ACCOUNTING FOR THE ENVIRONMENTAL IMPACT OF DATA PROCESSES

And the history of environmental impact taxation in the US and Europe

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This paper was written by Gemma Galdon Clavell and the team at Eticas. It is part of a collaboration under Ashoka's Tech & Humanity initiative, a global network of leading social entrepreneurs committed to ensuring tech works for the good of people and planet. This community is concerned about the societal and environmental harms of the data economy and is building innovative frameworks and tools to mitigate these harms.

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Introduction

The polluted world of personal data

Data has become an integral part of our daily lives, helping us to make better decisions and improve our quality of life in countless ways. However, the increasing amount of data that we generate and process also has its downsides. The constant exchange of data on the web requires enormous amounts of energy, which has negative social, economic, and environmental impacts. Data processes are all over, from sending emails and video streaming to browsing cookies and making Bitcoin transactions, our reliance on data is driving up energy consumption at an alarming rate. The growing demand of energy from data translates into a greater possibility of having carbon footprints. The good news is that there are ways to mitigate these negative impacts. Data minimization, less training for AI algorithms, switching to a different protocol in the case of Bitcoin and spam filtering are just some of the more credible mitigation measures out there. In this study, we will closely explore some of them. It is important to be aware that accurately measuring the carbon footprint of data is no easy feat. In fact, there is no universal agreement on how to do so, and many studies have attempted to tackle this issue by estimating footprints for individual data processes. However, the lack of consensus among these studies makes it difficult to come to a definitive conclusion and a number of factors such as location, user devices, and others can further complicate the process of measuring carbon footprints.

Environmental taxation, such as carbon taxes or cap-and-trade schemes, is a policy tool that governments can use to incentivize companies to reduce their environmental impact, including the environmental pollution of data. These types of taxes put a price on activities that have negative environmental consequences, making it more expensive for companies to engage in such activities and thus encouraging them to find more sustainable ways. But, overall, while environmental taxation is one potential strategy for addressing the environmental pollution of data, it is not a panacea and may not be sufficient on its own to persuade big firms to reduce their use of big data. In this study, we will explore potential ways to compensate for the environmental damage caused by data, with a focus on approaches that could be directly implemented in the European Union and potentially have also an impact beyond the EU's boundaries. We will also consider alternative solutions to environmental taxation as a means of encouraging companies to reduce their use of data. Predicting the future with certainty is impossible; however, through the use of imagination and knowledge of current trends and challenges, we can attempt to envision what the future might hold.

Environmental data pollution

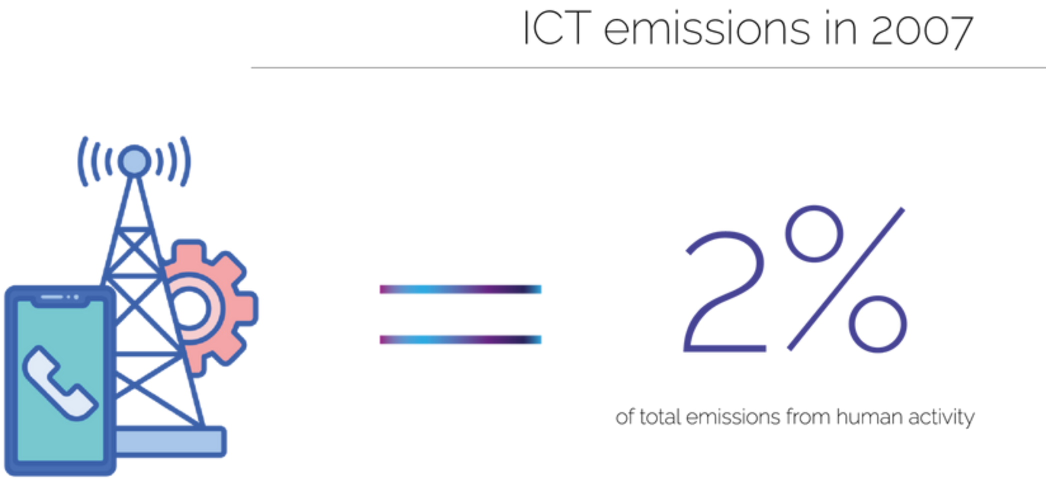
Data pollution is a new and confusing concept and most existing studies do not address it sufficiently. Ben-Shahar (2019) is one of the few exceptions. The author, in fact, implicitly recognizes the intrinsic complexity of data, creators of advantages and disadvantages at once. And, although leading to economic and social benefits, data are also behind the existence of some negative externalities.

"The concept of data pollution invites us to expand the focus and examine the ways that the collection of personal data affects institutions and groups of people—beyond those whose data are taken, and apart from the harm to their privacy" (2019:106)

Ben-Shahar's concept of data pollution places particular emphasis on the social cost of data, which the author reveals to be pretty hard to measure, as compared with the social cost of carbon. The reference to the carbon element seems to be used only to underline the difficulties of measuring the social cost of data. More nuanced is the fact that data itself can lead to carbon emissions. To prevent confusion and misinterpretation, this document will use the term "environmental data pollution (EDP)" to refer specifically to the carbon footprint of data and the potential environmental harm caused by data processing. The following sections will employ this terminology consistently.

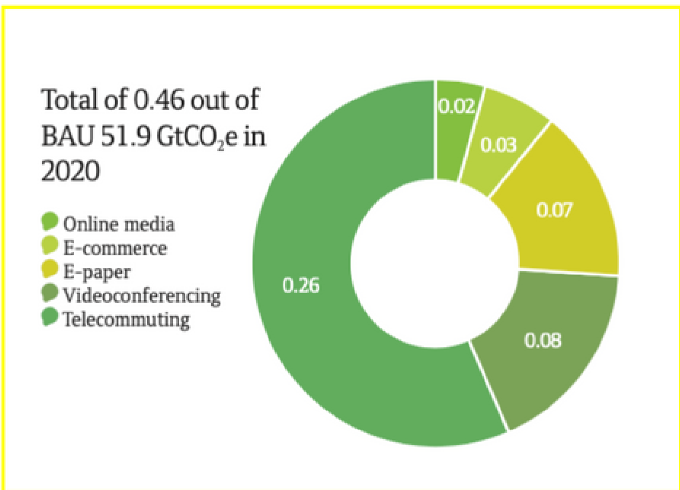
The ICT industry rising footprint

A 2008 report by the Global eSustainability Initiative (GeSI) has been one of the first studies to emphasize the correlation between the Information and Communication Technology (ICT) industry and the rise of the global carbon footprint. The report found that the total footprint emissions from the ICT sector, which includes personal computers (PCs) and peripherals, telecoms networks, devices and data centers, amounted to 830 metric tons of carbon dioxide equivalent (MTCO2e) in 2007 corresponding to 2% of the estimated total emissions from human activity released that year.



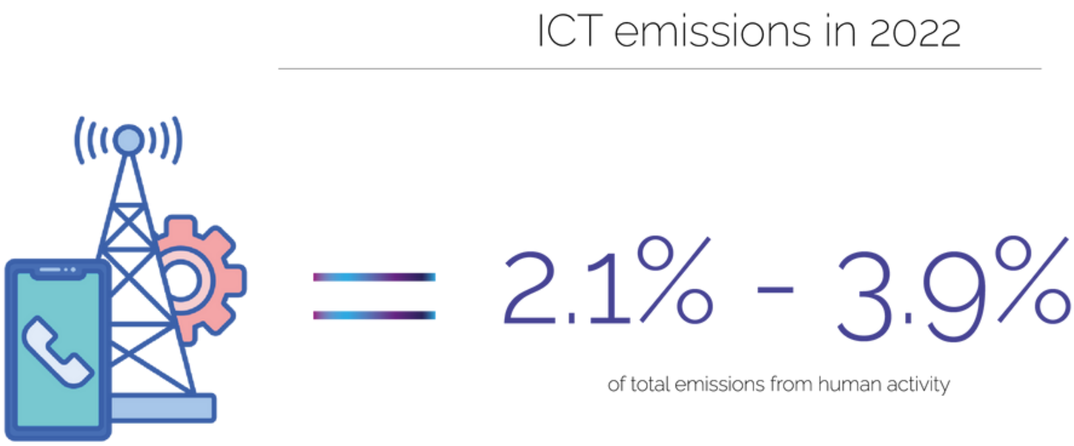
Graphic 1: ICT emissions in 2007 - Source: own elaboration

The report, analyzing the impact that dematerialization can have in reducing carbon emissions by replacing high-carbon products and activities with low-carbon alternatives, e.g. by replacing face-to-face meetings with videoconferencing or paper with electronic invoicing, highlighted some challenges. One of them would be having a precise estimate of energy savings and the reduction of carbon emissions following the dematerialization processes is still an uncertain forecast as there remains a high margin of unpredictability of technology adoption and development.



Graphic 2: The impact of dematerialisation - Source: Global eSustainability Initiative (GeSI). (2008). SMART 2020: Enabling the low carbon economy in the information age.

Although, as illustrated by Graphic 2, dematerialization (data) processes can help to reduce carbon emissions globally, many issues remain unresolved leading to the near impossibility of providing reliable predictions. Indeed, the study found that what existing case studies show is that the impact of working from home varies depending on the amount of time spent at home and the efficiency of the economy in which telework is introduced. Time and location matter, among other factors. For this reason, the study, while recognizing that the use of the technology introduced to dematerialize old processes in the public and private sectors could lead to a reduction of 500 MtCO2e in 2020 (the equivalent of the total ICT footprint in 2002, or little less than UK emissions in 2007) concluded that dematerialisation processes, if better implemented, could lead to a much greater reduction in carbon emissions, so as to reach their full abatement potential. The overall figure, as of today, is likely to be much bigger and, a recent study (Freitag et al., 2022) after comparing some advanced data from the most quoted recent academic pieces on the subject, came to the conclusion that the global emissions from the ICT sector are as high as 2.1% – 3.9%.



Graphic 3: ICT emissions in 2022 - Source: own elaboration

In a groundbreaking study conducted by the European Commission from 2020 [1], the EU institution provided several insights and clarifications on the relationship between the ICT industry, consumption energy and environmental impact of data processes. First of all, the study pointed out that energy consumption of data centers is set to increase in the coming years. Between 2010 and 2018, the energy consumption of data centers in the EU28 increased from 53.9 TWh/a to 76.8 TWh/a which accounted for 2.7% of the electricity demand in the EU28 [2] in 2018. At the same time, the EC study, after noting that a precise method for measuring CO2 emissions is far from being achieved, estimates that European data centers could produce something in between 0.4% and 0.6% of the entire EU greenhouse gas (GHG) emissions (EC, 2020: 57). The study also highlights that some key digital technologies, smart sensors and the IoT, big data analysis, blockchain, 5g & satellites, AI & deep learning will consume an ever-increasing amount of energy supply which will lead to higher consumption of carbon emissions in the near future (EC, 2020: 41-45).

[1] See, European Commission. (2020). Energy-efficient Cloud Computing Technologies and Policies for an Eco-friendly Cloud Market. Available at: https://digital-strategy.ec.europa.eu/en/library/energy-efficient-cloud-computing-technologies-and-policies-eco-friendly-cloud-market
[2] EU-28 is the abbreviation of European Union (EU) members which, before the exit from the union by the United Kingdom, consisted of a group of 28 countries (Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, United Kingdom).

Measuring EDP, but how?

"it is not possible to determine the exact share of greenhouse gas emissions, as reliable data on CO2 emissions is not available"

Estimating the near-exact amount of carbon emissions that data processes produce is a complicated matter. In academic literature, there seems to be no agreement on which method to adopt to measure the environmental impact of data flows and processes. One of the reasons behind this apparent stalemate is that each data process is made up of innumerable and imperceptible steps (which together lead to the data life cycle) and for each of the phases, it might be necessary to resort to as many measurement techniques. A further complexity arises from two crucial factors, time and location, which in many cases escape accurate measurement techniques, and both of them are big enough to matter (Carbon Trust, 2021). Other non-negligible variables to consider for measuring environmental data pollution are, as noted by Mytton (2020) the type of network, the energy consumption of a single individual device (computer, tablet, telephone, etc.) in a given place, the energy consumption of servers and data centers [3] that processes that data.

[3] In fact, it seems to be not possible to accurately estimate total CO2 emissions due to several factors, including the lack of data on the locations of the vast majority of global data centers and the emission intensities (measured in grams of CO2 per kilowatt hour) of their actual sources of electricity (Energy Innovation, 2020).

Last, but not least, the complexity of measuring carbon dioxide emissions in the case of data processes (i.e., dematerialized activities) is also affected by the lack of coherent and uniform standards in the measurement of two mirror phenomena, namely the magnitude of carbon emissions in the old "material" processes and the precise calculation of energy consumption in various production sectors. Not surprisingly, the European Commission in the above mentioned report of 2020 uncovered that:

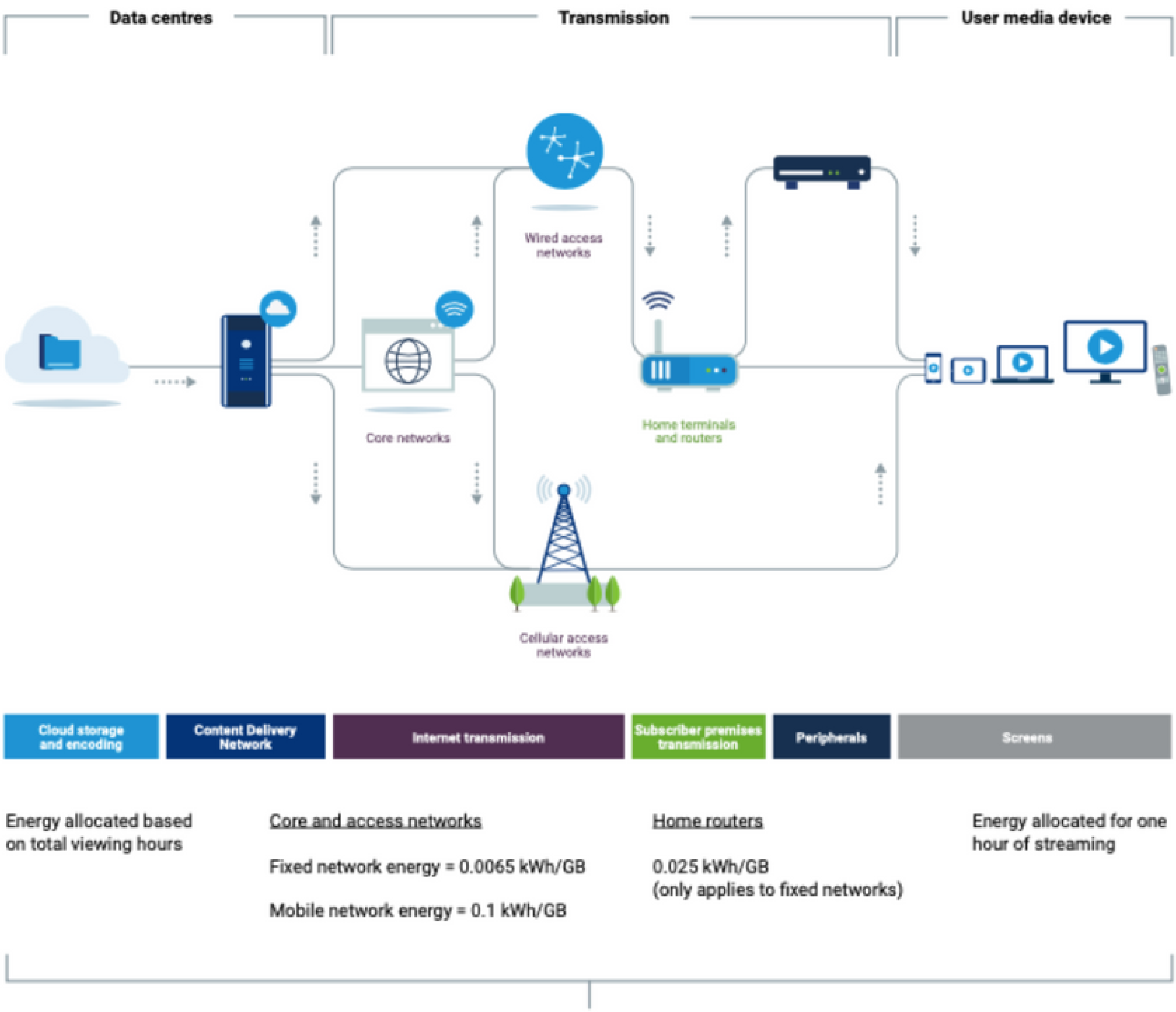
"it is not possible to determine the exact share of greenhouse gas emissions, as reliable data on CO2 emissions is not available" (EC, 2020: 57).

What actually seems to be inferred is that there is not, nor will there be in the near future, a general method for measuring environmental data pollution applicable to data processes as such, and this for a very simple reason: each data process is unique and it requires different tools and methodological approaches. As like algorithms, data processes are some sort of unique story that requires different solutions. Technical and social skills vary and must adapt to the different data processes taking place. Web scraping techniques may not be enough to fully understand the numerous nuances that each data process has and that differentiates it from the others. The attempt to measure the environmental impact (i.e. the exact value of carbon emissions) of web browsing, sending emails, watching videos, videoconferencing, among others, is quite another thing and varies from case to case. The data life cycle itself can vary too. This may be why most studies prefer to focus on environmental measurement for specific data processes and not on a general purpose measurement. What follows is a list of data processes methods that we have unearthed and which we believe are as interesting as the most reliable in terms of their methodological approach.

Video streaming

The carbon emissions of video streaming services (especially on-demand ones) have been the subject of what is very likely one of the most influential studies in the sector, which is the white paper (2021) of the UK based organization Carbon Trust [4]. The study, teaming up with a group of experts and researchers from the University of Bristol, Netflix, Sky, Ericsson Research and the International Energy Agency (IEA) among others, relied on what they called the conventional approach. This approach refers to a method that takes into account the average energy intensity, since it uses the average energy intensity of the transmission network, which is derived from academic research, to estimate the energy consumption of the network attributable to video streaming. This method, suitable for organizations that provide Internet services, such as video streaming providers, was built around three different stages of the process of streaming video, data center, transmission and end-user devices as shown in the figure below.

[4] Another research on carbon emissions of video streaming was conducted by The Shift Project, which came to the fore thanks to articles from numerous international newspapers, was harshly criticized by George Kamiya in "The carbon footprint of streaming video: fact-checking the headlines" (IEA, 2020)



Graphic 4: Data life cycle of the video streaming process. Source: The Carbon Trust. (2021). Carbon impact of video streaming.

The white paper adopted an approach that considers the life cycle perspective crucial for calculating the carbon footprint. As shown in Graphic 4, there are three macro areas in the video streaming life cycle to be considered: Data Centers (for originating and encoding of video content), Content Delivery Network (CDN - for temporary storage and delivery), Internet Network Transmission, Home Terminals and Routers, Home Peripherals (e.g. set-top-boxes), and End-User devices (screens). Taking into account the different components of the video streaming life cycle, the study concluded that the estimated European average carbon footprint corresponded to around 55 gCO2e per hour of video streaming for the year 2020, where the component of the user's devices accounted for the largest share of emissions in the video streaming footprint. Indeed, the carbon footprint of the end-user devices accounted for 401 MtCO2e, followed by networks (198 MtCO2e) and data centers (141 MtCO2e).

Browsing cookies

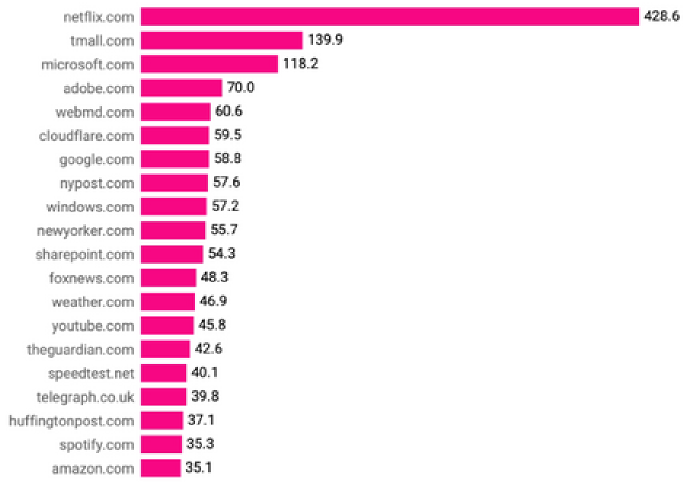
Cookies can also have an impact on the environment, further increasing the production of carbon emissions, as demonstrated by Carbolytics [5]. The research project was launched after a long period of preparation last February 2022 in a joint effort between Joana Moll, Barcelona-based artist working on the intersection of online surveillance, privacy and the environment, and the Barcelona Supercomputing Center (BSC) [6]. One of the main reasons that pushed Joana to start investigating the environmental effects of cookies was a concern over the online privacy of individuals, their massive surveillance in digital networks by tech giants and a reaction towards the digital ecosystem that arose in the late 1990s. In those years, Joana said that:

"Some Wall Street's key figures began to take their first steps and move to Silicon Valley, attracted by the emerging businesses in the much more lucrative tech world than the traditional banking and financial sector (Assia, 2015). With this move, the business model of the financial sector has slowly begun to take hold in the digital world, giving life to a new tech ecosystem where economic growth was the top priority at the expense of the privacy of individuals online."

Carbolytics research examined and analyzed the carbon emissions produced by the total number of cookies belonging to the top one million websites. The survey identified more than 21 million cookies for every single visit to all of these websites, belonging to more than 1200 different companies, which translates into an average of 197 trillion cookies per month, resulting in 11,442 monthly metric tonnes of CO2 emissions. The top one million most visited websites were gathered according to the Tranco list, collecting rankings from Amazon's Alexa browser extension, Cisco DNS services, and the Majestic Million. The rankings were later combined by applying the Dowdall system. Following this initial step, through the two online tools OpenWPM and Selenium, a site's crawling was launched to obtain data which led to a rate of approximately 2000 sites per hour, allowing nearly real-time data analysis. The total amount of computation time needed for completing the one million list was about 500 hours, with an estimated emission of 35.6 kg of CO2 equivalent. An estimation of energy consumption of internet usage was carried out on the basis of a 2015 study by Andrae and Edler that then was later divided by the total internet traffic estimated by Cisco, thus giving an average energy intensity of 1.8 kWh/GB that would lead, eventually, to a lower bound of 0.23 kWh/GB. Importantly, in this phase, the study considered (like the Carbon Trust white paper) a broader spectrum of variables, including data centers, telecom networks, and end users' networking equipment, computers and mobile devices, but excluding their manufacturing emissions. Finally, for measuring the carbon intensity of electricity the study relied on the international average estimate by the International Energy Agency of 475 grams of CO2e per kWh in the absence of clear data on renewable energy servers.

[5] See, https://carbolytics.org/
[6] See, https://www.bsc.es/

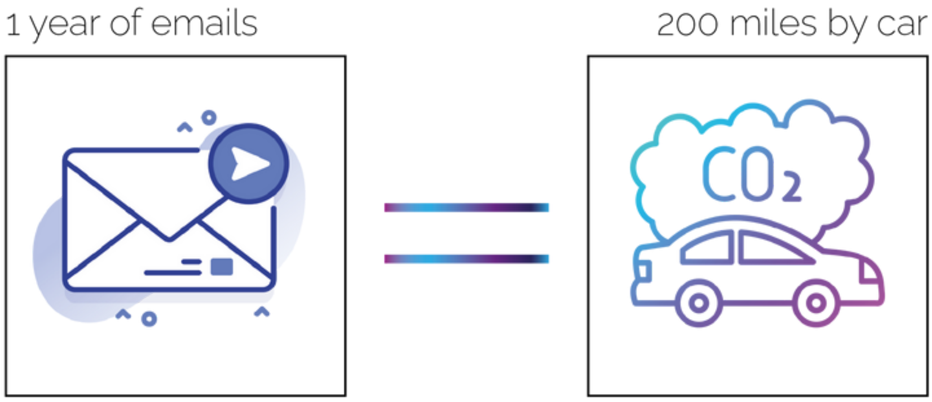
Results of the crawling were conducted on a total of 12,328,094 unique cookies after the removal of duplicates and other false positives. It was also found that the median cookie size (byte length of its name and value) was 35 bytes, with 21 bytes and 63 bytes in the 25% and 75% percentile. The study, in the end, estimated that the total number of carbon emissions for the cookies from the top one million websites amounted to 11,442 metric tons of CO2 per month with a lower bound of 1,400 and an upper bound of 17,100 metric tons of CO2 per month. This means that the carbon footprint of cookies from top websites in one year would be approximately 138.000 metric tons of CO2. The carbon emission of cookies, when compared with the most potentially polluting data industry, namely that of Bitcoin which, as we will see shortly, would be responsible for millions metric tons of CO2 per year, is not a particularly significant value. Nevertheless, cookies' environmental impact is something that deserves to be brought to attention beyond the numbers in absolute terms, as it highlights a deeper problem of the existing ecosystems of data: the breach of individuals' privacy which causes an environmental hazard. Most interestingly, Carbolytics found (see Graphic 5 below) that the site www.netflix.com turned out to be the top site for carbon emissions per cookie with 428.6 metric tons of CO2 per month.



Graphic 5: Top 20 sites by emission from cookies. Source: Carbolytics. (2022). An analysis of the carbon costs of online tracking.

Sending emails

The vast majority of online media and other digital press releases (Griffiths, 2020; Walkley, 2022; Eco2 Greetings, 2021; Mawby, 2022; Chu, 2022; SEDNA, 2021) covering the topic of carbon footprint emissions via email cite Berners-Lee's bestseller "How Bad Are Bananas?" (2010) as the main source. In the book, it is argued that an average spam email has a footprint of 0.3g CO2e, a proper email has a carbon footprint of 4g CO2e and emails with long and tiresome attachments have a carbon footprint of 50g CO2e. It mainly depends on the size and other characteristics not too dissimilar to those for sending postal mail. The environmental impact and the energy consumption are mainly related to the power that both data centers and personal computers are using for sending, filtering, and receiving emails. The author also clarifies that a year of incoming emails adds up to 135 kg (300 lbs.) CO2e which corresponds to over 1 percent of the 10-ton lifestyle and equivalent to driving 200 miles in an average car.



Graphic 6: Emails vs Cars. Source: Own elaboration.

However, the book does not seem to reveal any particular methodology and refers to a research conducted by McAfee regarding spam emails. To further confirm that, OVO Energy, a Bristol-based trading company, which following Berners-Lee's findings launched the remarkable "Think Before Thank" [7] campaign to warn British citizens about the carbon cost of unnecessary emails, it doesn't seem to reveal too much about a methodological approach. Meanwhile, and while waiting for the company to release more details on its study, they found that for every fewer thank-you emails sent per day by a British adult, there would be a saving of around 16,433 tonnes of carbon per year, equivalent to something like 81,152 flights to Madrid for a middle class passenger.

McAfee's study, instead, which commissioned ICF, a global consulting firm specialized in developing climate change policies, relied on a specific methodology on its paper "The Carbon Footprint of Email Spam Report". In fact, the measuring of the carbon footprint of spam emails calculated the energy-use associated with each stage in spam's life cycle, then applied the appropriate emissions intensity to the total energy associated with spam and spam filtering. The results demonstrate that the average GHG emissions per spam message total 0.3 grams of CO2-equivalent (CO2-e). The life cycle of spam emails has been described as follows:

[7] See: https://www.ovoenergy.com/ovo-newsroom/press-releases/2019/november/think-before-you-thank-if-every-brit-sent-one-less-thank-you-email-a-day-we-would-save-16433-tonnes-of-carbon-a-year-the-same-as-81152-flights-to-madrid

Graphic 7: The lifecycle of Spam. Source: McAfee & ICF International (2009).

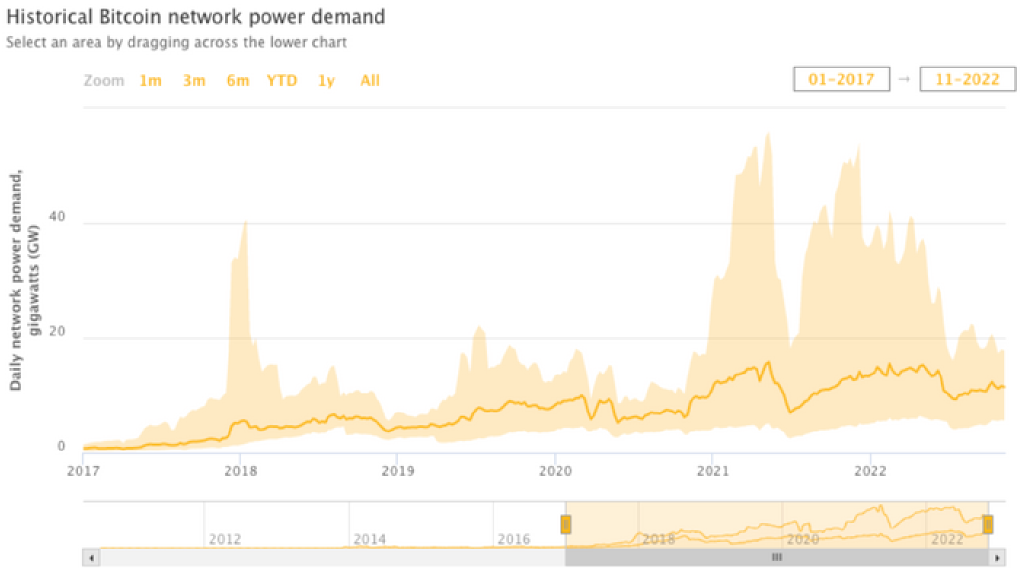
In the first phase of the spam life cycle, spammers harvest email addresses, typically by "scraping" websites, a process that uses automated software to download a website's entire content and search it for email addresses. The spammer then creates the spam campaign, after that a combination of zombie PCs (called botnets when they occur in large numbers) and conventional mail servers send the spam before traveling over the Internet hardware owned by ISPs and other network providers. Mail servers process spam and place it into disk storage and, finally, energy is used by spam filtering devices leading to both false positives and false negatives. Some of the key findings of the study, based on an estimated 62 trillion spam emails delivered in 2008, were that spam's annual energy use amounts to 33 billion kilowatt hours (KWh), or 33 terawatt hours (TWh), a total of 0.3 grams of CO2-e has been the average for a single spam email where the biggest amount of energy consumption (52 percent) comes from end-users deleting spam and searching for legitimate email (false positives).

Bitcoin and Crypto mining

Among all the data processes, Bitcoin is the industry with the highest degree of risk for the environment and carbon footprint emissions. One of the most prominent figures, who is working as a policy analyst on environmental risks, revealed to us that if we were to bet a penny on what is very likely to become one of the most polluting industries of the future, then that would be the Bitcoin's industry. And, this, partially, could be the reason why the greatest efforts of academic contributions have focused on this issue (McCook, 2018; Stoll et al., 2018; Trespalacios and Dijk, 2021; De Vries et al. 2022; Digiconomist, 2022). However, a thorough analysis and in-depth understanding of the real magnitude of cryptocurrencies' carbon footprint emissions remains a source of considerable academic disputes. One thing, at the same time, leaves room for hope and that is the Cambridge Bitcoin Electricity Consumption Index (CBECI) [8], which is regarded by many (Trespalacios and Dijk, 2021; De Vries et al. 2022; Digiconomist, 2022) as the most authoritative source for measuring Bitcoin's annual

[8] See: https://ccaf.io/cbeci/index

electricity consumption and a starting point for research to come. If it is true that in order to measure carbon emissions in general, not just for data processes, the understanding of electricity consumption is a necessary piece to consider, then the Cambridge Index would be the ideal starting point from which to take the first steps.



Graphic 8: Bitcoin electricity consumption (2017-2022). Source: Cambridge Bitcoin Electricity Consumption Index (CBECI)

In 2022, the global electricity demand of Bitcoin miners (electricity load) reached 11.55 gigawatts (GW) with a lower bound of 5.79 GW and an upper limit of 17.59 GW. The total yearly electricity consumption of the Bitcoin network, in the same year, peaked 101.29 terawatt-hours (TWh) with a lower bound of 50.73 TWh and an upper of 154.19 TWh. The trend of Bitcoin electricity consumption is constantly growing, as shown in Graphic 8 which represents the Bitcoin global electricity consumption over the past six years starting from 2017. And the more electricity is consumed, the more carbon emissions are released.

One of the latest studies on the subject, De Vries et al. (2022) estimated that the Bitcoin network could be responsible for around 65.4 megatonnes of CO2 per year. Based on the analysis of the repercussions of the mining crackdown in China during the spring of 2021, which might have reduced the use of renewable electricity sources for Bitcoin mining when miners were forced to move to countries such as the U.S. and Kazakhstan, the study (Digiconomist, 2022) speculated on a drastic increase in Bitcoin's carbon emissions. Researchers found that the average carbon intensity of electricity consumed by the Bitcoin network may have increased from 478.27 gCO2/kWh on average in 2020 to 557.76 gCO2/kWh in August 2021 which resulted in a 17% increase of carbon intensity of mining. Digiconomist [9], the independent research firm founded by de Vries providing live data on the

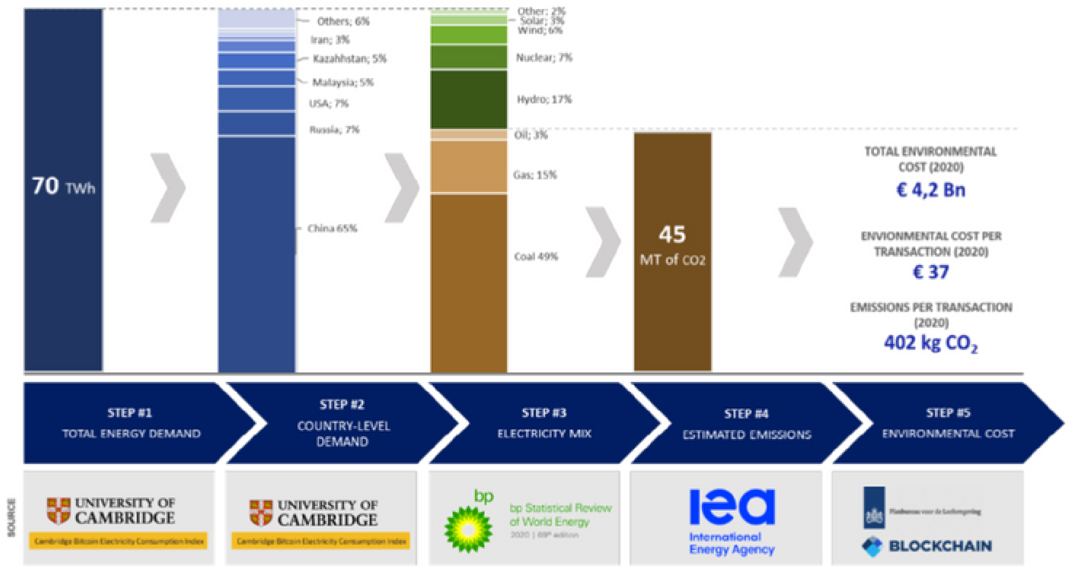
[9] See, https://digiconomist.net/

environmental impact of the Bitcoin market, also shows that the Bitcoin network could be responsible for consuming around 65.4 megatonnes of CO2 annually, which is comparable to country-level emissions in Greece (Digiconomist, 2022). In its latest figures from their Bitcoin Energy Consumption Index [10], Digiconomist found that the annual consumption of Bitcoin leads to 72.65 Mt CO2 of carbon emissions (comparable to the carbon footprint of Turkmenistan.), 130.25 TWh of electrical energy (comparable to the power consumption of Argentina) and 37.82 kt of electronic waste (comparable to the small IT equipment waste of the Netherlands).

Another notorious study (Stoll et al., 2018) came to different conclusions about Bitcoin's annual carbon emissions, which given its November 2018 annual electricity consumption of 48.2 TWh, that would be between 21.5 and 53.6 megatonnes of CO2 per year. The researchers, in particular, relied on the analysis of a number of indicators, including mining hardware, facilities and pools followed by the examination of the mining locations on a regional scale. Bitcoin's annual carbon footprint has been based on both total power consumption and geographic footprint and it was calculated by multiplying the power consumption by average and marginal emission factors of power generation. A previous study (McCook, 2018) that started from a correction of a previous version released in 2015 where the cost and impact of air-conditioning were not examined, reached conclusions not too far from De Vries et al. and Digiconomist. McCook, indeed, argued that the Bitcoin network was responsible for about 63 million tons of CO2 per year, about 0.12% of global greenhouse gas emissions and that of the 160,000 TWh of energy generated globally each year, the Bitcoin network consumed about 105 TWh per year (0.0661%).

A pretty interesting research on the vexed question on how to measure Bitcoin's carbon emissions was also conducted by De Nederlandsche Bank (Trespalacios and Dijk, 2021) which proposed the adoption of a completely new and blended method. Although it was preliminarily clarified the need for more research for consistent footprint calculations as a variety of possible design choices can result in large differences in the total footprint per transaction and given the lack of transparency and clarity of many of the existing methods, the study suggested a brand-new 5 building blocks method. The method breaks down in this fashion:

[10] See, https://digiconomist.net/bitcoin-energy-consumption#:~:text=The%20carbon%20footprint%20per%20VISA%20transaction%20is%20only%200.45%20grams%20CO2eq.&text=The%20number%20of%20VISA%20transactions,on%20average%20(1395.13%20kWh).



Graphic 9: The five open source building blocks to determine the carbon footprint of bitcoin per transaction.
Source: Trespalacios, J.P., & Dijk, J. (2021).

The five building blocks method of the study is based on some of the best indices from various research bodies and institutes currently existing on the market.

1. In the first phase, and following the Cambridge Bitcoin Electricity Consumption Index (CBECI), the main purpose is to provide an estimation of the annual value of electrical power consumption from the bitcoin network (TWh/year).
2. In the second, the method continues to explain the demand for electricity consumption at national level by calculating the annual average of the hash rate and breaking down the average annual consumption of electricity (TWh-Country/year) always on the basis of the same CBECI index.
3. The third step aims to measure the electricity consumption per country (looking at the BP Statistical Review of World Energy) by primary sources or fuels with data from British Petroleum as it provided the highest level of data granularity.
4. The fourth phase's goal is to convert the total electricity consumed from brown sources into estimated CO2 emissions, using the country's average CO2 emission coefficient from the International Energy Agency (IEA).
5. The last, and fifth phase, is designed to convert the estimated CO2 emissions into an environmental cost, using average Social Cost of Carbon (SCC) price as reported by the Netherlands Environmental Assessment Agency (PBL). Finally, this last is calculated by dividing the total global cost by the overall number of bitcoin transactions reported by Blockchain.com.

AI, ML and Deep Learning models training

Also training an AI model, in that case a Natural Language Processing (NLP) one, can be environmentally costly as shown by a 2019 research paper (Strubell et al., 2019). In fact, the researchers by training four different AI models (Transformer, NAS, ELMo and BERT) demonstrated that the overall cost of training in terms of CO2 emissions and cloud computing cost was not entirely negligible. In the case of training of the NAS AI model, the carbon footprint emissions (626,155) was nearly comparable to the carbon dioxide emission of five American cars during their lifetime.

Model	Hardware	Power (W)	Hours	kWh·PUE	CO_2e	Cloud compute cost
$\text{Transformer}_{base}$	P100x8	1415.78	12	27	26	\$41–\$140
Transformer_{big}	P100x8	1515.43	84	201	192	\$289–\$981
ELMo	P100x3	517.66	336	275	262	\$433–\$1472
BERT_{base}	V100x64	12,041.51	79	1507	1438	\$3751–\$12,571
BERT_{base}	TPUv2x16	—	96	—	—	\$2074–\$6912
NAS	P100x8	1515.43	274,120	656,347	626,155	\$942,973–\$3,201,722
NAS	TPUv2x1	—	32,623	—	—	\$44,055–\$146,848
GPT-2	TPUv3x32	—	168	—	—	\$12,902–\$43,008

Table 1: Estimated cost of training a model in terms of CO2 emissions. Source: Strubell, E., Ganesh, A., & McCallum, A. (2019)

The method of the study consists of several progressive and connected phases. First, the AI models were all trained using some default settings and samples of GPU and CPU power consumption for up to a day, and each AI model was applied to a different graphics card (i.e., NVIDIA Titan X GPU, 3 NVIDIA GTX 1080 Ti GPUs). Then, AI power consumption was converted in kilowatt-hours (kWh) combining GPU, CPU and DRAM consumption later multiplied by a Power Usage Effectiveness (PUE) of 1.58 as the global average for data centers. The total energy consumption was converted into an estimate of carbon emissions following the model of the United States Environmental Protection Agency (EPA) which leads to the following equation CO2e = 0.954pt. The researchers, then, concluded with the assumption that the U.S. breakdown of energy is comparable to that of the most popular cloud compute service, such as Amazon Web Services, leading them to believe that the conversion provided a reasonable estimate of CO2 emissions per kilowatt hour of computing energy used.

Similarly to what happens with AI models, training a machine learning (ML) model can also have a significant environmental impact. This has been the main research hypothesis advanced by Lacoste et al. (2019) in a joint paper where a group of Canadian researchers revealed the online tool *Machine Learning Emissions Calculator* [11] to estimate the carbon footprint (CO2eq) of Machine Learning processes. The first variable to be assessed in the study is the location of the cloud computing servers. Each different location corresponds to a certain value of carbon gas emissions which vary from place to place. The study demonstrated that the presence of GPU cloud servers located in North America can lead to very different carbon emissions, from 20g CO2eq/kWh in Quebec to 736.6g CO2eq/kWh in

[11] See: https://mlco2.github.io/impact/

Iowa. Once again, location matters. Computing infrastructure and training time are other two factors that can affect cloud computing carbon emissions, as in recent years there was an increase in energy consumption due to the rise in number of floating point operations per second (FLOPS) of GPUs and with the installation of neural network architectures. Finally, deep learning [12] model training can also lead to a massive amount of computational time needed and, thus, to carbon emissions as illustrated by the study conducted by Schwartz et al. (2019). The study supports Green AI, which is more environmentally friendly and inclusive AI research, as opposed to Red AI as an artificial intelligence research method that seeks to achieve cutting-edge results in terms of accuracy through the use of enormous computing power.

Video conferencing

In a blog post published in November 2020 [13], David Mytton, co-founder and CEO of the SaaS IT monitoring startup Server Density and researcher of sustainable computing at the University of Oxford, attempted to debunk the myth that video conferencing tools are much greener than face-to-face meetings. Mytton's arguments were also adopted as a methodological starting point for the online tool presented by Utility Bidder [14], a UK-based energy broker comparing business energy deals. Preliminarily, Mytton began by asking a series of basic questions:

"In the context of video conferencing, it is safe to assume that arranging a Zoom call is better than flying business class from London to New York, but is it better than both participants walking to a cafe in the city they both already live in? Maybe someone was going to drive their EV to the office. What about if you have many participants all over the world? How about if some connect via 4G vs others on a laptop?"

After realizing that Zoom has never made it clear the exact amount of carbon emissions from its online video conferencing systems, he started calculating an estimation data of the electricity consumed by the platform. Zoom offers different bandwidth requirements for 1:1 call and group video calling, The numbers were later converted into gigabytes as per Aslan et al. (2018) who identified the total amount of electricity intensity of fixed-line internet data transmission. It follows that a 1 hour 1:1 call could generate 1.08 – 3.24GB of network traffic using 0.0162 – 0.0486 kWh of electricity, while a group call of six people around 4.86 – 14.85GB of traffic and use 0.0729 – 0.22275 kWh of electricity. Having established the numbers for energy consumption, the next step was to speculate on the corresponding amount of carbon emissions. Here, again, location matters, Different locations can correspond to different levels of carbon emissions. To keep things simple, Mytton considered the hypothesis that video conferencing takes place within the same country. He found that for the UK, a 1:1 call HD 1080p of 1 hour between two people would require 0.25358 $kgCO_2$ per kWh with a corresponding CO_2 emissions of 0.012 $kgCO_2$ using the 2019 UK

[12] As clarified by IBM, "deep learning is a subset of machine learning, which is essentially a neural network with three or more layers. These neural networks attempt to simulate the behavior of the human brain—albeit far from matching its ability—allowing it to "learn" from large amounts of data. While a neural network with a single layer can still make approximate predictions, additional hidden layers can help to optimize and refine for accuracy." Available at: https://www.ibm.com/cloud/learn/deep-learning
[13] See, https://davidmytton.blog/zoom-video-conferencing-energy-and-emissions/
[14] See, https://www.utilitybidder.co.uk/business-electricity/zoom-emissions/

greenhouse gas conversion factors [15]. Similarly, in the US, for the same 1:1 call it would be around 0.28839 kgCO2 per kWh. However, this was the most basic experiment of two people within the same country doing the same Zoom 1:1 call, and Mytton warned that many other factors could make things much more complex such as differences of locations, type of network and devices, data centers and servers. This further, and somewhat crucial, consideration only confirms the extreme complexity in identifying the precise amount of carbon emissions of data and data processes given the presence of numerous variables that can escape from any empirical and precise calculations.

Negative Assumptions:

- There is no single method to measure environmental data pollution, and this is mainly due to the diversity of each data process (e.g., measuring carbon emissions for sending emails is quite a different thing than CO2 emissions from AI training or machine learning). There are several attempts to use different methods, but grouped for individual categories of data processes.
- Each of the individual methods used for a specific data process does not refer or communicate with the other methods used for different types of data processes. Individual methods tend to be closed and self-referential.
- Overall, time and place are two of the most important and problematic factors (as they can easily escape accurate calculations) of the data lifecycle that can have a major impact on the final carbon footprint calculation.
- The more steps there are in the individual data lifecycle, the more difficult would be calculating the environmental impact of that data.

Positive Assumptions:

- All methods show that, albeit the uncertainties exposed above, environmental data pollution can be measured (in some cases it is difficult to achieve a precise measurement, but anyway the value can be approximately estimated)
- There are two methods out there that deserve greater attention and value mainly for their openness and collaboration between different skills and expertises: the one proposed by The Carbon Trust (the conventional approach), one of the best practices as it relies on a blended approach, teaming up with some of the best expertises on the field. And the method suggested by De Nederlandsche Bank (5 building blocks method) which for each phase of the data life cycle is based on some of the best indices in the sector, thus showing a spirit of collaboration and union of forces in the field.

[15] See, https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019

Lowering polluted data. Mitigating measures

The less data is collected, the lower the risk of having environmental data pollution

We propose that methods for decreasing the environmental effect of data processes can be divided into two broad categories. A general one, corresponding to a good practice according to the GDPR standards, applicable to any data process regardless of the type and location, and the particular ones that are only suitable for certain data processes.

Data minimization

A general method to mitigate all risks associated with environmental data pollution can be to pursue data minimization good practices. In fact, the less data is collected, the lower the risk of having environmental data pollution. The concept of data minimization, firstly introduced in Europe by the GDPR, might well be extended outside the European boundaries.

Data minimization means collecting the minimum amount of personal data needed to deliver an individual element of the processing activity. Article 5(1)(c) of the GDPR, "Data minimization", says that personal data shall be:

"adequate, relevant and limited to what is necessary in relation to the purposes for which they are processed ('data minimization')"

The principle of data minimization establishes that collected data should not be more than what is strictly necessary in order to achieve the purpose of the processing. This principle boils down to the fact that no data should be collected if they are not strictly necessary for the declared purposes of the processing. In other words, if the utility of a piece of data is unclear, it should not be collected. Evidently, this requires a contextual judgment that takes into consideration the purpose of the processing and the suitableness of data in order to achieve it. In this context, data minimization means trying to minimize the amount of data subject to the process in order to prevent upstream cases of environmental data pollution.

In the United States it is a whole other story. Being a concept as its core incepted by the GDPR, data minimization has long been ignored outside Europe. And, despite the numerous efforts to introduce a common discipline among the different states in the U.S., it seems that most of the rules and guarantees on data privacy and protection are left to the individual federal laws. Last July 20, however, some progress has been made when the Committee on Energy and Commerce voted [16] to advance the American Data Privacy and Protection Act (ADPPA), to the full House of Representatives. Although some influential voices have expressed their opposition to the concrete contribution that the proposal can make, including the California Privacy Protection Agency [17], and Nancy Pelosi who said that the ADPPA "does not guarantee the same essential consumer protections as California's existing privacy laws" (Duball, 2022), the act could pave the way for the first-ever federal data protection law in the country. In a conversation with WIRED, data protection and consumer privacy expert Sara Collins, also working as a senior policy council at Public Knowledge, said that "The reason I really like this bill is, it takes a data-minimization approach first" (Edelman, 2022). Data minimization, therefore, could soon become a reality and a practical tool available to incentivize companies to pursue behaviors that respect both privacy and the environment in the US as well.

[16] See, https://crsreports.congress.gov/product/pdf/LSB/LSB10776
[17] See, https://www.dataguidance.com/news/california-cppa-sends-letter-opposing-adppa-house

Minimizing data could also improve the quality of the data processes outcome. By having less data, better outcomes might be achieved, among other things, with reducing environmental data pollution. If EDP is read as a negative externality (which is obviously a bad outcome), a decrease in pouring polluted data should be seen as an improvement, thus leading to a better outcome. Small data, indeed, might be preferable than big data in a number of cases. For instance Faraway and Augustin (2018) argued that:

"*where an inference of causation is desired, quality beats quantity in data*" (2018:3)

The more data, the more environmental data pollution assumption is a typical causal inference. And, if having more data (Big Data) increases the probability of EDP, in our case less data (Small Data) is to be preferred. Small data in virtuous data processes can lead to a better outcome, namely the certain reduction of carbon footprint emissions. Suffice it to say, in the case of training an AI, ML or Deep Learning model, the more data is processed by the internal algorithms of cloud computing, the more will be the computational cost and the corresponding value in energy consumption. Conversely, if the model is trained with a restricted number of data, more precisely and introduced after a preliminary study, the processing of the data will save both energy consumed and pollution produced.

Modular process, less AI training

A particular method to mitigate the impact of certain data processes, in particular the carbon footprint resulting from training an artificial intelligence model, is the modular AI approach developed by the German-based software provider elevait [18]. Their background assumption is that if models are to be trained for each AI project, this means that there is multiple training with a considerable waste of resources and energy. To avoid this risk, whic wouldwould lead, in fact, to an increase in environmental data pollution, the company has developed an AI modular building block in which all the different models are connected to each other. With the consequence that the AI training will be only one, thus avoiding unnecessary waste of energy and resources. The modular process aims to simplify the AI training by lowering the amount of time and energy required for training different models within the same process. Finally, the concrete implementation of the workflow of the project, which is based on the requirements of the individual project, will be the result of a collective effort between the company requesting the service and the company authoring the modular process service, not leaving the client company alone.

[18] See: https://www.elevait.de/

PoS replacing PoW for Cryptos

Another particular method, or in this case wish of strategic change, concerns the field of cryptocurrencies and questions the energy efficiency of their current protocol, the Proof-of-work (PoW), original consensus algorithm in Blockchain networks, is the widely used protocol and consensus mechanism for cryptocurrencies and cryptomining, for validating transactions and mining new tokens. Proof of Work (PoW) is a decentralized consensus mechanism that requires members of a network to devote efforts to solving an arbitrary math puzzle to prevent anyone from playing with the system [19]. It has been argued that (Gschossmann et al., 2022) the main reason behind the significant energy consumption of cryptocurrencies lies in its cryptographic protocol, which relies on the proof-of-work (PoW) consensus mechanism. To reduce the environmental impact of the Bitcoin network, it was proposed to switch from the existing PoW protocol to the different protocol Proof-of-Stake (PoS). Indeed, the main idea behind PoS is that to become a validator (or "miner") of transactions, network participants must lock up (or "stake") a certain amount of the underlying crypto-asset. These locked up crypto-assets are used as a form of collateral for the security of the network. Hence, the decisive factor that determines whether a validator can successfully mine a block is not computing power, but the amount of staked crypto-assets. Crypto-assets built on PoS blockchains thus rely on miners pledging crypto-asset collateral instead of computing power, leading to substantially lower energy consumption (Gschossmann et al., 2022). This call to change the Bitcoin protocol network has also been advocated by the "Change The Code, Not The Climate" Campaign [20], launched by Chris Larsen, co-founder of Ripple and Michael Brune, former executive director of the Sierra Club. The campaign manifesto, in fact, suggests that changing Bitcoin's mining method from proof of work (PoW), in which miners compete in a race where the winner takes everything to solve energy-hungry cryptographic puzzles, to proof of more energy efficient stake (PoS) would reduce the electricity consumption of the cryptocurrency.

Last September 2022, Ethereum, the world's second-largest cryptocurrency, switched its protocol from PoW to PoS. This could have major implications for the estimated carbon emissions of Ethereum's network. According to Ethereum Foundation, the move will save approximately 99.95% of the total Ethereum's energy consumption [21] and this appears to be confirmed by some recent studies (Kerr, 2022; ConsenSys, 2022; Digiconomist, 2022). This prediction was also confirmed by Alex De Vries of Digiconomist [22], who currently runs the only available index [23] on the total energy consumption of the Ethereum network. Alex, when asked why Bitcoin does not follow the same footsteps as Ethereum, replied that:

"Bitcoin will not make the transition easily as there are too many political and economic interests at stake and switching to the new protocol could result in a huge loss of value in the stock market."

[19] See: https://www.investopedia.com/terms/p/proof-work.asp#:~:text=Proof%20of%20work%20(PoW)%20is,transactions%20and%20mining%20new%20tokens.
[20] See: https://cleanupbitcoin.com/
[21] See: https://ethereum.org/en/upgrades/merge
[22] See: https://twitter.com/DigiEconomist/status/1569637645508087809
[23] See: https://digiconomist.net/ethereum-energy-consumption

On November 22, 2022, New York Governor Kathy Hochul signed into law a moratorium that will prevent cryptocurrencies mining running proof-of-work protocol to expand or renew air pollution permits unless the company will use 100% renewable energy (Ferré-Sadurní and Ashford, 2022). The new law temporarily freezes the issuance and renewal of air permits to companies that have transformed some of the state's oldest fossil fuel plants into cryptocurrency mining hubs (DeVon, 2022) and represents a groundbreaking change in the political debate. Indeed, the Bill A7389C [24] focuses on the environmental impact of cryptocurrency mining operations using proof-of-work authentication methods. The bill acknowledges that the mining industry is growing in the state, but also notes that this growth will greatly increase energy usage and potentially impact compliance with the state's Climate Leadership and Community Protection Act. The bill seeks to address these concerns and ensure that the state's mining industry is sustainable and environmentally responsible. New York's latest development means that some legislators are starting to recognize the potential impact of proof-of-work cryptocurrencies on the environment and are looking for ways to address it.

Spam filtering

As a mitigation measure specifically designed for emailing, spam filtering could be an effective way to contrast the carbon emissions of email spam as noted by the McAfee & ICF International research (2009). Even though spam filtering consumes approximately 5.5 billion KWh annually and about 16 percent of overall spam energy use, when compared to the energy users consume searching for false positives, viewing and deleting spam messages, the energy consumption of spam filtering is by far less impactful. The study, indeed, found that spam filtering saves 135 TWh of electricity per year. Spam filtering, however, is not the best mitigation strategy to rely on as it would be more desirable to combat spam at the source, as was the case with US-based web hosting provider McColo. In this case, as pointed out by the McAfee/ICF study, McColo, a major web hosting provider and source of online spam, was taken offline in late 2008 by its upstream Internet Service Provider (ISP), followed by approximately 70% drop of total spam volume resulting in energy savings equivalent to 2.2 million off-road passenger vehicles.

Therefore, and since the environmental impact (carbon emissions) of data processes can be mitigated through both general and particular measures, it may make sense to devise a mechanism to punish or discourage those who do not adopt environmental data pollution mitigation practices. One of the strategic choices that modern democracies have adopted to stem the growing phenomenon of pollution is the adoption of specific tax regimes aimed at punishing polluters following the "polluter pays" principle.

Could an environmental data pollution tax be the answer to address the environmental costs of data processes and create positive incentives for the adoption of best practices? In the next chapter we will briefly clarify the history of environmental tax law to see what such a commitment could be like.

[24] See, https://www.nysenate.gov/legislation/bills/2021/A7389#:~:text=A7389C%20(ACTIVE)%20%2D%20Summary,generic%20environmental%20impact%20statement%20review.

Taxes, answer to environmental pollution

The 1960s and 1970s, the birth of the largest movement of environmentalists.

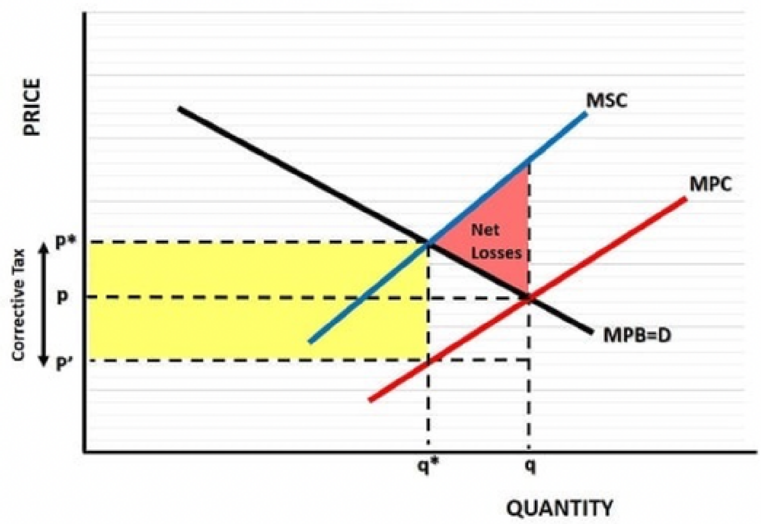
Taxation, ideologically, was not at the center of environmental law. However, in the late 1960s something began to take shape when the environmental cause attracted millions of people in their teens and twenties, and the energy of the young helped make environmentalism a mass movement (Rome, 2003). The 1960s and 1970s saw a series of major events that contributed to the birth of the largest movement of environmentalists. These events included the significant increase in air pollution due to the rise in cars and industries, as well as the Santa Barbara oil spill in 1969. Additionally, Rachel Carson's Silent Spring shed light on the environmental risks of commonly used insecticides, leading to increased awareness (Agarwal, 2009; Staniforth, 2013; Yeo, 2020). Supporters of the environmental movement proposed two basic strategies, one the one hand, the implementation of a system of direct "command-and-control" regulations setting objective environmental quality standards to be achieved through direct controls on polluting sources. On the other hand, an economic-oriented strategy that viewed pollution and other damage to the environment as external costs of economic activities that were not properly accounted for in free market decisions and therefore resulted in the so-called "market failures" (Gaines et al., 1992).

[3] In fact, it seems to be not possible to accurately estimate total CO2 emissions due to several factors, including the lack of data on the locations of the vast majority of global data centers and the emission intensities (measured in grams of CO2 per kilowatt hour) of their actual sources of electricity (Energy Innovation, 2020).

History has taught us that it was the economic vision that prevailed over the years. Indeed, as a response to the growing environmental issues of that time, the Organization for Economic Cooperation and Development (OECD) proposed the application of the so-called polluter pays principle in 1972, thus giving the theoretical basis for the introduction of environmental taxation (Tan et al., 2022). Built on the premise that environmental resources are in principle scarce and easily perishable which in turn lead to a case of market failure due to undue internal cost savings, the recommendation went on clarifying that the polluter pays principle:

"means that the polluter should bear the expenses of carrying out the above-mentioned measures decided by public authorities to ensure that the environment is in an acceptable state. In other words, the cost of these measures should be reflected in the cost of goods and services which cause pollution in production and/or consumption" [25]

The "polluter pays" principle is of fundamental importance in environmental taxation, meaning that those who cause pollution should be responsible for the costs that arise from it (EEA, 2004). This principle has also been reaffirmed by EU policies. Indeed, the European Parliament in a 2020 briefing note [26] after stressing the fact that the field of environmental taxation is one way of encouraging a shift towards more eco-friendly choices with the aim of factoring environmental damage, or negative externalities, in prices, in order to guide production and consumption choices in a more eco-friendly direction, has clarified the crucial role that the principle plays in the field of environmental taxation. Following the principle, the cost of the activities that generate pollution or harm the environment is raised in such a way as to be internalized in the producer's production process. The theoretical basis for this economic and trade-off approach can be traced back to the much acclaimed British economist Pigou who in his masterpiece of economic theory "The Economics of Welfare" of 1920 introduced the concept of the Pigouvian tax. Pigou, in particular, devised a cost-effective solution to pollution by setting the tax rate on emissions to be equal to the additional social damages from one more ton of pollution (Metcalf, 2019:115).



Graphic 10: Market with Negative Externalities. Source: DyingEconomy.com

[25] See: https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0102
[26] See: https://www.europarl.europa.eu/RegData/etudes/BRIE/2020/646124/EPRS_BRI(2020)646124_EN.pdf

In a market characterized by negative externalities (such as in the case of CO2 emissions from data processes), the adverse effects of those externalities might be corrected by levying taxes equal to the externalized costs (see, Graphic 10). The purpose of the tax is to fully internalize the social cost produced by the negative externality in such a way that the producers of the environmental damage are encouraged to behave in a more ecological way. The corrective tax, which reduces the demand for electricity, can simultaneously lower overall emissions, and the revenue generated can be used to address environmental damage or invest in cleaner generation technologies. The Pigouvian tax is the oldest and, to some extent, the most successful economic policy theory in environmental law.

Environmental taxes are those that aim to encourage or discourage certain activities that can have a significant impact on the environment. As for Regulation (EU) No 691/2011 [27], an environmentally related tax means a tax whose tax-base is a physical unit (or a proxy of a physical unit) of something that has a proven, specific negative impact on the environment, and which is identified in ESA 95 as a tax (Article 2(2)). In exactly the same terms, the OECD [28] defines environmental taxes as a tax whose tax-base is a physical unit (or a proxy of it) that has a proven specific negative impact on the environment. Importantly, the OECD also distinguishes four different categories of environmental taxes relating to energy, transport, pollution and resources. Within these four categories, pollution taxes have historically been one of the first measures taken to reduce greenhouse gas (GHG) emissions, and the introduction of a carbon tax, in particular, has been a popular approach. Finally, it is worth noting that in the EU the use of environmental taxation is known to be more widespread. In 2006, the environmental tax revenues were 2.5 percent of GDP and formed 6.4 percent of total tax revenues in EU-27 Member States on average, while the corresponding figures, for instance, in the US are below 1 percent and 4 percent respectively (Dias Soares et al., 2010:37).

Carbon tax

In Europe, the first environmental taxes were introduced in the late 1990s, with Finland as the first country ever to introduce a carbon tax with the aim of reducing the overall share of its greenhouse gas (GHG) emissions. The tax was originally implemented with the scope of limiting carbon emissions from fossil fuels in the Finnish industrial sector.

Peat, natural gas, and the wood industry were granted exemptions, as were fuels used as raw material or inputs for manufacturing, leading to criticisms (Nachmany et al, 2015). Interestingly, the carbon tax was implemented in a country where only 0.3 percent of global greenhouse gasses were emitted in the 90s (Khastar et al., 2020). Finland was later followed by Denmark, Sweden and Norway, which introduced their carbon taxes only one year later.

[27] See: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:192:0001:0016:EN:PDF
[28] See: https://stats.oecd.org/glossary/detail.asp?ID=6437

Since 1990, Finland has cut greenhouse gas (GHG) emissions by about a fifth and has set a highly ambitious goal of achieving emissions neutrality (annual carbon dioxide (CO2) equivalent emissions must be offset by annual absorption from carbon sinks) by 2035 (Parry and Wingender, 2021). In the mid-2000s, a second wave of carbon tax acts took place by Switzerland, Iceland, Ireland, Japan, Mexico and Portugal respectively. Over a period from 1994-2003, where the majority of European countries have engaged with several environmental tax reforms (ETR), EU member states recorded a general reduction of greenhouse gas emissions and the largest reductions estimated for the countries with the highest tax rates (Andersen, 2010).

Oddly enough, the United States had a much slower and more cautious development than Europe on environmental taxation and, among other things, remains one of the few countries where a carbon tax has never been adopted. However, political debates on the possible adoption of a carbon tax in the United States are long-term even though they have never led to substantial developments in the area. On the one hand, the critical voices question the real effectiveness of the measure as it could entail substantial losses for businesses or because after an initial drop the tax did not produce significant reductions in greenhouse gas emissions (Eccles et al., 2022; Murphy et al., 2016). Others see the introduction of the carbon tax as the simplest solution to reduce carbon pollution at the lowest cost to the US economy (Metcalf, 2019) or a way to provide substantial new revenue in the government budget to help mitigating the high levels of debt/GDP in the country (Parry et al., 2015). More recently, during the Biden administration, there has been a return to the topic when US Senator Chris Coons and Representative Scott Peters have recently proposed [29] draft legislation to introduce a border carbon adjustment (BCA) on polluting imports. The BCA, however, is something very different from a carbon tax.

It is an environmental trade policy (not a tax) that, as clarified by the International Institute for Sustainable Development (IISD), works by charging goods at the border a carbon price equivalent to what they would have paid had they been produced under the domestic carbon pricing regime [30]. BCA and carbon taxes appear to be interlinked measures that should work side by side, this is the reason why it has been argued that introducing a BCA measure in the absence of a carbon tax would make little sense (Matheson, 2021). A path followed by the US government, which further confirms the general trend towards incentives and financing rather than taxation, is the introduction of the 45Q credit in order to reduce the greenhouse gas (GHG) emissions in the atmosphere. Under the law, enacted last February 2018, industrial manufacturers that capture carbon from their operations can earn $50 per metric ton (t) of CO2 stored permanently or $35 if the CO2 is put to use, such as for enhanced oil recovery (EOR) [31].

a) Tax rate calculation approaches

From a historical perspective, as earlier mentioned, the carbon tax was conceived as a way to put an end to the incessant increase in greenhouse gas emissions in the 1990s and, for this reason, it has been incepted in the form of indirect tax. This is quite a crucial point.

[29] See; https://www.coons.senate.gov/news/press-releases/sen-coons-rep-peters-introduce-legislation-to-support-us-workers-and-international-climate-cooperation
[30] See: https://www.iisd.org/articles/principles-border-carbon-adjustment-modest-proposal
[31] See: World Bank, Putting a Price on Carbon with a Tax, at https://www.worldbank.org/content/dam/Worldbank/document/Climate/background-note_carbon-tax.pdf

Indirect taxation, in fact, is imposed on certain transactions involving a transfer of wealth in order to offset the occurrence of negative externalities (as carbon emissions) that such transactions normally produce. And, generally, environmental taxes (and thus carbon taxes) fall into the category of indirect taxes (Snape and Souza, 2006).

Since the carbon tax was introduced as an indirect tax, offsetting the negative externalities of the market, its calculation was made to coincide with the value of the externality produced. Indeed, carbon tax is a form of explicit carbon pricing and refers to a tax directly linked to the level of carbon dioxide (CO2) emissions, often expressed as a value per tonne CO2 equivalent (per tCO2e) [32]. The very first decision to be taken is to determine the tax rate for carbon dioxide.

Setting the tax rate is among the most important decisions facing jurisdictions when they adopt a carbon tax. This involves two major elements. First, policy makers have to choose the basis for setting the original carbon tax rate, and then they have to decide whether to set a trajectory for future prices or adopt a specific mechanism for adjusting the rate over time (World Bank Group, 2017).

In any case, the definition of the exact value of the negative externalities and of tax rates has historically been the prerogative of political power and political choices linked to given historical and cultural contexts. Setting rates of the carbon tax are therefore, first of all, the result of precise political choices. According to the World Bank Group (2017:89), there are at least four major approaches that policymakers have adopted through the years in order to set the carbon tax rate:

The social cost of carbon (SCC) approach	The abatement target approach	The revenue target approach	The benchmarking approach
This approach matches the carbon tax rate to estimates of the social costs of greenhouse gas (GHG) emissions. It is one of the most economically efficient approaches. While the wide range of estimates of the SCC makes this approach challenging, there is a strong argument for not permitting the effective carbon tax rate to fall below the minimum estimates of the SCC, as lower rates would go against the polluter pays principle.	This approach involves choosing a carbon tax rate that is expected to result in abatement levels consistent with the jurisdiction's emission reduction objectives; it is thus a good choice for jurisdictions seeking to meet specific mitigation targets.	This approach is designed to generate a particular amount of revenue through the application of the carbon tax. It is particularly useful for jurisdictions motivated by the need for additional public funds.	This approach links the tax rate to carbon prices in other jurisdictions, particularly neighboring countries, trading partners, and competitors.

Table 2: Carbon Tax Rate Approaches. Source: World Bank Group, (2017). CARBON TAX GUIDE A Handbook for Policy Makers.

As mentioned, Finland was the first country ever to adopt a carbon tax and, initially, the tax calculation corresponded to the application of EUR 1. 12 (USD 1. 41) per tonne of CO2 (Wong et al., 2019) and it has since been gradually increased to reach the current EUR 76.00 (USD 85.10) per tonne of CO2. However, according to the World Bank (2017:34) there is no

[32] See: World Bank, Putting a Price on Carbon with a Tax, at https://www.worldbank.org/content/dam/Worldbank/document/Climate/background-note_carbon-tax.pdf

information available on the methodology used to estimate the tax rate in the country. In Europe, Sweden which followed Finland a year later in introducing its first carbon tax in an effort to reduce fossil fuel consumption, decrease CO2 emissions and encourage technological innovation (World Bank Group, 2017) is now levying the highest carbon tax rate at EUR 117.30 (USD 129.89) per ton of carbon emissions (Bray, 2022). In particular, Sweden appears to have adopted the benchmarking approach in establishing carbon tax rates as tax rates are expressed in commonly used trade units and were initially set up in reference to different fuel types, such as gasoline, diesel, coal, and natural gas (World Bank, 2017:87). To date, Uruguay, whose carbon tax was first instituted in January 2022 by Decree No. 441/021, has the highest carbon tax rate in the world at USD 137 per metric ton of CO2 equivalent (USD / tCO2e), while Poland has a tax rate of less than one USD / tCO2e [33]. However, both countries do not clearly disclose the approach followed in the adoption of the carbon tax rate.

However, in the attempt to reach a tax calculation, it is not strictly necessary to model ex ante the assumed impacts of a carbon tax. For instance, if modeling resources are not available, government agencies can choose to gradually introduce a carbon tax over time and monitor its impacts. The initial carbon tax rate can be based on that of other countries or on the social cost of carbon (SCC) (World Bank Group, 2017) [34]. In particular, the social cost of carbon (SCC), widely used as the basis of carbon tax rate, is an estimate, in dollars, of the economic damages that would result from emitting one additional ton of carbon dioxide into the atmosphere [35]. Obviously, the value of the social cost of carbon is very complex to calculate given the numerous internal and external factors to be taken into consideration. And, political maneuvers can more easily be hidden. Indeed, the SCC is calculated through a complex cost-benefit analysis (the most successful is the integrated assessment modeling, IAM) in which the main components are what happens to the climate and how these changes affect economic outcomes, including changes in agricultural productivity, damage caused by raising the level of sea and the decline in human health and labor productivity (Backman, 2021). To put it into context, in the United States during the Trump administration, the social cost of carbon was about USD1-USD7 per ton of carbon dioxide emitted (Krane and Finlay, 2022) while the current Biden administration, signing an executive order that mandated a working group to determine the social cost of carbon (SCC), it decided to adopt a provisional figure of USD51 per ton backing up the figure introduced by Obama.

One of the reasons why Trump has so underestimated the overall figure of the social cost of carbon seems to be found in the fact that his administration decided to factor the impacts of emissions only at domestic level, not globally (Samuel, 2022). And, this further confirms how political considerations play a leading role in defining the carbon tax rate and the social cost of carbon. Moreover, another layer of complexity is due to on whether calculating the carbon

[33] See: https://www.statista.com/statistics/483590/prices-of-implemented-carbon-pricing-instruments-worldwide-by-select-country/#:~:text=As%20of%20April%201%2C%202022,first%20established%20in%20January%202022.

[34] Generally speaking there could be four different approaches to setting a tax rate: the social cost of carbon (SCC), the abatement target, the revenue target and the benchmarking approach (World Bank, 2017).

[35] See: https://www.rff.org/publications/explainers/social-cost-carbon-101/#:~:text=The%20social%20cost%20of%20carbon%20(SCC)%20is%20an%20estimate%2C,carbon%20dioxide%20into%20the%20atmosphere.

iemissions on a global scale which was confirmed to be the best and most accurate calculation by the Interagency Working Group (IWG) on the Social Cost of Greenhouse Gasses which recommended to all national agencies use this global measure, rather than domestic measures (Rowell, 2015). One of the latest studies (Rennert et al., 2022), conducted by a team of researchers and academics, revealed that the carbon emissions estimate in the United States could have a much higher figure than the current U.S. federal estimate of USD 51 per metric ton. The study found that the most reliable carbon estimation would be around USD 185 per metric ton as to consider updated versions of the likelihood of socioeconomic and emission trajectories in the future, the incorporation of a modern representation of the climate system and state-of-the-art methodologies for assessing the effects of climate change on other fields such as the agriculture, temperature-related deaths and energy expenditure.

Finally, the researchers also presented a Greenhouse Gas Impact Value Estimator (GIVE) model, which provides a transparent and accessible way for interested parties to view and build upon the data, and the Social Cost of Carbon Explorer, which demonstrates the working mechanics of the GIVE model and allows users to develop their own social cost of carbon estimates.

At any rate, at global level, the OECD appears to be the leading international authority on carbon rates estimation with the Effective Carbon Rate (ECR) tool [36]. For the 2021, the OECD has established [37] three general carbon price benchmarks (also clarifying that progress varies significantly across different sectors):

- €30/ton of CO_2, historic low-end price benchmark in the early and mid-2010s that do not trigger meaningful abatement; however, this carbon rate estimation in 2025 would be consistent with a slow decarbonisation scenario by 2060 according to Kaufman et al (2020);
- €60/ton of CO_2, low-end 2030 and mid-range 2020 benchmark according to the High-Level Commission on Carbon Pricing. this carbon rate estimation in 2030 would be consistent with a slow decarbonisation scenario by 2060 according to Kaufman et al (2020);
- €120/ton of CO_2, a central estimate of the carbon price needed in 2030 to decarbonise by mid-century under the assumption that carbon pricing plays a major role in the overall decarbonisation effort. The OECD notes that €120 is more in line with recent estimates of overall social carbon costs.

Cap-and-trade approach

The cap-and-trade scheme is the best-known alternative to carbon taxation. The two are, indeed, opposite sides of the same coin. While the carbon tax sets the price of carbon

[36] The Effective Carbon Rate (ECR) is the effective price signal applicable to carbon emissions, resulting from carbon taxes, fuel excise taxes, and the prices of tradable emissions permits. See https://www.oecd.org/tax/tax-and-environment.htm
[37] See: https://www.oecd.org/tax/tax-policy/effective-carbon-rates-2021-brochure.pdf

dioxide emissions and allows the market to determine the amount of emissions reductions, the cap-and-trade approach sets the amount of emissions reductions and lets the market determine the price (Frank, 2014). However, in some cases (hybrid) carbon taxes and cap-and-trade schemes may coexist with each other, leading to the presence of a dominant regime over the other (Dias Soares et al., 2010:344). A cap-and-trade policy aims to limit the overall carbon emissions by fixing the number of allowances, equal to the desired cap on total emissions, allowances are then distributed or sold to participating firms and those firms that find abatement more difficult can purchase excess allowances from others that reduce emissions more cheaply (Cleveland and Morris, 2016:86). Those environmental policies, also called "emissions trading" or "allowance trading", have two key components: a limit (or cap) on pollution, and tradable allowances equal to the limit that authorize allowance holders to emit a specific quantity (e.g., one ton) of the pollutant [38]. The Kyoto Protocol and the Chicago Climate Exchange (CCX) are two examples of existing cap and trade systems [39].

As a key pillar of European climate policy, the European Union (EU) introduced in 2005 the EU Emissions Trading System (EU ETS), the first and largest international agreement based on the cap-and trade approach. The EU ETS system works by setting a limit (cap) on the maximum amount of greenhouse gas emissions that can be emitted by the plants that are included in the system. Within this cap, companies can buy or sell shares as for their needs and the allowances represent the central currency of the whole system. The EU Trading System currently covers several sectors, the electricity and heat generation, the energy-intensive industry sectors including oil refineries, steel works, and production of iron, aluminum, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals, commercial aviation within the European Economic Area, the nitrous oxide (N2O) from production of nitric, adipic and glyoxylic acids and glyoxal; perfluorocarbons (PFCs) from production of aluminum [40]. Since its inception, the EU ETS has contributed to cut emissions by 42.8% in the main sectors covered, according to data from the European Commission [41]. This means that the EU ETS scheme has proven to be quite successful in pushing for a reduction in carbon emissions. Other sectors, like the marine and shipping industries, the road transport and buildings industries will soon be included in the newly EU ETS reform package [42]. Nonetheless, the ICT industry, which is one of the fastest growing greenhouse gas-emitting and energy management sectors [43] with around 7%of global electricity consumption and forecasted to reach 13% by 2030 [44], is not under the radar of the EU ETS yet [45].

[38] See: https://www.epa.gov/emissions-trading-resources/what-emissions-trading
[39] See: https://www.un-redd.org/glossary/cap-and-trade
[40] See: https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets_en
[41] See: https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3542
[42] See: European Commission, Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directive 2003/87/EC establishing a system for greenhouse gas emission allowance trading within the Union, Decision (EU) 2015/1814 concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading scheme and Regulation (EU) 2015/757, Brussels, 14.7.2021 COM(2021) 551 final 2021/0211 (COD). Available at: https://ec.europa.eu/info/sites/default/files/revision-eu-ets_with-annex_en_0.pdf
[43] See: https://joinup.ec.europa.eu/collection/rolling-plan-ict-standardisation/ict-environmental-impact-0
[44] See: European Commission, COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Digitalising the energy system - EU action plan, Strasbourg, 18.10.2022 COM(2022) 552 final. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022DC0552&from=EN
[45] See: https://www.europarl.europa.eu/doceo/document/E-9-2022-002947-ASW_EN.html#ref1

Tax Incentives

Over the years, the European strategy of the EU member states has gradually shifted from an exclusive sanctioning approach of the early times, solely based on the polluter pays principle, to an incentive-based regulatory approach. Following the latter, companies and citizens are encouraged to reduce energy consumption and therefore to emit less polluting gasses into the atmosphere through the recognition of tax incentives.

In fact, the aforementioned study by the European Commission (EC, 2020: 179) confirms the preference to be given in some cases to tax incentives when it says that:

"While a general CO2 tax can be seen as the most important and efficient market based policy instrument when it comes to dealing with negative externalities and improving energy-efficiency, incentives are an alternative to a missing CO2 tax"

The last phase of European environmental policy is the proposal for the EU Green Deal [46], the EU strategy consists of a series of interconnected measures, which aims to achieve climate-neutrality (an economy with net-zero greenhouse gas emissions) by 2050. In particular, the EU Green Deal acknowledges the crucial role of taxation in the transition to a greener and more sustainable economy, and this may drive the implementation of environmental taxes in coming years (EEA, 2022). Importantly, some hints on the pursuing of an incentive-based regulatory approach are offered by the introduction of the Climate, Energy and Environmental Aid Guidelines (CEEAG) that replacing the guidelines in force since 2014 (EEAG) will integrate the new objectives of the EU Green Deal. The CEEAG will allow EU Member States, through different methods including tax incentives and aids, to incentivise economic operators to reduce the amount of waste they produce, to use fewer resources, to re-use and to better recycle materials, to increase the usage of recycled and bio-based materials and, generally, to switch to more resource-efficient and eco-friendly production processes [47]. Along the lines of the EU Green Deal model, also the United States unveiled their long-term strategy [48] in November 2001 with the ultimate goal of achieving net-zero emissions no later than 2050. The leitmotif of the whole package is the focus on incentives and standards rather than taxation. Federal leadership should accelerate investments and incentives supporting the deployment of clean technologies in all sectors. The United States will also support research, development, demonstration, commercialization, and deployment of zero-carbon industrial innovations. This includes incentives for carbon capture and new sources of clean hydrogen, produced from renewable energy, nuclear energy, or waste, to power industrial facilities. To drive the market for these solutions, the US government will also use its procurement power to support early markets for these low and zero carbon industrial goods (p.16). Investments and incentives will also involve technologies and processes that directly capture CO2 from the atmosphere and store it (such as direct air or ocean capture, bioenergy with CCS, or enhanced mineralization). However, ultimately it would appear that both the EU's Green Deal and US long-term strategy do not address clearly, explicitly and directly the issue of environmental data pollution which in this sense remains a new topic yet to be written.

[46] See: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en
[47] See: https://ec.europa.eu/commission/presscorner/deta
[48] See: https://www.whitehouse.gov/wp-content/uploads/2021/10/US-Long-Term-Strategy.pdf

Taxing data processes, tax or incentive?

If only email were taxed. Just a cent per message would surely kill all spam instantly.

In *How Bad Are Bananas?*, Mike Berners-Lee defiantly argued that:

"If only email were taxed. Just a cent per message would surely kill all spam instantly. The funds could go to tackling world poverty, say. The world's carbon footprint would go down by 20 million tons even if genuine users didn't change their habits at all. The average user would save a couple of minutes of their time every day, and there would be a $170 billion annual fund made available. If one cent turned out to be enough to push us into a more disciplined email culture—with perhaps half the emails sent— the anti-poverty fund would be cut in half, but a good few minutes per day would be liberated in many people's lives, and the carbon savings would be around 70 million tons CO2e—that's nearly 10 percent of all of Canada's emissions." (2010:29)

Email taxes are not entirely new (Thompson, 2009). In 1999, the United Nations Development Programme (UNDP), UNDP Human Development Report 1999, proposed a bit tax, a very small tax on the amount of data sent through the Internet. The report claimed that sending 100 emails a day, each containing a 10-kilobyte document, would drive up a tax of just 1 cent, and such a tax would net Belgium $10 billion in 1998 and $70 billion in 1996 globally [49]. The bit tax, however, has never been implemented to date.

[49] See: https://hdr.undp.org/system/files/documents//hdr1999ennostatspdf.pdf

In fact, taxing data and data processes is certainly a challenge that could prove decisive for the safeguarding of the ecosystem in the near future, but it implies many complexities both on a practical and theoretical level. Ideally, environmental data pollution can be curbed by taking two different paths: an indirect taxation regime modeled on the carbon taxation system or on the different approach that pushes for a series of tax incentives when certain meritorious assumptions are met. That is to say, tax or tax incentives.

On the one hand, if we see data as something that causes negative externalities such as CO2 emissions, then we might think about taxing it along the lines of the carbon tax. Results of quantitative research such as those proposed by the Carbon Trust, Carbolytics, McAfee & ICF International, Digiconomist and De Nederlandsche Bank, among others, indicate that data processes involve a certain number of daily, monthly and yearly carbon emissions. In this perspective, the companies holding those data could be taxed in relation to the corresponding damage caused to the environment following a strictly sanctioning approach of retributive justice (i.e., the polluter pays principle). However, some hanging issues still remain and among them:

- First, we should agree on a general methodology to be adopted to measure the environmental impact of data processes (which can be of the most varied forms) and, in particular, on the technical method that would translate data processes into a corresponding value of CO2 emissions [50].

- Second, and as already mentioned by Ben-Shahar (2019:138-143), the introduction of a data tax would seek to approximate the social cost of data, a value which is very hard to measure. For a moment, let's imagine we have found a measurement method (the one in the point above), that the social cost of data is overlapping with the social cost of carbon, but then there are still two related problems. One, unlike for carbon emissions, it might be nearly impossible to predict which piece of data would be later harmful. An additional tangle is based on the recognition that data has many positive social effects and that their overall external benefits can far outweigh the harms. It is a matter of choice, balance, and proportionality. But, if the harmful effects of the data can be measured in carbon emission values, how positive effects should be calculated?

- Third, it also remains to be seen at which stage (production, storage, transmission) data should be taxed. If we rely on predictive analysis of environmental data pollution, taxation should be applied in advance based on statistical methods. Otherwise, we would have to wait for the actual damage to the environment to materialize and apply a tax ex-post facto. But, here, another question arises. Let’s think about emails and the environmental cost of sending them. Two customers are using Gmail. Marco, a construction worker, sends only one email a week, Jhon, a digital entrepreneur, sends a hundred emails a day. Should Google predict the IT behavior of all of its customers? Or does Google have to be taxed for the habits (which generally cannot be predicted) of its customers?

[50] The complexity of matter is further exacerbated by the absence of a single method of measuring the energy consumed.

The other way to tackle EDP would be the proposal of a different plan like tax credit, incentive or financing scheme for all businesses that put in place mitigation measures to reduce environmental data pollution. As discussed earlier, there are a number of mitigation measures aimed at reducing the environmental impact of data processes. Among them, data minimization, as a general mitigation measure, could push businesses to look at data from another perspective. Data to be kept to a minimum by avoiding an overload of purposeless or duplicate items. Not only that, the less data is collected, the lower the risk of environmental data pollution. Data minimization can also improve the overall quality of the data processes outcome since Small Data beats Big Data when an inference of causation is desired. A starting point would be to raise awareness among companies but also the general public about the risk that data could be harmful to the environment. The risk of EDP is not yet fully understood and, regrettably, both the EU's Green Deal and the US long-term strategy do not offer much food for thought. Last but not least, if we glance at data as a double-sided coin, useful and harmful at the same time, even the data minimization principle could also experience a new momentum. Not just a privacy by design tool, but a strategic keystone of environmental policy aimed at a change that develops from the inside out. At the same time, the introduction of a tax incentive for environmental data pollution is subordinated to the introduction of a “real tax” given that most tax incentives operate as a reduction from a certain tax base. It follows that all the challenges we have seen exist for taxes are simply borrowed for tax incentives. Taxes and incentives, in the end, seem to have many points of contact and similar practical and theoretical issues to be addressed.

Conclusions

There are a number of challenges associated with taxing data processes based on their pollution levels. For one, there is the issue of how to accurately measure the pollution levels of different types of data due to the lack of coherent and uniform standards in the measurement of carbon emissions. There may also be challenges in implementing and enforcing the tax in a fair and consistent manner. Finally, there is a further and notable challenge to the idea of taxing data based on its environmental pollution. Even if a tax on the environmental impact of data were implemented, this would not necessarily lead to a reduction in the amount of data stored and processed by the ICT industries. This is mainly because these fledgling industries are generally financially well-off, and thus, they may be able to easily afford to pay the tax without necessarily reducing the amount of data they use. Environmental taxation is, thus, not an all-or-nothing answer to drive down big data for the data industries. It is also true that in the absence of environmental taxation, some large firms may choose to voluntarily adopt self-taxation policies as a way to improve their reputation and show their commitment to environmental sustainability, as shown by the case of BITMEX. In fact, the cryptocurrency trading platform has chosen to voluntarily adopt self-taxation in the form of purchasing carbon credits as a way to offset its carbon emissions and improve its reputation in November 2021 (BITMEX, 2021). Finally, it is also true that using renewable energy to power data processes does not necessarily mean that environmental data pollution will disappear. This is because renewable energy is only a part of the whole data life cycle, and there are many other stages in the life cycle of data where environmental pollution can occur. For example, even if renewable energy is used to power data processes, the production and disposal of electronic devices used for data processing can still result in environmental pollution.

On another note, taxing customers or users for the environmental harm caused by data, as earlier suggested by Ben-Shahar (2019:141) is not feasible as also demonstrated by the failure of the bit tax proposal at international level. Despite the challenges, environmental taxation can still play a role. In the short term, a good advocacy strategy on taxation, at least, in the EU would be to push for the inclusion of the information and communication technology (ICT) industry within the EU Emissions Trading System (EU ETS). Currently, the ICT industry is completely left out from the EU ETS, even though the EU has warned that the industry is one of the fastest growing for electricity consumption. Including the ICT industry in the EU ETS would allow for the creation of a market-based mechanism to incentivize the reduction of greenhouse gas emissions from this sector. It is possible that, hypothetically, the inclusion of the ICT industry in the EU ETS could create a spillover effect outside the EU, affecting other jurisdictions. This is because the EU ETS is a large and influential system, and any changes to it could have broader implications. For example, if the inclusion of the ICT industry in the EU ETS leads to significant reductions in greenhouse gas emissions in the near future, it could encourage other jurisdictions to adopt similar approaches. In the long run, it is worth considering alternative solutions to the use of environmental taxation as a means of reducing data volumes as tax breaks for those companies that reduce their data volumes.

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About the author

Eticas is a non-profit organization with a mission to protect people and the environment in technology processes, while also ensuring that all people have the right to benefit from technological advances without fear of discrimination or unfair treatment. We work to translate the principles that guide our societies (fairness, transparency, or non-discrimination) into technical specifications, and to strike a balance between evolving social values, technical possibilities and legal frameworks.

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