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To meet the need for a high quality scientific publishing in its research fields of interest, the International Association of Research Organizations for the Information, Media and Graphic Arts Industries (iarigai) publishes the peer reviewed quarterly Journal of Print and Media Technology Research.

The Journal is fostering multidisciplinary research and scholarly discussion on scientific and technical issues in the field of graphic arts and media communication, thereby advancing scientific research, knowledge creation and industry development. Its aim is to be the leading international scientific periodical in the field, offering publishing opportunities and serving as a forum for knowledge exchange between all those scientist and researchers interested in contributing to or benefiting from research in the related fields.

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A word from the Editor

Nils Enlund
Editor-in-Chief

E-mail: nilse@kth.se

With this issue, the Journal of Print and Media Technology Research has entered into its third year of publication (actually it will be the fourth year, since a preliminary issue was published already in autumn 2011). During 2012-2013, we have published 35 peer reviewed scientific contributions and a regular Topicalities section on altogether 541 printed pages. Two of the issues have been thematic issues, compiled and edited by a guest editor.

Looking back, I feel satisfied and proud. Starting up a new scientific journal from scratch is a slow and painstaking task but, through the enthusiasm and activity of a large group of researchers and authors as well as with the support of the Scientific Advisory Board, we have rapidly succeeded in establishing a quality journal that has, to date, been recognized by Index Copernicus International and Smithers Pira. We are currently working toward full recognition by the major indexing organizations.

The quality of the submitted and published papers has been very good, the acceptance rate being around 70%. I am especially satisfied with the disciplinary breadth of the published papers. The topics range from color science to digital media experience, from paper-ink interaction to augmented reality applications, from printed functionality to climate impact. And this is as it should be - in the multifaceted media communication world of today it is necessary to cross traditional disciplinary borders and see the connections between printing technology, mobile media, environmental effects, consumer attitudes and market mechanisms. The best way of advancing our scientific field is to combine focused research with broad multidisciplinary observations.

In 2014, we will continue on the chosen path. You will see an exciting spectrum of important research in various fields, all published papers united by a common interest in the design, use and impacts of print and media technology. There will also be a thematic issue on a somewhat surprising topic. So keep reading and supporting the journal! And keep submitting those high quality research papers!

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Media content provided on different platforms: Environmental performance of online and printed versions of Alma Media newspapers

Yevgeniya Arushanyan[1], *Åsa Moberg*[1], *Minna Nors*[2], *Catharina Hohenthal*[2]

[1] KTH Royal Institute of Technology
Division of Environmental strategies research - fms
and CESC Centre for Sustainable Communications
Drottning Kristinas väg 30
SE-10044 Stockholm, Sweden

E-mails: yevgeniya.arushanyan@abe.kth.se
asa.moberg@abe.kth.se

[2] VTT Technical Research Centre of Finland
Tekniikantie 2, Espoo, P. O. Box 1000
FI-02044 VTT, Finland

E-mails: Minna.Nors@vtt.fi
Catharina.Hohenthal@vtt.fi

Abstract

Environmental issues are receiving increasing attention from various stakeholders and the media sector is no exception. With the introduction of electronic media, the question of whether electronic or traditional media are more environmentally friendly is often raised.

The stakeholders of the Finnish media publisher Alma Media are interested in obtaining more information about the company's environmental performance and thus commissioned a Life Cycle Assessment (LCA) study of Alma Media newspapers, in printed and online versions. This paper presents the results for the morning paper *Aamulehti* and Aamulehti.fi, and the evening paper *Iltalehti* and Iltalehti.fi to illustrate the potential environmental impacts of online and printed newspapers.

The whole life cycle of each newspaper was assessed as regards its environmental impacts related to printed and online versions. Special emphasis was placed on content production, which has not previously been studied in detail. The online newspapers studied were assumed to be read from laptops and desktop computers.

Content production appeared to contribute a rather significant share to the environmental impact of online and printed newspapers, particularly an online newspaper with few readers. With the improvements in other life cycle stages, e.g., more energy-efficient and smaller devices, this might become increasingly important. The reasons for content production impact originated mainly from manufacturing of electronic office equipment, business trips, electricity and heating used in the offices.

For printed newspapers, newsprint manufacturing, ink and plates production were the main reasons for the environmental impact. For online newspapers, the end-user devices (manufacturing and use) made the highest contribution to the environmental impacts in various impact categories. Online distribution contributed significantly to the environmental impact when the content of the website was media rich and download volumes large.

Comparison of printed and online versions is not straightforward. Here it was done in two different ways, with the environmental impact generated related to two different functional units: "one reader and week" and "one reading hour". The overall results of the comparison differed depending on the functional unit used. This shows the complexity of the question and indicates that there is no easy answer to whether online or printed versions of newspapers are more beneficial from an environmental point of view. In either case, media companies need to take action. Collaboration with value chain stakeholders is crucial for improvements, but collaboration regarding online newspapers will most probably differ from that related to printed newspapers, as the supply chain of the electronic end-user devices is not directly connected to the media company, but to its customers. Actions also need to be taken in-house, e.g., reducing the environmental impact of content production through rethinking business trips, introducing energy-efficiency solutions, using cleaner energy sources, placing environmental demands on procurement of electronic devices and extending their service life.

Keywords: Life Cycle Assessment (LCA), printed media, electronic media, content production, environmental impact

1. Introduction and background

There is an increasing awareness among different stakeholders about environmental issues and the need for actions for sustainable development. For the media sector, this has had various implications. When electronic media were introduced at some scale, there was a general idea that electronic media was "zero burden", i.e., that it had no environmental impacts. This misconception can perhaps be explained by the media content being delivered electronically and leaving no direct waste when it is consumed, in contrast to the very visible stacks of old newspapers piling up at home. However, environmental assessments have given other indications, since with a life cycle perspective there are considerable impacts also related to electronic media, for example, since electronic devices are used and need to be produced as well as disposed of (e.g., Enroth, 2009; Moberg et al., 2011).

From an environmental point of view, there are both pros and cons with printed media as well as with new electronic solutions for distributing and accessing media content (e.g., Reichart and Hischier, 2003; Nors et al., 2009; Moberg et al., 2010; Pihkola et al., 2010). Different stakeholders may put forward different arguments to prove the benefits of their own solutions. Some argue that the use of virgin fibres in pulp and paper making is not sustainable (at least if it is not from certified and well managed forests), whereas others argue strongly in favour of the renewable resources used for the printed media substrate. At the yearly international research conferences of iarigai, the International Association of Research Organization for the Information, Media and Graphic Arts Industries, the topic of environment and sustainability has become common during recent years (e.g., Viluksela et al., 2008; Pajula et al., 2009; Pihkola et al., 2010; Weidel, 2010; Kronqvist et al., 2010; Mirkovic et al., 2011; Picha and Moberg, 2011; Müller et al., 2011; Rajendrakumar et al., 2011), which was not the case some ten years ago.

This is a field where interest and concern are growing, and we need to learn more and get an increased understanding of how the environmental performance of media companies and media products can best be improved.

As a result of an inquiry to its stakeholders, the Finnish media publisher Alma Media learned that its stakeholders were interested in getting more information about the company's environmental performance (Alma Media, 2012). Thus, Alma Media decided to commission a life cycle assessment (LCA) in order to learn more about environmental impacts related to their mature and emerging products. With an LCA, the potential environmental impacts related to a defined product or service are assessed using a life cycle perspective, as explained below. The aim of this paper is to present potential environmental impacts related to printed and online newspapers based on the outcomes of an LCA study (Hohenthal et al., 2013) and on complementary calculations.

Particular emphasis is placed on content production, which has not previously been studied in such detail. Based on the conclusions drawn, some recommendations are put forward on how media companies can act in order to facilitate environmental improvements.

2. Methods

LCA is a method used to analyse the potential environmental impacts through a product's life from cradle to grave, i.e., from raw material acquisition via the production and use phases to waste management (e.g., Baumann and Tillman, 2004; Rebitzer et al., 2004; Pennington et al., 2004; Finnveden et al., 2009; Antikainen et al., 2012). LCA can be used for analysing single products or services or for comparing products or services that fulfil similar functions. An ISO standard has been developed for LCA, providing a framework, terminology and some methodological choices (International Standards Office, 2006a; 2006b). An LCA is divided into four phases: goal and scope definition, inventory analysis, life cycle impact assessment (LCIA) and interpretation. In the inventory phase, data on all inputs (material and energy resources) and outputs (emissions to air, water and soil) of the product system under study are gathered. These data are related to a so-called functional unit, which is a quantitative measure of the function(s) that the product or service provides. In comparative studies, the functional unit needs to be the same for the product systems compared and the definition of the functional unit is essential in order to perform the comparison on a fair basis.

In LCAs, boundaries are set in time, i.e., over what time perspective emissions should be considered. For example, if the boundary is set at 100 years into the future, which is a common practice, any emissions occurring later in time will not be considered. Another option is to use a longer or even infinite time perspective and consider "all emissions" whenever they occur in time. The time boundaries set may have considerable effect on the overall results, especially for activities such as landfilling and mining, for example, where emissions can occur over very long periods.

In a study of the environmental performance of five different print products using LCA and carbon footprint evaluation, the importance of covering several

different environmental impacts instead of focusing only on carbon footprint was highlighted (Pihkola et al., 2010). In an LCA, 'all' potential environmental impacts should preferably be considered. However, in practice, some types of impacts are easier to cover. This is because of data availability, possibility to quantify information, data certainty, etc. (Baumann and Tillman, 2004; Rebitzer et al., 2004; Pennington et al., 2004).

As all environmental impacts in an LCA are related to a functional unit, assessment becomes slightly complicated if more than one function is produced by the system under study. This is the case, e.g., when energy is recovered from incineration of waste newspapers. In this case, the waste treatment serves two purposes: dealing with a waste problem and producing a new product: heat and/or electricity. In an LCA on newspapers, the incineration plant can be considered part of the newspaper life cycle or part of the life cycle of heat and electricity generation, or part of both. One way of solving the problem of several functions provided is to expand the system boundaries and include both products in the system model. Then the emissions from the incineration are included in the product system, but an alternative competing source of energy is also included in the system model. Assuming that the energy recovered from the incineration of newspapers can replace energy from the competing source, this generation of heat and/or electricity is avoided and often referred to as an avoided process. The environmental impacts from these avoided processes are then subtracted from the product system. The newspaper product system is thus credited with producing heat and/or electricity. If the waste handling is recycling instead, the recycled material can replace paper from other sources. In the same way as for incineration, the newspaper product system is then credited with avoiding the production of paper from other sources. System expansion is recommended in the ISO standard (International Standards Office, 2006b).

Another case where there are several functions provided is computers. The manufacturing and waste management of a computer can be related to several different types of functions, where reading the online newspaper is one. In these cases the environmental impacts related to the manufacturing and waste management are often split between the different uses based on the share of the overall use time.

In the process of an LCA, data on all inputs and outputs to the product system studied are first gathered and thereafter translated into impacts in the so-called impact assessment phase. In this study, the impact assessment method ReCiPe Midpoint (Goedkoop et al., 2008) was used, as implemented in the VTT SULCA[1] software for the assessment of printed newspapers and as implemented in SimaPro[2] 7.3 for the assessment of online newspapers. This impact assessment method includes 18 impact categories, 13 of which were chosen for this study: climate change; ozone depletion; human toxicity; photochemical oxidant formation; particulate matter formation; terrestrial acidification; freshwater eutrophication; marine eutrophication; terrestrial ecotoxicity; freshwater ecotoxicity; marine ecotoxicity; mineral resource depletion; and fossil depletion.

The reason for excluding the remaining five impact categories was lack of inventory data. Furthermore, for some other impact categories the limitation in data availability and certainty proved to be considerable, at least for some processes. This was clearly the case for toxicity impact categories. The climate change impact category was the one that provided the most robust results, but the other impact categories were still included to get an indication of the magnitude and to discuss the uncertainties.

In most LCAs, some assumptions need to be made or some data are uncertain. In these cases it may be a good idea to test assumptions or data importance through performing sensitivity analyses. By altering assumptions or using different data sources and analysing the outcome, the sensitivity of the overall results to specific assumptions or data can be evaluated. This information should then be considered when interpreting the results of the LCA.

In addition to using data from the original study (Hohenthal et al., 2013), complementary calculations were made, including a new sensitivity analysis and partial recalculations for content production and for online newspapers using corrected data for electronic devices from Ecoinvent 3.0 (Weidema et al., 2013). The overall results were not influenced significantly by the recalculations. The new sensitivity analysis was carried out using different data for electricity (sections 3.7 and 4.5, Figure 16).

3. System descriptions and data inventory

3.1 Scope of the study

The assessment of two Alma Media newspapers in printed and online versions is described here: the morning newspaper *Aamulehti* and Aamulehti.fi, and the evening newspaper *Iltalehti* and Iltalehti.fi. For the printed newspapers, the product systems studied covered the upstream printing house supply chain, printing house activities, delivery to readers and final disposal of print versions. For the online newspapers, the product systems studied covered electronic storage and distribu-

[1] http://www.vtt.fi/research/technology/sulca_software.jsp?lang=en
[2] http://www.pre-sustainability.com/simapro

tion, manufacturing and disposal of the electronic devices, and electricity needed for downloading and reading for online versions. Content production was assessed for both product systems, as illustrated in Figures 1 through 3. The readers are located in Finland, but some of the manufacturing and transportation is performed in other countries. The data underlying the assessment represent the year 2010 and reading of the online newspapers was assumed to be on laptops and desktop computers. The full study and underlying data are presented in Hohenthal et al. (2013).

In the assessment, a 100-year time perspective was used for many processes. In much of the secondary data used, long-term emissions were considered using a time perspective of 60 000 years (Frischknecht et al., 2007). These secondary data sources include the landfill and mining processes, where such long-term emissions are expected to be of importance.

The functional units used were "one copy of the newspaper" for printed newspapers and "one reader and week" for online newspapers. However, when comparing the printed and online newspaper versions we needed to define a common functional unit, which is not straightforward. A reader often spends a considerably longer time per day reading the printed newspaper than the online version (Levikintarkastus Oy, 2011), the content is not exactly the same in both versions and the online newspaper may provide additional benefits such as continuously updated information and possibilities to search for further information through links to other internet pages. How can then the function or benefit provided by a newspaper be defined? The number of readers that have access to or have accessed the newspaper may be one relevant way of considering benefit, and we used this in our assessment. However, the number of readers does not say anything about the information, learning, entertainment, etc., that is obtained. This is inherently difficult to assess and define. Here, we chose to use reading time as a very rough estimate of this benefit. Thus, the comparative results were presented using two different functional units in separate analyses. These functional units were "one reader and week" and "one reading hour".

The environmental impact of "one reader and week" for printed newspapers was calculated from the impact of one newspaper copy divided by the number of readers per copy and multiplied by the number of days that the newspaper is published per week. For online newspapers, this was calculated from the impact of the yearly online newspaper production divided by the number of weeks per year and the number of readers per week.

The environmental impact of "one reading hour" for the printed newspaper was calculated from the impact of one newspaper copy divided by the reading time per copy (taking into account multiple readers). The environmental impact of "one reading hour" for the online newspaper was calculated from the impact of the yearly online newspaper production divided by total reading time for all readers during one year.

In the comparative analyses, a smaller set of impact categories were used: climate change, acidification, eutrophication, metal depletion and fossil depletion. These were selected as they are considered to be related to less uncertainty.

3.2 General information on the newspapers

The two newspapers studied are quite different. *Aamulehti* is a morning newspaper, delivered to homes, while *Iltalehti* is an evening newspaper, distributed to newsstands and cafés. The characteristics of these newspapers vary significantly for both printed and online versions (see Table 1).

Table 1: Characteristics of the four newspaper objects studied and readership information (2010)

	Aamulehti		**Iltalehti**	
	Print	Online	Print	Online
Number of readers per week	n/a	237 196	n/a	1 796 684
Number of readers per copy	2.3	n/a	5.6	n/a
Number of issues per week	7	n/a	6	n/a
Weight per copy, gram	282		201	
Reading time per reader and copy, min	35	n/a	23	n/a
Reading time per visit, min	n/a	02:20	n/a	01:20
Reading time per reader and week, min	245	6	138	9
Average size of download, MB/visit	n/a	0.6	n/a	15
Total download, MB/week and reader	n/a	2	n/a	100
Average size of a daily upload, MB/day	n/a	22.6	n/a	13.5

The differences in number of readers, number of copies (for the printed newspaper) and reading time are conditioned by the different audience and content of the newspapers. However, for the online versions, it is also a fact that Aamulehti.fi is an emerging newspaper, launched in 2010 and has rather light content (mainly text) and, in the year of study, few readers. Iltalehti.fi, on the other hand, is a more mature version with rather rich content (many photos and videos) and a higher number of readers. Data concerning number of readers of the online newspaper, frequency, duration and number of visits, as well as average size of download, were obtained from each newspaper's website statistics (TNS Gallup, 2010). Information on the average size of daily uploads was obtained from each newspaper. Similarly, data about number of readers of the printed newspaper, amount of printed newspapers and average daily reading time, average size of printed newspapers (printed paper weight, number of pages, etc.) were obtained from each newspaper.

3.3 Content production

Content production is a life cycle stage common to the online and printed newspapers. The content production includes electricity and heat used in offices used by journalists, marketing and administration personnel, manufacturing, transportation and use of equipment (computers, monitors, printers, servers, etc.) and materials (paper and toner), business travel (by cars, trains and planes) and mailing. The content production processes modelled here are presented in Figure 1 and described in more detail in Hohenthal et al. (2013).

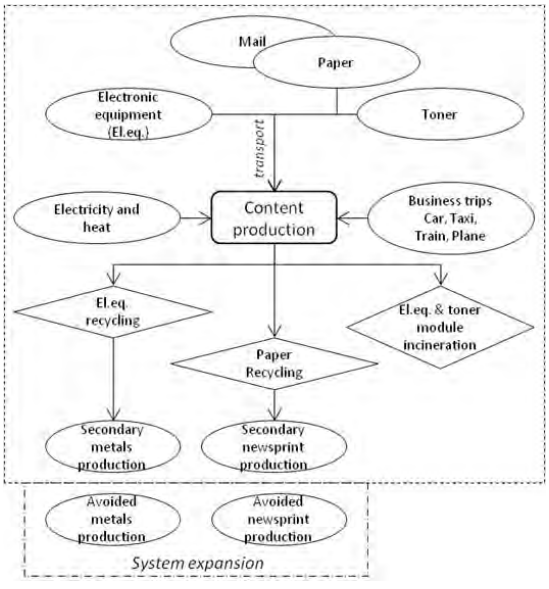

Figure 1: Content production system boundaries. Processes within the dotted line are included in the study

Content production for the online and printed newspaper versions is performed in the same offices for each respective newspaper, and heat, electricity, material etc. are shared between these two product systems. Thus, the related potential environmental impacts were split between the online and the printed newspaper versions in the following proportions (print/online): Aamulehti 85/15 and Iltalehti 59/41. The shares were defined based on the number of employees working only with the print or only with the online version, the number of marketing people divided between online and printed versions and the share of "print" content used also for the online version (based on personal communications with respective newspaper). For example, the shares of content production allocated to *Iltalehti* and Iltalehti.fi were calculated as follows. The number of employees working specifically with the printed and online version was provided by newspaper representatives. It was known that approximately half of the content produced for the printed newspaper is used also for the online version. Thus, it was assumed that 50% of employees working with the print newspaper spend 50% of their time on the online newspaper. The number of marketing employees was split equally between the printed and online versions, assuming that they spend an equal time working with either of the versions (actual data on this were not available). The same procedure was followed when defining shares of content production for *Aamulehti* and Aamulehti.fi, but marketing work was split differently based on the newspaper representatives' assumptions.

Electronic equipment

Electronic equipment covered manufacturing, including raw material acquisition and end-of-life use of devices, such as desktop computers, laptops, LCD screens, keyboards, mice, printers, network access devices and mobile phones. Stationary phones, faxes and tablets were omitted from the study due to the lack of data regarding those. The impact of leaving these out is considered to be low, since the number of such devices was relatively low at the time.

Data on the number of each type of electronic equipment were provided by the newspapers. The data for manufacturing processes were taken from Ecoinvent 2.0 (Hischier et al., 2007a) as implemented in SimaPro 7.3 and updated later with the corrected data from Ecoinvent 3.0. The data for end-of-life treatment processes were taken from Ecoinvent 2.0, modified based on later information from Ecoinvent reports (Hischier et al., 2007b; Classen et al., 2009) in order to include metals recovery due to recycling. More details on this are given in Hohenthal et al. (2013).

Paper and toner

Data on the amount of office paper and toner used over the year were provided by each specific newspaper. Here, production and end-of-life treatment were

considered. The data for production and end-of-life processes were obtained from Ecoinvent 2.0 (Hischier, 2007; Hischier et al., 2007c) as implemented in SimaPro 7.3. The process for recycling paper was modified in order to account for the benefit of avoided newsprint production from virgin fibres as a result of recycling.

Business trips

Business trips included trips by car (fuelled by petrol and diesel), taxi, train and airplane. Business trips by public transport as well as trips from and to work were not accounted for due to the lack of data for the former and due to the latter being outside of the scope of the study.

Data on the number of business trips, distances and means of travel were obtained from each specific newspaper. The inventory data for the travel were taken from LIPASTO (2010), taking into account fuel type for cars and type of flights (local, Europe or international).

Transport

Delivery, as modelled here, covered transportation of electronic equipment, paper and toner to the offices. Transportation distances for electronic equipment were calculated based on assumptions of the manufacturing location and information about the most common modes of transportation of electronic equipment. Transportation distances for paper and toner were calculated based on information from the delivery firms. The inventory data for transportation (ship, lorry, freight plane) were taken from the LIPASTO (2010)database.

Energy

The generation of electricity and district heating used in the offices was also considered. For a more detailed description of those processes see section 3.4. More details on the content production processes can be found in Appendix B.

3.4 Other common processes

For some general processes, such as energy use and transport, we utilised the same data for both the printed and online systems studied.

The sources of the electricity used for pulp and paper manufacturing, in the printing plant, during content production, for online media distribution and use, as well as the heat used in pulp and paper manufacturing and at the printing plant were assumed to be equal to a Finnish 5-year average (2005-2009). For the assessment of the district heating used for the content production offices, specific fuel consumption data from heat providers (Helsingin Energia, 2008; Tampereen Sähkölaitos, 2008) was applied. For information on electricity and heat mixes, see Appendix A. Both energy systems (electricity and heat generation) were modelled in the same way and included resource extraction, fuel production, power plant operation and transfer to the user. The infrastructure and waste management along these various processes was not covered. Data on the fuel supply and energy production were taken mainly from the EcoData database (Pihkola et al., 2007) and for some processes (hard coal production and energy production with natural gas in condensing power plants) from Ecoinvent 2.0 (Dones et al., 2007). Long term emissions are only covered in the data from Ecoinvent.

Transportation and travel in various parts of the newspaper product systems studied were covered using data mainly from LIPASTO (2010) and included fuel production and direct emissions from fuel combustion. Data for aircraft fuel were taken from Ecoinvent 2.0 (Jungbluth, 2007). Vehicle manufacturing and road infrastructure were not included. The set of emissions from transportation was somewhat limited and did not include the emissions of, e.g., metals.

3.5 Printed newspapers

In addition to the content production, the case studies of the printed newspapers covered pulp and paper manufacturing, transport 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. The system studied is presented in Figure 2 and described in more detail in Hohenthal et al. (2013).

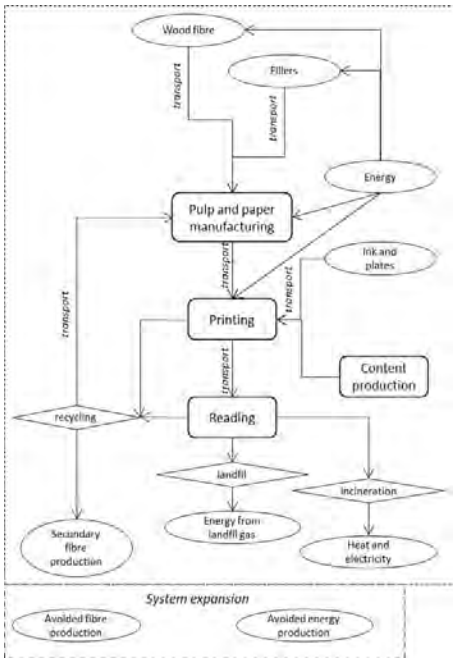

Figure 2: Printed newspaper system boundaries. Processes within the dotted lines were included in the study

Pulp and paper manufacturing starts with fibre supply, covering harvesting and sawmills, and energy supply for these processes. Next, the process of pulp and paper production was covered, including direct emissions from pulp and paper mills, production of grid electricity used in the process, manufacturing of fillers, main raw materials and fuels needed for production. EcoData (Pihkola et al., 2010b) and UPM paper manufacturer data (Juntunen, 2011) were used here.

Printing included processes associated with the printing house, i.e., manufacturing of printing ink (other chemicals not covered) and printing plates, production of heat and electricity used in the printing processes, and direct emissions from the printing house. Specific Alma Media data were used for the printing sites emissions. Ecoinvent 2.0, EcoData and EAA data were used for other processes (see Appendix C).

Delivery to customers included home delivery or delivery to retailers' warehouses. Specific data for Alma Media (distances, modes of transport and newspaper amounts) were obtained from the company.

Transportation of all major raw materials (wood, chemicals, fuel, etc.) and waste was taken into account. Specific data were obtained from UPM and Alma Media, complemented with EcoData and LIPASTO data.

End-of-life assumptions for the printed newspapers (79% recycling, 16% landfill and 5% incineration) were based on Finnish statistics and data from a recycling company. The landfill data applied here were specific for newsprint (Pihkola et al., 2010b) and assumed the efficient collection of landfill gases. The incineration processes used were specific to paper and based on backpressure technology (fluidised bed incineration). The benefits of recycling the printed newspaper and waste paper from printing, as well as the incineration and landfilling with energy recovery, were accounted for using system expansion. Recycled fibre was assumed to replace virgin fibre production. Only the surplus recycled fibre left the studied system. Surplus electricity at the landfill and incineration plant was assumed to substitute for the production of Finnish average electricity.

Some parameters of the two printed newspapers are presented in Table 2.

More details on the processes can be found in Appendix C.

Table 2: Characteristics of printed Aamulehti *and printed* Iltalehti.

	Aamulehti, 48 pages (broadsheet)	*Iltalehti*, 32 pages (tabloid)
Printing	Coldset web offset	Coldset web offset
Paper	Newsprint, 45 gsm, 75.5% Newsprint, 48.8 gsm, 4.3% Brite 68, 48.8 gsm, 20.2%	Newsprint, 45 gsm, 75.5% Newsprint, 48.8 gsm, 4.3% Brite 68, 48.8 gsm. 20.2%
Circulation	~132 000 copies per day	~107 000 copies per day

3.6 Online newspapers

The online newspaper life cycle included content production, online distribution (uploading content to a server and users accessing the newspapers from the server) and reading the online newspaper (from a desktop computer or a laptop, at home or at the office). The online newspaper system is presented in Figure 3 and described in detail in Hohenthal et al. (2013).

Content production is described separately in section 3.3. The online distribution system modelled here included manufacturing, transportation, energy use and end-of-life management of Alma Media servers and network access devices, and generic internet infrastructure (cable materials manufacturing and energy use). Data on the number of servers used was provided by the respective newspapers. Specific information on server electricity consumption was not available, so figures were calculated based on the assumption of 180 W power draw and servers always being on. A factor 1.3 (based on Taylor and Koomey (2007), Malmodin (2011) and Lundén (2011)) was used to account for energy use for supporting net-

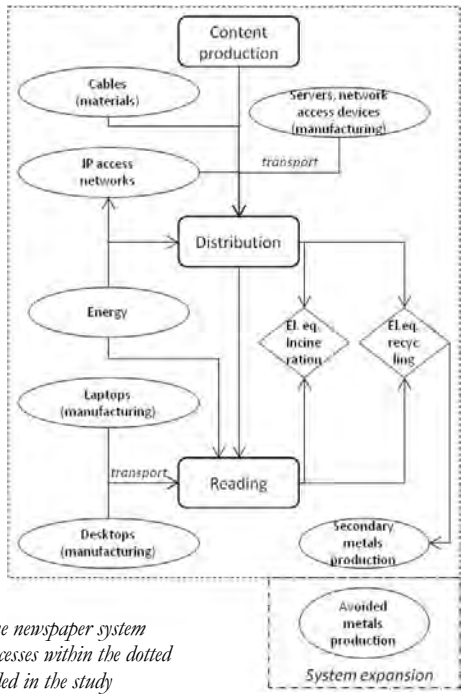

Figure 3: Online newspaper system boundaries. Processes within the dotted lines were included in the study

work and cooling. Manufacturing of the equipment was included using Ecoinvent 2.0 data (Hischier et al., 2007a; 2007b) and updated later with the corrected data from Ecoinvent 3.0. Internet infrastructure was included using Swedish data (Lundén, 2011) and covered manufacturing of materials for cables and electricity consumed by the network. Allocation was done based on the amount of information (in MB) transferred in the network.

The life cycle stage concerning reading of the online newspapers was divided into two parts - user electricity and user device (manufacturing, transportation and end-of-life). User electricity consumption allocated to reading the online newspaper was calculated based on the data on electricity consumption of the different devices used (desktops and laptops, network access devices) (IVF, 2007; J. Malmodin, 2011) and the reading time of the online newspaper studied. The average reader of the two newspapers was assessed, taking into account the average reader's location (home or office), electronic device (desktop computer or laptop with or without additional LCD screen), frequency of visits to the newspaper website and duration of the average visit (see Table 1) (TNS Gallup, 2010).

The modelling of the user device included manufacturing, transportation and end-of-life treatment of user's computers (desktop computers and laptops). The underlying assumption for end-of-life treatment was that all the devices are disposed of in waste electric and electronic equipment (WEEE) treatment. After dismantling, according to the model, the parts were sent for further treatment - incineration (e.g., LCD modules and plastic) or recycling (e.g., PWBs, batteries, electronic scrap) (Hischier et al., 2007b). The benefits of metal recycling were taken into account in this study. A relevant share of the environmental impact related to these activities was allocated to reading of the online newspapers, based on time of use. Overall computer use for home computers was based on Finnish statistics (Melkas, 2011). For office computers, an assumption was made based on the number of working hours per year (8 hours per 240 days a year). The lifetime of a desktop computer was set to 6.6 years and of a laptop to 5.6 years (Hischier et al., 2007a). More details on the processes can be found in Appendix D.

3.7 Sensitivity analyses

In order to test the influence on the results of some major assumptions and data used, sensitivity analyses were performed for both printed and online newspapers, altering the assumptions made.

In this paper we present analyses for the online newspapers where an assumption of shorter lifetime of the desktop and laptop computers used for reading online newspapers was tested and where different electricity mix data were used. For the former, the assumed 5.5 and 6.5 years were replaced by 3 and 3 years, respectively. The Finnish electricity mix data used in the assessment were replaced with Finnish electricity mix (2004) and UCTE (Union for the Coordination of the Transmission of Electricity, 2004) electricity mix from Ecoinvent 2.0.

The sensitivity analysis for the printed newspapers attempted to compare possible alternatives for waste management in the printing house according to the EU waste management policy, i.e., looking at waste as a valued resource, preferring reuse to recycling and recycling to disposal (EC, 2010). Thus, in a sensitivity analysis the paper waste was assumed to be used as a raw material in insulation manufacturing, rather than being recycled into new paper.

In this analysis, a newspaper-specific mass-based percentage of embodied environmental burden of the newspaper was allocated to the insulation raw material (i.e., printing paper waste). Additional sensitivity analyses are presented in Hohenthal et al. (2013).

4. Results

4.1 Content production

The results for the printed and online newspapers are presented to illustrate which activities in each product system contributed the most to each impact category. The total value for each category was set to 100%. It should be noted that this does not mean that the overall impact in one category was valued equal to the overall impact of another category. Rather, it was just to make the illustration of the contribution of the different activities to each category possible.

For some of the newspapers studied, the content production contributed a considerable share of the total environmental impacts. The reasons for the potential environmental impacts of content production of Aamulehti and Iltalehti were rather similar (Figures 4 and 5).

Even though the reasons for the impacts varied from one impact category to another, the major contributors were manufacturing of office equipment, business trips, electricity and district heating used in the offices.

The office equipment impact was mainly due to computers and screens, and the manufacturing of these was the major reason for several of the impact categories studied. The mining of gold to be used in production of integrated circuits (ICs) and printed wiring boards (PWBs), which are part of LCD screens and computers, was a major contributor to human toxicity, freshwater eutro-

phication, terrestrial ecotoxicity, freshwater ecotoxicity, marine ecotoxicity and metal depletion. For marine eutrophication, in addition to this, nitrogen compounds in the waste water effluent from the LCD module production and electricity from lignite used in the manufacturing were major contributors.

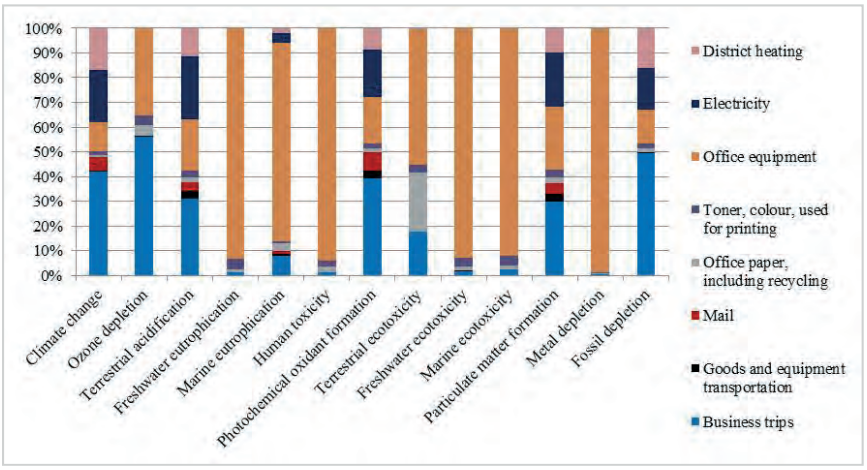

Figure 4: Environmental impact potential of Aamulehti content production (print and online) per year. Percentage share of lifecycle stages

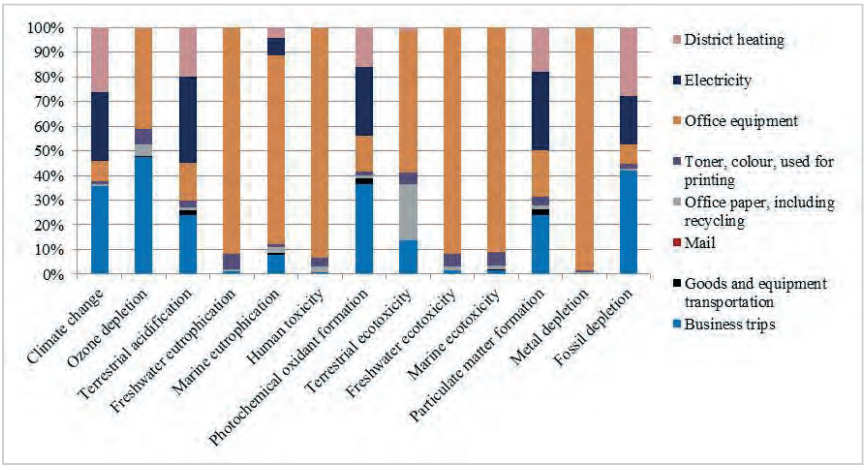

Figure 5: Environmental impact potential of Iltalehti content production (print and online) per year. Percentage share of lifecycle stages

Regarding ozone depletion, where office equipment contributed about 40 %, the production of wafers (semi-conductor material used in ICs) and use of electricity produced from natural gas in manufacturing were major contributors. Another significant contributor to the ozone depletion potential was business trips, i.e., flying, because of aviation fuel use.

Business trips also had a significant impact on climate change, fossil depletion and photochemical oxidant formation. The main contributors to these impacts were trips by car, mainly due to impact from petrol production, and flights within Europe, mainly due to aviation fuel production.

Electricity production contributed up to 30-35 % to some impact categories. The impact was caused mainly by the emissions from electricity generation due to a rather significant (15 %) content of coal in the mix.

Heating contributed significantly to some impact categories. It can be noted that the impact from heating in Aamulehti was lower than in Iltalehti, which might be due to rather clean mix of sources (see Appendix A) for Tampereen sähkölaitos heat used in Aamulehti offices.

4.2 Printed newspapers

4.2.1 Aamulehti

For the printed version of Aamulehti, newsprint production, content production and ink and plates manufacturing were the largest contributors to the various impact categories assessed here (Figure 6).

Newsprint production clearly had the highest impact on eight out of 13 environmental impacts. For the categories climate change, terrestrial acidification and particu-

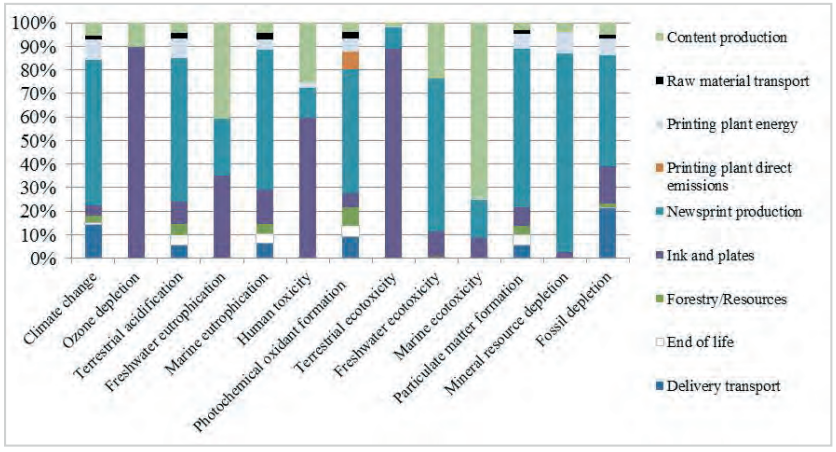

Figure 6: Environmental impact potential of printed Aamulehti*, per copy. Percentage share of lifecycle stages*

late matter formation, this was mainly due to energy and fuel use in the production system. Fossil and mineral resource depletion also originated mainly from energy use for pulp and paper production. The depletion impact was assessed by comparing the magnitude of use against the known reserves. The mineral and metal resources depletion impact was mainly caused by the grid electricity used in pulp and paper production. In the average Finnish grid mix, the share of nuclear power is around 30%, where an important fuel is uranium. Climate change impacts are caused by greenhouse gas emissions, mainly carbon dioxide. Acidification is mainly caused by sulphur and nitrogen oxide emissions.

Most of the particulates originate from the emissions of industrial activities, energy generation and transport. It can be noted that content production had the highest share of the potential impacts regarding marine ecotoxicity and freshwater eutrophication. The core area for a media company is content production and its environmental impact was elaborated upon in more detail in section 4.1.

Ink and printing plates manufacturing was the activity contributing most to ozone depletion (due to halon emissions from production of solvents used in inks manufacturing[3]), human toxicity (mainly due to arsenic emissions to water) and terrestrial ecotoxicity (due to herbicides/pesticides), with a share of almost 60% to almost 90%. Ink and plate manufacturing also affected freshwater eutrophication, but to a lower degree.

Delivery transport contributed between 10 and 20% to climate change potential and fossil depletion impacts. The relative impact of the printing plant due to direct emissions and purchased energy was around 10% for climate change, terrestrial acidification, photochemical oxidant formation, particulate matter formation, mineral depletion and fossil depletion.

4.2.2 Iltalehti

In general, the printed version of Iltalehti (Figure 7) had similar environmental impacts to the printed version of Aamulehti. The main difference between them was that the share of impact from transportation was lower for *Iltalehti*, since the newspaper is not delivered to homes.

[3] The data for solvents production are rather old and include use of Halon 1301 and 1211 in the processes of raw oil production.

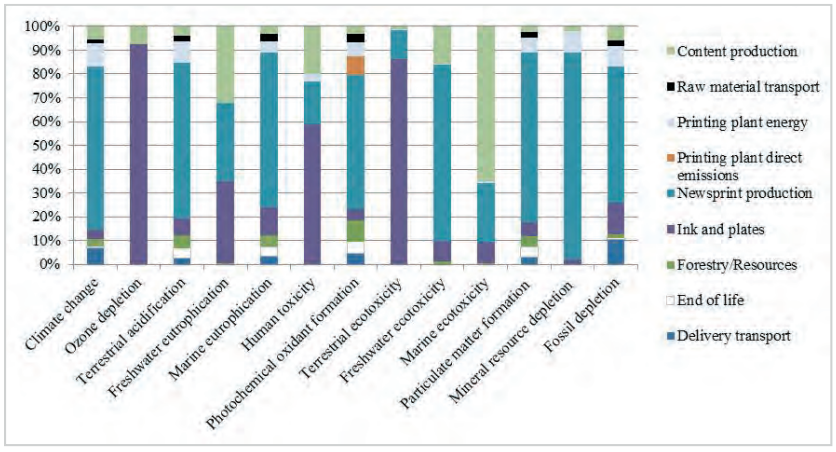

Figure 7: Environmental impact potential of printed Iltalehti*, per copy. Percentage share of lifecycle stages*

The possible environmental impact related to the reader getting the newspaper from the sales point was not included in the study.

4.3 Online newspapers

4.3.1 Aamulehti.fi

The potential environmental impact for Aamulehti.fi is presented in Figure 8.

Major reasons for the environmental impacts were the user devices, which contributed from 31% (climate change) to more than 80% (human toxicity, freshwater eutrophication, freshwater toxicity, marine ecotoxicity and mineral resource depletion). This was mainly due to computer manufacturing, i.e., extraction of raw materials for electronic equipment production, such components as PWBs and ICs. Transportation and end-of-life of the user devices were accounted for here, too but contributed a small share of the impact from the user device. Content production contributed some 50% of the climate change potential and fossil depletion, and 18 to 40% of the other impact categories. The environmental impact of content production is described in section 4.1. Online distribution constituted a small share of the impact due to the rather low number of readers and low weight of the website content (small amount of MB downloaded/reader and visit). User electricity contributed 12-20% in some of the impact categories (e.g., climate change). It has an impact lower than 2% in several other impact categories (e.g., human toxicity and terrestrial, freshwater and marine ecotoxicity). The user devices considered here were desktop computers and laptops, the manufacturing of which had a rather significant impact.

The relative impact of user electricity was also sensitive to the electricity mix considered. In this case, the Finnish 5-year average electricity mix was considered, with combined heat and power (CHP) production which generates lower emissions per MWh of electricity produced. However, the data used to describe these specific Finnish conditions had their limitations (as described earlier). This was tested in the sensitivity analysis (section 4.5).

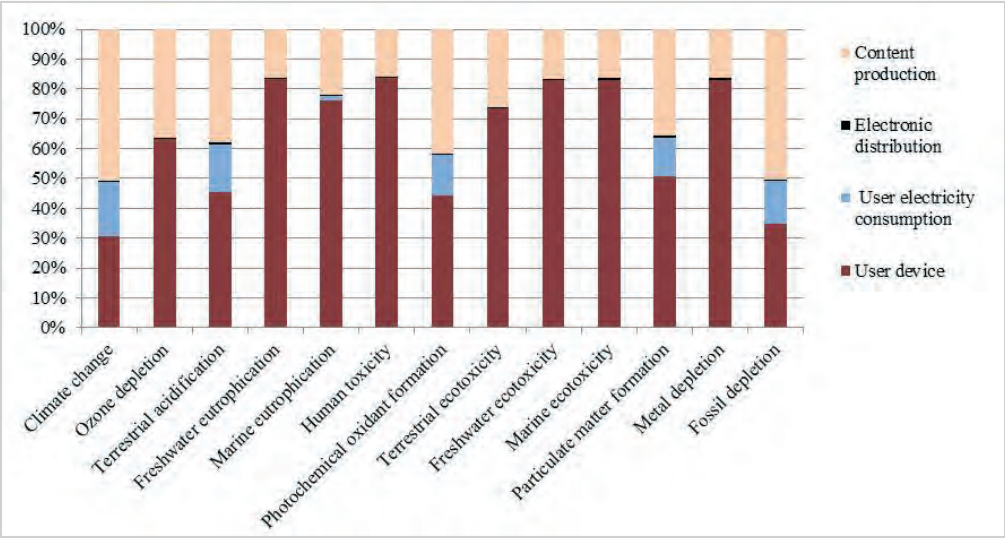

Figure 8: Environmental impact potential of Aamulehti.fi, reader and week. Percentage share of lifecycle stages

4.3.2 Iltalehti.fi

For Iltalehti.fi, the user device, mainly manufacturing of the readers' computers, was the main reason for the potential environmental impacts and was the major cause of all types of impacts assessed (Figure 9).

The relative impact from content production was clearly lower than for Aamulehti.fi. Online distribution and electricity consumption in the use phase occupied a significant share of the total impact in several impact categories.

The characteristics of the average Iltalehti.fi reader differ from those of the average Aamulehti.fi reader, hence the differences in results. For the former, the reading time is longer and the amount of data downloaded by readers (video, photo) higher, which led to a higher amount of energy use allocated for the online distribution.

4.4 Comparison between print and online newspapers

Printed and online versions of Aamulehti and Iltalehti were compared based on the common functional units - per reader and week, and per reading hour. In this comparison, the printed version of *Aamulehti* also included the Sunday supplement, as this would be included in a weekly reading or in an average hour of printed *Aamulehti* reading. Looking at the potential environmen-

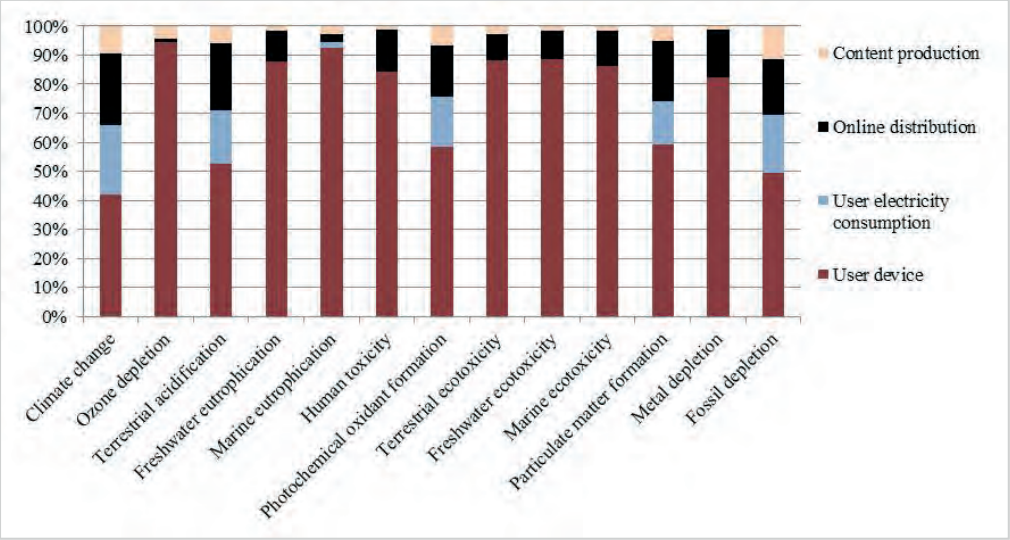

Figure 9: Environmental impact potential of Iltalehti.fi, per reader and week. Percentage share of lifecycle stages

tal impacts per reader and week for printed *Aamulehti* (including the Sunday supplement) and Aamulehti.fi, it was clear that the print version had a higher impact (Figure 10). The impact of the online version was less than 5% of that of the printed version for all impact categories assessed except freshwater eutrophication, where it was about 50% of the printed version impact due to the impact from user device manufacturing.

For Iltalehti, the difference was smaller, but still, for six out of seven categories compared, the printed version resulted in a higher impact. Here, however, the online version had a considerably higher impact regarding freshwater eutrophication.

The difference between Aamulehti and Iltalehti is due to *Aamulehti* having fewer readers per copy for the printed version than printed *Iltalehti*, and also to a smaller extent to the Iltalehti online reader giving rise to a higher environmental impact per week due to longer reading time and larger amount of data downloaded than Aamulehti.fi.

This illustrates an inherent difference between the two media solutions. In the case of the online newspaper, the more a person reads (and downloads) the higher the impact, whereas in the case of the printed newspaper the environmental impact is related to manufacturing and once it is produced, the time a person spends reading it will not affect the absolute environmental impact.

If a functional unit expressing the benefits in terms of reading time, information gained, etc., were to be used, the relative environmental impact in this case would decrease further.

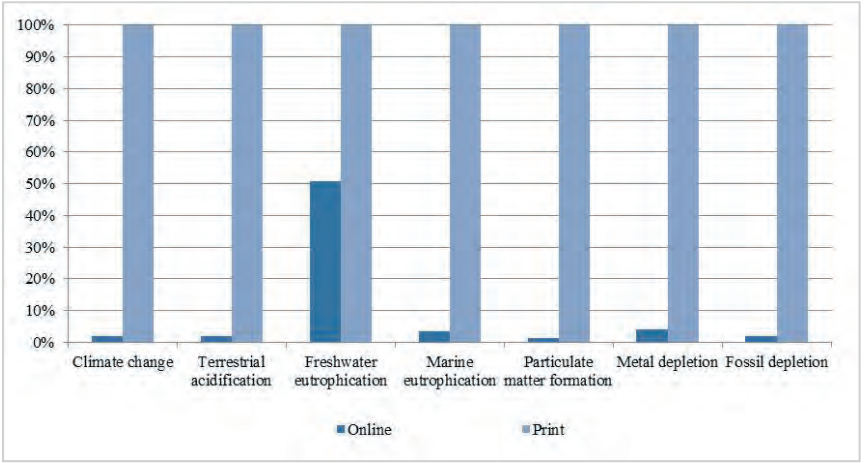

Figure 10: Environmental impact potential of Aamulehti.fi and printed Aamulehti *(including supplement), per reader and week. The printed version set to 100%. The total reading time per reader and week is 245 min for printed* Aamulehti *and 6 min for Aamulehti.fi with downloads of 2 MB/week per reader*

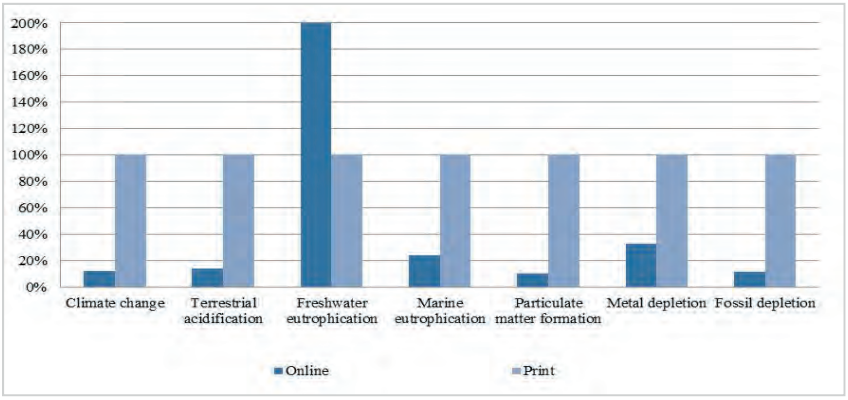

Figure 11: Environmental impact potential of Iltalehti.fi and printed Iltalehti*, per reader and week. The printed version set to 100 %. The total reading time per reader and week 138 min is for printed* Iltalehti *and 9 min for Iltalehti.fi with downloads of 100 MB/week*

When the environmental impacts of online and printed versions were compared in relation to the functional unit of one reading hour, the results were quite different (Figures 12 and 13).

For Aamulehti, the online version had a higher impact in three of the seven categories. For Iltalehti, the online version had a higher impact in all categories assessed. The difference in results was due to the fact that the reading time of printed copies does not influence the total environmental impacts, as the use phase is not related to any emissions or resource use in the system assessed. On the contrary, the online newspapers get increasing total impacts the longer they are read. For the newspapers studied here, the reading time was much higher for the printed versions than for the online versions. When using reading hours as a definition of the function, i.e., benefit provided, this means that the environmental impacts for the printed version were split over a larger benefit than the online version. Thus, this comparison showed a lower relative impact for the printed newspapers.

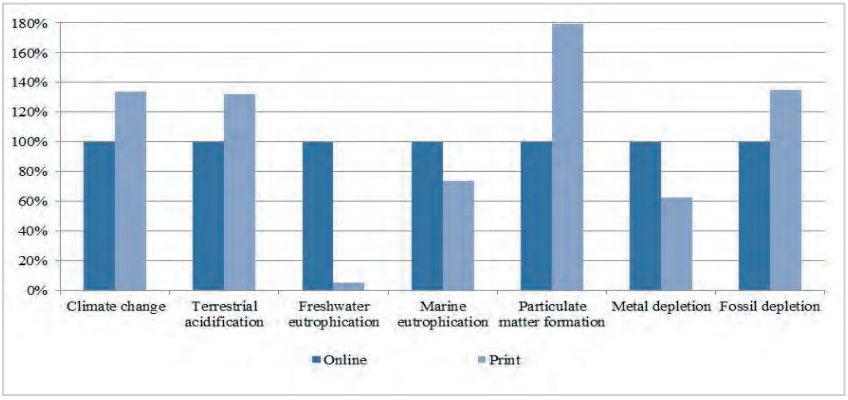

Figure 12: Environmental impact potential of Aamulehti.fi and printed Aamulehti*, per reading hour. The online version is set to 100 %*

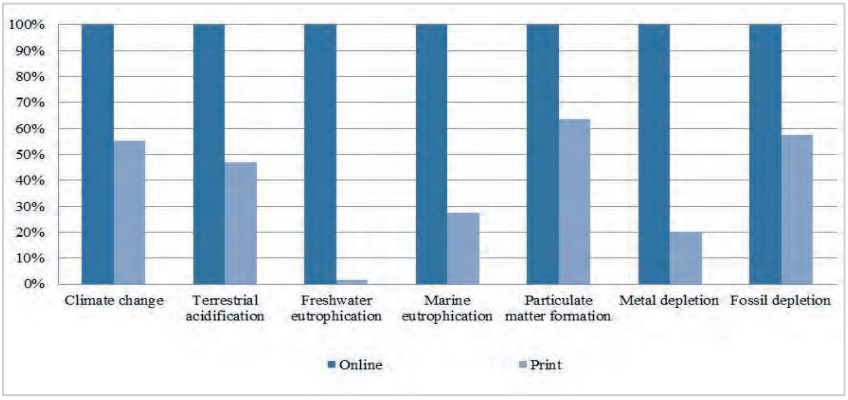

Figure 13: Environmental impact potential of Iltalehti print and online, per reading hour. The online version is set to 100 %

4.3 Sensitivity analyses

Sensitivity analyses were performed for both the printed and online version of the newspapers to test the case study assumptions. Some examples are presented here, for more examples and details see Hohenthal et al. (2013).

For printed newspapers, in the sensitivity analyses where paper waste was considered a raw material for insulation manufacturing, the environmental impacts were on average around 10% lower than in the reference case (Figure 14). The reason was that around 8% of embodied environmental burdens were allocated to the paper waste used as raw material for another product.

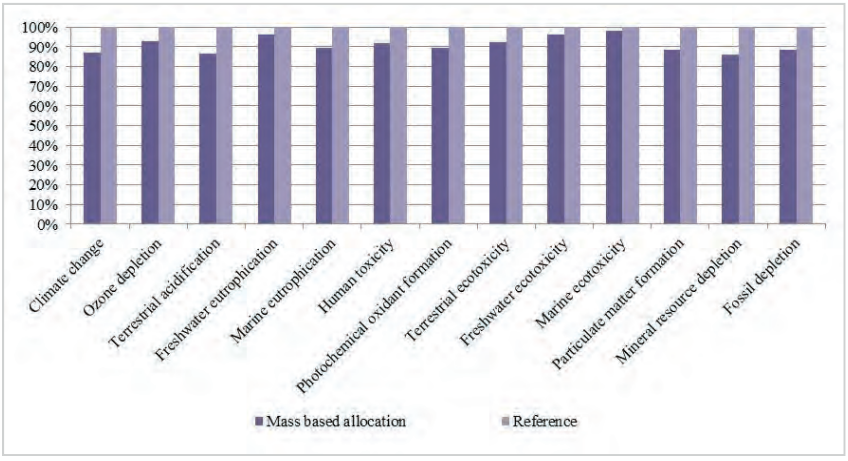

Figure 14: Sensitivity analyses for printed Aamulehti*: reference case and mass based allocation. The reference case is set to 100%*

For online newspapers, the importance of device life span and device overall use was tested. As the results presented in Figure 15 clearly illustrate, these two parameters were critical for the overall online newspaper environmental impact. The shorter the life span of the device used for reading the newspaper, the higher the share of impact from its manufacturing in the impact from online newspaper reading. In contrast, the higher the total overall use of a device, the lower the share of manufacturing allocated to newspaper reading. This emphasises the importance of user parameters and of the efficient and multifunctional use of electronic devices.

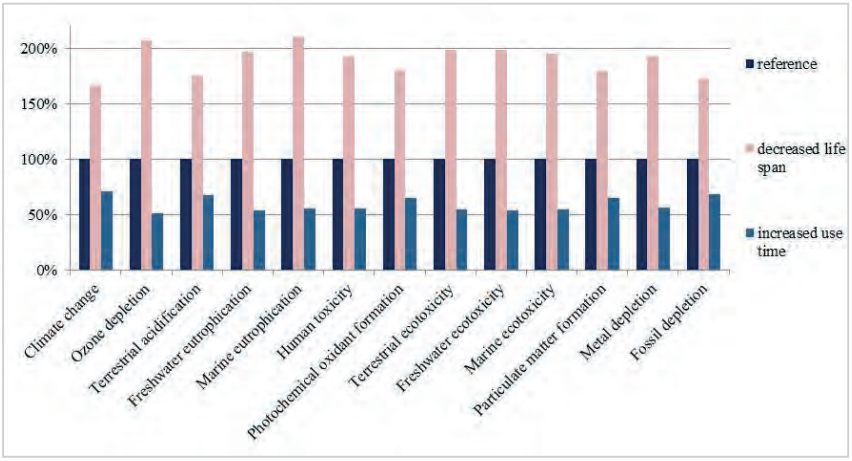

Figure 15: Sensitivity analyses for Iltalehti.fi: reference case, decreased life span of the user device, increased use time of the user device. The reference case is set to 100%

The data used here for electricity production had some limitations, e.g., by not covering all emissions. In addition, the electricity mix differs from country to country and thus impacts from reading the same online newspaper can be different in different countries. This was tested in sensitivity analyses using Ecoinvent 2.0 data for Finnish electricity and UCTE electricity (Figure 16). As can be observed from Figure 16, the difference in the results can be rather large due to differences in data used and electricity mixes considered. The UCTE electricity mix has coal as the dominant source, while in the Finnish electricity mix (year 2004, Ecoinvent 2.0) nuclear power dominates (23%), followed closely by coal (16%). The Finnish 5-year average mix (EcoData) con-

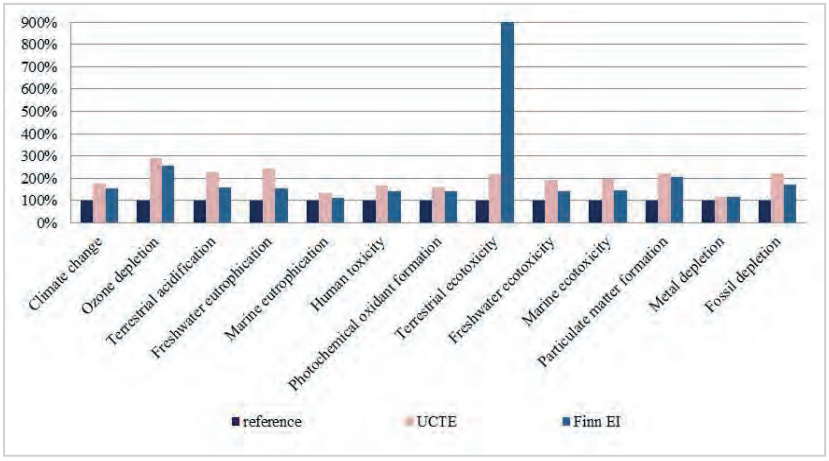

Figure 16: Sensitivity analyses for Iltalehti.fi: reference case (Finnish 5-year average electricity 2005-2009, EcoData), UCTE (year 2004, Ecoinvent 2.0), Finn EI (Finnish electricity, year 2004, Ecoinvent 2.0). The reference case is set to 100 %

sisted of 30 % nuclear power and 18 % hydropower and other sources (Appendix A). The differences between the impacts from Finnish electricity mixes from Ecoinvent 2.0 and from EcoData were rather large (see Appendix E). This especially concerned impact categories such as ozone depletion, freshwater eutrophication, human toxicity, terrestrial, freshwater and marine ecotoxicity, and metal depletion. However, the emissions in some of these impact categories were very low and therefore did not greatly affect the overall results. Very high differences between the use of the two Finnish electricity mix datasets were observed for ozone depletion, terrestrial ecotoxicity and particulate matter formation. Ozone depletion is affected mainly by electricity production from natural gas, i.e., gas transportation through pipelines. The high impact from the Finnish electricity mix (Ecoinvent 2.0) in the terrestrial ecotoxicity and particulate matter formation impact categories was the result of a rather large share (10 %) of energy generated from wood. With our data set, terrestrial ecotoxicity was affected due to ash disposal in agriculture (mainly short-term emissions). The difference may also seem large due to the terrestrial ecotoxicity impact from the reference scenario being rather low, and thus the relative difference becomes large. It should be kept in mind that all the results are presented in relation to a reference case set to 100 % and should not be compared between the impact categories.

The calculations also showed that when the electricity mixes in the sensitivity analysis were used, the electricity used for reading had a much higher share of the overall impacts (see Appendix F and G) than in the reference case.

5. Discussion

5.1 Content production

This life cycle assessment of printed and online newspapers from Alma Media indicated that content production may be an activity with a considerable contribution to the overall environmental impact of the newspaper product system in some impact categories. In the assessment, content production was covered in more detail than in previous LCAs of newspapers, which may be the reason for this result. In the special case of the Aamulehti.fi online newspaper, where there are few readers between which to split the environmental impacts resulting from content production, the relative impact was notable. Furthermore, since these readers do not spend much time on reading the content produced and do not download information to any extent, the share of the content production impact in relation to other parts of the product system (i.e., online distribution, reading and computers) was larger. This was highlighted when comparing the results for Aamulehti.fi with Iltalehti.fi, where the latter has more readers, longer reading times and more data downloaded per reader. The share of the overall environmental impacts of Iltalehti.fi was higher for online distribution and user electricity consumption instead.

For the printed newspaper versions, the content production was shown to have a varying share of the impact in the different impact categories (from only a few per cent up to 40-75 % in some impact categories), in which electronic equipment appeared to be the major cause of the impact from content production.

According to the results of the assessment presented here, the key areas to address in content production are electronic equipment, business trips, electricity and district heating. The shares of these vary among the impact categories, and also slightly between newspapers.

For example, for Aamulehti content production the major reason for climate change appeared to be business trips, contributing some 42% to the climate change potential. For Iltalehti, business trips, electricity and heating contributed almost equally (about 25-30% each) to the climate change potential. Electronic equipment was the major reason for several types of impacts (freshwater and marine eutrophication, human toxicity, terrestrial, freshwater and marine eutrophication and metal depletion) for both newspapers. The reason for the environmental impact from electronic equipment was mainly gold mining for the production of integrated circuits for PWB used in LCD screens and desktops. The cause for the environmental impact of business trips was mainly car trips, followed by airplane flights. The environmental impact from electricity and district heating production was caused mainly by fossil fuel combustion due to rather a high content of coal in the electricity and district heating used in Iltalehti's offices (15 and 40%, respectively). The district heating used in Aamulehti offices does not use coal and is thus cleaner.

Assumptions on how to allocate the impacts related to content production between printed and online version can be discussed. Online newspapers obtain rather much information from the content of printed newspaper, which we have tried to account for. However, exactly how this is shared is not known and thus the environmental impacts related to content production could be slightly lower or higher for the online and printed versions. What has been shown is that content production cannot in general be neglected when assessing media products.

The environmental impact from content production might look different in the case of producing only printed or only online newspapers. Then the total impact would probably be higher, since there is no opportunity to split some activities between two different media products.

This implies that considerations regarding content production should be made. For example, the number of business trips and the transport means used for these could be reconsidered to lower the impact on climate change and several other impact categories. The office equipment purchased should be considered from an environmental point of view, in order to lower the impact on metal depletion, human toxicity, freshwater and terrestrial toxicity and others. The choice of electricity and district heating sources should not be neglected either, since these have a significant impact in several impact categories.

5.2 Printed newspapers

The results justify efforts for more efficient raw material production and use (paper, ink and printing plates) in order to gain environmental improvements. Furthermore, improvement potential was found in relation to content production, as mentioned above. In addition to the resource efficiency considerations, the sensitivity analyses of mass based allocation showed the importance of a print manufacturer considering the utilisation aspects of secondary material flows (e.g., paper waste and recycled paper).

Those partners and suppliers in the value chain who can provide environmental performance information on their products (e.g., information such as a well-managed supply chain, certified products, eco labels, environmental product declarations, etc.) are valuable. Nowadays, paper producers can obtain third-party environmental certifications and labels to provide and communicate the environmental quality of products, support their customers in their choices and provide information for stakeholders. Furthermore, the more readers per printed newspaper copy and the more readers who choose to recycle their newspaper instead of letting it end up in landfill are clearly significant in decreasing the environmental impacts. Actual practice in recycling printed products is at high level (around 80%) in Finland, which has an influence on lowering the relative impact of end-of-life.

5.3 Online newspapers

Manufacturing of computers and display screens was the major contributor to the overall impact of the online newspapers. This life cycle stage includes extraction of raw materials, production and assembly of electronic devices, their transportation to the reader and end-of-life disposal. All impacts related to these processes were allocated to the environmental impact of the online newspaper based on the share of overall use time, i.e., the time for reading the online newspaper related to the total time for active use of the device. This means that more intensive overall use and longer service life of a device will result in an overall lower impact per hour of active use and therefore a lower impact allocated to the online newspaper reading. Consequently, different readers will have considerably different environmental impacts depending on their practice regarding the use of computers in general, in addition to the differences related to their different newspaper reading practices. Overall active use of the devices in this study was based on statistics and assumptions aiming to represent an average user. The limitations in the electricity data and the rather old data from Ecoinvent concerning personal computers and laptops might have had an effect on showing the user device as being the main reason for online newspaper impact. As shown and discussed in the sensitivity analyses, the overall impact from online newspaper reading and the share of electricity may increase with the use of another dataset for electricity due to differences in the mix considered and data used. As discussed in Arushanyan (2013), different studies often end

up with different conclusions regarding which life cycle stage - manufacturing or use - has the highest impact for ICT products. The sensitivity of the results to the user pattern assumed, the electricity mix chosen and the system boundaries is emphasised.

The overall conclusion that the manufacturing of electronic equipment for reading is a major cause of the overall impacts of online news can be regarded as a valid conclusion for this study. However, with the current increasing use of smaller devices with lower power draw, such as tablets and smartphones, this pattern may change (Ahmadi Achachlouei, 2013). This, in combination with a continuous decrease in electricity use per MB of data transmitted, may well lead to a future higher share for content production in the overall environmental impact related to electronic media solutions. However, the service life of new devices will still be a crucial factor. The longer the life span of the user device for reading the newspaper, the lower is the share of the impact from its manufacturing for each use.

5.4 Limitations

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

As the data source for the manufacturing of computers, screens and their components was rather old (2002-2004), the absolute figures presented here are uncertain, but the importance of the electronic devices is illustrated. It would have been valuable to test these data in a sensitivity analysis using newer data for computers. Long-term emissions contribute considerably to online newspaper potential impacts in certain impact categories. As shown here, this is due to emissions related to the extraction of resources needed to manufacture the electronic devices, e.g., gold, but also 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 further considered.

The problem of old data also occurred when considering ink production. The dataset from Ecoinvent 2.0 used to represent ink production contains some old (1992) data for raw oil production, which involves the use of halons. Due to this, the potential environmental impact on ozone depletion coming from ink production may be overestimated.

The emissions from the electricity use accounted for in the reference scenario seem to be limited, as the sensitivity analysis indicated major differences for several impact categories in comparison with the more generic Finnish electricity mix provided by Ecoinvent 2.0. However, EcoData (2005-2009) covers electricity production in combined heat and power (CHP) plants in Finland, while Ecoinvent data (2004) do not cover this technology and thus do not represent actual Finnish electricity production in a good way. Due to this, the impacts can be assumed to be intermediate.

5.5 Comparison

Even though comparisons between print and online versions are not straightforward, an attempt was made to do so here. It may well be that the printed and online versions studied are not likely to replace each other, but rather complement each other. Still, it may be of interest to learn more about the differences when it comes to environmental performance.

In this comparison, the choice of functional unit proved crucial. Here, the "per reading hour" functional unit attempted to give a functionality comparison, showing the impact of obtaining approximately the same amount of information from different types of platforms based on reading time. The "per reader and week" functional unit attempted more to reflect the access to the newspaper, so with this functional unit the actual use of the newspapers by the one reader is not reflected, but the function is the access as such.

The overall results indicated that the number of readers as well as the total reading time was central when relating the environmental impacts to functional units where the attempt was to cover the benefit of the media products. The number of readers differs substantially. For the printed versions it is 2.3 readers/copy (*Aamulehti*) and 5.6 readers/copy (*Iltalehti*). For the online versions the number of readers per week also varies considerably, being about 240 000 for Aamulehti.fi and almost 1.8 million for Iltalehti.fi. The number of readers affected the share of content production allocated to the impact of each reader. The absolute environmental impact resulting from overall newspaper production and consumption was of course also affected by the number of readers through the overall impact from paper manufacturing, printing and transportation of the printed newspaper, and by the impact from online distribution and the overall impact from the users' devices and electricity consumption for reading for the online newspaper.

There were also considerable differences in reading time per reader. Between the two printed and two online newspapers studied, this difference was almost twofold. The difference between online and printed versions of the same newspaper was huge, however. For copies of the printed versions the average reading time is around 2-4 hours per reader each week, whereas the online versions are read only 6-11 minutes per reader each week.

This is a good illustration of the difference in the function provided by these different media products. Even when users have access to the online newspaper and do read it, it is on average for a much shorter time than if the users were reading the printed newspaper. Readers use media products in a different way and most likely for different purposes.

It should be noted that the number of readers per copy as well as the reading time for the printed versions are based on surveys and may be rather uncertain. Variations in these figures were not tested within the study. Increased knowledge of different user practices related to media could offer valuable information for future assessments. Furthermore, the user practices are most likely to change, especially with new devices and product formats. The user practices are the key to the resulting environmental performance.

The sensitivity analyses indicated that a change to mass-based allocation in the printed newspapers system would not affect the comparison much, since the difference in the results for the printed newspaper product systems was up to about 12%. However, different assumptions on device life span or total overall use of the devices and different choice of electricity mix in the online newspapers systems may lead to changes in the overall comparative results in the case of *Aamulehti* and Aamulehti.fi when compared per reading hour. With even larger decreases in life span or increase in overall use other results may also be affected, which is truly a key issue for the comparative results.

6. Conclusions

For printed newspapers, key processes in the supply chain giving rise to environmental impacts are newsprint paper production (including raw materials, purchased energy and mill operations), production of ink and plates and content production. Distribution of the newspapers to offices, retailers and homes is another important contributor to climate change impact.

For online newspapers, the manufacturing of the laptops, desktop computers and screens used for reading is a key factor regarding overall environmental impacts. Electricity use for reading can be an important contributor to the overall impact depending on the geographical location (i.e., the electricity mix) and data used. Content production can also be a major contributor to the overall environmental impact where there are few online readers between whom to split the associated impacts. When the amount of information downloaded from the online newspaper website is large, online distribution can contribute a considerable share of the environmental impacts. Thus, the relative importance of different parts of the life cycle to the overall environmental performance of online newspapers varies depending on the number of readers, reader practices and the electricity type used.

This environmental assessment indicated that the environmental impacts related to content production may be relevant for both newspaper versions, particularly as the environmental performance of other parts of the life cycle, e.g., manufacturing and use of electronic devices, and printing, improves.

If more electronic media products with a small number of readers are introduced on the market, content production may become a more crucial part of media product overall environmental impacts. This is also dependent on the development of the content production, its processes and activities, e.g., number of business trips, type of energy purchased and types of equipment and how it is used.

The comparative results are highly dependent on number of readers per copy and reading time, so when comparing the environmental performance of printed and online media, the functional unit is of crucial importance.

Since printed and online newspapers are used in different ways and might even serve different purposes, the comparison is not straightforward and it is important to find a functional unit to reflect that.

7. Recommendations

Considering environmental impacts using life cycle perspective collaboration with stakeholders in the value chain will always be a crucial activity in improvement activities. Media companies need to take actions in their supply chains; collaborating with printing houses and pulp and paper makers, as well as other actors, e.g., in distribution.

In the case of online media products, the production and waste management of readers' electronic devices, the platforms for the online newspapers, will lead to a range of new important actors for collaboration. It can be assumed that actions for improvement related to the online newspaper will differ to some extent from those related to the printed newspapers, as the supply chain is not directly connected to the media company, but to its customers. In some cases, however, these supply chain stakeholders are part of the supply chain providing electronic devices for media content production, or handling the disposal of these. The manufacturing of devices

and their components is a complex process and much of it takes place in other countries. This is a new challenge for media companies, as new stakeholders are entering the media product life cycles. The readers are the key players when it comes to the resulting overall environmental impact of electronic media products.

Actions also need to be taken inhouse; reducing the environmental impact of content production through rethinking business trips, introducing energy-efficiency solutions, using cleaner energy sources, putting environmental demands in procurement of electronic devices and extending their service life. There is an environmental improvement potential within content production, but notably also related to readers' practices, e.g., choice of electronic equipment and use thereof. Media companies have a unique opportunity to act on environmental improvement by providing information, both of generic type and clearly aimed at their own products and readers, e.g., by providing concrete information on the environmental impact of different practices related to media use and in the way the reader interface is designed to communicate this. Furthermore, collaboration with suppliers should be established in order to facilitate the availability and transparency of data on environmental impacts. This would make environmental assessment easier to perform and actions to improve environmental performance more easy to target and follow up.

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Appendix A. Electricity and heat mixes

	Electricity, Finland, 5-year average	Heat, Finland, 5-year average	Heat, Helsingin Energia, 2008	Heat, Tampereen sähkölaitos, 2008
Coal [%]	15.4	17.6	40	-
Peat [%]	7.4	16.5	-	21.8
Oil [%]	0.6	6.8	7	4
Gas [%]	14.3	24.6	51	66.2
Biomass [%]	12.5	26.5	-	8
Waste [%]	0.6	2	-	-
Nuclear [%]	30.3	-	-	-
Hydropower [%]	18.1	-	-	-
Wind [%]	0.3	-	-	-
Geothermal [%]	-	0.2	-	-
Other sources [%]	0.6	5.9	2*	-

*Heat pumps

Appendix B. Content production

Description of data and Limitations	References
Sub-system: Electronic equipment *(manufacturing, incl. raw materials acquisition and end-of-life treatment, incl. recycling)*	
Manufacturing and end-of-life treatment of all the electronic equipment used for the office work: desktop, laptop, LCD screen, mouse, keyboard, mobile phone, TV set, printer, scanner, copy machine. Stationary phones and faxes are not included, but considered to be minor issues. Tablets not included due to lack of data. For mobile phones and TV sets, only a limited number of emissions are included. Generic data for manufacturing of desktops, laptops and screens are from 2002-2004 and thus the impacts may be different in current production. High uncertainties regarding environmental impacts resulting from end-of-life treatment.	Alma Media Hischier et al., 2007a Hischier et al., 2007b
Sub-system: Office materials *(office paper and toner: production and end-of-life)*	
Manufacturing of wood-free uncoated paper, including forestry. Manufacturing of toner and cartridge. Toner and paper transportation to the regional storage. End-of-life treatment, including recycling for paper and the avoided virgin production Stationery not included.	Alma Media Hischier et al., 2007c Hischier, 2007
Sub-system: Business trips *(car, train, airplane)*	
Vehicles: operation of private cars (petrol and diesel), including fuel production. Operation of planes for various types of trips, including fuel production. Operation of train, including electricity production No data on production and maintenance of vehicles and infrastructure such as roads and rail. Limitations on emissions covered for operation emissions and emissions from fuel production. No data on public transport. Not considering travel from home to office and back. Data used are for average Finnish conditions.	Alma Media LIPASTO, 2010 Jungbluth, 2007
Sub-system: Deliveries *(mail, delivery of office materials and electronic equipment)*	
Operation of vehicles for delivery of mail. Vehicle operation and fuel production for freight ship, lorry and freight air plane for deliveries to the office. No data on production and maintenance of vehicles and infrastructure such as roads and rail. For mail, no data on fuel production.	Alma Media LIPASTO, 2010 Itella, 2011 World airport codes, 2011 Sea route&distance, 2011
Sub-system: Electricity and heat	
Electricity and heat production including production of fuel. Electricity: Finnish average (2005-2009) District heating: Helsingin Energia, Tamperen Sähkölaitos. For fuel mixes see Appendix A.	EcoData (Pihkola et al., 2010b) Dones et al., 2007 Helsingin Energia, 2008 Tamperen Sähkölaitos, 2008

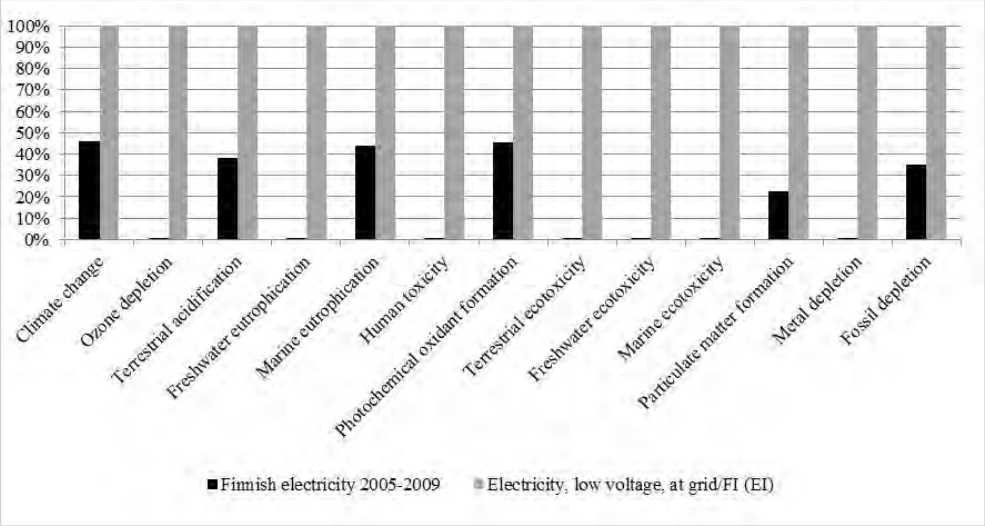
Appendix C. Printed newspaper

Description of data and Limitations	References
Sub-system: Fibre supply	
Harvesting, sawmills, fuel and energy supply in harvesting and sawmills.	EcoData (Pihkola et al., 2010b)
Sub-system: Paper and paper mill	
Direct emissions from pulp and paper mills. Limited number of emissions, e.g., no metals. Production of grid electricity purchased for pulp and paper mills. Manufacturing of fillers and fuels at pulp and paper mills.	UPM (Juntunen, 2012) EcoData (Pihkola et al., 2010b)
Sub-system: Content production	
See Appendix B	Appendix B
Sub-system: Printing	
Direct emissions from printing sites. Production of heat and grid electricity used at printing houses. Manufacturing of printing ink and printing plates.	Alma Media EcoData (Pihkola et al., 2010b) Ecoinvent, EAA, manufacturer's data
Sub-system: Delivery to customer	
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. Limitations on emissions covered for operation emissions and emissions from fuel production. Data used are for average Finnish conditions. Transportation of newspapers from retailers to homes (e.g., for *Iltalehti*) excluded. Distribution of *Aamulehti* only cover few emissions and only for operation.	Alma Media/Itella, 2011 LIPASTO, 2010
Sub-system: 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. Limitations on emissions covered for operation emissions and emissions from fuel production. Data used are for average Finnish conditions.	UPM/Alma Media/ EcoData LIPASTO
Sub-system: End-of-life	
79 % recycling; 16 % landfill; 5 % incineration	Pihkola et al., 2010b

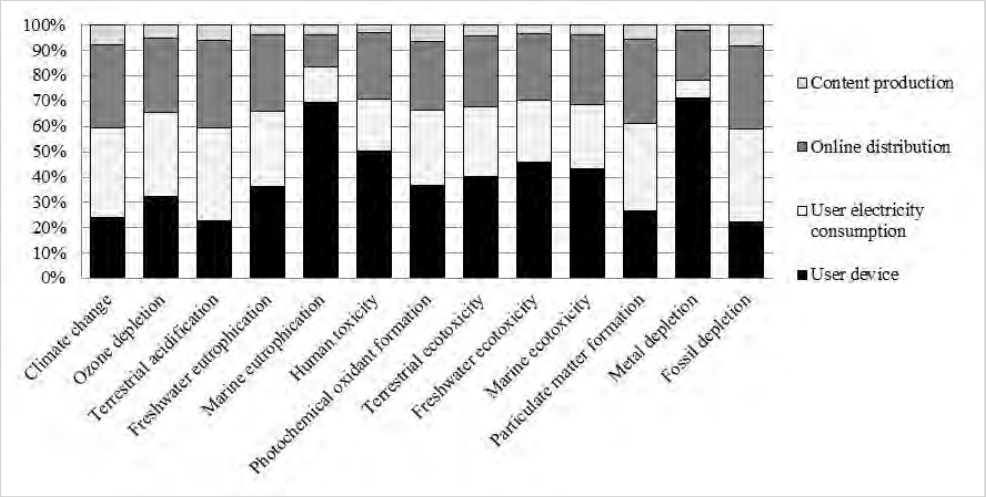
Appendix D Online newspaper

Description of data and Limitations	References
Sub-system: servers for online distribution	
Alma Media servers 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. Manufacturing of servers assumed to equal the manufacturing of 2 desktop computers.	Alma Media LIPASTO, 2010 World airport codes, 2011 Sea route&distance, 2011 Hischier et al., 2007a Hischier et al., 2007b Google maps, 2011 TNS Gallup, 2010
Sub-system: internet infrastructure	
Internet infrastructure operation: Electricity consumption by the IP access networks and transmission in core network. Raw materials used for cable manufacturing but no manufacturing itself, maintenance. Swedish data used, might mean a slight underestimation on electricity use per MB data transmitted. No data on manufacturing of the network parts (e.g. routers).	Alma Media Lundén, 2011 Malmodin, 2011
Sub-system: Reading	
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. 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 2002-2004 and thus the impacts may be different in current production. High uncertainties regarding environmental impacts resulting from end-of-life treatment. Assumptions regarding use patterns (overall device use) will inherently lead to uncertainty. This was tested in the sensitivity analysis.	Alma Media Melkas, 2011 LIPASTO World airport codes, 2011 Sea route&distance, 2011 Google maps, 2011 Hischier et al., 2007a Hischier et al., 2007b IVF, 2007 TNS Gallup, 2010

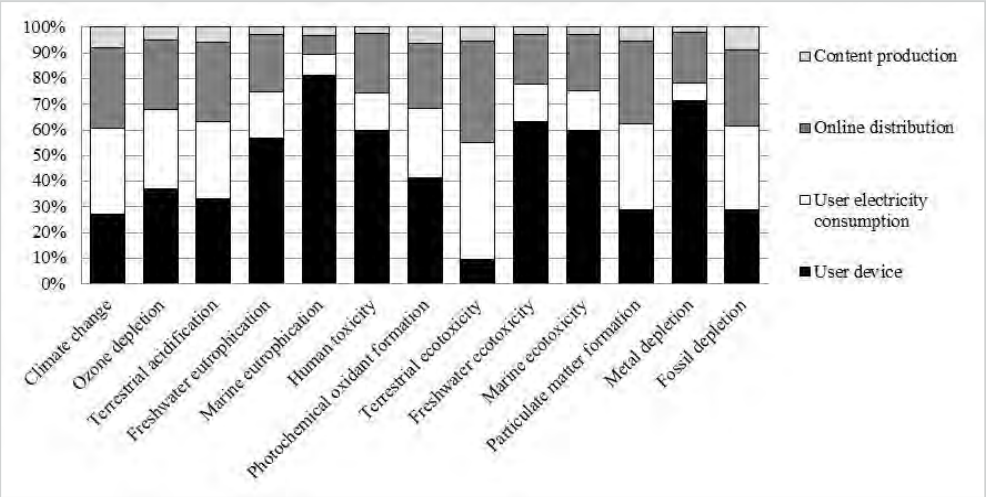
Appendix E. Comparison of Finnish electricity mix 2005-2009 (EcoData) to Finnish electricity mix (Ecoinvent)



Appendix F. Environmental impact potential of Iltalehti.fi, per year, with UCTE electricity mix. Percentage share of lifecycle stages



Appendix G. Environmental impact potential of Iltalehti.fi, per year, with Finnish electricity mix (Ecoinvent). Percentage share of lifecycle stages.



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Usability study of a Finnish digital public library

Olli Nurmi

VTT Technical Research Centre of Finland
P. O. Box 1000, FIN-02044 VTT
Espoo, Finland

E-mail: olli.nurmi@vtt.fi

Abstract

This research paper deals with the usability of a digital public library service. In public libraries, the customer base is far more heterogeneous and the usage patterns more diverse than in academic libraries, that have been the focus of many earlier usability studies. Typically, the users of academic libraries are seeking new knowledge and the user interface is designed to allow the efficient discovery of resources. In public libraries, users do not only have a utilitarian view of reading as a learning tool, but they also read for pleasure.

This paper specifies the user interface of a digital library service for public libraries and measures the usability and general user experience of the service. A digital library system was built according to the derived specifications. The usability measurement tool was developed according to the Nielsen usability framework. A digital collection of Finnish eBooks was made available for Helsinki Metropolian Area library users for a test period and usability was measured by web questionnaire.

The usability of online and offline reading modes were compared. The results show some differences in book lending and reading but no differences on returning loaned digital books.

This study shows that Nielsen's usability framework can be used to measure the usability of a digital public library. Mostly positive feedback was received and a majority of the users were also willing to recommend the service to their friends.

Keywords: digital public library, eBooks, Nielsen's usability framework, user experience, online and offline reading

1. Introduction

Public libraries are in the front line of the unresolved relationship situation between book publishers, eBook vendors and libraries. The demand for eBooks is escalating, and library users expect seamless access to eBooks using mobile devices both offline and online. However, pricing, restrictions on access, digital rights management and a multitude of formats and devices present challenges to public libraries.

The work described in this paper deals with a digital library system, eBib, developed for the Helsinki Metropolitan Area Libraries in Helsinki, Finland. Our purpose was to study the user experience of eBib and compare the lending, reading and returning options of book streaming and two types of offline reading software. In this project it was possible, for the first time, to obtain a reasonable collection of popular Finnish literature in ePub-format for the large-scale public library network operating in the Helsinki metropolitan area.

The eBib library system was designed to be compatible with the widest possible range of devices. When designing the user interface, special attention was paid to tablet users and the wide customer base of the public library with diverse computer skills. User feedback was gathered by a web questionnaire. Library users were asked to evaluate the overall system and the lending, reading and returning functions of two offline reading software programs: Adobe Digital Editions (Adobe, 2014) and Bluefire Reader (Bluefire Productions, 2014) and a book streaming software developed specially for eBib.

2. Public libraries in Finland and the reading motivation of their users

In 2011, there was 836 public libraries in Finland which equates to 1.5 libraries per 10 000 population, compared with an average across the 17 EU countries of 1.3 libraries per 10 000 population. Finland is known for its comprehensive library network, high user and lending rates and effective use of ICT technology and infor-

mation networks in libraries. Both public and research libraries are open to all. No fee is charged for borrowing or for the use of the collections of the library (Quick et al., 2013).

In Finland, library and information services promote equal access to education and culture, reading and art appreciation, a constant development of knowledge, skills and citizenship skills, internationalization and life-long learning.

The HelMET network (Helsinki Metropolitan Area Libraries) consists of the city libraries of Helsinki, Espoo, Kauniainen and Vantaa. Staffed by 900 library and media professionals, HelMET circulates nearly 17 million items a year, and provides 64 libraries and six bookmobiles to the metropolitan community. The HelMET Web library (www.helmet.fi) is the most frequently used library web site in Finland. HelMet is actively developing new electronic services for its library users (Helmet, 2014).

Libraries play an essential role in introducing eBooks to users. Finland's extremely high library utilisation rate makes it an excellent testing laboratory for eBooks. Libraries also play a key role as book buyers, purchasing 20% of Finnish fiction for adults (Tuulinemi et al., 2013).

The users of public libraries read for different purposes. Sometimes they read for pleasure, sometimes for learning. Their reasons for reading impact on the way they read and determine which kind of user interface functions that are relevant to them.

Reading can be divided into two: reading for pleasure and reading for some purpose. The latter is a goal-oriented activity; this "active reading" refers to a set of strategies for engaging with written material and is "the combination of reading with critical thinking and learning, and involves not just reading per se, but also underlining, highlighting, and commenting" (Adler and Doren, 1967). Nell (1988) defines pleasure reading as a form of play which is performed for its own sake. It allows us to experience other worlds and roles in our imagination.

While active reading can be performed with texts chosen for pleasure (e.g., a novel) it is often performed with a particular goal in mind. Adler et al. (Adler and Doren, 1967; Adler et al., 1998) identify four kinds of reading goals that they observed in the workplace: extracting information, integrating information, consistency checking, and critiquing or making a comment. For example, a researcher might read hundreds of papers and synthesize them into a literature review. Achieving these goals often involves working with others.

Nell (1988) constructed a model for explaining reading behaviour that determines the reading frequency. The model identifies reading attitude, social norms and reading proficiency as factors affecting reading frequency.

The reading attitude can be viewed as a multi-dimensional construct related to the consequences derived from reading. Broeder, Stokmans and Wang (2012) distinguish four attitude functions that are relevant also to reading fiction:

1. Pleasure function: reading is a pleasant activity because the reader amuses him/herself.
2. Empathy function: reading is a pleasant activity because the reader can dive into the story. One can enter another world, sympathize with the main character in the story and experience adventure.
3. Development function: this function relates to the value placed on reading in order to gain an insight into oneself, others, and/or life in general. It also incorporates moral aspects.
4. Education function: these consequences relate to the value placed on reading in attaining educational or vocational success for managing one's life.

The first two functions refer to a hedonistic attitude (reading as experience), and the latter two functions refer to a utilitarian attitude (reading as study).

3. Specifications and design of the digital library

Input for the specification of a digital library system was generated in workshops and meetings. Altogether 14 persons, representing the largest book publishers in Finland, metadata and service providers, major public libraries as well as usability and IT experts, attended the work-shops. In the workshops, the metadata and acquisition processes of digital books were modelled by drawing data flow diagrams creating an overview of the system and its process aspects. These diagrams showed what kind of information was input to and output from the system, where the data comes from and goes to, and where the data was stored.

The results of the workshops were elaborated and benchmarked to the OverDrive[1] digital library service. Finally, the specifications were refined by IT and usability experts. The work resulted in the following functional and user interface specifications.

Functional specifications:

1. A digital library should enable an immersive mobile reading experience that is consistent and predictable. The user interface should consist of meaningful tasks

[1] www.overdrive.com

that are relevant to the user and match the user's expectations and reading conventions.
2. Digital library users should be enabled to use the library's interface as an online service with a computer, mobile devices such as smartphones and tablets, and with other devices that have a browser and a network connection.
3. The digital book must vanish after the loan has expired. No copy of the digital book must remain in the user's end device after the loan period.
4. Clear instructions for the user should be provided. The user guidelines must be so clear that only a minimum amount of technical support is needed.
5. The licensing conditions should be clear and simple. The licensing model applied must allow reimbursement of the library license to the copyright holders.
6. The service should give access to an interesting book collection. The book collection should consist of newly published Finnish books that are of genuine interest to the patrons of the HelMET public library.
7. The system should allow both online reading using standard browsers and offline reading with different reading software programs supporting the Adobe DRM scheme.
8. The system should collect statistics about both users and books in order to allow an analysis of the digital library system.
9. An electronic bookshelf should be provided, allowing the user to manage their own loans, make reservations and return an online loan.

Specifications for the user interface:

1. All users should be permitted to search and display catalogue information (including copies available and the number of holds). The information displayed should include book metadata and enrichments such as cover art, summaries and user reviews.
2. The system should provide efficient eBook discovery tools
3. The users should be able to read sample pages also without borrowing the book. The sample should include enriched content where available (e.g., cover art, front matter, table of contents)
4. Authenticated users should be enabled to borrow and return content effectively, to place or cancel holds, to view what they have checked out, and to return items even before they expire.
5. Authenticated users should receive the first available copy of an item in the open ePub or HTML format compatible with most reading devices.

Based on these specifications, a test system was built and integrated into the Millenium library system of HelMET. Adobe DRM with Adobe Content Server (Adobe, 2014) was applied for book downloading for offline reading and a special content server system and a content protection scheme was developed for book streaming and online reading.

These specifications led to two restrictions in reading a digital book. The first was that the browser used for online reading must support HTML5 technology. The second was that the program installed for reading books offline must be compatible with the operating systems of Windows and Apple computers, as well as mobile devices' iOS and Android operating systems, and also support the Adobe DRM scheme.

Since it was estimated that some non-skilled computer users may consider the creation of an Adobe ID for Adobe DRM downloads complicated and somewhat confusing, special attention was paid to the formulation of the instructions for use of the pilot site.

A special effort was made to develop the HTML5 web application allowing the online reading of books. The web application runs on a standard browser and allows seamless reading even during temporary breaks in internet connection. Two consecutive chapters of the book are downloaded into local memory and new material is automatically downloaded whenever the internet connection is restored. Downloaded chapters are segmented and encrypted, so that is practically impossible to restore an unauthorised copy of the book.

Copying or printing of the eBooks was not allowed. However, the library users were allowed to make bookmarks and annotations.

It is essential for the reader to know where they are in the book while reading and how much there is still to read. This requirement was met by offering the reader a slider showing their reading progress and also allowing them to navigate to different places in the book.

Figure 1 shows the concept used to inform the reader of their reading position in the developed web application and in a commercial reading software, Bluefire Reader (Bluefire Productions, 2014). The offline reader, Bluefire Reader, also shows page numbers, but this concept has both technical and semantic challenges in the web application. The number of pages depends, among other things, on font size, page margin, screen size and browser window. Since the book is downloaded by chapters to the browser's local memory, complicated techniques would have to be applied to calculate the total number of pages. For this reason, the page number concept was not applied in the web application developed.

Book publishers Otava and Edita selected the eBooks by their recent production to be included in the library collection. There were 25 books from 15 writers from Otava and 11 books from Edita. HelMET libraries purchased a number of licenses for the books, altogether 490 licenses. The aim was to provide a sufficiently comprehensive selection of fiction, non-fiction, as well as literature for children and young adults.

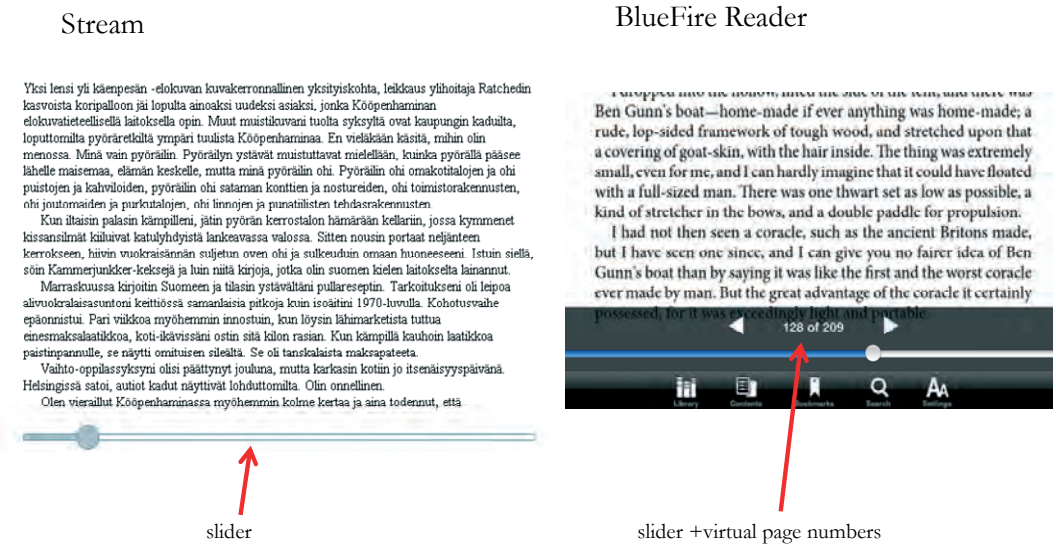

Figure 1: Concept used to show the reading position in the web application (Stream) and in commercial offline reading software (Bluefire Reader)

Estimating the number of licenses was fairly challenging, since experience of eBook lending volumes was still lacking. License quantities were thus estimated on the basis of the loan statistics for printed books.

In order to be able to offer eBooks to as many persons as possible, only one loan at a time was allowed for a single user. The loan period was either one day or seven days, after which the book was automatically returned to the library. It was, naturally, possible to return the book earlier.

The digital library system also included different administrative tools allowing the management of the collection and the gathering of detailed statistics. Linux, Apache, MySQL and PHP were used in the technical platform. The usage of the eBib service was analysed using Google Analytics.

4. Usability evaluation framework

Public services such as digital public library services are aimed at a heterogeneous group of users with varying needs for information and different computer usage skills. Therefore, demanding requirements are made on usability and accessibility.

Usability is a multidimensional construct that can be examined from various perspectives. The International Organization for Standardization (ISO 9241) defines usability as "The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use." (International Standards Office, 1996). According to this standard, measurements of system usability concerns three usability attributes:

1. Effectiveness: How well do the users achieve their goals when using the system?
2. Efficiency: What resources are consumed in order to achieve their goals?
3. Satisfaction: How do the users feel about their use of the system?

This definition includes the following components of usability: the user, his or her task, the equipment and environment that form the context of use and the product and goals that represent the intended outcome of the use. In order to specify or measure usability, it is necessary to identify the goals and to deconstruct usability into effectiveness, efficiency and satisfaction, which are the measures of usability.

Nielsen (1993) writes about a framework of system acceptability, where usability is a part of usefulness and is composed of five attributes: learnability, efficiency, memorability, low error rate and easy error recovery, and satisfaction. Subsequently, many other studies in different areas have mentioned various other attributes of usability. However, the following attributes are commonly applied: effectiveness, efficiency, subjective satisfaction and learnability. Effectiveness is related to the completeness with which users achieve their specified goal, efficiency refers to the resources used in completing a task, and subjective satisfaction refers to positive attitudes towards using the system. Finally, learnability measures how easy it is for casual users to learn a system.

Usability has several aspects, including interface design, functional design, data and metadata, and computer

systems and networks. Usability is a property of the total system. All the components must work together smoothly in order to create an effective and convenient digital library.

Usability of a digital library primarily relates to its accessibility, i.e., how easily users can interact with the interface of the digital library, how easily they can find useful information, how easily they can use the retrieved information, etc. In general, if information can be accessed easily, then the digital library will be frequently used.

The usability of a digital library depends on a number of factors, such as the effectiveness and efficiency of the information access system, the ease of use and friendliness of the user interface, users' needs, usage patterns, etc.

The heterogeneity and distribution of information resources is also a factor. A digital library is a space where users engage with the information infrastructure, and hence usability problems, user attitudes, specific use situations and work practices are of importance.

The method of evaluation and the focus of evaluation depend on the users, their needs and ways of using the product, and their heterogeneous skills in using it. This is especially important in the case of internet services, as internet competence differs greatly between groups and individuals.

Accessibility is also an important concept in an examination of public library internet services. Accessibility means that all services, equipment and information are designed so that they are easy to use despite functional limitations due to the context of use, the device in use or disabilities.

Although researchers are working to develop a common evaluation framework, standardized criteria and methods for digital library evaluation are still unavailable (Chowdhury, Landoni and Gibb, 2006).

Basically, two types of usability evaluation methods have been applied to digital libraries: inspection methods and empirical methods. Inspection methods mainly involve two strategies, a usability expert's judgment and authorized guidelines and principles, whereas empirical methods test digital library systems through an analysis of data on potential or actual users.

Inspection methods include heuristic evaluations, checklists and cognitive walkthroughs, whereas empirical methods include formal usability tests, interviews, focus groups, questionnaires, and other methods (Jeng 2005; Aitta, Kaleva and Kortelainen, 2008).

Earlier research has identified some usability evaluation criteria for digital libraries. Most of this research deals with the usability of academic libraries.

In this context, the items of efficiency and effectiveness dimensions has focused on resource searching, considering that the main purpose of an academic digital library uses lies in resource finding. Thus, most of items in the efficiency and effectiveness dimensions include wordings such as "find", "search task" or "searching resources" (Joo, 2011). This kind of approach is too narrow if applied to public libraries, where the service function of the library is much broader.

Furthermore, in many of the previous studies of internet library services the actual collections have not been available through the internet (Tenopir, 2003). EPub became an official standard of the International Digital Publishing Forum in September 2007 (IDPF, 2014). Therefore, the results of the studies that were carried out before 2007 are in many cases not relevant in cases where the digital books are accessible in ePub format. According to a recent EU study, the core service of 'books to read/borrow' is considered the most important in Finnish public libraries (Quick et al., 2013). This is why the usability testing in this work dealing with digital public libraries places special emphasis on testing and comparing the book borrowing, reading and returning options.

5. Experiments and data collection

The digital library service developed, eBib, was opened to all HelMET customers for a test period between October 15 and December 31, 2012. Users having a valid library card could borrow and read Finnish books using computers, tablets or mobile devices both offline and online. The library collection consisted of 36 books in ePub format, and there were 490 book licences altogether. The usability of the system was assessed by creating an electronic questionnaire based on Nielsen's heuristics. The questionnaire included questions drawn from the identified key measures (see Table 1).

The questionnaire consisted of statements which the respondents were asked to evaluate according to subjective criteria, and the level of agreement or disagreeement was measured using Likert scales. The subjects were asked to rank satisfaction with the system after the first usage session.

In addition, there was a post-test questionnaire that specifically examined satisfaction in the areas of book borrowing, book reading and returning the loan, comparing online reading and offline reading. The users were

Table 1: Usability measurement dimensions and items

Dimension	Item indicator
Efficiency	It was easy to find what I was looking for
Effectiveness	I could use the service the way I wanted to
Satisfaction	It is pleasant to use the service
	The service encouraged me to read more
	It was pleasant to read digital books
	I will continue reading digital books
	I recommend the service to my friends
Learnability	The user guidelines were clear
	It was easy to establish an Adobe user ID
	It was easy to install the reading programs
	It was easy to create a reservation for a book

also asked to compare the issues of user digression and navigation disorientation when faced with different reading options. Demographic data on the users, including gender, age, reading habits, previous experience of digital library services and digital book reading and ownership of a computer, eReader or tablet device were collected through the background information questionnaire.

A diverse range of statistical information related to the use of eBooks was compiled during the trial period. Statistics on eBook use were gathered by title, subject, and user group. Data was also collected regarding the types of devices used by customers for reading eBooks.

Customer feedback was collected through questionnaires, social media, and service addresses. Up-to-date customer feedback meant that, when customers began submitting the same types of feedback, the project was capable of rapidly altering the service in the directions wished for by customers.

6. The library users and use of the system

During the test period, there were 3 146 registered users and roughly half of them actually borrowed a book. Altogether 2 705 loans were made.

Downloading an eBook was the most popular loan method; browser reading accounted for approximately 40 % of the total number.

Many factors, the most important of which proved to be marketing, affected the development of the number of customers. When the service was launched, a substantial number of customers signed up. The number of visitors and loans during the first weeks is shown in Figure 2. A marketing action carried out on November 6, 2012 increased the number of new visitors.

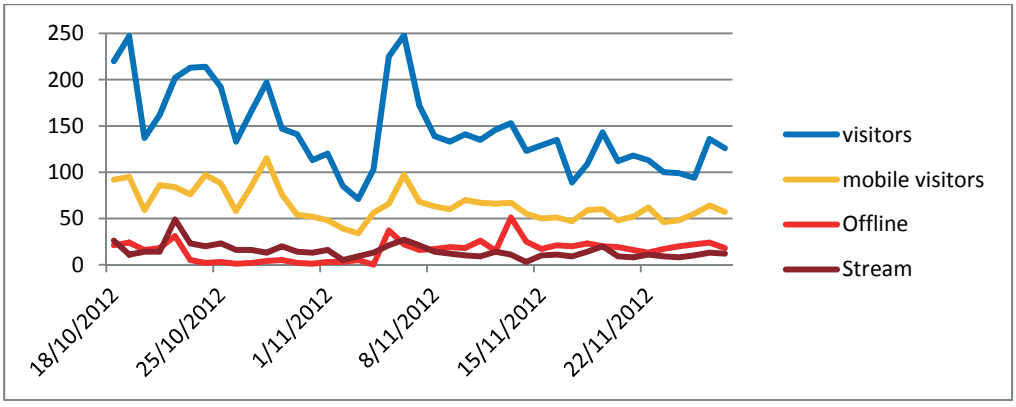

Figure 2: The number of visitors and offline and online loans during the first month of the experiment

Many alternative devices were used to access the eBib library during the trial period. Mobile devices were the most popular, with tablets accounting for more than 50 %. The most popular mobile device was the Apple iPad which was used by 67 % of the mobile visitors. Other mobile devices included the iPhone (10 %) and the Samsung Galaxy Tab (14 %).

Figures 3 and 4 show the age and gender distribution of the users. The largest user group of the digital library was young women. The users, however, included a large variety of age groups and the oldest user was 88 years old. 62 % of the users had already borrowed a book during the previous month. Typically, the users borrow 2-3 books per month. 1 % of the users borrowed over 20 books.

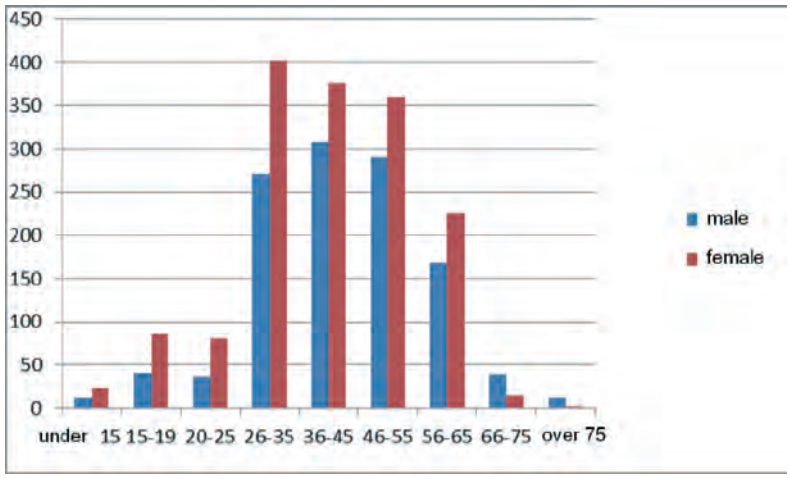

Figure 3: Age and gender distribution of eBib users

The utilisation rate of recent printed books was approximately 95%, but the utilisation rate of eBooks was approximately 47%. However, the rotation of eBooks was faster than that of printed books whose loan period is usually four weeks. Additionally, a printed book is not available after it has been returned during the time it is processed and re-shelved for a new customer. The usage by title in the eBib service followed the pattern of sales by title. Titles that were popular in the eBib service were also popular in print books. When interpreting usage statistics, one needs to remember that the eBib collection was rather limited, consisting only of 36 titles. Because of the restricted number of titles available for users, some users may not have found interesting titles to read.

When eBib user profiles were compared with those of average library customers, it was noticed that young people and children were underrepresented among the eBib users. The eBib library also had relatively more male users than the traditional library. Among traditional library users, the proportional share of women is 62% and 38% for men, but 57% of the eBook borrowers were women and 43% were men.

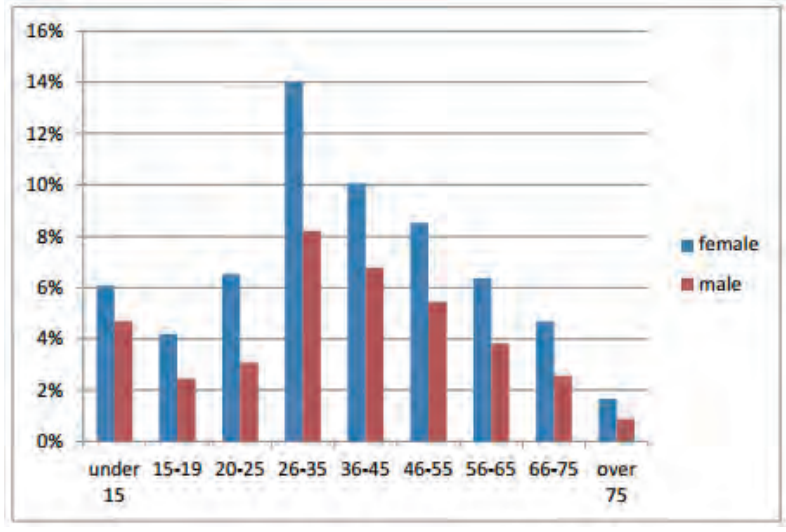

Figure 4: Printed books, customer profile

The usability of the digital library was tested empirically by designing an electronic questionnaire and presenting this questionnaire after the first usage session to the library users. In total, 569 answers were received, amounting to about 40% of those borrowing a book. 55% of the respondents were female. The respondents can be characterised as rather active readers who are used to using the digital services of the library. Almost all of the respondents have a stationary computer or a laptop, 70% have a smartphone, 60% have a tablet but only 16% have an eReader.

The respondents were accustomed to using the internet and to reading digital books, magazines or newspapers.

7. Results and discussion

The user experience of the eBib library system was generally evaluated as being good. The use of the service was felt to be pleasant and to increase the library users' willingness to read digital books. Most of the respondents will continue using eBib also in the future and will also recommend the service to their friends.

The results of the evaluation is shown in Figure 5.

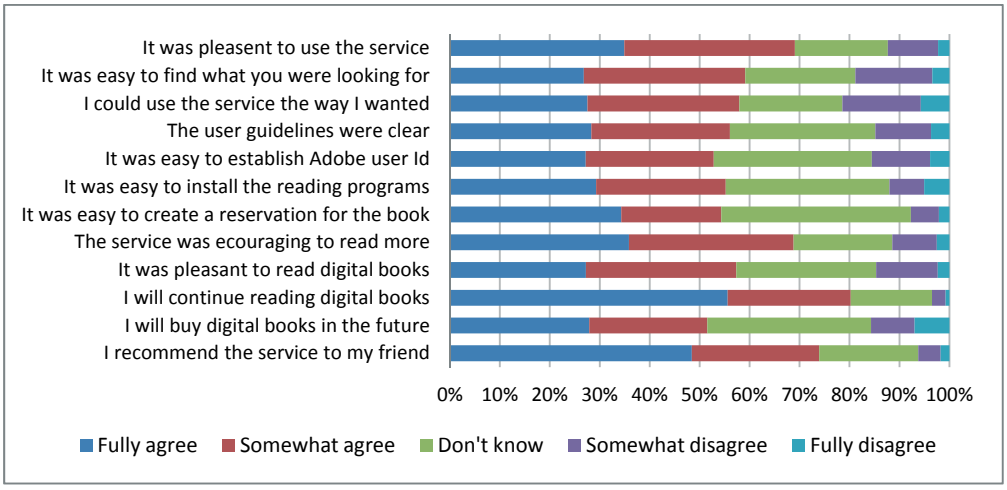

Figure 5: General evaluation of the eBib service

Previous experience of reading digital books had a positive effect on how easy the installation of the necessary offline reading software or the creation of an Adobe ID was considered. Those who felt that the service was encouraging them to read more also answered that they will continue reading digital books or buy digital books in the future. Young readers in particular gave the most positive evaluations of the service.

Fig. 6 shows the evaluation given by different age groups.

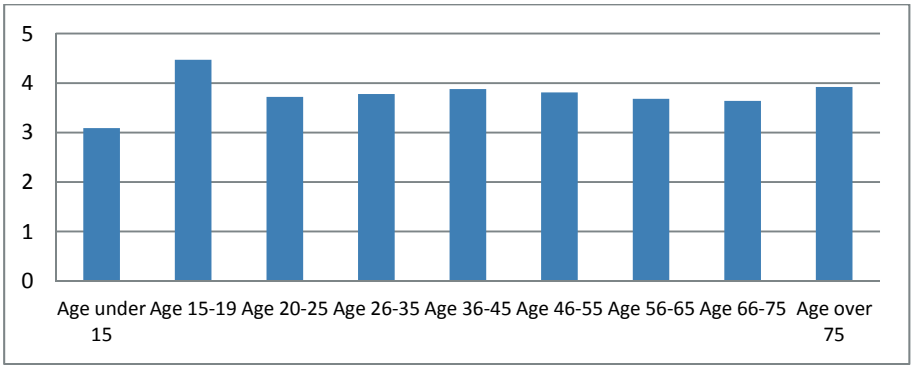

Figure 6: General evaluation (score 1-5) of the eBib service for different age groups

A digital library can also increase the commercial digital book market. The data showed that the intention to buy digital books from commercial books shops increases if the digital library service encouraged users to read more. 65% of those who felt that the system encouraged them to read more intended to buy digital books in the future (Table 2).

Figure 7 shows a comparison of the lending, reading and returning functionalities of book streaming (Stream), Bluefire Reader (BFR) and Adobe Digital Editions (ADE). Book lending was evaluated to be easiest with streaming. However, actual book reading was slightly more difficult with streaming than with ADE and BFR. There can be several reasons for this.

The sense of place is provided in ADE and BFR by page numbers. This option was not possible in book streaming due to technical issues. Instead, a progress bar showing the reader's place in the book was provided, but this turned out to be insufficient. The reading experience of streaming applications could be enhanced by providing a two-page reading view and allowing users change the background colour and side margins.

Table 2: Relationship between how the system encouraged reading and the intention of users to buy digital books

the service encouraged to read more	I intend to buy digital books					Total
	fully disagree	somewhat disagree	don't know	somewhat agree	fully agree	
fully disagree	3	4	3	2	1	13
	23.1 %	30.8 %	23.1%	15.4 %	7.7 %	100.0 %
somewhat disagree	7	7	7	11	14	46
	15.2 %	15.2 %	15.2 %	23.9 %	30.4 %	100.0 %
don't know	11	3	62	8	18	102
	10.8 %	2.9 %	60.8 %	7.8 %	17.6 %	100.0 %
somewhat agree	8	21	51	54	34	168
	4.8 %	12.5 %	30.4 %	32.1 %	20.2 %	100.0 %
fully agree	7	10	46	46	76	185
	3.8 %	5.4 %	24.9 %	24.9 %	41.1 %	100.0 %
Total	36	45	169	121	143	514

A small proportion of respondents regarded book returning as difficult in streaming. This can be improved by adding a response message confirming an accepted book return.

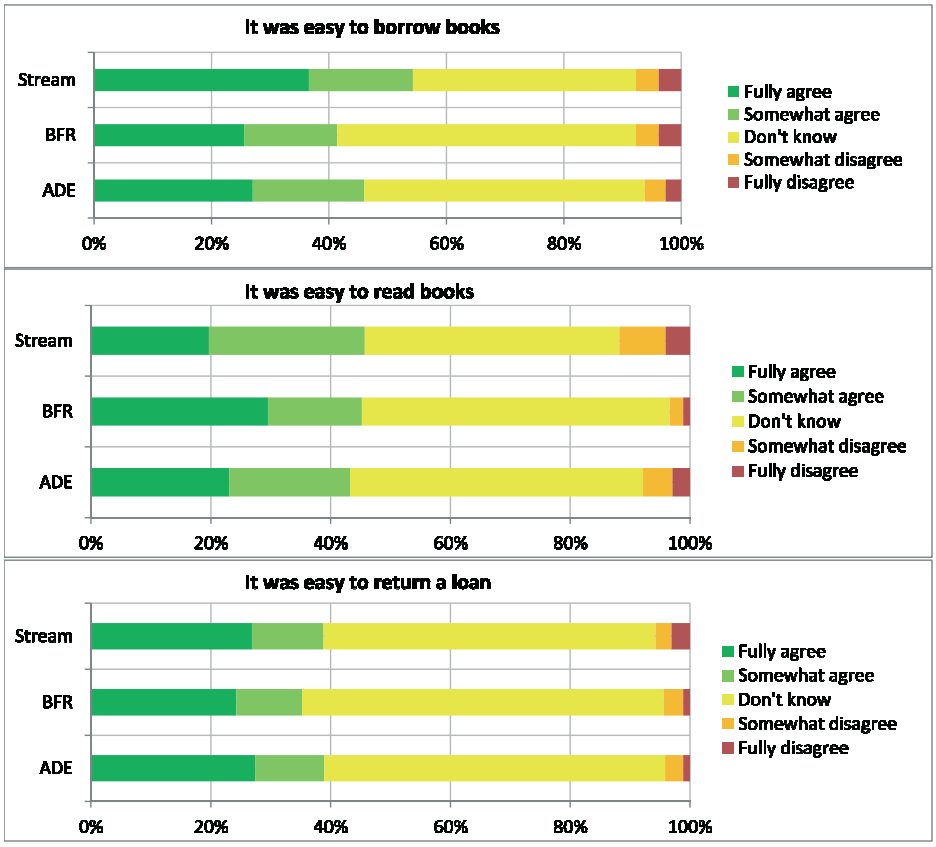

Figure 7: Summary of the user evaluations of eBook lending, reading and returning in the three options of the eBib-library system

The eBib library pilot collected feedback from customers through various channels: the comment fields of questionnaires, the eBib library's feedback channel, and Facebook.

Most of the feedback was received through questionnaire comment fields. The points raised were generally similar among the different feedback channels, and the feedback was, for the most part, positive.

A total of 500 feedback comments were received, and most feedback concerned the library's eBook collection which was considered to be too small. Also, a much feedback focused on the one-week loan period; customers felt that a one-week loan period is not long enough to read a book. Otherwise, the feedback primarily related to technical problems with eBook downloads and reading. Only a few respondents were surprised by the fact that an eBook has a limited number of simultaneous users.

8. Summary and conclusions

The differences in the user experiences of lending, reading and returning eBooks online and offline were studied in the public libraries. A test service, eBib, was developed and a web questionnaire circulated. The new digital library system was evaluated as good, and young users in particular liked the service. Analysis of the questionnaire showed some differences between streaming, BRF and ADE. More information about the reader's place in the streamed book has to be provided in order to reach comparable results as for BFR or ADE when reading a book.

User feedback can be used to develop the system even further. The following development areas were identified: integration of the eBib system more tightly with the library system of HelMET, services that allow management of the users own virtual library and adding new features to the web application, including management of the background colour and margins. Surprisingly, the Adobe DRM scheme did not provide any major problems for the user. The reason for this may be that the users of the eBib service were rather advanced users with a good knowledge of modern internet services.

When a digital library provides a pleasant user experience, it may also increase the commercial market. The study shows that users who were happy with the system also intended to buy digital books in the future. This finding supports earlier observations that heavy readers both borrow and buy books. Yet not all library users are potential book buyers.

Apart from platform development, user-friendliness was aimed for by developing a new easy way to read eBooks (streaming). Streaming allows library users to read eBooks without having to install any software or to acquire additional user IDs. Nothing is needed except an internet connection that does not have to be continuous.

For offline reading, users could still download and read e-books using Adobe DRM techniques. According to the feedback received from library users, the service was a success. The feedback was very positive, e.g., more than 70% of respondents would recommend the service to their friends. The abundant feedback also showed that users were eager to participate in developing the service even further.

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Management of press installation projects: method development and case study regarding newspaper press installation during full production

Johan Stenberg

Bold Printing Group
Box 36
SE-164 93 Kista, Sweden

E-mail: johan.stenberg@boldprinting.se

and

KTH Royal Institute of Technology
School of Computer Science and Communication
Dept. of Media Technology and Interaction Design
SE -100 44 Stockholm, Sweden

E-mail: jostenb@kth.se

Abstract

The newspaper industry is under pressure from new digital products and services and most traditional media companies are facing a revenue loss related to print products. In order to survive, many newspapers must assign resources for cost reductions and productivity generating activities. A modern, downsized and efficient printing plant can be a way to survive.

In this case study, modern production equipment has been installed at two sites at the same time as the project budgets were kept at a minimum in order to avoid future fixed capital costs in a decreasing market. To achieve this, a key factor was to re-use the buildings and as much as possible of the expensive infrastructure in terms and press tables, systems for heating, cooling etc., and thereby reduce the size of the investment by approximately 40-50 % in comparison with a green field solution. The decisions to go for new printing presses in the old buildings were taken late in 2010 (Akalla) and early in 2011 (Malmö). The decision was followed by a two year implementation project and another year of fine tuning.

A special project method was developed in order to achieve a cost efficient implementation with re-use of as much as possible of the already existing infrastructure in terms of buildings, press tables and piping, cooling etc. This method, CODSIM - Competition Driven Supplier InvolveMent, that requires deep involvement from competing press suppliers and their subcontractors such as printing press project specialists was a key to the success of the project.

Most deadlines and project objectives have then been met according to the initial project definition with a few exceptions - mainly related to the new control systems including software and parameter settings. The final deadline for closing the project could not be met due to a number of open items, but the presses have been used in daily production more or less according to a project plan worked out during spring 2010. In terms of budget issues, the budget developed after the pre-project has been carefully observed on a monthly basis and there has been no need for additional funding after the initial board decisions. The forecast is that the annual costs in the two plants will be reduced by more than 20 % from 2015 with equivalent volumes and the forecast is that the pay-off for the 15-year investment will be reached within five years.

Keywords: newspapers, printing press, printing plant, installation, project method, cost efficiency

1. Introduction

The newspaper industry is under hard pressure from new digital products. The circulation figures are decreasing and in addition new, digital products and services are hard competitors when it comes to advertising revenue streams (WAN-IFRA, 2012). In order to survive, many newspapers must put considerable resources into cost reductions and productivity generating activities. Especially the printing plants can be an area with a great productivity enhancement potential if the technology used and the associated organizations and processes are old fashioned and costly. A modern, downsized and efficient plant can be a way to ensure survival. Installation of newspaper printing presses does often imply very high investment costs in production equipment and new buildings. In one of the case projects described, 30 million Euro were invested in a highly automated 6-tower

90000 cph press including, for instance, auxiliaries for prepress, material handling and certain mailroom equipment.

In addition, an investment of similar size in terms of a new building may be needed if the old site cannot be reused. Such a heavy investment normally means 10-15 year of use with associated capital costs for the printing press and 50 years for the building.

In comparison, the Finnish media group Alma Media invested 70 million Euro in a completely new facility during the same period. The Finnish project included an 8-tower highly automated 90000 cph press with a new mailroom and a new building. The two projects are not fully comparable as the Finnish project included more equipment, especially in the mailroom, but the investment ratio between the two projects (2.33) is considerable (Pekkarinen, 2013; manroland, 2013).

During periods of strong newspaper economy in Sweden, for instance in the 1980's - 1990's, many newspapers moved their city located print facilities to new green field sites outside the city centre. This caused heavy investments in buildings, equipment and operation at two sites during the project period. This was the case when the completely new plants of Göteborgs-Posten 1985, Aftonbladet/Svenska Dagbladet 1989 and Dagens Nyheter/Expressen 1993 were built outside the city centers in the outskirts of Gothenburg and Stockholm.

The total cost for new buildings and new equipment makes the transition from the old to the new plant very capital intense, less risky in terms of production risks and gives a strong platform in order to establishing a new company culture. With a new building, the daily publishing and its printing can continue on a business-as-usual basis in the old plant in parallel to the green field project. When the new plant is prepared and ready for production, the production can gradually be moved from the old to the new plant.

One key question, when dealing with this kind of long term investments, is which direction the market for printed newspapers are heading when the publishing world is getting increasingly digital. Therefore, a printing press investment must start with an investigation and predictions related to future circulation for printed newspapers, development regarding the number of pages, editions, inserts and new opportunities for printed products.

The traditional way of managing a newspaper printing press project has been to start with a prestudy, using internal resources and sometimes assisted or even supervised by external consultants with an expertise in newspaper printing plant planning. The prestudy often results in a printing plant specification and a number of quotes and drawings from different suppliers in terms of printing press and mailroom vendors, builders, etc.

The easiest way to manage the installation is to put up a new press hall or even a green field print site and then install the printing press purchased based on the specifications from the prestudy. A rough figure for such a project is 2-3 years from project start to go-live.

2. The newspaper market and modern newspaper technology

The circulation figures and advertising income related to newspapers in Western Europe and North America are decreasing. The newspapers business meets hard competition from a variety of digital substitute products and services competing for the attention of the readers and money from the advertisers as described by, for example, Naldi et al. (2012) and Berman et al. (2011). The circulation (see Figure 1) and printed advertising income in Western Europe and North America has dramatically declined since 2007 (WAN-IFRA, 2012).

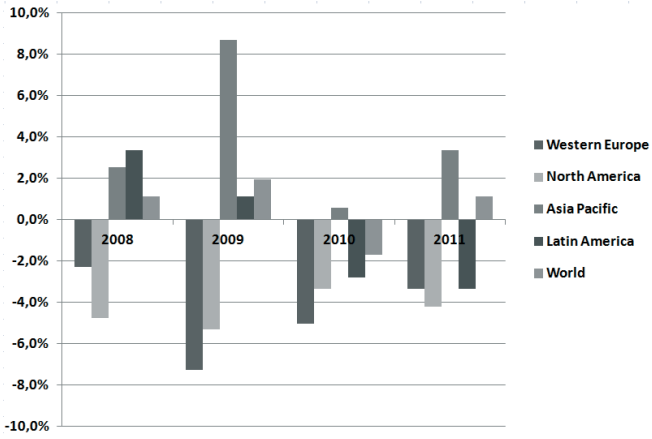

Figure 1: Year by year circulation trends by world region (WAN-IFRA, 2012)

In Table 1, the long-term situation in Sweden is illustrated and it follows the trend in Western Europe and is, according to figures from the Swedish Publishers' Association, even worse than average in countries in Western Europe (TU, 2013). Interviews with Swedish newspaper executives during a study in 2008-2009 indicated, that this trend was expected to continue for the foreseeable future (Stenberg, 2013). A common long-term prediction by the executives interviewed was a 3 to 5% annual drop with respect to circulation figures. A couple of years later, the conclusion is that the forecasts were not defensive enough. Instead the annual circulation drop for Swedish newspapers has accelerated from a 2.4% decrease in 2007 to a 6.6% decrease in 2012 (TU, 2013). The largest reduction can be found among the evening newspapers (-22.1% from 2011 to 2012).

For the print sites, one way to manage the shrinking newspaper market is to improve productivity and meet the decrease in revenue with cost reductions. Already during the 1980's and 1990's, printing presses and mailroom equipment gradually became digitally controlled and new automation technologies improved the performance (Stenberg, 1997). If the basic process infrastructure in terms of hardware and control system has reached end of life from a financial or technological standpoint, investments in modern technology can be a way to survive. During the first decade of 21th century, highly automated and compact newspaper printing presses became mature. Shaftless technology means, among other things, new possibilities for doing different make-ready activities in parallel. Thereby, the lead-time for non-productive activities can be substantially reduced.

*Table 1: Circulation development in Sweden 1999-2012 (TU, 2013; Dagspress, 2014). The method for calculation of evening newspaper circulation was changed 2011 and the figures from 2011 and 2012 are based on slightly different sources for a few of the larger titles in Sweden (*Aftonbladet, Dagens Industri *and* Dagens Nyheter*)*

Year	Daily morning papers (4-7 days/w)	% change year-to-year	Non-daily morning papers (1-3 days/week)	% change year-to-year	Evening newspaper (7 days/week)	% change year-to-year	Total circulation	% change year-to-year
1999	2 934 000	-	379 000	-	787 000	-	4 100 000	-
2000	2 932 000	-0,1%	389 000	2,6%	768 000	-2,4%	4 089 000	-0,3%
2001	2 950 000	0,6%	388 000	-0,3%	735 000	-4,3%	4 073 000	-0,4%
2002	2 914 000	-1,2%	392 000	1,0%	758 000	3,1%	4 064 000	-0,2%
2003	2 892 000	-1,4%	386 000	1,8%	777 000	-1,3%	4 055 000	-1,1%
2004	2 866 000	-0,9%	380 000	-1,6%	786 000	1,2%	4 032 000	-0,6%
2005	2 835 000	-1,1%	395 000	3,9%	768 000	-2,3%	3 998 000	-0,8%
2006	2 784 000	-1,8%	401 000	1,5%	743 000	-3,3%	3 928 000	-1,8%
2007	2 738 000	-1,7%	403 000	0,5%	692 000	-6,9%	3 833 000	-2,4%
2008	2 675 000	-2,3%	389 000	-3,5%	657 000	-5,1%	3 721 000	-2,9%
2009	2 581 000	-3,5%	385 000	-1,0%	625 000	-4,9%	3 591 000	-3,5%
2010	2 499 000	-3,2%	377 000	-2,1%	582 000	-6,9%	3 458 000	-3,7%
2011	2 418 000	-3,2%	393 000	4,2%	520 000	-10,7%	3 331 000	-3,7%
2012	2 309 600	-4,5%	396 000	0,8%	405 100	-22,1%	3 110 700	-6,6%

Prior to this case study, the productivity of the old and potential new presses was carefully analyzed and compared at the Bold Printing Group (BPG, see section 3) in Sweden. The project team obtained production statistics from a number of modern plants and compared key productivity figures such as make-ready time between jobs, start-up waste, average net speed, manning and paper utilization. The results were published in an internal report. The comparison, based on actual production data, shows how the technical development of newspaper presses can improve the productivity. The comparison focuses on the lead-time for a print job made in an almost 20 year old newspaper printing press (manroland Colorman S) and a modern press (KBA Commander CT) (KBA, 2013). The results are shown in Figure 2.

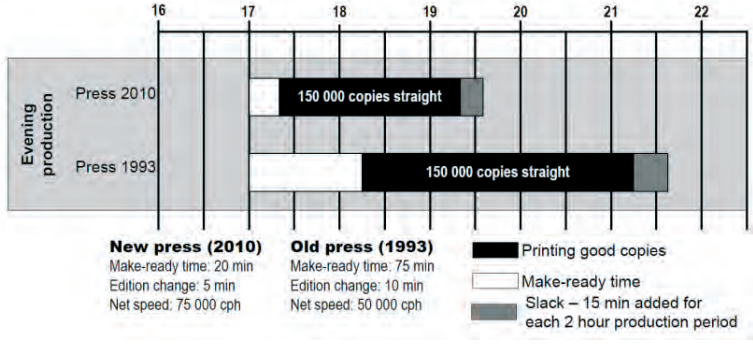

Figure 2: Typical lead-times for a single job in newspaper presses from 2010 and 1993

The make-ready time for similar products has been reduced from 75 to 20 minutes and the net output has gone from 50 000 copies per hour to 75 000 copies per hour for similar production runs in one single folder.

The total effect is a lead-time reduction (including slack) from 4.6 hours to 2.6 hours for a single 150 000 copy print run.

A conclusion drawn is that the development of automation technologies in the printing industry implies plants that need less space and less manning. The BPG case shows that one new modern printing press from year 2010 could replace two old presses from 1993. Compared to the old equipment, the new presses in one of the BPG plants (Akalla) just required 25 % of the space and 50 % of the staff in order to produce similar products and volumes.

In recent years, not very many large and completely new printing sites have been built in Western Europe or North America.

Table 2 includes figures for three modern green field newspaper print sites completed in the years 2007-2008. The table also contains information about one of the older print sites in this case study - Bold Printing Group Akalla.

Table 2: Share of building costs in four green field newspaper print site project (Newsprinters, 2013)

Site	Capacity	Building size (sqm)	Total investment	% Building costs	Year
Newsprinters Eurocentral Glasgow, Scotland	172 000 cph - maximum 144 tabloid pages	14 195	56 000 000 GBP	46	2007
Newsprinters Broxbourne, London, England	1 000 000 cph - maximum 120 tabloid pages	87 000	348 000 000 GBP	54	2008
Newsprinters Knowsley, England	430 000 cph - maximum 120 tabloid pages	38 000	120 000 000 GBP	45	2007
Bold Printing Group Akalla, Stockholm Sweden	240 000 cph - maximum 160 tabloid pages	93 000	2 400 000 000 SEK	58	1993

The Akalla plant was from the beginning designed for 320 000 copies per hour (cph) in the late 1980's, but one press line was cancelled during the project phase in the early 1990's and this, in combination with a considerably large building, is the explanation for the very large share of building costs in this case - 58 %.

In the projects presented in table 2, the building costs for the green field sites were 45-58 % of the total costs for the new plants. In our case project, a green field alternative was considered for the Stockholm business. But just the additional building costs including necessary auxiliaries reached 21.6 million Euro (+/- 15 %) for an 18 000 sqm plant if the expected production capacity should be hosted. Costs for land and roads were not included in the budget figure mentioned. An extension of the existing Akalla building in order to host a new press line was also studied.

The expected costs for this building extension was substantially higher than the necessary modification needed in order to re-use one of the existing press halls. A decision was taken to host the new presses in the present buildings and develop methods to manage the installation process in parallel to the daily production.

The conclusion is that when putting up a green field newspaper print site a large share of the budget is needed for the building itself and much costs can be saved if the old plant can be re-used.

3. The media group Bonnier and its newspaper printing plants

Bold Printing Group (BPG) is part of the international media group Bonnier (Bonnier, 2013). BPG, based in Sweden, is one of the largest printing groups in the Nordic area producing around 2 million newspaper copies per day and approximately 100 million Euro of revenue in 2012. A majority of the copies are printed between 20:00 in the evening and 06:00 in the morning. BPG consists of three newspaper printing plants at different locations in Sweden: Bold Printing Group Stockholm AB in Akalla - Stockholm, Bold Printing Group Malmö AB in the south, and Borås Tidning Tryckeri AB in the western part of the country. The printing group serves

internal Bonnier customers as well as a large number of external customers such as free papers and commercial advertising products (Bold, 2013).

During 2008, a project was started in order to secure a cost efficient future printing business. In Akalla and Malmö the printing presses used at that time were installed during the years 1992-1994 and their manning and productivity could not, around fifteen years later, compete with modern and highly automated newspaper printing plants such as the BPG plant in Borås from 2002.

In order to stay competitive in the long run, a modernization of the plants was considered as an alternative to closing down the two old plants and outsourcing of the production.

4. Research questions

How can a media group under hard pressure in a growing digital media world invest in new printing presses with a minimum of costs for construction work and buildings in order to focus the investment on value added activities related to cost effective future printing of newspapers? Is it possible to re-use the old and very expensive infrastructure needed for the new press - infrastructure in terms of press concrete tables, power supply, cooling systems, ventilation and supply of compressed air? How should this old infrastructure best be evaluated and acknowledged for re-use together with brand new printing presses without running into conflicts with the press suppliers regarding the combination of new presses and old infrastructure?

The paper is a case study of two newspaper printing press installations including analyses of the somewhat unusual project methods used and needed in order to replace printing presses in parallel to printing some of the largest newspapers in the country on a daily business-as-usual basis throughout the complete project. The great difference compared to the traditional project methods is, that the presses were installed on the old press tables and next to printing presses running 24/7-production. The objective of the paper is to describe and analyze the preconditions for the project and the project methods developed and used in order to manage a heavy investment and a complex project in a shrinking market.

5. The press project case study - methods and results

5.1 The PPS-method as a basis

Initially, a project organization was put together and a decision was taken to use the Practical Project Steering (PPS) method developed by TietoEnator as the main framework for all project work. PPS has a strong focus on structures, specifications, routines and project organizations (TietoEnator, 2002; 2013).

Other methods such as PROPS and its later version XLPM (Klamer 2012; Semcon, 2010) were considered, but PPS was chosen mainly because it is a well established, business independent project method widely used in Sweden with a large base of trained people, courses and professsional companies supporting it with knowledge and tools.

5.2 Project phases and organization

The project went through a number of consecutive stages: pre-study, pre-project, installation, go-live, take over and project finalization (Figure 3). The way the work was organized was throughout the complete project period 2008-2013 based on PPS. In addition, some of the stages required different supplementary methods depending on the objectives and characteristics for the specific stage. The project aimed for a large involvement from operators as well as experts already from the early project phases and that was managed by the organizational support found in PPS with steering committees, project management team, specialist groups and references groups. Some samples of the various skills used in the project organization are international printing plant layout experts, local architects and static engineers together with teams of printers and production managers.

5.3 Strategic work and strategy methods

Especially during the pre-study and pre-project stages, a combination of literature research and semi-structured interviews with newspaper customers and suppliers of equipment and systems to the newspaper industry were carried out in order to collect data. The literature research used sources like statistics from the Swedish Media Publishers' Association (Tidningsutgivarna, 2008; 2009; 2010) and WAN-IFRA (2012).

5.4 Net Present Value calculations

A Return-On-Investment calculation for the Stockholm plant shows a break-even during 2018, compared to a much longer pay-back in a conventional project including a new building. The main cost savings calculated was staff reduction, reduced costs for the building itself (heating, cooling, maintenance), and improved paper utilisation (Figure 3). One modern newspaper printing press replaced two old presses.

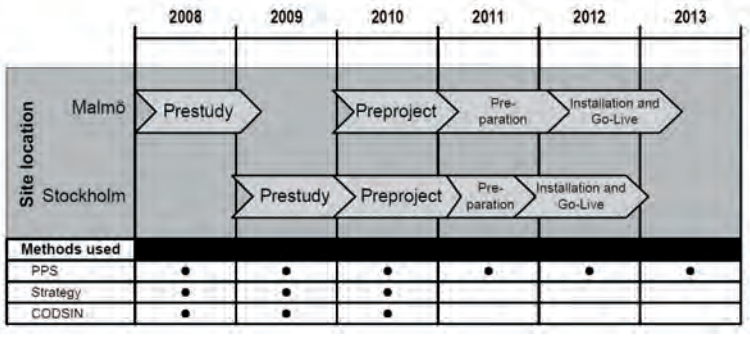

Figure 3: The project phases and methods used

Table 3: ROI calulation for the Stockholm plant. The NPV (Net Present Value) calculation shows a NPV value of 576 million SEK during the calculated life-span of the newspaper printing press. The uncertainty of future newspaper revenue streams makes the short term cash-flow more important and cash-flow break-even is reached already in 2018. The main cost savings are related to reduced staff

INVESTMENT PLANNING - NETPRESENT VALUE													Date/provided by: 2010-11-12/JS								
													Activity-code Press-project								
Unit: Million SEK		Interest	10%										Comments Sthlm 1 folder, 6 towers								
		Contract	Installation & Go live																		
Costs	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	TOTALT		
	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount			
(-) Cashflow																					
- Prestudy	-4																		-4		
- New equipment		-155	-47	-20															-222		
- Construction costs		-6	-4																-10		
- M&E technology		-7	-5																-12		
- Mailroom connection		-11	-6																-17		
- Consultants		-2	-3																-5		
- Extras (2%)		-2	-3																-5		
Total costs	**-4**	**-183**	**-68**	**-20**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	-275		
(+) Savings																					
+ Energy and paper	X	X	X	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	73		
+ Reduced staff	X	X	X	15	30	50	50	50	50	50	50	50	50	50	50	50	50	50	695		
+ Less maintenance	X	X	X	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	29		
+ Reduced production area	X	X	X	0	2	4	4	4	4	4	4	4	4	4	4	4	4	4	54		
+ I	X	X	X																0		
Total savings	**0**	**0**	**0**	**19**	**39**	**61**	**61**	**61**	**61**	**61**	**61**	**61**	**61**	**61**	**61**	**61**	**61**	**61**	851		
Cashflow	**-4**	**-183**	**-68**	**-1**	**39**	**61**	**61**	**61**	**61**	**61**	**61**	**61**	**61**	**61**	**61**	**61**	**61**	**61**	576	Internal interest	
NPV	**-4**	**-166**	**-56**	**0**	**27**	**38**	**34**	**31**	**28**	**26**	**24**	**21**	**19**	**18**	**16**	**15**	**13**	**12**	96	15,2%	

5.5 The CODSIM method

During the pre-study and pre-project, the CODSIM method (COmpetition Driven Supplier InvolveMent), was developed by the project team. Instead of telling the press suppliers exactly what to offer in terms of a carefully worked out specification, they were given a framework for the future business and as part of the RFP process (Request For Proposals), the suppliers were asked to present their solutions including future scenarios, to propose suitable printing press solutions, and to present drawings and requirements with respect to the building and its peripherals, third party investments needed, associated production plans and need for operators and maintenance staff.

The key reason for involving the suppliers according to the internally developed CODSIM method was to ensure that as muchs as possible of the expensive infrastructure in the building could be re-used in a cost efficient way and make the suppliers propose project methods for securing an installation project where the old equipment was used in parallel to the installation project of the new presses and then gradually move the production for the old to the new printing presses more or less seamlessly.

Workshops were carried out with all printing press suppliers involved and each of them was asked to present their proposal according to the structure defined in the RFP. Four different suppliers were invited to the first round and a total of seven different solutions were presented. An evaluation matrix was developed covering technology, economy, company and project credibility. Each factor was given a grade from 1 to 6. The future cost structures were paid particular attention and calculations based on NPV with a 15 year depreciation period was prepared and analyzed (Brealey et al., 2006).

The pre-studies ended in December 2009 and two suppliers and two different press concepts were chosen for the final round - a pre-project in two stages with the objectives to fine tune the technical solutions, time tables, costs, risks and finally to chose one supplier for the two plants. During the pre-project, the CODSIM method was further developed. Three different teams worked in

parallel to develop the best concept - one paid-for team from each press supplier and one internal expert team.

5.6 The final pre-project round

The two press suppliers that went on to the final round in the CODSIM competition, were asked to present the, according to them, most cost efficient way to re-use the building and its infrastructure. Now, the quality assurance and evaluation of the existing building and infrastructure was put in the hands of each press supplier.

The press suppliers in their turn, brought in experts in teams with static engineers, energy technology specialists (heating, cooling, compressed are, piping, power supply), architects and project specialists.

This was a "competition" and a paid-for work, but the costs would only be paid to the supplier that did not get the final order. If none of the suppliers received the order, both competitors would be paid for the pre-project. The costs for this "competition" were less than 1 % of the total budget for the final investment.

The expert teams evaluated the 20 year old press tables at each site in terms of their ability to manage the dimensions, static and dynamic loads from the new high speed presses. The re-use of the old press table (approx. 60 x 4 x 1 meters in concrete) was an absolute necessity in order to avoid expensive construction work.

In addition, an internal team - extended with some freelance experts - developed a third concept. After a milestone in the pre-project during the summer 2010, the number of concepts was reduced and both suppliers were once again asked to develop a more detailed solution including technology, project plans, quotes and a risk analysis. The internal team continued in parallel to the two suppliers and their contracted experts. At the end of the pre-project, all three concepts and the associated projects were evaluated and an investment proposal was prepared for the board.

In the final proposal, the ideas, budgets and timetables from all three reports were analyzed and to some extent merged. The final report before the investment decision gave the project team a solid ground for the implementtation project and many questions were deeply penetrated - especially costs, technical solutions, risks and timetables for the installation.

The pre-project results contained a master plan showing how to stay in the same press halls and install the new presses on the same press tables, just a few meters away from an ongoing daily production.

For the Stockholm Akalla plant, the investment decision was made in December 2010 and a contract with KBA for a 96 page, 90 000 cph Commander CT was signed in January 2011. Instead of replacing all three old press lines in the Stockholm plant, it was decided to keep one old press line for a limited number of years.

It was decided to replace two old press lines with one new printing press. The main reason for this decision was the uncertain newspaper market and the risk of investing in too much production capacity. The Malmö decision came a few months later.

5.7 The installation project

From January 2010 until the project was more or less finished at the end of 2012, the PPS method was the main management method used (see Table 3). This was in line with the plans, as most open questions where then answered and the project went in to a rather straightforward installation, training and go-live phase.

A BPG decision to stay in the existing buildings was taken during the pre-project with support from budget figures from one of the suppliers in the CODSIM process. This specific supplier also prepared one solution with a lean, green field site.

Installation on an existing press table, next to a press running in full operation means large risks. Another risk to manage was the difficulty to handle the overall time table and its milestones. New technology and the need for changed processes and routines in parallel to the start-up phase imply production problems which may influence the customers in terms of late deliveries due to production disturbances. A delayed project time table may also cause lack of funds at the end of the project. According to Kerzner (2013), a complex project must be carefully planned and risk management should be an integrated part of the project work. To manage the risks, a decision was taken to list, review and validate project and process risks on a monthly basis.

The most creative phase of the project was the pre-project. In order to define a project that would meet the requirement of re-using the existing buildings and mail-rooms and no production limitations for the customers, a rather different project approach was used.

In addition, a completely new solution for the internal paper logistics, new computer-to-plate (CTP) lines, a new prepress workflow system and production management software for copy counting have been installed. The guidelines for each project contained the following statements:

1. Installation of six printing towers and reel stands;
2. Installation of a 2:5:5-folder and a separate quarter folder;
3. Installation of a new system for internal reel logistics;

4. Installation/modification of system interfaces related to supply processes and IT-systems such as prepress, mailroom, material handling and system for order administration;
5. Installation of new CTP equipment including punch and bend and plate sorters;
6. Installation of pickup-stations and gripper-conveyors into the mailroom;
7. Necessary construction work and modification of cooling, heating, air condition, etc.;
8. Development of new working procedures suitable for the new situation;
9. Training and re-organizing routines and workflows;
10. Retrofitting of the working environment in terms of furniture and interior;
11. Dismantling and scrapping of the old printing presses.

Each installation project started with modifications to the old manroland presses. Initially, some mechanical and control system modifications were made in order to manage the product specifications despite a reduction from ten to seven printing units. The next step was the dismantling of three units in the old presses. There was also a need for a process supply preparation for the new press including installation of a power supply and preparation for parallel feeding of ink, water, cooling and electricity to the old and the new press.

After dismantling and bringing out three old units, there was enough space to install four new compact towers and a folder - enabling printing of 64-page tabloid products with full color in straight run. The installation and commissioning of this first section of each press took roughly four months and, in parallel to this work, production went on as usual in the old presses next to the preparation work.

5.8 The Go-Live procedure

The first month after go-live, the production runs were managed in parallel in the old and the new press in order have a backup-solution. When the performance of the new 64-page press was stable enough and some predefined productivity figures were met, the old presses were finally closed down. It took three weeks longer than planned to reach this stability.

The second installation phase included two more printing units and the print capacity was increased from 64 to 96 tabloid pages. Additional towers in the old press were dismantled in order to create space for the new printing units. This was followed by installation and commissioning work and this complete second stage took three months to finish. The final installation and commissioning phase was followed by a very long period with daily production in parallel with fine tuning of parameter settings in the press control system, mechanical fine tuning of the printing press and implementtation of new working procedures and training activities.

5.9 Major deviations

The overall result was that the initial time table was managed with a few exceptions:

- A strike at one of the factories manufacturing parts for the new press delayed the project five weeks already from the start. This could not have been predicted during the planning phase.

- A second minor delay occurred after the go-live. The time needed to reach the target productivity figures for the new press could not be managed within the planned two weeks. Instead, five week were needed in order to reach sufficient stability.

  The planned short start-up period was questioned by BPG during the planning phase, but the supplier insisted that the planned time was adequate. The reality showed that five weeks were needed.

- The largest delay was related to the final acceptance of the presses at both sites. Most critical milestones during the project were met, but in order to get final acceptance, a number of productivity and stability related targets had to be achieved.

  The presses have produced every day since go-live, but reaching the productivity goals has been a tough challenge for the supplier. Especially key figures related to up-time (error free production time) and press speed when printing large paginations has been paid much attention.

In the end, the overall time table in which the project should be ended during 2012 was managed and in general the planned productions have been managed in the new presses. A majority of all planned project activities were finished in conjunction with the key milestones in the master plan.

Stability and productivity issues resulted in a rest-list and a rest-project followed during 2013. The total cost was within the budget plan settled already at the end of the pre-project prior to the investment decision.

One year after the go-live most of the project objectives had been met. The average net speed for the large circulation print runs is close to the target value 75 000 copies/hour (Figure 4) and also the savings in terms of staff reduction and improved utilization of newsprint are on the target values

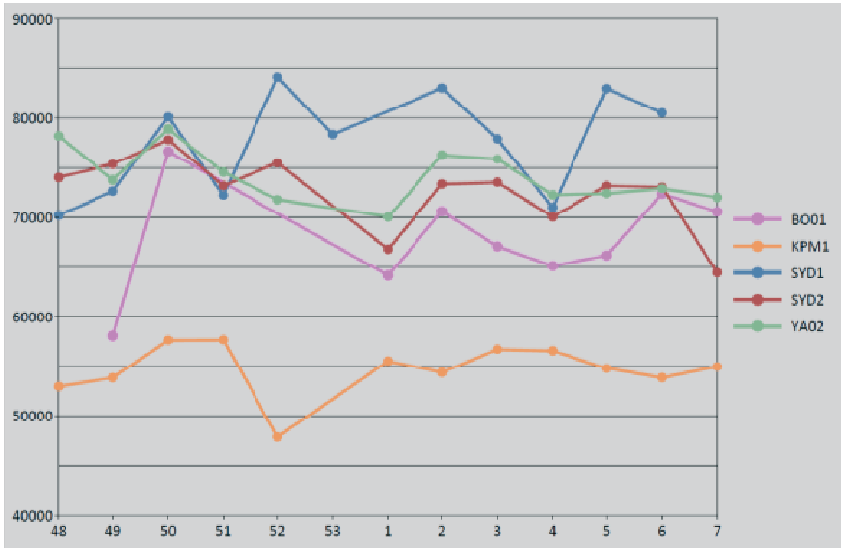

Figure 4: Average net production speed in copies/hour and newspaper title. Weekly average figures from the end of 2013 and beginning of 2014. Syd2 is the benchmark title. The weekly average (7 productions/week) is close to the target value of 75 000 copies/hour during the observed period. The new press has proven to be approximately 50 % faster than the old presses which had an average net speed of just less than 50 000 copies per hour in comparable productions

6. Discussion

The CODSIM method that was developed resulted in a very strong knowledge-base with professional experts that all together focused on solving a complex task given some basic input about the present business and expected future development.

In this kind of large scale and big budget projects, the cost for this type of pre-project activity is rather small compared to the total budget. The key to the success of this project was to keep the investment budget at a minimum while still being able to completely shift technology - from mechanically driven satellite printing presses from the early 1990's to highly automated shaftless compact 4-high presses from 2010-2011. The project team wanted to put as much as possible of the budget into productivity enhancement and development of processes and knowledge within the organization. They wanted to keep the 20-years old buildings and most of the 20-years old infrastructure in terms of power supply, piping, heating, cooling, ink supply, fount supply etc. etc., and just do minor upgrades or retrofitting activities.

The challenge was to identify which parts of the infrastructure could be re-used without refurbishment or reconstruction and which necessary changes were needed in order to provide the new presses with a solid printing press foundation (press table), energy, fount, ink and compressed air.

The CODSIM method paved the way for an extremely professional evaluation and, in the end, cost efficient solutions. The major reason was that the two competitors - the press manufacturers - had a strong reason to find cost efficient solutions related to the surrounding of the presses and in the end have the opportunity to win the final contract. We experienced that both suppliers hired very professional experts and the dual objectives for each supplier - to win the final contract and at the same time secure a smooth start of their production equipment - resulted in very high quality of the pre-projects and budget figures and technical solutions that worked out very well also in the implementation project.

Naturally, only one of the concepts could be properly evaluated as only one supplier got the final contract for the two print sites.

In the tough economic climate after 2008, it was rather easy to find skilled professional experts and eager suppliers willing to put in much of their own time and money in order to get a large printing press contract. In a strong or even normal economy it might be harder to obtain such strong teams without much higher costs.

Compared to recent large-scale green field print sites, about 50 % of the investment sum could be saved. The method used minimized the need for non-productive investments, but still around 50 million Euro has been invested at the two sites. In this case, it is difficult to see any other alternatives and to do nothing at all was a great risk. The cost structure of the old presses could not met the market demands and resulted in high production costs for the internal customers due to man-

ning, large buildings and high waste figures. Due to the investment and the reduction in space needed in Akalla, the building itself could be sold and a large share of it will be used for other purposes in the future. A lesson learned in this project is that all kind of new technology must be either validated through real live installations and real data or considered as non-validated and given extra time in the project plan. The main technical problem areas that this project dealt with were a new control system generation and a non-proven combination of folder, pagination and press speed. Even more time should have been spent on verifying the technology during the pre-project phase. Despite the carefully implemented pre-study and pre-project, there was a lack of awareness within BPG that part of the installation contained new solutions not tested nor proven under the circumstances they were supposed to operate in the BPG business. But two years after the investment decisions, the two plants are more or less fully operational with all the new equipment and systems in place, and this has happened without too much pain for neither the customers nor the organizations.

7. Conclusions and recommendations

In this case study, the competition from new media is countered through cost reductions in terms of modernization and productivity enhancement in the two printing plants studied. Modern equipment has been installed at the same time as the project budgets were kept at a minimum in order to avoid future fixed capital costs in a decreasing market. To achieve this, a key factor was to re-use the buildings and thereby reduce the size of the investment by approximately 40-50% in comparison with a green field solution.

Instead of investing a significant amount in new buildings, focus was on highly automated process equipment, training and process development. Around 50 million Euro has been invested at the two print sites and less than 10% of the budget was spend on building related costs and construction work. The project was started already in 2008 after a long planning phase and careful evaluation of a number of different alternatives. The decisions to go for new printing presses in the old buildings were taken in late 2010 (Akalla) and in early 2011 (Malmö).

The deep involvement by the press suppliers and their subcontractors, such as printing press project specialists, was a key to the success of the project. The almost one year long pre-project phase became a tough competition between two press suppliers. The pre-projects made both supplier candidates extremely aware of the business at the two sites and the preconditions for the project. Their deep involvement in the planning of the project provided a solid ground and reliable technical solutions, budget figures and time tables. In the end, the three different alternatives from three different teams were compared, analyzed and, in certain areas, merged before the final investment decision.

A drawback with the CODSIM method developed and used was the time needed for the pre-project. The total time used for the project was around 33-50% longer than a traditional newspaper press project. The pre-study and implementation project did not differ very much from a conventional project of the same complexity in terms of calendar time, but the one year pre-project must be seen as an extension caused by the complex preconditions for the implementation with full production next to the press installation and implementation sholder-to-shoulder on the same press-table as the old press.

Another drawback is the need for internal resources to manage parallel pre-projects with two suppliers developing two different concepts and in addition a third internal team with one additional concept. In the case studied, temporary additional internal resources were added in order to handle the pre-project year. But, in the end, the complex project could be carried out with a lean budget and without too many problems.

The two new 96-page and 90000 copies per hour KBA Commander CT presses have been installed during full production during the years 2011-2012. A key factor for the success of the project was the project methods used. The investment decision was carefully planned and almost three years was spent on pre-studies and pre-projects in order to identify suitable equipment based on the expected market conditions, to evaluate different alternatives regarding where and how to install the printing presses in parallel to the daily business and last but not least to identify risks and costs for the project.

An important factor in the project has been the CODSIM method developed in the project. The fundamentals of CODSIM has been to create a framework explaining the preconditions for the future situation and let expertise in terms of suppliers with the potential to win the printing press contract, compete in order to design the technical solutions, project plans and associated costs and risks. In parallel to the machine suppliers, an expert group made a similar solution and in the end the different proposals were compared and the best ideas were put together in order to secure that nothing or very little was unforeseen.

Most deadlines and project objectives have been met according to the initial project definition with a few exceptions - mainly related to the new control systems

including software and parameter settings. There is still an open items list with minor problems that need to be fixed. This means that the final deadline for closing the project could not be met, but the presses have been used in daily production more or less according to a revised project plan worked out during spring 2010. In terms of budget issues, the budget developed after the pre-study have been carefully observed on a monthly basis and there has been no need for additional funding after the initial board decision. The forecast is, that the annual costs in the two plants will be reduced by more than 20% from 2015 onwards, with equivalent volumes. The pay-off time for the 15-year investment will be less than 5 years.

Acknowledgment

This paper is a result of the co-operation between the Bonnier Group and KTH Royal Institute of Technology. Over the last couple of years, both organizations have shown a willingness and made efforts to let the academia and the industry exchange knowledge, ideas and resources. Special thanks to Leif Wiklund, now a retired former CEO of BPG, who first hired me and in addition was positive to the KTH co-operation.

The project work itself has been a hard fight that lasted for almost five years - that is a long period for a project. With huge efforts from colleagues, suppliers, different specialists and with strong support from owners and boards, this impossible project became real and even successful. Thank you all! Last but definitely not least I would like thank my family for their patience and support throughout these five years.

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Tailored printed primary battery system for powering a diagnostic sensor device

Andreas Willert[1], *Anthony J. Killard*[2], *Reinhard R. Baumann*[1,3]

[1] Fraunhofer Institute for Electronic Nanosystems ENAS
Technologie-Campus 3
D-09126 Chemnitz, Germany
E-mail: andreas.willert@enas.fraunhofer.de

[2] University of the West of England
Frenchay Campus
Bristol, BS16 1QY, United Kingdom
E-mail: tony.killard@uwe.ac.uk

[3] TU Chemnitz, Institute for Print and Media Technology
Chair of Digital Printing and Imaging Technology
Reichenhainer Str. 70
D-09126 Chemnitz, Germany
E-mail: reinhard.baumann@mb.tu-chemnitz.de

Abstract

Printed batteries are unique in their capability of providing customized electrical energy to various kinds of applications. A primary battery is fully charged during manufacture and so does not require charging prior to its first use. Therefore, the amount of energy included during production is immediately available for the designated application. Printing as a manufacturing technology enables the production of this type of battery with the ability to tailor voltage, energy content, and layout. One appropriate application for this type of energy supply is in single-use sensor devices used for blood testing. Such systems possess finite and well-defined energy requirements.

In this paper, the development of a power supply based on printed battery technology for just such a sensor system is described. The application of the sensor system is for the measurement of cholesterol in human blood. During the research and development process, the requirement was to support electrical power to two different types of systems: one controlled by a Si-chip and the other controlled by an organic circuit. The first setup required an operating voltage of 3 to 4.5 V while the second setup demanded +/–15 V. In this paper, the investigations and results for both types of batteries are described. Both types have been successfully characterized to fulfill the application demands.

Keywords: printed battery, primary battery, energy system, sensor, smart system, screen printing

1. Introduction

Printing technologies enable the deposition of patterns of functional materials on various substrates. This evident benefit is being widely studied for several devices and applications. The manufacture of products employing printing technologies promises mass production with low costs, especially in the area of Organic and Large Area Electronics (OLAE). One of the key elements for making electrons move inside any circuitry is electrical power. There are several approaches to the fabrication of printed batteries with different types of technologies such as primary, (i.e., one time discharge), (Willert and Baumann, 2009; Willert, Geyer and Baumann, 2010) secondary (such as NiMH) (Wendler, Krebs and Huebler, 2011) or lithium-based systems (Geyer et al., 2009). The efforts to produce printed batteries have for several reasons concentrated on primary batteries. Many intended applications are of a limited lifetime. Therefore, they have a well-defined energy requirement that can be matched perfectly by a printed primary battery. The battery itself can be designed into and also integrated directly into the application. Another argument is that if targeting low cost mass production, these requirements are not met by costly rechargeable devices. There are also companies such as Enfucell[1] or Blue Spark[2] that offer commercial primary batteries ranging from 1.5 V up to 6 V manufactured employing printing technologies. In a recent publication on research topics

[1] www.enfuell.com
[2] www. bluesparktechnologies.com

within a European funded project, also 24 V primary and secondary batteries have been mentioned without giving any technical data (Carta et al., 2013).

The work presented in this paper has been undertaken as part of the development of Smart Integrated Miniaturised Sensor (SIMS) systems. The concept of a SIMS device is the application of fully organic and printed electronics to the development of point-of-care diagnostic devices. The use of this technology makes these devices extremely simple to use as well as being mass producible at very low cost. SIMS combines a printed biosensor with printed batteries and an electrochromic display with an organic electronic circuit. The device now in question has been developed to measure cholesterol levels. Due to the use of organic and printed materials, the device is a single use and fully disposable, credit card-sized system that is much simpler to use than traditional strips and meters. The device is switched on, a small blood sample is added and the result is displayed on the display. The result can also be transmitted remotely to a general practitioner (GP) or a healthcare provider via a smartphone 'app'. This system has bespoke power requirements for the sensor, display and circuit.

In this paper, solely the issue of powering such a system is addressed. The constraints are given by the application under investigation, such as: device size, required bend radius, organic circuitry drive voltage and the one-time use of the device since the sensor material can be used only once. Thus, the use of a primary battery with specified parameters of voltage, current flow, defined capacity, and no requirement for recharging was seen as appropriate for this device. The main requirements for the battery were to drive a defined current at a defined voltage level for a defined period of time.

There are two scenarios described. The first one is to drive the application based on a Si circuit, the second one incorporates an organic semi-conductor instead.

Previous work has resulted in printed primary batteries of 3 V or 4.5 V, driving applications but at undetermined current levels (Espig et al., 2012; 2012a; 2012b). Alternative battery technologies are typically offered in the range of 1.5 V to 3.0 V (Savastano, 2011). However, 3.0 or 4.5 V batteries were investigated for driving a Si circuit prior to the development of the organic circuit (Willert, Hammerschmidt and Baumann, 2011). Analysis of the demands of the application driven by an organic circuit resulted in a voltage requirement of +/–15 V at a current of approximately 300 µA for about 5 - 10 minutes. Therefore the design, construction and manufacturing of such a high voltage battery were the particular objectives for this work.

To find a solution, two different setups were assessed against each other, before determining a qualified solution.

2. Methods

2.1 Initial considerations

For the battery fabrication employed in these investigations, only screen printing processes were used since the amount of energy is dependent on the amount of material within the battery. Only screen printing can deliver patterned layer thicknesses in the range of 20 to 100 µm, which results in adequate energy capacities.

Each cell of the battery delivers a nominal voltage of 1.5 $V_{nom.}$ (V_{nom} indicates the nominal voltage, the voltage level delivered by the chosen chemical system. This voltage level will vary depending on load and battery setup properties).

2.2 Investigation of stacked and lateral battery configurations

The basic approach of a battery is to have two current collectors (positive and negative), anode and cathode, and in between an electrolyte enabling the ion flow between both electrodes while the electrons are flowing in the circuit outside of the battery.

There are two basic approaches in arranging the electrodes geometrically: either side by side (i.e., lateral) or on top of each other (i.e., stacked) (Figure 1). The latter approach requires a separator layer between both electrodes to avoid any internal short circuit.

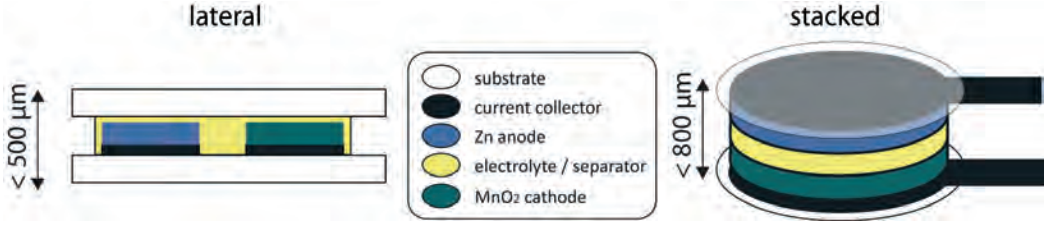

Figure 1: Basic printed battery configurations: lateral or stacked. In the stacked case, a separator layer is needed. (Willert et al., 2013)

For battery manufacturing, a substrate of 100 µm thickness of PET (polyethylene terephthalate) or PEN (polyethylene naphthalate) was chosen. Onto this, a conductive layer of carbon (Acheson Electrodag PF470C) was deposited by screen printing, followed by thermal curing. For the two electrode layers, printing inks were prepared consisting of raw metal grains and solvents. These inks were printed using a flatbed screen printer and dried after each printing step at temperatures below 120 °C due to the characteristics of the polymeric substrate. Thereafter, the battery cells were manually assembled employing an appropriate, chemical resistant glue tape.

During this assembly process, a gel electrolyte based on ZnCl was also added to the cell. In the case of the stacked battery, a porous paper was used as the separator.

A significant advantage of employing printing technology for manufacturing is, that a series connection of the batteries can be readily employed as depicted in Figure 2. Here, a setup of four single stacked cells, each delivering 1.5 V_{nom}, yielding up to 6.0 V_{nom}, is shown. The setups of the anode and cathode layers are interchanged in adjacent cells.

Therefore, interconnection can be achieved simply by using a common carbon current collector to connect the anode of one cell to the cathode of the adjacent cell. In case of 6.0 V_{nom}, these interconnections have to be done three times.

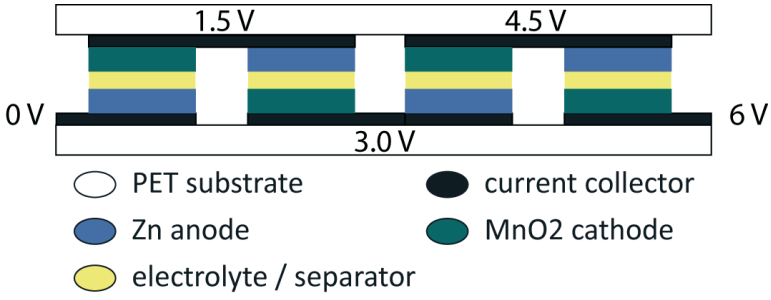

Figure 2: Basic setup for a series connection of four stacked batteries delivering 6 V_{nom} (Willert et al., 2013a)

2.3 Electrical characterisation of printed batteries

For the determination of the electrical properties, all batteries were discharged using a potentiostat/galvanostat (Biologic VMP3). Using this tool, a constant current was drawn from the battery according to the application's demands and the voltage level indicating the discharge behavior was recorded. The only limitation restricting the discharge experiments was the need to stay below a voltage level of 20 V. Therefore, the discharge characteristics for the +/–15 V batteries were done for each battery side separately.

2.4 Experiment design

The starting point of the investigations was a printed primary battery approach, delivering 3 V_{nom} and approximately a 200 µA current. On this basis, two sets of experiments were derived: one targeted to power the application controlled by an Si circuit (Figure 3a), the other to utilize an organic circuit (Figure 3b).

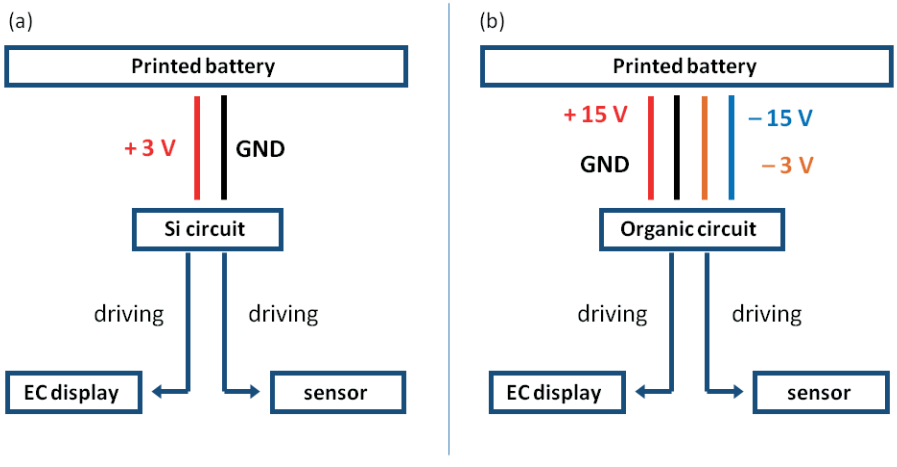

Figure 3: Block diagram for driving the measuring device employing (a) an Si or (b) an organic circuit

3. Results

3.1 Printed 3 V and 4.5 V batteries

The starting point of the investigations was a printed primary battery approach delivering 3 V_{nom} and approximately a 200 µA current. This approach had been optimized and adapted to the device under investigation. It was found that this battery approach was capable of driving 1 mA. A picture of such a manufactured cell is shown in Figure 4. Each battery cell has an electrode area of 6.8 cm².

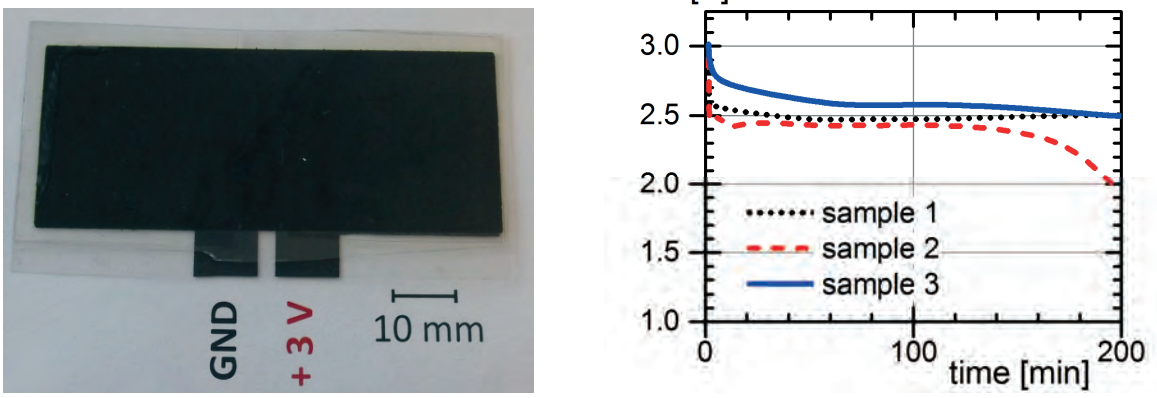

Figure 4: A 3 V_{nom} battery (left) and its discharge curve at 1 mA (right). (Willert et al., 2013a)

At a discharge current of 1 mA, the operating voltage decreased to 2.5 V (Figure 4) and was therefore not sufficient to drive the Si circuit. In Figure 4, the discharge curve of three 3 V_{nom} batteries are depicted. Due to the current of 1 mA and the internal resistance of the batteries, the resulting operating voltage level dropped to about 2.5 V. This voltage level was constant over a time period of at least 200 minutes. However, the intended application lifetime was only 5 - 10 minutes. Therefore, a battery of 4.5 V_{nom} was developed using a similar footprint (Figure 5). This type of battery was capable of delivering 1 mA of current at a voltage level of > 3.5 V and was therefore appropriate for the intended application of driving the Si circuit.

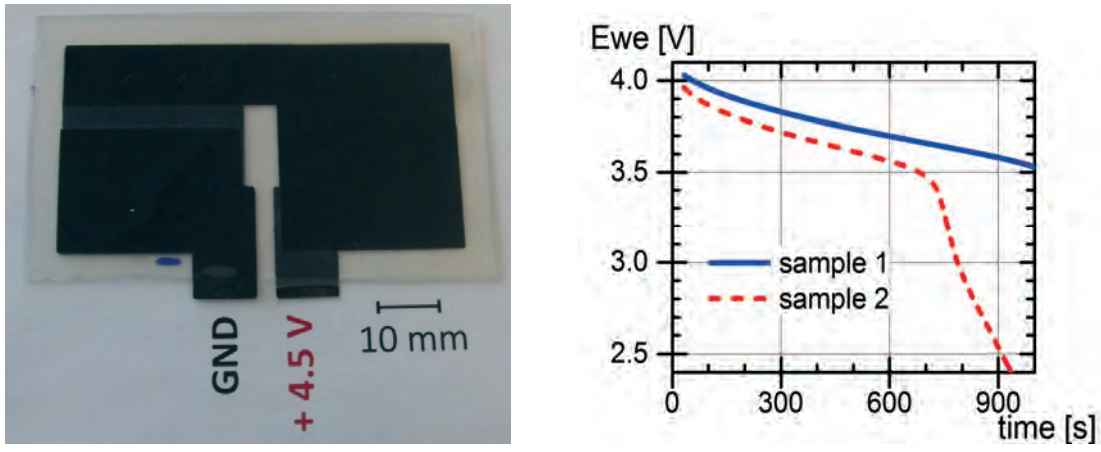

Figure 5: A 4.5 V_{nom} battery (left) and its discharge curve at 1mA (right). (Willert et al., 2013a)

There was little change in the footprint of these batteries as they went from two cells to three cells. To achieve a similar area for two batteries, the geometrical size of each electrode area of each cell was decreased from 6.8 cm² to 5.0 cm². In Figure 5 it can be seen that the rectangular cells on the left and right are interconnected at the top of the image by a third rectangular cell. This reduction in area was possible due to the fact that the original energy content had a significant surplus for driving the application and therefore it could be reduced in size and still supply the required energy. In Figure 5, the discharge curves of two 4.5 V_{nom} batteries are depicted. For these batteries, the voltage level decreased from 4.0 V to 3.5 V over a time period of more than 700 s (i.e., 11 minutes). This was sufficient for the intended application.

3.2 Printed 15 V battery

In the case of the 15 V batteries, which was the ultimate aim of this investigation, the research began with comparing the performance of lateral vs. stacked battery layouts.

The aim was to achieve this high voltage by increasing the number of batteries in series connection. The objective was to deliver approximately 300 µA at a voltage level of 15 V. In the end, for the requirement of +/–15 V, the application required a series connection of two such 15 V battery systems.

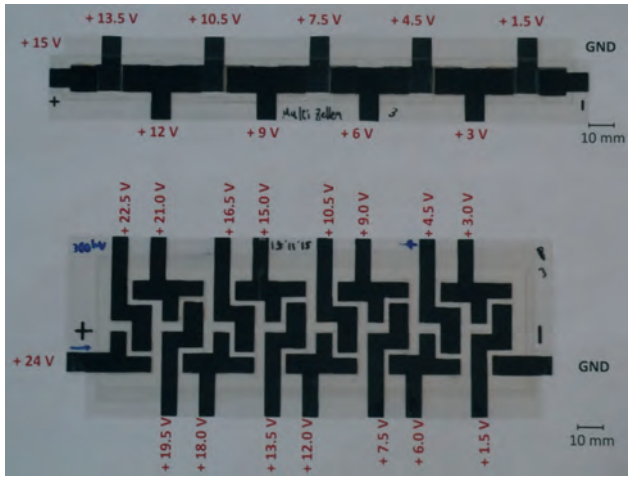

Figure 6: Series connection of 10 stacked cells (top) and 16 lateral cells (bottom) as intermediate research steps

In Figure 6, images of the two manufactured setup types are shown. In this design it was also possible to electrically contact every single battery cell by itself.

The top picture of Figure 6 shows 10 stacked cells (each electrode has an active area of 1 cm²) while the bottom picture shows 16 lateral cells (each cell has active areas of 0.36 cm² (Zn) or 0.90 cm² (MnO_2), respectively).

For the design of the lateral cells, preliminary investigations were performed to determine these appropriate electrode layouts, distances, and area sizes.

In Figure 7, the discharge curves of two 10 cell batteries (i.e., 15 V_{nom}) are shown. Both batteries were discharged at a current of 100 µA.

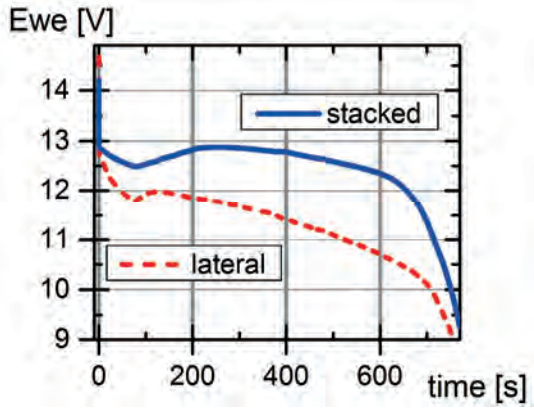

Figure 7: Discharge curves of 15 V_{nom} batteries at 100 µA discharge current (Willert et al., 2013a)

At the start of the discharge, both batteries showed an immediate drop in operating voltage from about 15 V to about 12.9 V because of the internal battery resistance.

During the discharge period of 12 minutes, the voltage level of the stacked battery remained significantly higher than that of the lateral approach which decreased during the entire test time.

During further investigations, the stacked type of battery was chained with 12 single cells delivering a nominal voltage of 18 V_{nom}. The discharge curve for a current of 300 µA is depicted in Figure 8. At the beginning of the discharge, a prompt drop from about 18 V_{nom} to about 17 V could be observed. After this initial stage the voltage decreased over more than 700 s to a voltage level of about 15 V.

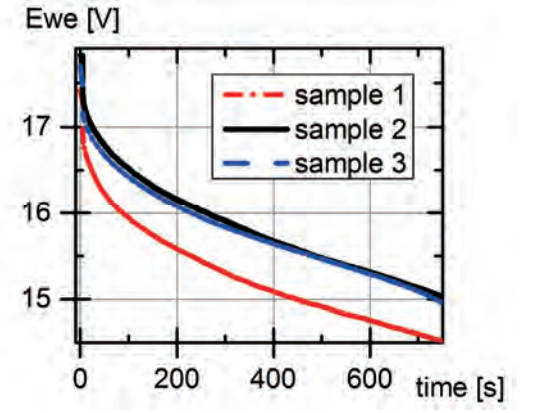

Figure 8: Discharge curve of 12 cells of stacked batteries at 300 µA discharge current (Willert et al., 2013a)

The conclusion of these discharge experiments was that a stacked setup of 11 battery cells was sufficient to drive a current of up to 300 µA at a voltage level of 14.9 ± 0.5 V (Figure 9).

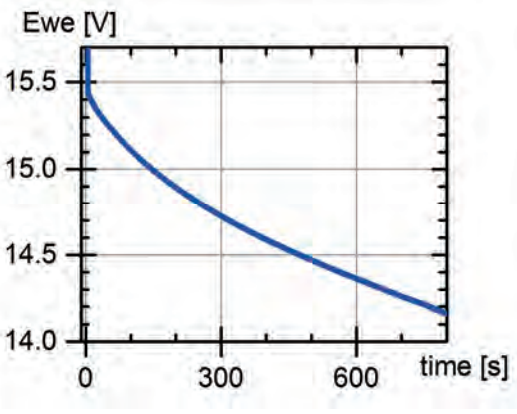

Figure 9: Discharge curve of 11 cells of stacked batteries at 300 µA discharge current

3.3 Printed +/–15 V battery

The previous results were the basis for the design and manufacturing for the +/–15 V battery in stacked setup. Having done some iterative research steps, the battery design depicted in Figure 10 was created and studied in detail.

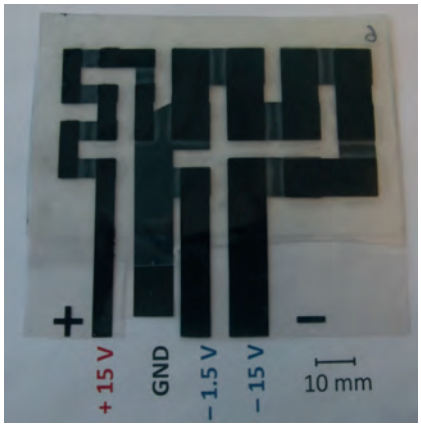

Figure 10: Image taken from the manufactured battery as research result for a +/–15 V series connection of stacked cells. The interconnecting lines are (bottom from left to right): +15V, GND, -1.5V, and –15V

For this battery (see Figure 3b) the calculated demands of the organic circuit were as follows: 11 µA at +15 V, 40 µA at -1.5 V and 300 µA at -15 V.

The results of the electrical measurements are given in Figures 11 through 13.

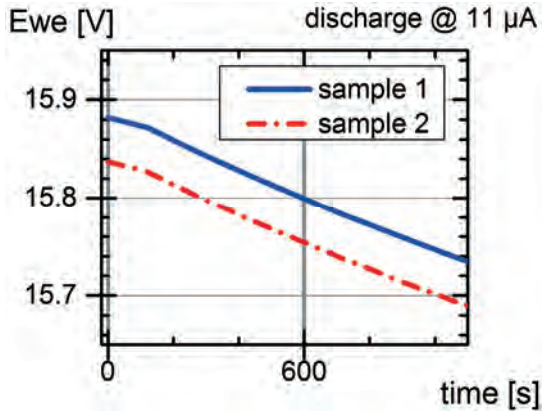

Figure 11: Discharge diagram for the +15 V power line

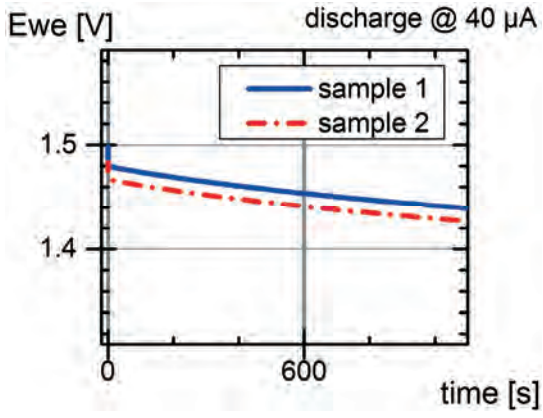

Figure 12: Discharge diagram for the - 1.5 V power line

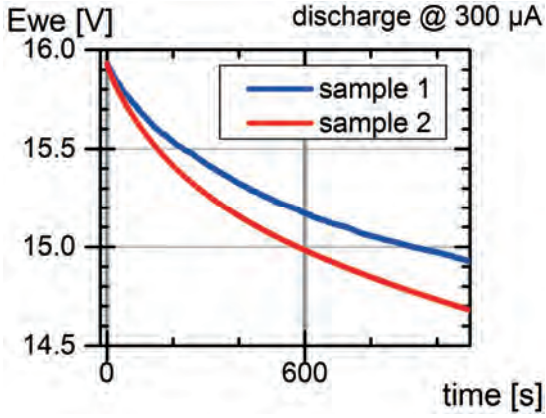

Figure 13: Discharge diagram for the -15 V power lines

4. Discussion

For the 3 V battery, the discharge curve (Figure 4) clearly shows that it was possible to increase the discharge current from 200 µA to 1000 µA - an increase by a factor of 5. In Figure 4, a dashed line (sample 2) is also presented showing a clear deviation from the other two curves. The drop of this line from about 2.5 V to a level of 2 V during about 200 minutes indicates that one of the two batteries was going to become discharged. It

can be seen that the manufacturing quality seems to be an issue for these individual samples of manually built batteries. In mass production or automatic manufacturing processes, an increase in quality is expected.

During the experimental investigations, it was determined that the Si circuit demanded > 2.7 V for proper operation. Therefore, a second development step was performed with the addition of a third battery cell (see Figure 5). In this case, the 4.5 V_{nom} battery maintained a voltage level of more than 3.5 V over a time period of more than 660 s (11 minutes), which was sufficient to drive the Si circuit. However, this period of time was longer than the intended application lifetime which was 5 - 10 minutes.

Investigations of the 15 V batteries revealed that, for the intended application, the stacked battery layout was more powerful than the lateral design (Figure 7). The operating voltage of the stack remained at a higher level and over a longer period of time. Therefore, further improvements were concentrated on the stacked layout.

Some further iterative optimization resulted in the battery design shown in Figure 10. Its discharge behavior is depicted in Figures 11 through 13.

For all three power lines, the requirements were met for the required time of >600 s. A decrease of the geometrical sizes of the battery cells for +15 V as well as for -1.5 V was also achieved (Figure 10).

Therefore, this battery layout with its discharge properties fulfilled the requirements of the intended application.

5. Conclusions

In this paper, studies on the production of printed batteries clearly show the potential of this type of energy supply for application in sensors and integrated smart systems. Battery performance can be readily customized, enabling specific power requirements such as the need for a 4.5 V battery to drive Si electronics, as well as a +/–15 V system to drive organic electronics, as demonstrated here. The requirements of driving a current of 1 mA by a 4.5 V_{nom} battery as well as driving a current of 300 µA by a 15 V battery were fulfilled. With the +/-15 V batteries, the more typical 6 V output of a printed battery has been multiplied by a factor of 5. The results of these investigations encourage evaluating this kind of batteries for similar types of applications.

Acknowledgment

The research leading to these results has received partially funding from the European Community's Seventh Framework Programme [FP7/2007-2013] under grant agreement no 257372.

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This paper is based on a preliminary version presented at the 40th International Research Conference of IARIGAI in Chemnitz, Germany, September 8-11, 2013.

Topicalities

Edited by Mladen Lovreček

Contents

News & more

First drupa Global Trends report

In their considering the future of the greatest world print and media trade show, the drupa team conducted a survey on the future of print and media sector. The results will be published in two separate reports based on answers provided by a representative panel consisting of leading executives from printers, suppliers and print purchasers from around the world, recruited primarily from the drupa 2012 visitor and exhibitor database. Messe Düsseldorf, in its role as drupa organiser, has appointed two independent consulting and market research companies Printfuture (UK) and Wissler & Partner (Switzerland) to conduct these two report series.

Some 2 500 decision-makers from across the globe (119 countries) participated in the survey in the fourth quarter of 2013 and answered the extensive questionnaire. The majority (58 %) came from print services providers, followed by suppliers (21%) and print purchasers (21%).

The first drupa Global Trends report provides analysis of the printing and media sector worldwide. Despite reporting significant regional variations, the "drupa Global Trends" report does reveal a number of critical and - sometimes surprising - trends that are shared by all economic regions and across print segments (Publishing Packaging and Commercial). As was to be expected, the report confirmed that the global printing industry's structural transformation is still ongoing, with increasing costs coupled with declining prices and shrinking margins. However, three other major findings of the study are more pivotal:

1. There are clear signs that economic conditions are improving. As a consequence the printing industry globally is planning increased investment over the next twelve months. Efficiency gains and the development of new services are driving investment in the industrialised world.

   North America is leading the way by gearing up for major transformation with high levels of investment in printing technology, IT and new services. In the emerging countries growing demand is the main driver.

2. The printing industry is in the midst of a transition from a product-driven industry to a service-driven one. The demand for new solutions and business models that better reflect the customer needs is clear.

3. As expected, digital printing plays an increasing role in the technology mix deployed. Among print services providers, 65 % produce using both conventional and digital methods and one-third of commercial printers already gain a quarter or more of their turnover from digital printing. But conventional printing (especially sheet-fed offset) continues to be an important pillar for the print sector. Planned investment reflects this point as 29 % of all printers say they intend to invest in sheet-fed offset printing.

Instead of paper, another practical use of wood

With the uncertain future of newspapers and the world market dropping down, Scandinavian paper manufacturer UPM turned their attention to another practical use of trees - UPM's Biofore concept car is made from and runs on wood.

A group of students from Helsinki's Metropolia University designed and built a vehicle showcasing the use of UPM biomaterials, thus replacing plastics with thermoformable wood - including the floor, console and door panels - and biocomposite (front mask, skirts, dashboard, door and interior panels). It runs on wood-based renewable diesel produced by the Scandinavian papermaker.

The car - a modified Morgan - was presented at the International Motor Show in Geneva in early March 2014.

A move to new technology

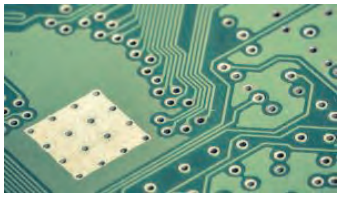
One of the world's most prestigious daily newspapers - *The Times* - has completed a move to new publishing technology. Publishing operations have switched to EidosMedia's Méthode platform, with the system also used for its online editions, weekly supplements and separate *Times Literary Supplement*. Other titles including the *Sunday Times* and *The Sun* are set to follow, with the platform set to serve a total of 1 500 journalists and editors.

THE TIMES

This huge investment in the paper's future, will improve the publishing operations, both in terms of the new software and the training and education program. The project will give the tools to get to grips with multiplatform journalism in the digital age.

Printed electronics - a fast growing industry

When the term 'printed electronics', is mentioned, the subject usually generates a nod of recognition and understanding, although confusion still surrounds its scope and applications.



Printed electronics can be defined as "a set of printing methods used to create electrical devices on various substrates. Electrically functional electronic or optical inks are deposited on the substrate, creating active or passive devices, such as thin film transistors or resistors. Printed electronics is expected to facilitate widespread, very low-cost, low-performance electronics for applications such as flexible displays, smart labels, decorative and animated posters, and active clothing that do not require high performance." (Wikipedia).

The majority of that business is in OLED displays used mainly in the form of illuminated displays for smartphones, as well as conductive inks employed for a wide array of applications such as PV "bus bars", touch screen bezels and antennas. There are many more emerging technologies and components, from stretchable electronics such as those used in sportswear, as well as memory and thin film transistors to printed and flexible sensors such as those used in biotechnology.

However printed electronics are defined, one thing is certain: it's a fast growing industry.

Partnership for inkjet imprinting

Following an agreement with Kodak, the German press maker manroland will cooperate closely on inkjet imprinting, thus covering Stream inkjet technology for web press systems The partnership enables manroland web systems to offer 'single source' imprinting solutions, and covers Kodak's Prosper S20 and S30 systems.

The overall impression, draw from the survey is that - in spite of turbulent maket and technology changes - global investment in the print industry will be stronger in the next 12 months as confidence returns.

In addition the reports will allow variations between the world's major economic regions to be analysed. Finally the insights gained will serve to further improve drupa's positioning. This first drupa Global Trends report provides an initial assessment of the state of the global print industry. In order to monitor the trends going forward, the survey will be repeated in the fourth quarter each year. In parallel drupa will publish a series of Global Insight reports that will offer detailed analysis into specific Industry-relevant topics. An Insights report on The Impact of the Internet on Print will kick off the series in June of 2014. The objective will be to show the effects of the Internet on e-commerce, digital marketing, mass customisation and IT on the world of print and illustrate how future strategies and business models need to adapt.

In these two report series, drupa will be able to offer first-rate, representtative market data and information that will enable the market players - be they providers of print services, suppliers or print purchasers - to make better strategic decisions.

Printing press manufacturer to face radical changes and restructuring

With the world market for web presses reduced by around 70 % and that for sheetfed presses halved in recent years, the prospect for recovery cannot be expected in the following years. The management of KBA, one of the world leaders in press production, has decided on the group's strategic realignment, comprising a package of measures aimed at strengthening long term profitability and future development potential.

KBA
Koenig & Bauer AG

The plan is a response to changes in the worldwide print industry's media sector, characterized by concentration processes among publishers and printers and overall reshaping of the print branch. The consequence is a continued reluctance to invest, which has led to significant excess capacities across the whole press manufacturing industry.

The attention will be focused on sustainable structural adjustments to secure core business activities, the optimization and concentration of value creation at the various locations, and changes to organizational structures within the entire group, placing a focus on future growth fields. KBA group is to be split into four autonomous divisions: for web and sheetfed business, manufacturing and special applications.

Production is being reorganized at the five European locations - Würzburg, Radebeul, Frankenthal, Mödling (Austria) and Dobruška (Czech Republic) - with closures and disposals not excluded, and headquarters administrative expenses to be reduced. These measures will affect between 1 100 and 1 500 jobs, while tens of millions of Euros will be written off.

This swift and radical restructuring are expected to facilitate development into a decentralized organization and highly flexible press manufacturing company which - complementing its core business - is active above all in profitable niche markets.

Digitally Modulated screening

Third generation of DM screening technology is a revolutionary new type of screening that enables both violet and thermal platesetters to produce images that emulate the quality of a traditional 200-400 lpi screen for newspaper printers (depending on CtP), whilst also producing rosette-free, moiré-free and noise-free flat tints that equal or better the smoothness of conventional screening, along with reduced ink consumption of between 10-20% on typical newspaper pages.

Auraia-6 Digitally Modulated Screening was developed by the UK based company Hamillroad. It utilizes ground-breaking technology in creating a unique product that is most accurately described as a fusion of the best characteristics of AM, FM, XM, GS and CS screening techniques, whilst avoiding their limitations and problems. By maximizing the lithographic plate and press properties of halftone screening, it dramatically enhances quality, stability and gamut, whilst offering ink savings over conventional technologies. Taking advantage of the immense computing power now available, DM screening is so named because it digitally modulates each and every pixel it produces, precisely controlling not only the dots in each separation, but also between the separations so as to completely eliminate noise. It does this through the use of a "stochastic rosette", which interleaves the screens in all the separations. By doing so, it eliminates noise (and moiré). The "stochastic rosette" also maximises the amount of ink-on-paper and minimizes the amount of ink-on-ink, which expands the available color gamut whilst eliminating color shifts on mis-registration.

The result of this is a quality of print, especially on violet devices that was previously unachievable. Based on years of research and experience, this advanced screening represents a fundamental change in the expectation a printer should have on the quality of print that is achievable. No longer are printers restricted by issues with moiré, mis-registration, rosette drift, color shifts, banding, dot gain, dot loss, shadow loss, etc... but they are free to do what they do best - print 'beautiful' pages.

Kodak - a new start

After facing turbulent times, Kodak has begun a new post-bankruptcy era under the slogan 'What's next starts now'. A new Board will lead the reorganized company, following completion of the final steps in the restructuring process

Kodak has emerged as a technology company serving imaging for business markets - including packaging, functional printing, graphic communications and professional services.

Kodak completed the final steps setting a trajectory for profitable growth. With the right technology at the right time as printing markets increasingly transition to digital, offering broad portfolio of offset, hybrid and digital solutions Kodak issued shares of a new class of common stock to participants in the rights offerings and will issue additional shares of this new class of common stock to unsecured creditors as provided in the plan of reorganization.

New wide-format printer series

Replacing and rebranding the former Designjet series, HP launched three smaller and lowest cost wide format printers under the new name Latex.

The 300 series now replaces the 260. The 360 in particular is twice the speed of the 260 for a similar price. The 330 and 360 are 64 inch printers, slightly wider than the 260.

The new 1.3 metre Latex 310 is particularly aimed at design studios, offices and man-in-garage users as well as anywhere that's short of space. These prospective customers may have an aqueous printer already and want to move into outdoor media, textile banners, self-adhesive labels and so on, but without the perceived disadvantages of eco solvent, which range from a mixed environmental message to having to wait for outgassing to subside before lamination and finishing. Another office-friendly aspect is that these printers are particularly quiet.

The 310 is one of three printers in the new Latex 300 family, which collectively replace the 61 inch Latex 260 (originally launched as the Designjet L26500 and renamed last year).

A survey of wide-format printing industry

Within their Profit for purpose program, FESPA launched the Global Census project, the world's largest data gathering project in the wide-format printing industry.

The information gathered - once analyzed and published - forms the backbone of how global organizations plan the development of their structure, train their staff, spot emerging trends and grow their business.

Census results will be published in form of a survey, twice yearly in March and September and in the core languages of FESPA's audience.

Hybrid web press system

For a variety of print jobs which involve regular repeat printing in high volumes, with personalization and distribution to targeted areas Goss has developed the new *M-600* web press with integrated inkjet. The new press is expected to improve productivity by as much as 85 % of specialized print jobs currently produced on sheetfed presses.

GOSS | INTERNATIONAL

The 16-page *M-600* model features *Autoplate* plate changing and configured as four units with a *Conti-web CS* zero-speed splicer, a *Goss Eco-cool* dryer, a JF-48 jaw folder and a VITS *Rotocut S* sheeter, all supplied by Goss.

Kodak inkjet heads are mounted inline, after the dryer to provide zoning and personalization capabilities. The new inline operation can deliver a much more streamlined, more efficient workflow, allowing maximize press uptime and better utilize sheetfed capabilities.

UV flatbed printer

As an addition to its stable of high-productivity UV flatbed inkjet printers Screen developed the 150 sqm/hour Truepress Jet W3200UV HS.

The Truepress Jet W3200UV HS (for "High Speed") is an exciting new machine that combines the renowned quality with outstanding productivity. Offering an output speed of 150sqm/hr, the the printer delivers almost double the productivity of the 85 sqm/hr previous version. The new model is a six colour + white device designed to meet the demands of the POS, signage and decor markets, with the ability to print onto a wide range of rigid and flexible media up to 3.2 x 1.6 m in size and up to a maximum 50 mm thickness.

The printer enables tremendous flexibility for added-value applications such as lenticular and multi-layer print at an even faster print throughput.

New solutions for industrial printing

A comprehensive solutions portfolio for the industrial printing sector will be introduced soon by ColorGate, that is for the last 10 years, delivering solutions for industrial printing applications.

ColorGATE

The new product is *CG SmartControl IP OS*, where IP OS stands for Industrial Printing Operating System The term Operating System refers to the wide control functions of *CG SmartControl IP OS*, which are covering all important system functions starting with, print data management and the data transmission to the print head controllers, the control of the ink supply system and the maintenance functions, right through to the monitorring of the motion systems via interfaces to all leading PLC's.

The core applications of *CG SmartControl IP OS* are *CG SmartControl Server* and *CG SmartControl Touch*. Basically, the main task of *CG Smart Control Server* is the in time print data preparation and transmission to the inkjet print heads. Currently print heads of the following manufacturers are supported: Fujifilm Dimatix, Konica Minolta, Kyocera, Ricoh, Seiko and Xaar, as well as the controllers of all leading manufacturers.

Via *CG SmartControl Touch* individual human machine interfaces (hmi) can be realized, which are typically controlled by the print-operator via touch screen. *CG SmartControl Touch* triggers all relevant parameters for the used application within the printing system. This contains machine control for the system preparation with functions such as nozzle control and cleaning and management options for positioning and prioritization of print jobs. Furthermore, *CG SmartControl Touch* is monitoring all connected sub-systems for example, the ink supply system, PLC's for transport and motions control as well as connected drying units (UV or IR).

The core product *Productionserver 8 (PS 8)* will be shown in the *PS8 Industrial Printing Edition*. By the connection of premium components Production server is able to deliver constant color reproduction results by meeting maximal productivity demands. The latest *Adobe PDF Print Engine 3* is the center piece of the Productionserver for the surprise-free and fast production for graphically-rich content.

PS8 Industrial Printing Edition stands out by the generic Industrial Inkjet driver. This driver is configurable to support all industrial printing systems and applications. It outputs halftone data (1bit or multilevel) for almost all color models and resolutions used in common file formats. The included *Profiler Suite (PFS)* allows creating color accurate print data for the Productionserver from established graphic documents (PDF, PS, TIFF, JPEG etc.). The *PS8 Industrial Printing Edition* contains all features to test and trial industrial printing systems right from the beginning of their development, in terms print quality expectations. Even output quality effects of alternative ink set usage are retrievable at an early testing stage with *PS8 Industrial Inkjet Edition*.

A flawed prepress workflow or inaccurate print data preparation within the printing system which are causing print quality limitations can be ruled out by using *PS8 Industrial Printing Edition* and moreover time and cost consuming troubleshooting processes can be significantly shortened.

The common objective of all mentioned offerings is to flexibly fast-track the development process of industrial printing projects until they become market-ready and to offer support after the completion.

Bookshelf

Handbook of Paper and Paperboard Packaging Technology

This book discusses all the main types of packaging based on paper and paperboard by providing in-depth coverage of all aspects of packaging which involve the most ecologically acceptable material, namely paper and paperboard. It considers the raw materials, the manufacture of paper and paperboard, and the basic properties and features on which packaging made from these materials depends for its appearance and performance. The manufacture of twelve types of paper and paperboard-based packaging is described, together with their end-use applications and the packaging machinery involved. The importance of pack design is stressed, as well as how these materials offer packaging designers opportunities for imaginative and innovative design solutions. Environmental factors, including resource sustainability, societal and waste management issues are addressed in a dedicated chapter.

The book is directed at readers based in companies which manufacture packaging grades of paper and paperboard, companies involved in the design, printing and production of packaging, and companies which manufacture inks, coatings, adhesives and packaging machinery. It will be essential reading for students of packaging technology and technologists working in food manufacturing who are users of paper and paperboard packaging products.

Handbook of Paper and Paperboard
Packaging Technology, Second edition
Editor: Mark J. Kirvan
ISSN: 978-0-470-67066-8
Publisher: Wiley-Blackwell, 2013
428 pages

The Anatomy of Type:
A Graphic Guide to 100 Typefaces

The Anatomy of Type explores one hundred traditional and modern typefaces in loving detail, with a full spread devoted to each entry. The full character set from each typeface is shown, and the best letters for identification are enlarged and annotated, revealing key features, anatomical details, and the finer, often-overlooked elements of type design.

Containing in-depth information on everything from the designer and foundry, the year of release, and the different weights and styles available, The Anatomy of Type is more than a reference guide to the intricacies of typeface design. It is a visual send-up of some of the world's most beloved typefaces, beautifully displayed in vibrant color.

The Anatomy of Type:
A Graphic Guide to 100 Typefaces
Authors: Stephen Coles and Tony Seldon
HarperCollins, 2012
ISBN: 978-0-062-20312 0
256 pages
Hardcover

Mechanics of Paper Products

Kaarlo Niskanen, Editor

Publisher:
de Gruyter, Berlin 2011
ISBN: 978-3-11025461-7
258 pages
Paperback

This book focuses on the mechanical properties and performance of products made of fiber-based materials such as paper and board. The book aims to help students develop effective skills for solving problems of product performance and engineering challenges in new product development. Therefore the material is organized with a problem-based approach - a practical example of product performance is presented and then the relevant mechanics are analyzed to deduce which material properties control the performance.

Paper and board specific topics such as loading and strength of board boxes, stress-strain behavior, fracture mechanics, creep and hygroexpansion and micromechanics of paper products, extension to biocomposites, etc.

The Future of Digital Print for Packaging to 2018

Publisher: Smithers Pira
October 2013
Formats: Hard copy, Digital copy, Online
259 pages
12 figures, 160 tables

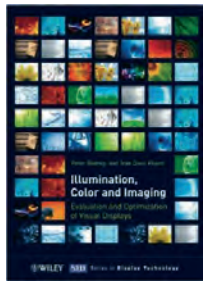
Printing and packaging markets and technologies are the areas of permanent expertise. Primary research for this report was based on many discussions with leading experts from the supply chain, the results of which were verified against secondary sources using a combination of expert knowledge and field research.

Globally, the market for digital printed packaging and labels continues to expand rapidly, driven by run length reduction, last stage customization, versioning and personalization, environmental factors and more. Smithers Pira forecasts that digital print for packaging will more than double from 2013 to 2018. The report provides a detailed explanation of these and other trends.

Illumination, Color and Imaging:
Evaluation and Optimization of Visual Displays

A part of the Wiley SID Series, this comprehensive and modern reference on display technology, illumination sources and color imaging focuses on visual effects and how reproduced images are best matched to human visual features.

As such, it explains readers how to exploit the knowledge of human color information processing to design usable, ergonomic, and pleasing displays or visual environments. The contents describe design principles and methods to optimize self-luminous visual technologies for the human user, including modern still and motion image displays, and indoor light sources. Design principles and methods are derived from the knowledge of the human visual system, with a special emphasis on color vision, color cognition, color harmony, color preference and visually evoked emotions. The expert authors include the most important and latest applications of the design principles and methods, forming a comprehensive view of human color information processing from the receptors through the retina via high-level visual perception right up to the level of cognition, preference, harmony, as well as visually evoked emotions.



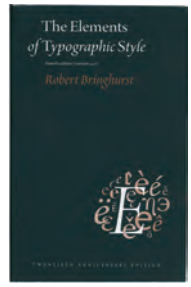
Illumination, Color and Imaging:
Evaluation and Optimization of Visual Displays
Authors: Peter Bodrogi and Tran Quoc Khanh
Publisher: Willey, 2012
ISBN: 978-3-527-41040-8
395 pages
Hardcover

The Elements of Typographic Style

Since its first edition in 1996, *The Elements of Typographic Style* has established itself as a standard in its field. Not only useful to graphic designers and those interested in the history of printed letterforms, it became the house manual at most American university presses, a standard university text, and a reference work in studios of designers around the world.

The author, Robert Bringhurst, brings clarity to the art of typography with this masterful style guide. Combining practical, theoretical, and historical, this book is a must for graphic artists, editors, or anyone working with the printed page using digital or traditional methods.

This book covers the design of individual characters and entire alphabets, as well as the layout of pages, including unusual typographic characters, such as the Croatian "dyet" and the German "sharp s".



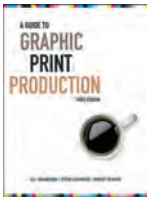
The Elements of Typographic Style
Author: Robert Bringhurst
Publisher: Hartley & Marks, Vancouver
4th Edition, 2013
ISBN 978-0881-792-065
382 pages
Paperback

A Guide to Graphic Print Production

Delivering information that reflects all aspects essential for understanding the ins and outs of digital printing, *A Guide to Graphic Print Production,* is an ideal resource for professionals of graphic design, print production, visual communication and production technology.

All graphic designers and illustrators must be familiar with the steps involved in preparing their work for publication. The fully revised third edition of the most comprehensive and up-to-date reference on print production reflects the latest technology and trends. *A Guide to Graphic Print Production* is the complete guide to the entire process of print production, from the early stages of conception and planning, to the technical stages of manufacturing and off-press processing. Structured around the graphic print production flow, essential material is included for all aspects of the process including coverage of computers, color management, layouts, digital images, image editing, prepress, paper, printing, finishing and binding, legal issues, environmental issues and much more.

This practical reference book is organized in ten chapters, covering the entire production process, from conception to manufacturing to archiving. New topics are added, such as variable data printing, large/wide format printing, sustainability, inks, color management etc. The book is richly illustrated, with updated images and screenshots, and includes sidebars offering design tips, troubleshooting hints, and key points to consider for every stage of design.



A Guide to Graphic Print Production, 3rd Edition
Authors: Kaj Johansson, Peter Lundberg, Robert Ryberg
Publisher: Willey, November 2012
ISBN: 978-0-470-90792-4
400 pages

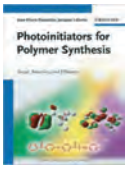
Interaction of Color

One of the most influential books on color ever published, *Interaction of Color* is a masterwork in art education. Conceived as a handbook for artists, instructors and students, this exceptional book presents author's unique approach to complex principles and singular explanation of complex color theory principles. Originally published by Yale University Press in 1963 as a limited silkscreen edition with 150 color plates, *Interaction of Color* first appeared in paperback in 1971, featuring ten color studies, and has remained in print ever since. With over a quarter of a million copies printed its various editions since 1963, *Interaction of Color* remains an essential resource. This new edition is published to celebrate the 50th anniversary of the first one; it presents a significantly expanded selection of close to sixty color studies alongside author's original text, demonstrating such principles as color relativity, intensity, and temperature; vibrating and vanishing boundaries; and the illusion of transparency. This landmark edition will find new audiences in studios and classrooms around the world.

Interaction of Color
Author: Josef Albers
Publisher: Yale University Press
50th Anniversary edition, July 2013
ISBN: 978-0-300-17935-4
Two-volume paperback

Photoinitiators for Polymer Synthesis: Scope, Reactivity, and Efficiency

Authors: J. P. Fouassier, J. Lalevée



Publisher: Willey-VHC, 2012
ISBN: 978-3527332106
494 pages
Hardcover

Photoinitiating systems have a key role in many polymerization reactions widely encountered in a variety of traditional and high-tech sectors, such as radiation curing, laser imaging, micro electronics, optics and medicine.

This book extensively covers radical and nonradical photoinitiating systems The four parts present the basic concepts of photopolymerization reactions, review all of the available photoinitiating systems and deliver a thorough description of the encountered mechanisms.

This book allows the reader to gain a clear understanding by providing a general discussion of the photochemistry and chemistry involved. The most recent and strong developments in the field, as well as the promising prospects for new applications are outlined.

Letterpress Now:
A DIY Guide to New & Old Printing Methods

Author: Jessica White

Publisher: Lark Crafts,
1st edition 2013
ISBN-13: 978-145470329-7
176 pages
Paperback

Letterpress printing may be technologically obsolete, but the reports of it continues to grow in popularity as a hobby, and also as a specialty printing service.

This book is a contemporary how-to reference on letterpress, a traditional craft that's experiencing a great resurgence. Not only does *Letterpress Now* explain how to use a variety of presses, it also covers an wide range of techniques, all with step-by-step photos: setting metal and wood type, lino/relief block prints, photopolymer plates, die-cuts, and more. Many conspicuous projects, from cards and calendars to posters and business cards - plus features on some of the best letterpress artists and community print shops - make this guide essential.

Bookshelf

Academic dissertations

Doctoral thesis - Summary

Author:
Bertrand Quesne

Speciality field:
Fluid mechanics, Energy, Processes

Supervisors:
Didier Chaussy, Nadège Reverdy Bruas and Davide Beneventi

Defended:
5 December 2013 at INP Pagore/LPG2 Grenoble, France

Contacts:
didier.chaussy@pagora.grenoble-inp.fr
Nadege.Reverdy@pagora.grenoble-inp.fr
davide.benveneti@pagora.grenoble-inp.fr

Design, processing and characterization of innovative functional bio-nano-materials for packaging

The present work investigates the potential of microfibrillated cellulose (MFC) coated onto cellulosic substrates as controlled delivery system (CDS) of antibacterial molecules for food-packaging.

Two coating processes and three substrates were compared. MFC was coated onto paper and cardboard substrates, enhancing their air resistance and bending stiffness with a minimum coat weight of 8 g/m². Microscopic analyses at nanoscale underlined the nanoporous MFC network preserved onto the substrate surface even after coating.

For the first time, this network was used as CDS of various molecules and proved its efficiency by releasing molecules more progressively and over a longer period. The antibacterial activity was effective against nonpathogenic bacteria, leading to the improvement of the food shelf-life. The application of this new material was broadened up by using simultaneously cyclodex-trins and MFC, which also led to very promising results.

This PhD proposing 8 articles in scientific journals, paves the way for new high-added value applications in the field of controlled delivery systems by using MFC-based materials, within active packaging or medical fields.

Doctoral thesis - Summary

Author:
Nathalie Lavoine

Speciality field:
Materials, Mechanical, Civil Engineering, Electrochemistry

Supervisors:
Julien Bras and Isabelle Desloges

Defended:
15 November 2013 at INP Pagore/LPG2 Grenoble, France

Contacts:
julien.bras@pagora.grenoble-inp.fr
isabelle.desloges@pagora.grenoble-inp.fr

Study of the marbling phenomenon on flexible PVC printed in rotogravure

The objective of this thesis is to study a recurrent printing defect when industrial printing of PVC flooring, the marbling. This defect appears randomly in the printing production line with variable levels. It appears like a textured print instead of normally uniform solid print which generates many nonconformities of the products. The purpose of this work is to understand the origin of the phenomenon of marbling in order to identify the cause(s).

To achieve this objective, it was necessary to develop a reliable and non-subjective tool to quantify the defect based on an image analysis technic. This was used to study the main parameters that may be the cause of the marbling: the substrate wettability, the printing process parameters as well as the inks properties (surface tension, rheology).

All of this work has highlighted the role of the formulated inks flow threshold, the phenomenon being linked to instabilities like Saffman-Taylor type raising in the cleavage of the ink film during the printing step of the flooring.

The Journal of Print and Media Technology Research will publish summaries of high quality academic thesis within the scope of the journal. Short summaries should be submitted to <journal@iarigai.org> by the thesis supervisor. Information on type and field of the thesis, author, supervisor, date and university of defense or presentation, as well as on how the full thesis can be obtained must be provided.

Events

21st International Book Festival

Budapest, Hungary
24 to 27 April 2014

International Book Festival Budapest is a recognized event of the international world of books, as one of the important professional and intellectual forums of the region. The Book Festival awaits its visitors at Millenáris, which provides a rich cultural milieu, a modern atmosphere, an even smarter exhibition area and very good accessibility. International Book Festival traditionally invites the most renowned authors of the world.

International Book Festival Budapest hosts representtatives of world literature and of domestic intellectual life (about 100 authors from 25 countries, more than 400 Hungarian authors, scientists and artists) and offers a wide range of cultural programs, such as meetings with authors, signings sessions, book premiers and presentations, roundtable discussions, concerts, theatre performances, exhibitions and films.

The Book Festival is also a professional and business forum, where trade meetings, conferences and lectures are held on the key issues of the book market and of reading habits. Librarians' Club, the professional event of librarians is one of the special features of the Book Festival. International Book Festival Budapest is a major fair with about 60 000 visitors annually, about 50 000 titles and hundreds of new publications. Gyerek(b)irodalom (Children's Lit Kingdom) is organized especially for children to satisfy the interest and needs of young generations with promotion of children's books and special programs for kids.

Book World 2014

Prague, Czech Republic
15 to 18 May 2014

Each year the themes of the fair are informed by readers' current interests, literary subgenres and the context of the international book market and literary scene. This year's fair will present the following pro-gram blocks:

History As Reflected in Literature: Many publishers have historical literature on their lists. Book World will offer a forum to historical novelists and their publishers. A discussion on developments in literature in post-communist countries since the fall of the Berlin Wall will take in cooperation with Index on Censorship magazine and other partners.

The Many Faces of the Book: At a time when forms of the book are subject to dynamic evolution, he development in book design through history will be highlighted, right up to the digitization of print and the use of modern technologies for electronic and audio-visual access to literary texts. Events will include a ten-year retrospective exhibition of award-winning books from the Most Beautiful Czech Books of the Year competition. Visitors can also look forward to a large display of the wares of antiquarian booksellers.

Grafik'Art

Montreal, Quebec, Canada
7 to 9 May 2014

The 8th Grafik'Art show is a reference for all professionals in the graphic, binding of the ink, presses to printers, paper to computer, display to printers, the exhibitors will have the use of more than 120 000 square feet to display their newest products and services for an attentive and selected audience. This event meets a strong need in Quebec, which is in the forefront in creating graphics, editing and printing, across North America and internationally.

The event will offer tailor-made training on topics that are in the forefront in these sectors: Pre-press and Press techniques, Sales and marketing and Management. Furthermore, the Conference on future opportunities and special event and meeting will be organized as well.

Afro Packaging

Cairo, Egypt
19 to 21 June 2014

Afro Packaging Exhibition is the gate to the Egyptian and the African Market. Afro Packaging is the largest and the most recognized packaging & processsing exhibition in Egypt and North Africa. Featuring over 300 exhibitors every year, Afro packaging unites the local and international brand producers. The annual fair provides the exhibitors with an invaluable platform to share their products, develop and increase their business on an area of 12 000 m^2.

The market in Egypt is concentrated primarily in the rapidly growing food processing, pharmaceutical, and chemical manufacturing industries. Packaging equipment for the food processing industry represents 50 % of the total market, opening up huge opportunities for international business.

FESPA Digital and FESPA Fabric

Munich, Germany
20-23 May 2014

As the leading wide format digital print exhibition, which will be the biggest to date, visitors will have the chance to see the latest technological developments from hundreds of international manufacturers.

Regardless of the primary print business activity, FESPA Digital will provide printers with a wide range of opportunities to dive deeper into digital.

Some of the 400 exhibitors will exclusively launch the very latest machinery and consumables at FESPA Digital for visitors to view and test.

The event will enable visitors to access a number of seminar sessions, workshops, and showcases that will for sure generate new ideas for print businesses.

The exhibition will showcase the finalist in the newly designed annual FESPA Awards covering a range of categories.

At the same time, also in Munich, FESPA Fabric 2014 will be organized. It is intended for textile print professionnals, retailers, designer labels, clothing brands to see the latest developments from within the industry and stay up-to-date with the hottest trends. The show is returning to Munich where it was first launched in 2010. Since then FESPA Fabric has established its presence within the industry by hosting some of the biggest names from within the market place and also offering inspiring educational content to visitors at the show.

Visitors will gain access to the latest, most innovate technology for garment decoration and textile print from around the world. Technologies on display will include: Direct to Garment, Digital textile printing, Sublimation, Screen printing, Embroidery, Heat transfer and vinyl, Blank Apparels and Promotional Products, Rhinestones and more.

Fantasy & Sci-fi: The next instalment in a comprehensive program event dedicated to bestselling genres has been prepared in cooperation with the Academy of Fantasy, Sci-fi and Horror and the magazines Pevnost and XB-1. It will include readings, exhibitions, discussions and a common sales point for publishers with a major interest in this theme. A special area will be reserved for events focused on fantasy and sci-fi.

PrintPack India

30 May to 1 June 2014
Ludhiana, Punjab, India

This b2b exhibition runs through the upstream and downstream of all kind of printing & packing industry in order to showcase a comprehensive picture of the up to date market trends which lead the rapid development of the Indian markets. This show will provide an ideal platform to the interested customers across the country for direct sourcing of consumer products from leading manufacturers and suppliers.

India's leading exhibition is intended as an opportunity to accelerate the business growth in the related industry.

The show will target the visitors from printing and packing industry within North India to visit the show. The show will be prominently promoted to fetch thousands of target customers to promote major manufacturers and suppliers of printing and packing machinery and related materials. Over 45 000 visitors are expected to attend the show.

Symposium of Information and Graphic Arts Technology

5 to 6 June 2014
Ljubljana, Slovenia

University of Ljubljana, Faculty of Natural Sciences and Engineering organizes the 7th edition oft his traditional international symposium, which will be combined with the EcoPaperLoop event - conference on improving the quality of paper for recycling. The conference will be supported by iarigai - The International Association of Research Organizations for the Information, Media and Graphic Arts Industries and IC, the International Circle of Educational Institutes for Graphic Arts, Technology and Management.

The symposium is expected to bring a number of high-quality presentations, selected and evaluated by prominent international experts in the corresponding fields.

The symposium will address the following topics: New materials, Quality control, Graphic and media design, Marketing, Printed electronics, Printing technology, Interactive media, Advances in printed communication, Innovative packaging and Typographic design.

Digital Print for Packaging USA

Atlanta, GA, USA
5 and 6 June 2014

Digital printing technology is going from strength to strength in the packaging market as brand owners and converters begin to realize and utilize its inherent benefits. A new report from Smithers-Pira, The Future of Digital Printing to 2024, predicts that digital print will grow by 225 % based on its 2013 value.

So, what can digital print offer both brands and consumers, and what are the challenges yet to be faced in terms of widespread adoption? Some of the answers - if not all - can be found at the forthcoming Digital Print for Packaging conferences. Besides its European edition, Smithers-Pira is regularly organizing an event on the same topic in the United States.

Many prominent expert speakers already confirmed their participation, among them Brandi Parker (Pearlfisher), Jared Smith (Blue Media), Bill Baxter (Inca Digital Printers), Kristof Dekeukelaere (Landa Digital Printing), Sean Smyth (Smithers Pira) and others. All major manufacturers will join the adjacent exhibition, presenting their latest technology and service solutions.

European version of the Digital Print for Packaging is scheduled for December 2014 in London, UK, and more details on the program will be revealed soon.

South African Book Fair

Cape Town, South Africa
13 to 15 June 2014

The well-known Cape Town Book Fair will return to the original venue in 2014 but this time as the South African Book Fair. Scheduled to take place from 13 to 15 June, the country's now national book fair, provides not only unique and interesting insights into the publishing world but also a premier platform for the literary, publishing and all stakeholders in the book value chain to gather and trade, network and exhibit.

By re-establishing the Fair as a national one, it will do much to draw increased interest from current participants from a location point of view. In addition, it is targeting increased participation from brand new stakeholders for whom the Fair previously may not have been seen as a beneficial platform.

Plans to change the fair model from a business entity to a non-profit one. The new non-profit model will allow greater participation from government, thereby increasing the possibility of available funding to assist emerging local authors and publishers to establish themselves on the global stage. Furthermore, with Africa a key focus for many international delegates that attend our Fair, from a trade perspective it makes sense to have the flexibility to host the fair in all major centers around the country. This makes it both a convenient and affordable destination and will draw a greater number of African based exhibitors.

While the fair will move towards a non-profit model, it will retain some of the commercial imperatives that have established it as the pre-eminent book fair in sub-Saharan Africa.

World Newspaper Congress
World Editors Forum
World Newspaper Advertising Forum

Torino, Italy
9 to 11 June 2014

The newspaper industry is now going through a process of transformation, but still plays a significant role. based in Paris, France, and Darmstadt, WAN-IFRA, Germany, as the global organization of the world's newspapers and news publishers selected Torino, Italy as a most appropriate venue to host the traditional annual summit meetings. Alongside the 66th World Newspaper Congress, the 21st World Editors Forum, the 24th World Advertising Forum Info Services Expo will present innovative solutions from the international suppliers community, giving an overview of the technical solutions that drive the news publishing business today. From showing the latest trends in tablet publishing, editorial systems, digital services, the offerings from content providers as well as news agencies, up to the latest developments in printing technology.

The congress will discuss some of the currently hottest topics:

- The potential growth in digital revenues
- How to navigate the digital disruption
- Innovation: from ideas to impact
- The exponential growth of video and mobile
- How to engage with the new social-local-mobile consumers
- The tablet miracle
- Best practices to build new services based on customer insights
- Performance based advertising
- Native advertising and brand extension

Newsrooms is permanently changing. Being first and accurate with news online matters. Managing these diverse demands, with limited resources, can be challenging. World Editors Forum will introduce the new tools, new thinking and new newsroom technology to influence quality of the fast and slow news.

Call for papers

The Journal of Print and Media Technology Research is a peer-reviewed periodical, published quarterly by iarigai, the International Association of Research Organizations for the Information, Media and Graphic Arts Industries.

Authors are invited to prepare and submit complete, previously unpublished and original works, which are not under review in any other journals and/or conferences.

The journal will consider for publication papers on fundamental and applied aspects of at least, but not limited to, the following topics:

- Printing technology and related processes

  Conventional and special printing; Packaging, Fuel cells and other printed functionality; Printing on biomaterials; Textile and fabric printing; Printed decorations; Materials science; Process control

- Premedia technology and processes

  Color reproduction and color management; Image and reproduction quality; Image carriers (physical and virtual); Workflow and management

- Emerging media and future trends

  Media industry developments; Developing media communications value systems; Online and mobile media development; Cross-media publishing

- Social impacts

  Environmental issues and sustainability; Consumer perception and media use; Social trends and their impact on media

Submissions for the journal are accepted at any time. If meeting the general criteria and ethic standards of scientific publishing, they will be rapidly forwarded to peer-review by experts of high scientific competence, carefully evaluated, selected and edited. Once accepted and edited, the papers will be printed and published as soon as possible.

There is no entry or publishing fee for authors. Authors of accepted contributions will be asked to sign a copyright transfer agreement.

Authors are asked to strictly follow the guidelines for preparation of a paper (see the abbreviated version on inside back cover of the journal). Complete guidelines can be downloaded from:

http://www.iarigai.org/publications/

Papers not complying with the guidelines will be returned to authors for revision.

Submissions and queries should be directed to:

journal@iarigai.org or office@iarigai.org

Guidelines for authors

Authors are encouraged to submit complete, original and previously unpublished scientific or technical research works, which are not under review in any other journals and/or conferences. Significantly expanded and updated versions of conference presentations may also be considered for publication. In addition, the journal will publish reviews as well as opinions and reflections in a special section.

Submissions for the journal are accepted at any time. Papers will be considered for publishing if meeting the general criteria and ethic standards of the scientific publication. When preparing a manuscript for JPMRT, please strictly comply with the journal guidelines, as well as with the ethic aspects. The Editorial Board retains the right to reject without comment or explanation manuscripts that are not prepared in accordance with these guidelines and/or if the appropriate level required for scientific publishing cannot be attained.

A - General

The text should be cohesive, logically organized, and thus easy to follow by someone with common knowledge in the field . Do not include information that is not relevant to your research question(s) stated in the introduction.

Only contributions submitted in English will be considered for publication. If English is not your native language, please arrange for the text to be reviewed by a technical editor with skills in English and scientific communication. Maintain a consistent style with regard to spelling (either UK or US English, but never both), punctuation, nomenclature, symbols etc. Make sure that you are using proper English scientific terms.

Do not copy substantial parts of your previous publications and do not submit the same manuscript to more than one journal at a time. Clearly distinguish your original results and ideas from those of other authors and from your earlier publications - provide citations whenever relevant. For more details on ethics in scientific publication, please consult:

http:// www.elsevier.com/ethicguidelines.

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B - Structure of the manuscript

Title: Should be concise and unambiguous, and must reflect the contents of the article. Information given in the title does not need to be repeated in the abstract (as they are always published jointly).

List of authors: i.e. all persons who contributed substantially to study planning, experimental work, data collection or interpretation of results and wrote or critically revised the manuscript and approved its final version. Enter full names (first and last), followed by the present address, as well as the e-mail addresses.

Separately enter complete details of the corresponding author - full mailing address, telephone and fax numbers, and e-mail. Editors will communicate only with the corresponding author.

The title of the paper and the list of authors should be entered on a separate cover page (numbered as 0). Neither the title nor the names of authors can be mentioned on the first or any other following page.

Abstract: Should not exceed 500 words. Briefly explain why you conducted the research (background), what question(s) you answer (objectives), how you performed the research (methods), what you found (results: major data attained, relationships), and your interpretation and main consequences of your findings (discussion, conclusions). The abstract must reflect the content of the article, including all the keywords, as for most readers it will be the major source of information about your research. Make sure that all the information given in the abstract also appears in the main body of the article.

Keywords: Include three to seven relevant scientific terms that are not mentioned in the title. Keep the keywords specific. Avoid more general and/or descriptive terms, unless your research has strong interdisciplinary significance.

Abstract and keywords should be entered on a separate page, numbered as page 1. Do not continue with the main body of the text, regardless of the possible empty space left on this page.

Introduction and background: Explain why it was necessary to carry out the research and the specific research question(s) you will answer. Start from more general issues and gradually focus on your research question(s). Describe relevant earlier research in the area and how your work is related to this.

Methods: Describe in detail how the research was carried out (e. g. study area, data collection, criteria, origin of analyzed material, sample size, number of measurements, equipment, data analysis, statistical methods and software used). All factors that could have affected the results need to be considered. Make sure that you comply with the ethical standards, with respect to the environmental protection, other authors and their published works, etc.

Results: Present the new results of your research (previously published data should not be included). All tables and figures must be mentioned in the main body of the article, in the order in which they appear. Do not fabricate or distort any data, and do not exclude any important data; similarly, do not manipulate images to make a false impression on readers.

Discussion: Answer your research questions (stated at the end of the introduction) and compare your new results with the published data, as objectively as possible. Discuss their limitations and highlight your main findings. At the end of Discussion or in a separate section, emphasize your major conclusions, specifically pointing out scientific contribution and the practical significance of your study.

Conclusions: The main conclusions emerging from the study should be briefly presented or listed, with the reference to the aims of the research and/or questions mentioned in the Introduction and elaborated in the Discussion.

Introduction, Methods, Results, Discussion and Conclusions - as the scientific content of the paper - represent the main body of the text. Start numbering of these sections with page 2 and continue without interruption until the end of Conclusions. Number the sections titles consecutively as 1, 2, 3 ..., while subsections should be hierarchically numbered as 2.1, 2.3, 3.4 etc. Use Arabic numerals only.

Note*: Some papers might require different structure of the scientific content. In such cases, however, it is necessary to clearly name and mark the appropriate sections.*

Acknowledgments: Place any acknowledgments at the end of your manuscript, after conclusions and before the list of literature references.

References: The list of sources referred to in the text should be collected in alphabetical order on a separate page at the end of the paper. Make sure that you have provided sources for all important information extracted from other publications. References should be given only to documents which any reader can reasonably be expected to be able to find in the open literature or on the web. The number of cited works should not be excessive - do not give many similar examples. Responsibility for the accuracy of bibliographic citations lies entirely with the authors.

Please use only the Harvard Referencing System. For more information consult, e. g., the referencing guide at:

http:// libweb.anglia.ac.uk/referencing/harvard.htm.

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Appendix: If an additional material is required for better understanding of the text, it can be presented in the form of one or more appendices. They should be identified as A, B, ... etc., instead of Arabic numerals.

Above sections are supplementary, though integral parts of the Scientific content of the paper. Each of them should be entered on a separate page. Continue page numbering after Conclusions.

C - Technical requirements for text processing

For technical requirement related to your submission, i.e. page layout, formatting of the text, as well of graphic objects (images, charts, tables etc.) please see detailed instructions at http:// www.iarigai.org/publications/journal.

D - Submission of the paper and further procedure

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Your paper will be forwarded for anonymous evaluation by two experts of international reputation in your specific field. Their comments and remarks will be in due time disclosed to the author(s), with the request for changes, explanations or corrections (if any) as demanded by the referees. After the updated version is approved by the reviewers, the Editorial Board will consider the paper for publishing. However, the Board retains the right to ask for a third independent opinion, or to definitely reject the contribution. Printing and publishing of papers once accepted by the Editorial Board will be carried out at the earliest possible convenience.

1-2014

Journal of Print and Media Technology Research

A peer-reviewed quarterly

The journal is publishing contributions in the following fields of research:

- Printing technology and related processes
- Premedia technology and processes
- Emerging media and future trends
- Social impacts

For details see the Mission statement inside

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