The environmental costs of being *selfie*sh

coreecon

Economics for a changing world

1. Introduction

Climate change is one of the most important challenges in our century, and its correlation with CO_2 (Carbon Dioxide) is extensively demonstrated in scientific research. Despite the rising attention on this issue, many human-related activities have a hidden negative impact in terms of CO_2 emissions, and their social costs might not be internalized by a selfish or an unaware consumer.
In this report we focus on Internet-related activities, such as posting a selfie from a smartphone, estimating their CO_2 emission. For this reason, we introduce a converter, called Selfie Index, which measures the pollution costs of online activities, and we suggest several examples to show the alarming hidden contribution in terms of CO_2 emissions for different social networks, services and apps. We then describe some proposals to raise consumers' awareness on the contributions they make with their daily actions, as well as increasing communication reports and data transparency of ICT (Information and Communication Technologies) businesses.

2. Smartphones and Climate Change

The rapid increase of temperature on our planet and its relationship with anthropogenic CO_2 is one of the most discussed subjects in our century. It has been proven that the rise of temperature is highly dependable on the CO_2 released in the atmosphere, most of which is made by humans. In Fig. 1, the increase in annual temperature anomalies is shown along with the increase of CO_2 emissions in the last 50 years.
In the last decades, many discussions and initiatives have been proposed to reduce our emissions for the most polluting sectors. The most recent and ambitious example is the Paris Agreement (United Nations, 2015), whose goal is to hold "the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C". The countries that signed the agreement will make an effort to reduce their GHG (Greenhouse Gases) emissions, most notably CO_2, and develop a production system that is sustainable for the environment.

Annual temperature anomalies and CO2 emissions

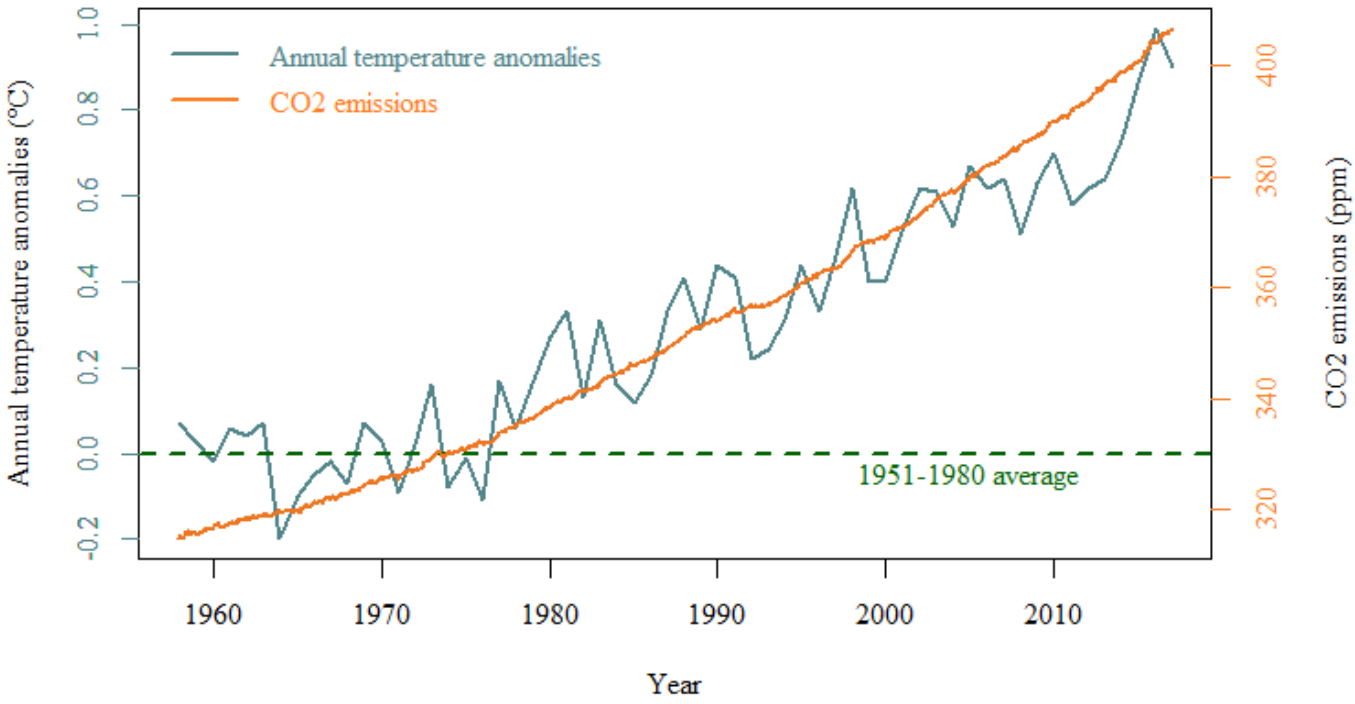


Fig. 1: *Relationship between CO_2 and increasing average annual temperature between 1960-2020, using the 1951-1980 temperature average for comparison. Sources: Goddard Institute for Space Studies (2019), US National Oceanic and Atmospheric Administration (2019)*

Although many sectors are involved in CO_2 emissions, we take particular interest in two elements: smartphones and data centers. Smartphones are now everywhere, and their diffusion and penetration are growing in every corner of the world, even considering different socio-economic factors (Kakihara, 2014). It might be that you are reading this report on a smartphone.
In the life cycle of a smartphone, the production chain is the most relevant part on CO_2 emissions. However, most studies do not consider a "hidden" component: smartphones are basically useless if they cannot connect to the Internet. Suckling & Lee (2015), for example, have shown how GHG emissions, across the life cycle of a smartphone, heavily increase if servers are taken into account. These emissions could increase exponentially along with the growth of people connected to the Internet around the world. In Fig. 2, we can see how Internet users have grown in the last decade, thanks also to the global diffusion of smartphones.

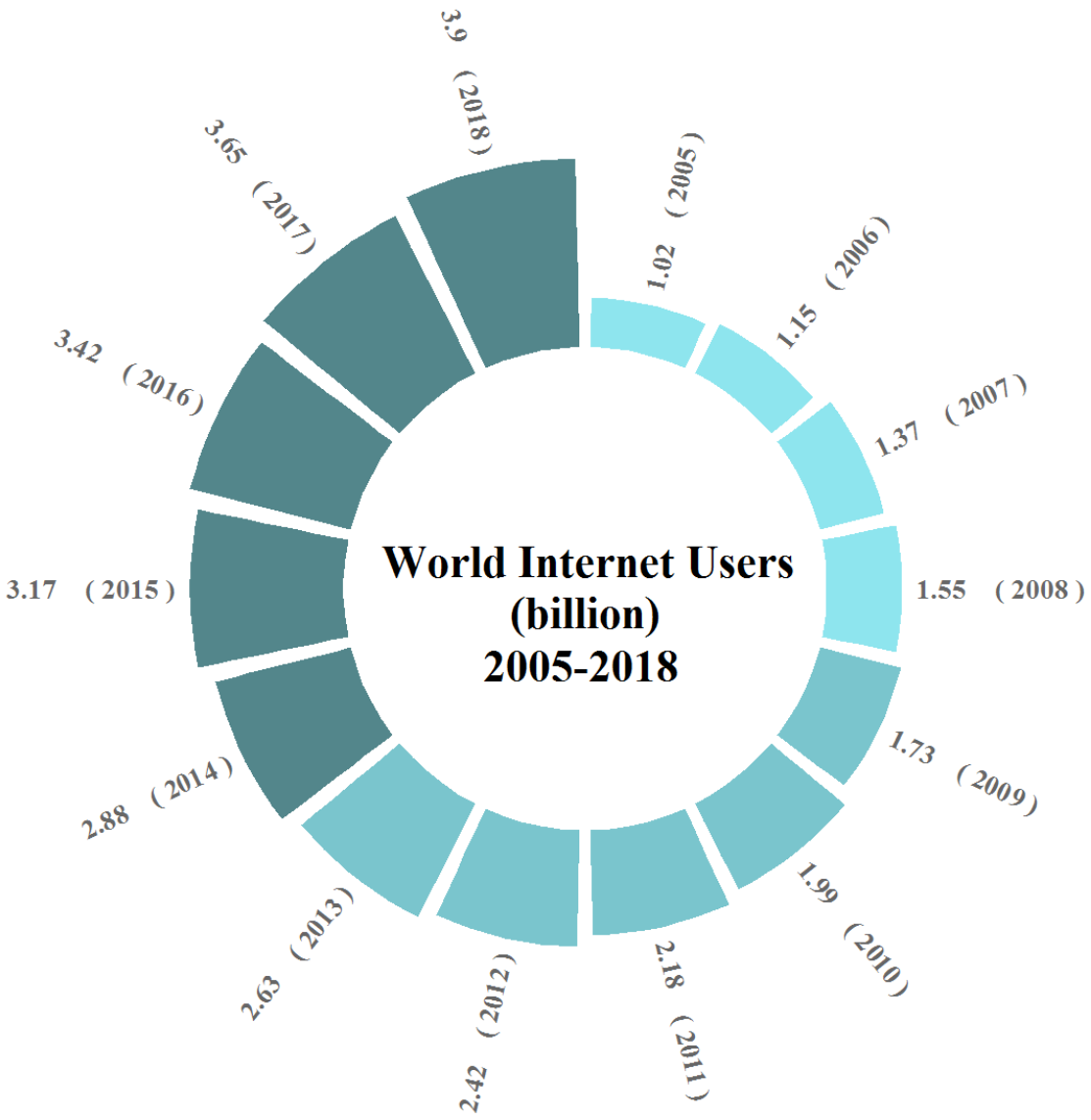


Fig. 2: *Number of Internet users in 2005-2018. Source: International Telecommunication Union (2018).*

3. The Selfie Index

To express the impact of online smartphone usage in terms of CO_2, we identified a unit of measurement highly connected with it: a selfie.
A picture might not seem that much, but if we put it online, it goes through several networks and data centers that require plenty of electricity to function; this process releases a lot of CO_2 in the atmosphere. However, a picture uploaded in Brazil does not have the same impact as one uploaded in India, because they have different levels of electricity efficiency in terms of CO_2 emissions, as shown in Fig 3.

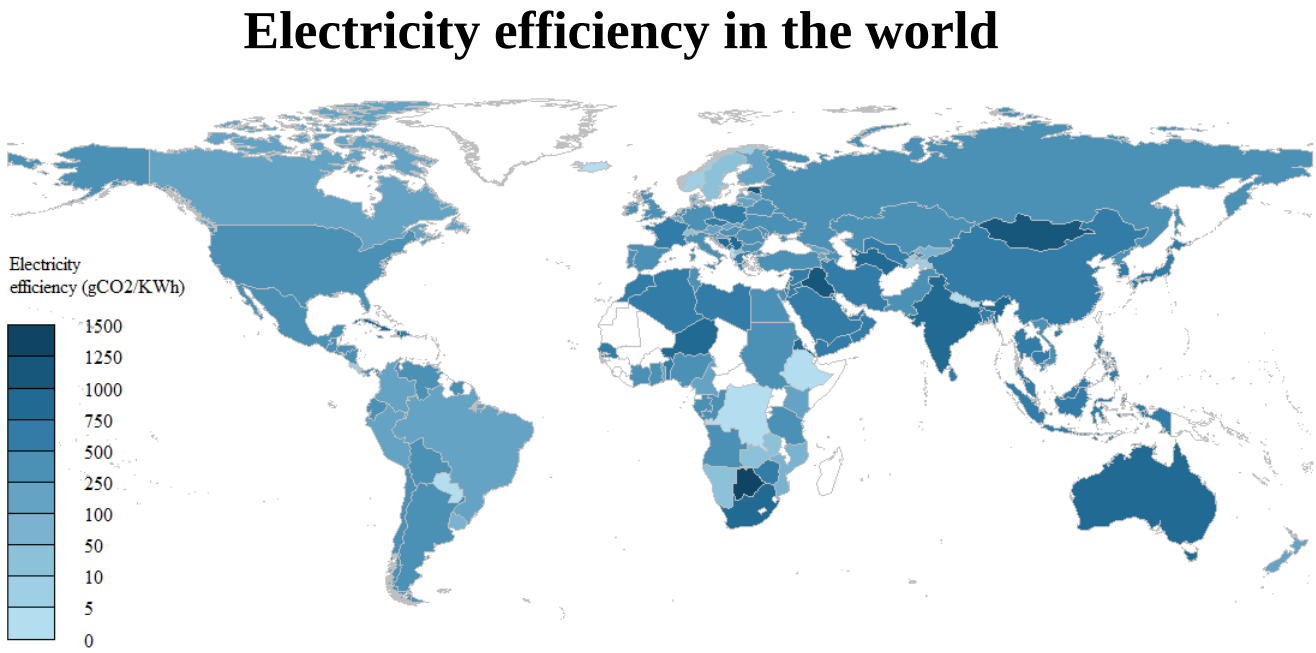
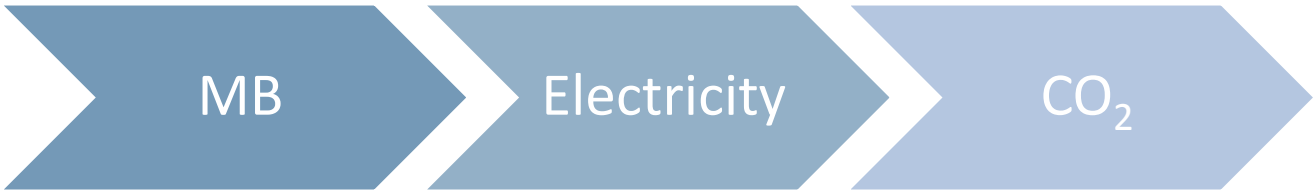


Fig. 3: *Amount of CO_2 released for every kWh produced, for every country. Source: International Energy Agency (2019).*

We produce a converter to express any number of MB (Megabytes) into CO_2 emissions, and use it to calculate a single selfie in terms of CO_2 emissions: this is our **Selfie Index**.[1] For MB, we use as benchmark the estimated weight of a selfie uploaded on Instagram, which is 2 MB.[2] Then, we express this value in terms of kWh required to process the picture through networks and data centers. The value we choose to convert a selfie into kWh is the one proposed by Costenaro and Duer (2012), which is 5.12 kWh/GB. We then convert a single selfie into CO_2 emissions, using an average global value for $kgCO_2/kWh$.[3]



With the Selfie Index, the CO_2 emissions of 10 selfies can be compared with 1 km travelled by an average EU car (European Environment Agency, 2017). To show how high is the impact on the environment of selfies, we consider the daily CO_2 absorption of an average tree: even though it cannot absorb all the emissions of a car, it can barely sustain 10 selfies a day.[4]

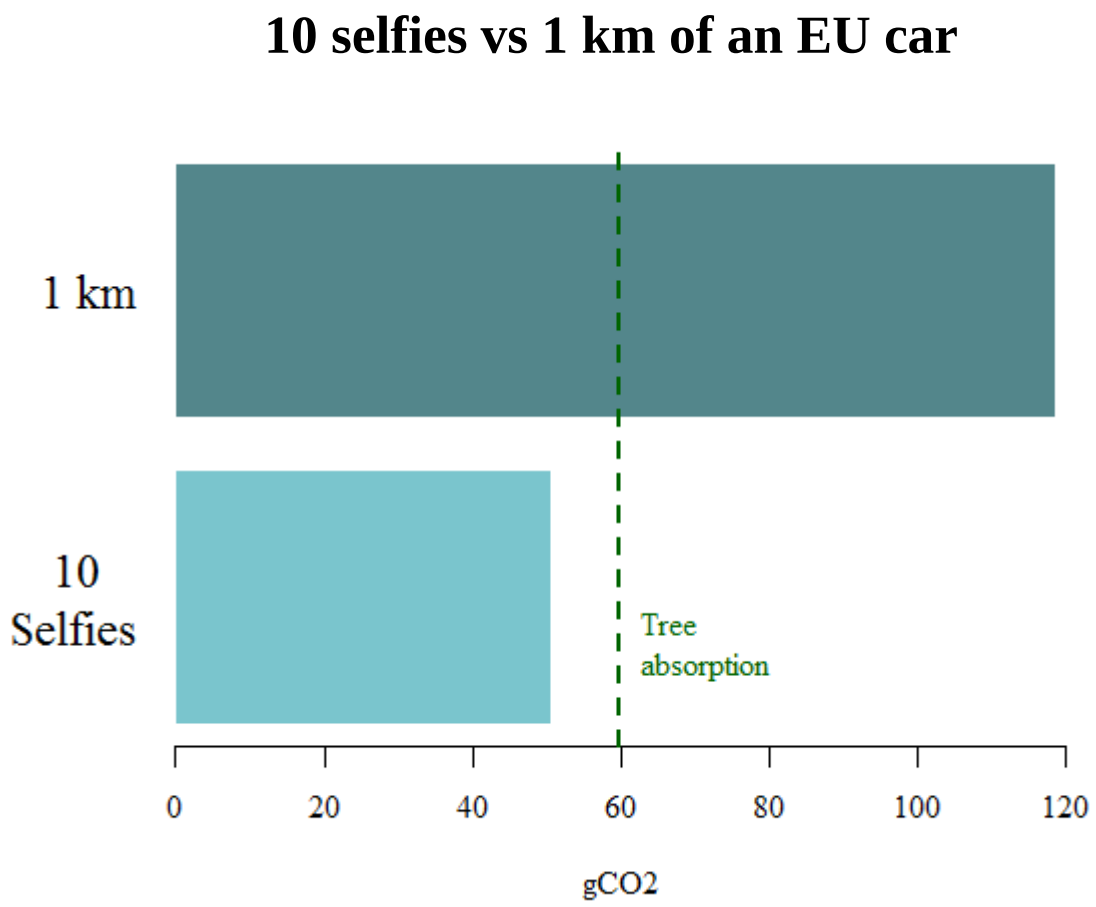


Fig. 4: *The amount of CO_2 emitted by 10 selfies and by 1 km travelled by an average EU car. For further perspective, we also considered the daily CO_2 absorption of an average tree. Sources: European Environment Agency (2017), McAliney (1993)*

The Selfie Index can also be used to measure the huge environmental impact of the most common social networks and apps. We consider Facebook, Instagram and WhatsApp, three popular social networks and chat apps, all possessed by Facebook Inc.
Fig. 5 shows the total CO_2 emissions of all pictures, uploaded or sent, in one year.[5] Facebook, Instagram and WhatsApp host 80 million, 350 million and 4.5 billion of pictures a day respectively, an impressive amount of data with a significant impact in terms of CO_2 emissions, growing year by year.

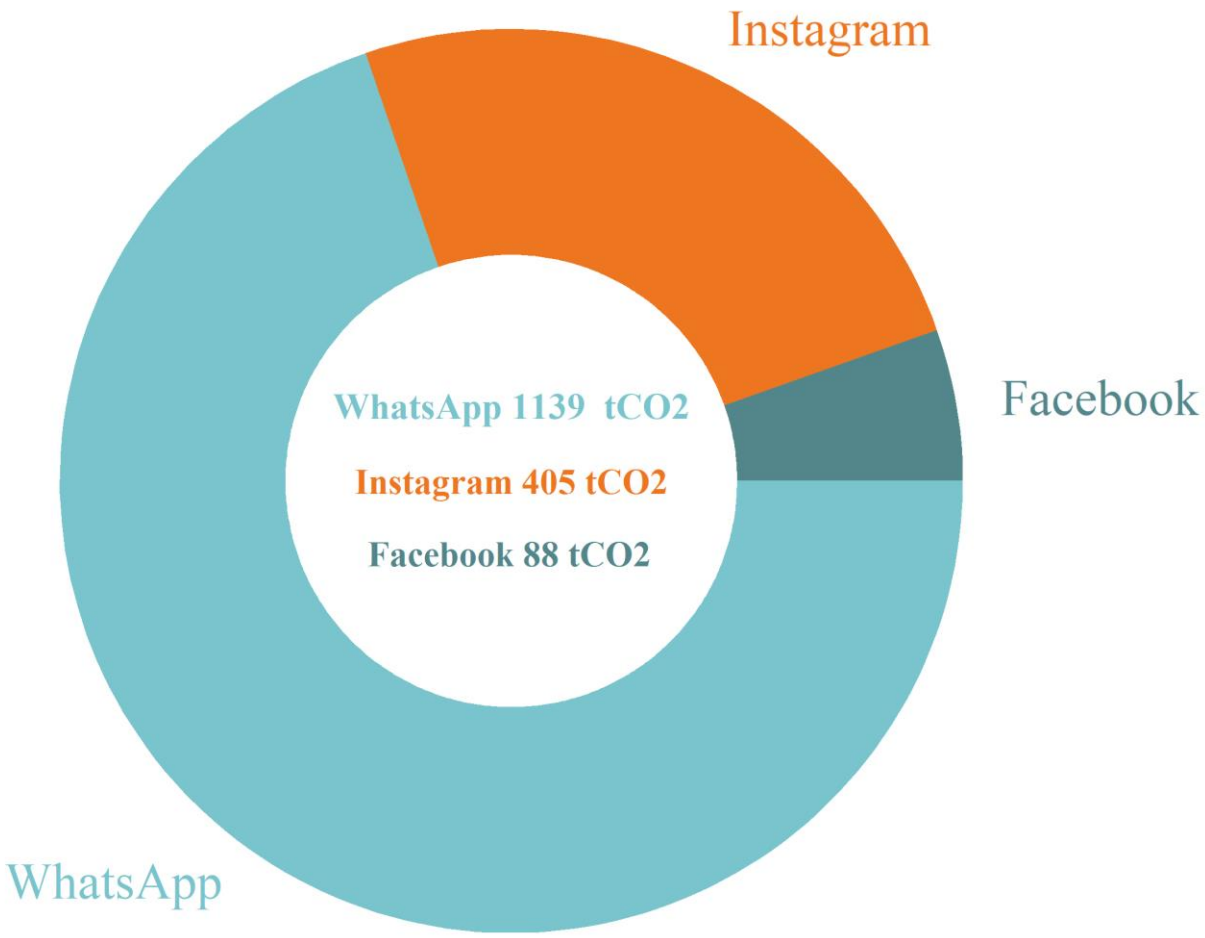


Fig. 5: *Average CO_2 emissions in one year from Facebook, Instagram and WhatsApp. Note that a single picture uploaded on Facebook and WhatsApp weights much less than one on Instagram. Sources: Facebook (n.d.), WhatsApp (n.d.) and Instagram Press (2015).*

The Selfie Index can be used for things other than selfies: since we are converting Megabytes into CO_2, we can use many other Internet-related things. In Fig. 6, over a year period, we choose to compare the CO_2 emissions of all hours watched on Netflix in the world with all cars in EU and all flights departing from EU. Even though car emissions are by far the highest, the CO_2 emissions of Netflix and EU flights are remarkably close to each other.

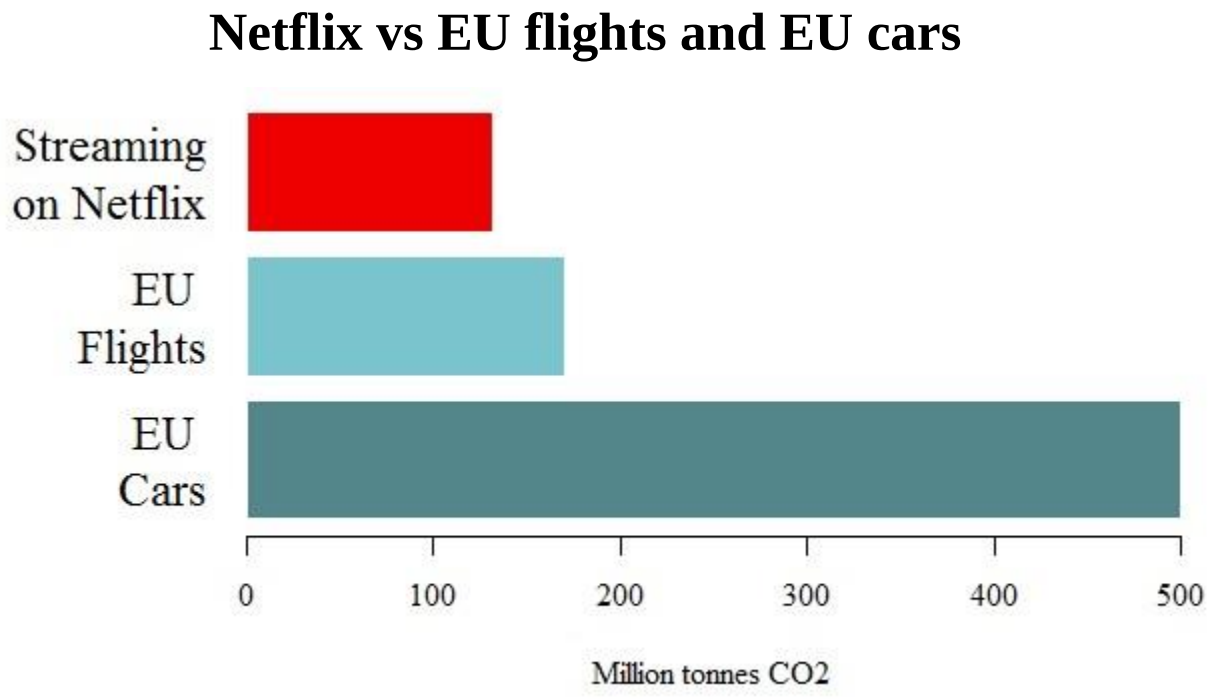


Fig. 6: *The amount of CO_2 emitted by Netflix, all EU cars and all EU flights, in one year. Sources: Netflix Media Center, European Environment Agency (2019), European Aviation Safety Agency (2016).*

4. Policy proposals

The Selfie Index is a simple, powerful instrument to measure CO_2 emissions of Megabytes that go through networks and data centers, and it shows how ordinary, harmless actions have a huge impact on climate change. However, the issues we highlighted are currently underestimated, and it should be evident that they cannot be addressed without some regulations and transparency:

- More information should be disclosed by ICT industries that operate with data centers. Facebook, Google, Amazon, Netflix and other businesses already publish data, charts and press releases to inform both investors and the general public of their activities. However, we believe it is not enough to monitor their environmental impacts. Specifically, we propose the introduction of an annual report in which businesses have to specify the electric consumption of their data centers, the amount of renewable energy used to power them and a global estimate of their CO_2 emissions.

- On the consumer side, we believe that everyone should be more aware of the impact of their Internet activity on climate change. This could be achieved through the introduction of user-friendly notifications, like pop-ups, captions or periodical e-mails from social networks, where CO_2 emissions of selfies posted, videos watched and data downloaded could be more easily visualized.

5. Conclusions

In this report we mainly consider Internet-related activities of smartphones, social networks and media services. However, these are just a small percentage of all Internet traffic: websites, forums, bank transactions, e-mails, video and gaming platforms, clouds and many other online services also need plenty of energy to function, which increases the environmental impact in terms of CO_2 emissions exponentially. At the same time, Internet of Things (IoT) has been changing our relationship with objects in ways never imagined before, connecting previously offline devices and generating an enormous flow of data, which silently contributes to climate change.
If our demand for online services keeps growing at this pace, it is likely that sustainability of electric consumption will become a massive problem in the short future. Renewable energy is essential to tackle this issue, although it could not be enough if all energy required to power the Internet were not efficient, because the total demand for energy could exceed supply. For this reason, further research is needed to estimate more precisely future trends in energy request, production, renewability and efficiency.

Appendix

1: We assume that uploading and downloading a same sized file require the same amount of energy, although uploading and downloading speed are usually different. Furthermore, we are assuming that the re-scaling process, applied by many websites and apps to upload a file, is mostly made by devices (smartphones, tablets etc.), and does not have an impact on the overall energy used by data centers.

2: We considered Instagram because it is a social network strongly image-based and in constant growth. We estimated the average weight of a picture uploaded on Instagram by the resolution (1080x1080) above which Instagram downscales every picture.
To convert that resolution in MB, we considered the picture in JPEG and used this website: https://toolstud.io/photo/megapixel.php?width=1920&height=1080&compare=video&calculate=compressed. This resulted in approximately 1.75 MB, that we rounded to 2MB.

3: The amount of energy estimated to upload 1 GB of data is influenced by many factors and has several methodological problems. We considered the estimate 5.12 KWh/GB by Costenaro and Duer (2012), despite being a study of 7 years ago, because it includes all the subsystems required for uploading and processing Megabytes. Aslan et al. (2018) show that several studies produced different numbers, with different infrastructure and networks considered. We suppose that this value is valid for different data centers, regardless of their electric efficiency and their location.
The conversion is as follows: 2 MB ≈ 0.002 GB. 0.002*5.12 ≈ 0.01 kWh. From this value, we calculated the CO_2 emissions for all our graphs by considering the global value, found in the International Energy Agency (2019) dataset, which is 506.312 gCO_2/kWh. For a single selfie, the CO_2 emission calculated is 0.01*506.312 ≈ 5.06 gCO_2.
For a further discussion on methodological issues, see Coroama and Hilty (2014).

4: From this quote by McAliney (1993), we know that "A single mature tree can absorb carbon dioxide at a rate of 48 lbs./year and release enough oxygen back into the atmosphere to support 2 human beings." Converting 48 lbs/year into g/day, we obtain 59.65 gCO2/day. (48 lbs/year = 21,7724kg/y = 0.05965 kg/day = 59.65 g/day).

5: As mentioned in Appendix 1, we considered 2 MB to be the average weight of a picture posted on Instagram. For Facebook and WhatsApp, we considered 100 KB to be the average weight, since Facebook downscales every picture above 100 KB, and we assume the same limit is embedded on WhatsApp. Moreover, regarding the number of photos uploaded every year, we found data for different periods: 2013 for Facebook, 2015 for Instagram and 2017 for WhatsApp. Given that all three apps are in constant growth, that they are all possessed by Facebook Inc., and that they do not update these numbers very often, we considered these data to be comparable.

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