Environmental Assessment of E-media Solutions

Challenges Experienced in Case Studies of Alma Media Newspapers

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Abstract—**The rapid and continuous development of information and communication technology (ICT) in society today is providing new means for various societal activities. To facilitate that new ICT solutions reduce environmental impacts and bring social improvements the potential impacts of those new solutions should be assessed. One way of making environmental assessments is Life Cycle Assessment (LCA).**

This paper presents and discusses challenges in assessing, comparing, communicating and acting on the results of an LCA of traditional media products and of new ICT solutions for media products, based on case studies of three newspapers in their printed and online versions.

The case studies revealed the complexity in assessment and comparison of online and printed newspapers due to differences in functions and characteristics, choice and availability of data (specific and generic data, data gaps and quality), methodological choices (functional unit, allocation, scope) and assumptions on reader profile.

Often no single answer can be given regarding the best option from an environmental perspective, leading to challenges in communicating the results to different stakeholders. A particular challenge is how to combine easily communicated messages with robust, transparent background information.

Index Terms— **Life cycle assessment (LCA); electronic media; new media solutions; data; methodological choices; user behaviour; communication.**

I. Introduction

In the information and communication technology (ICT) sector, continuous and rapid development is constantly putting novel end-consumer products on the market and providing new means for a number of societal activities through ICT solutions [1]. With the aim of achieving sustainable development, these ICT solutions should preferably lead to lower environmental impacts and to social improvements. Therefore assessments of ICT solutions need to be made to determine their potential impacts in order to avoid negative and facilitate positive impacts. These assessments may be even more difficult to perform than comprehensive assessments of current solutions, as less information is available. When new ICT solutions need to be compared with traditional ones the challenges are even greater, as the basis for assessment (e.g. data availability, knowledge about the systems, practices involved) is most probably weaker for the new ICT solutions. It is also common for ICT solutions to provide slightly different or additional functions.

One area where this is all relevant is the media sector. In modern, technology-driven society, new means of producing and distributing media and novel devices for accessing the content are constantly being introduced [2]. LCAs and carbon footprint analyses have been used to assess the environmental impacts related to different media solutions [3, 4, 5, 6, 7]. In many cases the assumptions made in such analyses on user behaviour and decisions regarding which environmental impacts to assess are decisive for the results. The results are often not clear-cut and may be difficult to communicate to stakeholders and decision-makers. Still, there is a need for more knowledge and information regarding the environmental performance of media products and the consequences of the rapid development in the sector.

The aim of this paper is to present and discuss potential challenges in assessing, comparing, communicating and acting on the results of LCA studies of traditional media products and of new ICT solutions for these (further – e-media solutions). This is mainly done based on experiences from performing LCAs on three newspapers in their online and printed versions (for full studies, with data and references see [8, 9]) and communicating the results of the study to the stakeholders and public.

II. Case Studies

A. Method

LCA is a method for analysing the environmental impacts of a product or service along its life cycle from cradle to grave, from raw material extraction through production and use to end-of-life treatment [10]. LCA consists of four stages: goal and scope definition (setting the goal of a study, defining system boundaries, functional unit, allocation procedures, data requirements and necessary assumptions), inventory analysis (data collection), impact assessment (potential environmental impacts are evaluated using inventory results) and interpretation of the results [10].

In the case studies presented in this paper the full life cycles (from cradle to grave) of the printed and online newspapers were assessed. System boundaries were set to include all the

processes related to the life cycles. System expansion was used to account for the benefits of recycling or energy recovery due to waste treatment.

Both printed and online newspapers were assessed in terms of several different functional units. When assessed separately, the functional unit "per year of newspaper production" was used for online newspapers and "per newspaper copy" for printed newspapers. For comparison of the results of the printed and online versions of each newspaper three functional units were chosen: "per year of newspaper production", "per reader and week" and "per reading hour".

Data concerning the foreground system (system of primary concern) was collected mainly from the publishing company and its supply chain. Some national average data were also used. For the background system (processes feeding into the foreground system, e.g. energy and materials) two types of data were used - generic (Ecoinvent [11]) and specific (EcoData [5]). The LCA was carried out using the ReCiPe Midpoint life cycle impact assessment method [12]. The ReCiPe method includes 18 impact categories, however 13 impact categories[1] were selected for the assessment of online and printed newspapers due to lack of data in some of the datasets used. Comparison of printed and online newspapers was made in 7 out of the 13 impact categories[2], where the data were considered to be more comprehensive than for the other 6 categories.

During the process of performing the LCA a number of challenges were experienced. In this paper, these challenges were grouped into two categories: assessment and comparison; and communicating and acting on the results.

B. System description

1) General information about the newspapers

Three newspapers, in their print and online versions, were studied: the morning newspaper Aamulehti, the evening newspaper Iltalehti and the financial newspaper Kauppalehti.

The newspapers differed significantly in their characteristics, such as number of readers/copy of printed newspapers, number of copies/edition, reading time (6-11 min/reader and week for online newspapers and 115-245 min/reader and week for printed newspapers), and size of uploaded (14-745 MB/day) and downloaded (2–100 MB/week and reader) content for online newspapers.

The systems studied are described briefly below.

2) Content production

In contrast to most previous LCA studies on media products the content production for each of the three newspapers was inventoried in detail. The resulting overall potential environmental impact was split between printed and online versions based on the number of full-time equivalent (FTE) employees working with the respective version. The relative proportions (printed:online, %) were: Aamulehti 85:15, Iltalehti 59:41, Kauppalehti 71:29. The difference in proportions may illustrate the importance of the online version for the different newspapers.

Content production covered the offices used by journalists, marketing and administration personnel, manufacturing and associated use of equipment and materials, business travel and mailing (via post) (Fig. 1). The foreground data were obtained from Alma Media specifically for each newspaper. For background data, average Finnish data were used for heating, electricity, transportation of materials and travel; company-specific data were used for mailing; and generic Ecoinvent 2.0 data were used for manufacturing and end-of-life disposal of paper, toner and electronic equipment.

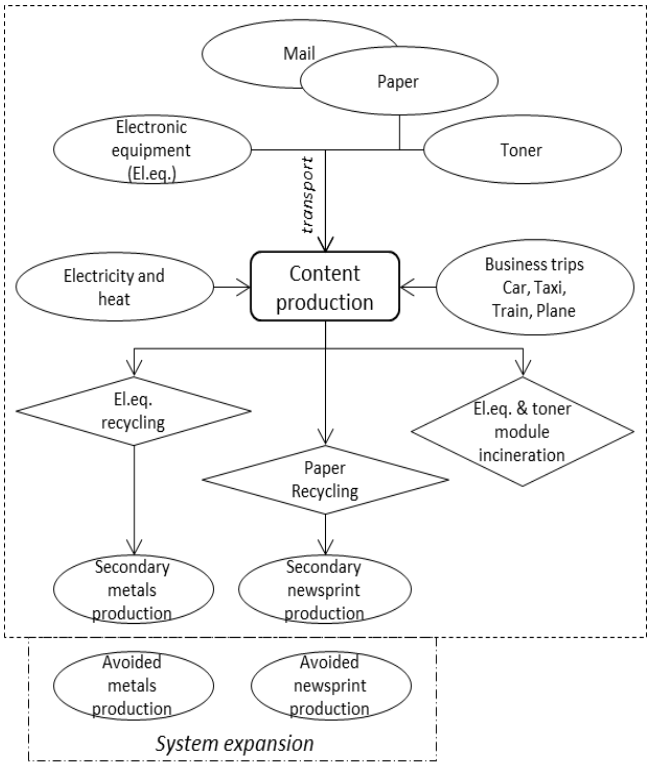

Figure 1. Content production flowchart [9].

3) Printed newspapers

The life cycle of printed newspapers includes pulp and paper manufacturing (including harvesting and raw material manufacturing), transport of raw materials, content production, print manufacturing, distribution of final products from the printing house to the consumer (home delivery) or to retailer, transport related to paper and waste collection, paper recycling, incineration and disposal to landfill (Fig. 2).

Specific data related to printed newspaper were obtained directly from the actors of the Alma Media value chain (e.g. data on distance for transportation of raw materials, paper manufacturing, printing methods and processes, newspaper delivery, etc.). Some national average data were used, e.g. for

[1] climate change, ozone depletion, human toxicity, photochemical oxidant formation, particulate matter formation, terrestrial acidification, freshwater eutrophication, marine eutrophication, terrestrial ecotoxicity, freshwater ecotoxicity, marine ecotoxicity, mineral resource depletion, fossil depletion

[2] climate change, acidification, freshwater eutrophication, marine eutrophication, particulate matter formation, metal depletion and fossil depletion

wood harvesting operations and newspaper's end-of-life treatment. An extensive databank of EcoData covering process-specific LCI (Life Cycle Inventory) data was also used for e.g. raw materials for pulp and paper production, heat and electricity, and end-of-life treatment for newspapers [8, 5].

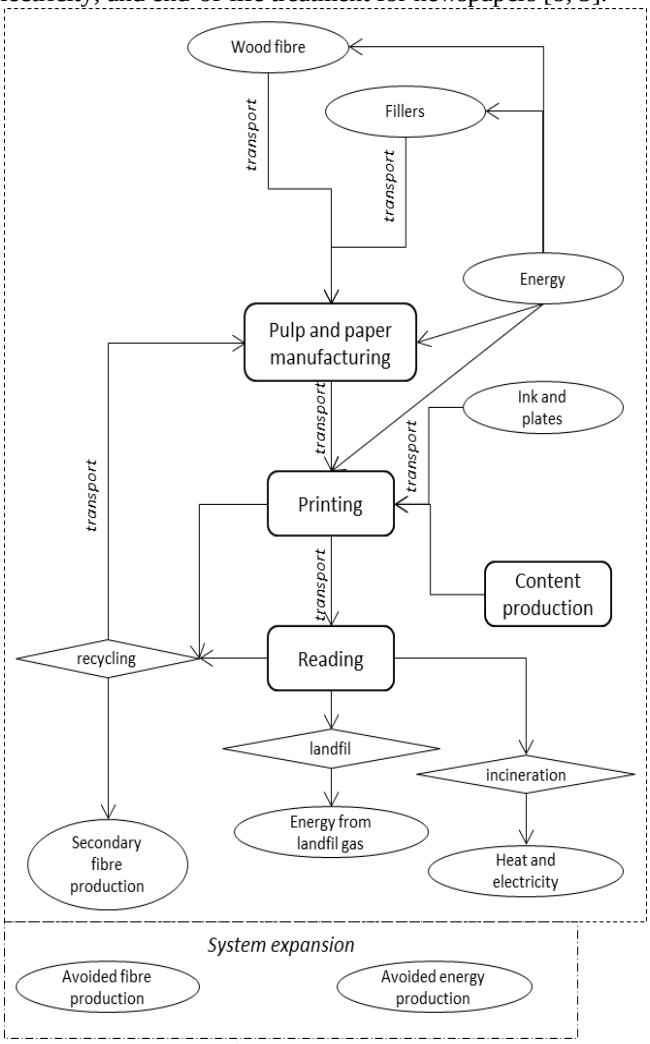

Figure 2. Printed newspaper flowchart [9].

4) Online newspapers

The life cycle system of online newspapers covered content production, electronic distribution (uploading content to the server and reader's access to it via the website) and reading (on desktops/laptops), including the manufacturing, transportation, electricity consumption and end-of-life disposal of the electronic devices used (Fig. 3).

An average reader profile was created for each newspaper, taking into account frequency of visits, time spent per visit and user location (home or office) (based on each newspaper's own statistics); type of electronic device used (desktop/laptop) (each newspaper's user survey); total computer use at home (Finnish average); total computer use at office (own assumption); and device service life (European average).

Specific data on number of readers, size of daily upload/newspaper (GB), size of download/reader (GB), and number of servers were obtained from Alma Media. Electricity consumption by the servers was calculated based on assumption of server's power consumption and the fact that they are always on, also a factor of 1.3 was applied to account for the energy use of supporting network and cooling. Electricity consumption by the user devices was based on European average of electricity consumption by computers (laptops and desktops respectively), including relevant share of non-active modes. Manufacturing of the devices (servers, network access devices, desktops and laptops) was assessed using generic Ecoinvent data. Internet infrastructure data, covering manufacturing materials for cables and network electricity consumption, were based on Swedish figures [13, 14].

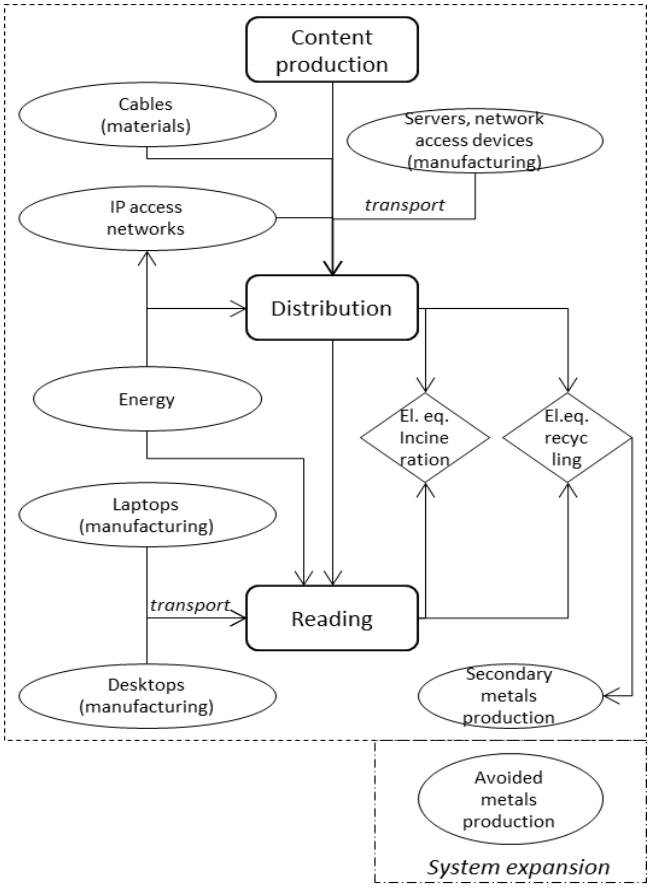

Figure 3. Online newspaper flowchart [9].

III. Results and Discussion

A. Assessing and comparing printed and online newspapers

The challenges in assessing and comparing traditional media products to e-media solutions originate primarily from differences between the products themselves, the functions provided and their characteristics, i.e. in a sense they are not directly comparable. Other challenges arise from differences in choice and availability of data, methodological choices, assumptions, etc., which are partly related to the differences just mentioned.

Below challenges are identified and possible ways of handling them are suggested, followed by descriptions on how this was handled in the case studies and the effect on the results.

1) Data used

Data availability and quality, as well as choice of data type, are crucial when trying to get the most relevant and comprehensive data. Data availability problems concerning ICT products have been widely discussed [15, 16, 17, 18, 19]. Also a general lack of data [20], lack of data due to the complexity of some ICT products [18] and uncertainty in secondary data [21] is a problem. This is quite different from the case for paper-based products, like printed newspapers, where studies are plenty (e.g. [4, 5]) and products are more mature.

When there is data available, the choice of specific or generic data can be challenging. Generic data in commercial databases are often easily available and at the same time often more comprehensive, covering a wider range of resources and emissions, and a larger part of the upstream processes. However, generic data do not describe the actual company and processes in question. Specific data are specific for a company or process in question, but can often be less detailed due to the limited possibility of gathering all data. Furthermore, the system boundaries can often differ for specific and generic datasets (e.g. inclusion or exclusion of infrastructure).

The rapid technological development of the ICT sector makes it difficult to have up-to-date, high-quality data for the assessment [15, 21]. This is certainly the case in the e-media sector, where new consumer devices are constantly put on the market, which makes the results often short-lived. Furthermore, the use of high purity materials in the manufacturing processes makes generic materials data less relevant [16, 17]. The availability of data may also depend on who performs the data collection.

Data sources such as publicly available environmental product declarations (EPD) are increasing the availability of specific data, allowing more and smaller actors to assess and present their environmental performance. However, public EPDs are not as useful as input to more comprehensive assessments, as these are often limited to few emissions and some resources used and might lead to a risk of important environmental impacts being omitted.

Although both specific and generic data can be the best choice, depending on the process and context, use of both types of data in the same study is rather common, which was also the case in this study, and this can lead to additional challenges in interpretation. Possible differences in data coverage, system boundaries and methodological choices need to be kept in mind when interpreting results.

A separate discussion can be held on data availability and quality regarding end-of-life treatment of electronic devices. According to Umair et al. [22] around 80% of electronic waste is transported to developing countries for informal recycling, causing severe environmental and health problems. The availability of inventory data for informal recycling is limited owing to the informal nature of the process. It constitutes a large share of the end-of-life treatment of electronic devices, but is usually not accounted for due to lack of data. Again, the case is quite different for paper-based products, like printed newspapers, where waste handling is often more local/regional and assessing it is not as complex as the flows are easier to follow and the recycling system is well developed.

In the Alma Media case studies, different types of data were used depending on applicability and availability: generic data from commercial databases, specific data from Alma Media and their suppliers and from the EcoData database and national average data.

For the printed newspaper supply chain, specific data were available for most of the processes, which made it possible to model the conditions for a specific paper mill, paper grades, printing house activities, etc., and also to present the results with good certainty. This supply chain is closely related to the media company itself. With a long tradition of doing business together, printed media companies have considerable experience in managing sustainability in the value chain.

Finnish national average data were used for the environmental impacts related to electricity and transport for both printed and online newspapers and heat for pulp and paper production and the printing house. This choice of national average data was considered suitable, as national averages are believed to provide good estimates for Finnish conditions.

The specific and average data used were often covering a limited number of emissions (e.g. from transportation) or not considering the infrastructure.

In contrast to the printed newspaper product system, where newsprint manufacturing and production of ink and printing plates are the main contributors to the environmental impact, for new e-media solutions the most of the environmental impact is related to electronic devices used by end-consumers (device manufacturing and energy consumption). There are no traditional connections between media companies and the actors in the value chain for these electronic devices. Furthermore, the specific brands and types of devices used by the readers are not easily identified. Thus, in this case average or generic data were chosen. Also, due to the lack of easily available data, it was not possible to include new media devices such as tablets or smart phones, which are expected to give a lower environmental impact from reading online newspaper [23]. The generic data used in the present case studies also had some flaws, e.g. they were rather old. When assessing content production, more specific data for electronic devices could have been used, since data on the exact types and models of computers, etc. were available. These data on the manufacturing of electronic devices can possibly be gathered from EPDs (e.g. [24, 25, 26, 27, 28]), but as mentioned earlier the datasets are not sufficiently comprehensive. Regarding electronic storage, distribution and waste management of electronic devices, more specific data, i.e. data on a national level (company-specific for storage), would have been valuable. The data used here for distribution were specific for Swedish conditions, which are slightly different than Finnish but the best available for the study. The waste management data used were Swiss datasets in the commercial database

Ecoinvent, since no other detailed data were easily available. Finnish data would have been preferable.

In the case studies, some data were not available at all or were not of the desired quality, so assumptions had to be made or data gaps introduced, e.g. in the case of server electricity use, which was calculated based on assumptions. In contrast, the data on e.g. printing house operations are in many cases well documented. This indicates the differences in assessment of old and new media products and the differences in company awareness and experiences from previous requests and assessments.

In the case studies performed here the use of specific and national data for the printed newspaper system meant that it was not possible to cover as many impact categories for the printed media solutions as for the electronic. The comparison was made in only seven impact categories, considered to be relatively well covered for both versions. Even though this is broader than the carbon footprint assessments commonly presented, it clearly illustrates that there are data gaps that still need to be filled.

It is difficult to say whether the drawbacks on comprehensiveness regarding scope, upstream processes, emissions and resources outweigh the benefits of company-specific or country-specific data. It is important to bear in mind any limitations when interpreting the results. However, for a company to improve and develop its own products, specific information covering the specific value network is crucial. The main issue is to draw conclusions supported by the material available, and even with limitations in the data LCAs provide possibilities for increased learning.

2) Methodological choices

In LCA there are several methodological choices to be made when defining a study, e.g. geographical and time boundaries, choices on allocation, etc. The boundaries in time are crucial as e.g. emissions from landfills may occur over a very long period. Different datasets consider different periods for emissions, which might yield different results (e.g. [29]). For some products and some impact categories, inclusion of these long-term emissions will not make a significant difference, but for online newspapers the long-term emissions are an important issue due to the environmental impacts related to mining residues from metal extraction for the manufacturing of electronic devices. On the other hand, adding long-term emissions may also add uncertainty. Moberg et al. [30] showed that use of different models accounting for different time frames can result in different magnitudes of toxicity and eutrophication potentials arising from e.g. gold extraction when assessing ICT products.

In order to determine the importance of inclusion or exclusion of long-term emissions in the case studies, a sensitivity analysis was made. The difference in the results with and without long-term emissions was rather significant for impact categories such as human, freshwater and marine toxicity and freshwater and marine eutrophication (Figure 4).

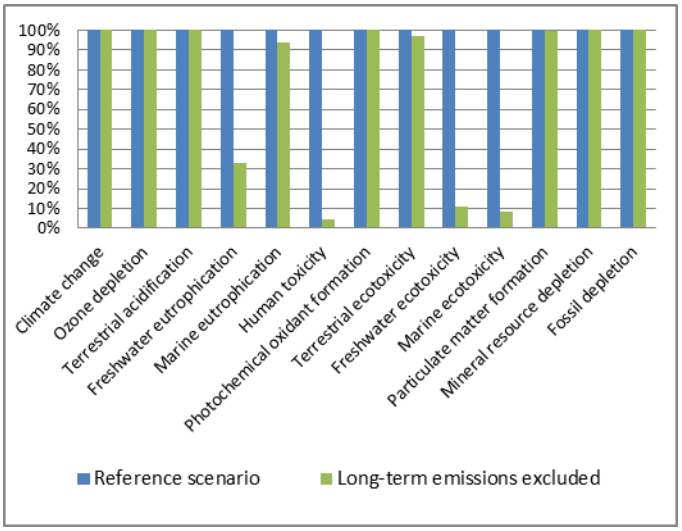

Figure 4. Sensitivity analysis including and excluding long-term emissions. Reference scenario (including long-term emissions) is set to 100%.

For media using electronic devices, the allocation of manufacturing and disposal of the devices becomes crucial, as does the energy use of 'always on' devices such as home modems and routers. The allocation is often based on use time. In the case studies an average user was assessed and the overall computer use time was based on Finnish statistics for home computer use and calculated based on the average working hours for office computer use. However, it could be argued that all types of use time should not be valued similarly. This is an issue which will be relevant for all services provided using electronic devices. Regarding electronic distribution and the infrastructure for this, the allocation is usually based on the amount of data transmitted (MB) as was done in the case studies too.

3) Choice of functional unit

Comparison of online and printed versions is not straight-forward, as different benefits are provided and reader practices differ. Although emerging e-media products may be considered substitutes for their printed counterparts, this is not necessarily the case.

The importance of choice of functional unit for the comparison of different types of media is discussed by Reichart and Hischier [3], who obtained different results using different functional units, making a strict functionality comparison (per news item) in one and trying to reflect the reality (per daily news) in the other. The problems of choosing functional unit are further discussed by Cooper [12] and Reap et al. [32]. They identify multi-functionality, difficult-to-quantify functions and strict functionality comparisons as sources of probable errors arising from defining the functional unit.

Since the online and printed newspapers differ somewhat in the functions and benefits they provide, the functional units chosen were not all the same for the two versions. The different functional units provided good reference for the assessments of each respective newspaper, but using different functional units for printed and online made it impossible to compare them. Consequently, both versions were also analysed in terms of the

same three functional units "per year", "per reader and week" and "per reading hour".

Application of different functional units (as suggested by Reichart and Hischier [3]) yielded a variety of results, indicating the complexity of the issue. Comparing printed and online versions (Fig. 5), the Alma Media online newspapers showed lower environmental impacts than their printed versions per year and also per reader and week. However, impacts per reading hour were lower for printed newspapers in many cases.

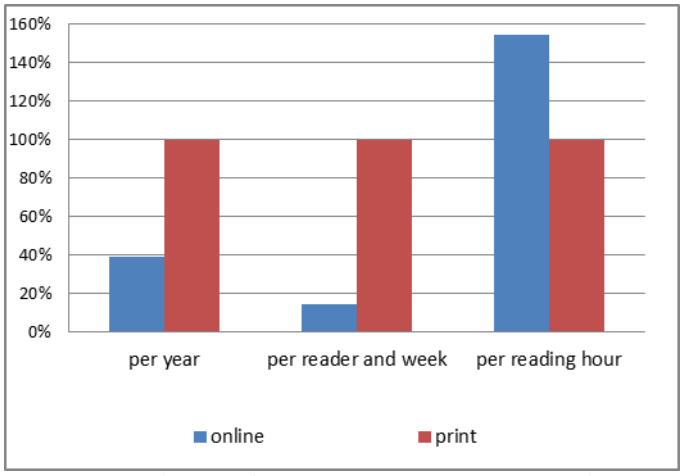

Figure 5. Carbon footprint of printed Kauppalehti and Kauppalehti.fi per year, per reader&week, and per reading hour. Printed version set to 100%. ("Per year" corresponds to 99,7 hrs of reading printed version and 9,5 hrs of reading online version; "per reader and week" corresponds to 115 min of reading printed version and 11 min of reading online version)

Using different kinds of perspectives, e.g. different functional units, gives more comprehensive information, increased knowledge and better understanding of the complex entity. The "per year" unit gives an overview of the environmental impact of annual newspaper production, while "per reader and week" and "per reading hour" present more reader-orientated results. The "per hour" unit gives a strict functionality comparison, trying to consider the information amount obtained. Since the readers of the assessed newspapers tend to spend more time reading printed versions rather than online [9], they actually get different amounts of information from the two versions. Furthermore, it may well be the case that reading the online version gives quite different information (different selection and choices made by the reader) than reading the printed version [33, 34]. The analysis did not take into account that one reader might read both printed and online newspaper and that the reason for the low time spent on reading the online version might be that the information is obtained from the printed version. This is also an important issue, since it may be that e-media solutions do not substitute printed versions but rather complement them.

4) User profile

User profile is an important issue in the environmental assessment of media products. User behaviour is variable and individual, and there is a lack of data that describe average user profiles. Studies comparing e-media products to their conventional analogues (e.g. e-book and printed books, magazine on a tablet and in print, etc.) have shown that user behaviour strongly influences the overall environmental impact. Therefore assumptions on user profile affect the results significantly (e.g. [35, 7, 36, 3, 37]). This adds to the variability in the results of assessments, which can be seen not only as a problem, but also as an opportunity for showing the complexity of an issue and the possibility to influence the overall impact as a user. A challenge here is to clearly illustrate this variability and dependence on different factors, and express this in a way that makes the results transparent.

Future ICT developments and their integration into various spheres of life will affect user profile [38, 39]. User behaviour may be changing as emerging products mature or as a result of new electronic devices put on the market, which may influence environmental performance.

In the case studies, average user profiles were created based on information from Alma Media and Finnish statistics. Some assumptions concerning the user profile were made and tested in sensitivity analyses [9].

Choosing to assess the average newspaper reader has its drawbacks and benefits. While it allows the impact of the average reader to be demonstrated, nobody is an average reader and the impact depends rather significantly on the individual reader's profile. Another way of assessing this might be to assess several 'extreme' reader profiles, showing a range of possible impacts and illustrating the user parameters which make a major difference regarding environmental impacts.

The sensitivity analyses helped to illustrate the importance of the e-media user parameters. Varying the overall use time and the device life span showed that the assumptions on use time and device life span can be crucial and can lead to large differences in the overall environmental impact. Also, the effect of the geographical location of the reader and thus the electricity mix used was tested. The choice of electricity mix proved to be important for the overall results and distribution of the environmental impacts between life cycle stages (i.e. manufacturing and use phase).

B. Communication and acting on the results

Challenges in communicating the results to non-LCA experts may relate to both: explaining the LCA methodology and related terminology and understanding the potential environmental impacts assessed in the study [40, 41]. For correct interpretation of the results, it is important that the results are communicated transparently and that the complexity of the system is illustrated. However, it is not necessarily clear how this could be done in practice. In the case of Alma Media's newspapers, additional challenges related to communicating the impacts and significance of choice of data, functional unit and assumptions. Many of the comparisons provided "it depends" conclusions, which did not allow a single answer to be given. However, customers and end-users would prefer simple answers and guidelines for environmentally responsible behaviour [5, 42]. For the case studies performed, it proved difficult to explain and understand the "per reader and week" versus "per reading hour" idea in terms of what these actually mean. Various ways of communicating the results

were used: a full report with the results of the study was published [8], a number of internal and external presentations were made, a scientific journal article was written [9] and a video presenting the results in a more simple way for the broad public was made [43].

In the case of media companies, communication of results to the public is possible through their own products (e.g. newspapers), which can be used to raise awareness among readers about the importance of their behaviour for the environmental impact of both online and printed newspapers. Nonetheless, acting on the results internally should not be forgotten.

According to Riikka Poukka, Corporate Responsibility Manager, Alma Media [44], the findings of the case studies were actively applied by the company in both internal and external communication. In internal communication, the results were applied in educating staff about the environmental performance of the products and in increasing general awareness on the issue. In external communication, an advertisement campaign in Alma Media's newspapers was held to share environmental information with readers, which gained mainly positive feedback. Active efforts and open communication of the results provided the company with visibility on several professional platforms and opened up new cooperation possibilities for evaluating the environmental impacts with advertisers and within the value chain of electronic media.

In the case study, main challenges in acting on the results related to handling the environmental impacts that occur in various parts of the product life cycles. Printed newspaper impacts largely occur in the printing house supply chain and in delivery to readers, whereas online newspapers impacts are mainly associated with the electronic device supply chain, and to some extent electricity use for reading and distribution. This means that impacts occur on both local and global scale, in the traditional (closely related to the media company) and new (not directly related to the media company) value chains and thus require different approaches and actions for improvement, possibly involving new types of collaborations.

For improving the environmental performance of the company, the main advantage of the study according to Poukka [31] was related to pointing out bottlenecks in data collection, which need to be handled in the future in order to allow the environmental impacts to be accurately monitored annually. Thus most of actions taken were related to internal and external communication, attitudes and ways of thinking, while the realisation of more concrete actions was still at the planning phase at the time of the interview.

Together with active communication efforts (both internal and external), management support and the commitment of key personnel were considered central for effective utilisation of the research results within the company [44]. This is in line with the findings from the CSR (Corporate social responsibility) literature, stating that management commitment, allocating enough resources for the work and involving enough key persons from the organisation are essential for integrating corporate responsibility actions and achieving organisational learning [45]. It can be stated that for achieving the original goal of the study in raising awareness of the environmental impacts of different media products, actions conducted after the study were as important as the process of conducting the study itself.

IV. Conclusions

Challenges in assessing and comparing printed and e-media solutions were experienced when performing case studies of online and printed newspapers. These related to choice of data (specific or generic), data quality and availability, methodological choices (e.g. defining the functional unit and scope), impact allocation, and assumptions concerning user behaviour.

Both generic and specific data have their benefits and drawbacks in LCA studies. This is especially apparent when comparing electronic and printed media solutions. The former in many cases involved specific media content distributed to a range of different user devices, and the latter - specific media content distributed as one specific product to the consumer. This implies that generic data on reader devices can be the best choice for e-media solutions, while for printed products specific data are preferable. However, both types of data are often used, so better-quality, up-to-date data of both types are necessary for future LCA studies to assess a wider range of impacts. Challenges in using generic and specific data in foreground processes in LCAs will decrease if both types of data are comprehensive and if methodological choices affecting the inventory data are transparent and adjustable in accordance with the scope of the assessment. Furthermore, when assessing new e-media solutions, better data concerning end-of-life flows of electronic devices are necessary to assess the full scope of environmental impact.

The choice of functional unit proved very important for the overall results. This is certainly relevant for media products where new solutions provide more or less different benefits to the user and the definition of a common functional unit for comparison is not an easy task. Choosing to present the results through a number of functional units, i.e. a number of different perspectives, can help demonstrate the complexity of the case and can result in important learning. The importance of user behaviour should not be underestimated, as was shown in the case studies. Thus better data on user behaviour regarding e-media solutions is needed and different user behaviour should be illustrated e.g. through sensitivity analyses or by using different user profiles.

Due to the complexity involved and lack of "single answer" conclusions, communication of the results to stakeholders, such as end-consumers and value chain actors, is challenging. However, the possibilities for limiting environmental impacts can still be pointed out for the system studied, which provides valuable information for actions on improvements. To enable this, results need to be communicated transparently and the complexity of the assessment and the systems studied should be presented. In addition, resources need to be allocated for communication activities, to manage complexity of the results and to reach both internal and external stakeholders. In future,

simple tools or guidelines for communicating LCA results to the public need to be developed, to allow the environmental impacts of the products to be clarified and to present actions needed to reduce them in a clear and robust way.

For integrating and utilising the results both internally and externally, enough resources need to be allocated by the company for the process and activities carried out after the actual LCA study is conducted. Active internal and external communication, management support and commitment of key personnel proved crucial for fruitful utilisation of the research results.

Challenges for media companies in acting on results concerning the environmental impacts of ICT solutions arise also due to the new value chain actors involved, which are not directly related to the media company and due to a weak link between actions aimed to decrease environmental impact and better business. Different types of actions for improvement are necessary for new value chain actors related to electronic media products, including new types of collaborations. However, there may be a need for additional incentives from e.g. customers or authorities to encourage this action.

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