WHICH ENVIRONMENTAL IMPACTS FOR ICT? – LCA CASE STUDY ON ELECTRONIC MAIL

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Abstract

Purpose. ICT is widely used in everyday life and environmental benefits are generally assumed. However no comprehensive and in depth impact assessment has been carried out. The French Environment and Energy Management Agency (ADEME) has thus initiated a study to improve its knowledge regarding the environmental impacts of electronic mail.

Methods. A Life Cycle Assessment (LCA) study is conducted covering all the equipment required for the ICT service under study, the quantity of data transmitted being used as functional unit. Both professional and domestic users are studied. Data were collected in available literature and ICT experts have also been involved. The same equipment being shared between different services, allocation rules based for example on active use time for computers and data traffic for transmission equipment have been defined. The study has been peer reviewed.

Results. The manufacturing of computers and the use phase are the major contributors. The impacts of the manufacturing phase come mainly from the production of printed wiring board. For the use phase, most environmental potential impacts arise from electricity consumption of datacenters. The relative contribution of each phase varies between professional and domestic users because of a more intensive use of equipment in a working environment.

Conclusion. From the user's perspective it is advisable to use electronic devices as long as possible and to optimize the amount of data stored. For datacenters attention should be given to the power usage effectiveness (PUE) and to energy-efficient equipment.

Keywords

Life cycle assessment, email, electronic devices, allocation, datacenters.

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1. INTRODUCTION

The present study initiated by French Environment and Energy Management Agency (ADEME) focuses on the application of the Life Cycle Assessment methodology (LCA) as a tool to evaluate in an objective and comprehensive manner the environmental impacts of electronic mail. So far, the LCA methodology has mainly been used to evaluate the environmental impacts of consumer products and the application of LCA to ICT services is a complex task. It requires addressing the specificities of the ICT sector which is characterised by a large number of equipment and components, variability and uncertainty related to the use phase, and multiple services.

2. METHODS

The study has been conducted by BIO Intelligence Service on behalf of the ADEME and following the ISO 14 040 and 14 044 standards relative to LCA. It has been peer reviewed by a panel of independent experts.

2.1 Goal & scope

The goal of this study was to quantify the potential environmental impacts of electronic mail. The system studied is representative of the exchange by electronic mail of a pdf document with text and images that could take the form of a newsletter. The functional unit was defined as the transmission of a 1 Mo document to one person.

The system boundaries comprise the following steps:

- Manufacturing of IT equipment (computers, servers…) and of paper and printers if the email is printed;
- Sending and storage of sent items;
- Transmission, from the sender to the receiver;
- Data treatment in datacenters;
- Receipt and use of received items (read on screen or print);
- End-of-life of equipment and of paper if the email is printed.

It has been necessary to identify all the equipment that is required for these different steps and different subsystems have been considered based on main life cycle steps: sender, transmission, datacenter (sender and receiver), receiver.

2.2 Scenario setting & data collection

The analysis was conducted on the basis of a reference scenario whose main assumptions are presented in Table 1. The time required to elaborate the document being transmitted was not considered since the document may not have been written by the sender. A French geographical scope has been considered for end-users equipment (computers, set-top boxes and printers). For datacenters equipment, a world context has been considered since an email can be transferred via datacenters that can be located in any country.

2.3 Data collection

Regarding the modelling of IT equipment, direct data collection with IT companies has not been possible mainly due to confidentiality issues. Primary data regarding equipment and related electronic components (e.g. type, quantity, energy consumption) were therefore collected via extensive literature research including product data sheets. The model built based on this research has then be submitted and reviewed by experts from the ICT sector. A main concern was that there is not one single path followed by an email since the equipment used can vary depending on the service operator and user. It is therefore not possible to determine an “average” model as such. The model has been established to be as realistic as possible from a functional point of view while being compatible with the requirements of the LCA methodology. The data that have been collected to evaluate the impacts related to the production of IT equipment are representative of technologies used between 2000 to 2007 in Europe, China and in the world.

Table 1: Selected parameters for the reference scenario

Summary of main parameters for the reference scenario	
Email size	1 Mo
Storage duration in inbox/sent items folders	1 year
On-screen reading time	5 minutes
Type of computer	Average home computers in France (mix of desktop computers with CRT or LCD screens and laptops)
Daily use time for computers	≈ 4 hours/day (domestic use)
Computers lifetime	4 years (6 years for screens)
Printing	No
Electrical mix for end-user equipment	France
Electrical mix for datacenter equipment	World

2.4 Allocation procedure

A key issue for LCA of ICT services is that the same equipment is often shared between different services. As a result, only a fraction of the equipment should be allocated to the service under study. Allocation rules have been defined based on the service provided by each equipment, such as active use time for computers and data traffic for transmission equipment (routers and servers).

2.5 Impact categories

The environmental impact assessment methods ReCiPe and CML were used. 18 environmental impact indicators were included as shown in Table 2.

3. RESULTS

The environmental life cycle impacts for the functional unit – transmitting a 1 Mo document to 1 person – for the reference scenario are shown in Table 2. The receiver sub-system is the largest contributor for most indicators. The cumulated contribution of both datacenter sub-systems and of the transmission sub-system represents more than 50% of the potential impacts for the climate change potential and the abiotic depletion potential.

The detailed analysis of the potential impacts arising from the receiver highlights that the manufacturing of the receiver's computer holds more than 80% of the potential impacts for most indicators. However, it should be underlined that these results are strongly linked to the chosen assumptions for the daily use time over the computer's lifetime. The impacts of the manufacturing phase mainly come from the production of printed wiring boards

Almost all potential impacts related to datacenters come from the storage of the electronic message. The electricity consumption of storage units is the main contributor for all indicators except metal depletion potential. The consumption of metal resources for the manufacturing of the storage units explains this result.

Table 2: LCA results for the reference scenario – Functional unit: transmission of a 1 Mo document to 1 person

	Indicator	Unit	Total	Sender	Receiver	Datacenter sender	Datacenter receiver	Transmission
ReCiPe	Climate change potential	g CO_2 eq	22	18%	29%	26%	26%	0,78%
	Ozone depletion potential	g CFC-11 eq	3,3E-06	27%	45%	14%	14%	0,45%
	Photochemical oxidation potential	g NMVOC eq	0,064	21%	34%	22%	22%	1,23%
	Particulate matter formation potential	g PM10 eq	0,034	21%	36%	20%	21%	1,72%
	Ionising radiation potential	g U235 eq	19	31%	51%	9%	9%	0,28%
	Terrestrial acidification potential	g SO_2 eq	0,10	20%	33%	22%	23%	1,66%
	Freshwater acidification potential	g P eq	1,7E-03	34%	57%	3,7%	3,7%	0,98%
	Marine eutrophication potential	g N eq	0,030	33%	55%	5,5%	5,6%	0,31%
	Metal depletion potential	g Fe eq	7,5	35%	59%	2,2%	2,2%	1,94%
	Fossil depletion potential	g oil eq	6,1	15%	26%	29%	29%	0,93%
CML	Abiotic depletion potential	g Sb eq	0,16	15%	25%	29%	29%	0,86%
	- Rare metals	g Sb eq	6,2E-04	36%	59%	2,4%	2,4%	0,19%
	- Energetic resources	g Sb eq	0,15	15%	24%	30%	30%	0,87%
	Non-renewable primary energy consumption	MJ primary	0,45	22%	36%	21%	21%	0,68%
	Renewable primary energy consumption	MJ primary	0,027	20%	33%	23%	24%	0,95%
	Human toxicity potential	g 1,4-DB eq	16	31%	52%	6,4%	6,5%	4,6%
	Freshwater aquatic ecotoxicity	g 1,4-DB eq	9,9	28%	47%	1,8%	1,8%	22%
	Marine aquatic ecotoxicity	g 1,4-DB eq	35427	28%	47%	11%	12%	1,6%
	Terrestial ecotoxicity potential	g 1,4-DB eq	0,12	28%	47%	10%	10%	5,0%
	Freshwater sedimental ecotoxicity potential	g 1,4-DB eq	25	28%	47%	1,7%	1,7%	22%

4. DISCUSSION

Alternative scenarios were studied. The scenario analysis reveals that the relative contribution of each phase varies significantly between professional and domestic users because of a more intensive use of equipment in a working environment. Results also show that the potential impacts are clearly reduced when a laptop is used instead of a desktop computer. A comparison between on-screen reading and printing was also conducted. Considering that the document accounts for 4 pages when printed, the analysis shows that on-screen reading is better than printing from an environmental point of view if the reading time remains below 3 to 4 minutes per page.

5. CONCLUSION

The LCA shows that the sender and receiver of the electronic mail hold a large part of the potential environmental impacts. Beyond the energy consumed for the use of the computers, the manufacturing of the electronic components is an important contributor to the environmental burden of electronic mail. Main issues related to equipment manufacturing are metal depletion arising from the use of rare metals and water pollution resulting from manufacturing processes. It is therefore advisable to use electronic devices as long as possible from a user's perspective. Datacenters are the other main contributor to the environmental impacts of electronic mail due to the electricity consumed by data storage units. Related impacts are mainly fossil depletion and climate change. The electricity mix and the energy efficiency measured through the PUE are therefore key issues. In addition, to reduce storage requirements, best practices should be promoted among email users, e.g. inbox sorting, sending links rather than enclosed documents, selecting carefully the receivers.