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Carbon Footprinting the Internet

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Abstract

Recent analysis suggests that global IT, a rapidly expanding sector, is responsible for two to four percent of global greenhouse gas (GHG) emissions. How is the use of computers and networks affecting our planet's atmosphere? Through the example of Google, the world's most visited website, this article explores the ways in which the Internet generates GHGs, the difficulties in quantifying these emissions, and the possible mitigation of negative planetary impacts.

Author's Note

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1. Sizing up the problem of the Internet's carbon footprint

1.1 The magnitude of the Internet's GHG emissions

According to Saul Griffith, a leading innovator in green technology, "the Internet's energy and carbon footprints now probably exceed those of air travel... perhaps by as much as a factor of two" (Owen). This statement is surprising in at least two ways: firstly, that the Internet's carbon footprint has exceeded that of such a notorious greenhouse gas emitter like air travel and, secondly, that the estimated magnitude of the Internet's carbon footprint is so uncertain. Though online activities may seem benign, they are, in fact, a major contributor to global warming. So what is the extent of the problem, and what can we do to fix it?

1.2 What is a carbon footprint?

Before exploring the energy use and carbon footprint of the Internet, it is important to understand what is meant by the term 'carbon footprint' and why it is so hard to calculate it accurately. The word is somewhat of a misnomer, since a carbon footprint refers to "total greenhouse gas emissions caused directly and indirectly by a person, organization, event or product," gases that include non-carbon compounds. The greenhouse gases (GHGs) are carbon dioxide (CO₂), methane (CH₄), Nitrous Oxide (N₂O), Sulfur Hexafluoride (SF₆) and a class of compounds known as fluorocarbons.¹ To calculate a carbon footprint, the amount of

¹ Water is also an important GHG, but its residence time in the atmosphere is too short to be included in this list.

GHG emissions that a certain process causes is converted to a carbon dioxide equivalent. In other words, the carbon footprint is the amount of carbon dioxide that would cause the same amount of warming as all of the greenhouse gases actually emitted.

There are a number of different databases used to calculate carbon footprints, and they often spit out drastically different values for the same process or product. These differences occur for two main reasons. One is that each database includes a unique set of greenhouse gases. The class of greenhouse gases known as fluorocarbons contains over a hundred compounds, some of which are included in certain carbon foot-printing databases and not in others. In this way, there is actually some disagreement about what is and what is not a greenhouse gas.

The other difference between databases relates to how far upstream or downstream a calculation extends. For example, if you are carbon footprinting a bottle of soda, do you include the GHG emissions of the fertilizer used in the making of the corn syrup? Do you include the GHG emissions of the construction of the factory, which produced the bulldozer, which transported the fertilizer? Do you include the impact of the employees at that factory driving to work? (Do you include the carbon footprint of the bottle of soda those workers drank at lunch?) The complexity of these decisions explains why carbon footprinting is such a difficult process and why achieving consistent results across databases is nearly impossible. Many companies exploit this inter-database variation by simply choosing the database that calculates the lowest carbon footprint.

2. Global networks: the Internet and the atmosphere

2.1 How the Internet is responsible for GHG emissions

With these inherent complications in mind, let's try to understand how the use of the Internet is impacting the world's atmosphere. The Internet consumes a huge amount of GHG-emitting energy, which can be divided into two pieces. Technology companies must manufacture (by extracting raw materials and assembling in factories) and ship (using airplanes, trucks, etc...) the Internet's hardware: servers, personal computers, iPhones, et cetera. Then, those devices must be powered and cooled, drawing electricity from their local grids, energy that is generated in different ways with varying GHG emissions. For example, in China, where Google maintains vast arrays of servers, coal power plants produce most electricity. Coal is plentiful and cheap, but the least efficient of the fossil fuels. In comparison with fossil fuels like natural gas and petroleum, coal emits the greatest amount of GHGs per calorie of energy produced.

Gartner Inc., an international consulting firm, recently tried to quantify all of the components of global information technology, calculating that the Information and Communications Technology (ICT) industry is responsible for two percent of global CO₂ emissions, the same as aviation (Remember that Griffith thinks it may be twice that of the aviation industry). Gartner's definition of ICT includes "in-use phase of PCs, servers, cooling, fixed and mobile telephony, local area network (LAN), office telecommunications and printers, all commercial and governmental IT and telecommunications infrastructure worldwide, and the embodied (that used in

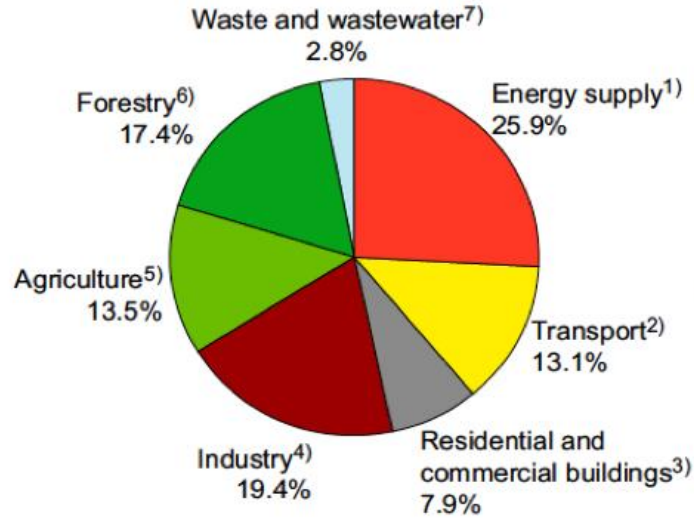


Figure 1: The IPCC's 2007 sector-by-sector breakdown of GHG emissions does not include global ICT.

design, manufacture and distribution) energy in large-volume devices.” Calculating the global GHG emissions of the Internet is unprecedented, and it is interesting to observe that the International Panel on Climate Change's (IPCC's) 2007 fourth assessment does not include the IT industry in its sector-by-sector breakdown of GHG emissions (Fig. 1). Given that global IT makes up a substantial percentage of global GHG emissions (two percent according to Gartner, maybe more according to Griffith), perhaps it is worth including in future IPCC reports.

2.2 A closer look at Google and YouTube

A good model for understanding the energy usage and carbon footprint of the Internet is Google, the world's largest search engine. This multi-national corporation operates over one million servers around the world and processes one billion search requests each day (Pandia). At its current rate of expansion, Google is installing 100,000 servers per quarter (Kuhn). The production and distribution of these servers requires a huge output of GHG-producing energy.

In addition to server production, there is also an output of GHG gases each time one searches Google. Every unique search requires multiple servers. Google works by indexing the Internet, creating a virtual copy of the web. To maximize the speed of each search, Google combs through multiple servers, on which these copies of the Internet are stored. By querying multiple servers there is a greater chance that one of those servers will respond quickly. This approach gives fast results, but is also power-hungry, using more energy than is truly necessary (Leake). Google could reduce energy usage (but compromise the speed of its searches) by querying one server instead of many.

How much GHGs does an individual Google search generate? This question, one that has only been addressed in the last few years, recently generated buzz among prominent scientists and Google's public relations branch. The debate was

sparked by a statistic from Harvard physicist Alex Wissner-Gross, who claimed that a Google search accounts for seven grams of carbon dioxide emissions. Seven grams of CO₂ emissions is equivalent to boiling a pot of tea or driving a car 52 feet. The figure prompted Google to respond by publishing a counter-statistic of .2 grams of carbon dioxide per search (Hölzle). The wide-ranging disparity (over an order of magnitude difference) can be partially accounted for by the differing way each study interpreted a 'search.' Google's statistic refers to one individual search, while Wissner-Gross's figure includes the multiple attempts it may take to find a desired result. However, for this explanation to make the two results compatible would require an average of 35 tries to complete a search, a number which is clearly too high. Therefore, these two statistics indicate an underlying uncertainty about how much CO₂ a Google search truly emits into the atmosphere.

If we adopt the middle ground between Wissner-Gross and Google and assume a Google search creates one gram of CO₂ emissions, it is possible to calculate the total impact of Google searching on the Earth's atmosphere. With one billion Google searches occurring every day, there are one billion grams of CO₂ being emitted into the atmosphere due to Google searches alone. This is the same as driving a car 2,375,000 miles (or 80,000 people commuting to work 15 miles each way).

Of course, Google searches are only a single component of Internet activity. Wissner-Gross estimates that looking at a webpage with pictures or video emits .2 grams of CO₂ per second. YouTube users watch two billion videos every day and upload hundreds of thousands more (YouTube factsheet). If the average time a user watches a video is ten seconds (a random guess), then watching of videos on YouTube accounts for another four billion grams of CO₂ emissions, or an additional 320,000 car commuters.

Given that the two examples of YouTube and Google only represent a portion of online content, it is easy to see how the Internet as a whole is a major contributor to global CO₂ emissions. However, it may be some time before we can precisely quantify the impact of the Internet and global IT on our planet's atmosphere.

3. Powering the Internet with clean energy?

The issue of energy consumption and carbon output is one that Google appears to be taking seriously. Its philanthropic subsidiary, Google.org, recently invested 15 million dollars in Makani, a wind-energy corporation. (Makani has a somewhat unconventional plan for creating renewable energy. They take advantage of the powerful and consistent winds at high altitudes by flying airplane-mounted turbines around in circles, thousands of feet above the Earth's surface (Owen)). While fifteen million dollars is an impressive investment, Griffith points out that for any alternative energy company to actually join the grid requires about 100 million dollars and five to ten years of time (Owen). That sobering reality makes Google's 15 million look a lot smaller.

As the internet continues to expand its high-bandwidth content, there will be further demand for production of new servers, servers that require GHG-emitting energy to produce, distribute, power and cool. Google may be interested in lassoing

the high winds, but like most other websites, the majority of its servers currently derive their energy from coal, the cheapest and most abundant fossil fuel. A transition to an Internet powered by renewable energy is remote and may be a cool and breezy dream.

Bibliography

- Gartner, Inc (April 26, 2007). *Gartner Estimates ICT Industry Accounts for 2 Percent of Global CO2 Emissions*. <http://www.gartner.com/it/page.jsp?id=503867>
- Hölzle, Urs (January 11, 2009). “Powering a Google search.” *The Official Google Blog*.
- IPCC (2007). *Climate Change 2007: Synthesis Report*.
http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf
- Kuhn, Eric (December 18, 2009) “CNN Politics — Political Ticker...Google unveils top political searches of 2009.” *CNN*.
- Leake, Jonathan and Richard Woods (January 11, 2009). “Revealed: The Environmental impact of Google searches.” *The Sunday Times*.
- Owen, David (May 17, 2010). “The Inventor's Dilemma: A eco-minded engineer discusses the limits of innovation.” p. 42-50. *The New Yorker*.
- Pandia Search Engine News (July 2, 2007). “Pandia Search Engine News — Google: one million servers and counting.”
- Youtube Factsheet. http://www.youtube.com/t/fact_sheet.