VTT-CR-02104-13

# Environmental performance of **Alma Media's online and print products**

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**Confidentiality:** Public

# Summary

Alma media ordered a research study from VTT and Centre for Sustainable Communications (CESC) at KTH, in order to evaluate the environmental performance of specific Alma Media products. The report covers the results of the life cycle assessments for printed newspapers; Aamulehti, Iltalehti and Kauppalehti as well as online newspapers; Aamulehti.fi, Iltalehti.fi and Kauppalehti.fi.

With the help of a life cycle assessment the potential environmental impacts related to a defined product life cycle is evaluated, taking into account raw material acquisition, production, use, and end-of-life treatment. Thus, various kinds of environmental impacts were considered.

The results indicate that the environmental performance of printed and online versions of Alma Media's newspapers includes different types of environmental impacts, and that these are distributed differently in the value chain and geographically. The majority of the impacts of printed newspapers occur from paper and printing manufacturing, which are located in Finland. On the other hand, environmental impacts related to online newspapers are to a large extent dependent on the manufacturing of electronic devices used for reading the online content. These impacts occur in other countries and at the suppliers not directly related to Alma Media. With few readers of the online versions the content production may also be a considerable part of the overall potential environmental impact. The actions to take towards improvements will need to be different related to the value chain. Furthermore, Alma Media as a media company can have a key role in sharing environmental information in order to improve user practices and stakeholder practices along the value chain.

The study covered a number of environmental impacts, which was important because the environmental impacts for online and printed newspapers were clearly different. The study also pointed out the importance in being careful when assessing impact categories where there may be substantial data gaps and where there are greater uncertainties related to the assessment of impacts, e.g. toxicity impact categories.

Comparisons between print and online versions are not simple, as print and online versions provide different types of information and the readers use them in different ways. Furthermore, the printed and online newspapers from Alma Media may not replace each other, but rather complement each other which can mean adding up environmental impacts from printed and online versions. The functional unit chosen is very decisive regarding the environmental performance of printed and online media, if they are to be related to each other. Using different kinds of perspectives through functional units gives more information and increased knowledge.

# Contents

## List of abbreviations

| | |
|---|---|
| BRD | Broadsheet |
| BSI | British Standards, National Standards body of the UK |
| CEPI | Confederation of European Paper Industries |
| CF | Carbon footprint |
| CH4 | Methane |
| $CO_2$ | Carbon dioxide |
| $CO_2$eq. | Carbon dioxide equivalent |
| COD | Chemical oxygen demand |
| CSWO | Coldset web offset printing method |
| CTP | Computer to plate |
| DIP | Deinked pulp |
| FTE | Full time employee |
| GHG | Greenhouse gas |
| GWP | Global warming potential |
| IPA | Isopropanol, isopropyl alcohol |
| IPCC | Intergovernmental Panel on Climate Change |
| ISO | International Standardization Organization |
| LCA | Life cycle assessment |
| LCI | Life cycle inventory |
| LCIA | Life cycle impact assessment |
| $N_2O$ | Nitrous oxide |
| PAS 2050 | Publicly available specification 2050:2011<br>Specification for the assessment of the life cycle greenhouse gas emissions of goods and services |
| PM | Particulate matter |
| $SO_2$ | Sulphur dioxide |
| TMP | Thermo-mechanical pulp |
| TSP | Total particulate matter |
| TVOC | Total volatile organic compound |
| VOC | Volatile organic compound |
| WF | Water footprint as a concept |

# Foreword

Alma media has ordered a research study from VTT Technical Research Centre of Finland and Centre for Sustainable Communications (CESC) at KTH, Royal Institute of Technology in Stockholm, in order to evaluate the environmental performance of specific media products of Alma Media. This report describes the main research activities and outcomes of the project, which was carried out in collaboration between VTT and KTH. VTT has assessed the printed media products and KTH the online media products as well as the content production needed for both. The integrated results and discussion have been produced jointly.

Alma Media is a dynamic media company whose best-known products are Aamulehti, Iltalehti, Kauppalehti and Etuovi.com. Aamulehti, Iltalehti and Kauppalehti are offered to readers in print and online form. Alma Media employs nearly 2,800 professionals. The company's net sales in 2010 totalled 311 MEUR. The core elements of Alma Media's responsible business are reliability, competence, interaction, communality, and environment. In this research project, the environmental issues of Alma media products are in focus. The study has been carried out in order to receive up-to-date information on environmental performance of Aamulehti, Iltalehti and Kauppalehti, which is required, for example, in business-to-business and in other stakeholder communication as well as in order to guide the product development into a more sustainable direction.

# 1. Introduction

All kinds of consumption and manufacturing of products have environmental impacts. From a Finland household's consumption point of view, the greatest contributors to climate change are housing (28%), food (16%) and driving a car (13%).The impact of newspapers, books and paper products is lower in this broad context. See Figure 1. (Seppälä et al. 2009) According to the results of the LEADER project (carried out in 2007–2010), about 1% of the greenhouse gas emissions caused by the Finnish households consumption originates from printed newspapers, books and paper products. (Pihkola et al. 2010.) Another study, made by Malmodin et al. 2010 show that the contribution of ICT and media sectors to the global greenhouse gas emissions in 2007 was roughly 1–2% for each sector. (Malmodin et al. 2010)

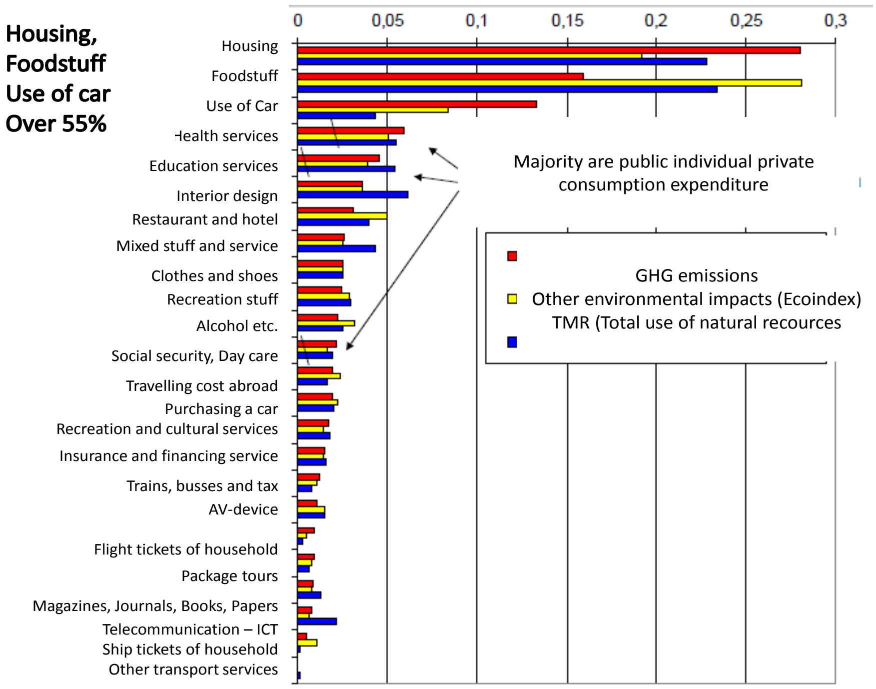


*Figure 1. Households consumptions based on Envimat. (Seppälä et al. 2009).*

Climate change is one of the main global challenges nowadays. Every sector of industry and trade needs to respond to this challenge by decreasing its overall GHG emissions. The media sector has also a role in this global challenge, both by being a channel for distributing information and a discussion forum and also by acting on impacts related to its own activities and products.

Other environmental impact potentials also need to be addressed, such as acidification, eutrophication, toxicological impacts and resource depletion. In many cases, data availability may be lower and impact assessment methods less developed than for climate change. There is less knowledge and consensus about how different emissions contribute to these impacts and how this might be measured and calculated. Also, the assessment of resource depletion, including water and land use, is related to uncertainties and different opinions. Still, impacts other than climate change need to be considered in some way, keeping in mind the uncertainties related to the assessments.

The media sector is willing to address environmental and sustainability issues. In recent years, several initiatives have been taken in the fields of environment and corporate social responsibility, both by companies and by sectorial/industry organisations. Currently an ISO working draft (WD 16759) of Graphic technology is being prepared in order to cover quantification and communication for calculating the carbon footprint of print media products (source ISO/TC 130).

A considerable number of environmental assessments of media products have been carried out. These address the environmental performance of newspapers, magazines, books, etc. (e.g. Enroth 2009; Moberg et al. 2009; Boguski 2010; Kronqvist et al. 2010; Moberg et al. 2010; Pihkola et al. 2010). Studies of printed newspapers often show that the newsprint production is a major reason for the environmental impacts, while the studies of electronic versions show that the production of electronic devices and the electricity needed to use these devices are major reasons for overall impacts (e.g. Moberg et al. 2009; Pihkola et al. 2010). A previous study on the environmental impacts of newspaper in a printed version, online read from a computer and online read from an e-reading device with an e-ink screen concluded that the printed version and the online version had environmental impacts per reader in the same range, when the online version was assumed to be read 30 minutes per day (Moberg et al. 2009). Similar results were presented by Hischier and Reichart (2003) comparing printed and online newspapers and TV. They showed that 20 minutes of online newspaper reading would produce a similar environmental impact to that of reading the printed version. Of course, these results are dependent on the scope of the study and the assumptions made, but still give an indication of the magnitude of the impacts.

Many of the studies have focused on energy-related impacts and often especially on climate change potential. The literature study of Öman et al. 2011 aims to add the understanding of how print and digital media differentiates from a greenhouse gas (GHG) emissions life cycle point of view with the help of nine comparative studies. The literature study shows that the outcome of a comparative analysis may be heavily influenced by changes in the underlying assumptions. Assumptions regarding consumer transport, number of readers, electricity mix, period of use of an e-reader, waste management, and printing are parameters that could influence the outcome of a comparison between various types of print and digital media.

The importance of covering several environmental impacts throughout the value chain instead of focusing on only to the carbon footprint was highlighted by Pihkola et al. 2010. The study covered five different print products' (local newspaper, weekly magazine, hardcover book, photo book and advertisement leaflet) environmental performance with the help of life cycle assessment and carbon footprint evaluation.

The role of the media is multifarious. According to KMT 2011 study Finnish people spend around 44 minutes per day reading printed newspapers and magazines and around 11 minutes among online newspapers and magazines. Based on another study, newspapers are on a daily basis read 31 minutes and magazines 18 minutes by consumers in Finland. In addition, consumers use 167 minutes of their time to watch TV and over 50 minutes to use the Internet (TNS Atlas 2009). The time spent on different kinds of media is presented in Figure 2. In addition, based on a study on how Finnish people use their free time, people spend around 43 minutes reading and around 38 minutes to use a computer per day. Of the computer use one third (12 min.) is spent to search for information, 10% (5 min.) for communication (emails etc.) and playing games takes one fifth and other non-specified use the one third. (SVT statistics 2009.)

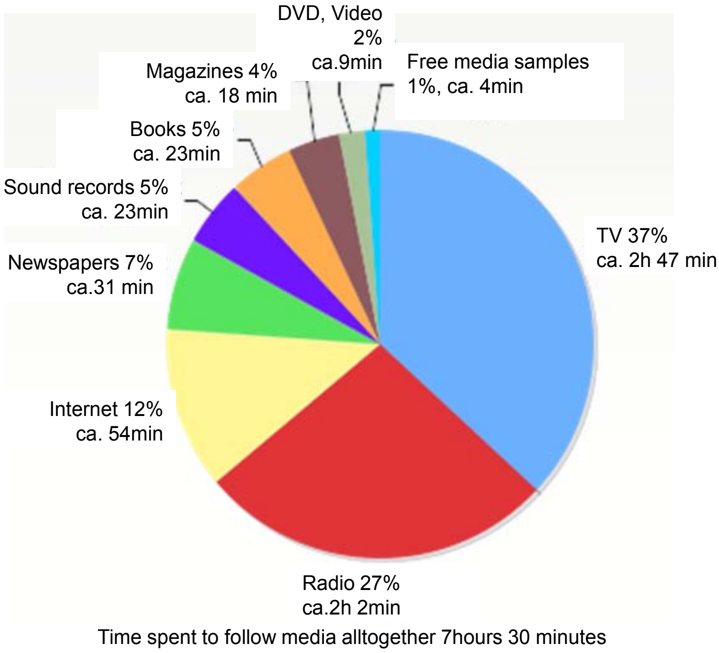


*Figure 2. Time spent to follow media in Finland. Source: TNS Atlas 2009.*

However, the significance of the media in people’s everyday lives is not possible to evaluate based on reading time only, while the media is used every day by different people and for different reasons. Furthermore, the importance of the media should not only be understood on a daily basis but also to see the significance of the media in the long term related to cultural values covering such issues as knowledge and relevant information, opportunities for learning and the possibilities of relaxation with entertainment. There are studies related to media use that approach the issue from different angles related to different media types (e.g. Leinonen et al. 2009; Sarvas et al. 2007; Luomanen 2010). Leinonen et al. 2009 examined the correlation of welfare and diffusion of various electronic media and production of print media in various countries. Sarvas et al. 2007 examined people’s media use patterns and constructed a prototype solution for personal media creation.

The emphasis of the study (Luomanen 2010) is on understanding the significance of the media and mobile communication devices in the context of people’s everyday life. The newspapers seem to have such high cultural values attached to them that the mere act of reading them appears to symbolise a valued membership of society. Furthermore, the descriptions of the use of the Internet vary depending on the context in which it is being discussed. Some uses such as search for timetables, work-related information, or using online banking services were accounted for. Also, many other types of uses, particularly those not related to work were accounted for. According to the cultural studies media and communication technologies have significant effects on the daily organisation of modern societies. People are surrounded by different media or communication applications. Many of the things that shape our views are available to us exclusively through the media. Modern communications and the media are central to organising almost every aspect of contemporary life. (Luomanen 2010.) Being such an important part of our lives, and under constant development, the media sector needs to be active also in the field of sustainable development. As a first step knowledge is needed, and also responsibility and action.

## 2. Description and objectives

The aim of the study was to make an evaluation of the environmental performance of selected Alma Media products, both in printed and electronic format, used by consumers on a daily basis.

Environmental impacts were covered by life cycle assessment (LCA) including carbon footprint (CF, a.k.a. climate change potential) information from a cradle to grave perspective.

Furthermore, the study provides an overview of the data needs for the calculation of a water footprint for a print product. This is done with the help of a student exercise work at Aalto University.

The study objectives are:

- To provide Alma Media with quantified and qualitative information about the environmental aspects and potential environmental impacts of the six case products (printed and online media) by using case studies.
- To make it possible to apply the results of the case studies in internal and external communication and in product development.
- To submit at least one scientific article
- To make it possible for the results of the case studies to be extended later to other Alma Media's products and/or be updated with data from the new printing house.

The following Alma Media product systems are studied:

1. Printed Aamulehti and one Aamulehti Sunday supplement
2. Aamulehti.fi
3. Printed Iltalehti
4. Iltalehti.fi
5. Printed Kauppalehti
6. Kauppalehti.fi

Aamulehti is a daily newspaper, Iltalehti an afternoon paper and Kauppalehti a financial newspaper.

# 3. Methods

## 3.1 Life cycle assessment (LCA)

In the study, the environmental performance of Alma Media's products was assessed using life cycle assessment (LCA) methodology, including carbon footprint (CF) information from cradle to grave perspective. The methods utilized in the study are in accordance with the life cycle assessment ISO-standard 14040-14044. The life cycle impact assessment (LCIA) method ReCiPe is applied. (ISO 14040-44: 2006.)

LCA analyses the potential environmental impacts across the product life cycle from cradle to grave, including raw material acquisition, production, use, end-of-life treatment, recycling, and final disposal. LCA assesses the potential environmental impacts of product systems in accordance with the stated goal and scope.

Life cycle assessment has been developed in order to gain a better understanding of the potential environmental impacts of products. As an example, LCA can be used for:

- identifying opportunities for improving the environmental performance of products.
- informing decision-makers in industry, government or organizations .
- selecting relevant indicators of the environmental performance of products.
- marketing products (for example, making an environmental claim or applying for an eco-label or background information for environmental product declaration ). (ISO 14040:2006.)

### 3.1.1 The four phases of LCA

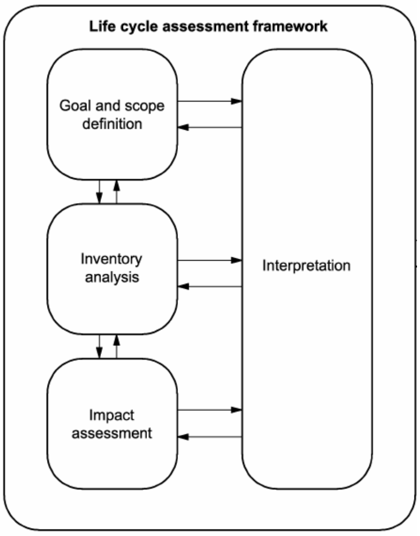


*Figure 3. Four phases of LCA.*

***Goal and scope definition***

In practice, LCA has four stages (Figure 3). Goal and scope definition is the first stage. It defines the goal of the study, sets the system boundaries, and lists the assumptions needed in the calculation. The goal of a study covers issues such as the intended application, the reasons behind the study, the intended audience and whether the results are intended to be used in comparative assertions for the public. The scope includes information about the product system and cases, the functional unit, the system boundary, the allocation procedures, data requirements, assumptions, limitations, data quality requirements and type of critical review studied. Concerning this study, the critical review is excluded, because the LCA cases are focused on Alma Media's products and they are not compared to others' products. (ISO 14040:2006)

The functional unit of an LCA defines what is being studied. The functional unit is the reference value that forms the basis to which all inputs and outputs are related. On example of a functional unit is one copy of a printed newspaper, and the impact assessment results are then expressed, for example, as kg $CO_2$-eq. per copy. The functional unit can also be related to the reading time, e.g. one hour of reading a newspaper. In the case studies presented here, the functional units are different depending on the Alma Media product system (printed, online or integration of the results) studied. It is clearly stated in each section which functional unit is used.

Even though the life cycle assessment methodology is ISO-standardized, the goal and scope, system boundary and level of detail of an LCA calculation can vary a lot depending on the study. For these reasons the results of different LCA studies cannot be compared with each other without careful evaluation of their functional units, system boundaries, methodological choices, assumptions related to calculations, etc.

***Life cycle inventory***

The life cycle inventory (LCI) includes data collection and the balance calculation of all unit processes in the life cycle. The results are presented as inputs and outputs of the entire system.

***Life cycle impact assessment***

The results from the inventory can be converted into impacts in the third stage, the impact assessment. The different parts of the impact assessment are presented in Figure 3. In the life cycle impact assessment (LCIA) phase, the significance of potential environmental impacts is evaluated using the LCI results. LCIA involves associating inventory data with specific environmental impact categories and category indicators. The mandatory elements in the LCIA phase are (ISO 14040:2006):

- selection of impact categories, category indicators and characterization models
- assignment of LCI results (classification)
- calculation of category indicator results (characterization).

In addition, normalisation, grouping and weighting can be carried out.

In this study, the LCIA was performed using the ReCiPe Mid/Endpoint method, (version November 2009) (Goedkoop et al. 2009). ReCiPe is an LCIA method that is harmonized in terms of modelling principles and choices, but offers results at both the midpoint and endpoint level. In the midpoint-level assessment used in this study, the emissions of hazardous substances and extractions of natural resources are converted into impact category indicator results for impact categories such as acidification, climate change and ecotoxicity. One example of this is the carbon footprint calculation; the greenhouse gases (GHGs) emitted in the inventory calculation are converted into global warming potentials at the impact assessment stage.

Normalisation and weighting are optional stages in the life cycle assessment. In characterisation, different environmental emissions and resource extractions etc. are grouped together to impact category indicator results on the basis of the relevant environmental processes. Impact scores are expressed in units, which differ between impact categories. Their absolute value as an assessment measure remains difficult to interpret if it is not placed in a decent environmental context. The aim of normalisation is to place case-specific LCIA results into wider context. Normalisation shows the magnitude of different impact categories relative to reference information, and weighting aims to weight different impact categories to each other and may present a single value result. Weighting is not performed within the study (Figure 4).

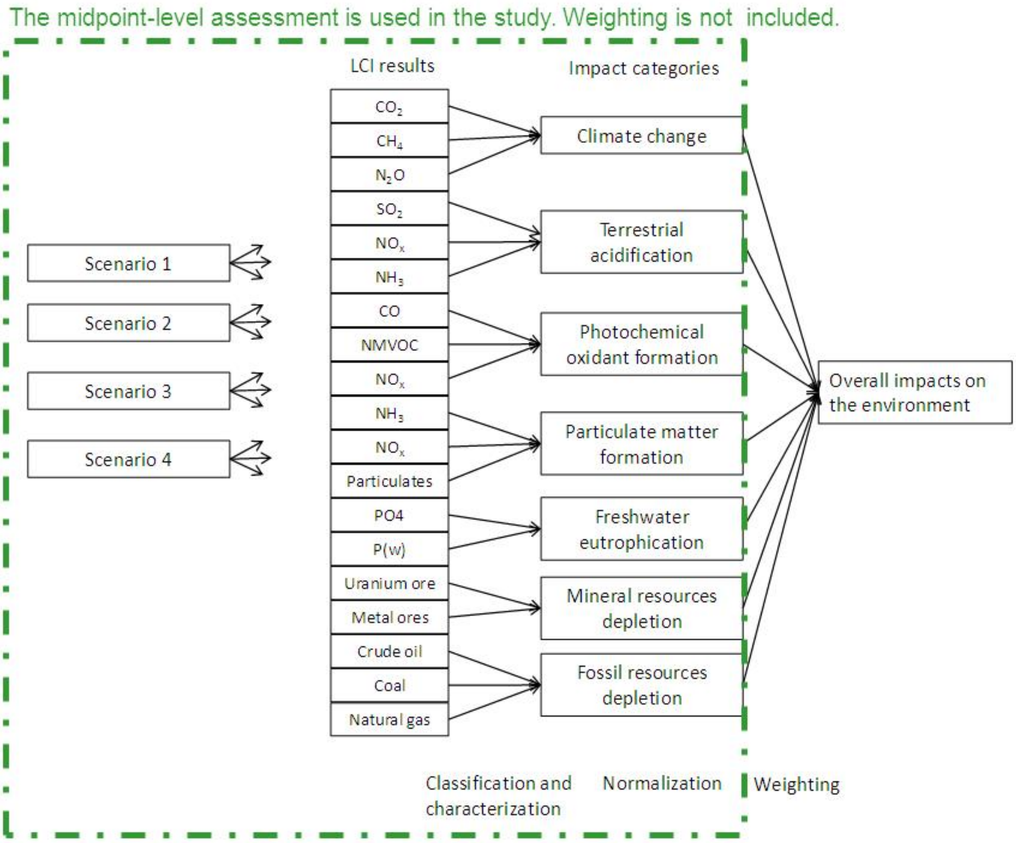


*Figure 4. The phases of an LCIA. (Pihkola et al. 2010)*

***Interpretation***
The final stage of LCA is interpretation of the results, which is based on all three previous stages of the assessment. The stages of the life cycle assessment are presented in Figure 3.

### 3.1.2 Methodological issues

***Allocation***
When there are processes connected to more than one function or product, there may be difficulties in dividing the environmental impact related to that process between these functions/products. This is called an allocation problem. Allocation means partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems (ISO 14040-44). This may be necessary when there are by-products of manufacturing processes and where several functions are provided by the same process, e.g. internet, but allocation also applies to reuse and recycling situations. When products or materials disposed of and recycled in the product system studied are subsequently used in other systems (e.g. recycled fibre is used to produce another fibre product), it may be justified to allocate some of the environmental burdens between these product systems.

In the ISO standard it is advised to try to avoid the need for allocation by finding more detailed information and then being able to account for environmental impacts actually related to the different product systems concerned, or through system expansion. Using system expansion, the system studied is expanded to take into account more than one function, e.g. the production of the recycled fibre from waste newspapers in addition to the studied newspaper copy. This is often done also by subtracting this additional function produced in another way. Taking the example of recycled fibre, this would mean that the production of the same amount of fibre (e.g. from virgin fibre) would be subtracted from the system, and all the environmental impact related to this production would be subtracted as well.

If these solutions are not possible, allocation has to be made. This may then be done by so-called partitioning, which should preferably reflect underlying physical relationships between products, or if this is not possible should be based on other relationships, e.g. energy content or economic value.

The allocation procedures used in this report are explained in more detail in Chapter 4.5.

***System boundaries***
System boundaries are set in geographical terms and in time; also boundaries are set regarding which processes to include in the studied systems. The study performed here considers three newspapers in Finland, and the readers are assumed to be in Finland. Some manufacturing and raw materials extraction occurs in other countries.

Boundaries in time can be set. If not covering a long enough time period, e.g. setting the boundary at 100 years into the future, emissions occurring later in time will not be considered. This may be of importance for the overall results, especially for processes like landfill and mining sites where emissions can occur for very long periods. For the print media product system long-term emissions were considered in case of hard coal extraction (fuel production for energy production) and printing colour production, for paper production only short-term emissions were considered due to lack of relevant data for long-term emissions. The time boundary in these systems was 100 years. For the online media product systems, both short-term and long-term emissions were considered in the reference scenario. This means mainly that in the secondary data used where mining or landfills were included, emissions occurring later than in 100 years were considered. The time boundary was 60 000 years (Frischknecht et al. 2007). The impact on the results was tested in a sensitivity analysis where only short-term emissions were considered.

In the product systems studied, potential environmental impacts related to infrastructure manufacturing, construction or maintenance are not considered. This means that e.g. the manufacturing of pulp- and paper-producing equipment and printing presses, and construction of the facilities are not covered, neither is the construction or maintenance of roads or other transport infrastructure. This is because these data were not available for some major processes. There are, however, some notable exceptions to this, as the manufacturing of cables for the ICT networks as well as construction and maintenance are included.

## 3.2 ReCiPe impact assessment method

The life cycle impact assessment (LCIA) phase was performed by applying the ReCiPe Midpoint method (Goedgoop et al. 2008). ReCiPe is a LCIA method, which offers results at both the midpoint and endpoint level. The midpoint-level assessment is used in this study, emissions and extractions of natural resources are converted into impact category indicator results for impact categories such as acidification, climate change and ecotoxicity. The endpoint-level assessment is not used in the study.

As the print and online case studies were performed by different actors, the assessments were made in different software. The ReCiPe impact assessment method was used, as implemented in KCL-ECO 4.1 for the printed product systems, and as implemented in SimaPro 7.3 for the online product systems.

Altogether the ReCiPe impact assessment method includes eighteen midpoint indicators (Goedkoop et al. 2009). Thirteen categories were selected into this study; these are listed here:

- Climate change (a.k.a. carbon footprint)
- 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 (a.k.a. metal depletion)
- Fossil depletion

The main reason to exclude some of the impact categories was the lack of data in applied data sets (e.g. land use and transformation data is missing from the KCL EcoData data sets). Excluded impact categories were: ionising radiation, agricultural land occupation, urban land occupation, natural land transformation, and water depletion. A more detailed description of the environmental impact categories selected for this study is presented in Appendix 1.

However, also for some other impact categories the data proved to be very limited in the data sources used, at least for some processes. This was clearly so for toxicity impact categories. Thus, the climate change impact category is the one that provide most robust results in the study and the other are included to get an indication on the magnitude and to discuss the uncertainties.

In addition to presenting the characterised results, these were also normalised against the impacts caused by one European inhabitant during one year, based on ReCiPe midpoint normalisation. In this case, the reference information is the overall environmental impact in each category, which is set to 1 for an average European. The characterized value resulting from the assessment, i.e. the environmental impact caused by the product system studied for each impact category, is related to the respective reference value (normalisation factor), thus indicating the contribution of the studied system to the overall impact for an average European.

## 3.3 Carbon footprint (CF)

Carbon footprint (a.k.a. climate change potential) refers to the quantity of greenhouse gases (GHGs) produced during a product's life cycle. Thus, a carbon footprint calculation includes GHG emissions based on energy and material consumptions in the products' value chain (from cradle to gate/customer/grave). The carbon footprint is the same as the climate change impact category in the ReCiPe impact assessment methodology. It is presented here separately and in the results section, as this impact category produces results with the least uncertainties related. This is due to the availability of data, but also to the characterisation method, where it is defined how different greenhouse gas emissions could be converted into carbon dioxide equivalents. This method is well developed according to methodology developed originally by IPCC (Intergovernmental Panel on Climate Change). In the study, we have used a 100-year perspective for the global warming potentials, which is common practice.

The carbon footprint calculations in this report include all the greenhouse gas emissions that are mentioned by IPCC and in PAS 2050 (2011). However, the majority of the carbon footprint of a media product is composed of carbon dioxide, methane and nitrogen oxide. The global warming potentials (100 year.) of these three GHGs are presented in Table 1.

*Table 1. Conversion factors of the most important greenhouse gases to carbon dioxide equivalents.*

| **Greenhouse gas** | **Global warming potential, 100 years. (IPCC)** |
|---|---|
| Carbon dioxide, $CO_2$ | 1 |
| Methane, $CH_4$ | 25 |
| Nitrogen oxide, $N_2O$ | 298 |

The method utilized is in accordance with the life cycle assessment ISO-standards 14040-14044. In addition, the knowledge about on-going ISO-standardization and preparations for Carbon footprint of products (ISO14067), Carbon Footprint of Print media products (ISO CD 16759) and Carbon footprint of organizations (ISO14069) is used. (ISO 14040-44 (2006), PAS 2050 (2011))

## 3.4 Water footprint (WF)

In order to get familiar with the new concept of water footprint (WF), the different approaches of WF is clarified in this chapter and the data requirements based on one printed product – Aamulehti – is evaluated in the chapter 6.1.3.

A way of looking at sustainable water use is by incorporating it into LCA by covering the direct and indirect water consumption, as well as water pollution over the whole life cycle of the product. Even though the Water Footprint Network's methodology is widely used, this study does not explain the water footprint as presented by the Water Footprint Network and the term 'water footprint' is used to indicate the concept of accounting water consumption.

The rapid development of different methodologies since the launch of the Water Footprint Network has led to a wide spread of different approaches, both at product level and at organisational level, with the ultimate goal being to promote sustainable water management. Water consumption and pollution at all stages of the product life cycle are to be included as presented in Figure 5. Knowledge of the on-going ISO standardization and preparations for water footprint of products is used. The basic data needs for water footprint calculation are presented for one of the print products (i.e. Aamulehti) in order to see the specific data requirements and quality needed for future calculation of the water footprint.

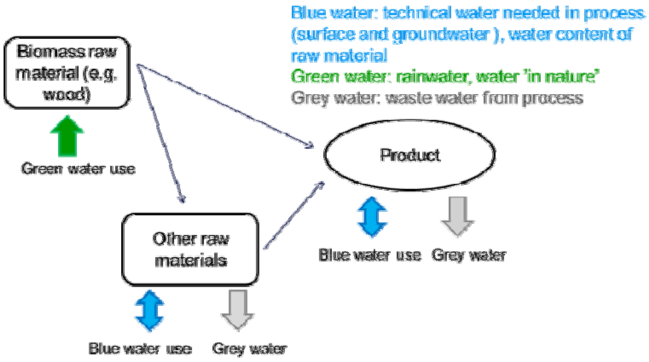


*Figure 5. Principles of different kinds of water in water footprint.*

In general, water data is hardly ever available in such a way that a water footprint could be calculated without any data-related problems. Because of the lack of data in parts of the supply chain, companies can start the process of water accounting by defining their technical water use, as this data is available and the easiest to gather within the company or at the production site.

The methodology used in water footprint has been greatly influenced by the Water Footprint Network (WFN) and therefore this terminology is applied in the present study as well. A water footprint consists of three different kinds of water as presented in Figure 5. Green water is defined by the WFN as the evapotranspiration of a crop divided by the annual yield. This is the water that is stored in the soil and that does not recharge the groundwater resources. Part of this water is used by crops, but some of it evaporates straight from the soil. Blue water describes the water used in production processes. This is the consumptive water use of fresh ground or surface water that is either evaporated during the process, incorporated in the product, returned to a different basin than that of withdrawal, or returned in a different period (e.g. drawn during the dry period and returned during the wet period) as presented by the WFN. Grey water defines the physical or thermal fresh water pollution associated with the production process. The WFN definition says that this is the volume of fresh water needed to dilute the load of pollutants in wastewater to the purity of the receiving water body. (Hoekstra et al. 2011.)

Water footprint methodology is currently being developed by several different organisations around the world. Both organisational level and product or process level approaches are examined, as shown in Figure 6. On the organisational level, the widest method used is the Global Water Tool developed by the World Business Council for Sustainable Development (WBCSD 2010). On the product or process level, the methodology developed by the Water Footprint Network (Hoekstra et al. 2011) has received the most attention as it is developed the furthest, but also the development of ISO 14046 is closely followed (ISO 14046). When looking at an applicable method for accounting for water consumption, one should first think of the purpose of the study. The method chosen may depend on whether the study focuses on water-related risk assessment (e.g. GEMI), social sustainability reporting (e.g. WBCSD) or supply chain management (e.g. WFN). For example, the PREPS Water Tool has combines best practices of different methodologies for the printing industry when choosing the most sustainable paper (PREPS 2010).

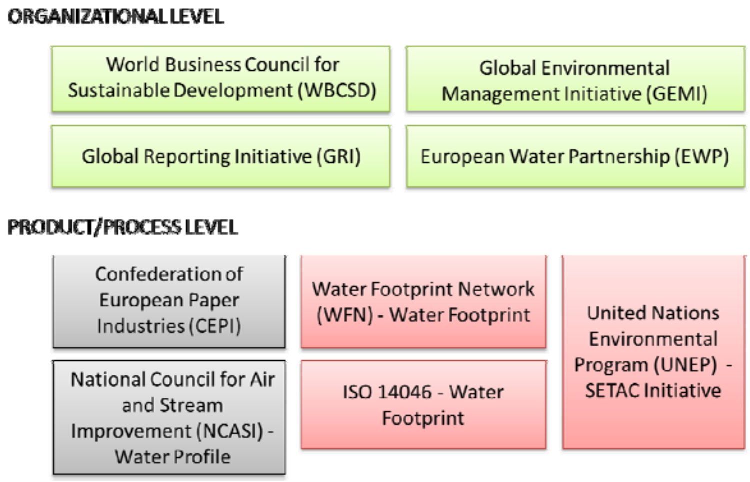


*Figure 6. Main developers of water footprint methodologies.*

A more thorough explanation of the different methods was presented to Alma Media in a separate report done as a part of the project (Koskimäki 2011).

# 4. Systems descriptions of case studies

## 4.1 Common processes for print and online

### 4.1.1 Energy

The electricity production is assumed to be the Finnish 5 year average (years 2005–2009). This is used for pulp and paper manufacturing, printing plant energy, content production, and online media distribution and use. The Finnish 5 year average electricity data (2005–2009) was used in the study, because Nord pool (electricity supplier to some processes) could not provide information on their actual fuel mix, which is needed in the modelling phase. Heat used in pulp and paper manufacturing and at the printing plant is also assumed to be the Finnish 5 year average (years 2005–2009).

The applied data set for the Finnish 5 year average electricity and heat supply includes resource extraction, fuel production, fuel combustion and transfer losses. In addition to the fuel mix, the type of electricity generation affects the emissions from the electricity and heat production. The combined heat and power (CHP) plants that are commonly used in Finland are more energy efficient, and create fewer emissions per MWh energy than the condensing power plants more commonly used for electricity production, for example, in central Europe. For this reason, the share of CHP plants vs. condensing plants is taken into account in country average energy profile modelling. Emissions from the CHP plant are allocated to electricity and heat based on their energy contents. Waste management of the waste created in incineration facilities and other electricity generation units is excluded.

In case of district heating of offices, specific fuel consumption data from Helsingin Energia (2008) and Tampereen Sähkölaitos (2008) was applied in the modelling. Modelling itself was done similarly to that for average Finnish electricity and heat production (e.g. the share of CHP plants is taken into account).

The system boundary of the applied energy model is presented in Figure 7. The average fuels and resources used in the electricity and heat production in Finland are described in Table 2. The fuels and resources used in the heat production in Helsingin Energia (2008) and Tampereen Sähkölaitos (2008) are described in Table 3.

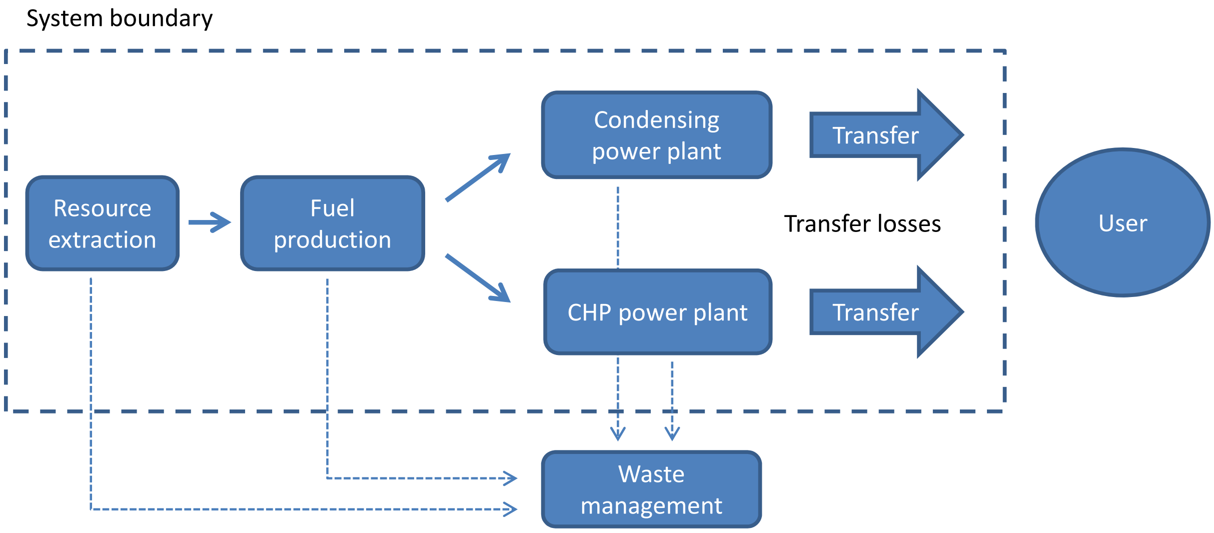


*Figure 7. System boundary of applied energy production model.*

*Table 2. Fuels and resources used in electricity and heat production modelling for 5 year (2005-2009) average in Finland, source: IEA 2010.*

| | **Electricity, Finland, 5 year average** | **Heat, Finland, 5 year average** |
|---|---|---|
| Coal [%] | 15.4 | 17.6 |
| Peat [%] | 7.4 | 16.5 |
| Oil [%] | 0.6 | 6.8 |
| Gas [%] | 14.3 | 24.6 |
| Biomass [%] | 12.5 | 26.5 |
| Waste [%] | 0.6 | 2 |
| Nuclear [%] | 30.3 | - |
| Hydropower [%] | 18.1 | - |
| Wind [%] | 0.3 | - |
| Geothermal [%] | - | 0.2 |
| Other sources [%] | 0.6 | 5.9 |

*Table 3. Fuels and resources used in heat production modelling for heat consumed in district heating.*

| | **Heat, Helsingin Energia, 2008** | **Heat, Tampereen sähkölaitos, 2008** |
|---|---|---|
| Coal [%] | 40 | - |
| Peat [%] | - | 21.8 |
| Oil [%] | 7 | 4 |
| Gas [%] | 51 | 66.2 |
| Biomass [%] | - | 8 |
| Other sources* [%] | 2 | - |

*Heat pumps

The main source for the data on the supply of the fuels and the energy production applied in this study is the KCL EcoData database, which is based mainly on the information from fuel manufacturers and energy producers in Finland. Data on hard coal production and energy production with natural gas in condensing power plant is from EcoInvent (Dones et al. 2007). In addition, for example, environmental permits in Finland are applied to fill possible data gaps.

Concerning the long-term emissions (see 3.1.2) from the energy production, e.g. from landfills or from mine tailings from coal mines, it should be noted that those are included only in cases when the data is acquired from the EcoInvent database.

### 4.1.2 Transport

The study includes all raw material transportation and newspaper delivery for the printed newspaper, but also the travel of journalists, administration and marketing people related to the content of the newspapers and the transportation of materials and electronic equipment used for content production and for online newspaper reading.

The transport modes used in the modelling are all from the LIPASTO database. Emissions from transports included emissions from “well to wheel”, including the fuel production and direct emissions caused from fuel combustion during the transport, but not the vehicle manufacturing or road and infrastructure construction and maintenance (Figure 8).

It is important to note that the data is covering a limited set of emissions, for example, no emissions of metals are covered and hydrocarbons are not specified.

Modes of transport used are listed in following Table 4.

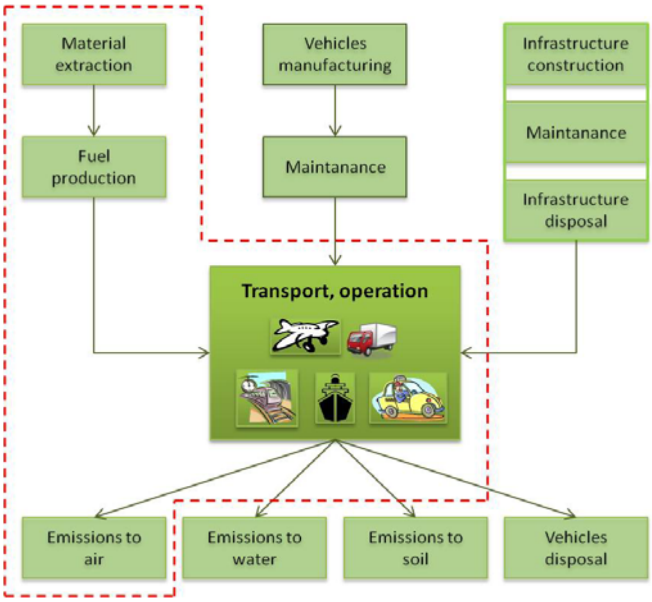


*Figure 8. Transportation system boundaries.*

*Table 4. Modes of transport used in the modelling. Source: VTT KCL-EcoData and VTT LIPASTO.*

| | | |
|---|---|---|
| **Road transport** | Truck 2.7t EURO5 (50% load – delivery driving) | Delivery of printed newspapers |
| | Truck 2.7t EURO5 (highway driving) | Delivery of printed newspapers |
| | Truck 3.5t EURO5 | Delivery of printed newspaper, office paper and toner |
| | Truck 9t EURO5 | Delivery of printed newspapers |
| | Truck 25t EURO5 | Transportation of electronic equipment, aluminium plates (printing), printing ink, newsprint to printing plant, fillers, recycled paper |
| | Truck 42 tonne, wood transport | Wood transport to sawmill / pulp and paper mill, chips |
| **Sea transport** | Ship, general cargo, small | Aluminium plates (printing) |
| | Ship, barge 8 000 DWT | Wood transport, chips |
| | Ship, container ship, 1 000 TEU | Transportation of electronic equipment, fillers |
| | Ship, ferry, 60 trailers | Printing ink |
| **Rail transport** | Train, diesel, wood transport | Wood transport to sawmill / pulp and paper mill, chips |
| | Train, electric FI | Business trips, fillers |
| **Air transport** | Freight aircraft, long-haul international flights | Transportation of electronic equipment |
| | Passenger aircraft, domestic, short-distance ≤ 463 km | Business trips |
| | Passenger aircraft, domestic, long-distance > 463 km | Business trips |
| | Passenger aircraft, Europe, short-distance ≤ 463 km | Business trips |
| | Passenger aircraft, Europe, long-distance > 463 km | Business trips |
| | Passenger aircraft, long-haul flights | Business trips |
| **Passenger car** | Gasoline driven car, average (highway + street) | Business trips |
| | Diesel driven car, urban driving | Business trips |
| | Diesel driven car, average (highway + street) | Business trips |

For the air transport and travel data, no information on vapour trails and $NO_x$ emissions occurring at high altitude was included. According to Lee et al. (2009) the total climate change from emissions from plane operation is 1.9–2.0 times higher than that from $CO_2$ only, and, based on this, we have used a factor two for $CO_2$-emissions to get a more feasible value for climate change. Data for aircraft fuel production was taken from the Ecoinvent database (Jungbluth 2007).

Data for petrol and diesel production for cars and trucks, and heavy fuel oil production for ships are generic Finnish data obtained from Neste Oil. No differentiation between 95 and 98 octane petrol is made in production. The emissions considered are also in this case quite limited.

## 4.2 Content production (including administration and marketing activities)

### 4.2.1 General overview

The content production is part of the life cycle for both print and online newspapers. This stage covers the activities related to the process of newspaper content production including the offices used by journalists, marketing and administration people, manufacturing and use of equipment and materials for this work, business travel and mailing (Figure 9).

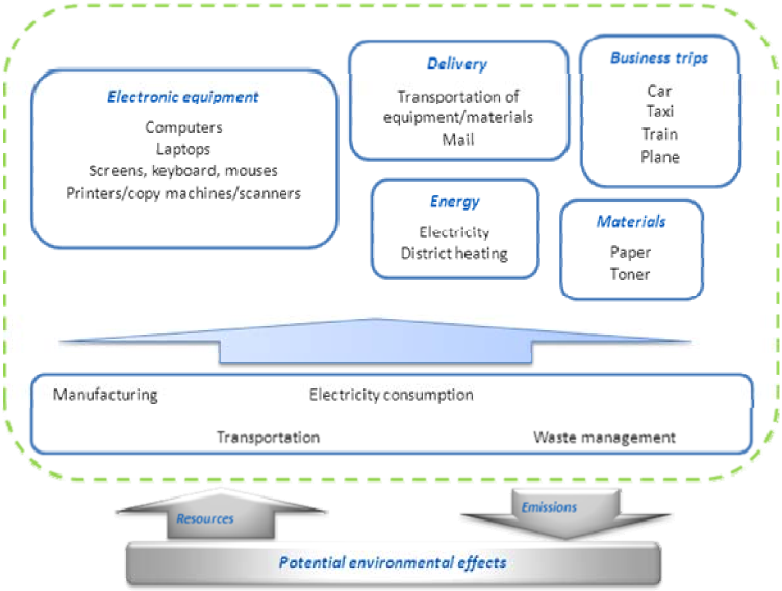


*Figure 9. Content production system.*

The processes included in the content production system are described in Table 5 below in more detail.

*Table 5. Content production sub-systems and processes.*

| Description | Processes included | Description of data and Limitations | References |
|---|---|---|---|
| **Sub-system: Office electronic equipment** | | | |
| All the electronic equipment used for the office work: desktop, laptop, LCD screen, mouse, keyboard, mobile phone, TV set, printer, scanner, copy machine. | Manufacturing of the equipment, including raw materials extraction, end of life treatment, including recycling of metals and the avoided virgin production. | Stationary phones and faxes are not included, but considered to be minor issues.<br>iPad is not included due to the lack of data.<br>For mobile phones and TV sets, only a limited number of emissions are included.<br>Generic data for manufacturing of desktops, laptops and screens are from years 2002-2004 and thus the impacts may be different in current production.<br>High uncertainties regarding environmental impacts resulting from end of life treatment. | Alma Media<br>Hischier et al. 2007a<br>Hischier et al. 2007b |
| **Sub-system: Office materials** | | | |
| Office paper and toner | Manufacturing of wood-free uncoated paper, including forestry.<br>Manufacturing of toner and cartridge.<br>Toner and paper transportation to the regional storage.<br>End of life treatment, including recycling for paper and the avoided virgin production | Stationery not included. | Alma Media<br>Hischier et al. 2007c<br>Hischier 2007 |
| **Sub-system: Business trips** | | | |
| All the work process related trips. | Vehicles operation of private cars (petrol and diesel), including fuel production.<br>Operation of planes for various types of trips, including fuel production.<br>Operation of train, including electricity production. | No data on production and maintenance of vehicles and infrastructure such as roads and rail.<br>Limitations on emissions covered for operation emissions and emissions from fuel production<br>No data on public transport.<br>Not considering travel from home to office and back.<br>Data used are for average Finnish conditions. | Alma Media<br>LIPASTO<br>Jungbluth 2007 |
| **Sub-system: Deliveries** | | | |
| Mail sent.<br>Delivery of paper, toner and electronic equipment to the office | Operation of vehicles for delivery of mail.<br>Vehicles operation and fuel production for freight ship, lorry and freight plane for deliveries to the office. | No data on production and maintenance of vehicles and infrastructure such as roads and rail.<br>For mail, no data on fuel production either. | Alma Media<br>LIPASTO<br>Itella, 2011<br>World airport codes, 2011<br>Sea route&distance, 2011 |
| **Sub-system: Electricity and heat** | | | |
| Electricity and heat consumed as a result of office activity | Electricity and heat production including production of fuel. | See chapter 4.1.1. | See chapter 4.1.1. |

Since the content production for the online and printed newspaper versions is performed in the same office and some of the content is used both for online and printed versions of the respective newspapers, the overall content production of each newspaper studied is split between the online and print versions in the following shares presented on Table 6.

*Table 6. Content production split between online and print versions:*

| | print | online |
|---|---|---|
| Aamulehti | 85% | 15% |
| Iltalehti | 59% | 41% |
| Kauppalehti | 71% | 29% |

The percentage for Aamulehti and Kauppalehti was provided by representatives from the newspapers, taking into account the number of "online" and "print" employees, the distribution of marketing people working between online and printed versions of newspaper and the share of content produced by "print" employees, but used also for the online version. For IL the percentage was calculated based on the following assumptions. It was discussed that approximately half of the "print" content is used for the online version as well, so it was assumed that 50% of employees producing "print" content spend approximately 50% of their time on the online version. The number of marketing people, which was given by an IL representative, was split equally between online and print versions, assuming that they devote equal time to working with marketing of IL print and online.

The figures shown in Table 6 indicate that Aamulehti is still focusing to a great extent on the print version of their newspaper, while the difference is smaller for the others. It should be noted that, if only the printed or only the online version were produced, the content production would be relatively higher.

Apart from regular employees, each unit has a number of subcontractors. Some of them sit in the Alma Media offices; others work from home (or another office). The subcontractor employees working from AL/IL/KL offices were considered to be covered by the data gathered for the offices (e.g. electricity, heat, paper and toner). For those, working from somewhere else, the average (per full time employee, FTE) electricity and heat consumption as well as use of paper and toner was added. Each subcontractor (FTE) is considered to use one desktop computer or laptop. The share of subcontractors using laptops and the share of those using desktop computers is assumed to be the same as those shares for the FTE within each respective newspaper. As for business trips, IL subcontractors are assumed not to make any trips, KL subcontractors travel twice as much as average FTE by trains and planes, AL subcontractors travel equally to average FTE. Assumptions on business travel by subcontractors were made by representatives of the newspapers. No additional mailing was taken into account for subcontractors.

The data gathered cover the overall processes at the Aamulehti, Iltalehti and Kauppalehti offices and for related employees and subcontractors. For Kauppalehti most figures provided included also Optio, these figures were adjusted based on the share of employees.

The overview of the content production system and its boundaries is given in Figure 10.

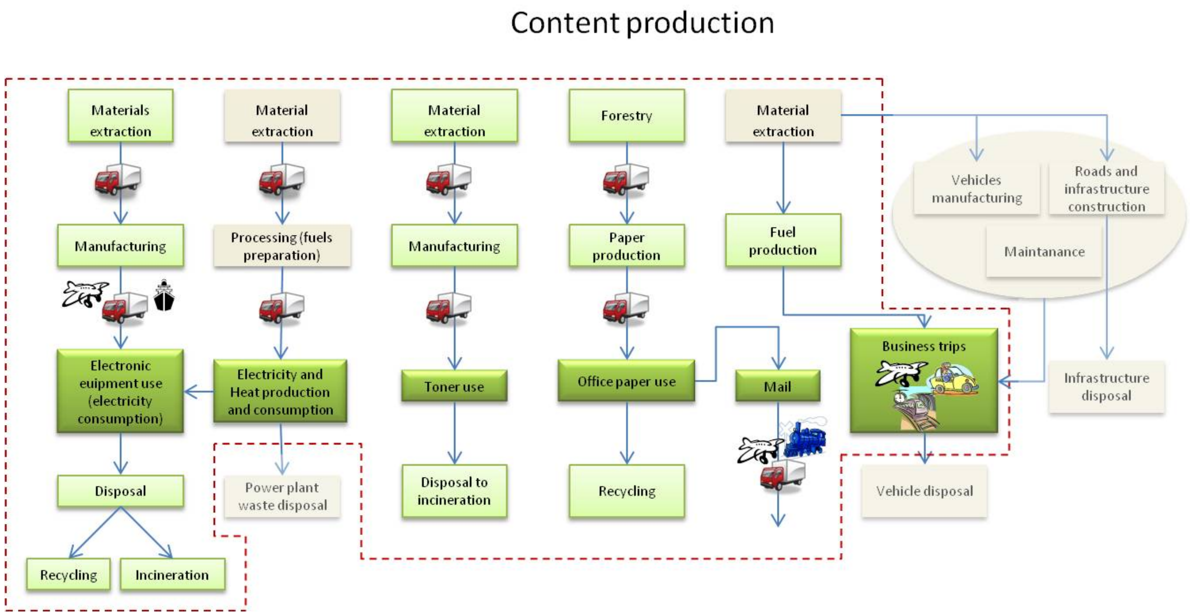


*Figure 10. Content production system boundaries. Processes within the dotted line are included in the study.*

### 4.2.2 Office equipment

***Manufacturing – Electronic devices***

The types and number of electronic equipment used in the offices was provided by each newspaper representative.

For manufacturing of desktop computers, LCD screens and laptops, generic Ecoinvent data (Hischier et al. 2007a) as implemented in SimaPro 7.3 is used. The data includes raw material extraction, manufacturing of components and assembly of devices as well as transportation and waste management related to the manufacturing process. The data are generic and relatively old, and thus related to some uncertainty, however they will indicate the environmental impact related to the manufacturing of these devices.

Transportation of the devices from the production site to the offices is included in the “delivery” sub-system (see below). The electricity for using the devices is part of the overall electricity use at the office, inventoried separately.

For mobile phones, only carbon dioxide equivalent emissions were modelled from the raw materials extraction and production, manufacturing, transportation and disposal, as the inventory data were not presented in the source used (Bergelin 2008). Utilization was excluded, as it was assumed that the phones are charged at the office, so electricity use is included in the general office electricity consumption figure.

Data for the TV sets covers only carbon dioxide and sulphur dioxide emissions to air and phosphate emissions to water originating from production, distribution and disposal. (Fraunhofer 2007)

***End of life – Electronic devices***

Waste disposal of electronic equipment is included in the system, but with certain restrictions. It is assumed that all the electronic equipment is disposed to the waste electric and electronic equipment (WEEE) treatment. The Ecoinvent data modeled for the WEEE treatment of electronic equipment as implemented in SimaPro includes some waste treatment processes, covering disassembling and dismantling of the equipment, incineration of some components and sending others for recycling. These are used in the study. However, the recycling process and resource recovery from the recycling is not taken into account in the processes as provided in SimaPro; a cut-off is made. Thus the recycling processes for desktops, laptops and screens (as the most significant ones) were modified using the information from Ecoinvent reports (Hischier et al. 2007b and Classen et al. 2009) in order to include metals recovery and the benefits of avoidance of virgin production using system expansion. This is described in more detail below. The waste treatment data in Ecoinvent are based on Swiss conditions and will serve as a rough estimation of the environmental impacts related to the waste treatment of electronic devices in Finland. Transportation to the waste treatment facilities is not included.

In the data used, the modeling of disposal of WEEE starts with equipment dismantling (manual and mechanical).Following this, various components are directed to different types of treatments (see Figure 11). In the original data this meant that LCD module, capacitors, plastic and residues from mechanical treatment (shredding) were incinerated, and the other components were forwarded to recycling, but the processes of recycling were not considered, but cut-off. In order to include more comprehensive information on the end of life environmental impacts, the processes were modified in order to estimate impacts and benefits resulting from the recycling. Focus was put on components with considerable share of metals and where information on their composition and relevant recycling processes were easily available. This resulted in re-modelling the printed wiring boards and “electronic scrap” waste treatment for laptops, desktops and LCD screens. The main flows of the waste treatment process are presented in Figure 11.

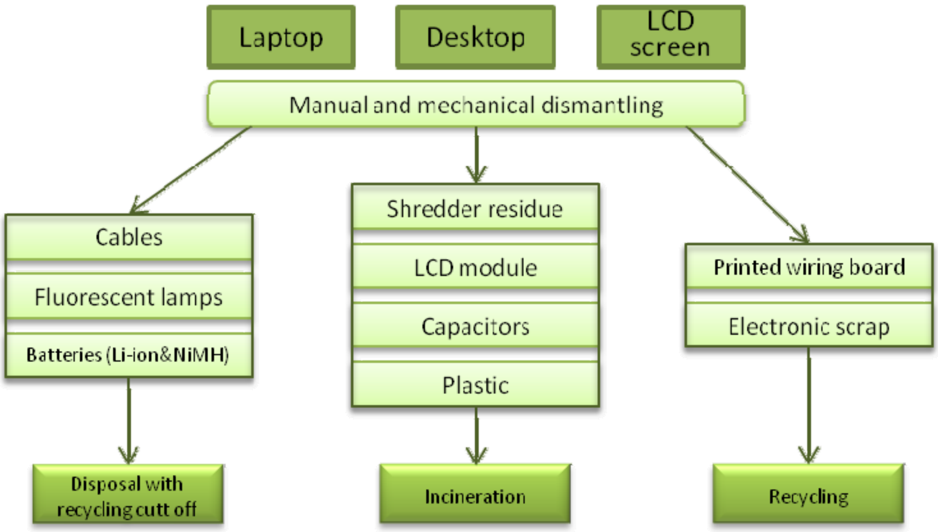


*Figure 11. Electronic waste treatment.*

In the result of the manual and mechanical dismantling various parts are sent to the different treatments. The LCD module, big capacitors and 50% of the plastic outside parts are sent directly for incineration. Power cables without plugs, fluorescent lamps and batteries are sent for recycling, which is cut-off as modelled in SimaPro 7.3. Metal outside parts, together with metal and plastic inside parts, the rest of the plastic outside parts, slide-in modules (HDD, DVD/CD-ROM), cables with plugs and small capacitors are sent for shredding. After shredding, various metal fractions are separated by magnet and sent for metal recovery as “electronic scrap”. The residues are incinerated. Printed wiring boards are sent for recycling, where they are shredded and then also sent for metal recovery. (Hischier et al. 2007b)

For printed wiring boards and electronic scrap, the metal content was estimated. The recovery of the following metals was covered: copper, aluminium, lead, nickel, iron, palladium, gold and silver.

The amounts of these metals in the electronic scrap from desktop computers, LCD screens and laptops going to recycling were provided in the Ecoinvent report (Hischier et al. 2007b). The recycling processes were available in the Ecoinvent database as implemented in SimaPro. Part of the recovered metals was assumed to be used within the product system studied, so called closed-loop recycling. However, more metal was recovered than the amount of secondary metals used as input to the system. To account for this extra amount of recovered metals, system expansion was used and benefits from avoiding virgin production were accounted for. We assumed the average mix of primary and secondary metals as presented in the Table 7. This is an uncertain assumption.

*Table 7. Shares of primary metals in electronic equipment manufacturing. Average of metal production mixes (Classen et al. 2009).*

| | % of primary metal in production mix (average) |
|---|---|
| Lead | 25% |
| Nickel | 100% |
| Copper | 78% |
| Palladium | 97% |
| Silver | 72% |
| Gold | 69% |
| Iron | 50%* |
| Aluminium | 68% |

*own assumption

The composition of the metal scrap from printed wiring board (PWB), which is not part of the “electronic scrap” modelled separately, going to the recycling was not specifically given in the Ecoinvent report on electronic waste. However, in the report it was stated that the electronic scrap from PWB goes to a secondary copper plant. The process of metals recovery in this plant as modelled in Ecoinvent consists of three consecutive multi-output processes: 1. Secondary copper conversion, where lead is recovered and the rest of the metal mix goes to 2. Secondary copper refining, which gives an output of nickel, copper and precious metals mix, and the latter goes to 3. Precious metal refining, where palladium, silver and gold are recovered. In this study, the amounts of metals recovered were calculated based on the mass balance of the metal recovery process described above for average electronic scrap, given in the Ecoinvent report (Classen et al. 2009). The process is generic for electronic scrap, and is therefore used as a rough estimation for PWB metal recycling. However, as the metal composition of the disposed PWB is not specified, there are large uncertainties in this assumption.

***Paper and toner***

The amounts of office paper used per year were given by IL and AL representatives, while for KL it was calculated as a share of the total amount of office paper used by Alma Media in 2010, taking into account the number of employees in total and for KL specifically.

For paper manufacturing, generic data from Ecoinvent was used (Hischier 2007) including average European wood-free uncoated paper production and transportation to regional storage. Paper recycling into newsprint is based on generic Ecoinvent data with the addition of the benefit of recycling – avoided newsprint production from virgin fibre. It is assumed that 100% of office paper goes to recycling, where 85% is actually recycled and the rest is going to incineration and landfill waste.

The amounts of toner used were given by AL, while for IL and KL the amounts were approximated using the total expenses for toner at Alma Media in 2010, the average price of toner and the share of employees.

For toner manufacturing, generic Ecoinvent data (Hischier et al. 2007c) covering average European production of toner and cartridge, their transportation and final disposal was used.

### 4.2.3 Business trips

Business trips include employees travelling by taxis, trains, corporate cars and planes. All the information was obtained from the specific newspapers or from Alma Media travel agency.

Taxi and train trips were estimated approximately, taking into account the number of trips per year and the estimated average travelled distance. Finnish specific data (see 4.1.2) was used for the operation of taxi (car, diesel, urban driving) and train (electric train).

Information for corporate cars was given in litres/year per type of fuel. All corporate cars have full tank benefit and therefore also include private travel. It was impossible to separate business travel from private travel for these cars, thus this portion of the business trips will be overestimated. Since it is a small portion, this will not influence the overall results. In addition, the data for types of fuels used includes so-called “foreign fuel”, which was filled abroad. This part of the fuel was split into petrol and diesel in the same share as the average for each specific newspaper. Finnish specific data for car operation (see Section 4.1.2) was used: passenger car, diesel/petrol, average driving, which implies a combination of highway and street driving (35% of urban driving).

Information about flights was given by the Alma Media travel agency as a list of destinations with an indication of one-way or return flight. The distances between destinations were calculated using online tools (Distances between airports, 2011). Finnish specific data (see Section 4.1.2) was used for the aircraft operations, divided into five categories: domestic short and long distance, Europe short and long distance, and long-haul flights.

### 4.2.4 Delivery

Delivery includes transportation of material and electronic equipment to the office as well as mail sent from the office.

The data concerning paper and toner delivery was obtained from the specific newspapers, except for toner delivery for KL, where it was roughly assumed that the distance of delivery is the same as for office paper.

As for electronic equipment, the distances and means of transportation were assumed, based on general information about equipment manufacturing and transportation, information from Ecoinvent reports as well as communication with Madeleine Bergrahm at HP (personal communication, 26-08-2011). Based on this information, it was decided to assume that:

- Screens, keyboards, mouses, printers and 50% of the laptops are transported by boat from Shanghai, China to Rotterdam, the Netherlands, and from there by lorry to Helsinki;
- Desktops and servers are delivered to Helsinki from Prague, Czech Republic by lorry. But since the manufacturing of the components is assumed to take place in China, the transportation from China (Shanghai to Prague) was taken into account (in the same way as screens, printers, etc – boat from China to Netherlands and then lorry);
- 50% of laptops are transported by plane from Shanghai to Helsinki.

How the electronic devices are transported depends to a large extent on how fast the customers want to have the product delivered.

Finnish specific data was used for all vehicles operation and fuel production (see Section 4.1.2), except for aviation fuel, which was taken from Ecoinvent. TV sets and mobile phones were not included in transportation, since the data sets used already include emissions from transportation. The number of mails (letters, advertising and invoices sent out) was given by the specific newspapers and processed using emissions data from Itella (Itella 2011). Only a few emissions are provided and these only reflect the operation of the vehicles.

### 4.2.5 Energy

Electricity and district heating consumption figures were obtained from the specific newspapers. The inventory data on electricity and district heating production are presented above (Chapter 4.1.1).

The data for electricity and district heating use were specific for the offices used by the respective newspapers. The electricity figures also included electricity consumption by cooling. Since the electricity consumption reported covers all the activities of the office, some adjustments concerning servers were made. Some servers located at Iltalehti's offices are used by Kauppalehti and vice versa, so the electricity consumption per one server was estimated and subtracted/added from/to the total electricity consumption of the respective units.

## 4.3 Print media

The case studies cover the life cycle of print products from cradle to grave: pulp and paper manufacturing (including harvesting and raw material manufacturing), transports of raw materials, 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. Content production including administration and marketing related to newspaper was included.

In Table 8 below and subsequently the main life cycle stages of printed media products are presented in more detail.

*Table 8. Main life cycle stages of printed media products.*

| Life cycle stage | Description | Processes included | Limitations | References |
|---|---|---|---|---|
| Fibre supply | Fibre supply | Harvesting, sawmills, fuel and energy supply in harvesting and sawmills | | EcoData |
| Pulp and paper mill | Direct emissions from pulp and paper mills | Direct emissions from pulp and paper mill sites | Limited number of emissions, e.g. no metals | UPM |
| | Purchased electricity at pulp and paper mills | Production of grid electricity | | EcoData |
| | Fillers and fuels at pulp and paper mills | Manufacturing of Fillers, raw materials (other than wood) and fuels | Manufacturing of process chemicals used in pulp and paper mill excluded | EcoData |
| Content production | Emissions from content production | Heat, electricity, transport office paper and toner, mailing related to the editorial work (see chapter 4.2) | | KTH |
| Printing | Direct emissions from printing | Direct emissions from printing sites | | Alma Media |
| | Purchased electricity and heat at printing houses | Production of heat and grid electricity | | EcoData |
| | Chemicals, materials and fuels used in printing | Manufacturing of printing ink and printing plates needed in printing | Manufacturing of printing chemicals other than ink are excluded | EcoInvent ink and plates EAA data was verified partly with the help of manufacturer's CF information |

continue

Table 8 continues.

| Life cycle stage | Description | Processes included | Limitations | References |
|---|---|---|---|---|
| Delivery to customer or end user | Delivery to customer or end user | Distribution of newspapers to consumers (home delivery) or transportation to retailer's warehouse | No data on production and maintenance of vehicles and infrastructure such as roads and rail.<br>Limitations on emissions covered for operation emissions and emissions from fuel production<br>Data used are for average Finnish conditions.<br>The transportation of newspapers from retailers to homes (e.g. for IL) is excluded<br>Distribution of KL only cover few emissions and only for operation. | Alma Media / Itella<br>LIPASTO |
| Other transportation | Other transportation | Wood, chemical, fuel, other raw material and waste transportation | No data on production and maintenance of vehicles and infrastructure such as roads and rail.<br>Limitations on emissions covered for operation emissions and emissions from fuel production<br>Data used are for average Finnish conditions. | UPM / Alma Media / EcoData<br>LIPASTO |
| End of life | Processes related to product end of life | Energy needed in recycling, processing of collected paper, landfill emissions, emissions from energy recovery | | EcoData |
| Avoided emissions | Emissions avoided due to, e.g. recycling or combustion | Processes and energy production avoided, specified separately in each case | | EcoData |

### 4.3.1 Fibre supply

Fibre supply includes the emissions from harvesting operations (including fuel production used in the harvesters) in the forest. The production of chips and the recycled fibre supply is also included here. Carbon sequestration in forests was excluded from the case studies.

### 4.3.2 Raw material transports

The distances of transport of raw materials to the newsprint manufacturing plant, and paper to the printing plant were exact distances reported by the paper manufacturer and the printing plant.

Modes of transportation and distances applied in the study for different raw materials are described in Table 9.

*Table 9. Modes of transportation and distances applied in the study.*

| Raw material | Description of transport modes | Distance |
|---|---|---|
| Fresh fibre transport | Truck 42 tonne (69%)<br>Train, diesel (27%)<br>Ship, barge 8000 DTW (3%) | 135 km<br>315 km<br>341 km |
| Recycled fibre | Truck, 25 tonne EURO5 | 245 km |
| Filler 1 | Truck, 25 tonne EURO5 | 580 km |
| Filler 2 | Train, electric FI<br>Ship , container ship, 1000 TEU | 250 km<br>8800 km |
| Ink | Truck, 25 tonne EURO5<br>Ship, ferry, 60 trailers | 2010 km<br>320 km |
| Plates | Truck, 25 tonne EURO5<br>Ship, general cargo, small | 681 km<br>1776 km |
| Newsprint | Truck, 25 tonne EURO5 | 100 km |

### 4.3.3 Pulp and paper manufacturing

For the printed cases, all three paper grades used are manufactured at the UPM Kaipola mill in Finland. The manufacturing data was collected directly from UPM.

The three paper grades used for Alma Media's print products are:

- Newsprint 45 gsm
- Newsprint 48,8 gsm
- Brite 68 48,8 gsm

More than half of the fibres used in newsprint are recycled. The rest of the furnish is fresh fibres and fillers. The biogenic carbon stored to the newspaper was not included because of the short life time of the media products (under one year).

The direct emissions from pulp (Deinking and thermo mechanical pulp (TMP)) and paper manufacturing include air emissions from fossil fuel combustion ($CO_2$ (biogen and fossil), particulates, $NO_x$, $SO_2$) and emissions to water (N, P, BOD COD and TSS). No emissions of metals such as zinc, mercury or arsenic were included, thus there are data gaps for some toxic emissions. The emissions derived from purchased electricity are also taken into account as well as emissions from fuel manufacturing and filler manufacturing. (See flow sheet in Figure 12.)

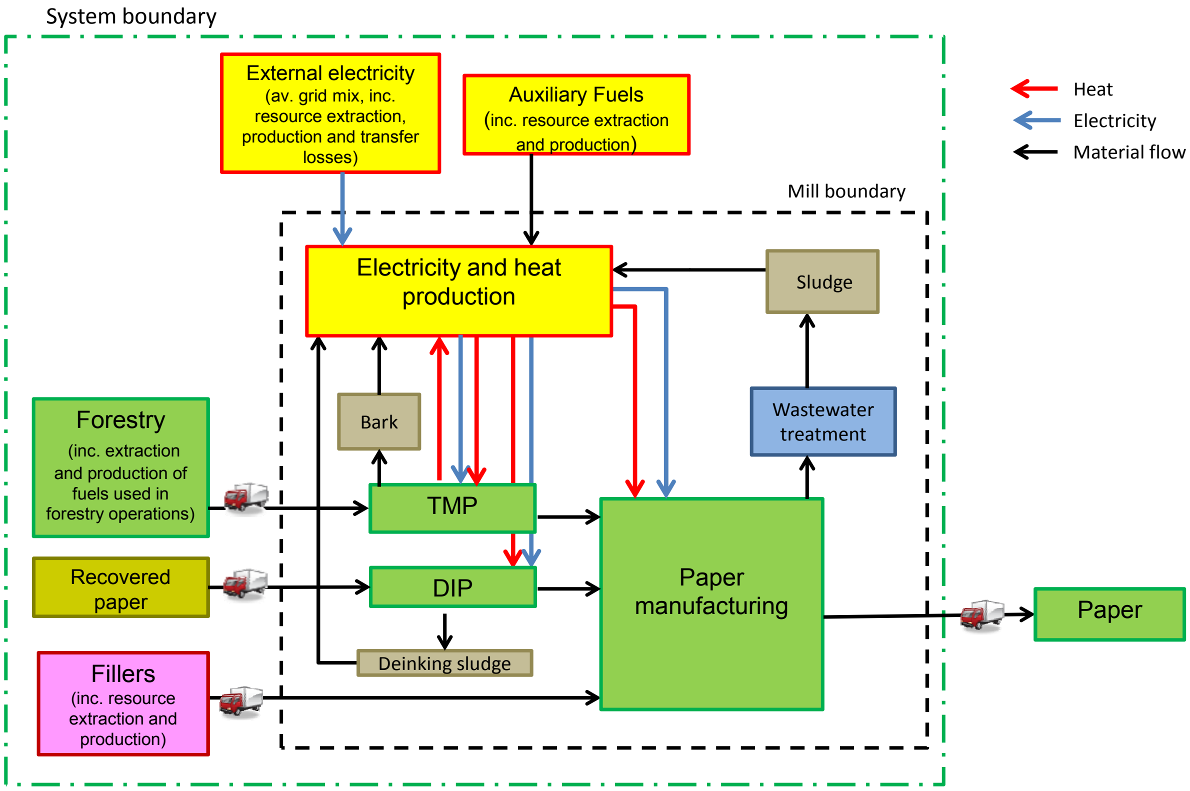


*Figure 12. Figure of paper mill agglomerate.*

Typically, newsprint is a paper with high bulk and good opacity. The paper is typically made by using machine calendaring without other surface treatment. It has traditionally been produced from mechanical pulp, but nowadays it is increasingly made from deinked pulp. Deinked pulp (DIP) is produced from recycled paper and the printing ink is separated from the fibres by means of a flotation process. Thermo-mechanical pulp (TMP) is made from wood chips that are treated in a TMP refiner, applying pressure and heat to separate the fibres. TMP also contains lignin from the wood. Fillers in newspaper are mainly clay and calcium carbonate (CaCO3) and their ratio depends on the paper manufacturer and the quality of the recycled paper. (Pihkola et al. 2010)

### 4.3.4 Coldset web offset printing

The selected print media are coldset offset printed newspaper products: Aamulehti, Aamulehti Sunday supplement, Iltalehti and Kauppalehti. The coldset presses are fast, with typical web widths of 0.6 to 2 meters. Newspaper printing is a local business with tight timetables. In the printing house, several printing webs are printed simultaneously, and the webs are combined to form the final product. The offset printing method is a very common but complex printing process in which the printing plate is divided into differing image and non-image areas by photochemical reactions (i.e. hydrophilic and hydrophobic areas). In the printing process, the plate is first dampened with a fountain solution, which adheres to the non-image areas of the plate. Secondly, the nip ink rollers apply ink to the image areas of the plate. The image on the plate is transferred via a rubber blanket to the paper under nip pressure. Inks used in coldset offset are mineral- or vegetable oil-based (data source: EcoInvent, which covers mixture of coldset offset, sheed fed offset and heatset offset ink). Inks do not dry, but rather set to the paper. The inks are delivered by ink tanks to printing house and from tank the ink is pumped to the printing press. The empty ink tank is recycled back to ink manufacturer to be refilled. The aluminium-based printing plates (97%) and maculature paper (100%) are recycled. (Oittinen et al. 1999, Viluksela et al. 2005)

### 4.3.5 Distribution

The delivery transport data for Aamulehti and Iltalehti was acquired directly from Alma Media. An exception was the delivery data for Kauppalehti, which was acquired directly from Itella.

Emissions from the delivery of Aamulehti and Iltalehti were modelled with the help of distances, modes of transport (used car/truck types), and transported newsprint amounts. In the case of Aamulehti and Iltalehti, results from the distribution phase include direct emissions from delivery driving, but also indirect emissions from the fuel manufacturing.

Concerning the distribution of Kauppalehti, only direct emissions from the fuel combustion during the distribution transport were included into the study. The data for the amount of fuel consumed during the transport was not available and for that reason the fuel manufacturing was left out.

In addition concerning the delivery routes, Aamulehti and Kauppalehti are mainly delivered to homes and offices while Iltalehti is delivered mostly to retailers. Unfortunately there is no accurate data or statistics available on how the readers pick up their printed newspapers from retailers (by car or by foot or picking up it with the other products or only the newspaper etc.). For this reason the evaluation of this part is excluded from the study.

### 4.3.6 End of life

The assumptions concerning end-of-life shares are based on the data collected from a Finnish paper recycling company and from statistics. In general, the paper-recycling rate in Finland is very high, but it is estimated that a small amount of newspapers is still disposed of in landfills or incinerated.

The following assumptions have been used in the calculations of printed media:

Recycling 79%
Landfill 16%
Incineration 5%

***Landfill***
The IPCC have provided estimations and recommendations on how the methane production and release from the landfills should be calculated. According to some researchers these are over-estimated for wood based products, due to the relatively high methane production potentials. In case of wood based products including lignin, it should be took into account that that the lignin is very durable against the bacterial attacks (both aerobic and anaerobic) under the landfill conditions (Barlaz 2006, Ximenez et al. 2008).

The landfill scenario was here chosen to be the calculation made for newsprint biogenic carbon content and its methane production potential developed by the Technical University of Denmark (DTU). It should be noted that the landfill module was prepared especially for newsprint and for that reason selected for this study. It is assumed that the landfill gases are collected efficiently and paper decays slowly at the landfill. Thus its emissions are remarkably lower than those of the landfill assessed with IPCC default values Due to the lignin content in the newsprint the degradation is slow, and the methane emissions from landfilling the newspaper waste at the Finnish landfills can be assumed to be somewhere in between the results gained with the models developed by DTU and IPCC. (Pihkola et al. 2010).

***Incineration***
The incineration process applied in the study is based on backpressure technology and is case specific for paper incineration. This means that the waste paper is burned with fluidized-bed technique among other fuels. In this case the cleaning of combustion gases with electrostatic precipitation has been taken into account, but the thermal loss caused by ash has been excluded from the study.

The incineration module applied in the study includes only the emissions from the paper incineration. It is assumed that the composition of waste paper input is: mechanical pulp 88%, kraft pulp11%, and pigments 1%. Calculated heat value for incinerated waste paper is 18.5 MJ/kg dry matter and data applied Finnish average from the year 1992.

***Treatment of recycled fibre***
After a fibre-based printed product is used, it can be recycled. Maculature from printing is also recycled and used as a raw material in either paper manufacturing or other industrial processes. It can be assumed that recyclable fibre is a co-product of the system and a methodological choice must be made of who gains the benefits of recycling. There are several ways of treating the recycled fibre and allocating the environmental load of manufacturing to that part of the fibre that can be reused again (see chapter on allocation). Here the sensitivity analyses describe the impacts of the different recycling scenarios.

***Avoided emissions***
When modelling the life cycle of a printed product, it can be seen that a printed product is not the only outcome of the system studied. As mentioned before, the system studied produces recyclable fibre. In addition, printed products can be combusted in a waste incineration plant in which the energy content of a product is utilized and the energy recovered, producing both electricity and heat. Electricity and heat are also produced in landfill micro-turbines. If it is assumed that the system studied produces not only printed products, but also recycled fibre and energy, benefits can be calculated for the system. A transparent way of calculating the benefits is accounting for avoided emissions. In this study, avoided emissions are emissions that are avoided either by replacing primary fibre in paper production or by replacing average electricity or heat production. Depending on, for instance, what kind of electricity is assumed to be replaced, the impact of avoided emissions might be significant. (Pihkola et al. 2010) The assumptions of the reference case and the sensitivity analyses are explained in more detail in the following chapters.

### 4.3.7 Reference scenario

The goal of the printed newspaper case studies was to examine the potential environmental impacts of the newspaper. Three different scenarios were studied in order to evaluate possible variations in the results. Here the scenarios are presented in more detail. The functional unit used in all scenario studies was *one copy of newspaper*. The system boundary of the reference case is presented in Figure 13.

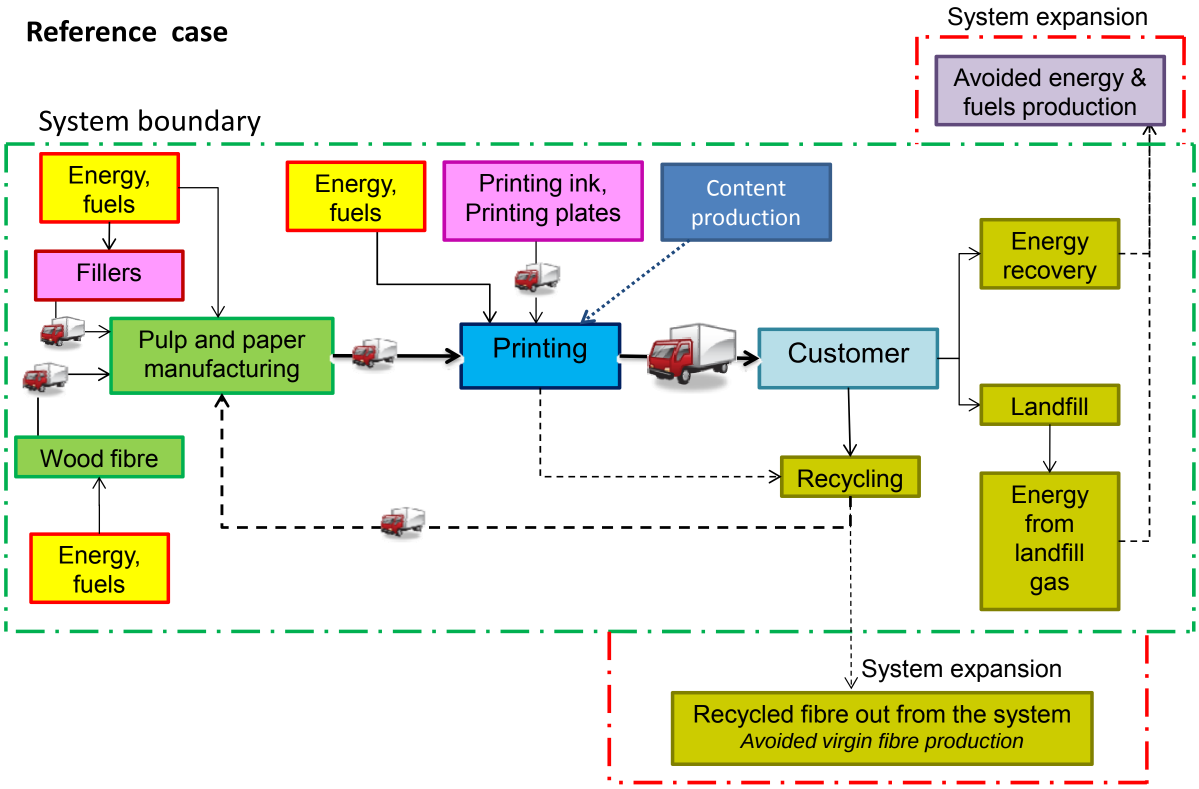


*Figure 13. System boundary of the reference case – system expansion applied.*

In addition to counting all potential environmental impacts in the reference cases, the potential avoided emissions were also determined. It was assumed that the recycled fibre replaces the production of virgin fibre in a corresponding system. It was also assumed that the system itself uses as much of recycled fibre as it needs in every specific newspaper production case, and only the surplus of recycled fibre is going out of the studied system (system expansion).

In case of surplus electricity at the landfill and incineration plant, it was assumed that it substitutes the production of Finnish average electricity.

#### 4.3.7.1 Printed Aamulehti

The goal of the printed Aamulehti case study was to examine the potential environmental impacts of the Aamulehti newspaper. The functional unit used in this study was *1 copy of the Aamulehti newspaper*. In the following Table 10 the assumptions in the reference case of Aamulehti newspaper are presented.

*Table 10. Case study assumptions for Aamulehti newspaper in reference case.*

| | |
|---|---|
| Print product | Aamulehti, 48 pages (broadsheet) |
| Printing | Coldset web offset |
| Paper | Newsprint 45 gsm 75.5%<br>Newsprint 48.8 gsm 4.3 %<br>Brite 68 48.8 gsm 20.2 % |
| Circulation | ~132 000 copies per day |
| Yearly subscription | 356 issues/ year |
| Weight (air dry) | 282 g / piece (including daily supplements) |

The study of printed Aamulehti was made including the daily supplements, but excluding the Sunday supplement.

#### 4.3.7.2 Printed Aamulehti Sunday supplement

The Aamulehti newspaper also includes the Sunday supplement. Table 10 below presents the assumptions in the reference case of the Aamulehti Sunday supplement newspaper. The goal of the printed Aamulehti supplement case study was the same as for the Aamulehti newspaper. The functional unit used in this study was *1 copy of the Aamulehti Sunday supplement.*

*Table 11. Case study assumptions for the Aamulehti Sunday supplement in reference case.*

| | |
|---|---|
| Print product | Aamulehti Sunday supplement, 24 pages (broadsheet) |
| Printing | Coldset web offset |
| Paper | Brite 68 48.8 gsm 100 % |
| Circulation | Approximately the same as for Aamulehti |
| Annual subscription | 51 Issues/year |
| Weight (air dry) | 119 g / piece |

#### 4.3.7.3 Printed Iltalehti

The goal of the printed Iltalehti case study was to examine the potential environmental impacts of the Iltalehti newspaper. Table 12 below presents the assumptions in the reference case of Iltalehti newspaper. The functional unit used in this study was *1 copy of the Iltalehti newspaper.*

*Table 12. Case study assumptions for the Iltalehti newspaper in reference case.*

| | |
|---|---|
| Print product | Iltalehti, 32 pages (broadsheet) |
| Printing | Coldset web offset |
| Paper | Newsprint 45 gsm 75.5%<br>Newsprint 48.8 gsm 4.3 %<br>Brite 68 48.8 gsm 20.2 % |
| Circulation | ~107 000 Copies / day |
| Annual subscription | 301 issues/ year |
| Weight (air dry) | 201 g / piece |

#### 4.3.7.4 Printed Kauppalehti

Table 13 presents the assumptions in the reference case of the Kauppalehti newspaper. The goal of the printed Kauppalehti case study was the same as for all the newspapers studied. The functional unit used in this study was *1 copy of the Kauppalehti newspaper.*

*Table 13. Case study assumptions for the Kauppalehti newspaper in reference case.*

| | |
|---|---|
| Print product | Kauppalehti, 19 pages (broadsheet) |
| Printing | Coldset web offset |
| Paper | Newsprint 45 gsm 75.5%<br>Newsprint 48.8 gsm 4.3 %<br>Brite 68 48.8 gsm 20.2 % |
| Circulation | ~70 000 copies/day |
| Annual subscription | 249 issues/year |
| Weight (air dry) | 96 g / piece |

### 4.3.8 Sensitivity analyses

In order to test the consequences of the choices made in the system boundary setting in reference cases, two sensitivity analyses were conducted. In the cut-off case presented in Figure 14, all potential avoided emissions were excluded from the study and no credits were calculated to benefit the system studied. System boundaries in the cut-off case represent the worst case scenario.

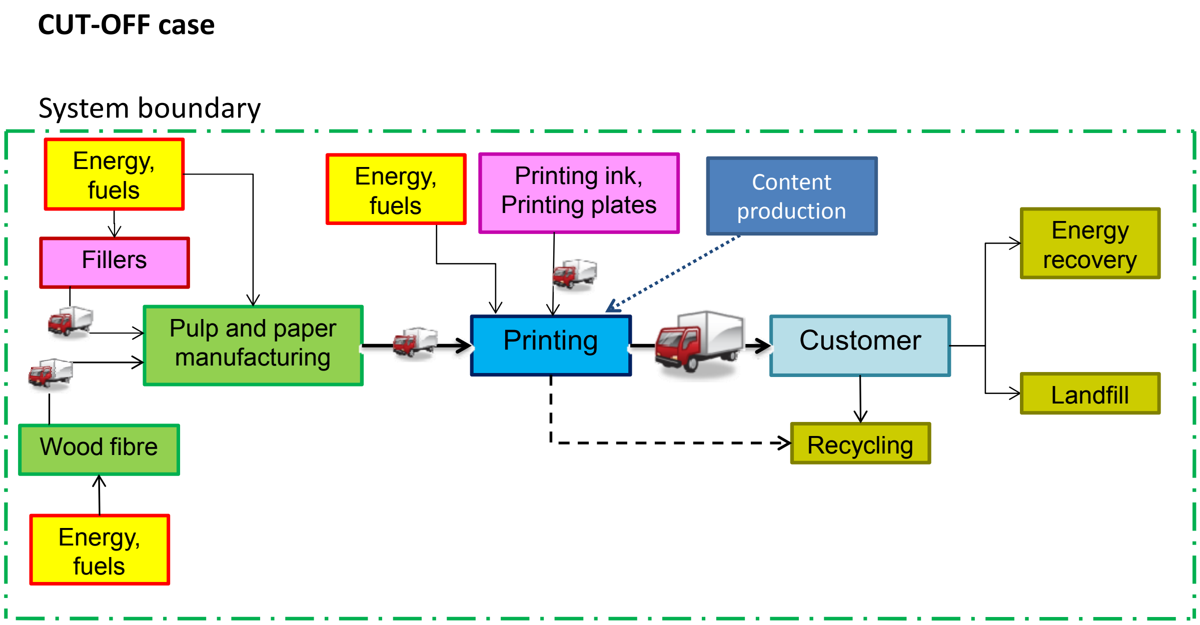


*Figure 14. System boundary of the cut-off case – without any credits from the end of life phase.*

The third scenario of system boundaries is presented in Figure 15. In addition to the system expansion, also mass based allocation was applied. It was assumed that maculature which is a by-product from the printing process, is used as a raw material in insulation manufacturing. For that reason, a newspaper-specific mass-based percentage of embodied environmental burden of the newspaper was allocated to maculature. System boundary setting in the mass based allocation case represents the best case scenario.

The allocation procedures are described in more detail in Chapter 4.5.2.

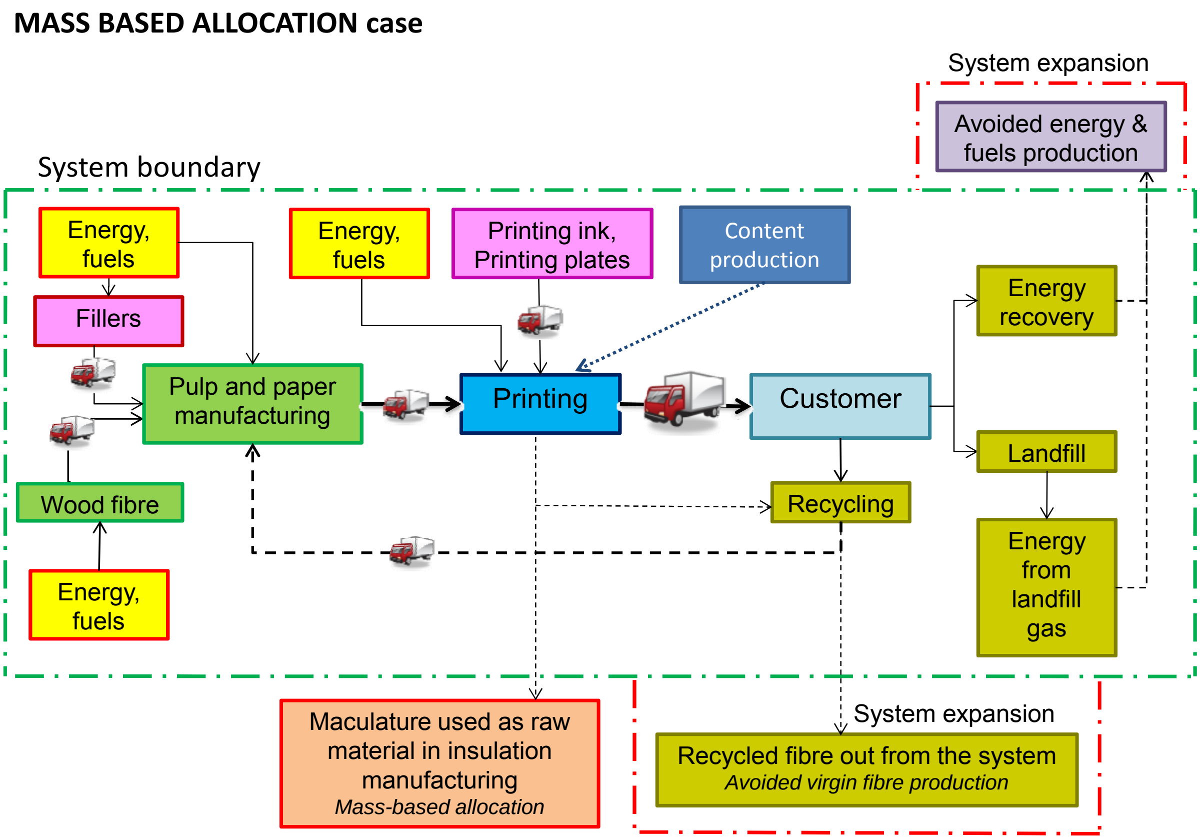


*Figure 15. System boundary of the mass-based allocation case – in addition to system expansion also mass-based allocation applied.*

## 4.4 Online media

### 4.4.1 Overview

The goal of the online newspaper case studies was to examine the potential environmental impacts of the online newspapers. The functional units used were "*one year online newspaper production", "one reader for one week"* and *"one reading hour"*. Three different functional units were used in order to show the impact of the overall production and reading of the newspaper per year, the impact of one reader regularly reading an online newspaper during the week, and the impact of reading an online newspaper for one hour. These different functional units provide an opportunity of showing the importance of the number of readers and the duration of reading for the environmental impact per benefit provided, and how results are presented. The life cycle of the online newspaper includes content production, electronic distribution, and reading. For details on the content production, see Chapter 4.2. The electronic distribution and reading system includes the servers with the supporting network, internet infrastructure and readers' equipment as well as the electricity consumption in the different parts of the system. (Figure 16)

The systems studied are:

- Aamulehti.fi
- Iltalehti.fi, excluding TV streaming and programs, recipes and games
- Kauppalehti.fi, excluding business information services, real estate, renting business

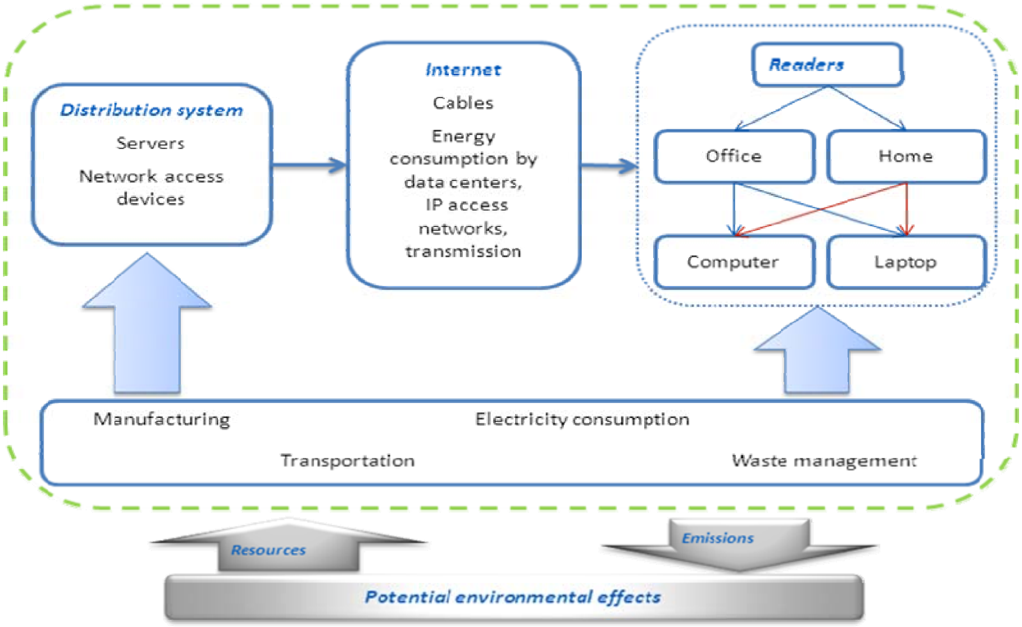


*Figure 16. Online distribution and reading system.*

The components of the system and the processes included are covered in Table 14 and described below.

*Table 14. Online distribution and reading system.*

| Description | Processes included | Limitations | Reference |
|---|---|---|---|
| Sub-system: servers for online distribution | | | |
| Alma Media servers with network access devices for online newspaper distribution | Server and network access device manufacturing (including raw materials extraction), transportation, electricity consumption during use and end of life including recycling | Uncertainty in estimations of electricity use.<br>Manufacturing of servers is assumed to equal the manufacturing of 2 desktop computers. | Alma Media<br>LIPASTO<br>World airport codes, 2011<br>Sea route&distance, 2011<br>Hischier et al. 2007a<br>Hischier et al. 2007b<br>Google maps, 2011 |
| Sub-system: internet infrastructure | | | |
| Internet infrastructure operation | Raw materials used for cable manufacturing but no manufacturing itself, maintenance.<br>Electricity consumption by the IP access networks and transmission in core network | Swedish data used, might mean a slight underestimation on electricity use per MB data transmitted.<br>No data on manufacturing of the network parts (e.g. routers). | Alma Media<br>Lundén 2011<br>Malmodin 2011 |
| Sub-system: reading | | | |
| Reading from office and home, from desktop and laptop | Manufacturing of the reading devices (desktop and laptop + screen, keyboard and mouse at the office and for desktops at home), including raw materials extraction, their transportation and end of life, including recycling.<br>Electricity consumption by the equipment, including the relevant share of the electricity consumed during non-active use time. | Generic data for manufacturing of desktops, laptops and screens are from years 2002-2004 and thus the impacts may be different in current production.<br>High uncertainties regarding environmental impacts resulting from end of life treatment.<br>Assumptions regarding use patterns will inherently lead to uncertainty. This is tested in sensitivity analysis. | Alma Media<br>Statistics Finland, 2010<br>LIPASTO<br>World airport codes, 2011<br>Sea route&distance, 2011<br>Google maps, 2011<br>Hischier et al. 2007a<br>Hischier et al. 2007b |

### 4.4.2 Electronic distribution

The online newspaper distribution life cycle stage includes the newspapers' uploading of new information for the website to the server and then the readers' accessing information from the website. The main components of the system are Alma Media specific servers, network access devices and generic internet infrastructure. The overview of the system and its boundaries is presented in Figure 17.

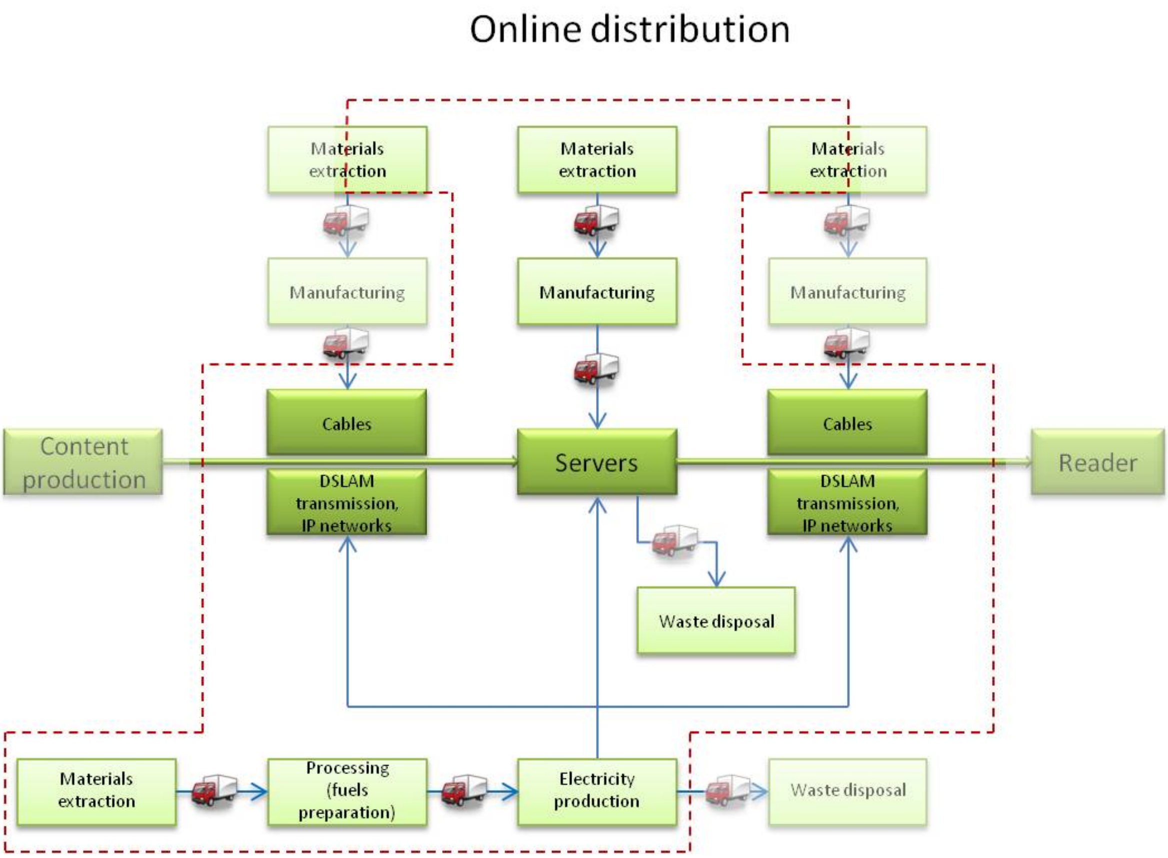


*Figure 17. Online distribution system boundaries. Processes within the dotted line are included in the study.*

In the case study servers manufacturing, transportation of servers to the data centre and electricity consumption over the life time are taken into consideration. In addition, manufacturing and electricity consumption of network access devices was covered.

The Alma Media servers for the electronic distribution are located in subcontractors' premises, and are part of a new data centre with a highly efficient cooling system, according to Niilo Ursin, Kauppalehti (personal communication, 2011.09.07). The number of servers and/or their shares was given by the respective newspapers. It was not possible to obtain specific data for the electricity consumption of the servers; therefore, it was calculated assuming the power draw of the server as 180 W and that it is "on" all the time, and then modified by a factor of 1.3 (Taylor and Koomey, 2007; personal communication with Malmodin and Lunden, 2011.08.06) in order to cover the electricity consumption of supporting network and cooling. The electricity use of access network devices was estimated to 0.043 kWh/hour, always on, based on personal communication with Malmodin (2011).

Manufacturing of the devices (servers and network access devices) was assessed using Ecoinvent data in the same way as for electronic equipment (see Section 4.2).

Internet infrastructure includes data for materials for manufacturing and maintenance of the cables as well as electricity consumed by the access network, i.e. digital subscriber line access multiplexer (DSLAM), and IP core network. The electricity consumption by the internet for the respective online newspapers is calculated in relation to MB of information transmitted, taking into account the size of the daily uploads by the newspaper and the size of the average download per visit. The electricity use by the internet is based on Swedish figures provided by TeliaSonera (D. Lundén personal communication) and is probably a slight underestimation for Finnish conditions.

### 4.4.3 Reading

The online newspaper reading life cycle stage includes the readers' accessing of the information from the website, using their computers. This stage covers the manufacturing of computers used for reading, their transportation from the plant to the user, and the electricity consumption by computers allocated to the reading. The Figure 18 shows the system and its boundaries in more details.

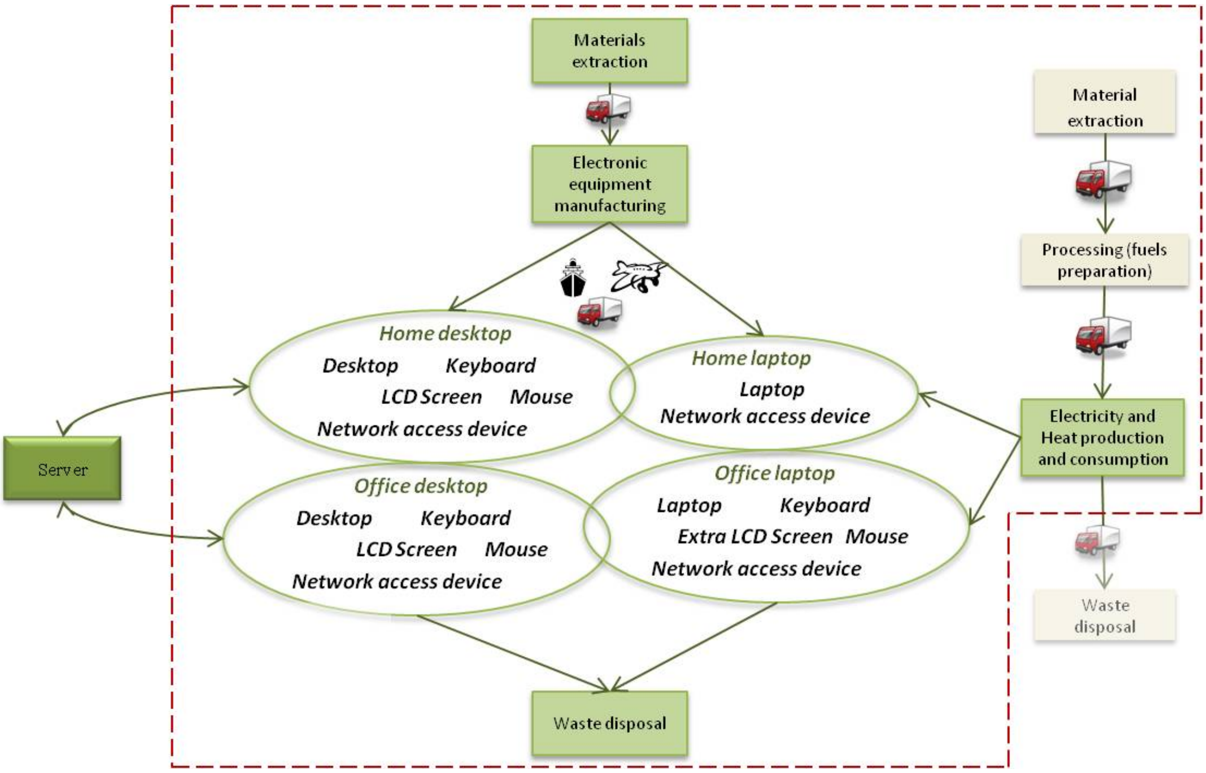


*Figure 18. Reading. Processes within the dotted line are included in the study.*

***Reader profiles***

Reading part of the system for the online newspaper takes into account the readers' location (home or office), electronic device (desktop or laptop), total computer use, frequency of visits to the specific online newspaper website and time spent per visit. The specific information for each newspaper is presented in the Table 15.

*Table 15. Aamulehti.fi, Iltalehti.fi and Kauppalehti.fi reader profiles.*

| | AL | IL | KL | |
|---|---|---|---|---|
| Number of visitors | 237 196 | 1 796 684 | 615 354 | visitors/week |
| Number of visits per visitor | 2.6 | 6.7 | 3.6 | number/week |
| Time spent per visit | 02:20 | 01:20 | 02:57 | min/visit |
| Reading time | 6 | 9 | 11 | min/week and reader |
| Average size of download | 0.6 | 15 | 2.72 | MB/visit |
| Total download | 2 | 100 | 10 | MB/week and reader |
| Average size of a daily upload | 22.6 | 13.5 | 745.4 | MB/day |
| User location , home | 51 | 58 | 39 | % |
| User location , work place | 49 | 42 | 61 | % |
| User device , desktop computer | 54 | 55 | 52 | % |
| User device , laptop | 46 | 45 | 48 | % |
| Total computer use , at home | 17 (8.6 hours/ person) | | | hours/week |
| Total computer use , at work | 37 (8 hours per day, 240 days per year) | | | hours/week |
| Desktop lifetime | 6.6 | | | years |
| Laptop lifetime | 5.6 | | | years |
| Screen lifetime | 6.6 | | | years |

The number of unique visitors and number of visits per unique visitor was provided by each newspaper representative based on Alma Media statistics (TNS Gallup, 2010). Based on the statistics of the websites visits (number of people per hour) during a week, user location was estimated with the assumption that office hours are 8.00 to 17.00 and everybody reading the newspaper during these hours is assumed to be at the office. This is a rough estimation and some people will read the online news from home during those hours and some will read the online news at the office during other hours. However, no information was available about this specifically.

User device percentage, i.e. the share of desktops and laptops respectively, is based on each newspaper's user survey. Mobile reading devices, such as smart phones and tablets, were not considered, which according to the Alma Media surveys account for some 17% of reading online newspapers. Total computer use in a household was derived from Finnish statistics (personal communication with Melkas, 24-10-2011), combining the information about the average duration of computer use in Finland (8.6 hours per person and week) and the average number of people in a household (2 people). We assumed one computer per household on average.

No Finnish statistic data was available for the total computer use at the office. It was assumed to be equal to office hours – 8 hours per day, 240 days per year. Desktop and laptop life time is based on IVF (2007)

Reading time per visit was obtained from Alma Media, and total reading time per week takes into account the number of visits per visitor and week as well as the reading time per visit. It can be noted that the reading time per week is relatively short, compared to the KMT (2011) study reporting an average of 11 minutes per day for online newspapers and magazines by Finnish people.

In order to calculate the environmental impact from the reading of the online newspaper, the following issues were taken into account:

- User device manufacturing, transportation and end of life, including recycling
- Reading time

- Time spent in reading a newspaper as a share of the total active use time for the device over its whole lifetime
- Electricity consumption by the user devices (desktop/laptop and network access device) during reading and during non-active use time

The following sets of user devices are considered in the study:

- Home desktop with LCD screen (17 inch), keyboard, mouse, network access device
- Home laptop with network access device
- Office desktop with LCD screen (17 inch), keyboard, mouse, network access device
- Office laptop with extra LCD screen (17 inch), keyboard, mouse, network access device

For the more details about modelling of manufacturing, transportation and end of life of the electronic equipment see chapter 4.2 and Hischier et al. 2007a and 2007b.

Electricity consumption by computers and screens was calculated based on the data from IVF (2007), taking into account electricity consumption in the on, sleep and off modes and then redistributing it over the hours of active use. Electricity consumption of desktop, laptop and screen in various modes are presented in the Table 16.

*Table 16. Electricity consumption of desktop, laptop and screen (from IVF 2007).*

| | home | | | office | | | |
|---|---|---|---|---|---|---|---|
| | Laptop | Desktop | Screen | Laptop | Desktop | Screen | |
| On mode | 44.4 | 123 | 40.5 | 83.6 | 179 | 81.2 | kWh/year |
| Sleep mode | 8.71 | 6.32 | 2.37 | 8.99 | 7.03 | 3.42 | kWh/year |
| Off mode | 6.70 | 11.6 | 3.87 | 4.73 | 8.87 | 1.9 | kWh/year |

### 4.4.4 Sensitivity analyses

In order to test some major assumptions and methodological choices, three sensitivity analyses were carried out. These regard the recycling of metals from electronic waste, the total use of home computers, the service life of a computer and the inclusion of long-term emissions in the assessment.

***Increased computer use***
The environmental impact related to reading an online newspaper consists of environmental impacts related to the electricity consumed by the electronic device, but also a share of the environmental impacts from manufacturing the devices. How large this share is depends on the overall use of the device. The share is calculated as the active use time for reading the online news divided by the active use time of the device over its whole life. Thus, it is of great importance how many people use one computer or how many hours per day the computer is used. The higher the total computer use, the lower is the share for the online newspaper reading.

In the reference scenario, Finnish average figures for computer use in households were used. This means that there are computers that are used more and less than this. In a sensitivity analysis we tested this assumption by running the analysis with a total computer use at home four times higher than that in the reference scenario (this means about 10 hours per day and computer, or 5 hours per day per person). This describes a case with a very high computer use, and is presented to illustrate how this high total use would influence the overall results for the online newspaper.

***Shorter service life***
The electronic devices may also be used less, for example if the service life is shorter than in the assumptions in the study. In a sensitivity analysis, we altered the service life of the electronic devices (desktop, LCD screen and laptop) of the end-consumers to three years. Keeping the same hours of

active use per computer as in the reference case, this means roughly halving the total active use time of the electronic devices during their service life.

***Cut-off***

The original recycling processes of electronic devices as Ecoinvent data are implemented in the SimaPro software was modified for this study to account for the benefits of metals recovery (described in 4.2.2). This lead to some uncertainty, since this modification included some assumptions. As it has proved that manufacturing of electronic devices gives rise to a significant part of the potential total environmental impact of the systems studied, it was decided to test how important the inclusion of the recycling and avoided virgin production, with the assumptions made, is for the overall results. This was done in a sensitivity analysis in which the waste treatment process of recycling of electronic equipment is cut off immediately after the components bound for recycling are separated. No environmental burdens related to the recycling process or benefits from the material recovery and avoided virgin production are taken into account, since all of those burdens recycling are considered to be allocated to the production process. This is the way the processes are given in SimaPro.

***No long-term emissions***

In the reference scenario, all emissions are included in the system boundaries. When long-term emissions were inventoried, e.g. for manufacturing of electronic devices, these form part of the assessment. For some of the impact categories, the contribution from these long-term emissions is considerable. There are some uncertainties regarding these, and there are also different opinions on the methodological choice of including long-term emissions. In a sensitivity analysis, we wanted to test how this influences the overall results, and we assessed the systems excluding long-term emissions.

## 4.5 Allocations

Some of the processes in the systems studied provide more than one product or service, which leads to a multi-output allocation problem. This is the case for e.g. the sawmill, printing plant, internet system used for online distribution, for computers used for reading the online newspapers, for the recycling of parts of the electronic devices, content production. There are different ways to carry out an allocation. Guidelines are given in the ISO 14040-44 standards on what principles the choice of allocation should be based on. In addition, a short description is given in 3.1.

### 4.5.1 Content production

All processes included in the content production sub-system and the environmental impact related to these were split between the print and online versions of the respective newspapers based on number of full-time employees (FTE) (see chapter 4.2).

When recycling electronic devices, parts of the materials are recycled into new material, which may be used in new production processes. In this study, this additional output from the system studied is handled by so-called closed loop recycling and system expansion. This means that, when recycled material is used as input to the manufacturing of the components and devices concerned in the study (i.e. as proposed in the Ecoinvent datasets), recycled material resulting from the end of life processes within the systems studied is modelled as used within the system, a “closed loop”. If a larger amount of the material is recycled than the amount used in the manufacturing, the extra amount of recycled material is handled by system expansion. This means that the recycled material is assumed to be replacing some other material, in this case material of the same kind but with virgin origin. The environmental impacts of producing the material from virgin sources are credited to the system studied, i.e. becoming avoided impacts through recycling of material. In one of the sensitivity analyses, the end of life allocation problem is handled in another way (see 4.4.4).

### 4.5.2 Printed media

**Wood fibre production:**
The environmental burdens of forestry operations were volume-based, allocated between logs and fibre wood. Fibre wood is the wood used for pulp manufacturing.

**Sawmill:**
Allocation between sawn timber and chips was made based on mass for the specific process steps at the sawmill that refer to chips manufacturing. (Jungmeier et al. 2001)

**Printing plant:**
The maculature and waste paper was in the reference case closed loop allocated within the system.

In the mass-based allocation scenario, the environmental burdens were mass-based, allocated between printed newspaper and maculature. The maculature percentage differed between the newspapers studied from 8–20%. The highest share of maculature was produced when printing the AL Sunday supplement, because it is a cut tabloid. The allocation here means that from cradle to printing plant all the environmental burdens are shared between newspaper and maculature depending on the percentage, e.g. 8% for maculature and 92% for newspaper.

Printing plates:
Printing plates in newspaper manufacturing are manufactured from primary aluminium. Data on aluminium is based on the LCA study of the European Aluminum Association (EAA 2008) and the data received from the EAA. In addition, the manufacturer of the plates used at Alma Media gave carbon footprint information related to their plate product and it was used to verify the quality of EAA data. Printing plates are manufactured 100% from primary aluminium. Printing houses recycle the plates very efficiently. In this study, it was assumed that 97% of printing plates are recycled and the loss in the recycling process is about 0.7%. Open-loop allocations were used, because the further use of recycled printing plates was not known exactly. Open-loop allocation gave an allocation factor of 13.6% for the primary aluminium, and the rest (86.4%) of the inputs and outputs are allocated to the recycled printing plates. The allocation percentage for recycled aluminium is rather high due to the high recycling rates and good recyclability of aluminium. In general, aluminium enjoys high recycling rates at the European level, e.g. approximately 90–95% for transport and construction applications. Comprehensive systems for the recovery of used aluminium now exist in all major European countries (EAA 2007). In Finland, Kuusakoski Oy has manufacturing facilities for secondary aluminium ingots. They are tailor-made for customers from recycled metals. The main utilization areas are the automotive and electronics industries. Offset printing plates are good raw material for ingots, because of their low-alloy properties. Partly, the offset plates are delivered directly to industry in Finland and abroad for use as raw material. (Kuusakoski Oy 2010.)

**Recycled fibre:**
In the study, it was assumed that 79% of newspapers are recycled after use. As Figure 13 shows, recycled fibre can be re-used in the system, because the newsprint studied is manufactured partly from recycled fibre. The system studied produces more recycled fibre than it uses, and therefore a small share is allocated out of the system studied by open-loop allocation. The principles of open-loop allocation can be found in ISO standard 14044.

**Energy generated at end of life:**
Newspaper is recycled, disposed to landfill or disposed to energy waste after being read by consumers. As a newspaper decays in a landfill, it produces landfill gas – this gas can be collected and burned in a flare without energy recovery, or its energy content can be utilized. As previously mentioned in Chapter 4.3.6, it was assumed that landfill gas is combusted in a micro-turbine that produces heat and electricity. In addition to landfilled newspaper, a small proportion of newspapers end up in waste incineration plants that produce heat and electricity. All of the electricity produced is utilized in the system studied. When it comes to heat, the system uses less auxiliary heat than it

produces, and therefore it was assumed that the heat produced replaces average Finnish heat production (system expansion).

### 4.5.3 Online media

In the online newspaper product system, the electronic devices as well as the internet distribution system are used for many purposes. For the internet system, the environmental impacts modelled are split between different kinds of use, based on the total amount of data transferred in the system (in MB). This means that, irrespective of the reason for transferring data or what kind of information is transferred, each MB will account for the same amount of environmental impact.

For computers and related equipment, the environmental impact related to the manufacturing, transportation and end of life is split on the total active use of the devices. This means that only the time that the device is assumed to be actually used bears the environmental burden of manufacturing, transportation and waste management. Then the time using the computer for reading the online newspaper will be given its share of the impact based on the time of active use for this specific purpose. Similarly the total electricity use for operation (active mode, stand-by mode and off mode) is split on the active use time.

In addition, when recycling electronic devices some of the metals and other material are recycled into new materials, which may be used in new production processes. How this is handled in the study is described above (4.5.1).

## 4.6 Limitations

As in all LCA studies, there are some limitations and data gaps in the current study. These are presented below, and some also mentioned in the text above.

### 4.6.1 Generic and Specific data

In this study, both generic data from commercial databases and specific information from Alma Media and their suppliers was used. In some cases specific data has been the best choice, i.e. for the production of paper used in the printed newspapers, for the specific printing office and content production and for producing the district heating used in the offices, but in other cases generic data has been the best choice, e.g. when modelling the manufacturing of the readers' computers.

However, there are pro's and con's with both generic and more specific data. Specific data may be less comprehensive than the generic and the generic less correct and case specific. An example where the choice of data is not straight-forward is the case when site-specific data is used for paper manufacturing and heat production (district heating for offices) and Finnish data is used for transportation, distribution and electricity production. In these cases we have used data, which are more correct for the specific site or Finnish conditions, but which are less comprehensive regarding scope and number of emissions inventoried.

Concerning paper manufacturing the emissions provided by the manufacturer is limited to emissions to air from fuel combustion and main emissions to water. For these emissions the data are very valid, however some emissions that are not observed by the paper manufacturer may be missing and data gaps may exist. An example of this is the heavy metal emissions rising from the paper manufacturing. In case of Kaipola the main source of heavy metals are burning of wood based materials, such as bark and wood residuals, burning of peat, burning of deinking and wastewater treatment sludges (where the metals are combined into the DIP sludge and primary sludge). In this case, the dissolving amounts of metals are calculated instead of measuring and therefore left out of the scope. Notable is that the bottom ash from the incineration plant (fuels: peat, wood residuals, bark, DIP sludge, and primary sludge from wastewater treatment) fulfils the requirements for fertilizer (Regulation (EC) No. 2003/2003) and is used e.g. soil improvement purposes in cultivation. (Juntunen 2012)

For transportation, Finnish data are used to reflect the specific conditions for transportation within Finland. However, these data only cover some emissions from the operation of vehicles and environmental impact related to the production of fuel. This means that the production and maintenance of the vehicles and infrastructure is not considered, and the range of emissions considered is somewhat limited. Thus, the environmental impacts related to transportation may be slightly underestimated.

Even more limited is the data for distribution of mail and for distribution of Kauppalehti. Data provided by Itella only covers emissions of $CO_2$, CO, HC, $NO_x$, $SO_2$ and PM and only covers emissions related to the operation of the vehicles; no fuel production included.

Overall the use of specific data seems to lead to the focus of a certain range of emissions, often emissions leading to toxicity impacts seem to be missing, thus, contributing to the uncertainty in the results for these impact categories. Thus, continuous improvement of the specific data is needed in order to evaluate comprehensively and decrease several environmental impacts of a specific product.

### 4.6.2 Data availability

For some electronic devices, the manufacturing data are limited. In these cases, the available data was used as an estimation. The manufacturing of servers is assumed to equal the manufacturing of two desktop computers; the manufacturing of a copier or a scanner is assumed to equal the manufacturing of an office printer; the manufacturing of a large network access device in a data centre is assumed to equal the manufacturing of a desktop. The LCD screens manufacturing data available in the database were for 17-inch screens, which are rather smaller than those actually used in the offices of Alma Media; however, the data were not scaled, as it is not clear how this should be done. This means that the environmental impact related to manufacturing of screens may be slightly underestimated.

No new data was easily available for the manufacturing of electronic devices, so the data provided in the Ecoinvent database describing the production processes in 2002-2004 was applied. The environmental impacts in today’s manufacturing may be different, but we use these data to indicate the potential environmental impacts.

For mobile phones, data were only readily available for carbon dioxide emissions (Bergelin, 2008). The data for TV sets covers limited emissions to air and water from manufacturing, distribution, and disposal (Fraunhofer 2007). These devices used for newspaper content production and the related environmental impacts are assumed to be small in relation to those related to computers and screens at the newspaper offices.

Due to the lack of specific Finnish data, Swedish data, provided by TeliaSonera, was used for estimating electricity use for transmission of data in the internet access and core system. This might be a small underestimate in terms of electricity consumption, as the Finnish internet system is spread over a larger number of different operators.

Specific data for servers’ electricity consumption was not available and therefore calculated through combination of an assumption of the server power draw (180 W) and working regime (24 hours, 365 days per year), information from Taylor and Koomey (2007) and personal communication with Jens Malmodin (Ericson) and Dag Lunden (TeliaSonera).

Data on resource use and emissions related to e-waste handling, incineration and recycling, are not easily available for Finland specifically, and the Swiss data provided in the LCA database Ecoinvent are used. Some major assumptions were necessary in order to use these data for our purposes, and this added further to the uncertainties related to the assessment of the disposal of electronic equipment.

### 4.6.3 Missing data

Data for manufacturing of faxes, stationary phones and iPads used at the newspaper offices were not available, and manufacturing office network equipment (cables, UPS, etc) was not taken into account. This is assumed to be of no relevance for the overall results.

### 4.6.4 Methodological issues

Some methodological choices can be considered as limiting the environmental assessment. It was necessary to make these choices as the data availability was limited. No construction or maintenance of infrastructure is included, except for the internet core and access networks. For these, the production of copper cables as well as optic fibre cables and their maintenance is covered.

# 5. Life cycle assessment results of Content production

In this section, the results of the LCA for the content production part are presented. These values represent the overall potential environmental impact related to the content production at each respective newspaper. The content production is split (shares are presented in 4.2) into content production for printed and online versions when these are assessed and included in both studied product systems.

## 5.1 Aamulehti

### 5.1.1 Carbon footprint

In Aamulehti content production, the major reason for climate change (a.k.a. Carbon footprint) is business trips, where travel by car and flights within Europe contribute most, followed by domestic flights (Figure 19). Also the generation of electricity and heat used in the office premises contribute to the climate change impact, as does manufacturing of office equipment. The environmental impact related to manufacturing is mainly caused by manufacturing of screens and desktops and to a lower degree laptops.

According to the study made, potential greenhouse gases emissons related to the Aamulehti content production are 840 tonnes/year (Figure 19). This is 3 tonnes/FTE.

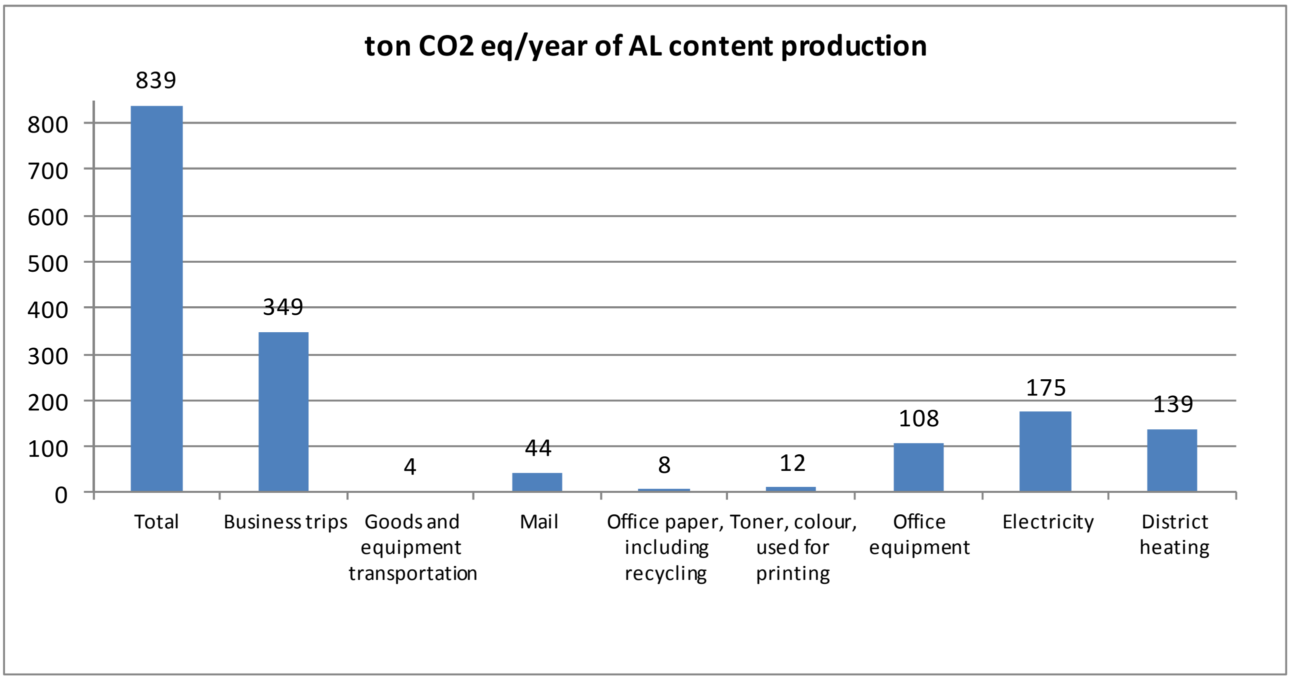


*Figure 19. Carbon footprint of Aamulehti content production per year.*

## 5.1.2 Other LCIA results

The reasons for the environmental impacts are different for the different types of impact categories assessed, which is illustrated in Figure 20. In this figure, the share of the total potential impact represented by the respective processes is shown. All total values are set to 100%. It should be noted that since all total values are set to 100%, a high share might be a high share of a small or high overall impact.

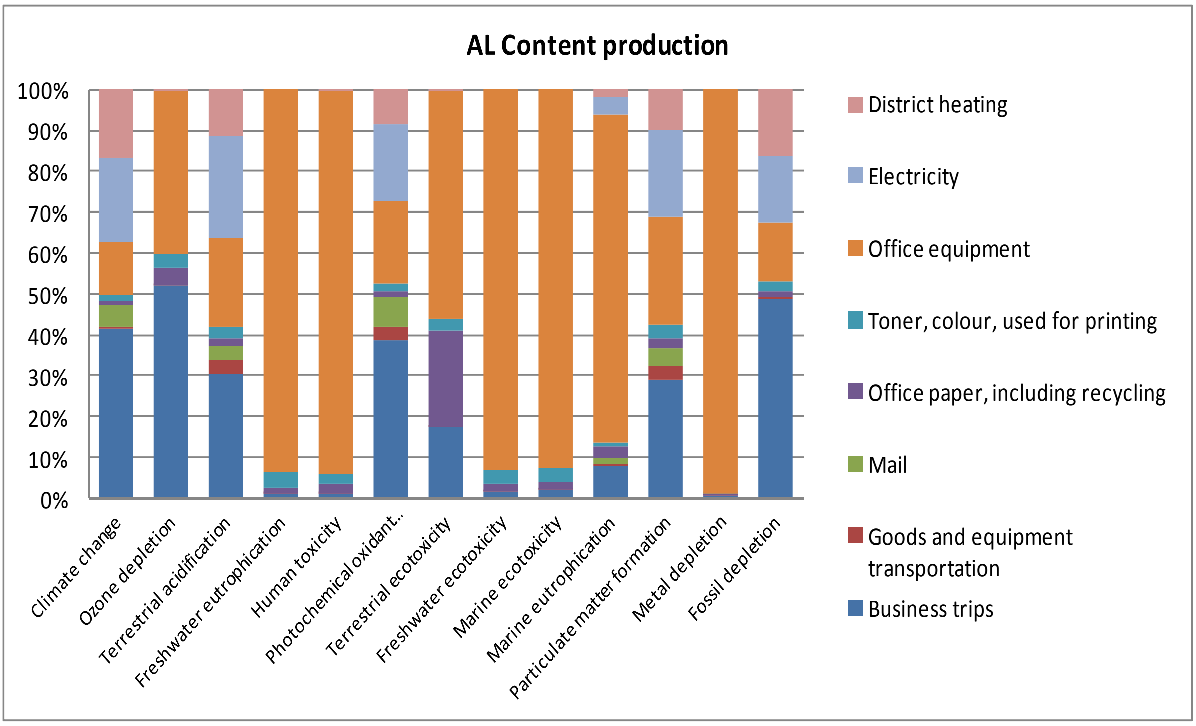


*Figure 20. Environmental impact potential of Aamulehti content production per year.*

Some impact categories show a similar pattern to the climate change impact category; the potential photochemical ozone creation, particulate matter formation, terrestrial acidification and fossil depletion are mainly caused by the same processes as mentioned for climate change.

The manufacturing of electronic devices is the major reason for several of the impact categories. The main contribution to the human toxicity, freshwater eutrophication, terrestrial ecotoxicity, freshwater ecotoxicity, marine ecotoxicity and metal depletion comes from the gold mining used for production of integrated circuits and PWB, which are parts of the LCD screens and desktops. The reasons for marine eutrophication, except for the gold mining for the integrated circuits manufacturing, are nitrogen compounds in the waste water effluent from the LCD module production, and lignite in the electricty mix used in the manufacturing.

Office equipment is also responsible for about 40% of the ozone depletion potential in the result of production of wafer (semi-conductor material used in integrated circuits) and use of natural gas in the electricity mix used for manufacturing. Another significant contributor to the ozone depletion potential is business travels, i.e. flights because of kerosene use.

For terrestrial ecotoxicity, the office paper used shows a rather major contribution to the overall potential impact, some 20%. This is mainly due to the use of rosin size in the process of recycling paper into newsprint.

It should be noted that the results for the toxicity impact categories are uncertain. By including these impact categories the aim is to illustrate that there are other impacts than climate change and that the major reason for these other impacts may be different than for climate change.

## 5.2 Iltalehti

### 5.2.1 Carbon footprint

In Iltalehti content production, the major reasons for climate change are business trips, generation of electricity and generation of district heating both used in the office premises (Figure 21). The major contribution to the climate change potential of the business trips comes from car journeys. To a lesser extent long-haul flight and flights within Europe also contribute to this impact. According to the study, potential greenhouse gas emissons related to the Iltalehti content production are 490 tonnes/year (Figure 21). This is 2.7 tonnes/FTE.

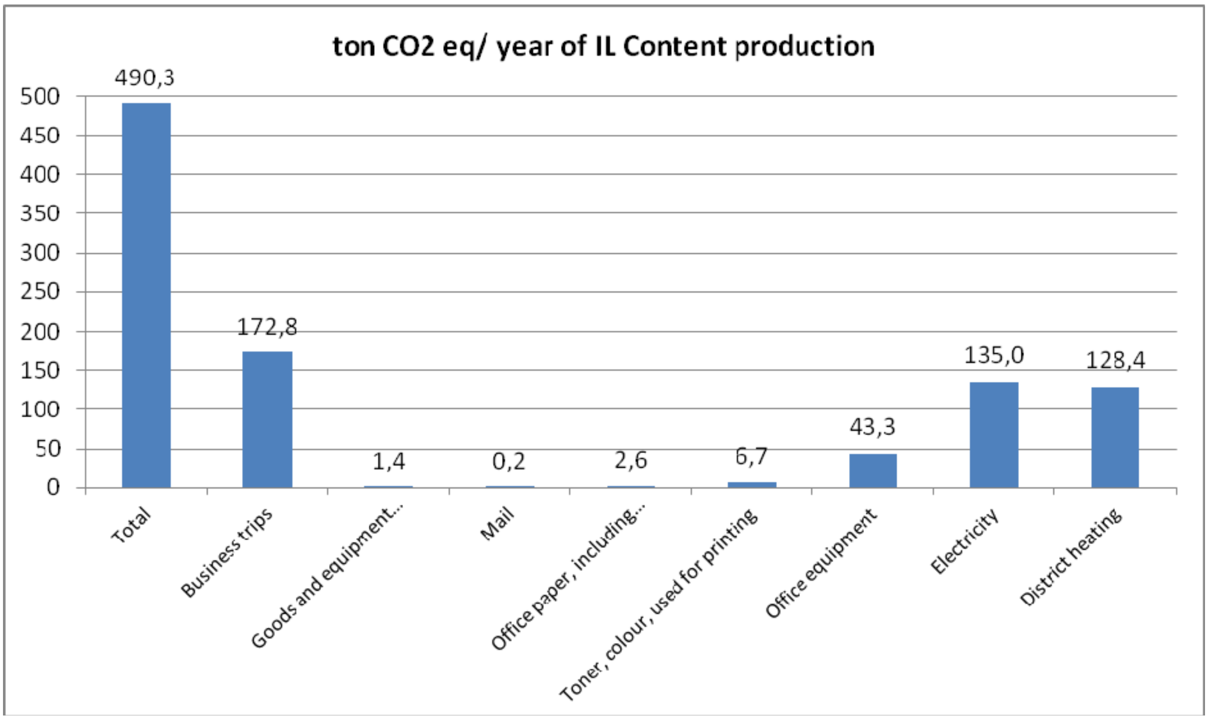


*Figure 21. Carbon footprint of Iltalehti content production per year.*

### 5.2.2 Other LCIA results

The reasons for environmental impacts from content production are different for the different types of impact categories assessed (Figure 22). In this figure the share of the respective processes' as part of the total potential impact for each category is shown. All total values are set to 100%. It should be noted that since all total values are set to 100%, a high share might be a high share of a small or high overall impact.

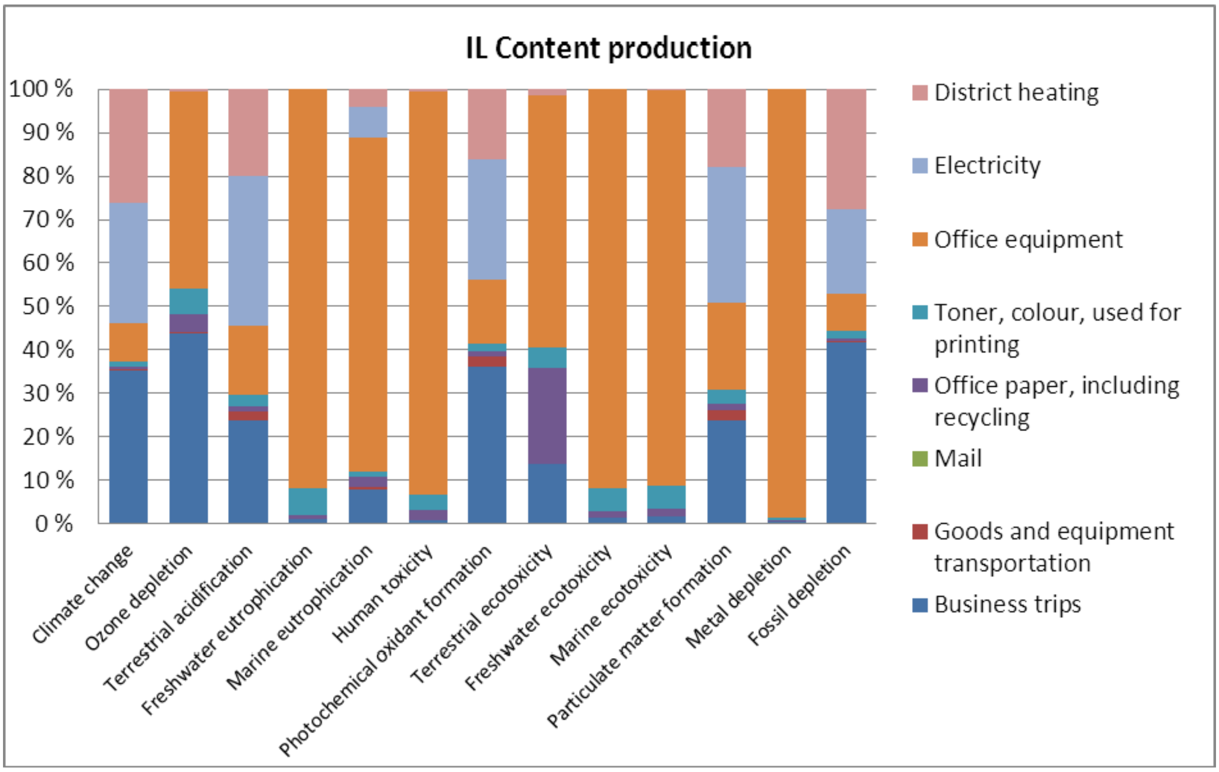


*Figure 22. Environmental impact potential of Iltalehti content production per year.*

The impact category fossil depletion shows a similar pattern to the one for climate change. Other impact categories have the same major processes, with the addition of manufacturing of office equipment. These impact categories are  photochemical ozone creation, particulate matter formation and terrestrial acidification. The environmental impact related to manufacturing of office equipment is mainly caused by the manufacturing of screens and desktops ,and to a lesser degree laptops.

The manufacturing of electronic devices is the major reason for several of the impact categories. The main contribution to the human toxicity, freshwater eutrophication, terrestrial ecotoxicity, freshwater ecotoxicity, marine ecotoxicity and metal depletion comes from the gold mining used for production of integrated circuits and PWB, which are parts of the LCD screens and desktops. The reasons for marine eutrophication, except for the gold mining for the integrated circuits manufacturing, are nitrogen compounds in the waste water effluent from the LCD module production, and lignite in the electricty mix used in the manufacturing.

Office equipment is also responsible about 45% of the ozone depletion potential in the result of production of wafer (semi-conductor material used in integrated circuits) and use of natural gas in the electricity mix used for manufacturing. Another significant contributor to the ozone depletion potential is business travels, i.e. flights because of kerosene use.

For terrestrial ecotoxicity, the office paper used shows a rather high contribution to the overall potential impact, some 20%. This is mainly due to the use of rosin size in the process of paper recycling into newsprint.

It should be noted that the results for the toxicity impact categories are uncertain. By including these impact categories the aim is to illustrate that there are other impacts than climate change and that the major reason for these other impacts may be different than for climate change.

# 5.3 Kauppalehti

## 5.3.1 Carbon footprint

In Kauppalehti content production, the major reasons for climate change (Figure 23) are business trips, generation of electricity and generation of district heating, both used in the office premises. The main reason for environmental impacts related to business trips is travel by car. The next biggest contributors are flights. It is also notable that mail is the reason for 7% of the potential climate change impact of Kauppalehti content production.

According to the study, potential greenhouse gases emissons related to the Kauppalehti content production are 450 tonnes/year (Figure 23). This is 3 tonnes/FTE.

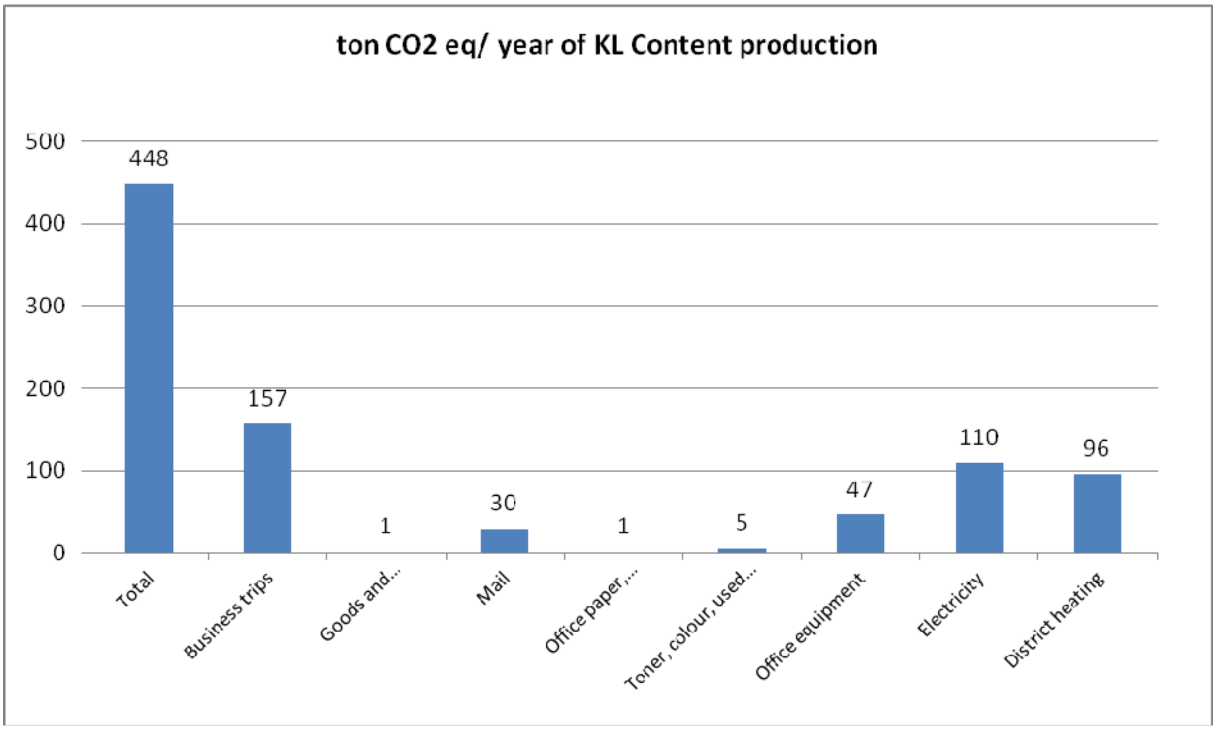


*Figure 23. Carbon footprint of Kauppalehti content production per year.*

## 5.3.2 Other LCIA results

The reasons for the environmental impacts are different for the different types of impact categories assessed, which is illustrated in Figure 24. In this figure, the share of the respective processes as part of the total potential impact for each category is shown. All total values are set to 100%. It should be noted that since all total values are set to 100%, a high share might be a high share of a small or high overall impact.

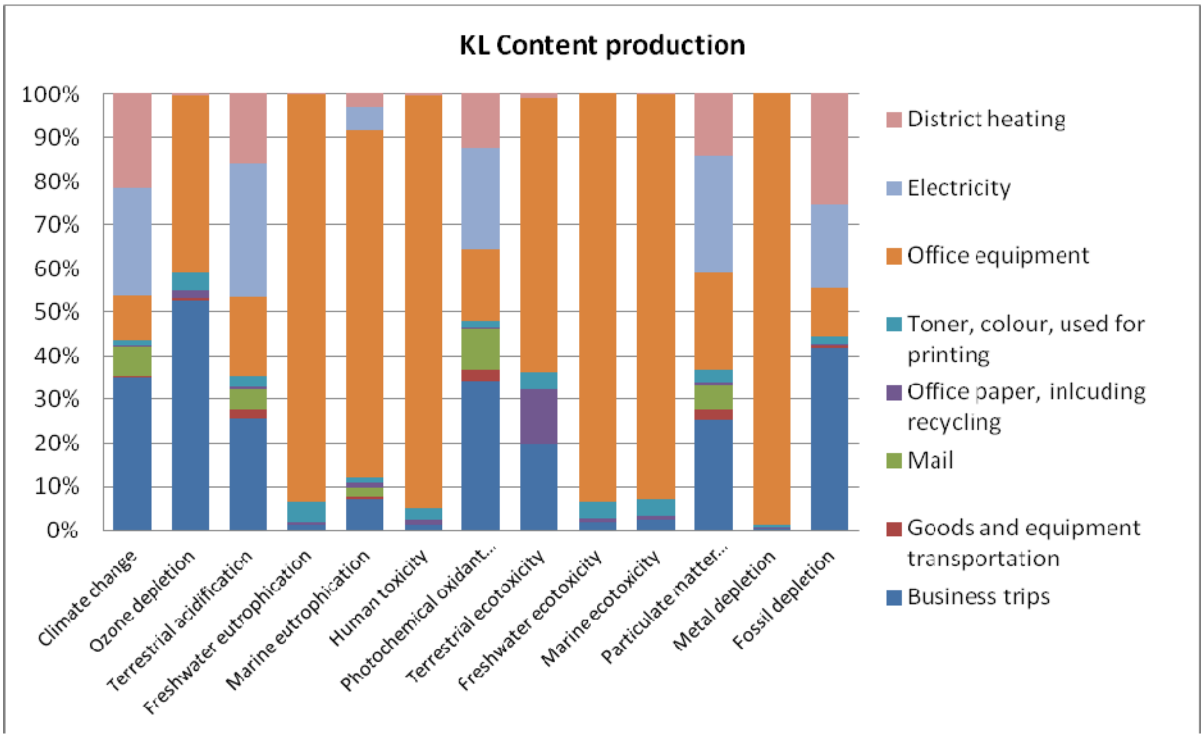


*Figure 24. Environmental impact potential of Kauppalehti content production per year.*

The impact category fossil depletion shows a similar pattern to the one for climate change. Other impact categories have the same major processes with the addition of manufacturing of office equipment. These impact categories are photochemical ozone creation, particulate matter formation and terrestrial acidification. The environmental impact related to manufacturing of office equipment is mainly caused by the manufacturing of screens and desktops, and to a lesser degree laptops.

The manufacturing of electronic devices is the major reason for several of the impact categories. The main contribution to the human toxicity, freshwater eutrophication, terrestrial ecotoxicity, freshwater ecotoxicity, marine ecotoxicity and metal depletion comes from the gold mining used for production of integrated circuits and PWB, which are parts of the LCD screens and desktops. The reasons for marine eutrophication, except for the gold mining for the integrated circuits manufacturing, are nitrogen compounds in the waste water effluent from the LCD module production, and lignite in the electricty mix used in the manufacturing.

Office equipment is also responsible about 40% of the ozone depletion potential in the result of production of wafer (semi-conductor material used in integrated circuits) and use of natural gas in the electricity mix used for manufacturing. Another significant contributor to the ozone depletion potential is business travels, i.e. flights because of kerosene use.

It should be noted that the results for the toxicity impact categories are uncertain. By including these impact categories the aim is to illustrate that there are other impacts than climate change and that the major reason for these other impacts may be different than for climate change.

## 5.4 Content production specific conclusions and discussion

The overall highest climate change impacts are due to business trips, electricity generation and generation of heat for offices. For other impact categories also the manufacturing of electronic devices, including raw material extraction, is an important process.

# 6. Life cycle assessment results of printed newspapers

The carbon footprint and other potential environmental impacts of the printed newspaper are described in this chapter. The results are presented for the reference cases for all three printed newspapers and one supplement. The reference case describes the case where the maculature and waste paper is closed loop allocated within the system and with avoided emissions (system expansion, see Chapter 5 for more details).

The carbon footprint includes the greenhouse gas emissions produced during the entire life cycle of products (for more information see Chapter 3.3).

The environmental impacts of printed newspapers are calculated with ReCiPe midpoint method (for more information see Chapter 3.2).

## 6.1 Printed Aamulehti results (ref. case)

The Aamulehti printed newspaper weighs on an average 282g, including all the daily supplements. The weekly Sunday supplement is analysed separately to see the differences in a cut tabloid vs. broadsheet newspaper. The results here are presented per one newspaper if not stated otherwise.

### 6.1.1 Carbon footprint results

The (cradle to grave) carbon footprint of one copy of Aamulehti newspaper is 244g $CO_2$ eq. / newspaper. The result is presented in Figure 25 below.

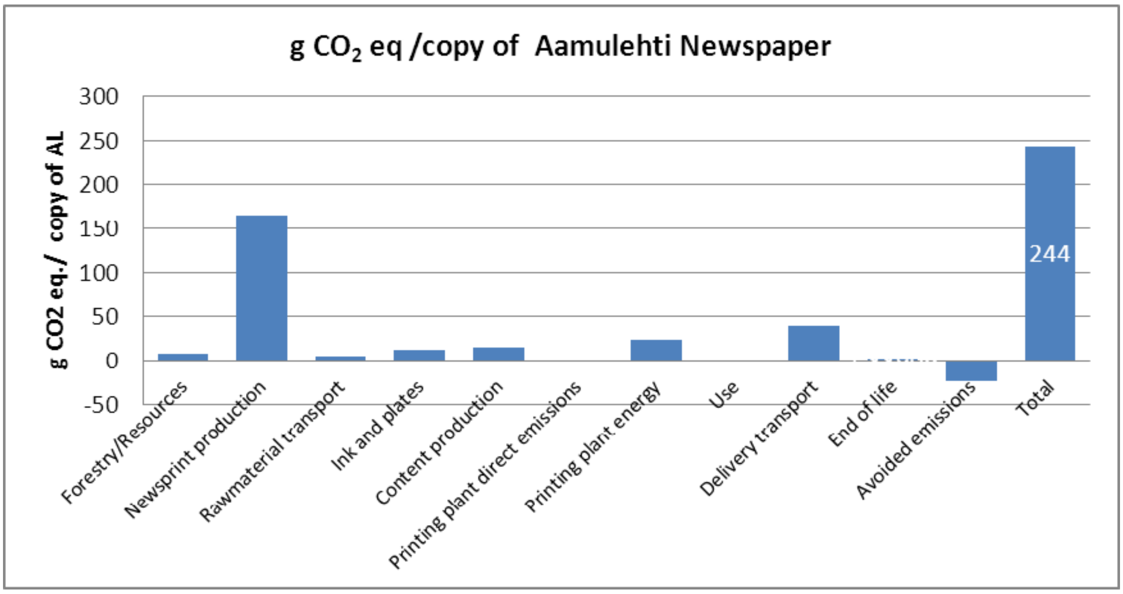


*Figure 25. Carbon Footprint results per one copy of Aamulehti (282g).*

As can be seen from the Figure 25, where the carbon footprint is given per life cycle stage, most of the greenhouse gas emissions come from the newsprint production: 65% (including fossil fuel combustion at mill and purchased electricity to the mill). Delivery to customer has a considerable contribution to the carbon footprint, accounting for about 16% of the total greenhouse gas emissions. The energy purchased to the printing plant contributes to 9% of the greenhouse gas emissions. On the other hand, the same amount (9%) of avoided emissions is taken into account due to energy generetion at end of life and avoided pulp production due to recycled fiber.

### 6.1.2 Other LCIA results

The potential environmental impacts of one printed Aamulehti newspaper according to the ReCiPe method can be seen in the following Figure 26 and Figure 27.

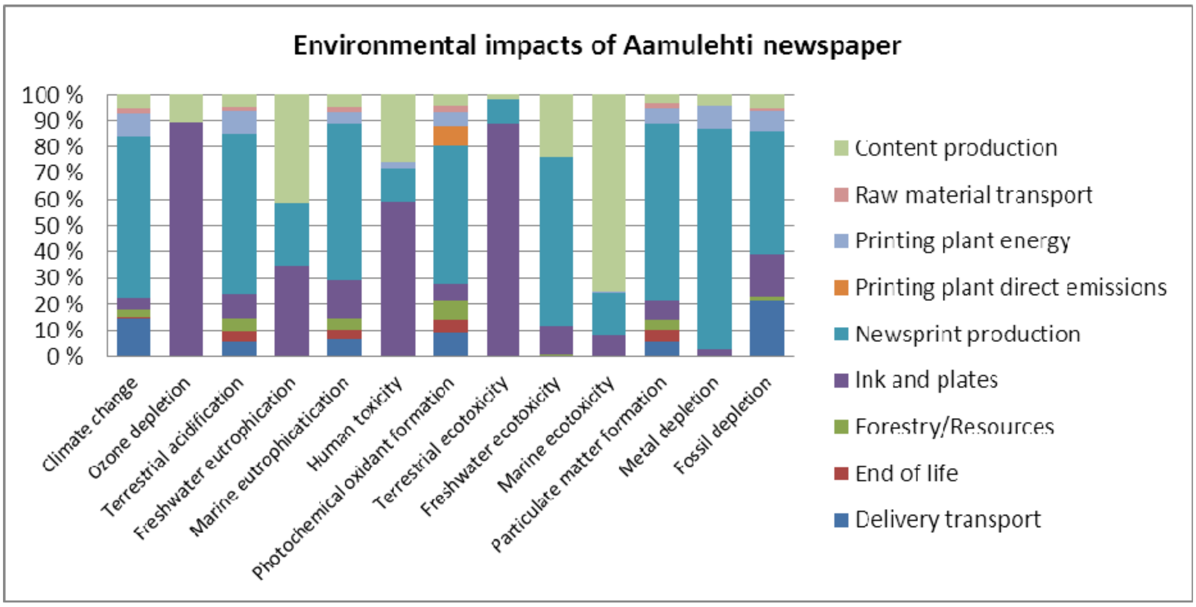


*Figure 26. Environmental impacts of the Aamulehti newspaper. Percentage share of lifecycle stages.*

Figure 26 above shows how the different life cycle stages contribute to the selected environmental impacts. The newsprint production (including fossil fuel combustion at mill and purchased electricity to the mill) has clearly the highest impact on climate change, terrestrial acidification, marine eutrophication, photochemical oxidant formation, freshwater ecotoxicity, particulate matter formation and both mineral and fossil depletion. In total on 8 out of 13 environmental impacts.

The majority of the impacts in the categories climate change, terrestrial acidification and particulate matter formation are due to energy and fuel use in the system. Climate change impacts are caused by greenhouse gas emissions, mainly $CO_2$. Acidification is mainly caused by sulphur and nitrogen oxide emissions, which also have a role in particulate formation. Most of the particulates originate, however, directly from the emissions of industrial activities, energy production and traffic. Small particulates can penetrate deep into the lungs and cause respiratory disorders.

The other life cycle stages with clearly higher impacts are the content production and the ink and plates for printing. The content production has clearly the highest (75%) impact on marine ecotoxicity, but also on freshwater eutrophication (40%).

Freshwater eutrophication impacts are caused by the phosphorus emissions from pulp and paper production, content production and the printing ink manufacturing chain. Eutrophication leads to changes in species, to algae blooms and to excess shoreline vegetation.

The majority (90%) of impacts in the ozone depletion and terrestrial ecotoxicity are due to the printing ink production chain. The ozone depletion is affected by halon emissions and terrestrial ecotoxicity by herbicides/pesticides. The printing ink manufacturing chain also contributes to 60% of the human toxicity, mainly due to arsenic emissions to water.

The photochemical oxidant formation impacts are mostly due to nitrogen oxide emissions produced by heat and power production and transport vehicles. Methane and carbon monoxide also give rise to photochemical oxidant formation. Ozone and other photo-oxidants cause breathing problems, damage to plant leaves and reduced grain harvests.

In view of the potential impacts in the resources depletion categories (both fossil and mineral), the pulp and paper (newsprint) production phase is clearly the biggest contributor. The depletion impact is assessed by comparing the magnitude of use against the known reserves. The mineral resources depletion impact is almost solely caused by the grid electricity used in pulp and paper production. Uranium is an important fuel in the production of the average Finnish grid mix, where the share of nuclear power is 30% (see Table 2). In addition, the fossil resources depletion impacts are connected to energy use in the product system.

The relative impact of printing plant (direct emissions and purchased energy) forms around a 10% share in impact categories climate change, terrestrial acidification, photochemical oxidant formation, particulate matter formation, metal depletion and fossil depletion. The relative impact of delivery transports i.e. distribution is between 10-20% related to climate change and fossil depletion.

It should be noted that since all total values are set to 100%, a high share may de a high share of a small or high overall impact.

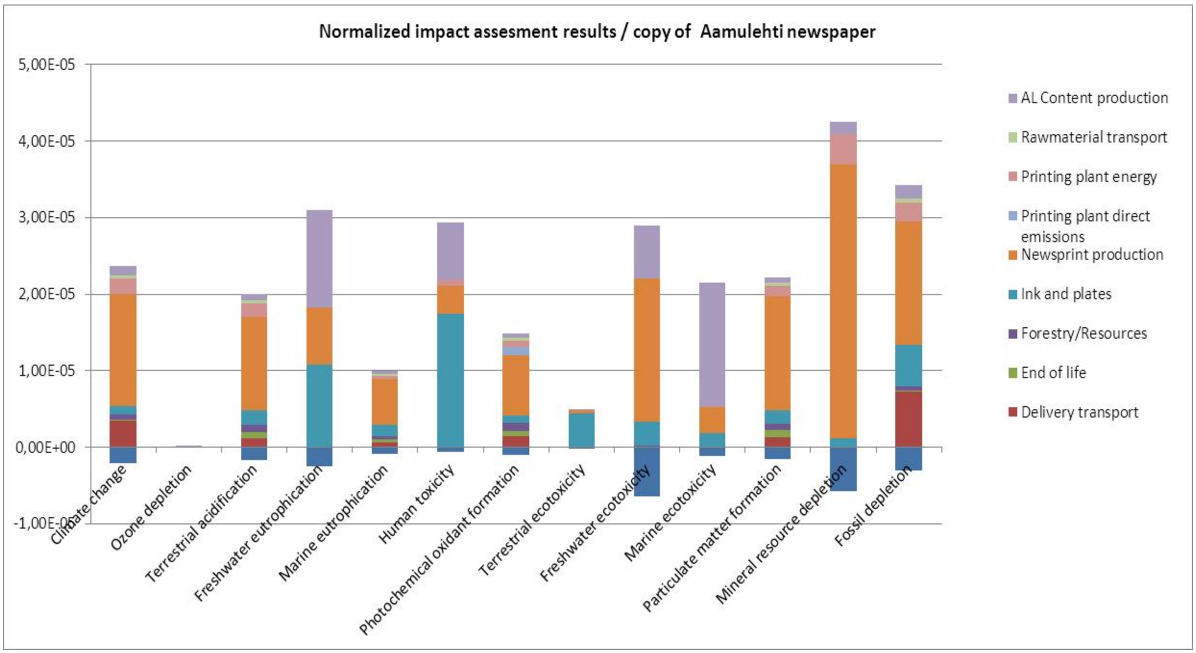


*Figure 27. Normalised impact assessment results per one copy of Aamulehti.*

Figure 27 above shows the normalized impacts of one copy of Aamulehti newspaper. Normalisation has been performed against the environmental impacts caused by one European inhabitant during one year. The high impact on mineral depletion is due to the use of uranium in the nuclear-generated electricity purchased to the paper mill.

### 6.1.3 Water footprint information data requirements

For some years now, the forest products industry has been actively participating in the development of water footprint methodologies, as it is a water intensive industry. This issue could also be addressed by the printing industry to provide a full water footprint through the whole supply chain of a printed product. As the methodology development is still on-going, data availability is limited. The water footprint has been noted as an emerging indicator and, for example, the Ecoinvent database is publishing a wider range of water data with the release of Ecoinvent v.3 in June 2012 (Weidema et al. 2011).

As explained in Chapter 3.4, the water footprint consists of the green water footprint, the blue water footprint and the grey water footprint over each stage of the supply chain. Data collection for a water footprint study of a printing press can be divided as presented in Figure 28. Dividing the data in such a way shows the different kinds of water data required, and furthermore which data can be measured at the production facility and which data needs to be acquired from previous parts of the supply chain. Transportation data has been omitted from the figure as the water consumption data for transportation is still not detailed enough.

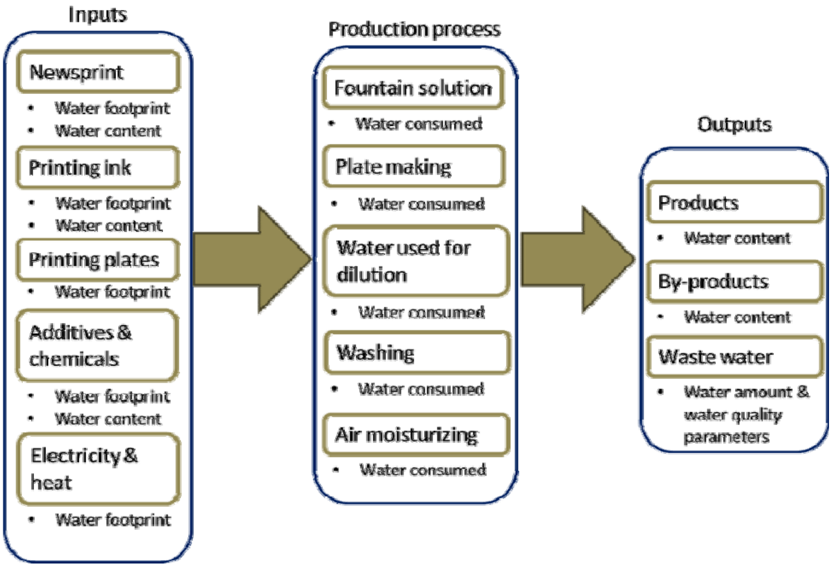


*Figure 28. Division of water data requirements for a water footprint study of a printing press.*

***Inputs***

Covering the input water flows can be accounted for either by looking at the water footprints of different inputs or by taking into account the water content of the inputs. The latter can often be the easier way of looking at the water consumption figures of the printing press, as water footprint studies have not been performed over the whole industry. Moreover, looking at the water contents of inputs may well result in more specific water management actions, as newsprint does not take such a large share of the total inputs as shown in Figure 29. Nevertheless, it should be noted that, where possible, figures for the green, blue and grey water footprints should be included.

Figure 29 shows the material breakdown of a printed newspaper. Divided by weight, newsprint contributes by far the largest share with a 97.6% share and the remaining 2.4 w-% come from printing ink (2.1%), printing plates (0.3%) and dampening solution (0.003%). The share of additives and chemicals was found to be even smaller than that of the dampening solution and it was therefore excluded from the figures. There is a possibility that the large share of newsprint might disorientate the printing industry to think that their actions make no difference to the total water footprint of their product. This is controversial to the ideology of water footprinting, as the indicator was made to tackle the issue of consumption of the scarce water resources.

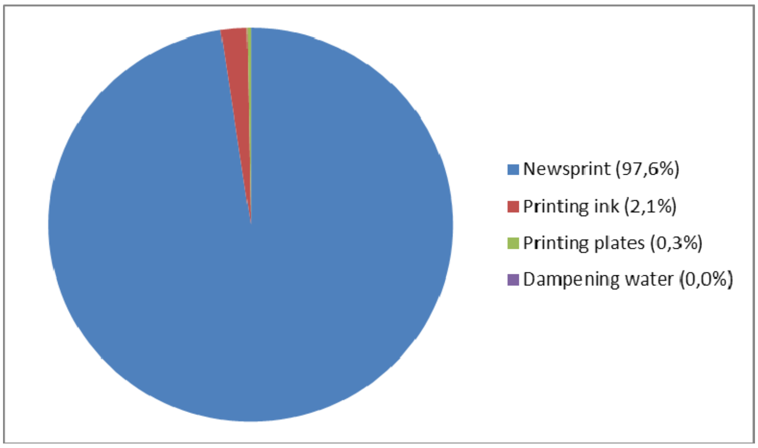


*Figure 29. Mass based material breakdown of a printed newspaper[1].*

**Production process**
The water consumption at the printing press can be divided into fountain solution, water used in the plate making, water used for diluting chemicals, water used in washing the machines and water for increasing the relative humidity of the pressroom. All of the pressroom water consumption processes are measurable and contribute to the blue water footprint of the printed product. In the case of coldset web offset printing, the evaporative water consumption, i.e. water that evaporates during the production process, is diminishingly small, as most of the water from the fountain solution remains in the paper.

***Outputs***
The water or moisture content of the printed product should be measured, as this adds to the blue water footprint. No by-products are formed during the newspaper printing process, and therefore the water consumed as moisture in the paper can be accounted for by the paper used in printing. Printers can adjust this water consumption to some extent by the choice of paper, as more porous papers tend to absorb more water and printing ink (Wells 2008).

The waste water in the output section should be quantified and qualified for water footprint accounting. The quantification and qualification are needed irrespective of the water footprint method chosen. Common waste water parameters can be used, with the addition of temperature control for thermal pollution control. A direct grey water footprint, as presented by the WFN, would require co-operation with the municipal waste water treatment facility.

For addressing the consumptive water use at a printing press, it is suggested that the printing press first measures its direct blue water consumption during production and waste water parameters of their production process. For the incoming virtual water flows, a way of avoiding the extensive impact caused by newsprint and the lack of data is to account for the relative water contents of the different inputs. Furthermore, the water consumption figures can be evaluated by different water stress indices to evaluate the relative environmental impact associated with the water use (e.g. Pfister 2009).

A more extensive water footprint study could be carried out with other parties to the supply chain to calculate the total water footprint of a printed newspaper. Further information on the subject was presented to Alma Media in a separate report produced as a part of the project (Koskimäki 2011).

### 6.1.4 Case specific conclusions and discussion

The overall highest environmental impacts are due to the energy use at the pulp and paper mill. Delivery to customer makes a major contribution to the carbon footprint, accounting for about 16% of

[1] Figures based on yearly average consumption

the total greenhouse gas emissions. Ink manufacturing and content production, life cycle stages also have significant environmental impacts.

## 6.2 Printed Aamulehti supplement results (ref. case)

The printed Aamulehti Sunday Supplement weighs on an average 120 g per newspaper. The Sunday supplement is a cut tabloid included in Aamulehti on Sundays. The results for the Sunday supplement do not include content production or the delivery to customer, since these figures are included in the Aamulehti figures and could not be separated.

### 6.2.1 Carbon footprint results

The (cradle to grade) carbon footprint of one copy of Aamulehti Sunday supplement newspaper is 93 g $CO_2$ eq. / newspaper. The result is presented in Figure 30 below.

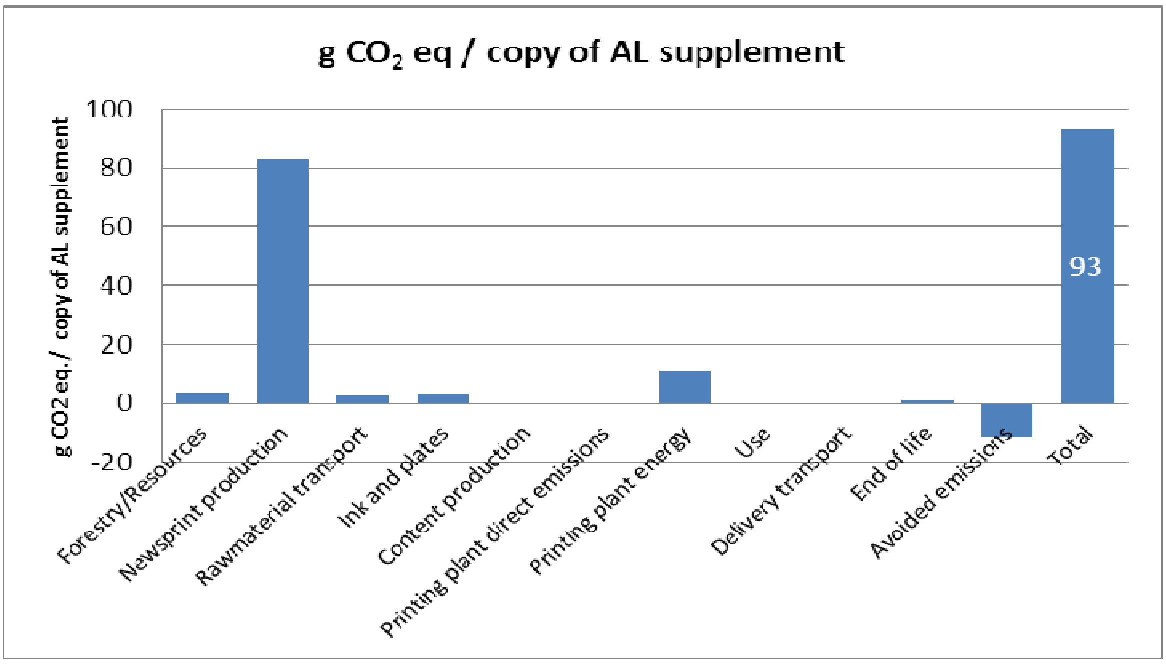


*Figure 30. Carbon Footprint results per one copy of Aamulehti Sunday supplement (120g).*

The newsprint production here has an even higher share of the total carbon footprint as the supplement is cut and therefore the need for paper is higher per copy of the newspaper. Almost 90% of the total greenhouse gas emissions come from the newsprint production (including fossil fuel combustion at mill and purchased electricity to the mill). Another thing worth noting is that there are no content production and delivery emissions for the supplement as they are included in the Aamulehti results.

### 6.2.2 Other LCIA results

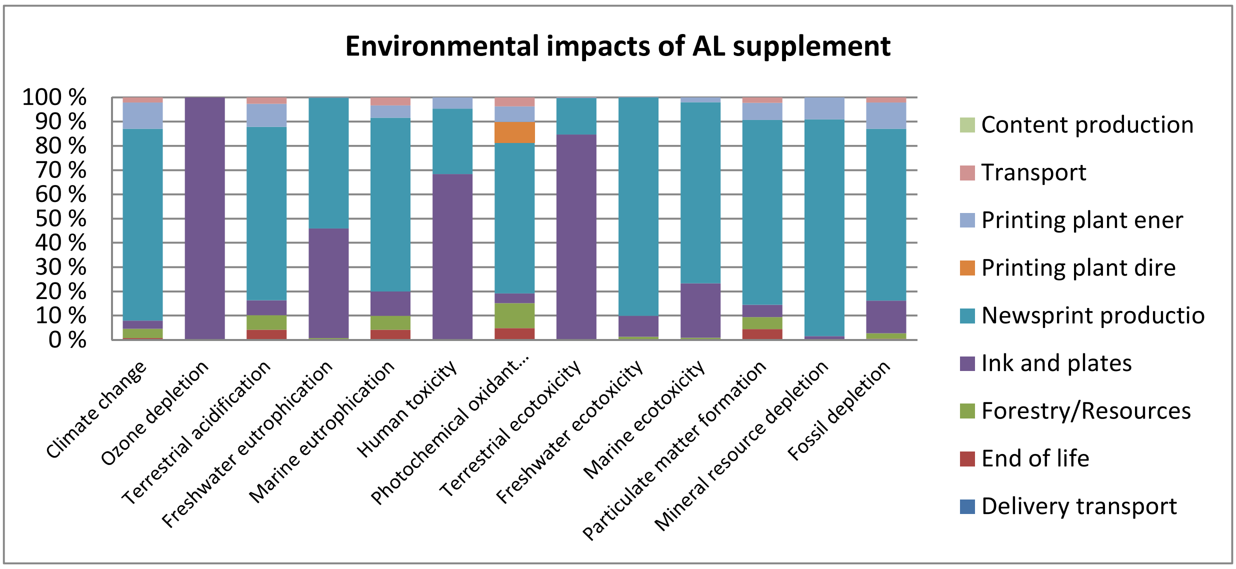


*Figure 31. Environmental impacts of Aamulehti Sunday supplement newspaper. Percentage share of lifecycle stages.*

Figure 31 above shows how the different life cycle stages contribute to the selected environmental impacts. The newsprint production (including fossil fuel combustion at mill and purchased electricity to the mill) has clearly the highest impact on climate change, terrestrial acidification, freshwater and marine eutrophication, photochemical oxidant formation, freshwater and marine ecotoxicity, particulate matter formation and both mineral and fossil depletion. In total on 10 / 13 environmental impacts.

The majority (85–100%) of impacts in the ozone depletion and terrestrial ecotoxicity are due to the printing ink production chain. The ozone depletion is affected by halon emissions and terrestrial ecotoxicity by herbicides/pesticides. The printing ink manufacturing chain also contributes to 70% of the human toxicity mainly due to arsenic emissions to water.

The relative impact of printing plant (direct emissions and purchased energy) form around 10% share in the impact categories climate change, terrestrial acidification, photochemical oxidant formation, particulate matter formation, metal depletion and fossil depletion.

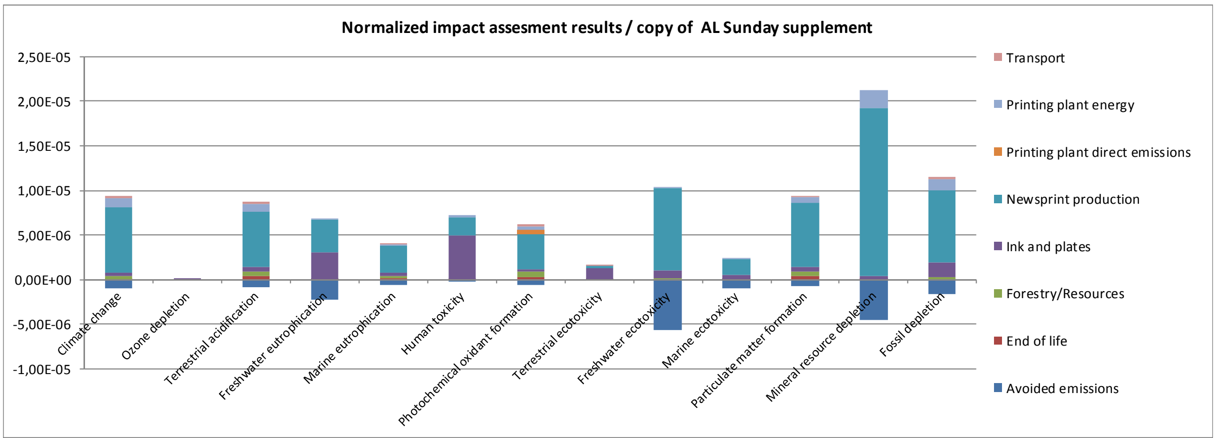


*Figure 32. Normalised impact assessment results per copy of Aamulehti Sunday supplement.*

Figure 32 above shows the normalized impacts of one copy of Aamulehti supplement newspaper. Normalisation has been performed against the environmental impacts caused by one European inhabitant during one year, equalling 1. The impact of one newspaper copy is not very informative and therefore in Chapter 8.2 the normalized results of subscribing to Aamulehti for one year are more significant, from the perspective of relating it to one European overall yearly impact. Here the normalisation is made to see which environmental impact is most significant for Aamulehti. The high impact on mineral depletion is due to the use of uranium in the nuclear-based electricity purchased to the paper mill.

### 6.2.3 Case specific conclusions and discussion

The environmental impacts of the Aamulehti supplement are even more focused on the newsprint manufacturing due to two main reasons: no content production and delivery transport is allocated to the supplement, and the newspaper is a cut tabloid with higher paper use per newspaper copy.

## 6.3 Printed Iltalehti results (ref. case)

### 6.3.1 Carbon footprint

The (cradle to grade) carbon footprint of one copy of Iltalehti newspaper is 161 g $CO_2$ eq. / newspaper. The result is presented in Figure 33.

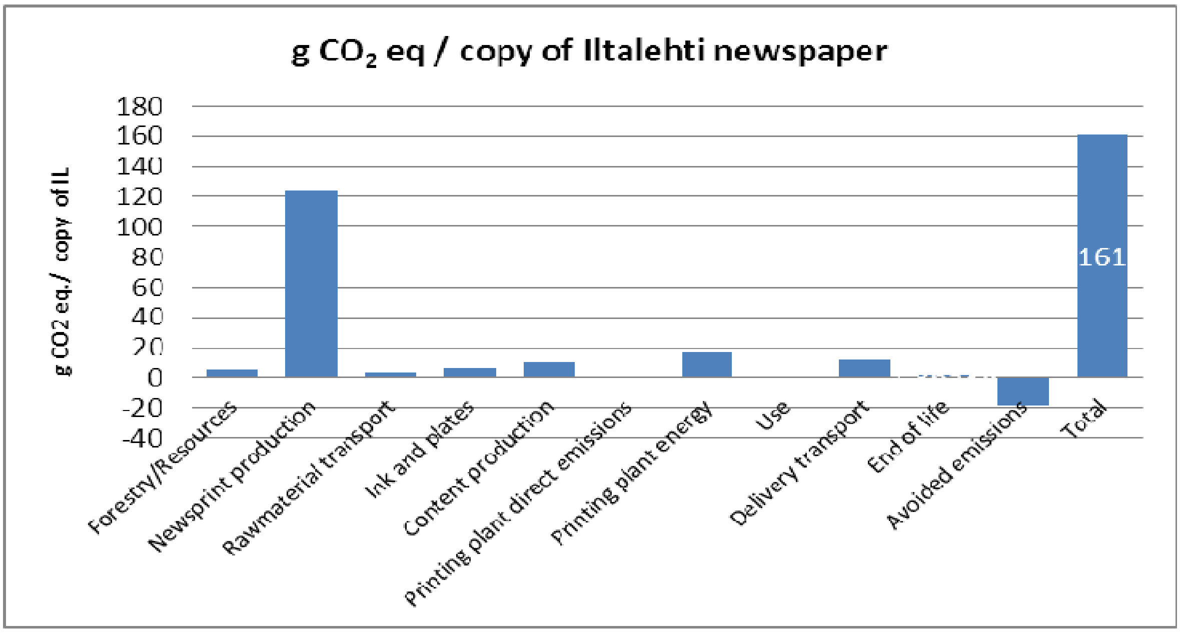


*Figure 33. Carbon Footprint results per one copy of Iltalehti (201g).*

As can be seen from the Figure 33 dividing the carbon footprint per life cycle stage, most of the greenhouse gas emissions come from the newsprint production 75% (including fossil fuel combustion at mill and purchased electricity to the mill). Because Iltalehti is not delivered to homes as is Aamulehti, the delivery to customer has a lower contribution to the carbon footprint, accounting for about 7% of the total greenhouse gas emissions. The energy purchased to the printing plant contributes to 10% of the greenhouse gas emissions. On the other hand, the same amount (11%) of avoided emissions are taken into account due to energy generetion at end of life and avoided pulp production due to recycled fiber.

### 6.3.2 Other LCIA results

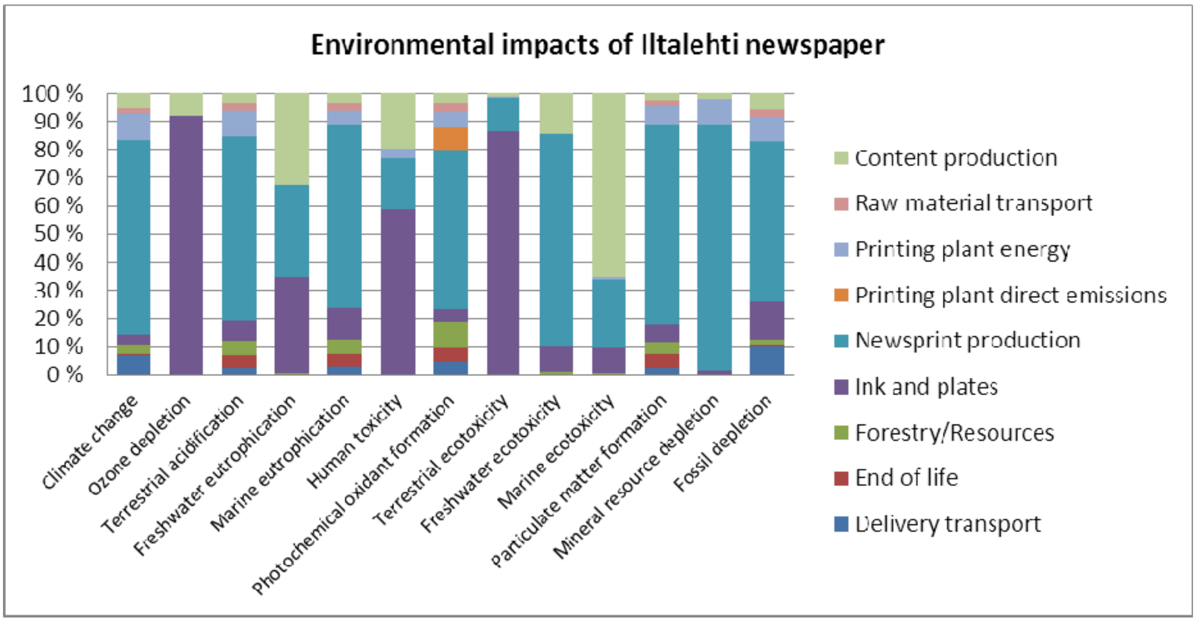


*Figure 34. Environmental impacts of Iltalehti newspaper. Percentage share of lifecycle stages.*

The Figure 34 above shows how the different life cycle stages contribute to the selected environmental impacts. The newsprint production (including fossil fuel combustion at mill and purchased electricity to the mill) has clearly the highest impact on climate change, terrestrial acidification, marine eutrophication, photochemical oxidant formation, freshwater ecotoxicity, particulate matter formation and both mineral and fossil depletion. In total on 8 / 13 environmental impacts.

The majority of the impacts in the categories climate change, terrestrial acidification and particulate matter formation are due to energy and fuel use in the system. Climate change impacts are caused by greenhouse gas emissions, mainly $CO_2$. Acidification is mainly caused by sulphur and nitrogen oxide emissions, which also have a role in particulate formation. Most of the particulates originate, however, directly from the emissions of industrial activities, energy production and traffic. Small particulates can penetrate deep into the lungs and cause respiratory disorders.

The other life cycle stages with clearly higher impacts are the content production and the ink and plates for printing. The content production has clearly the highest (75%) impact on marine ecotoxicity, but also on freshwater eutrophication (40%).

Freshwater eutrophication impacts are caused by the phosphorus emissions from pulp and paper production, content production and the printing ink manufacturing chain. Eutrophication leads to changes in species, to algae blooms and to excess shoreline vegetation.

The majority (85–90%) of impacts in the ozone depletion and terrestrial ecotoxicity are due to the printing ink production chain. The ozone depletion is affected by halon emissions and terrestrial ecotoxicity by herbicides/pesticides. The printing ink manufacturing chain also contributes to 60% of the human toxicity mainly due to arsenic emissions to water.

The photochemical oxidant formation impacts are mostly due to nitrogen oxide emissions produced by heat and power production and transportation vehicles. Methane and carbon monoxide also give rise to photochemical oxidant formation. Ozone and other photo-oxidants cause breathing problems, damage to plant leaves and reduced grain harvests.

In view of the potential impacts in the resources depletion categories (both fossil and mineral) (Figure 34), the pulp and paper (newsprint) production phase is clearly the biggest contributor. The depletion impact is assessed by comparing the magnitude of use against the known reserves. The mineral resources depletion impact is almost solely caused by the grid electricity used in pulp and paper production. Uranium is an important fuel in the production of the average Finnish grid mix, where the share of nuclear power is 30% (see Table 2). Also the fossil resources depletion impacts are connected to energy use in the product system.

The relative impact of printing plant (direct emissions and purchased energy) form around 10% share in impact categories climate change, terrestrial acidification, photochemical oxidant formation, particulate matter formation, metal depletion and fossil depletion. The relative impact of delivery transport i.e. distribution is 5–10% related to climate change and fossil depletion.

It should be noted that since all total values are set to 100%, a high share may de a high share of a small or high overall impact.

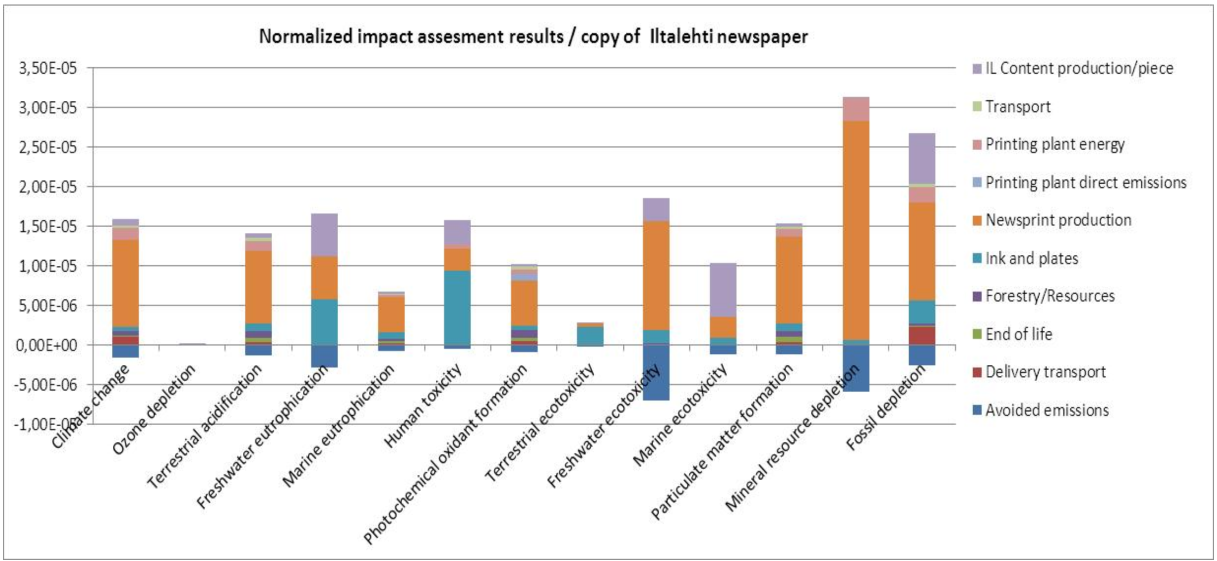


*Figure 35. Normalised impact assessment results per one piece of Iltalehti.*

The Figure 35 above shows the normalised impacts of one copy of Iltalehti newspaper. Normalisation has been performed against the environmental impacts caused by one European inhabitant during one year. The high impact on mineral depletion is due to the use of uranium in the nuclear-based electricity purchased to the paper mill.

### 6.3.3 Case specific conclusions and discussion

Iltalehti has on the whole similar impacts as Aamulehti, most impacts are due to energy production for pulp and paper manufacturing., the most significant difference is that the delivery of Iltalehti has a very much lower impact as it is not delivered to homes and therefore the transport emissions are lower. Content production and ink manufacturing are significant life cycle stages in terms of environmental impacts.

## 6.4 Printed Kauppalehti results (ref. case)

### 6.4.1 Carbon footprint

The (cradle to grade) carbon footprint of one copy of Kauppalehti newspaper is 97g $CO_2$ eq. / newspaper. The result is presented in Figure 36 below.

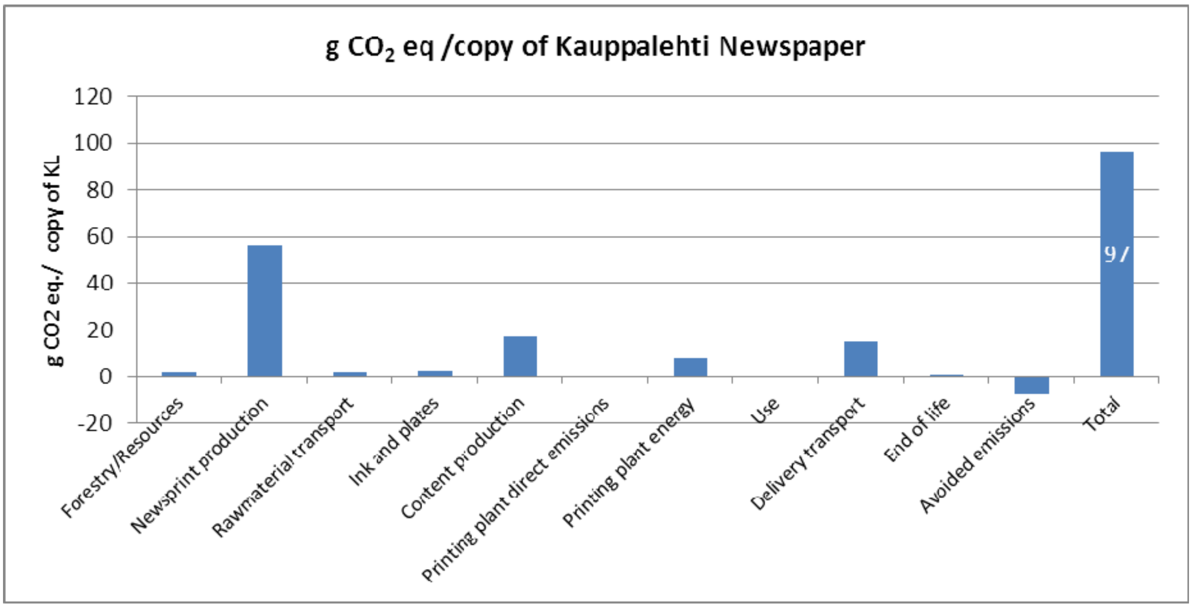


*Figure 36. Carbon Footprint results per one copy of Kauppalehti (96g).*

As can be seen from the Figure 36 apportioning the carbon footprint per life cycle stage, most of the greenhouse gas emissions come from the newsprint production 57% (including fossil fuel combustion at mill and purchased electricity to the mill). Content production of kauppalehti contributes to 17% of total greenhouse emissions and delivery 15% of the total. The printing plant energy stands for 8% of the emissions.

### 6.4.2 Other LCIA results

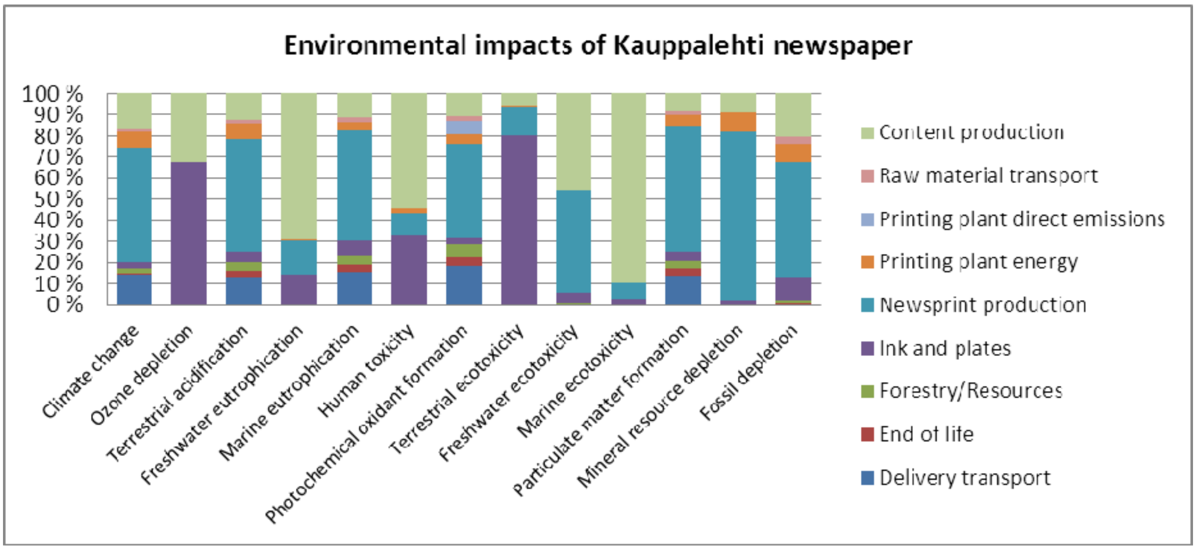


*Figure 37. Environmental impacts of Kauppalehti newspaper. Percentage share of lifecycle stages.*

The Figure 37 above shows how the different life cycle stages contribute to the selected environmental impacts. The newsprint production (including fossil fuel combustion at mill and purchased electricity to the mill) has clearly the highest impact on climate change, terrestrial acidification, marine eutrophication, photochemical oxidant formation, freshwater ecotoxicity, particulate matter formation and both mineral and fossil depletion. In total on 8 / 13 environmental impacts.

The content production has the clearly highest impact on fresh water eutrophication (70%), human toxicity (60%) and marine ecotoxicity (90%). The content production is a very significant part of the printed Kauppalehti environmental burdens.

The majority (60–80%) of impacts in the ozone depletion and terrestrial ecotoxicity are due to the printing ink production chain. The ozone depletion is affected by halon emissions and terrestrial ecotoxicity by herbicides/pesticides. The printing ink manufacturing chain also contributes to 60% of the human toxicity mainly due to arsenic emissions to water.

The relative impact of printing plant (direct emissions and purchased energy) form around a 10–15% share of the impact categories climate change, terrestrial acidification, mineral resource depletion and fossil depletion. The relative impact of delivery transport i.e. distribution has the highest impact on photochemical oxidant formation (20%). The photochemical oxidant formation impacts are mostly due to nitrogen oxide emissions produced by heat and power production and transportation vehicles.

It should be noted that since all total values are set to 100%, a high share may de a high share of a small or high overall impact.

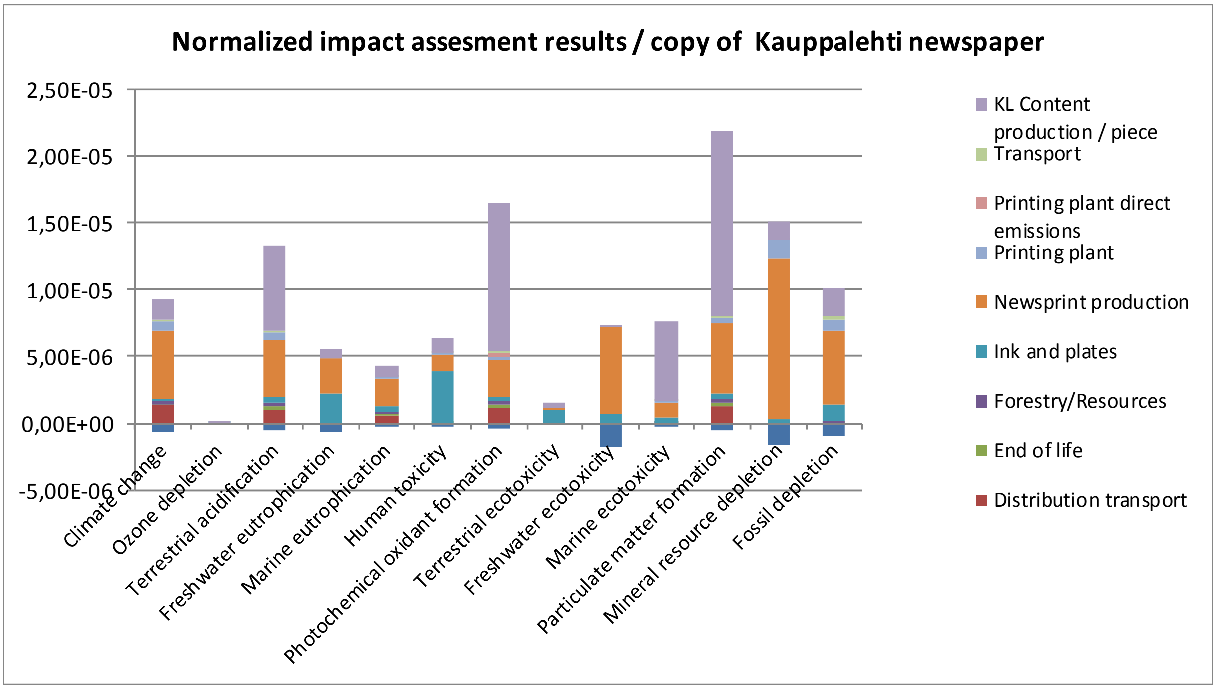


*Figure 38. Normalised impact assessment results per one copy of Kauppalehti.*

The Figure 38 above shows the normalised impacts of one copy of Kauppalehti newspaper. Normalisation has been performed against the environmental impacts caused by one European inhabitant during one year. The high impact on mineral depletion is due to the use of uranium in the nuclear-based electricity purchased to the paper mill.

### 6.4.3 Case specific conclusions and discussion

The content production of Kauppalehti has an overall higher impact than the content production of the other newspapers. 20% of the greenhouse gas emissions are from the content production phase. This is due to that KL has more FTE per newspaper copy produced than AL and IL; also KL office has larger area per FTE.

## 6.5 Sensitivity analysis of printed media results

To test some major assumptions two sensitivity analyses were made.

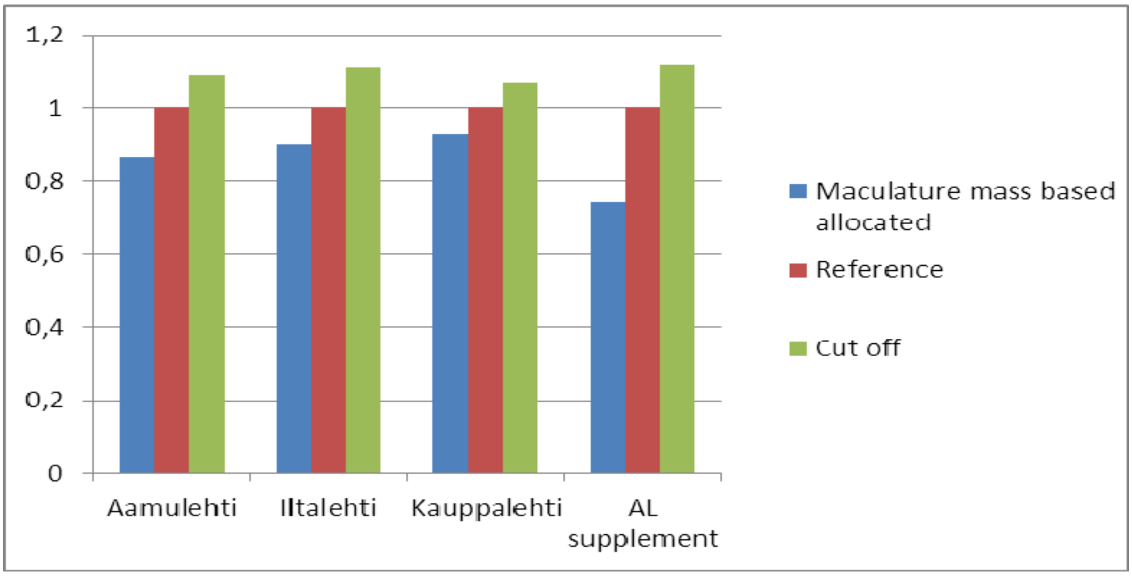


*Figure 39. Sensitivity analyses results for carbon footprint per one copy of printed newspaper. The reference is set to 100%.*

In Figure 39 the carbon footprint of the different scenarios are presented for all the printed newspapers. See Chapters 4.3.7 and 4.3.8. As can be seen, the cut off scenario, where no avoided emissions, but also no burdens for the use of recycled fibres, are taken into account makes the carbon footprint 9%–12% higher.

The Figure 40–41 below show the environmental impacts of all three scenarios for all four newspapers.

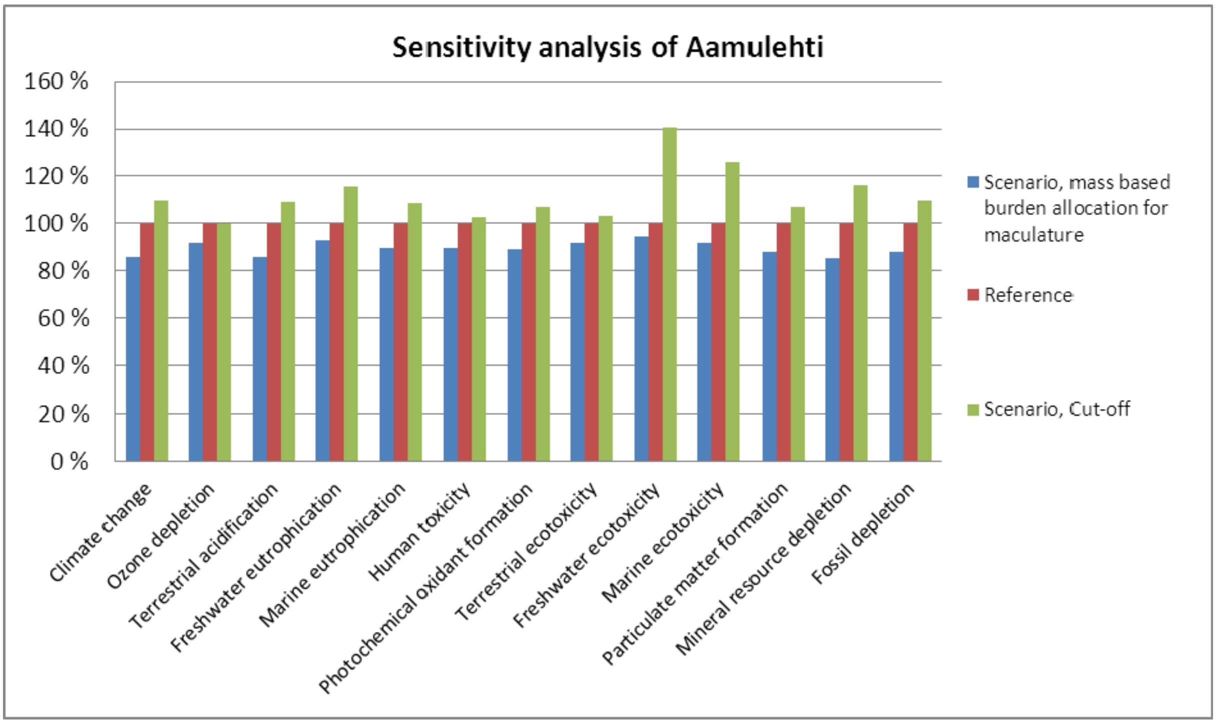


*Figure 40. Results for sensitivity analysis of printed Aamulehti. The reference is set to 100%.*

Figure 40 shows how the two sensitivity scenarios affect the environmental impacts of Aamulehti. The most significant effect can be seen in the fresh water ecotoxicity. The cut off scenario corresponds to 40% higher impact on fresh water ecotoxicity due to the phosphorous emissions from TMP pulp manufacturing that is not avoided. At pulp and paper mills, wastewaters are purified before being released into the water system and nitrogen and phosphorous are applied in the water purification process. (Antikainen et.al 2004.) The phosphorous leaving the purification plant is bound to different substances and solid matters and is therefore not pure or free phosphorous which has a very high toxic characterisation factor. The impact here is calculated as all the phosphorous would be pure and free and therefore the toxicity impact is most probably too high. The main reason that the impacts of the mass based case are lower is that 8% of the embodied environmental burdens are allocated to the maculature.

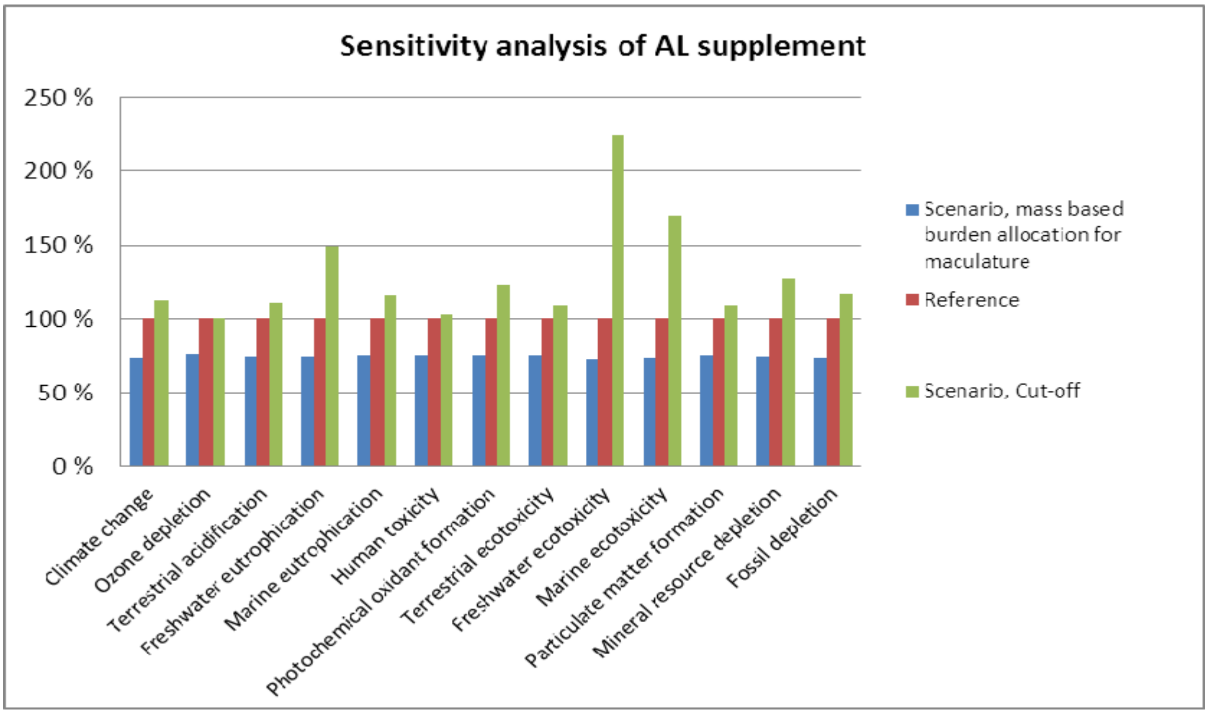


*Figure 41. Results for sensitivity analysis of printed Aamulehti Sunday Supplement. The reference is set to 100%.*

As can be seen in Figure 41 the effect of the missing avoided phosphorous emissions lifts both fresh water and marine ecotoxicity to very high levels in the cut off scenario. Also the fresh water eutrophication is 150% compared to the reference case. This higher effect for the AL supplement is due to the high maculature amount and therefore higher amount of recycled fibre leaving the system, leading to avoided emissions. The phosphorous leaving the purification plant is bound to different substances and solid matter and is therefore not pure or free phosphorous, which has a very high toxic characterisation factor. The impact here is calculated as if all the phosphorous were pure and free, and therefore the toxicity impact is most probably too high. Therefore this toxicity is most probably too high.

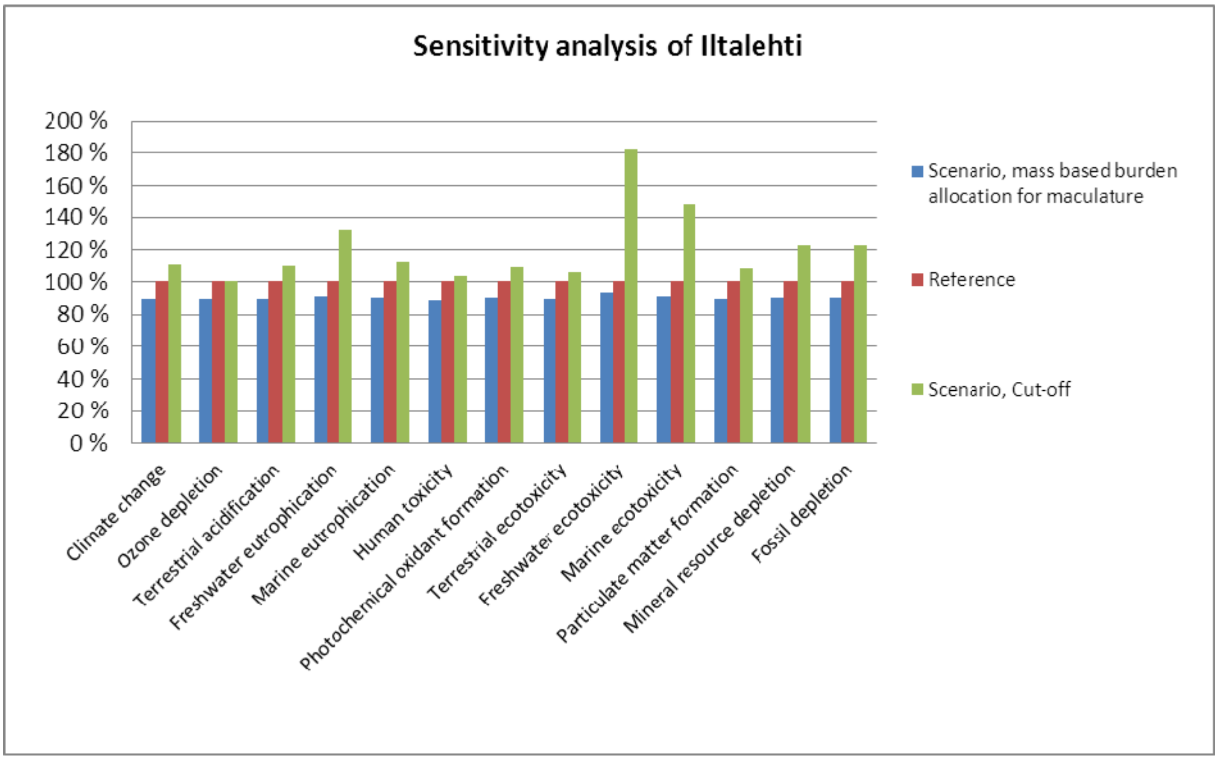


*Figure 42. Results for sensitivity analysis of printed Iltalehti. The reference is set to 100%.*

As can be seen in Figure 42 also for Iltalehti the impact on the water toxicity is most significant. The amount of maculature caused in the printing plant is higher for Iltalehti than for Aamulehti and therefore more recycled fiber is leaving the system and more avoided phosphorous emissions from TMP manufacturing are gained. The phosphorous leaving the purification plant is bound to different substances and solid matter and is therefore not pure or free phosphorous which has a very high toxic characterisation factor. The impact here is calculated as if all the phosphorous were pure and free and therefore the toxicity impact is most probably too high.

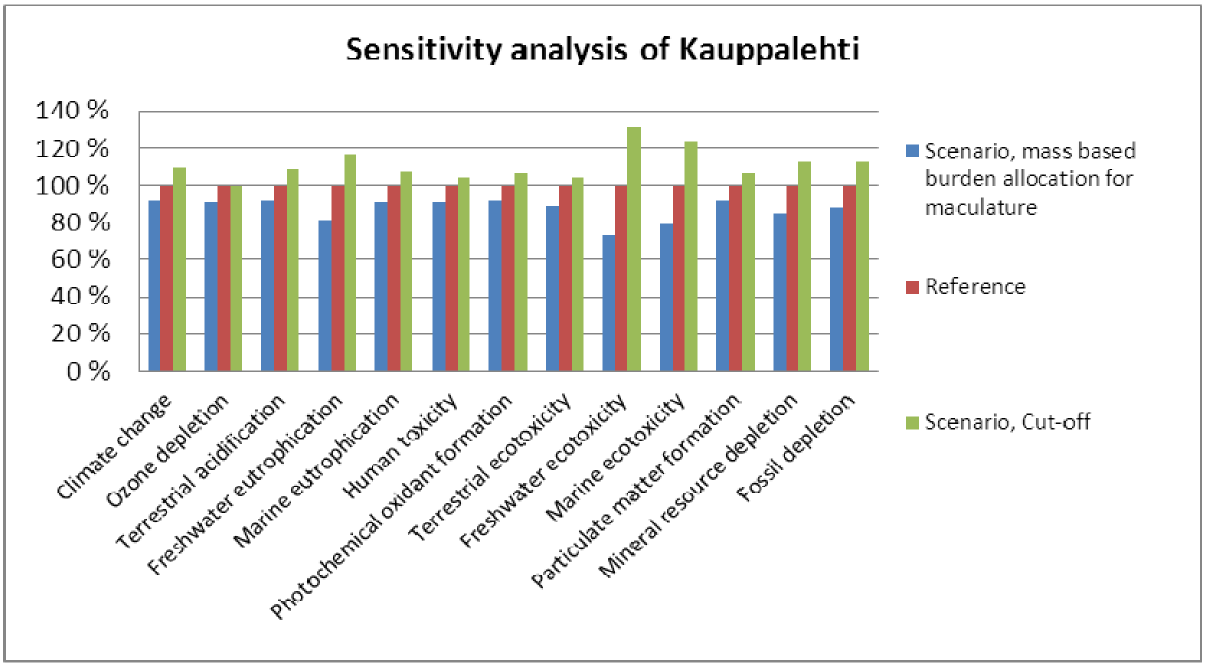


*Figure 43. Results for sensitivity analysis of printed Kauppalehti. The reference is set to 100%.*

Figure 43 shows that the difference of the cut off scenario (water toxicity) is not as high as for the other newspapers due the higher amount of recycled fibre used in newsprint production for Kauppalehti. Also the maculature amount is lower than for Iltalehti /AI supplement.

# 7. Life cycle impact assessment results for online newspapers

The carbon footprint and other potential environmental impacts of the online newspaper versions are described in this chapter. The results are presented for the reference cases for Aamulehit.fi, Iltalehti.fi and Kauppalehti.fi and for sensitivity analyses.

The carbon footprint includes the greenhouse gas emissions produced during the entire life cycle of products (for more information see Chapter 3.3).

The environmental impacts of online newspapers versions are calculated with ReCiPe midpoint method (for more information see Chapter 3.2).

## 7.1 Aamulehti.fi results

### 7.1.1 Carbon footprint

The overall potential climate change impact (a.k.a carbon footprint) resulting from Aamulehti.fi is 260 tonnes of $CO_2$eq/year (Figure 44). Content production is responsible for 50%. Furthermore emissions related to the end user account for 49% of the total impact, mainly due to the manufacturing of devices, which is 32% of the total potential greenhouse gas emissions.

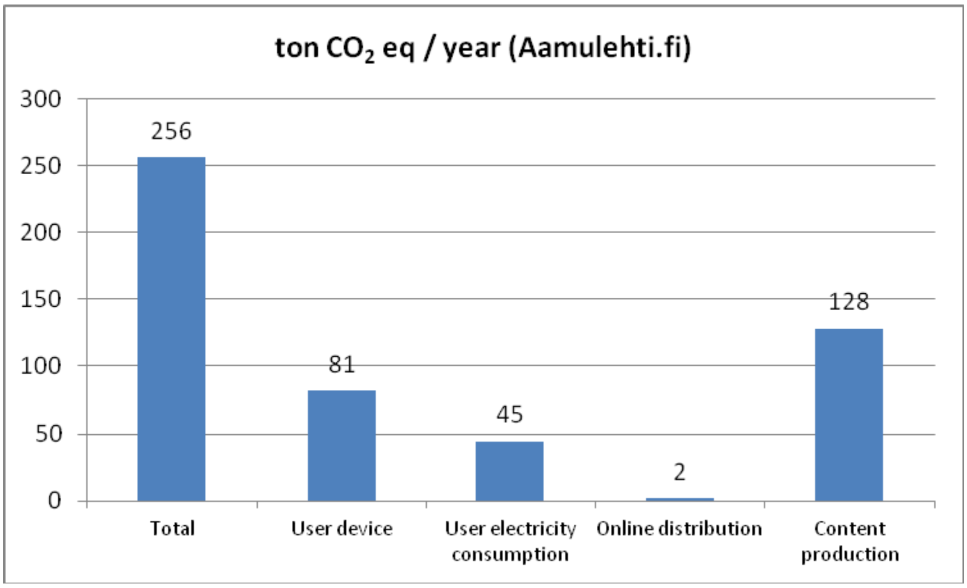


*Figure 44. Carbon footprint of Aamulehti.fi per year.*

### 7.1.2 Other LCIA results

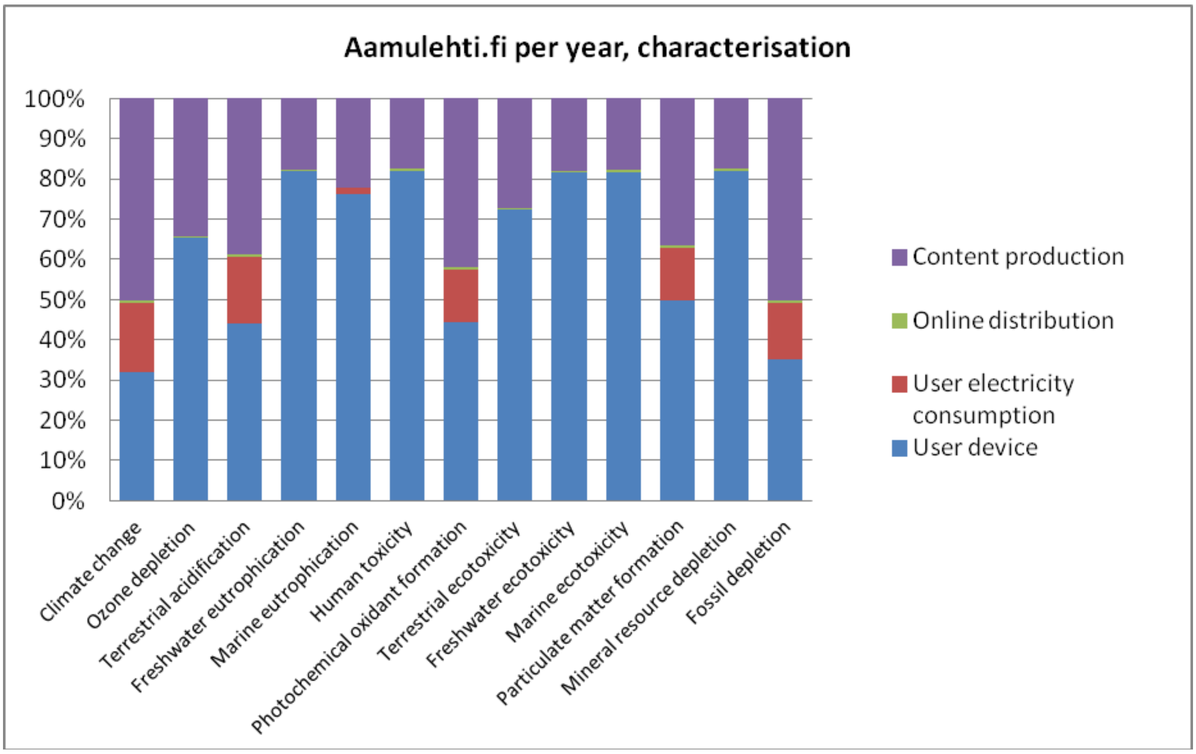


*Figure 45. Environmental performance of Aamulehti.fi per year, characterisation.*

The share for each process with respect to the total potential impact for each category is shown in Figure 45. All total values are set to 100%. It should be noted that since all total values are set to 100%, a high share may be a high share of a small or high overall impact.

As illustrated in Figure 45, most of the environmental impacts studied related to the online version of Aamulehti are mainly due to end user devices, i.e. desktops, screens and laptops. The share for manufacturing and disposal of the electronic devices that are allocated to reading Aamulehti.fi is the major cause, from 32% of the total value for climate change to more than 80% for human toxicity, freshwater eutrophication, freshwater toxicity, marine ecotoxicity and mineral resource depletion. Major reasons for environmental impacts related to the manufacturing of electronic devices are described in Section 5, content production.

The environmental impact related to content production is considerable for Aamulehti.fi, this is because the number of readers of Aamulehti.fi and their overall reading time is rather low and thus the environmental impact related to the content production is relatively larger (in comparison to Iltalehti.fi and Kauppalehti.fi). For climate change and fossil depletion the content production is the reason for half the potential impact. For the other impact categories it is giving rise to roughly 20–40%.

End user electricity consumption in using electronic devices also contributes to the potential environmental impacts through electricity generation and fuel production, about 15% to climate change, photochemical ozone creation, particulate matter formation, terrestrial ecotoxicity and fossil depletion.

It should be noted that the results for the toxicity impact categories are uncertain. By including these impact categories the aim is to illustrate that there are other impacts than climate change and that the major reason for these other impacts may be different than for climate change.

The normalised results for Aamulehti.fi per reader and year are presented as a share of the total environmental impact of one European person per year. Human toxicity, freshwater eutrophication, freshwater ecotoxicity and marine ecotoxicity score high in the normalization. This indicates that these are the impact categories where Aamulehti.fi has a relatively larger share of the total contribution by one European person, compared to the other impact categories, contributing up to about 0.16% of the total impact of one European (Figure 46). For these impact categories long-term emissions related to gold mining are a major reason for the impact. For climate change the normalized result is about 0.01% of the total climate change impact for one European.

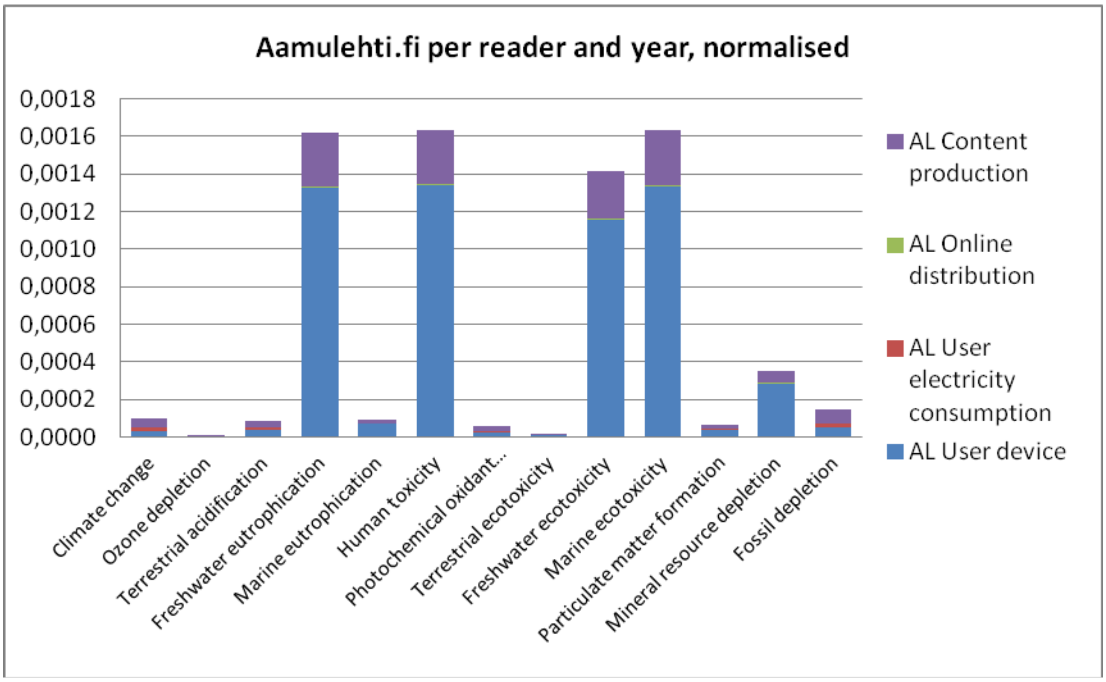


*Figure 46. Aamulehti.fi per reader and year, normalised. The reference for normalization is one European inhabitant during one year.*

### 7.1.3 Sensitivity analysis

Four sensitivity analyses were done in order to test some major assumptions.

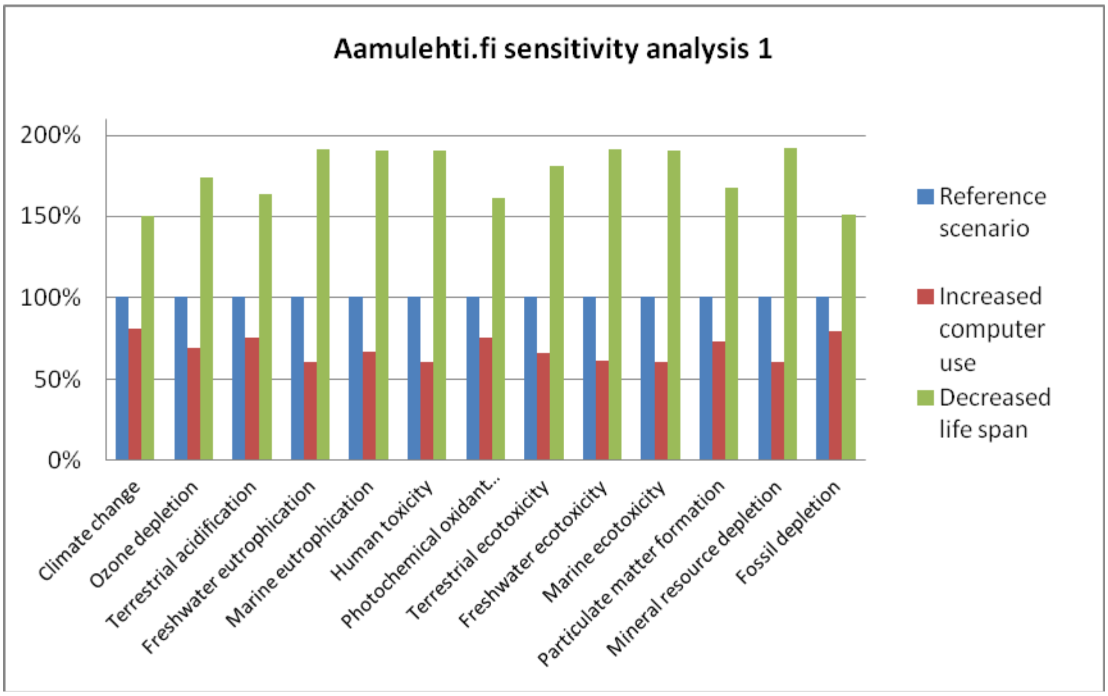


*Figure 47. Sensitivity analyses for Aamulehti.fi, related to the total environmental impact of the reference scenario (set to 100%).*

In the sensitivity analysis where a hypothetical case with very high total use of electronic devices in the home is considered, the resulting potential environmental impact is considerably lower than the impact in the reference scenario (20% to 40% in various impact categories (Figure 47). The change in the impact is not even larger, since a considerable share of the environmental impact of Aamulehti.fi comes from content production, which is not affected by the end-user practices. Still the sensitivity analysis illustrates that the allocation of environmental impact for manufacturing electronic devices is important. Thus efficiently using an electronic device, in addition to a long service life, may decrease the environmental impact related to each use activity. Figure 47 also shows that a shorter service life for electronic devices will lead to higher environmental impact in all impact categories.

Figure 48 illustrates how excluding the recycling of metals and the benefits gained by avoiding virgin production leads to changes in the overall results for some impact categories and not others. This illustrates the environmental impacts related to virgin production of metals, the avoidance of which is not taken into account in the system studied in the sensitivity analysis. This uncertainty regarding the waste treatment of electronic devices is shown to be more of importance for the impact categories human toxicity, particulate matter formation, terrestrial acidification, freshwater eutrophication, terrestrial acidification, freshwater ecotoxicity, marine ecotoxicity and metal depletion. On the other hand, climate change, ozone depletion, photochemical ozone creation, marine eutrophication and fossil depletion are not shown to be very affected.

When excluding long-term emissions (Figure 48), a considerable change in overall potential impacts can be seen for some impact categories: freshwater eutrophication, human toxicity, freshwater ecotoxicity and marine ecotoxicity. The other impact categories are not very affected by the change in system boundaries in time. This illustrates the complexity of the system studied and some of the impacts. It is not easy to assess these impacts, and considerable differences in results will be found depending on the time perspective used.

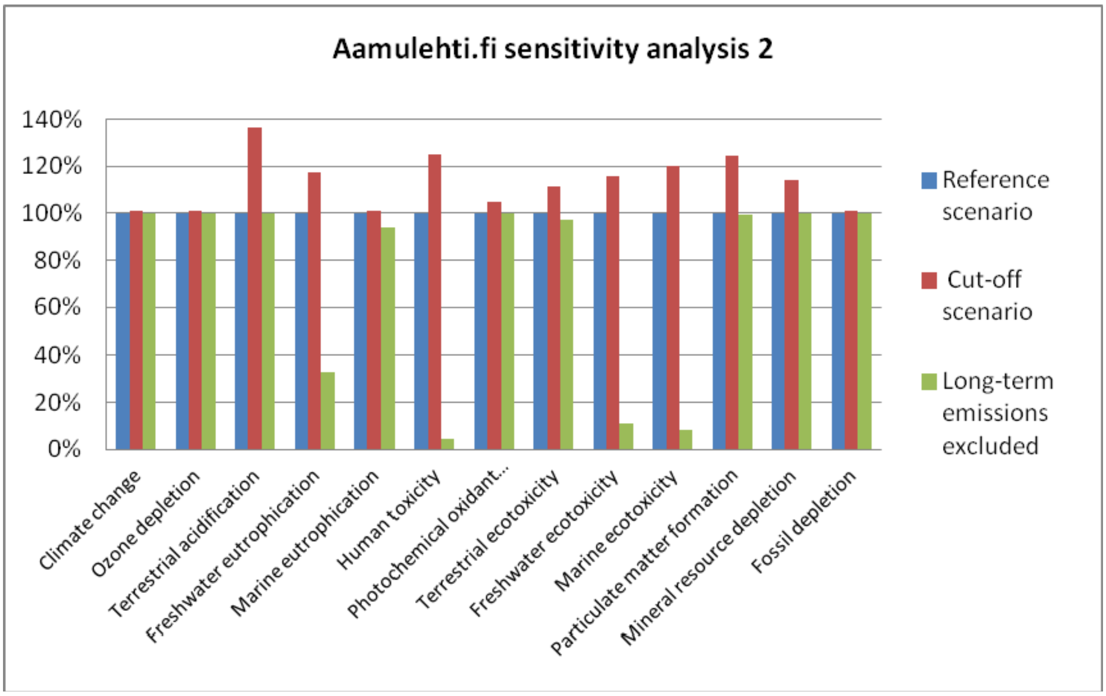


*Figure 48. Sensitivity analyses for Aamulehti.fi, related to the total environmental impact of the reference scenario (set to 100%).*

### 7.1.4 Case specific conclusions and discussion

The potential environmental impact related to the online version of Aamulehti during 2010 is to a large extent dependent on the electronic devices used by readers, but also to content production. For climate change the content production was the reason for 50% of the overall potential impact. The relatively high share of the total environmental impact is related to the content production in this case, and this is due to relatively few readers and low overall reading time of Aamulehti.fi in 2010. The manufacturing of devices was the major cause for many of the other impact categories studied. The environmental impact related to the extraction of raw materials, production of components and assembly of the electronic devices which was taken into account in the study was based on the share of time spent for reading Aamulehti.fi from the total active use time of the electronic devices. This means that a computer much used, and with a long service life will give a lower environmental impact per hour of active use. In the study statistics and assumptions are used to estimate the average overall computer use times of the readers. Thus, there are uncertainties regarding the resulting quantitative figures and in practice the values would be different for each unique reader. However, the overall conclusion is that manufacturing electronic equipment for reading the news online plays a key role.

The environmental impact related to electricity consumption for reading the news online is also dependent on user practices, as the electricity consumption is both the actual electricity used during reading but also a share of the electricity consumed while the device is not in active use. This share is based on the overall active use time.

In the case of Aamulehti.fi, the distribution of content to the reader has a very low environmental impact. This is due to the small amount of data downloaded by readers.

Some uncertainties in the assessment of Aamulehti.fi, apart from user practices, include limitations in data coverage for transportation and generation of electricity and heat and internet infrastructure. The effect of only considering production of fuel and emissions for vehicle operation is assumed to be rather small, as transportation and travel is limited within the system studied. The same reasoning can be applied to heating, which is only contributing to a part of the content production environmental impact. However, for electricity generation it is notable that this is a not insignificant reason for environmental impact for five of the impact categories. The contribution from electricity generation is almost none for the other categories. This may partly be due to more detailed inventories in the generic data used for manufacturing of devices.

Overall, it should be noted that the results for the toxicity impact categories are uncertain. By including these impact categories the aim is to illustrate that there are other impacts than climate change and that the major reason for these other impacts may be different than for climate change.

The power draw of the electronic devices will to some extent affect the environmental impact resulting from the user part of the system. A rather high power draw was assumed in the study, and the overall resulting environmental impact for the categories where electricity consumption is notable will be lower if a more efficient device is used. The results for Alma Media online products would also be different if they were read in another region with another electricity mix. Furthermore, assessing a reader who uses other electronic devices for reading the news online would give different results. With smaller, multi-purpose devices, e.g. smartphones, the environmental impact related to the online news may be lower.

## 7.2 Iltalehti.fi results

### 7.2.1 Carbon footprint

The overall potential climate change impact (a.k.a carbon footprint) resulting from Iltalehti.fi is 2200 tonnes of $CO_2$/year (Figure 49). Emissions related to the end user account for 67% of these, mainly the manufacturing of devices, which is 43% of the total potential greenhouse gas emissions. For Iltalehti, online distribution is a major cause of potential climate change impact as well (24%), due to the large amount of data downloaded by readers.

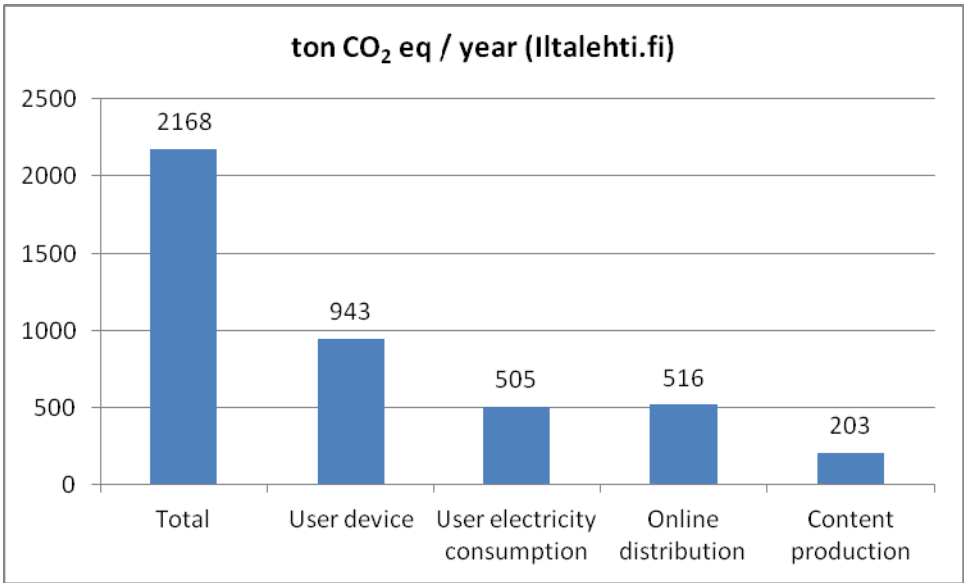


*Figure 49. Carbon footprint of Iltalehti.fi, characterisation.*

### 7.2.2 Other LCIA results

The share for each process with respect to the total potential impact for each category is shown in Figure 50. All total values are set to 100%. It should be noted that since all total values are set to 100%, a high share may de a high share of a small or high overall impact.

As illustrated in Figure 50, the environmental impacts related to the online version of Iltalehti are mainly due to end user devices, i.e. desktops, screens and laptops. The share of manufacturing and disposal allocated to reading Iltalehti.fi is the major cause for all types of environmental impact assessed, from 40% of the total value for climate change to more than 80% for ozone depletion, human toxicity, freshwater eutrophication, marine eutrophication, terrestrial ecotoxicity, freshwater ecotoxicity, marine ecotoxicity and metal depletion. Major reasons for environmental impacts related to the manufacturing of electronic devices are described in Section 5, Content production.

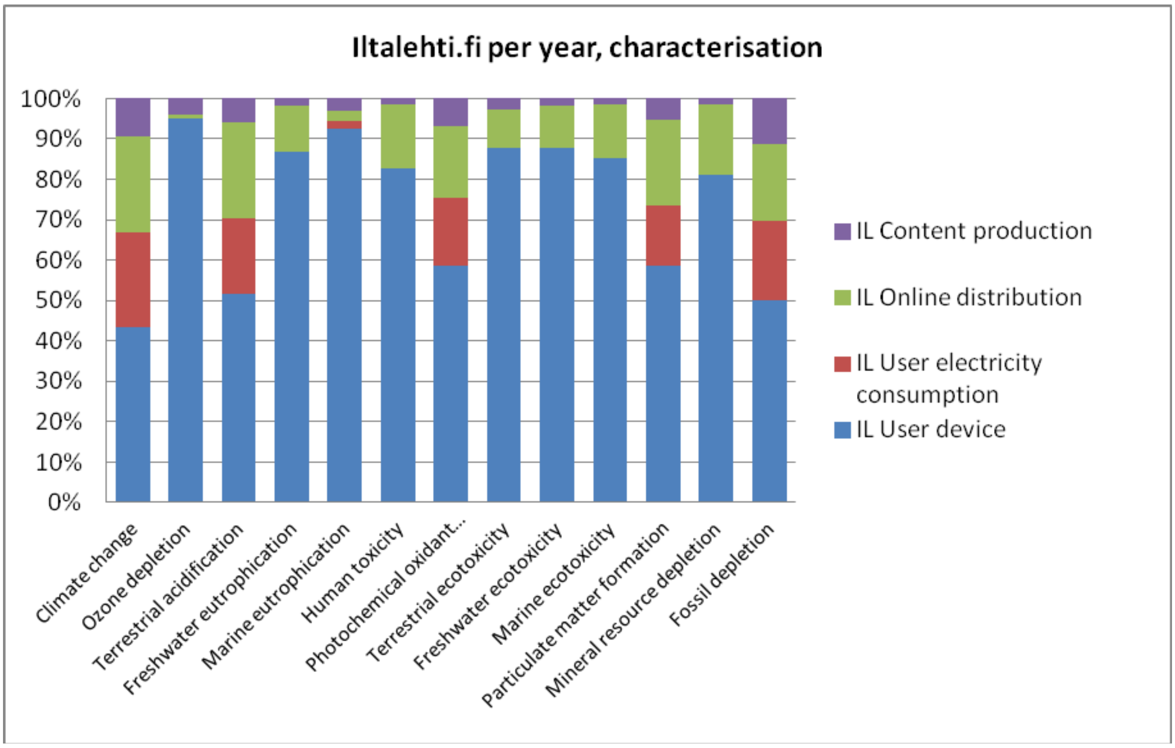


*Figure 50. Environmental performance of Iltalehti.fi, characterisation.*

In addition, end user electricity consumption in using electronic devices contributes to the potential environmental impacts: around 15–20% for climate change, photochemical ozone creation, particulate matter formation, terrestrial acidification and fossil depletion.

The potential environmental impact related to online distribution is also considerable for several impact categories, contributing around 15 to more than 20% to climate change, human toxicity, photochemical ozone creation, particulate matter formation, terrestrial acidification, metal depletion and fossil depletion. The relatively high share of environmental impact related to online distribution is due to the amount of data downloaded by readers. The relative environmental impact related to content production is smaller, at most about 10% for climate change and fossil depletion.

It should be noted that the results for the toxicity impact categories are uncertain. By including these impact categories the aim is to illustrate that there are other impacts than climate change and that the major reason for these other impacts may be different than for climate change.

The normalised results for the online version of Iltalehti per reader and year are presented as a share of the total environmental impact of one European person per year. The results are illustrated in Figure 51.

Human toxicity, freshwater eutrophication, freshwater ecotoxicity and marine ecotoxicity score high in the normalisation. This indicates that these are the impact categories where the online version of Iltalehti has a relatively larger share of the total contribution by one European person, compared to other impact categories, contributing 0.25% to the total impact of one European. For these impact categories long-term emissions related to gold mining are a major reason for the impact. For climate change the normalized result is about 0.02% of the total climate change impact for one European.

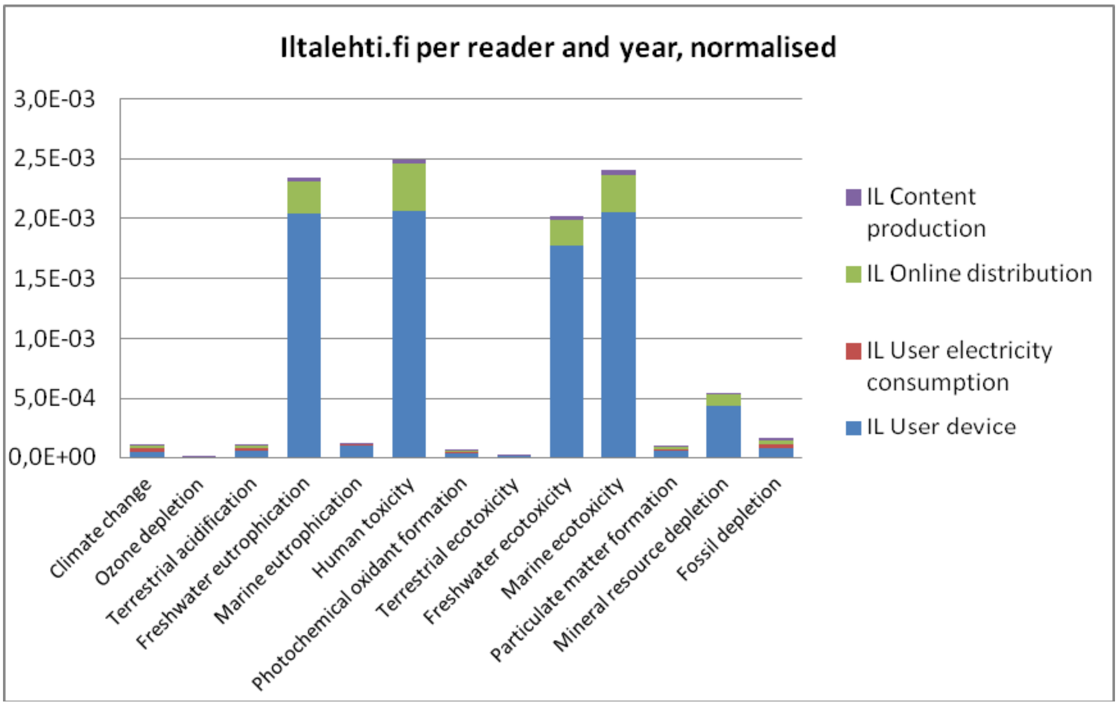


*Figure 51. Iltalehti.fi per reader and year, normalised to one European inhabitant impact during one year.*

### 7.2.3 Sensitivity analysis

Sensitivity analyses were done to test some crucial assumptions.

One of the sensitivity analyses done (Figure 52) considers a hypothetical case with very high total use of the electronic devices in the home. The resulting potential environmental impact is in this case considerably lower than the impact in the reference scenario for all impact categories studied; it is almost halved for many categories. This clearly illustrates that the allocation of environmental impact for manufacturing electronic devices is crucial, and thus efficiently using an electronic device, in addition to a long service life, will decrease the environmental impact related to each use activity. Figure 52 also shows that a shorter service life for electronic devices will lead to higher environmental impact in all impact categories.

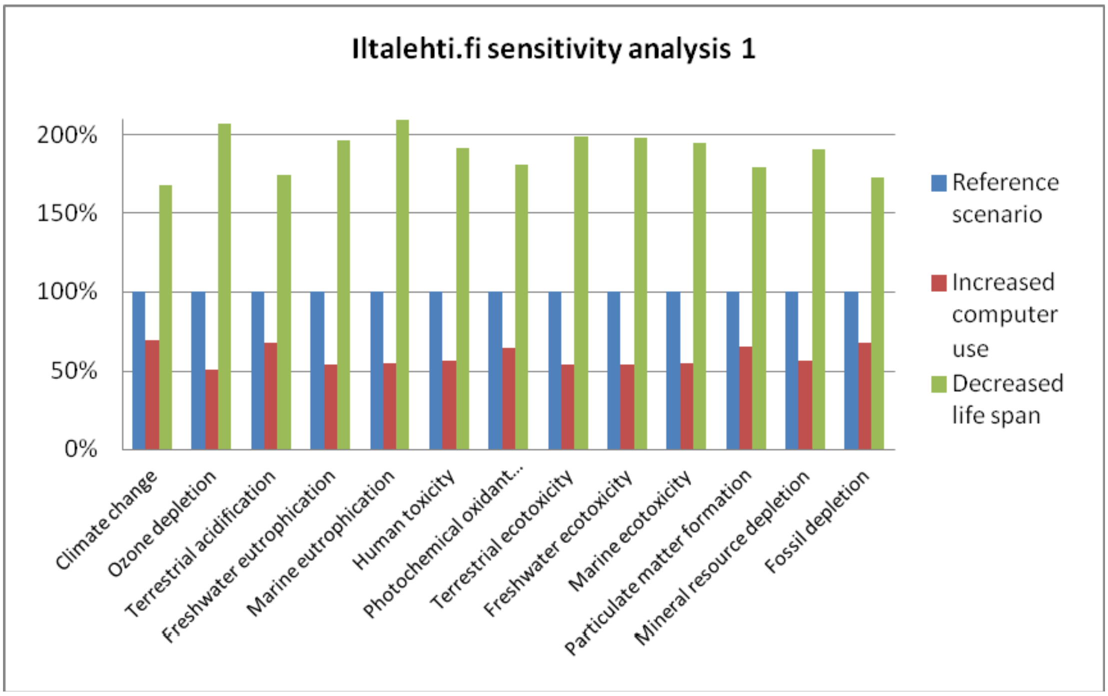


*Figure 52. Sensitivity analyses, Iltalehti.fi per year, related to the total environmental impact of the reference scenario (set to 100%).*

Figure 53 illustrates how excluding the recycling of metals and the benefits gained by avoiding virgin production leads to changes in the overall results for some impact categories and not others. This illustrates the environmental impacts related to virgin production of metals, the avoidance of which is not taken into account in the system studied in the sensitivity analysis. This uncertainty regarding the waste treatment of electronic devices is shown to be more of importance for the impact categories human toxicity, particulate matter formation, terrestrial acidification, freshwater eutrophication, terrestrial acidification, freshwater ecotoxicity, marine ecotoxicity and metal depletion. On the other hand, climate change, ozone depletion, photochemical ozone creation, marine eutrophication and fossil depletion are not shown to be very affected. Sub-systems affected by the changes made in the recycling sensitivity analysis include user devices and office equipment.

When excluding long-term emissions (Figure 53), a considerable change in overall potential impacts can be seen for some impact categories: freshwater eutrophication, human toxicity, freshwater ecotoxicity and marine ecotoxicity. The other impact categories are not very affected by the change in system boundaries in time. This illustrates the complexity of the system studied and some of the impacts. It is not easy to assess these impacts, and considerable differences in results will be found depending on the time perspective used.

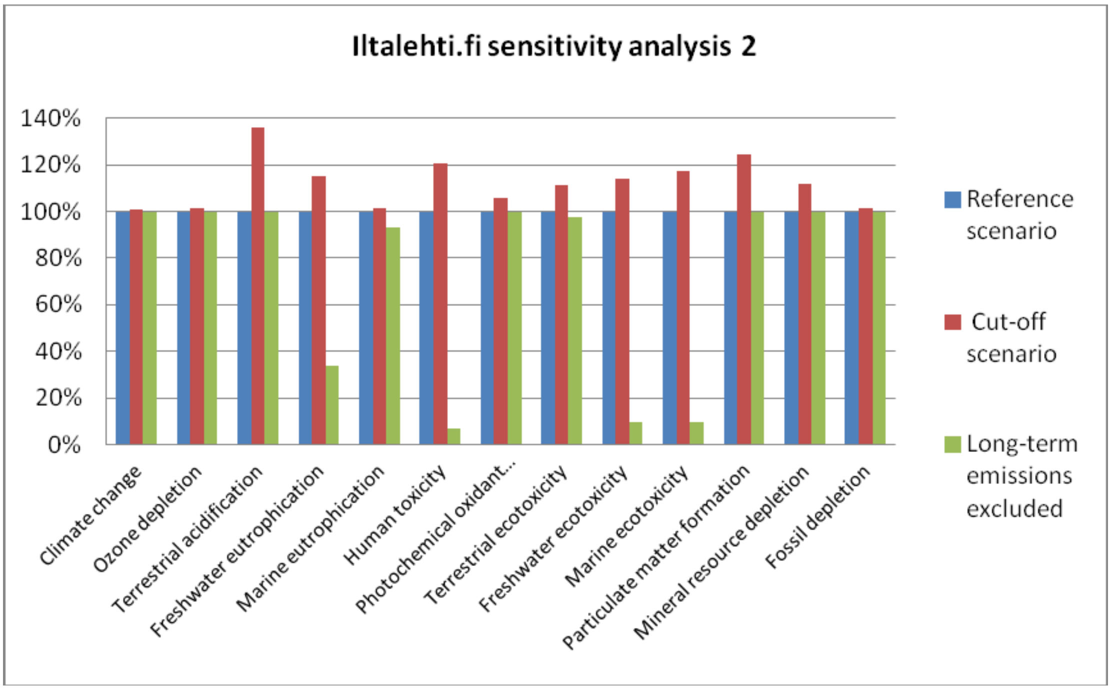


*Figure 53. Sensitivity analyses, Iltalehti.fi per year, related to the total environmental impact of the reference scenario (set to 100% ).*

### 7.2.4 Case specific conclusions and discussion

The potential environmental impact related to Iltalehti.fi during 2010 is to a large extent dependent on the electronic devices used by readers. The manufacturing of these devices was the major cause for all impact categories studied. The environmental impact related to the extraction of raw materials, production of components and assembly of the electronic devices which was taken into account in the study was based on the share of time spent for reading Iltalehti.fi from the total active use time of the electronic devices... This means that a computer much used, and with a long service life will give a lower environmental impact per hour of active use. In the study statistics and assumptions are used to estimate the average overall computer use times of the readers. Thus, there are uncertainties regarding the resulting quantitative figures and in practice the values would be different for each unique reader. However, the overall conclusion that the manufacturing of electronic equipment for reading is a major cause for the overall impacts of online news is a valid conclusion.

The environmental impact related to electricity consumption for reading the news online is also dependent on user practices, as the electricity consumption is both the actual electricity used during reading but also a share of the electricity consumed while the device is not in active use. This share is based on the overall active use time.

The electronic distribution of content to the reader accounts for a considerable share of the environmental impact related to the online version of Iltalehti: 10–20% for most impact categories. This is due to the amount of data downloaded by readers. The environmental impact of the distribution system (manufacturing of cables and servers, as well as electricity consumption for operation of the full network) is allocated on different use based on the share of the total data transmitted, in MB.

Content production has a rather low share for online version of the Iltalehti's overall environmental impact. The largest share is 10% for climate change and fossil depletion.

Some uncertainties in the assessment of Iltalehti.fi, apart from the user practices, include limitations in data coverage for transportation, electricity and heat generation and internet infrastructure. The effect of only considering production of fuel and emissions for vehicle operation is assumed to be rather small, as transportation and travel is limited within the system studied. The same reasoning can be applied to heating, which is only part of the content production. However, when considering the process data for electricity generation it is notable that this is an important reason for environmental impact for five of the impact categories. The contribution from electricity generation is almost none for the other categories. This may partly be due to more detailed inventories in the generic data used for manufacturing of devices.

The data used for electronic distribution was to a large extent based on Swedish figures regarding cables and electricity use for operating core and access networks. The data for operation probably slightly underestimate the electricity needed, and thus the distribution of Iltalehti.fi could have an even larger share of the overall environmental impact. In this case user practices regarding how much data is downloaded will affect the assessment.

Overall, it should be noted that the results for the toxicity impact categories are uncertain. By including these impact categories the aim is to illustrate that there are other impacts than climate change and that the major reason for these other impacts may be different than for climate change.

The power draw of the electronic devices will to some extent affect the environmental impact resulting from the user part of the system. A rather high power draw was assumed in the study, and the overall resulting environmental impact for the categories where electricity consumption is notable will be lower if a more efficient device is used. The results for Alma Media online products would also be different if they were read in another region with another electricity mix. Furthermore, assessing a reader who uses other electronic devices for reading the news online would give different results. With smaller, multi-purpose devices, e.g. smartphones, the environmental impact related to the online news may be lower.

## 7.3 Kauppalehti.fi results

### 7.3.1 Carbon footprint

The overall potential climate change impact resulting from Kauppalehti.fi is 700 tonnes of $CO_2$/year (Figure 54). Emissions related to the end user account for 78% of these, mainly the manufacturing of devices, which is 50% of the total potential greenhouse gas emissions. Content production contributes to 19% of the greenhouse gases emitted.

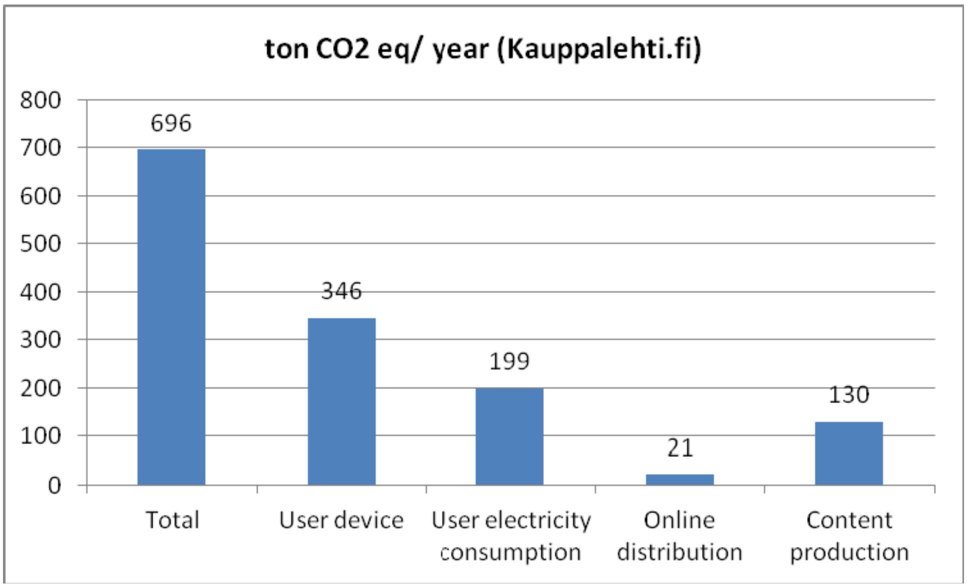


*Figure 54. Carbon footprint of Kauppalehti.fi per year.*

### 7.3.2 Other LCIA results

The share for each process with respect to the total potential impact for each category is shown in Figure 55. All total values are set to 100%. It should be noted that since all total values are set to 100%, a high share may de a high share of a small or high overall impact.

As illustrated in Figure 55, the environmental impacts related to Kauppalehti.fi are mainly due to end user devices, i.e. desktops, screens and laptops. The share of manufacturing and disposal allocated to reading Kauppalehti.fi is the major cause for all types of environmental impact assessed, from almost 50% of the total value for climate change to more than 90% for human toxicity, freshwater eutrophication, marine eutrophication, terrestrial ecotoxicity, freshwater ecotoxicity, marine ecotoxicity and metal depletion. Major reasons for environmental impacts related to the manufacturing of electronic devices are described in Section 5, content production.

It should be noted that the results for the toxicity impact categories are uncertain. By including these impact categories the aim is to illustrate that there are other impacts than climate change and that the major reason for these other impacts may be different than for climate change.

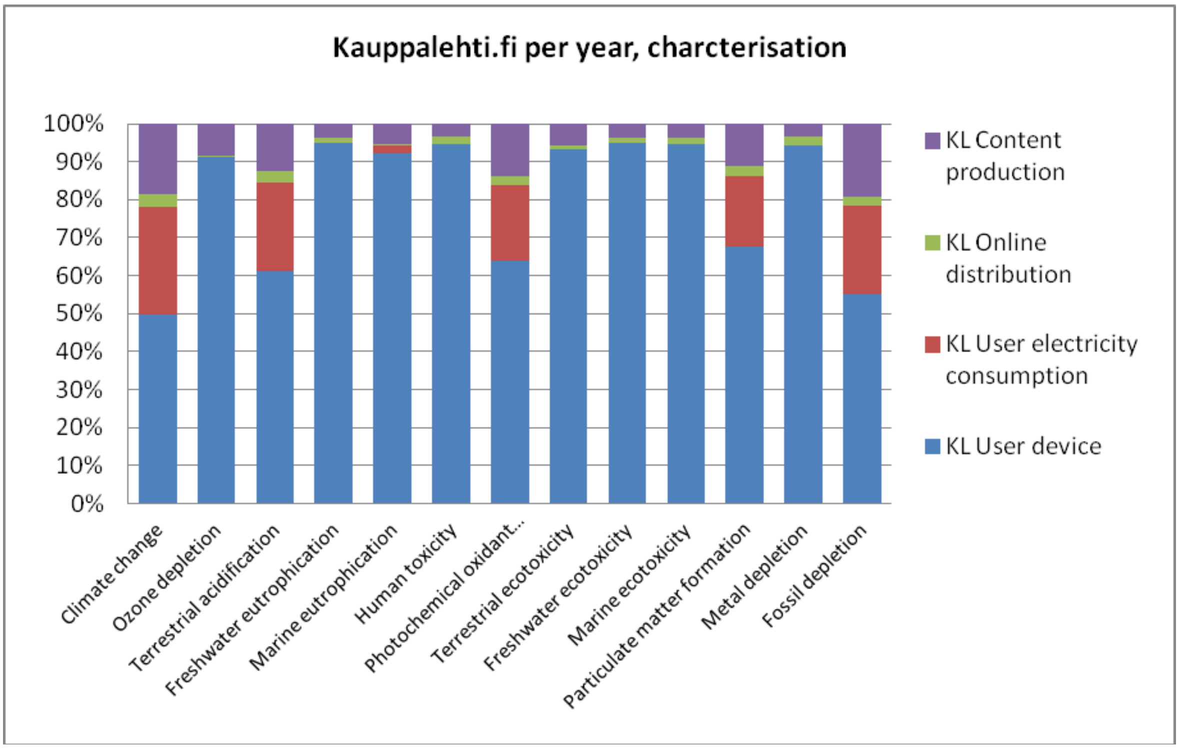


*Figure 55. Environmental performance of Kauppalehti.fi per year, characterisation.*

In addition, end user electricity consumption in using the electronic devices contributes to the potential environmental impacts: around 20–30% for climate change, photochemical ozone creation, particulate matter formation, terrestrial acidification and fossil depletion.

The normalised results for Kauppalehti.fi per reader and year are presented as a share of the total environmental impact of one European person per year. The results are illustrated in Figure 56.

Human toxicity, freshwater eutrophication, freshwater ecotoxicity and marine ecotoxicity score high in the normalisation. This indicates that these are the impact categories where Kauppalehti.fi has a relatively larger share of the total contribution by one European person, compared to other impact categories, contributing up to 0.23% of the total impact of one European. For these impact categories long-term emissions related to gold mining are a major reason for the impact. For climate change the normalized result is about 0.02% of the total climate change impact for one European.

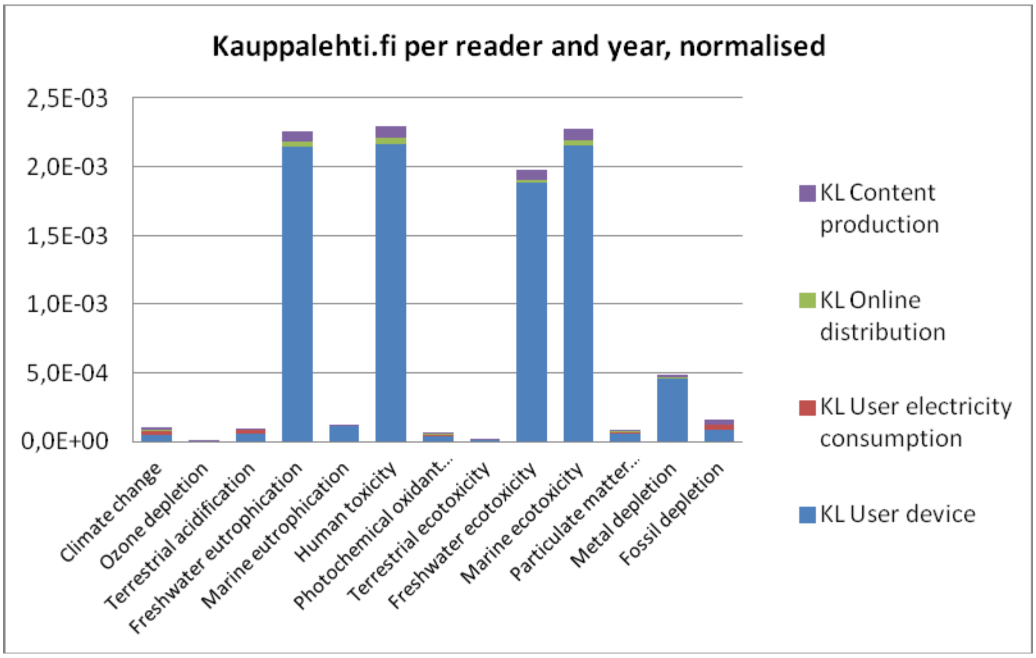


*Figure 56. Environmental performance of Kauppalehti.fi per reader and year, normalised to one European inhabitant impact on one year.*

### 7.3.3 Sensitivity analysis

Four sensitivity analyses were done to test some crucial assumptions.

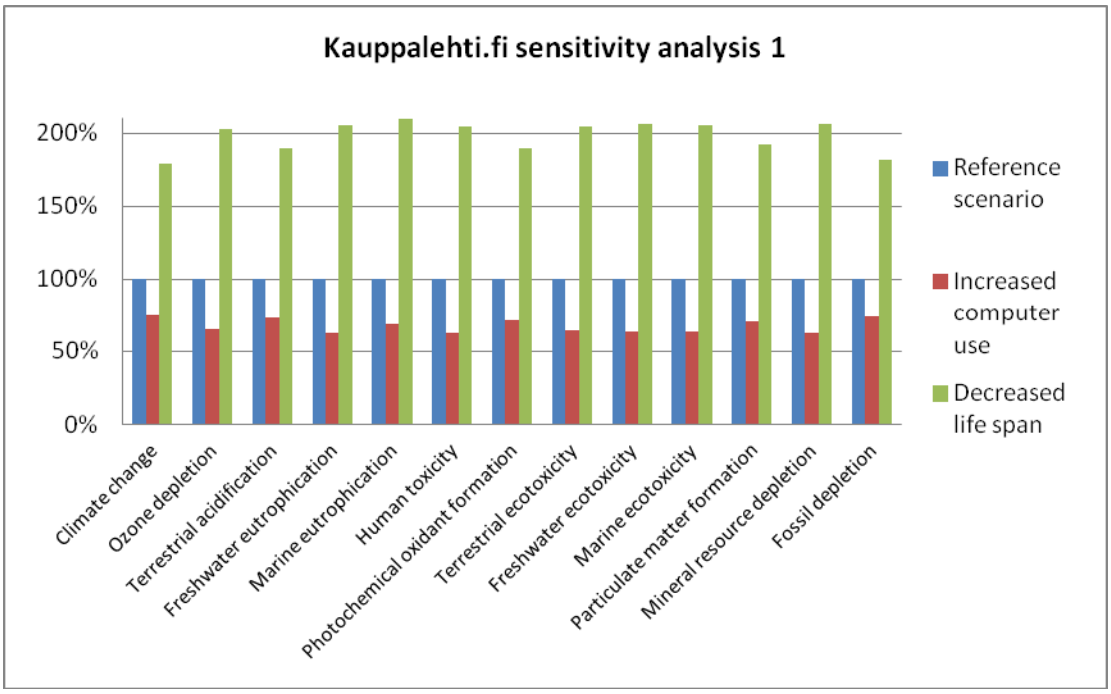


*Figure 57. Sensitivity analyses, Kauppalehti.fi per year, related to the total environmental impact of the reference scenario set to 100%.*

One sensitivity analysis (Figure 57) considers a hypothetical case with very high total use of electronic devices in the home. The resulting potential environmental impact is in this case considerably lower, around 60–70% of the resulting impact in the reference scenario. This clearly illustrates that the share of environmental impact for manufacturing electronic devices is crucial, and thus efficiently using an electronic device, in addition to a long service life, will decrease the environmental impact related to each use activity. Figure 57 also shows that a shorter service life for electronic devices will lead to higher environmental impact in all impact categories as a consequence.

Figure 58 illustrates how excluding the recycling of metals and the benefits gained by avoiding virgin production leads to changes in the overall results for some impact categories and not others. This illustrates the environmental impacts related to virgin production of metals, the avoidance of which is not taken into account in the system studied in the sensitivity analysis. The uncertainty regarding the waste treatment of electronic devices is shown to be more of importance for the impact categories human toxicity, particulate matter formation, terrestrial acidification, freshwater eutrophication, terrestrial acidification, freshwater ecotoxicity, marine ecotoxicity and metal depletion. On the other hand, climate change, ozone depletion, photochemical ozone creation, marine eutrophication, and fossil depletion are not shown to be very affected. Sub-systems affected by the changes made in the recycling sensitivity analysis include user devices and office equipment.

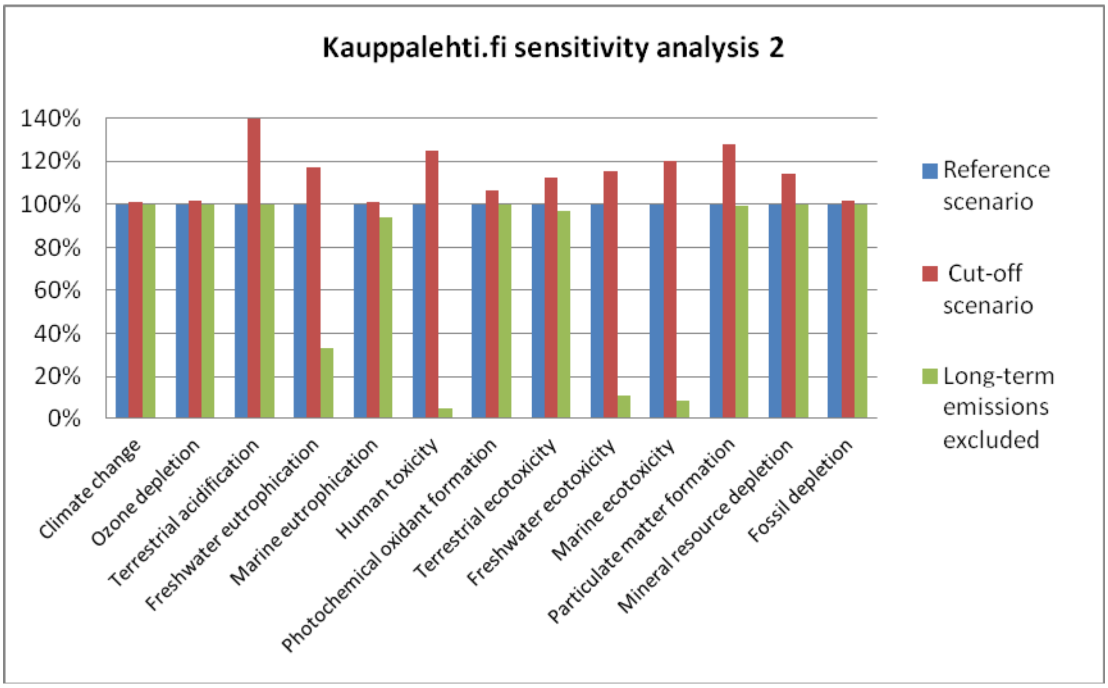


*Figure 58. Sensitivity analyses, Kauppalehti.fi per year, related to the total environmental impact of the reference scenario set to 100%.*

When excluding long-term emissions (Figure 58), a considerable change in overall potential impacts can be seen for some impact categories: freshwater eutrophication, human toxicity, freshwater ecotoxicity and marine ecotoxicity. The other impact categories are not very affected by the change in system boundaries in time. This illustrates the complexity of the system studied and some of the impacts. It is not easy to assess these impacts, and considerable differences in results will be found depending on the time perspective used.

### 7.3.4 Case specific conclusions and discussion

The potential environmental impact related to Kauppalehti.fi version during 2010 is to a large extent dependent on the electronic devices used by the readers. The manufacturing of these devices was the major cause for all impact categories studied. The environmental impact related to the extraction of raw materials, production of components and assembly of the electronic devices which was taken into account in the study was based on the share of time spent for reading Kauppalehti.fi from the total active use time of the electronic devices. This means that a computer much used, and with a long service life will give a lower environmental impact per hour of active use. In the study statistics and assumptions are used to estimate the average overall computer use times of the readers. Thus, there are uncertainties regarding the resulting quantitative figures and in practice the values would be different for each unique reader. However, the overall conclusion that the manufacturing of electronic equipment for reading is a major cause for the overall impacts of online news is a valid conclusion.

The environmental impact related to electricity consumption for reading the news online is also dependent on user practices, as the electricity consumption is both the actual electricity used during reading but also a share of the electricity consumed while the device is not in active use. This share is based on the overall active use time.

Content production has a significant share (15–20%) of the Kauppalehti.fi version environmental impact for some impact categories. The reason for this is business travel, use of electricity and heat in the office and manufacturing electronic devices used in the office.

Some uncertainties in the assessment of Kauppalehti.fi, apart from the user practices, include limitations in data coverage for transportation, electricity and heat generation, internet infrastructure. The effect of only considering production of fuel and emissions for vehicle operation is assumed to be rather small, as transportation and travel is limited within the system studied. The same reasoning can be applied to heating, which is only part of the content production. However, when considering the process data for electricity generation it is notable that electricity generation has significant shares for five of the impact categories studied. The contribution from electricity generation is almost none for the other categories. This may partly be due to more detailed records in the generic data used for manufacturing of devices.

Overall, it should be noted that the results for the toxicity impact categories are uncertain. By including these impact categories the aim is to illustrate that there are other impacts than climate change and that the major reason for these other impacts may be different than for climate change.

The power draw of the electronic devices will to some extent affect the environmental impact resulting from the user part of the system. A rather high power draw was assumed in the study, and the overall resulting environmental impact for the categories where electricity consumption is notable will be lower if a more efficient device is used. The results for Alma Media online products would also be different if they were read in another region with another electricity mix. Furthermore, assessing a reader who uses other electronic devices for reading the news online would give different results. With smaller, multi-purpose devices, e.g. smartphones, the environmental impact related to the online news may be lower.

# 8. Integration of results and discussions

## 8.1 Content production

The potential environmental impacts of Alma Media products during 2010 have been presented in earlier sections of this report (see Chapter 5). Aamulehti, Iltalehti and Kauppalehti are three newspapers with somewhat different scopes and target groups, different numbers of readers and numbers of pages per copy. The environmental impacts from content production for the three newspapers in respect of each other are illustrated in Figure 59 for all the impact categories studied. The environmental impact of Iltalehti content production is set to 100%.

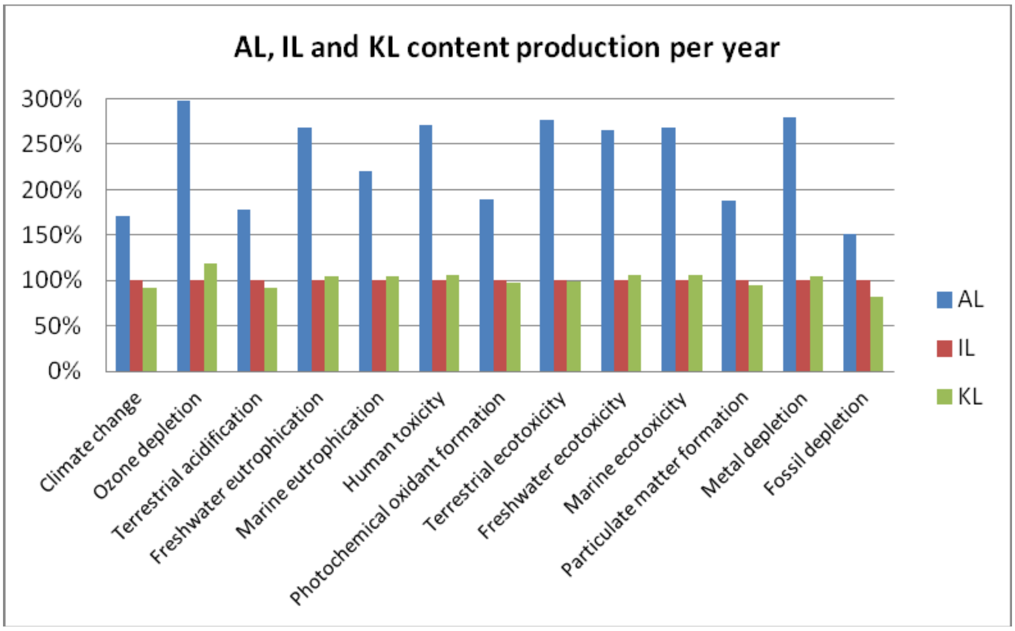


*Figure 59. Potential environmental impact of AL, IL and KL content production per year, year, related to the total IL environmental impact which is set to 100%.*

It can be seen that Aamulehti's content production has a higher impact during one year in all categories, which is due to the higher number of pages per copy and consequently higher number of employees for content production. This results in greater electricity consumption, more business travel and more electronic equipment used per year. Figure 60 presents the carbon footprint for content production for the three newspapers, and there it can be seen that the main reason for differences are business travel, but also to some extent electronic equipment and energy use. Kauppalehti and Iltalehti have similar yearly contribution to climate change from content production.

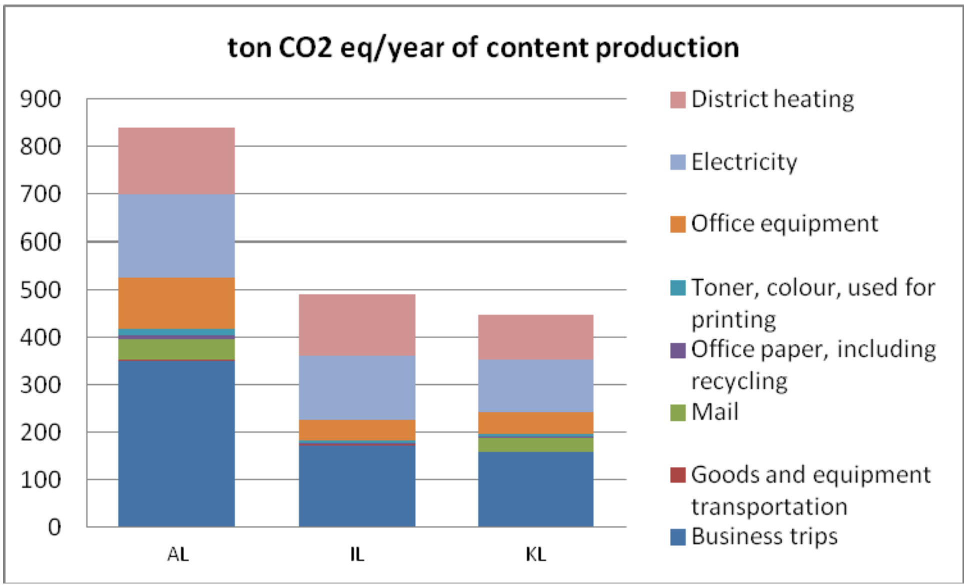


*Figure 60. Carbon footprint of AL, IL and KL content production per year.*

Overall, the results of the content production assessment show that business trips is the major cause of climate change impacts, and around 35–40% of the total potential climate change impact in all systems studied. Around 20% of the potential climate change impact is related to electricity generation and district heating respectively. In relation to the number of employees the three newspapers have 2.7–3 tonnes $CO_2$-eq./FTE.

## 8.2 Printed media

The potential environmental impacts of Alma Media print products during 2010 have been presented in earlier sections of this report (see Chapter 6.) If the absolute values of printed media production are compared, it is obvious that printed Aamulehti production has the biggest overall environmental impact. This is a direct consequence of highest production volume compared to Iltalehti and Kauppalehti (AL 41 million copies + AL supplement 7 million copies; IL 30 million copies and KL 19 million copies per year).

Carbon footprint results per one tonne of the newspapers are presented together in Figure 61 to compare the environmental burdens.

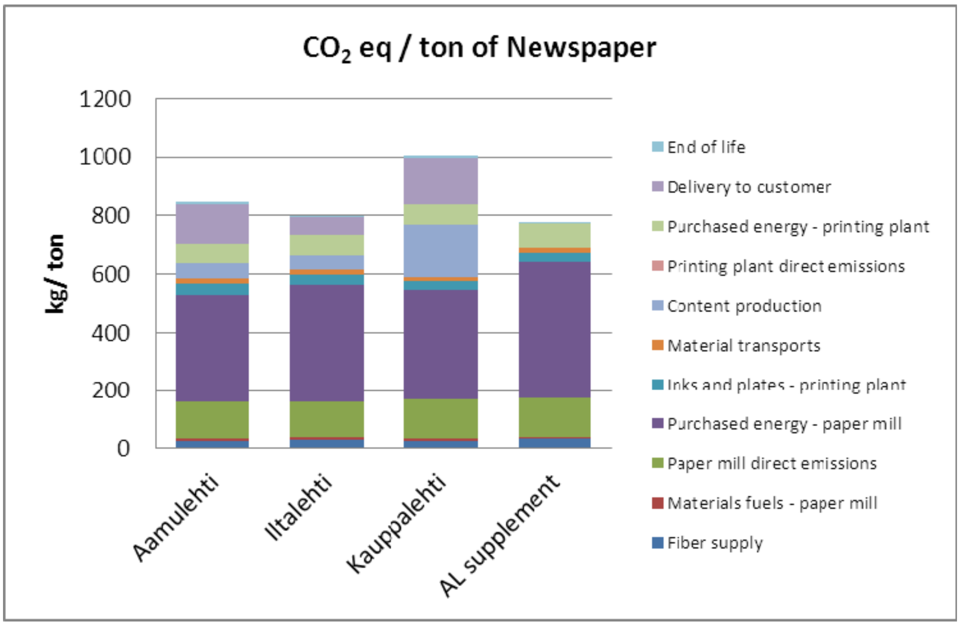


*Figure 61. Comparison of carbon footprints per tonne of newspaper.*

Figure 61 shows the carbon footprint per tonne for the different newspapers (reference case). Here, the avoided emissions are compensated both for purchased electricity to paper mill and printing plant.

When the results are compared per tonne of product, it can be seen that the overall contribution of Kauppalehti is the highest. This largely results from the higher contribution of content production environmental impact per tonne of newspaper when compared to Iltalehti and Aamulehti. This is due to Kauppalehti having 2-3 times more full-time employees (FTEs) per tonne of newspaper. The environmental impact of most of the processes in the printed newspaper product system is highly correlated to the amount of newspaper produced, except for content production, where the impact is more related to the number of employees. The carbon footprint for content production per employee is in between those of Iltalehti and Aamulehti.

Also, the emissions resulting from distribution differs notably when different printed newspapers are compared. The emissions from distribution are similar for Aamulehti and Kauppalehti (15% share), while the impact for Iltalehti is lower (7%). The explanation for this is that the newspapers studied have different modes of distribution: Aamulehti and Kauppalehti are mainly delivered to homes and offices while Iltalehti is delivered to retailers. It is not accurately known how readers pick up their printed newspapers, i.e. by car or by foot or together with other products or only the newspaper, etc., to evaluate this aspect. Thus the share of distribution is lower for IL. Concerning the Aamulehti Sunday supplement, it should be kept in mind that the content production and distribution are wholly allocated to Aamulehti.

*Table 17. Comparison of $CO_2$ eq emissions of reading newspapers to driving a car.*

| | | Aamulehti | | Iltalehti | | Kauppalehti | |
|---|---|---|---|---|---|---|---|
|  | Unit | *per copy* | per annual subscription (inc. Sunday supplement) | *per copy* | per annual subscription | *per copy* | per annual subscription |
| **Carbon footprint** | g $CO_2$ eq. | ***244.0*** ⇩ | **91607.0** ⇩ | ***161.0*** ⇩ | **48461.0** ⇩ | ***97.0*** ⇩ | **24153.0** ⇩ |
| **Distance of driving a car** | km | ***1.4*** | **525.9** | ***1.0*** | **295.5** | ***0.6*** | **147.3** |

*Average direct emissions from driving a car per km are assumed to be 164 g $CO_2$/km.

Table 17 above shows how the carbon footprint of either one copy of Aamulehti newspaper or per annual subscription can be compared to driving a car. Figure 62 below presents the normalised impact assessment results for a copy of Aamulehti from a different perspective than in Figure 27 in Section 6.1.2. Figure 62 clearly shows that the most meaningful processes in the life cycle of the printed Aamulehti are newsprint production (including fillers, purchased energy and mill operations), ink and plate production supply chains and the content production supply chain. This same pattern can be found in all printed media cases observed within this study. The only exception is the Aamulehti Sunday supplement, where content production was excluded (see Section 6.1.4).

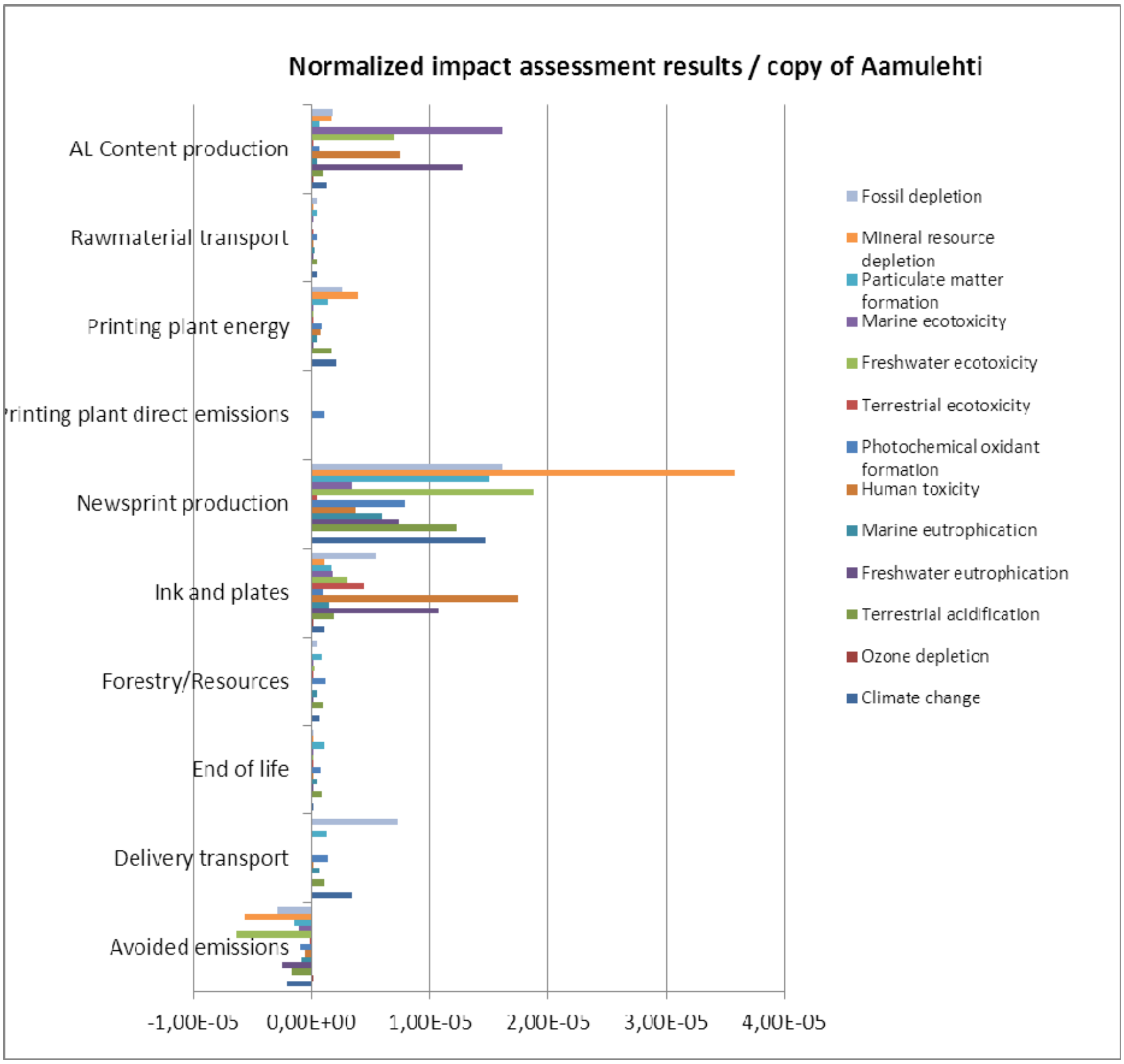


*Figure 62. Normalised impact assessment results per copy of Aamulehti. Normalisation has been performed against the environmental impacts caused by one European inhabitant during one year.*

Even though some of the processes in the life cycle of printed media have a major role, it still should be kept in mind that overall environmental performance is an accumulated sum of different life cycle phases in the products value chain. Consequently, in order to measure, control and decrease the environmental impacts of Alma Media's print products, the steps towards energy and material efficiency are valid.

In order to see what environmental impact reading a daily newspaper has, Figure 63 below shows the normalised impact of a yearly subscription of Aamulehti. Subscribing and reading a printed Aamulehti newspaper every day is contributing a maximum 1.3% of the total environmental impact of an average European citizen (ReCiPe method). From this, the conclusion can be drawn that reading the printed version of Iltalehti or Kauppalehti will not even have that high an impact.

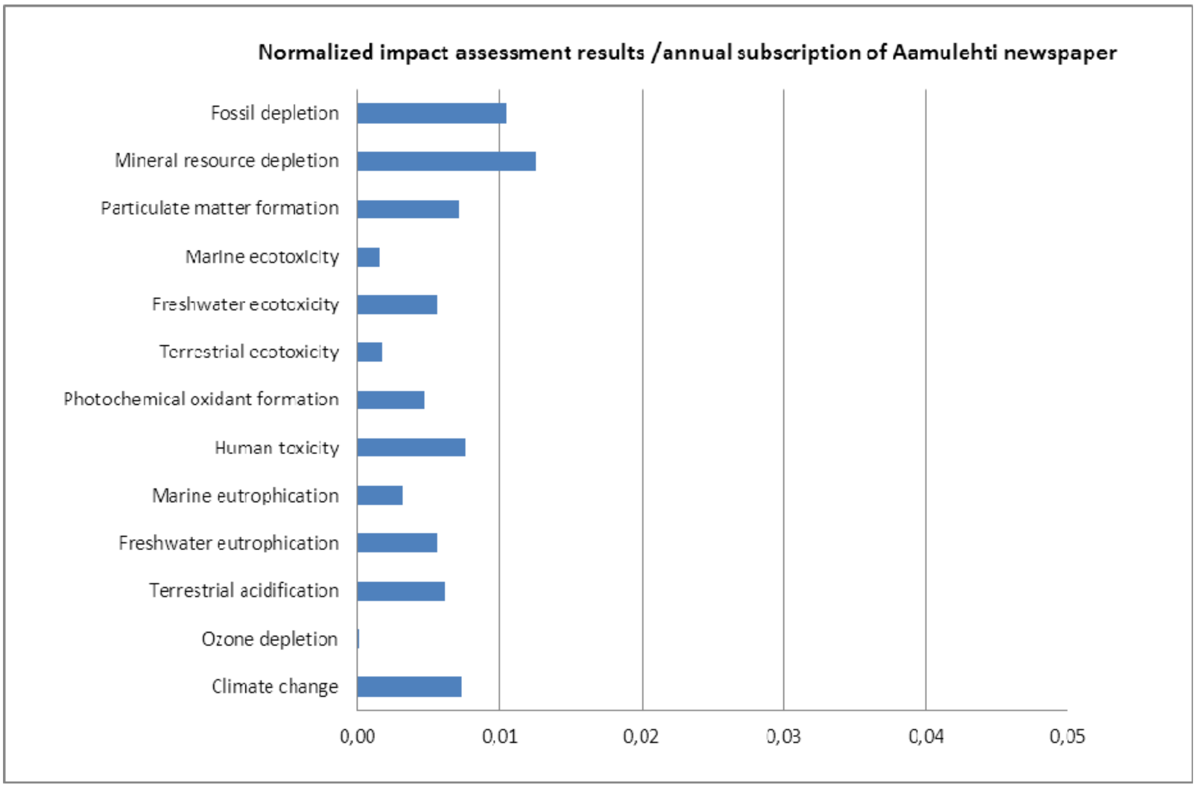


*Figure 63. Normalised impact assessment results per annual subscription of Aamulehti newspaper (356 copies per year).*

Concerning the reliability of printed media results, it is worth noting that the results for climate change, fossil fuel depletion, acidification, eutrophication characterization categories are the most reliable. The data in the print cases are direct process specific data from the pulp and paper manufacturer, and are therefore very high quality and specific for these cases. Most of the impacts are also related to the newsprint mill. The VTT KCL EcoData datasets that have been applied in this study are good quality process specific data that cover emissions and resource uses related to these impact categories well. On the other hand, the greatest uncertainties are connected to impact categories related to toxicity. For example, the emissions of metals and hazardous organic compounds into the air represent a clear data gap in the KCL EcoData datasets applied.

## 8.3 Online media

The potential environmental impact of Alma Media online products during 2010 has been presented in earlier sections of this report.

The reasons for the environmental impact of the three online versions of the newspapers differ. Regarding climate change the major reason for Aamulehti.fi is content production and for Iltalehti.fi and Kauppalehti.fi it is manufacturing of electronic devices used by readers.

For the other environmental impacts studied the manufacturing of end consumer devices (desktops, screens and laptops) is an overall major reason. This means that user practices regarding computer use is crucial to the resulting environmental performance. A reader who has an energy efficient laptop that is used for many years before being disposed of and that is used many hours per day for different purposes will have a lower environmental impact for the online newspaper versions than a reader who has a desktop computer with a large screen with considerable power draw who does not use the device for many purposes. Thus the specific environmental impact of the online newspaper versions will differ between different readers.

In addition to manufacturing electronic devices and the electricity needed to use them, content production is also a considerable part of the overall environmental impact for Aahmulehti.fi and to a lesser extent Kauppalehti.fi. The major reasons for content production environmental impact are the manufacturing of office electronic equipment, business trips and electricity and heat in the office. It is interesting to note that environmental impact from content production is large for Aamulehti.fi even though only 15% of the total content production at Aamulehti is allocated to the online version (see Table 6). This is because there are relatively few readers and low reading time per reader, and thus the yearly environmental impact from reading is relatively small. Iltalehti.fi has little environmental impact related to content production, but on the other hand a rather large share related to online distribution. This is due to many readers and larger size of average download compared to Aamulehti.fi and Kauppalehti.fi, resulting in relatively high electricity consumption by the internet infrastructure.

Concerning the reliability of online media results, the results for the climate change and fossil fuel depletion characterisation categories are the most reliable. In these cases, the inventory data is more comprehensive and also the characterisation method for climate change is well developed. This should be taken into account when interpreting the results. There are some similarities between the climate change impact categories and other categories when considering the importance of the processes within the studied systems. The manufacturing of electronic devices is a major cause for other impact categories, especially toxicological categories. Even though the results regarding the toxicity impact categories are uncertain, this seems feasible, considering the mining of metals, use of cleaning agents in the manufacturing, etc.

Considering the results for the three online versions of the newspapers, it is clear that the total potential environmental impact is highest for Iltalehti.fi (Figure 64 and Figure 65). The environmental impact of Kauppalehti.fi during 2010 is about 30% of the impact resulting from Iltalehti.fi, and Aamulehti.fi is about 10%. However, it should be taken into account that Iltalehti.fi has considerably more readers than Kauppalehti.fi and Aamulehti.fi, – 1.8 million readers per week in comparison with 0.62 million readers per week of Kauppalehti.fi and 0.24 million readers per week of Aamulehti.fi. As the major cause of environmental impact related to the online newspapers is related to end user devices, the more these are read the higher the overall environmental impact. Online distribution is also significant for Iltalehti.fi.

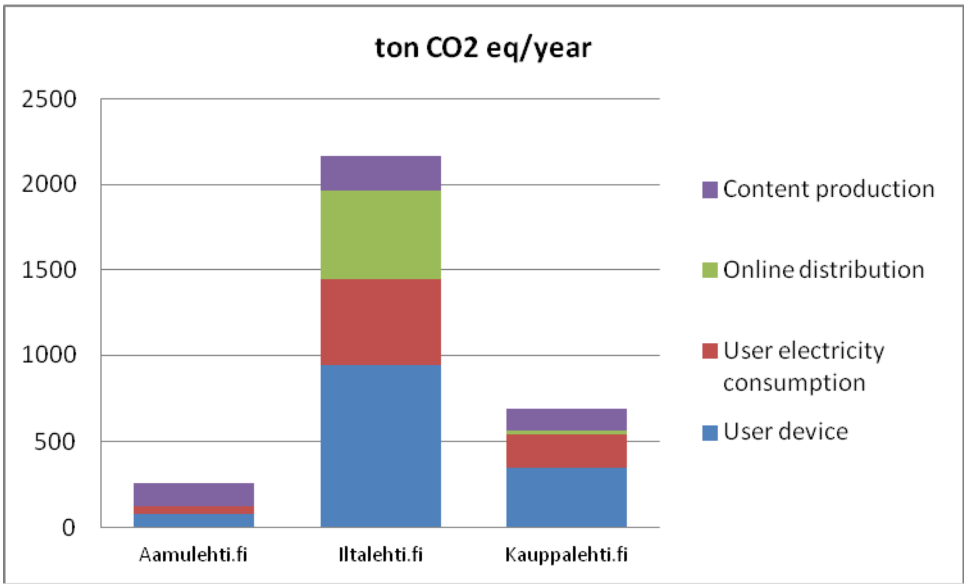


*Figure 64. Carbon footprint for Aamulehti.fi, Iltalehti.fi and Kauppalehti.fi per year.*

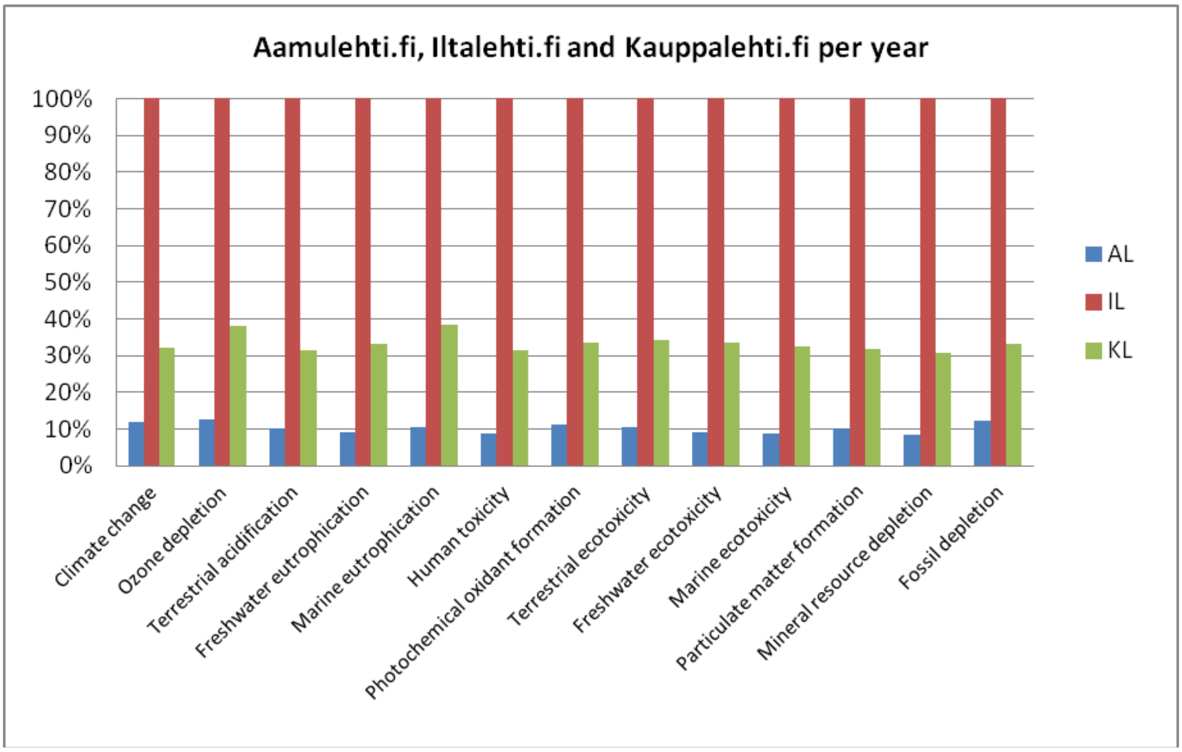


*Figure 65. Environmental performance of Aamulehti.fi, Iltalehti.fi and Kauppalehti.fi per year, related to the total Iltalehti.fi environmental impact which is set to 100%.*

Taking the number of readers into account, we also consider the environmental performance of the online versions of the newspapers per reader and week. Figure 66 and Figure 67 illustrate how the environmental impact per reader and week is distributed differently than the overall impact during a year. In this case, the environmental performance is more of the same magnitude. This is because Iltalehti.fi, with a higher yearly environmental impact has considerably more readers per week to split this impact between.

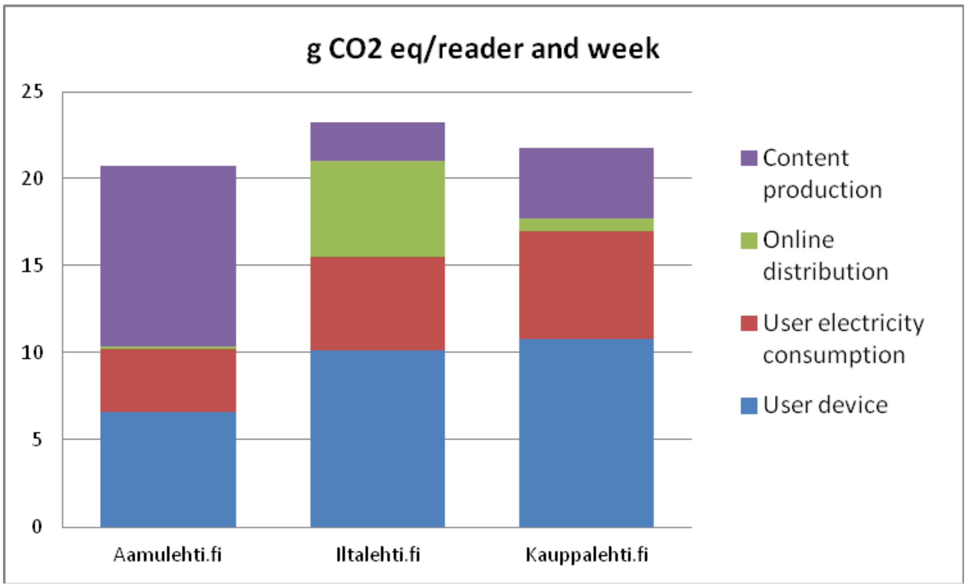


*Figure 66. Carbon footprint per reader and week.*

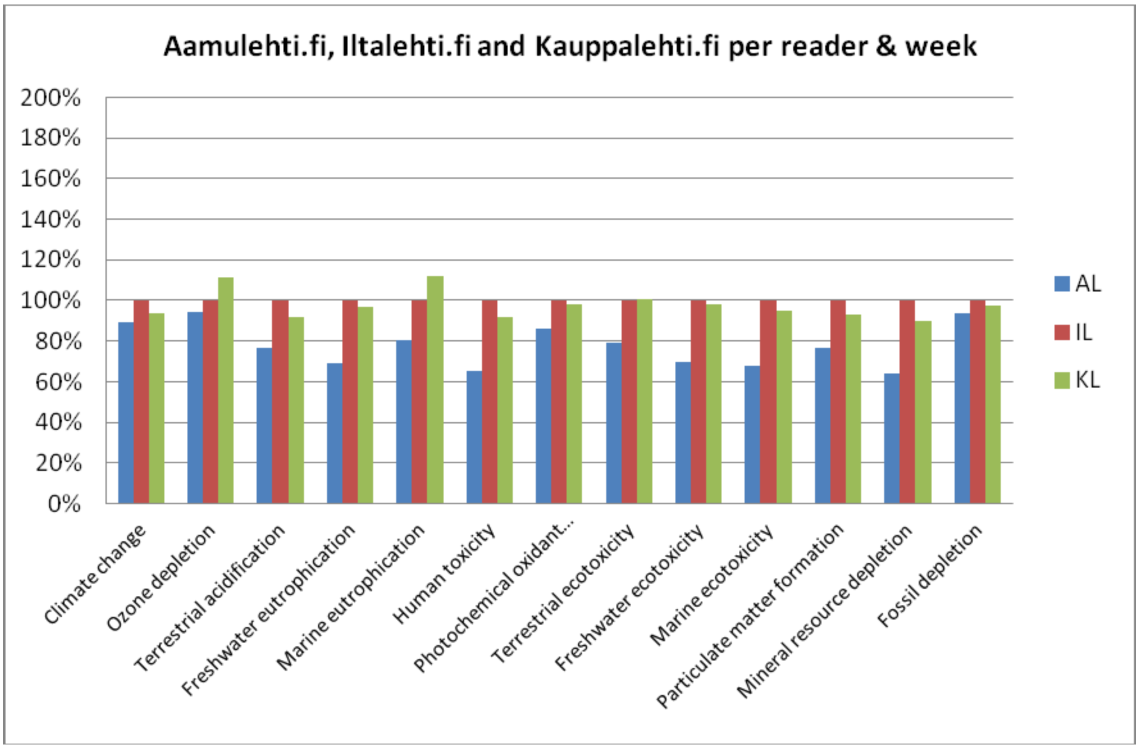


*Figure 67. Environmental performance of AL, IL and KL online versions per reader and week related to the total environmental impact of Iltalehti.fi which is set to 100%.*

Each Aamulehti.fi reader also reads slightly shorter per week than the readers of Kauppalehti.fi and Iltalehti.fi.. The fact that the three online versions are read for varying amounts of time per reader and week could be interpreted as a difference in benefit for the readers. Iltalehti.fi is read for nine minutes per reader and week, Kauppalehti.fi 11 minutes per reader and week and Aamulehti.fi 6 minutes per reader and week. Considering the environmental performance per reading hour (Figure 68), the resulting environmental impact is generally higher for Aamulehti.fi than the others. Kauppalehti.fi has the lowest potential environmental impact for all impact categories studied. These results are in line with the difference in total reading time. (Figure 69).

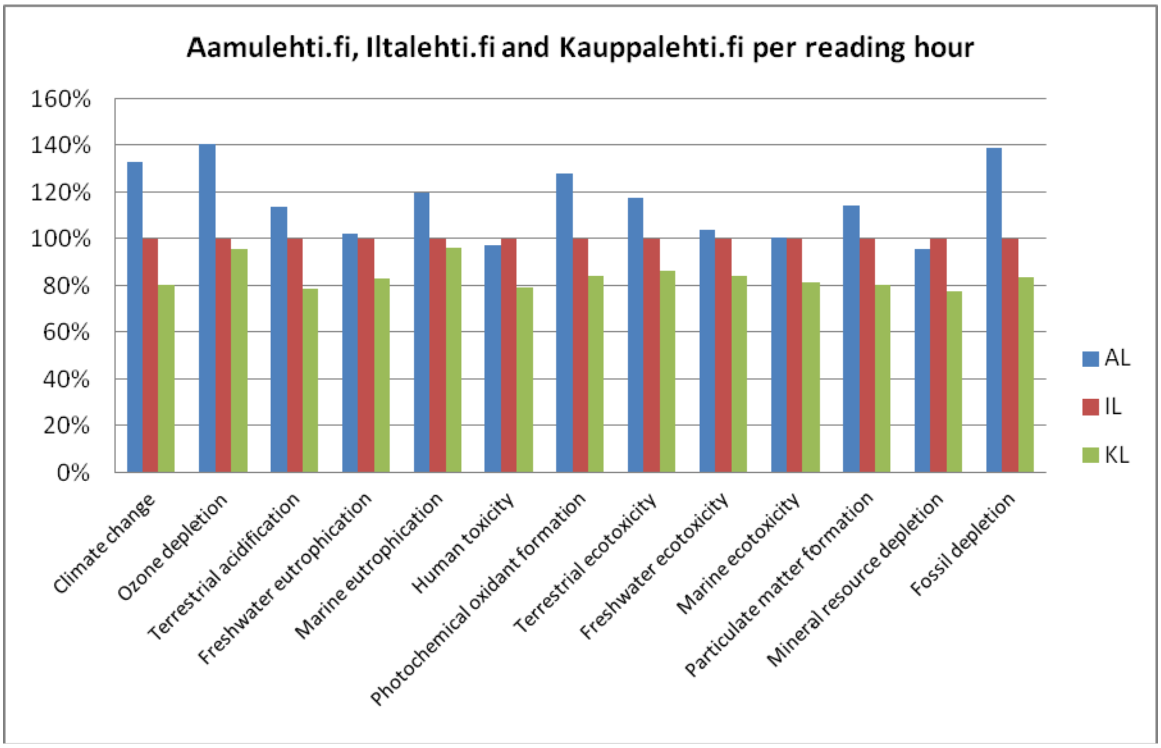


*Figure 68. Environmental performance of Aamulehti.fi, Iltalehti.fi and Kauppalehti.fi per reading hour, related to the total environmental impact of Iltalehti.fi which is set to 100%.*

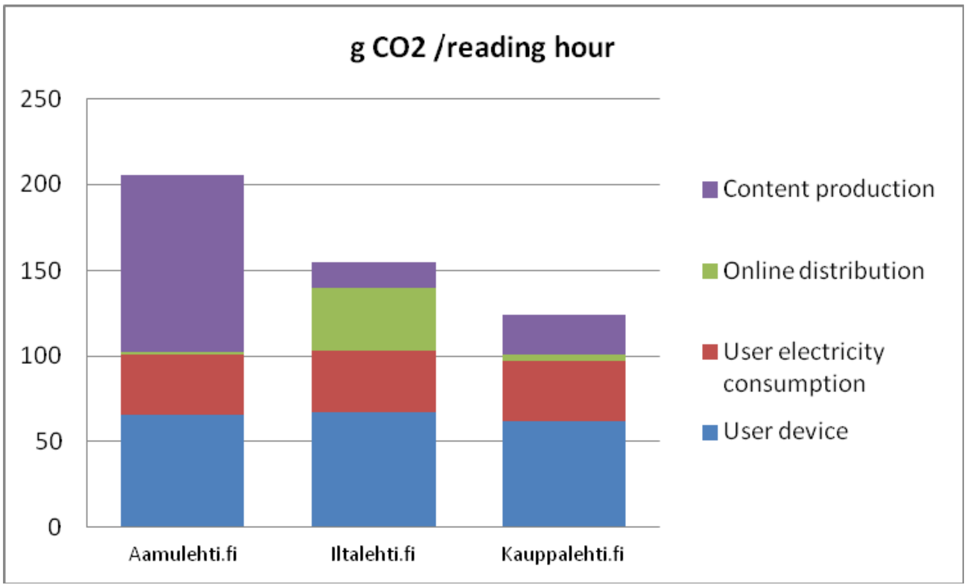


*Figure 69. Carbon footprint per reading hour.*

Overall, the environmental impacts regarding the online versions are mainly related to the number of readers and how much they read. Online distribution environmental impact is related to the amount of data downloaded, as the electricity for the distribution network is allocated based on the amount of data transmitted. Content production environmental impact does not directly correlate to the number of readers and reading time, but is more related to the number of employees working with online content. However, in relative terms the relative importance of the content production environmental impacts is related to the number of readers. With the same content production, increasing number of readers and reading time will lead to a relatively lower contribution of content production to the overall environmental impacts. With increasing numbers of readers and reading time the overall environmental impact will however increase in absolute terms. Increased impacts could be counteracted by more efficient devices and by avoiding the need for large downloads.

The following Figure 70 presents the normalized impact assessment results for one reader of Kauppalehti.fi per year. It is indicated that the activities related to the Kauppalehti.fi life cycle which contribute to the largest share of an average European's overall environmental impact, are the user device and content production. Online distribution contributes to the total impact to the lesser extent. The similar pattern can be observed for Aamulehti.fi, with the difference that online distribution has even smaller share of overall impacts and content production contributes more. A different picture can be observed for Iltalehti.fi, where the situation is the opposite than that for Aamulehti.fi – content production has a very small share of the total impact, while online distribution contributes up to 0.04% to the overall environmental impact of an average European person. The figure shows that impact categories where this product system has most significant share are the human toxicity, terrestrial acidification, freshwater eutrophication, marine and freshwater ecotoxicity. These are impact categories where long-term emissions are a considerable part of the results. This pattern is the same for all three online newspapers studied.

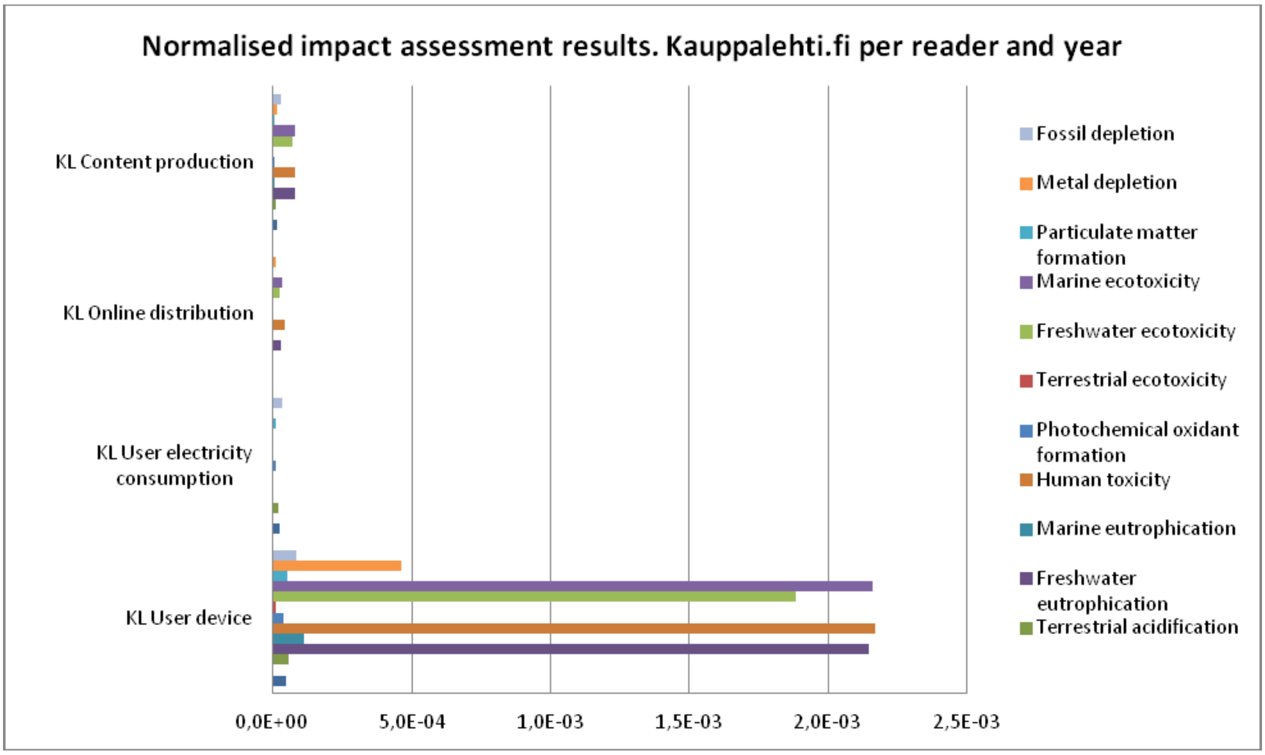


*Figure 70. Normalized impact assessment results of Kauppalehti.fi per reader and year. Normalization has been performed against the environmental impacts caused by one European inhabitant during one year.*

In order to be able to reflect upon how large or small the environmental impacts caused by the online versions of newspapers are in various impact categories, the studied product systems were compared to the environmental impact of the manufacturing of one laptop (Table 18). The laptop manufacturing data are from the Ecoinvent data (Hischier et al. 2007a), thus the same data source as used in the study.

*Table 18. Relating the online newspaper versions' environmental impact per reader and year to the environmental impact from the production of a laptop.*

| | Aamulehti.fi | Iltalehti.fi | Kauppalehti.fi | Laptop production |
|---|---|---|---|---|
| Climate change | 0.54% | 0.60% | 0.57% | 100% |
| Ozone depletion | 0.29% | 0.31% | 0.35% | 100% |
| Terrestrial acidification | 0.31% | 0.40% | 0.37% | 100% |
| Freshwater eutrophication | 0.17% | 0.24% | 0.23% | 100% |
| Marine eutrophication | 0.66% | 0.82% | 0.92% | 100% |
| Human toxicity | 0.16% | 0.24% | 0.22% | 100% |
| Photochemical oxidant formation | 0.55% | 0.64% | 0.63% | 100% |
| Terrestrial ecotoxicity | 0.24% | 0.30% | 0.31% | 100% |
| Freshwater ecotoxicity | 0.18% | 0.25% | 0.25% | 100% |
| Marine ecotoxicity | 0.17% | 0.25% | 0.23% | 100% |
| Particulate matter formation | 0.34% | 0.44% | 0.41% | 100% |
| Metal depletion | 0.20% | 0.31% | 0.28% | 100% |
| Fossil depletion | 0.62% | 0.67% | 0.65% | 100% |

Table 18 indicates that the impacts from reading the online newspapers during one year (6-11 minutes per week) is comparatively small compared to the manufacturing of one laptop for most impact categories. This is in line with the fact that use of these electronic devices for the purpose of reading online news is a small part of the total use.

With the introduction of electronic media, newspaper companies are part of a new supply chain/system. Manufacturing electronic devices is necessary for the reader to be able to access the online newspaper, and consequently the subsequent disposal of these devices. Thus, the environmental impacts related to the manufacturing and disposal of electronic devices are part of the online newspaper supply chain and should be taken into consideration by newspaper companies.

## 8.4 Integration of printed and online results

### 8.4.1 General introduction

This chapter integrates the results from the environmental assessments of printed and online versions of newspapers at Alma Media. The purpose of integrating the results is to indicate the differences in environmental impacts related to printed and online media products, but also to illustrate that different ways of presenting results, i.e. in relation to different types of functional units, will provide different bases for interpreting the results.

Comparing these different ways of distributing and accessing media is not straightforward due to the different ways these media are used by readers for different purposes, often complementary. Printed newspapers usually have more comprehensive articles and much more information, while online newspapers tend to include more entertainment (videos, games, blogs, etc.), but also the possibility to easily search for more information about a subject or use links to get further additional insights. Printed newspapers are usually read for about half an hour per day and one copy is usually read by more than one person, while online newspapers are browsed for just a few minutes. Increasing the number of readers of a printed copy will not increase the overall environmental impact, but will decrease the environmental impact per reader (benefit). The reading time of the printed newspaper does not affect the overall environmental impact. Increasing the reading time of the online version will increase the overall environmental impact, as the environmental impact is closely related to the reading time.

Defining a functional unit that is useful and relevant for both media products is hard. Still, it is interesting to assess them in parallel and discuss differences, benefits and drawbacks with the different product systems from an environmental perspective.

The results were integrated in three ways:

- environmental impact of a specific newspaper per year, printed and online version combined;
- environmental impact of printed and online versions respectively per reader and week;
- and environmental impact of printed and online versions respectively per reading hour.

Some results from the LCAs of printed and online versions of Alma Media products presented above have major data gaps and other sources for uncertainty. Putting printed and online versions in the same diagrams the impact categories: climate change, acidification, eutrophication, metal depletion and fossil depletion were selected as they are believed to be related to less uncertainty than the other impact categories in this study.

When interpreting the integrated results, it is necessary to keep in mind that each newspaper (and their print and online versions) has different number of readers, number of pages, copies per issue, time spent reading, etc. This data is presented in Table 19.

*Table 19. Relevant parameters for the different products.*

| | Aamulehti | | Iltalehti | | Kauppalehti | |
|---|---|---|---|---|---|---|
| | print | online | print | online | print | online |
| Number of readers per year | 305 000[a] | 237 196[b] | 602 000 | 1 796 684 [b] | 214 000 | 615 354 [b] |
| Number of readers per copy | 2.3 | n/a | 5.6 | n/a | 3.1 | n/a |
| Number of copies per year | 41 286 000 | n/a | 29 539 000 | n/a | 18 672 000 | n/a |
| Number of issues per week | 7 | n/a | 6 | n/a | 5 | n/a |
| Weight per copy, gram | 282 | | 201 | | 96 | |
| Reading time per copy, min | 35 | n/a | 23 | n/a | 23 | n/a |
| Reading time per visit, min | n/a | 2:20 | n/a | 1:20 | n/a | 2:57 |
| Reading time per week, min | 245 | 6 | 138 | 9 | 115 | 11 |

[a]The number of readers per year was calculated as number of copies per day * the amount of readers per copy; [b]The number of readers per year was assumed to be the same as the number of unique readers per week.

### 8.4.2 Yearly environmental performance

Figure 71, Figure 72 and Figure 73 combine the potential environmental impact of printed, supplement and online versions of AL, IL and KL newspapers respectively.

***Aamulehti***

Total environmental impact for Aamulehti includes the Aamulehti.fi and printed Aamulehti as studied here and the Aamulehti Sunday supplement (Figure 71). The Sunday supplement takes a share of the overall impact that corresponds well to it being distributed once a week only.

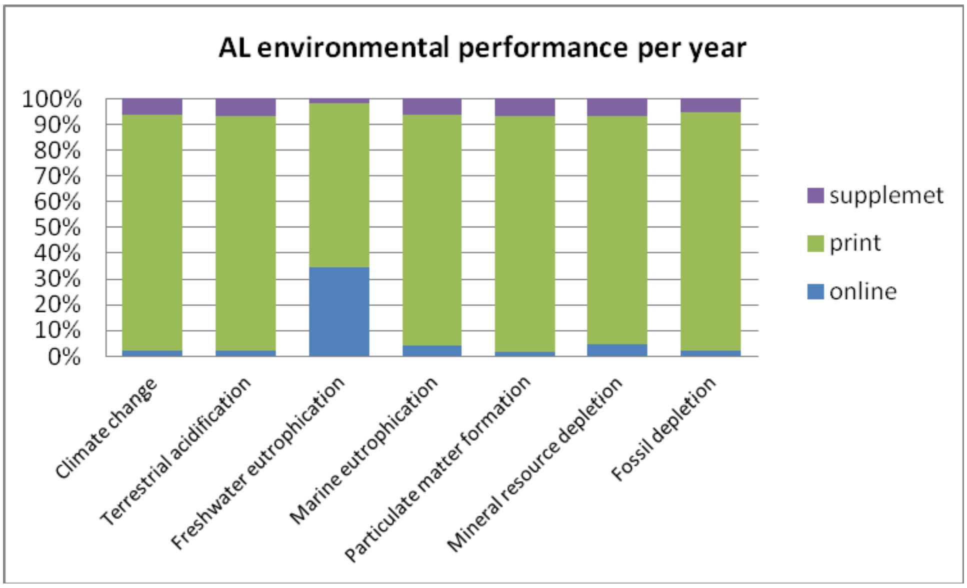


*Figure 71. Shares of environmental impact of Aamulehti per year from print, Sunday supplement and Aamulehti.fi respectively.*

Aamulehti.fi has a small share of the overall Aamulehti environmental impact per year, mainly due to rather small number of online readers and that a small share of content production is allocated to the online version. 85% of emissions rising from content production are assigned to printed media. For climate change, the online version is related to less than 3% of the yearly total.

However, for freshwater eutrophication the online version is responsible for about 35% of the potential impact. This impact is mainly due to emissions related to the manufacturing of the electronic devices used by the readers.

Since the analysis of the online newspaper reference cases included long-term emissions, but the analysis of the print newspaper did not, a sensitivity analysis was done where long-term emissions were excluded from the online newspaper analysis as well. In this case, the impact from online newspapers in freshwater eutrophication is significantly lower. It could however be argued that long-term emissions are more important for the online versions using electronic devices that need mining and parts of which may end up in landfills where degrade slowly,

***Iltalehti***

The shares of the environmental impact from Iltalehti.fi and the printed version of Iltalehti as studied in the project are rather evenly distributed. Iltalehti.fi has a rather high number of readers and a significant share of content production is allocated to the online version as well. Therefore its share of the total impact is quite significant. For climate change, the online version relates to roughly half the impact of the printed version. For freshwater eutrophication more than 90% of the overall impact results from the online version. The reason for this is the manufacturing of user electronic equipment for the many online readers.

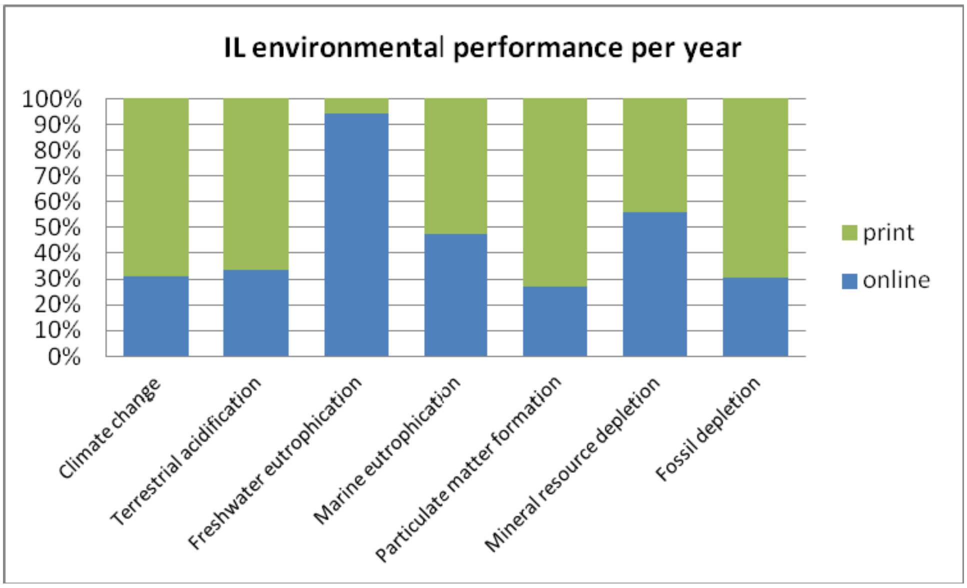


*Figure 72. Shares of environmental impact of Iltalehti per year from print and Iltalehti.fi respectively.*

When long-term emissions are not included, the impact categories where the online version had the highest share evened out slightly.

***Kauppalehti***
The distribution of Kauppalehti's potential environmental impact between print and online versions is similar to that of Iltalehti. Again, it is freshwater eutrophication, where online has the highest share. Furthermore, metal depletion and marine eutrophication are to a large extent caused by the online version.

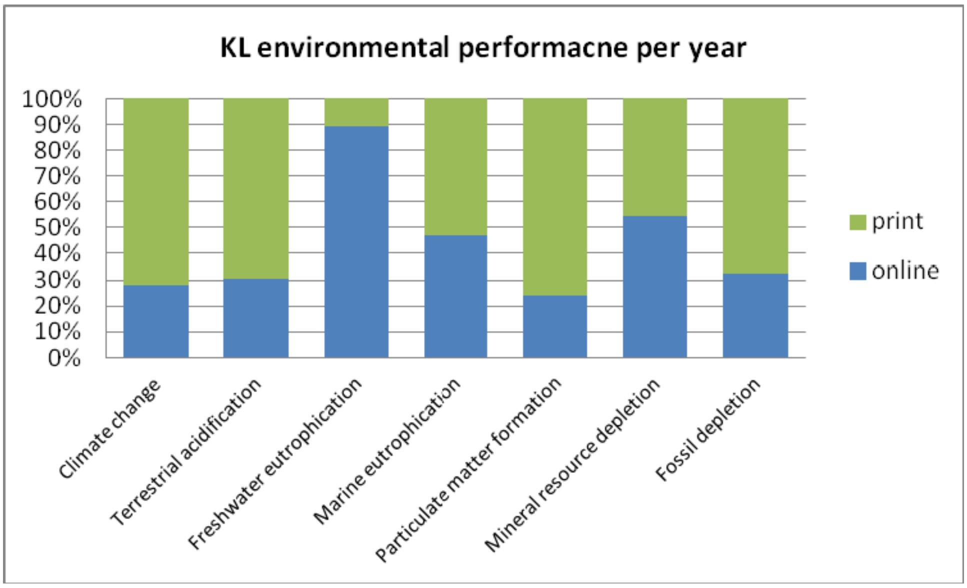


*Figure 73. Shares of environmental impact of Kauppalehti per year from print and Kauppalehti.fi respectively.*

Again, when long-term emissions are not considered, the impact categories where the online version had the highest share even out slightly, metal depletion stay at the same level.

***Discussion – Yearly environmental performance***
Depending on the number of readers and their behaviour, as well as the number of copies and pages per copy of the printed newspaper, the overall yearly environmental performance of the three

newspapers studied are to a varying degree dependent on the printed or online versions for different impact categories. For climate change, which is the impact category with most reliable results, as studied here, the printed versions of KL and IL result in double the amount of climate change impact compared to the online versions on a yearly basis. For AL the share for the online version is small, less than 3% of the total for climate change.

In the impact categories freshwater eutrofication the online versions have a considerable share for all newspapers studied. The high values in the assessment are mainly due to emissions related to the mining of gold to be used in the manufactutring of electronic devices. The emissions are mainly leakage from mining tailings, some of them long-term emissions. These emissions are part of the generic processes used from the Ecoinvent database.

When the coverage of long-term emissions are considered, it should be noted that printed media is based mainly on biobased raw material (wood), and degradation time in landfills is short compared to the emissions from mine tailings or electronic components in landfills. This is the case especially with kraft pulp based products where the lignin is removed in the processing. For this reason it can be assumed that the long-term emissions resulting from the printed media supply chain are not as relevant as they are in the case of online media.

If the production chains for online and printed media are compared, it is obvious that there are big differences. A major difference between the printed and online environmental impact is that the former largely occurs in the supply chain of the printing office and during distribution to readers, which is rather local in the case of the Alma Media products studied. The latter is mainly connected to the supply chain of producing the electronic devices used by readers, which mainly concerns other geographical areas.

### 8.4.3 Environmental impact per reader and week

The yearly figures for environmental performance of the three newspapers can be linked to certain benefits. Only considering the environmental impact during a year’s production does not say anything about the benefit produced; a relatively high environmental impact for a very high benefit is of course quite different from a relatively high environmental impact for a very low benefit. The number of readers that have access to/have accessed the newspapers may be a relevant way of considering benefit.

The number of readers differ substantially both in the case of printed and online versions of the newspapers studied. For the printed versions, it is 2.3 readers/copy (AL), 5.6 readers/copy (IL) and 3.1 readers/copy (KL), and for the online versions the number of readers per week varies considerably as well(see Table 19). It should be noted that the number of readers for the printed versions is based on surveys and may be rather uncertain. Thus it may be that the average copy of Iltalehti is not in practice read by 5.6 readers. Variations in these figures have not been tested within the study.

In Figures 74, 75, 76 we consider the environmental burdens of the respective newspaper products related to one reader during one week. The environmental impact of the newspaper per reader and week was calculated as follows:

*Print*

$$\frac{one\ newpaper\ copy}{readers\ per\ copy} * published\ days\ per\ week = results\ per\ \frac{reader}{week}$$

*Online*

$$\frac{online\ version\ during\ one\ year}{(number\ of\ readers\ in\ average * number\ of\ weeks\ in\ a\ year)} = result\ per\ \frac{reader}{week}$$

For the number of readers for each newspaper, number of copies and number of issues per week, etc. see Table 19.

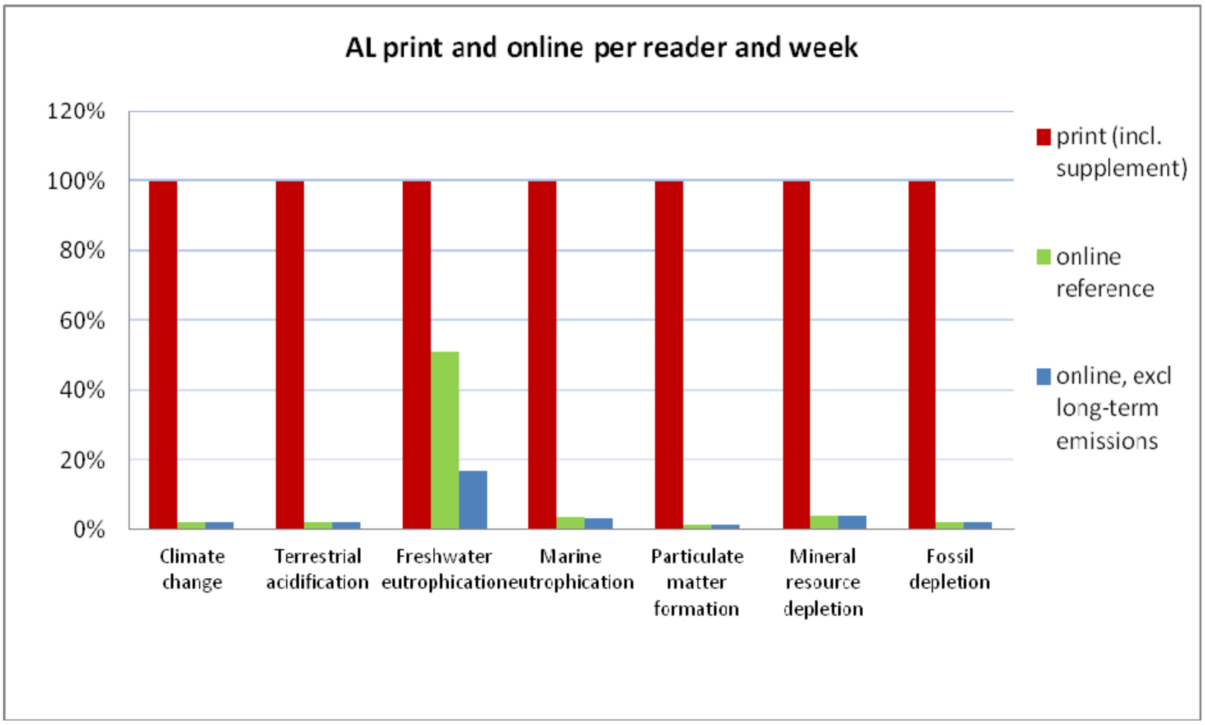


*Figure 74. Environmental performance of Aamulehti.fi and printed Aamulehti per reader and week, related to the total environmental impact of print version set to 100%.*

Taking the number of readers of Aamulehti into account, the distribution of environmental impact is still similar to the results for the yearly performance. This is because the number of readers is similar between the two versions (Table 19). In the climate change category, the printed version gives rise to considerably more impact per reader and week than the online version.

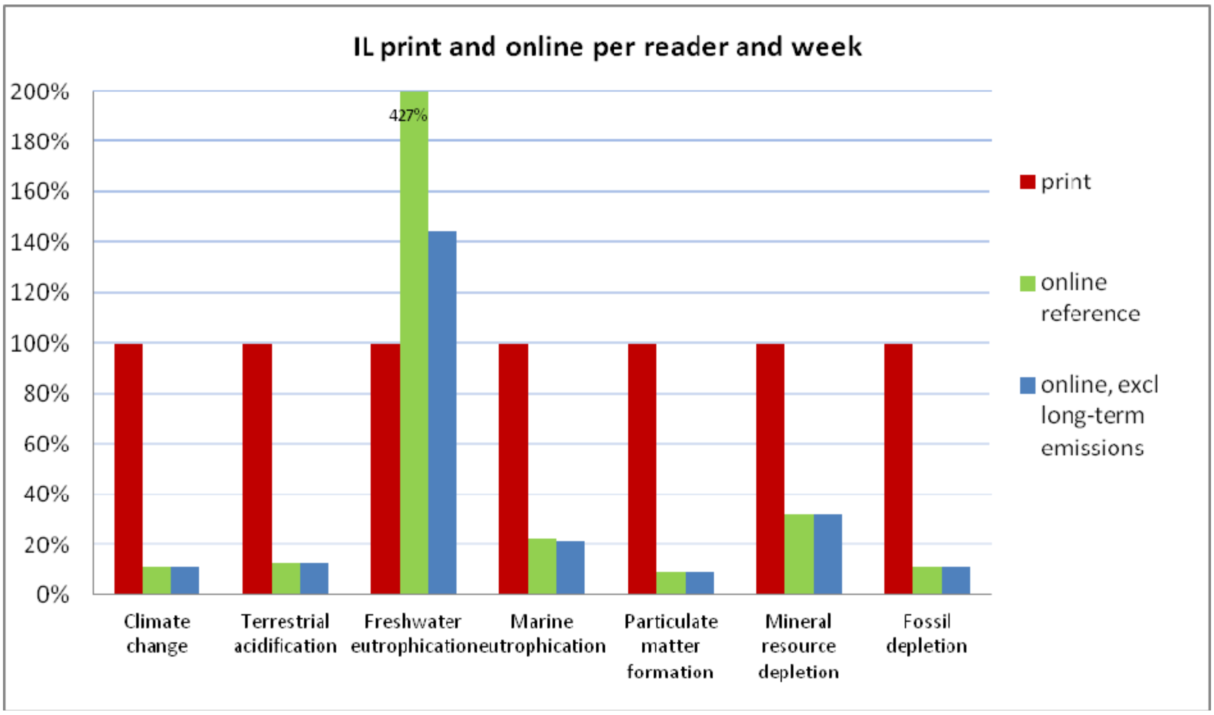


*Figure 75. Environmental performance of Iltalehti.fi and printed Iltalehti per reader and week, related to the total environmental impact of a print version set to 100%.*

As Iltalehti.fi has a larger amount of readers than the printed version, Figure 75 shows a rather low environmental impact for the online version in general when impacts are evaluated per reader and week (since the yearly impact is divided among more readers). For the climate change impact category, the printed version gives rise to almost eight to nine times more potential impact per reader and week than the online. However, for freshwater eutrophication the assessment of the online version still indicates higher potential impact than the printed version. In this category the inclusion of long-term emissions has a considerable impact on the results.

Moreover, Kauppalehti.fi has many online readers and shows rather low environmental impact for the online version compared to the printed version per reader and week (Figure 76). Similar to Iltalehti, the climate change potential impact is about 7 times higher for the printed version per reader and week. For most other impact categories, the potential impact is higher for the printed version, with the same exception as for Iltalehti.

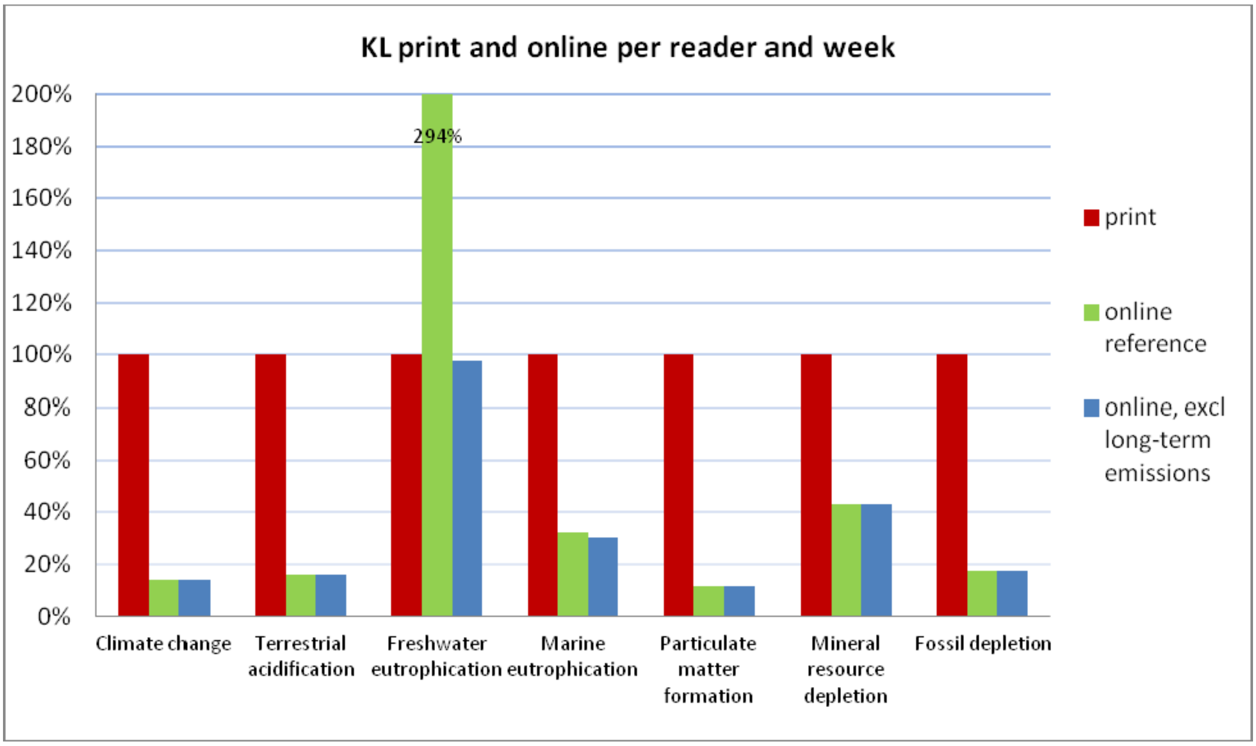


*Figure 76. Environmental performance of Kauppalehti.fi and printed Kauppalehti per reader and week, related to the total environmental impact of a print version set to 100%.*

### 8.4.4 Environmental impact per reading hour

Relating the environmental impact to the readers of the newspaper is one way of trying to make results more comparable. However, it does not say anything about information, entertainment, etc. that is gained. This is, however, inherently difficult to assess and define in a functional unit. The benefits of reading a newspaper may be very roughly assumed to be related to the time of reading. The quality of what is read and how it is presented, what can be seen beside the text and many other parameters will influence the benefit provided per hour of reading, but this is very hard to measure or get information about. There are differences in reading time between the different printed newspapers, and between the different online versions; however, this difference is in the size of a factor 2. The difference between online and printed versions is huge though. The reading time spent on copies of the printed versions is around 2–4 hours per reader per week, whereas the online versions are read 6–11 minutes per reader and week. This is a good illustration of the difference in the function provided by these different media products. Readers use the media products in a different way and most likely for different purposes. However, the reading time figures for the printed versions may be uncertain since they are based on reader surveys.

In this study, the results are also presented per reading hour in order to show how different functional units will affect the results, and also to illustrate that the media products assessed are clearly providing different functions/benefits.

The environmental impact of the newspaper per reading hour was calculated as follows:

*Print*

$$\frac{one\ newspaper\ copy}{(readers\ per\ copy * reading\ time\ per\ day)} * minutes\ per\ hour[60min] = results\ per\ \frac{reader}{hour}$$

*Online*

$$\frac{impact\ per\ year}{(number\ of\ readers\ per\ year * reading\ time\ per\ year\ for\ one\ reader)} = results\ per\ \frac{reader}{hour}$$

For the number of readers per copy, number of readers per year and reading time, see Table 19. Using this very rough estimation of newspaper benefit, the potential environmental impact related to one hour of reading the printed and online versions of Aamulehti respectively is presented in the Figure 77. The reading of the printed version gives rise to 20% more greenhouse gas emissions per hour of reading compared to the online version. The results are varying for the different impact categories presented. This indicates the importance of considering more than one impact category, and also that these two media products give rise to different types of environmental impacts. For three of the seven categories covered, the online version shows higher impact per hour of reading based on the study done.

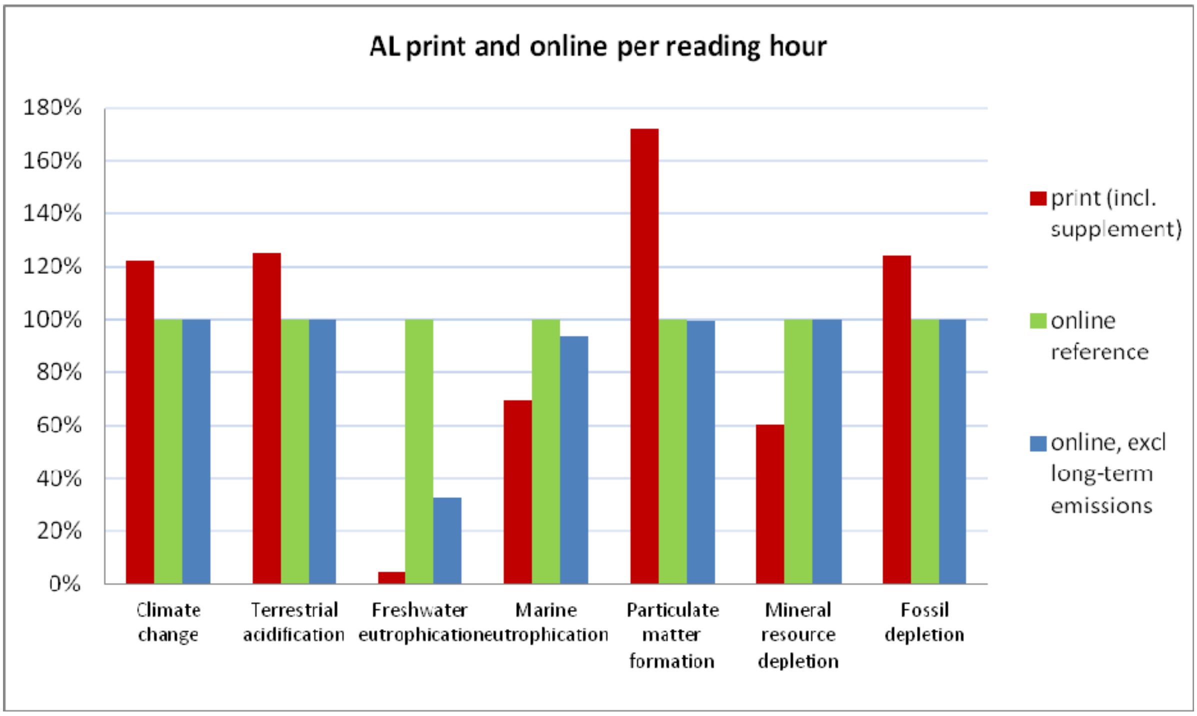


*Figure 77. Environmental performance of Aamulehti.fi and printed Aamulehti per reading hour, related to the total environmental impact of the online version set to 100%.*

For Iltalehti and Kauppalehti, Figure 78 and Figure 79 show different results as when considering the impact per year or per reader and week. When considering the environmental impact in relation to the reading time, Iltalehti.fi and Kauppalehti.fi result in higher environmental impact than the printed versions. Regarding potential climate change impact, online reading per hour results in double the impact for Iltalehti, and for Kauppalehti reading the printed version gives rise to 65% of the impact of the online version. For freshwater eutrophication the differences is really large.

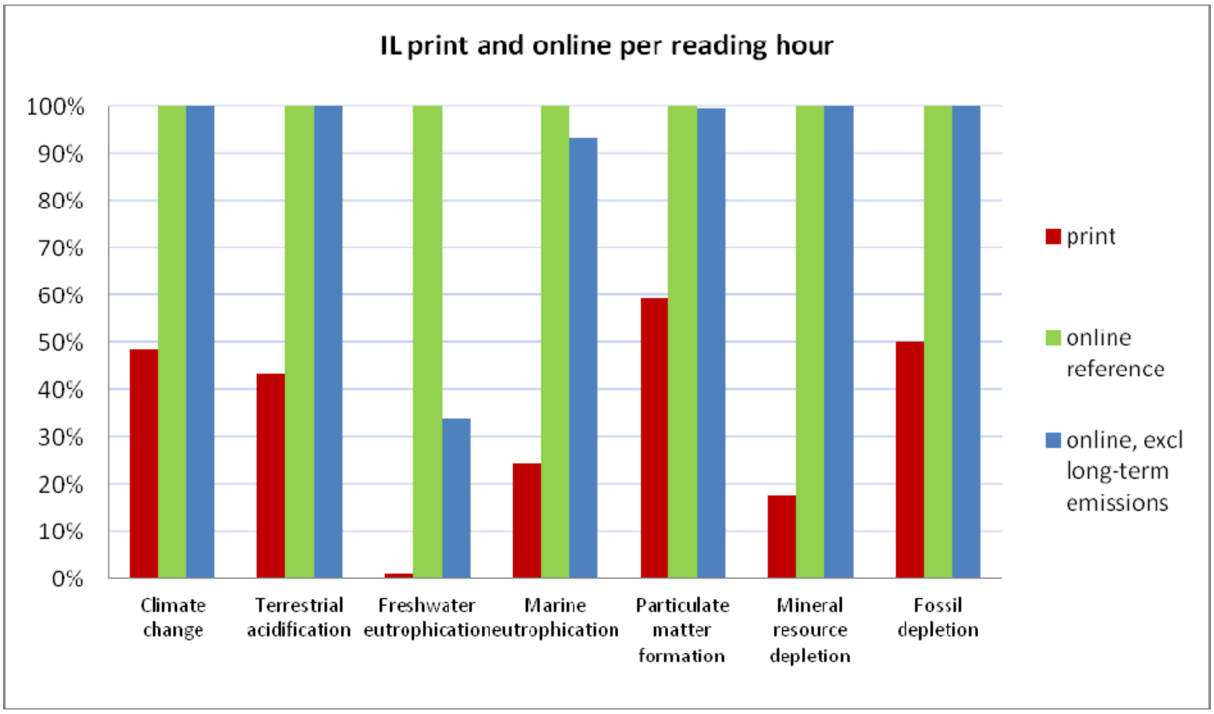


*Figure 78. Environmental performance of Iltalehti print and online per reading hour, related to the total environmental impact of the online version set to 100%.*

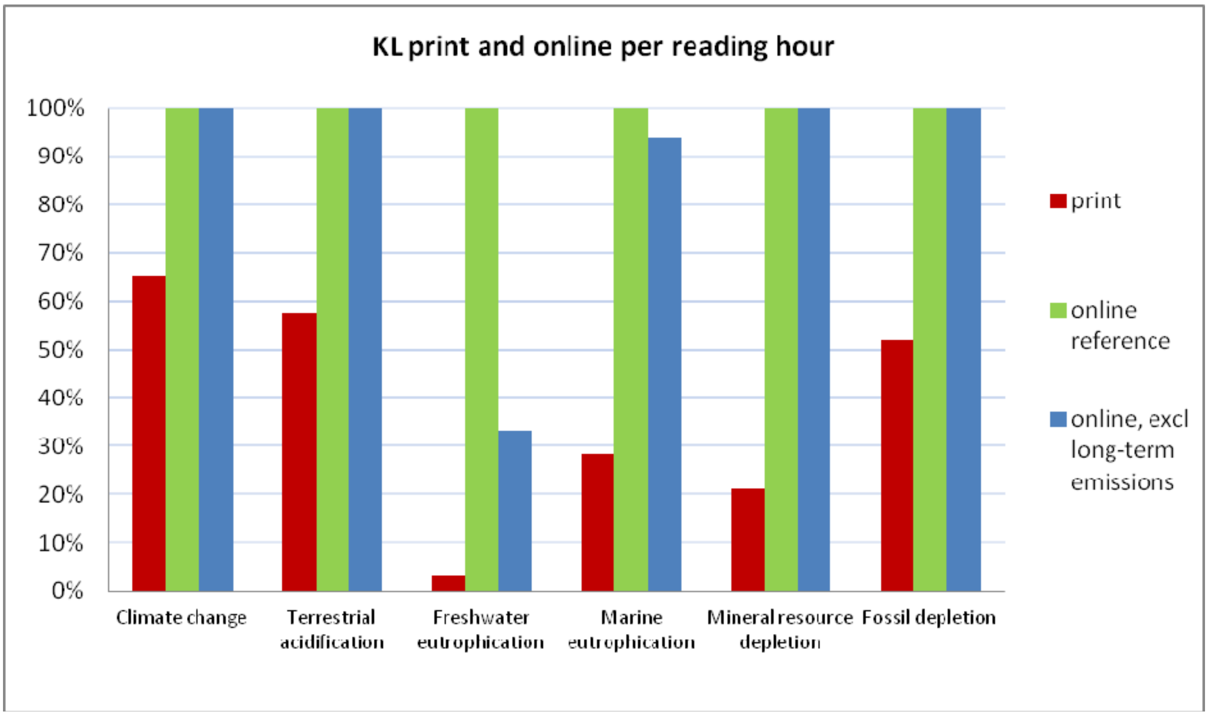


*Figure 79. Environmental performance of Iltalehti print and online per reading hour, related to the total environmental impact of the online version set to 100%.*

### 8.4.5 Discussion – integration of results

Considering the environmental performance of the online and printed versions of the newspapers Aamulehti, Kauppalehti and Iltalehti, it is clear that the type of environmental impacts that the different versions contribute more to differs and that the major impacts occur in different parts of the studied product systems. Furthermore, the use of different functional units indicates different correlations between the online and printed versions of the newspapers and their environmental performance.

Looking at the results for the printed and online versions of the newspapers together, one should be careful when making any comparisons. As stated above, the different newspapers do not provide the same type of benefit and the results will be very dependent on the functional unit used. Also, in many cases an online version complements a printed version rather than substituting it, and thus the environmental impacts will in the end be added. Still, it is interesting to reflect on the environmental impacts that correspond to the different versions and how they are related to each reader and to each unit of time spent reading.

The number of readers and each reader's time spent reading are important for the resulting environmental performance regarding the product or benefit assessed. Thus, every unique reader will have a different environmental profile related to the media she or he uses. In the study we have assessed average readers. In this particular case studying the online and printed versions of Alma Media products, it should be noted that the number of readers and the reading time for the online versions are actually measured, whereas the figures for the printed versions are based on surveys. It may be possible that when asked about reading time it is easy to think of how long you spend reading when you do read, but maybe that is not every day of the week, or it may be difficult to estimate your average reading time at all. On the other hand, the reading time for the online versions may include time when you are on the website but not sitting by the screen. However, the overall effect on the final results per reading hour would probably be greater for differences in the printed newspaper reading time, as increased reading time of the online versions also increase total environmental impact.

Different types of data have been used in assessing the print and online systems respectively in this study. For printed versions of the newspaper, site-specific data is to a large extent applied, while for online versions, in many cases the best choice has been to use generic data from LCA databases. For example, for the manufacturing of desktops, screens and laptops, there is no better Finnish or Alma Media reader-specific data available, and all users will have different devices and different use patterns. This generic data has often been more comprehensive, with a large range of different resources and emissions covered in the process records; however, this data may be less relevant than more specific data derived from the specific companies or context. This is clearly illustrated for the electricity mix data, where Finnish-specific data was used for all product systems studied. In the event of using generic data for the Finnish electricity mix as provided by Ecoinvent (Frischknecht et al. 2007), the environmental impact per kWh of electricity produced would be considerably higher. This is partly due to the generic mix not using any data for combined heat and power production, which is common in Finland, and which has better environmental performance. The toxic impacts may be lower due to less comprehensive data sets for the Finnish specific data.

The generic data for manufacturing of electronic devices are old, illustrating 2002-2004 situation. Improved data for electronic devices, also for their disposal, would be useful as these are considerably contributing to the overall results. This is also needed for new mobile devices which are increasingly used for accessing media.

When different impact categories are compared, it can be noted that the method developed by IPCC to assess climate change potential is the most widely accepted and applied, while the methods, for example, behind the toxicity potentials, are still under discussion. Also, inventory data is more comprehensive for this category than for many others and thus the climate change results are believed to be more robust than the results for the other impact categories. By presenting results also for impacts categories with larger uncertainty the necessity to also regard other impacts is highlighted, however the results should be interpreted with the uncertainties in mind.

# 9. Conclusions

## 9.1 Content production conclusions

The content production is the core activity at a newspaper company. In this study we considered content production as covering editorial work, administration and marketing, i.e. all office work and journalist field work. At the Alma Media newspapers studied, the major causes of potential climate change impacts for content production were business trips, electricity used at the office and the heating of offices. For other types of environmental impacts, which are related to greater uncertainties, the major causes of environmental impacts were manufacturing office equipment, business trips, electricity used at the office and the heating of offices. There were some differences between environmental performances for content production at the three newspapers studied, but the overall pattern of major processes was similar.

## 9.2 Printed newspaper conclusions

Concerning the overall environmental impacts – especially climate change – for printed newspapers, it can be concluded that the key processes in the supply chain are newsprint paper production, production of ink and plates and content production, while the actual printing manufacturing has less importance from an overall environmental impact perspective. The major role of newsprint paper production is partly a clear consequence of the fact that the main “platform” for printed newspapers is almost completely made from newsprint paper. In addition, the transport related to delivering printed newspapers to offices, retailers and homes is an important factor for climate change.

In order to gain environmental improvement potential for printed newspapers within the value chain, the media company should:

- be able to follow, measure and decrease the products' environmental impacts through product-specific environmental data for its own processes (content production, material and energy efficiency issues), and with help of increasing amount of supplier data from the value chain related to different life cycle stages
- improve material efficiency in printing → ecodesign and production planning of printed newspaper in order to keep the maculature level at a minimum
- improve energy efficiency in printing → monitor major sources of energy consumption related to manufacturing a specific product
- improve delivery options for the final printed product in collaboration with value chain actors
- focus on paper manufacturing and its fuel mix for energy production has the most significant contribution; thus, even more efficient paper and energy production is one way towards a win-win situation in the value chain.

When the validity of the results for the printed newspaper is evaluated, it can be concluded that the results are really case specific and the data applied is of high quality. This is the especially the case for the paper manufacturing supply chain, where the process-specific data from the paper manufacturer and EcoData were applied. However, this is not the case for all impact categories, as the emissions reported by paper manufacturers are limited and there may be gaps in data for emissions relevant to toxicity impact categories.

## 9.3 Online newspaper conclusions

Manufacturing the electronic devices that readers use to read the Alma Media online newspapers, as well as the electricity to use them, are the key to the resulting potential climate change impact. Content production is also important, especially when there are not very many online readers as in case of Aamulehti.fi. For Iltalehti.fi, online distribution also contributes to the total climate change impact, as the amount of information downloaded from this site is greater.

Manufacturing end user devices is the overall major reason for environmental impacts related to Iltalehti.fi and Kauppalehti.fi. For Aamulehti.fi also content production is a major reason for the overall environmental impact. As the data source for the manufacturing is rather old, the absolute figures of the results are uncertain however, the importance of the electronic devices is illustrated. The magnitude of the impact related to the electronic devices is highly dependent on the overall use of the device, among which the environmental impacts are divided. Thus, user practice is an important parameter in this case.

Long-term emissions contribute considerably to online newspaper potential impacts in certain impact categories. This is, as modelled here, due to emissions related to the extraction of resources needed to manufacture the electronic devices, e.g. gold, but also related to the coal mining needed for electricity generation. The assessment of these emissions and the impact categories concerned are uncertain, but the conclusion is that these activities and emissions need to be carefully considered and considered further.

Regarding online newspapers, there is environmental improvement potential within content production, but notably also related to readers' electronic equipment and use thereof. Media companies can act here by providing information, both generic and clearly aimed at their products and readers, e.g. by providing concrete information on the environmental impact of reading online and by the way the reader interface is designed to communicate this. It will also be important to collaborate with different stakeholders in the supply chain of electronic devices, the platforms for the online newspapers, as well as stakeholders related to the disposal of the devices. Actions for improvement related to the online newspaper will be to some extent different from those related to the printed newspapers. However, when buying electronic equipment for content production, similar demands can be made of these suppliers as others, as suggested below.

As electronic devices are key to overall potential impacts, the current development towards smaller devices that also use less energy will be important. It is notable that total usage of these devices will influence the environmental impacts that will be allocated to each activity the device is used for. More information about the environmental performance is needed. Also, new devices and new activities or media products need to replace other activities or products, or else the overall environmental impact in absolute terms will continue to increase.

## 9.4 Integrated conclusions

Printed and online media result in different types of environmental impacts. The distribution of environmental impacts throughout the life cycles of Alma Media's printed and online newspapers are different. A major difference between the printed and online environmental impacts are that the former largely occurs in the supply chain of the printing house and during delivery to readers, and the latter is mainly connected to the supply chain in producing the electronic devices used by readers, and to some extent the electricity used for reading and for electronic distribution. The environmental impacts related to content production are relevant for both types of products.

Major impacts of printed Alma Media newspapers to a large extent occur more locally than the impacts from the online media, as the paper and printing manufacturing are located in Finland. The environmental impacts related to the online media versions (such as Iltalehti.fi) to a large extent occur in other countries and with suppliers not directly related to Alma Media. Actions for improvement will thus need to be different.

Comparisons between print and online versions are not straightforward, as print and online versions provide different information in distinct ways, and readers use the media products differently. Thus, the printed and online newspapers from Alma Media are not likely to replace each other, but rather complement each other. Increased information on different user practises related to media throughout the day could offer valuable information about possible ways to decrease environmental impacts and the possibility of providing guidelines for this.

The printed newspapers studied generally showed a larger environmental impact than the online versions when considering the impact related to one year or to one reader during one week. When environmental impact is related to active reading time, the printed versions were more often showing a lower environmental impact than the online version. These results are highly dependent on number of readers per copy and reading time for the printed newspapers studied. Increased reading time affects online, but not printed versions' total environmental impact.

Considering the environmental performance of printed and online media, the functional unit is of crucial importance, especially if the two versions are to be compared to each other in some way. A more comprehensive understanding can be gained by using different functional units (year, reader week and reading time was tried here).

The media company could be a leader in communicating environmental information in order to improve user practices and stakeholder practices along the value chain.

## 9.5 Recommendations and further research needs and ideas

- Collaboration with suppliers and transparent data
    - Ask for environmental information when new supplier contracts are concluded or contracts are updated that may increase the level of environmental protection in the supply chain as well (new external reporting of environmental issues). Suggest that this information could be communicated openly to all those interested to make environmental performance more transparent. Thus, if more information is provided by suppliers, the more exact steps towards decreasing of impacts are possible, and a win-win situation can be achieved through this collaboration.
    - Request environmental information related to electronic device in purchase situations and increase collaboration with producers of electronic devices aiming to improve environmental performance in manufacturing and disposal.

- Information to and collaboration with readers
    - Provide information to readers on how to decrease the environmental impact related to printed and online newspapers. End consumer practices are key aspects for online newspapers as well as other media.
    - Encourage readers to buy efficient devices and to ask about environmental performance in computer production. Also, the need to buy new versions of devices frequently should not be encouraged.
    - Encourage readers towards general material and energy efficiency, recyclability and recovery in order to avoid resource scarcity and decrease impacts.
    - Media companies can potentially use different media channels to share valuable information about environmental issues among stakeholders.

- In house action
    - In content production, reconsidering the number of business trips and the means of travel, more energy efficient solutions and cleaner energy sources.
    - When purchasing electronic devices, both power draw and environmental aspects of manufacturing should be considered. The total service life of devices should also be considered.

**Further research needs and ideas**

- Assessing the effect of improvements made at Alma Media
- Gathering and publishing more specific data required related to modern electronic devices, internet infrastructure in Finland, printing ink, etc. Specific data related to the supply chain is increasingly needed in order to decrease environmental impacts of specific products.
- To gain wider view of environmental impacts related to products, aspects other than climate change should be evaluated. Thus, it is important to learn more about how to assess toxicity

impacts, and decrease the uncertainties related to inventory data, characterisation and normalisation related to these impacts.

- Assessing newspapers read from other electronic devices (e.g. smartphones, new electronic devices and tablets), online and applications.
- Studying Alma Media environmental performance in 2020 through scenarios for future newspapers/media, e.g. different user practices and new solutions provided by media companies
  - newspapers only distributed electronically
  - combined subscriptions to printed and electronic (printed on the weekends)
  - different functions provided by printed and online/applications
  - actual user practices regarding media use

## 10. Summary

This research is the result of a joint project initiated by the Alma Media Company, with the aim to evaluate environmental performance of selected products and to improve this performance in future. VTT Technical Research Centre of Finland and KTH Centre for Sustainable Communications (CESC) carried out the research, with the aim of undertaking a life cycle assessment (LCA) for printed newspapers from Aamulehti, Iltalehti and Kauppalehti as well as Aamulehti.fi, Iltalehti.fi and Kauppalehti.fi.

When performing a life cycle assessment the potential environmental impacts related to a defined product life cycle is evaluated, taking into account raw material acquisition, production, use, and end-of-life treatment. Various kinds of environmental impacts should be considered. Concerning the reliability of the results, the results for the climate change and fossil fuel depletion characterisation categories are the most reliable. In these cases, the inventory data is more comprehensive and also the characterisation method for climate change is well developed.

The printed newspaper product systems studied covered the content production (editorial work, marketing and administration), upstream printing house supply chain, including paper, ink and plate manufacturing, printing manufacturing (including content production, prepress, press and post-press operations), delivery to readers (either to home and offices or to retailers) and reading. In addition, the recycling of printed newspaper and incineration, as well as disposal of the printed newspaper in landfills, was covered. Alma Media specific information was used for content production. Data from previous Finnish study Pihkola et al. 2010 was used for recycling, incineration, and landfill.

The results related to potential environmental impacts (including climate change) for printed newspapers, as illustrated for Iltalehti in Figure 80, indicates that the key processes in the life cycle are newsprint production (including fillers, purchased energy and mill operations), ink and plate production supply chains, and the content production supply chain. The transport used to deliver printed newspapers to offices, retailers, and homes is also important regarding climate change.

More efficient raw material production (paper, ink, and plates) for Alma Media is required in order to gain environmental improvement potential for printed newspapers within the value chain. In addition, improvement potential can also be found in Alma Media's content production. It is also worth noting that Alma Media as a media company can have a key role in sharing environmental information in order to improve user practices and stakeholder practices along the value chain.

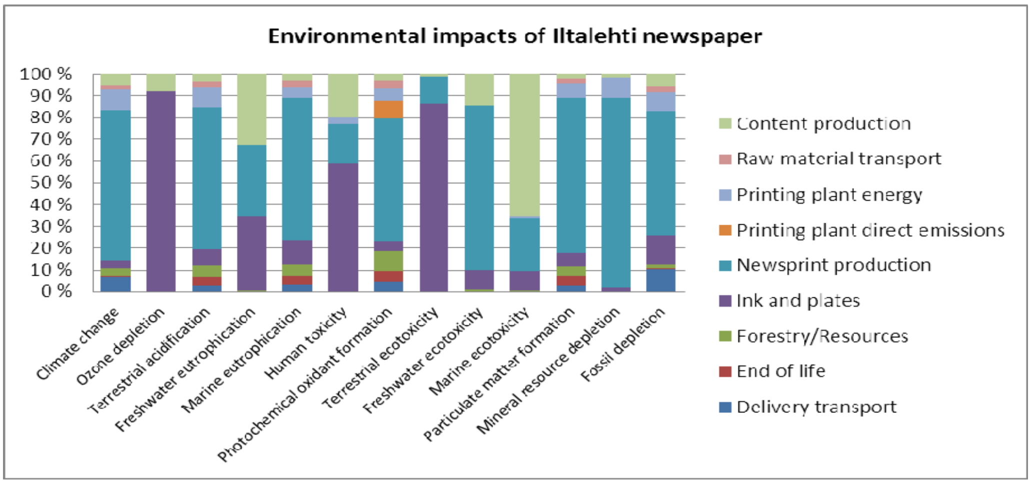


*Figure 80. The relative shares of resulting potential environmental impacts of different parts of the Iltalehti printed newspaper life cycle.*

The product systems of the online versions of the newspapers studied included content production (editorial work, marketing and administration), electronic distribution and reading. The manufacture and disposal of electronic devices used for reading were also covered. Only use of laptops and desktop computers were included in the study; reading the online newspaper on e.g. a smartphone was not covered. Alma Media-specific information was used for content production and as far as possible for information about distribution of content and about readers' practices. Generic data sources were used for manufacturing and disposal of electronic devices.

The results of the study indicate that key processes for potential climate change related to Alma Media online newspapers are manufacturing of electronic devices that readers use, as well as the electricity for using them. Content production is important, at least when there are not very many readers; as here in the case of Aamulehti.fi where content is the major reason for climate change. For Iltalehti.fi, online distribution also contributes to the total climate change impact, as the amount of information downloaded from this site is greater.

Manufacturing of end user devices is the overall major cause of environmental impacts related to the online newspapers studied (Figure 81). This is the case both for the climate change impact category and for more uncertain results regarding other impact categories. As the data source for the manufacturing is rather old, the absolute figures of the results are uncertain however, the importance of the electronic devices is illustrated. The magnitude of this impact is dependent on the overall use of the electronic device, since environmental impacts related to manufacturing are shared between all uses of the device.

Regarding online newspapers, there is environmental improvement potential for Alma Media within content production, but notably also related to readers' electronic equipment and their use of it. For the latter, action needs to be taken in collaboration with the readers as well as stakeholders outside the company's own supply chain.

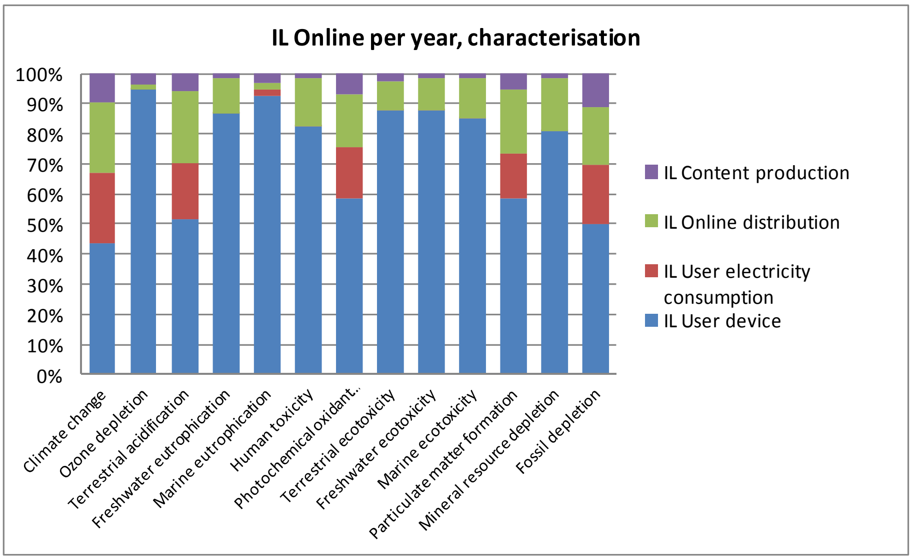


*Figure 81. The relative shares of resulting potential environmental impacts of different parts of the Iltalehti.fi life cycle.*

The results clearly indicate that the environmental performance of printed and online versions of Alma Media's newspapers includes different types of environmental impacts, and that these are distributed differently in the value chain and geographically. The majority of the impacts of printed newspapers occur from paper and printing manufacturing, which are located in Finland.

On the other hand, environmental impacts related to online newspapers are to a large extent dependent on manufacturing electronic devices used for reading the online content. These impacts occur in other countries and at suppliers not directly related to Alma Media. Consequently, the actions to take towards improvements will need to be different, as well as concerning different segments of value chain stakeholders. A major difference between printed and online environmental impacts is therefore that the former largely occurs in the supply chain of the printing house and during delivery to readers, and the latter is mainly connected to the supply chain producing the electronic devices used by the readers and to some extent the electricity use for these.

The study covered various environmental impacts, which was important because the environmental impacts for online and printed newspapers were clearly different. But at the same time, the study also points out the importance in being careful when assessing impact categories where there may be substantial data gaps and where there are greater uncertainties related to the assessment of impacts, e.g. toxicity impact categories. Interpretation becomes challenging and difficult due to the large uncertainties in inventory data, characterisation and normalisation of toxicity impacts.

Comparisons between print and online versions are not simple, as print and online versions provide different types of information and are used in different ways by readers. The printed and online newspapers from Alma Media may not replace, but rather complement each other which can mean adding up environmental impacts from printed and online versions.

Reflecting on the differences in environmental impacts relating to the printed and online versions studied here, it can be said that printed newspapers generally showed a larger environmental impact than online versions when considering the impact related to one year or to one reader during one week. The overall production and use of the newspapers led to larger environmental impacts in total, and also when divided by the number of readers. From the point of view of active reading time, the environmental impacts of the printed versions more often showed a lower environmental impact than the online version. This is due to the printed newspapers being read for a substantially longer time per day than the online versions. The results are highly dependent on number of readers per copy and reading time per day for the printed newspapers studied.

Increased reading time per reader affects online, but not printed versions' total environmental impact. Consequently, the functional unit chosen is very decisive regarding the interpretation of environmental performance of printed and online media, especially if they are to be related to each other. Using different kinds of perspectives through functional units gives more information and increased knowledge.

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# Appendices

Appendix 1 Short description of studied environmental impact categories according to ReCiPe LCIA method.

# APPENDIX 1. Short description of studied environmental impact categories according to ReCiPe LCIA method. (Goedkoop et al. 2009.)

| Impact category, ReCiPe LCIA method | Unit | Description |
|---|---|---|
| Climate change | kg $CO_2$ eq. | Radioactive forcing (IPCC equivalence factor). Global warming potential of substance x over time T. Takes into account greenhouse gases such as $CO_2$, $CH_4$,$N_3O$ etc. |
| Ozone depletion | kg CFC-11 eq. | The ozone depletion potential (ODP) has been defined as a relative measure of the ozone depletion capacity of ozone depleting substance (ODS). The characterization factor for ozone layer depletion accounts for the destruction of the stratospheric ozone layer by anthropogenic emissions of ODS. Affecting emissions: CFC, HFC and Halon compounds etc. |
| Terrestrial acidification | kg $SO_2$ eq. | Atmospheric deposition of inorganic substances such as sulphates, nitrates, and phosphates, cause a change in acidity in the soil. Major acidifying substances are NOx, $NH_3$ and $SO_4$. |
| Freshwater eutrophication | kg P eq. | Aquatic eutrophication can be defined as nutrient enrichment of aquatic environment. Biomass growth in aquatic ecosystems may be limited by different nutrients. Most of the time, aquatic ecosystems are saturated by either nitrogen or phosphorous, and only the non-saturated element (the limiting factor) can cause eutrophication. Fresh waters are typically limited by phosphorous, P eq. Method takes into account P and $PO_4$ emissions to water as well as if P is used as fertilizer to soil (in manure or in artificial fertilizer). |
| Marine eutrophication | kg N eq. | Aquatic eutrophication can be defined as nutrient enrichment of aquatic environment. Biomass growth in aquatic ecosystems may be limited by different nutrients. Most of the time, aquatic ecosystems are saturated by either nitrogen or phosphorous, and only the non-saturated element (the limiting factor) can cause eutrophication. Marine waters are usually limited by Nitrogen, N eq. Method takes into account $NH_3$, $NO_3$,CN, NOx emissions to air and N, $NH_4$, CN emissions to water. In addition the method takes into account fertilizer use of N and its emissions to soil and air. |
| Human toxicity | kg 1.4-dichlorobenzene eq. | The characterisation factor of human toxicity and ecotoxicity accounts for the environmental persistence (fate) and accumulation in the human food chain (exposure), and toxicity (effect) of a chemical. USES-LCA 2.0 toxicity model is applied in evaluation of the effect of different substance in characterization factor development. Characterization factors of human toxicity are based on the inverse of effect dose 50% (ED50) extrapolated to humans. The chemical 1,4-dichlorobenzene is used as a reference substance (to urban air for human toxicity). |
| Photochemical oxidant formation | kg NMVOC eq. | Photochemical oxidant formation indicator is developed so that the contribution of individual substances to ozone formation can be evaluated. It refers to the phenomenon whereby nitrogen oxides and volatile organic compounds form ozone when subjected to bright sunlight. Photochemical oxidant formation is harmful to both humans and plants. Method takes into account, for example, CO, $C_2H_2$, $CH_2O$, NMVOC etc. to emissions to air. |

| Impact category, ReCiPe LCIA method | Unit | Description |
|---|---|---|
| Terrestrial ecotoxicity | kg 1.4-dichlorobenzene eq. | Important aspects behind the characterisation factor are the environmental persistence (fate) and accumulation in the human food chain (exposure), and toxicity (effect) of a chemical. Effect factors are based on the inverse of the average toxicity derived from half maximal effective concentration (EC50) data. The chemical 1,4-dichlorobenzene is used as a reference substance (to industrial soil for terrestrial ecotoxicity). |
| Freshwater ecotoxicity | kg 1.4-dichlorobenzene eq. | Important aspects behind the characterisation factor are the environmental persistence (fate) and accumulation in the human food chain (exposure), and toxicity (effect) of a chemical. Effect factors are based on the inverse of the average toxicity derived from half maximal effective concentration (EC50) data. The chemical 1,4-dichlorobenzene is used as a reference substance (to freshwater for freshwater ecotoxicity). |
| Marine ecotocicity | kg 1.4-dichlorobenzene eq. | Important aspects behind the characterisation factor are the environmental persistence (fate) and accumulation in the human food chain (exposure), and toxicity (effect) of a chemical. Effect factors are based on the inverse of the average toxicity derived from half maximal effective concentration (EC50) data. The chemical 1,4-dichlorobenzene is used as a reference substance (to seawater for marine ecotoxicity). |
| Particular matter formation | kg PM10 eq. | Particulate matter with a diameter of less than 10 µm (PM10) represents a complex mixture of organic and inorganic substances. It is generated by the combustion processes of industrial applications and transport. Particulate matter penetrates deep into the lungs and can cause respiratory diseases. |
| Mineral resource depletion | kg Fe eq. | Or metal depletion used in some contexts describes the effect of mineral extraction to the diminishing of the Earth's mineral supplies. This will have an effect to the mineral costs in the future. Method takes into account mineral resources used such as different metals and uranium. |
| Fossil depletion | kg oil eq. | Or fossil resource depletion used in some contexts. The term fossil fuel refers to a group of resources that contain hydrocarbons including volatile materials (e.g. methane), liquids (e.g. crude oil) as well as non-volatile materials (e.g. coal). The characterization factor is based on the energy content (higher heating value) of materials.. |