electrical and electronic equipment (EEE) placed on the market and the quantity of WEEE generated by weight in each Member State.

The former is calculated with the "apparent consumption method": EEE placed on the market = domestic production + imports – exports[223]. The latter must be based on the amount of EEE placed on the market in the past three years and the estimated product lifespan. The European Union has made a "WEEE calculation tool" available for the Member States to support the calculation.

REMEMBER!
In 2017, the European Commission also published the WEEE compliance promotion exercise report[224], which is a measure to supervise and evaluate the behaviour of each Member State in implementing the WEEE directives. In this report, Member States have been grouped into three different groups (see Table 3), following their fulfilment of WEEE directives' targets and focusing on quantitative criteria (achievement of statistical targets) and qualitative criteria (an approach used to implement the directives).

[221] Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE), 2012, art. 8.

[222] Commission Implementing Regulation (EU) 2017/699 of 18 April 2017 establishing a common methodology for the calculation of the weight of electrical and electronic equipment (EEE) placed on the market of each Member State and a common methodology for the calculation of the quantity of waste electrical and electronic equipment (WEEE) generated by weight in each Member State, 2017.

[223] Ivi, annex I.1.

[224] European Commission, Directorate-General for Environment, Kling, M., Zotz, F., Huranova, D., "WEEE compliance promotion exercise: final report", Publications Office, 2018, https://data.europa.eu/doi/10.2779/918821.

Groups	Achievements	Countries
Group A	High achievements in quantitative criteria and implementation of a robust set of qualitative measures	Austria, Bulgaria, Germany, Hungary, Ireland, Lithuania, Finland, France, Spain, United Kingdom.
Group B	High achievements in quantitative criteria and Implementation of several quantitative measures.	Belgium, Latvia, Luxemburg, Netherlands, Poland, Portugal, Slovakia, and Sweden.
Group C	Low or stagnating achievement in quantitative criteria or Implementation of limited or no qualitative measures.	Czechia, Croatia, Cyprus, Denmark, Estonia, Greece, Italy, Malta, Romania, Slovenia,

Table 3 Clustering of Member States Depending on the Evaluation in Implementing WEEE Directives[225]

In 2014, 19 Members out of 28 reached the goal of collecting at least 4kg of e-waste per inhabitant (see Figure 58), as required by Directive 2002/96 /EC, and 11 Members had already fulfilled the target of 45% of WEEE collected (see Figure 59), as settled for 2016 by Directive 2012/19/EU. Two members (Bulgaria and Lithuania) had reached the target of 65% for 2019.

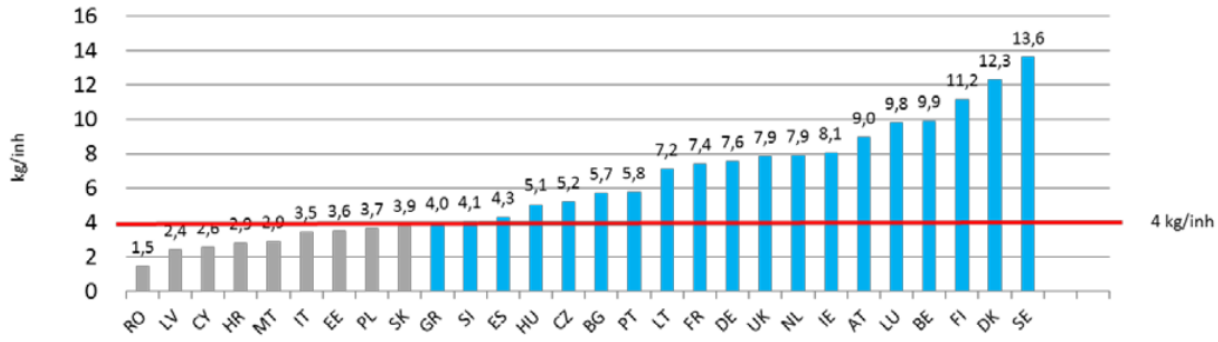

Figure 58 Achievement Of The Collection Target 4kg/Inhabitant Per Member State In 2014[226]

[225] European Commission, Directorate-General for Environment, Kling, M., Zotz, F., Huranova, D., "WEEE compliance promotion exercise: final report", Publication Office, 2018, table 2.2.

[226] European Commission, Directorate-General for Environment, Kling, M., Zotz, F., Huranova, D., "WEEE compliance promotion exercise: final report", Publications Office, 2018, Figure 2-9.

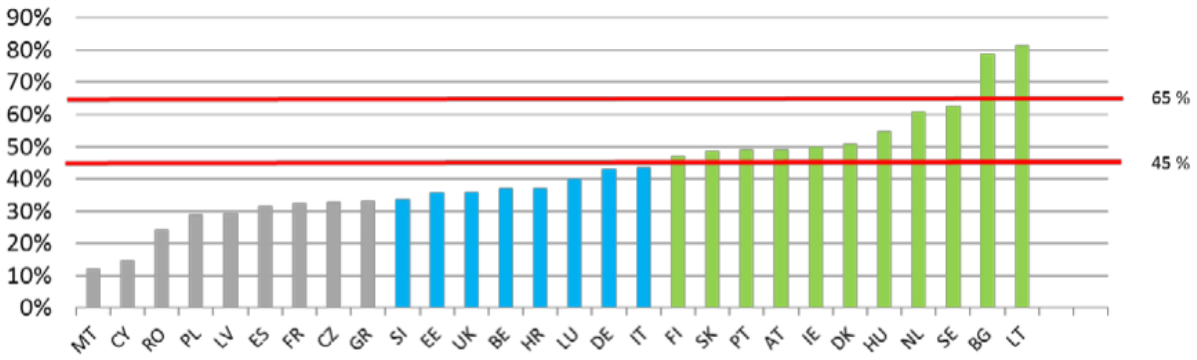

Figure 59 Achievement Of Separate Collection Of WEEE Targets Per Member State In 2014[227]

In 2019, Eurostat published a new study on the total collection rate for WEEE per Member State, referring to 2016-2018 (see Figure 60). Seven more States reached the 2016 target, while Croatia and Poland had already reached the 2019 target. On the contrary, although the vast majority of the States consistently improved their WEEE disposal efficiency, Italy, Portugal, Denmark, The Netherlands, and Lithuania registered worse statistics in 2018 than in 2014.

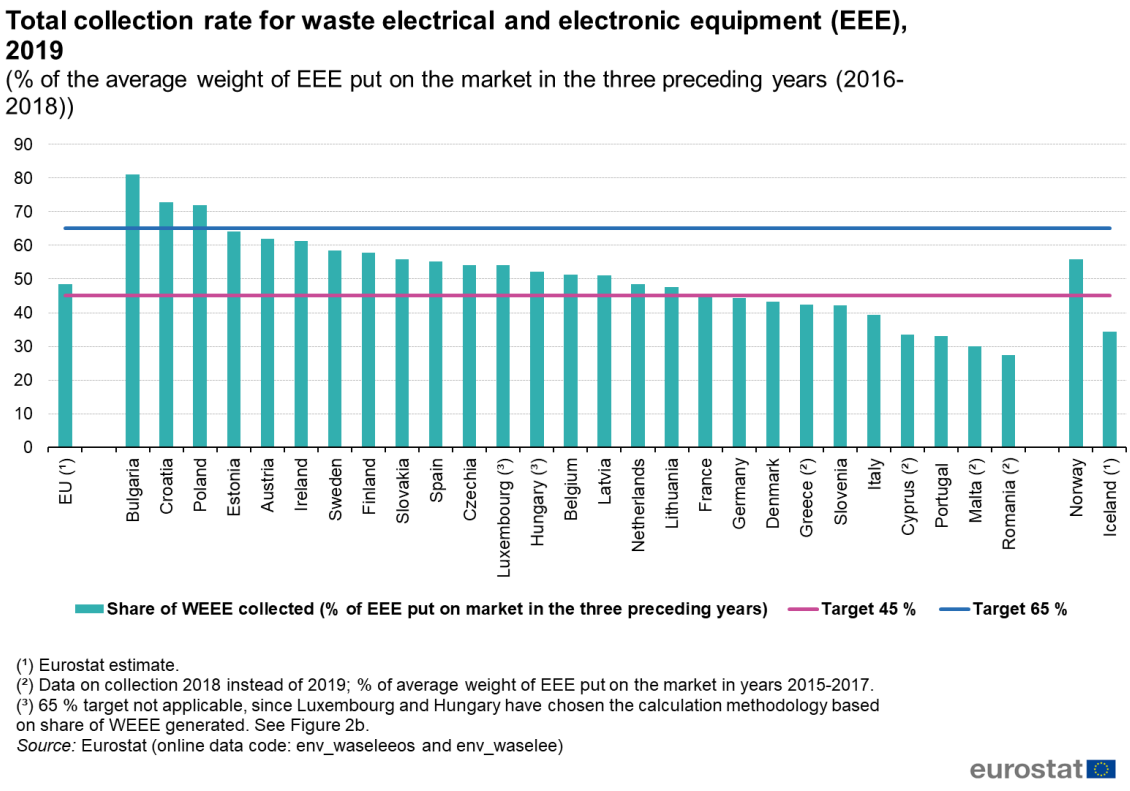

Figure 60 Achievement of Separate Collection of WEEE Targets per Member State Between 2016 and 2018[228]

[227] European Commission, Directorate-General for Environment, Kling, M., Zotz, F., Huranova, D., "WEEE compliance promotion exercise: final report", Publications Office, 2018, Figure 2-10.

[228] Eurostat, "Total collection rate for waste electrical and electronic equipment (EEE) as % of the average weight of EEE put on the market in the three preceding years (2016-2018)", 2019.

Conclusions

Technology undoubtedly supports other industries reduce their carbon footprint by making them more efficient. Regardless, the global carbon footprint of the overall Information and Communication Industry (ICT), including primary consumer devices, data centres, and communication networks, could exceed 14 per cent of the 2016-level worldwide Greenhouse Gas Emissions (GHGE) by 2040[229]. According to the same study, electricity used by computer centres will account for more than 14 per cent of total world emissions, and just a tiny percentage of the energy now utilized is generated responsibly.

As a result, the Information Technology Industry could contaminate the environment more than automobiles or motorbikes, considerably increasing greenhouse gas emissions. Among the GreenCo project, we call this phenomenon the “invisible menace” and aim to address it through a series of initiatives.

In contrast to physical and visible pollution, where much work has to be done, but progress is being made rapidly, digital pollution is almost invisible. The GreenCo initiative, funded by the Erasmus+ European Union Programme under Reference № 2021-1-ES01-KA220-VET-000025159, seeks to raise awareness about the environmental effect of excessive data use and to suggest simple and easy-to-implement solutions to minimize it. This e-book is part of this awareness initiative, aiming to introduce you to a variety of information regarding green computing on four different topics, namely Energy Consumption, E-Waste Recycling, Relevant Initiatives and Legislation.

Another goal of the GreenCo Project is to provide the tools you need to examine your influence and understanding of digital pollution. Through the GreenCo mobile application, we are developing a gamified self-assessment experience to promote younger audience involvement.

Finally, we are developing a MOOC on digital pollution to train you on sustainable behaviours that you can adopt into your everyday routine.

Many of us are unaware of the true meaning of sustainability in this day and age. With our ever-increasing digital dependence, and our growing need to address the environmental threats we face today, we require trustworthy sources of awareness on topics such as digital pollution, e-waste, and sustainability practices. We sincerely hope this material will serve as a reliable information source for you in the near future on sustainable ICT and green computing.

[229] Lotfi Belkhir, Ahmed Elmeligi. Assessing ICT global emissions footprint: Trends to 2040 & recommendations, Journal of Cleaner Production, Volume 177, 2018, Pages 448-463. DOI: 10.1016/j.jclepro.2017.12.239

List of Abbreviations

ABBREVIATION	DEFINITION
ABS	Acrylonitrile Butadiene Styrene
AC	Activated Carbon
AI	Artificial Intelligence
BAT	Best Available Technology
CO2e	Carbon Dioxide Equivalent
CRT	Cathode Ray Tubes
CE	Conformitè Europëenne
EEE	Electrical and Electronic Equipment
ETS	Emissions Trading System
EOL	End Of Life
EED	Energy Efficiency Directives
ErP	Energy-related Product
EuP	Energy-using Product
EAP	Environment Action Programme
EHS	Environment Health Safety
EN	European Norm
EU	European Union
EPR	Extended Producer Responsibility
GWP	Global Warming Potential
GHG	Greenhouse gas
ICT	Information and Communication Technologies

ABBREVIATION	DEFINITION
IT	Information Technology
ITU	International Telecommunication Union
KPI	Key Performance Indicator
kWh	kilowatt-hour
LDA	Large Domestic Appliances
LED	Light Emitting Diode
LCD	Liquid Crystal Display
LIB	Lithium-Ion Battery
LAN	Local Area Network
MRF	Materials Recovery Facility
MDG	Millennium Development Goal
NF	Non Ferrous metal
NGO	Non-Government Organization
OEF	Organisation Environmental Footprint
POP	Persistent Organic Pollutants
PPE	Personal Protective Equipment
PBB	Polybrominated biphenyls
PBDE	Polybrominated diphenyl ethers
PCB	Printed Circuit Boards
PEF	Product Environmental Footprint
RES	Renewable Energy Sources
SDA	Small Domestic Appliances

ABBREVIATION	DEFINITION
SDS	Sustainable Development Strategy
TV	Television
TEU	Treaty on the European Union, or Treaty of Maastricht
TFEU	Treaty on the Functioning of the European Union
TL	Tube Lamp
UN	United Nations
WEEE	Waste Electrical and Electronic Equipment
W	Watt
Wh	Watt-hour
WAN	Wide Area Network

Table of Figures