ANALYSING THE ICT – PAPER INTERPLAY AND ITS ENVIRONMENTAL IMPLICATIONS

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Executive summary

This report studies the interplay between the use of paper and of information and communication technology (ICT). The aim is to explore how these two products/services can be compared from an environmental point of view. Similarities, differences and functions of ICT and paper are analysed in order to address the question: what are the environmental implications from substituting the use of paper with ICT, and vice-versa? As paper and ICT services are currently and to large extent are used complementarily, the report also discusses the perspective of how these services could co-exist.

Taking into consideration the complexity of both sectors, the report looks not only at the impact of one ICT application versus one type of paper use, but three – substitution, generation and complementary use. Three ICT applications have been selected for an in-depth study, on:

- service – traditional delivery mail versus communication using electronic e-mail;
- technology – the e-book reader that is undergoing a rapid development; and,
- concept – higher education being an early adaptor of technology.

Using results of LCA comparisons

Comparisons of the environmental impact throughout the life-cycle chain between ICT applications and paper products can be made using life cycle assessment (LCA) studies. The studies referred to in this report revealed that paper has its biggest environmental impact in manufacturing, transportation and storage. However, interpretations of the results need to be made with careful consideration as a number of methodology-technical issues must be taken into account.

When comparing LCA results of products and/or services stemming from different types of functional systems, the results need to differ largely, preferably in orders of magnitudes, if we are to conclude that one option is more environmentally preferable than the other. The challenges when comparing LCA studies, include LCA border setting, the assumptions made, the availability and quality of the input data, rapidly changing markets and products/models as well as prevailing rebound effects.

Will paper products be a more preferable alternative?

The inter-correlation between ICT use and paper consumption is complex although some predictions about future trends can be made. In a future where environmental performance is a key success factor and a situation where a choice can be made between a paper product and a digital alternative, when would then the paper alternative be the preferable alternative?

- Some paper products which have ICT alternatives are here to stay, at least for the foreseeable future. The paper product can compete with its counterparts when:
  - the paper alternative is the cheapest, most cost-effective one;
  - the characteristics and functionality of paper is superior;
  - the intrinsic value of the paper product is high;
  - the environmental impact of the paper option is considerably less.
- Some traditional paper based products could be marginalised by ICT services e.g. where paper items are used for plain reporting, storing, and non-personal messages.
• Old habits die hard; people who are accustomed to using paper products are likely to stick to their habits.
• Increased focus on environmental issues, promoting paper alternatives in case they have clear environmental advantages (and vice versa for the digital alternatives). Stronger pressure to reduce natural resource consumption and resource intensity. The scarcity of raw materials and related policy options will be crucial in the future. This raises the issue of sustainable consumption for both industries.

**ICT and paper co-existence**

The three cases suggest that after a period of parallel growth of both paper products and the equivalent ICT applications, the substitution effect of ICT will start reducing the use of paper. However, in most cases the two options will be available, sharing overlapping functional areas. The rationale for selecting one over the other of the two services is dependent on both contextual and situational factors and is largely an optimisation exercise considering many parameters. Environmental and social performances are parameters of increasing weight in the selection process.

Digital and traditional paper based versions can provide the same or equivalent service, side by side. However, the “service” will develop and expand, in reaction to changing conditions and demands. As the digital alternatives are more rapid and versatile in this process, it will likely lead to a gradual shift towards the digital alternatives. But complementary options will probably last longer. The traditional paper version of a service will, in many cases, be transformed into a digital format and then re-materialised as a print-out. The three cases mentioned in this report – sending mails, publishing books or providing educational material – are all functions that will build on product-service systems consisting of a combination of paper and digital services.

**Recommendations**

The paper industry has long experience in reducing the environmental impact from the paper production, and many companies have become very good at this. The knowledge and experience built up within the industry should be used and communicated widely. Digital technologies rapidly change and more services will become digitalised, but also leading to increased re-materialisation. However, the unique characteristics of paper still make it preferable to read or carry around. Based on findings, the paper industry may consider to:

• take an advisory role throughout the entire product life cycle not limited to recycling;
• seize opportunities by developing business models in cooperation with the ICT industry; and
• win credibility through the strategic promotion of sustainable consumption and use of paper.
CEPI foreword

The digital era started a long time ago. E-mail, online invoicing, Kindles and iPads have brought immense value to society. Life cycle assessment (LCA) shortcomings have also been here for quite some time. More recently, information and communication technology, or ICT, has been highlighted as the solution to reduce environmental impact in communication.

In order to be equipped for an informed and balanced stake in that debate, the Confederation of European Paper Industries (CEPI) commissioned the author, Dr. Peter Arnfalk, to conduct an independent study on the interplay between the use of paper and of ICT with a special focus on the environmental impact. We wanted to promote the understanding of how the debate has to be put into perspective and how using electronics is not the only direct line to saving the planet, as some claim.

The author’s role has been to provide an objective perspective on the issue, illustrated with representative cases and to draw conclusions based on an analysis of the existing research. The report clearly shows that easy answers do not exist, that all environmental claims need substantiation, and that, most importantly, the future is not either/or but and/and i.e. that paper and electronics can co-exist from an environmental point of view. This shows us that a constructive debate should integrate competing values rather than limit it to a confrontation of values.

CEPI recommends that this report be read as a whole and not be cherry-picked for details. Many questions are answered, many are not, but the report is a good contribution to raise awareness of the need to always put things into perspective.

Brussels, November 2010

Teresa Presas

Managing Director
CEPI – Confederation of European Paper Industries

About the author

Dr. Peter Arnfalk has a PhD in Industrial Environmental Economics from Lund University, Sweden, and currently holds a position as Associate Professor at this university. He has extensive experience of environmental research, with a particular focus on ICT and sustainability issues. He is working as a consultant and is also involved in policy development in this area e.g. for the European Commission and the Swedish Government.
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1. **Introduction**

In this report the interplay between the use of paper and of information and communication technology (ICT) is discussed. The aim is to explore how these two different products/services can be compared from an environmental point of view. Guiding questions in this work has been:

- Which are the similarities, differences and functions of the two options: ICT and paper?
- Why are (existing) results comparing paper products and ICT differently? Why do other materials and products have different scope/boundaries than paper?
- Is it environmentally relevant to substitute the use of paper with ICT, and vice-versa?
- How can paper and ICT services co-exist?

1.1. **A brief historical perspective**

A growing environmental concern has triggered an interest in the question whether ICT could help reduce some of the negative environmental impacts associated with the more traditional, non-digital products and services. Ever since the MIT professor Nicolas Negroponte (1995), envisioned the transformation “from atoms to bits” numerous forecasts, scenario studies, simulations and other studies have been conducted, trying to foresee and estimate the potential environmental impact of dematerialisation.

ICT has the potential to decrease resources consumption since it is based on a high flow of information and a low material and energy intensity. This could help to facilitate a dramatic increase in resource productivity, by a factor of four which the Club of Rome sees as necessary (von Weizsäcker, Lovins et al. 1997) or even a factor ten, as suggested by the German Wuppertal institute. Several countries have introduced policies and strategies encouraging the use of ICT for environmental reasons e.g. Sweden, Denmark, Finland, Japan, the US and the UK (see for instance (IT-politiska Strategigruppen 2006; Myoken 2008; HM Government 2010). A material often mentioned in the dematerialisation discussion is paper.

1.2. **Concepts and nomenclature used**

The possibility of replacing a physical product such as paper with a digital service e.g. a letter with an e-mail, is an example of de- or e-materialisation. This type of substitution and its environmental implications is often referred to as an indirect or 2nd order effect from using the technology. These indirect changes in consumption patterns may also lead to other, consecutive effects in society such as restructuring of postal services, changed traffic load, etc. These societal-level effects are often referred to as system effects or 3rd order effects. But ICT and its hardware technology behind the services also come at an environmental cost, throughout the entire life cycle of these products and services, and this impact is referred to as direct or 1st order effects. The first order environmental costs, in terms of energy consumption, emissions to air and water, use of natural resources etc., can be
estimated using a life cycle assessment (LCA) methodology. The ICT industry’s efforts to reduce this type of impact are often referred to as ‘Green IT’.

In response to efficiency gains, in environmental terms called eco-efficiency, so-called rebound effects almost always occur. As we make things more efficient, we can save time, money and other resources. However, these can, in turn, be used for more or other types of consumption; by releasing purchasing power we can consume more of the same thing, or use additional functions, products, and services. These effects are not unique for ICT. An interesting rebound effect to dematerialisation is so-called re-materialisation, when a digitalised service is materialised again e.g. when an e-mail is being printed.

However, when technology moves in, the effect is not simply that the old product (in this case paper) completely moves out. We see three optional outcomes or effects:

- **Substitution** – the product is partially or fully replaced with the digital alternative;
- **Complement** – the digital service is used in addition to the “traditional” product;
- **Generation** – the use of the digital alternative induces an increased use/consumption of the traditional product.

Empirical research reveals that these three effects are seldom seen exclusively but tend to operate in a mix, with emphasis on one or two of the effects.

For the paper industry, the effect of this digitalisation development is a highly relevant and topical area. The possible and actual dematerialisation effects on paper are discussed in more detail in the following chapters. Recognising the fact that there is a vast array of paper types and functions (tissues, diapers, packaging, etc.), a special focus has been placed on the comparison between the environmental life-cycle impact of a few, selected paper products and their digital counterparts.

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1) The environmental impact of the ICT industry, its products and services, is significant and not the least its carbon footprint. Annual worldwide emissions of 500-600 million tons CO₂ have been estimated, corresponding to emissions from driving approximately 320 million small cars.
2. Paper and ICT crossroads – a general perspective

2.1 Impact of ICT on paper use

ICT based dematerialisation of paper has been estimated by WWF (2008) to reduce current global paper consumption by 13%, leading to an estimated annual saving potential of 70 million tonnes reduction of CO₂ emissions through computer-supported digitalisation of billing, invoicing, filing, etc. The Climate Group (2008) assumes the elimination of 25% of all paper being replaced with e-paper would result in an equivalent saving potential in year 2020. These are just two of numerous estimates of the potential paper savings that different ICT-applications could lead to.

But how likely is this to happen? What does recent history tell us? According to the e-Business Watch, the growth of paper consumption has outperformed GDP growth since 1991 – while GDP grew by 25% in the Europe between 1991 and 2004, paper consumption grew about 40% during the same period. It is noticeable that the most dramatic increase in paper consumption in the late 1990s happened at the same time, as there was a sharp rise of ICT and Internet in offices and households. Moving into the twenty-first century, this trend seems to have continued. In a survey among more than 600 Swiss companies it was found that paper consumption increased by 20% in the period of 2000–2005, despite the fact that 70% of the organisations used some type of software system for document management. In practical terms, this means that an increased saving and archiving of digital data and an increased printing of hardcopy reports and documents have occurred in parallel (Empirica 2006).

So, what can we conclude from macro and micro-scale trends regarding ICT impact in actual paper consumption? The e-Business Watch report ‘Pulp, Paper and Paper Products’ (2006) concludes: “ICT and e-business cannot make a significant contribution to ease environmental effects on paper production”. Moreover, the same report points out that the growth of emerging economies is probably the single most important factor governing the global demand for pulp and paper, out-competing all other factors such as substitution of paper products through ICT-based services.

However, this perspective may be outdated as a deep economic recession has since changed the playing field for many businesses, including that of the paper industry. Paper sales have plunged globally. At the same time, some ICT applications have grown at an explosive rate, such as smart phones e.g. iPhone and social media e.g. Facebook, Twitter. Has the harsh economic climate triggered a move towards e-services? In the case of the Swedish advertising sector we can get an indication: between 2008 and 2009 they experienced a dramatic shift away from paper-based products (periodicals -26%, catalogues -17%, newspapers -20%) to mobile and internet advertising increasing 33 and 2.5%, respectively (Ekman 2010).

2.2 The challenge of comparison

If we try to set up some kind of correlation between the use of ICT and paper consumption we run across a number of challenging uncertainties. First of all, the use of different ICT applications is far from the only thing affecting paper consumption. Economic growth and business cycles are likely to have a greater impact on paper consumption than ICT use. This makes it difficult to distinguish and quantify the specific impact of ICT with aggregated data.
Secondly, the impact of ICT use is also a multi-faceted question: ICT consists of a countless number of different products and services, of which a multitude able to replace paper. (See Table 1).

Table 1. Table represents ICT-based services that have, or potentially have, an impact on paper consumption.

<table>
<thead>
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<th>Some ICT applications</th>
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<tr>
<td>e-governance</td>
<td>e-commerce, B2B, B2C</td>
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<td>e-taxation</td>
<td>e-mails</td>
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<tr>
<td>e-ticketing</td>
<td>e-banking</td>
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<tr>
<td>on-line billing</td>
<td>e-books</td>
</tr>
<tr>
<td>digital signatures</td>
<td>scientific databases</td>
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<tr>
<td>on-line education</td>
<td>digital photography</td>
</tr>
<tr>
<td>on-line manuals</td>
<td>print-on-demand</td>
</tr>
<tr>
<td>on-line directories</td>
<td>E-bay</td>
</tr>
<tr>
<td>on-line advertisements</td>
<td>Google Earth</td>
</tr>
<tr>
<td>on-line newspapers</td>
<td>digital press technology</td>
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Each of these applications has a different implication on paper use, affecting different types of paper products. Moreover, the impact of one ICT application e.g. e-mail, depends on the conditions in which it is used: by whom, where, its purpose etc. The predominant implication for these ICT-based services is that they substitute (replacement) the function that is traditionally paper-based i.e. tax forms, tickets, invoices, books, journals, manuals, letters, photos, etc. There will also be complementary use and generating effects.

When estimating the ICT impact on a particular category of paper use, such as printed dictionaries, the task becomes somewhat more manageable. However, there are several ICT applications that compete with traditional dictionaries: on-line dictionaries, hand-held electronic translators, translators in mobile phones, etc. In this sense we would have to estimate an aggregated impact from a palette of ICT uses that are rapidly growing in number, capacity and user-friendliness. If we select one of these electronic devices for comparison, say a telephone, the correlation exercise has to compare the traditional dictionary with a *running target* as a new model or version of the telephone is released on a monthly basis. Hence, the relevance for such an analysis and comparison has a rather short time-span.2

Finally, narrowing down the analysis to ascertain the impact of one ICT application on one type of paper use, we see the outcome as being not only one type of impact on the paper consumption but rather three, as presented in the previous section: substitution, generation and complementary use. In the case of the dictionary, we can imagine that we may decide not to buy the printed dictionary because we have access to a good on-line dictionary and automatic translators (substitution). On the other hand, the Internet and its language tools may boost our interest in other cultures, countries and languages so that we decide to buy more printed dictionaries for trips abroad (generation and complementary use). The sale of printed dictionaries will be influenced by the aggregated effect from all of these three outcomes.

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2) The average replacement rate of mobile phones in Europe is 18 months, accounting for 500 million handsets replaced last year in Europe alone.
3. Comparing environmental impact – a closer look at three ICT applications

As described above, ICT consists of many different products and services, and some of these will impact paper consumption. For the purpose of this report, three areas of focus have been selected:

- **Service:** *mail*. The on-going shift from traditional mail-delivery to e-mail and other forms of electronic communication are transforming greatly the postal industry, as well as our private and professional communication patterns.

- **Technology:** *the e-book reader*. This product is very topical and is currently undergoing rapid development.

- **Concept – higher education.** This area is highly influential, being an early adaptor of technology.

In the following sections we will take a closer look at how these three applications can influence paper consumption and what environmental consequences this may have.

3.1 Focus on a service: sending mail

Sending a message via mail is a service that has been around for thousands of years; there are historical references to postal systems in Egypt dating back to about 2000 B.C. Today, sending mail is an impressively large and global business. The Universal Postal Union (2009) has 191 postal service members all over the world with more than five million postal employees, working in over 660,000 postal outlets. These service members deliver some 430billion ($10^9$) mail items each year, including 6billion parcels.

The traditional letter, however, has got competition. In 1972 electronic mail (e-mail), was introduced as an application of the Arpanet, the predecessor to Internet (Leiner, Cerf et al. 2010). Since then, e-mail has constantly grown – in the number of messages and users, data volumes and in the types of use. There are currently 2.9billion e-mail accounts worldwide, and this number is expected to increase to over 3.8billion by 2014. About 75% of these accounts belong to consumers and the remaining 25% to corporate users (Radicati 2010).

Figures surrounding e-mail and its volumes are astounding. In 2008, 55billion ($10^9$) e-mails were sent daily (Hoang 2009). This adds up to 15-20trillion ($10^{12}$ or one million million) non-spam³/legitimate e-mails sent annually worldwide, accompanied by a staggering 62 trillion spam e-mails (McAfee 2009). The amount of data sent via e-mail across Internet has been estimated at 426PB (PetaBytes, $10^{15}$ or a thousand million Megabytes).

Comparing the volumes of these two forms of sending mail, we find that for each traditional letter, card or other postal delivery, about 40 ‘legitimate’ e-mails are sent or received.

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³ SPAM: slang term for ‘Unsollicited Commercial Email’ (UNE)
3.1.1 Why this comparison?

E-mail was one of the first uses of the Internet and, for decades, it has held top position as the most common Internet activity (Nie and Erbring 2000; Peter 2004). It was selected early as a candidate among e-services that could lead to dematerialisation, primarily by replacing traditional, paper-based letters (Markus 1994; Negroponte 1995; von Weizsäcker, Lovins et al. 1997). However, it is also a prominent example of how the predicted paperless office failed to (de)materiaise, with parallel growth of both traditional and digital mail services. Moreover, the huge volumes and growing importance of e-mail in business as well as private communication, makes it an interesting choice meriting a closer look.

3.1.2 How are e-mails affecting printed mail and paper consumption?

Over the last few years there has been a decline in postal letter volume, as communication moves from physical to virtual, such as e-mail. In the early 1980s, the United States Postal Service (USPS) commissioned an analysis of how electronic mail and messages systems would affect the USPS mail stream and labour force (OTA 1982). They then concluded that “… it seems clear that two-thirds or more of the current mainstream [postal deliveries] could be handled electronically and that the volume of USPS-delivered mail is likely to peak in the next 10 years”.

Apparently, their prediction was not completely off-the-charts, although it took more than 20 years before the predicted peak in mail volumes would be reached. From 2006 to 2009, USPS experienced a 17% volume decline (USPS 2010). A similar trend has the Royal Mail Group in the UK experienced. The volume of letters sent in the UK increased from 16.4 billion in 1993 to a peak of 22.5 billion in 2005/2006. Since then, rates have turned downward, and a further drop in volumes is predicted (see Figure 1). Many other postal firms expected total letter volumes to fall 5–10% in 2009 according to the Economist (2009).

In parallel with this development, during the last decade, the use of e-mail has continued to increase. For instance, in the UK, in 2000, only 9% of the population used e-mail. In 2007, it rose to 54%.

Another turning point in this respect was reported by the Direct Marketing Association (Goldie 2007) as volumes of e-mail marketing overtook direct postal mail for the first time, in 2006.

![Figure 1. Annual volume of letters posted in the UK (source: Cap Gemini).](image-url)
Menno Sanderse, an analyst at Morgan Stanley in London, predicts that European postal services could lose half of their mail volume over the next ten years. The postal service and communication analyst Howard Wright (2010) thinks along the same lines and estimates that these trends will continue, to a point that in 10-20 years time letter traffic will reach such a low point that it will become uneconomical to fund and operate a national postal infrastructure.

Based on these predictions, the impact of e-mail on traditional mail can be considered as a substitution effect. However, as the volume of e-mail is about 40 times that of traditional mail, it is clearly complementary as well. What about the generation effect?

Half a decade ago, paper consumption was physically limited by the speed at which paper copies could be produced: “...fifty years ago, an expert typist, operating the good old Imperial typewriter, could produce five but not more than five legible copies of a typescript using carbon paper.” (Campbell 2004). Today we can send thousands of e-mails within a few seconds (a fact that is heavily exploited by spammers), which naturally allows volumes to go up.

Another major factor of the generating effect is the printing of e-mails. A study among students and teachers at Berkeley University in the U.S. showed that 10% (one copy per day) of the students’ office paper daily consumption was printed e-mails. The equivalent figure for staff was 14% or, on average, five sheets of paper per day (Riley 2001). What percentage of e-mails gets printed today? In a recent US study, the following assumptions were made: 10% of business e-mails get printed and 30% of consumer e-mails (Wright 2009)4.

One reason for printing e-mails may be that printed media is considered easier to read than the digital equivalent. In a German study by Ipsos on behalf of Minolta a decade ago, only 7% of the respondents said that they would read e-mails entirely on the screen (Bleich 2000). According to a more recent study conducted by Harris Interactive, most adults in the US reported that they feel more comfortable when they have something on paper than when it’s on computer screen. Nearly two out of three (64%) workers prefer ink on paper to a computer screen when it comes to reading (WhatTheyThink 2009). An interesting development here is whether these preferences will change as e-readers become more commonplace.

In parallel with the declining trend of letters being sent, we have the e-commerce development and e-mails are often used to facilitate transactions. There has been a corresponding increase in the volumes of parcel and packet traffic as people shop online. This generates a need for extra packaging, much of which is made out of paper.

But, all in all, how does this affect paper consumption? Are we seeing a move towards the paper-less office or not? Perhaps; there are indications that the long-lasting trend of increased office printing seems to level out. In the US, 2007 marked a turning point when reduction in the amount of paper being used per worker in the workplace flattened out (Swartz 2007).

### 3.1.3 What are the environmental tradeoffs?

Traditional postal deliveries come at a cost in terms of greenhouse gases (GHG). The Universal Postal Union reports that its members’ postal services produce at least 26 million

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4) Seemingly high%ages, but to be used as reference as empirical data was not found (author’s comment).
tonnes of carbon dioxide (CO₂) emissions annually, corresponding to 0.07% of all anthropogenic CO₂ emitted globally. Europe’s share of emissions is 8 million tonnes. However, these data include only emissions from postal installations and vehicles, and do not include those generated by private operators and subcontractors, air transport, waste management, or the manufacturing of envelopes and parcels.

The marginal energy cost of sending an e-mail is very small, but as we are sending so many, the figures add up. In western Europe, in 2006, energy consumption amounted to 15 TWh for servers and 37 TWh for data centres (Baggini 2008). Storing growing volumes of e-mails uses a considerable share of these servers and data centres.

The CO₂ emissions stemming from a ‘legitimate mail’ (non-spam) has been calculated to 4 grams by Wright (2009) and to 9 grams by the Internet-security and anti-spam company McAfee (2009). This can be compared with a typical postal letter, generating somewhere in-between 20-25 grams of CO₂ (Wright 2009).

One of the drawbacks of e-mail is the annoying and time-consuming spam messages. A report from McAfee (2009) estimated that a total of 62 trillion spam e-mails were sent in 2008, or about 80% of all mails sent worldwide. As the report estimates that each spam is accountable for 0.3 grams of CO₂ spam e-mails would annually use 33 billion kWh, equivalent to the electricity used in 2.4 million (average U.S.) homes.

The consultant group ICF International (who McAfee commissioned to write the report) have calculated that the average business e-mail user is responsible for 131 kg of CO₂ per year in e-mail related emissions, and 22% of that figure is due to spam. It is emphasised that much of the energy associated with spam – nearly 80% – comes from end users deleting spam and searching for legitimate e-mails.

So, in a direct comparison between one traditional letter and one e-mail, the e-mail comes out as having 2-6 times less carbon footprint than its counterpart. However, taking into account that about 40 times more e-mails than traditional letter are being sent, the aggregated carbon footprint of “legitimate” e-mails is 7-20 times as big. Moreover, including the environmental cost of spam, e-mails makes the difference even larger.

We need to be aware of that these figures represent a snap-shot of today’s situation. But we are constantly changing our habits and our current practices and values, such as when to send paper-based letters, an electronic communication, or when to print an e-mail. Our habits are likely to change and be significantly different in 5 - 10 years. The carbon footprint of services is not static either. For instance, postal companies are setting up aims and programmes to reduce their GHG emissions. The large German postal company ‘Deutsche Post’ has committed to improving their carbon efficiency by 30% by 2020 compared to 2007 (Deutsche Post 2009). On the other hand, e-mail servers and services are getting more energy efficient, making the current comparison obsolete in a few years.

5) Mail in industrialised countries emitted around 11 million tonnes of CO₂ or 41% of the total, while those in the developing countries emitted 15 million tonnes, or 59% of the total.
6) The big difference in carbon emissions between legitimate and spam e-mails is mainly that most spam messages never reach the addressee and therefore does not take energy being read nor manually deleted. Spam that reaches mailboxes is often just deleted and not read. The little spam that succeeds in being read do not retain the reader’s attention for as long as legitimate ones.
7) The report has been criticised for some of its assumptions i.e. the time spent for handling each spam mail received and, consequently, that the time used for spam handling by the end user would extend the time the computer and its screen is turned on (and thereby consumes more energy).
Another change in the postal business that the competing array of e-services may trigger is to no longer offer costly overnight delivery of mail, and to cut down in the number of days postal services operate. Slower and less frequent delivery service is less energy-intensive and has a lesser environmental cost.

E-mails cannot only be seen as a direct replacement of traditional letters but rather as offering a different and extended array of functions and services. With attached links to different files and multimedia, collaboration tools such as Google documents, social media networks, e-mail has developed to become a backbone for electronic communication and collaboration, both in the private and professional spheres. But this does not necessarily mean that e-mail can and will replace all the functions of traditional letters, postcards etc. There is an emotional dimension to greeting cards and love letters, where the physical paper product and its appearance can indicate respect, importance, etc. One way of expressing the value of paper products is framed by the journalist and author Fredrik Virtanen “Imagine if we just had computers and then suddenly the book was invented. Can you realise how people would rejoice?” (Arvidsson 2006).

In these environmental comparisons only the carbon footprint of the two services has been discussed. If we look beyond greenhouse gases, the two forms of mail services are naturally also associated with other forms of environmental impacts in a life-cycle perspective. However, this type of extensive analysis and comparison is beyond the scope of this report.

Finally, one interesting example of re-materialisation is showcased by the company Craftbits. If you print a map of a location you wish to invite someone to, using Google Maps, you to fold the map into an envelope and send it as a personal invitation!

![Pre-Internet technology: paper e-mail. Source: Think Geek.](http://www.thinkgeek.com/homeoffice/supplies/a4db/)

### 3.2 Focus on a technology: the e-book reader

An e-book reader is not a new thing; it’s been around for more than a decade and avant-gardes such as the half a kilo “Rocket e-book” from Nuvo Media was already available in the US market in 1999 (European Commission 2001). But the technology has evolved and it is now definitely possible, from a technical and increasingly also from a market perspective, to read books, newspapers and magazines using an electronic reader (e-reader). There are several products on the market i.e. Amazon’s ‘Kindle’ and more than 20 manufacturers and
more than 40 major companies involved in the e-paper product development (NanoMarkets 2009). 

The on-line book retail company Amazon naturally focuses on selling books via their e-book reader Kindle (with more than 500 000 book titles available) but users can also subscribe to newspapers and magazines such as the New York Times, Le Monde, Frankfurter Allgemeine and Time. Moreover, via Kindle you also get access to dictionaries such as the New Oxford American Dictionary and Wikipedia (Lewan and Kristofersson 2009).

![Figure 3. The e-book reader ‘Kindle’ from Amazon.](image)

Market leader Kindle has got a number of powerful competitors i.e. Sony’s Reader Daily Edition, who also uses e-ink, have 3G connection and are connected to a large bookstore such as Sony’s eBook Store (so far only in the U.S.). With this reader you should also be able to borrow books through the distributor Overdrive.com. A potentially even more powerful competitor is the e-book reader ‘Nook’ from the large book company Barnes and Noble. Its advantages over Kindle is that Nook, in addition to the 3G connection, can also connect using wlan, the memory can be extended with normal SD-cards, and parts of the screen are touch sensitive and has colours. Nook’s other features include: reading PDF files, access to more than 500 000 books free of cost, following the signed agreement between Barnes and Noble, Google and Adobe (Adhikari 2009).

Apple released its iPad in April 2010 and it has been a tremendous sales success so far with about one million iPads expected to be sold only the first month. The iPad is a tablet computer meant for Internet browsing, media consumption, gaming, and light content creation. It runsiPad-specific applications as well as those written for the iPhone and iPod touch, including e-book readers. Hence, it is not exclusively or even primarily an e-book reader, but rather a small computer on which you can read e-books.

The iPad has an optional iBooks application (compare Apple’s program iTunes for music) which can be downloaded from Apple. In this application, books and other publications are displayed in the ePub format content, downloaded from the iBookstore (compare with iTunes Store). So far the iBookstore is available only in the U.S. A number of magazines will

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sell iPad subscriptions and The New York Times will begin publishing daily on the iPad (2010).

Figure 4. The Apple iPad (to the right).

Incentives to go from traditional paper to the electronic counterpart could be the text-to-speech (audio) function, translations, dictionaries, combinations with text, audio and video, etc. Considering this, the use of e-paper is not a direct substitution for a paper-based product; it's a new, extended and developed way to consume media.

Google runs a project on digitalising books, and currently they are stocking up to about 10 million titles. A smaller rival, the Gutenberg project, offers out-of-copyright works for free (Fenton and Davoud 2009). In the US, out of the 50 000 best selling book titles, already 90% are available as e-books.

Technologies overlap as some of the e-books can not only be read from their e-book readers but can also be accessed from a normal computer, telephones, Apple’s iPhone and iPod Touch or other Personal Display Assistants (PDA).

3.2.1 Why this area?

In addition to the numerous reports and articles covering the general digitalisation metamorphose, one of the most covered and discussed ICT/paper crossroads is e-book readers vs. traditional paper. Although e-books do not have a major effect on paper consumption today, it is currently under extremely rapid development and has been projected as one the most powerful replacement for traditional paper. This makes it an interesting case study to focus on and to test our approach on. Moreover, it is possible that this technology reaching a technological threshold effect - the tipping point when e-paper is of sufficiently good quality to be an acceptable or preferred way of reading.

One essential technical breakthrough for the e-paper is the ability to read in daylight, without backlight. A popular technology used is called e-ink. This technology allows you to read in daylight, to avoid screen fatigue, and text stays on the screen without the need for

10) A Google search for articles containing the both term “paper” and “e-book reader” results in 438 000 hits (December 19, 2009).
continuous power supply. The race is on and development intensified in the search for enhanced features i.e. colours, thinner and lighter products, flexible screens and at a lower cost. All of these characteristics will make e-paper a more realistic substitute for traditional paper.

![Diagram of e-ink technology](image)

**Figure 5.** The e-ink technology (Vizplex Imaging Film) used in e-readers such as Amazon’s Kindle and Sony’s reader

When these certain tipping points or “iPod” moments are reached, the market for electronic readers is likely to leapfrog. One of these would be to get a paper that is thin as paper and foldable. This type of paper is currently being developed by HP and Arizona State University, together with DuPont chemicals and the MIT budding company E-Ink (Schultz 2009).

### 3.2.2 How are e-book readers affecting paper consumption?

So far, only one million e-readers have been sold, affecting only a minute part of the book and newspaper industry. However, projections are that sales will rapidly increase, reaching more than 14million units in 2012 (Siberly 2009). Another forecast, by medialIDEAS (Johnson 2009), predicts that by 2020 the global annual e-reader sales will reach 446million units with a value of over US$25 billion.

In terms of e-book sales, the U.S. has the largest market where currently about 2% of the US$ 17billion book market are e-books. Worldwide markets adds up to $ 1.1billion, about 1% of total sales. Overall, industry executives and analysts expect the digital books to reach about 20–25% on the market over the next decade (Fenton and Davoud 2009). In Table 2, some trends of electronic and paper-based products and services are listed. The figure shows that traditional paper-based media (books, magazines and newspapers) are in decline while several of the digital media (home-video service and mobile data for smart-phones) increases. The use of the Internet has, also according earlier studies, led to reduced time spent on other activities, such as watching TV or reading a newspaper (Nie and Erbring 2000).

As of August 2009, in the United States:
- 81% of households subscribed to a television service
- 76% of households pay for Internet subscriptions
- 17% subscribe to an on-line music service or satellite radio
- 14% subscribed to on-line gambling subscription service
- 14% of consumers subscribed to home-video service, up 2%
- 9% of consumers subscribe to mobile-data-plan for smart phones, up 3%

Paper based products:
- 2% of book sales were e-books, up > 1% (+ 150%)
- 41% of population subscribed to magazines, down 2%
- 29% of population subscribed to newspapers, down 2%
- overall book sales were down 4%

A possible development is that we will see a re-materialisation of digital books, through so-called Espresso-printing and binding machines for print-on-demand (Fenton and Davoud 2009).

![Espresso print-on-demand machine](image)

Figure 6. The Espresso print-on-demand machine, printing and binding books from a digital template.

It is clear that e-books are predicted to have a bright future and that the growth in numbers and sales are expected to increase exponentially. The question is how these e-book readers will look in 5-10 years, what functions they will have, if they will have been merged with some other product, or if they will exist at all? In this perspective, the estimate of 446 million units sold in 2020 seems uncertain.

Another important question to ask is “to what extent the increased sale of e-books and e-book readers will actually affect the consumption of printed books?” Judging from the debate in newspapers, blogs and in other media, many people have a strong opinion about the issue often in defence of the printed book. The arguments in favour of book are that books are remarkably well engineered – they are easy to use, portable, relatively cost-effective, and they require no instructions or manuals for their use. e-reader critics have argued that these devices are not conducive to long sessions of reading text from a screen, and they lack the tactile appeal and “atmosphere” of conventional books. The digital alternatives are also inconvenient to use as they represent yet another device that the user
must purchase and learn to use. People who read many books are likely to use both alternatives – the paper version perhaps in the bathtub, on the beach, on the vacation trip, etc. Moreover, e-book readers have reported that they, after reading the e-book, found the story so intriguing that they also went and bought the book in paper format. This calls for a complementary use, not only substitution.

People reading only a few books per year can hardly justify investing in an e-book reader. The currently high price of more than US$200 will come down considerably, but is will take a long time before it can compete with the cost of one or two pocket-books.

![Internet users desert the mass media. The impact of Internet use on reading newspaper and watching TV. Source: Nie and Erbing (2000).](image)

**Figure 7.** Internet users deserts mass media. The impact of Internet use on reading newspaper and watching TV. Source: Nie and Erbing (2000).

### 3.2.3 What are the environmental tradeoffs?

A number of comparative, simplified LCA-studies have been conducted at the Royal Institute of Technology in Sweden (Moberg, Johansson et al. 2007; Moberg, Johansson et al. 2009). In one study, the environmental impact from reading a daily newspaper in the traditional format has been compared to the impact of reading the news with the help of an e-book reader (or tablet e-paper) and reading the news on-line on your computer. At an early stage of the research, Professor Göran Finnveden, leading the research team conducting the newspaper study at KTH, said that the e-book reader has the potential to cut CO₂ emissions substantially as compared to normal newspapers and on-line reading. He referred to preliminary results indicating that current readers would generate about 10 kg of CO₂ annually compared to 27 kg for one newspaper (Ahlberg 2007).

The researchers concluded that reading the newspaper for 30 minutes a day on e-paper instead of a regular newspaper is environmentally preferable. Reading the Internet or web-based newspaper alternative for ten minutes yields the same load on the environment. However, the researchers point out that you obviously get more out of reading 30 minutes than 10 minutes, and that reading the paper version is not really comparable to reading electronically. Moberg and her colleagues note that the definition of the functional unit in

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11 The study from 2007 was revised two years later using e.g. updated information on energy consumption of screens, and, including the energy consumption for sending data through the Internet.
comparison between alternatives is not straightforward in this case, and that comparing a new area like the ICT sector to more established technologies leads to differences in availability of data.\textsuperscript{12}

One study is comparing the environmental life-cycle impact of reading an e-book with traditional books bought via either a traditional ‘bricks-and-mortar’\textsuperscript{13} bookshop, or ordered via an Internet bookshop. The scenario used for this comparison was based on the readership of 24 books annually over two years (48 books in total). The e-book came out as the ‘greenest’ option also in this comparison and the books bought in a traditional bookshop had the largest impact (see Figure 8). The break-even point i.e. the number of books when the alternatives had the same environmental impact, was at 33 books.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure8}
\caption{A comparison between the global warming potential (in CO$_2$ emission equivalents) from three ways of consuming a book: paper-based book via “bricks and mortar bookshop (left), paper-based book bought via Internet (middle), and an e-book read on a e-book reader (Borggren and Moberg, 2009).}
\end{figure}

Another interesting study in this respect is the Cleantech Groups’ report “The environmental Impact of Amazon’s Kindle” (Siberly 2009). The report indicates (referred to without having analysed the full report) that the carbon emitted in the lifecycle of a Kindle is fully offset after the first year of use. The author of the report claims that the annual savings of CO$_2$ adds up to 168 kg, which would be equivalent to the manufacture and distribution of 22.5 books. On an aggregate scale, the Cleantech group estimates that e-reader devices would help to prevent more than 5 million tonnes of CO$_2$ emissions in year 2012, or nearly 10 million tonnes during the four year period 2009–2012.

These comparisons are based on a lot of assumptions and estimates and, therefore, the uncertainties in the results are relatively high.

Let’s have a look at the case of traditional books. The most apparent assumption is the number of books read per year: 24 in the KTH study and 22.5 in the Cleantech LCA. The

\textsuperscript{12} To illustrate how data used in the LCA comparison will influence the results we can look at CO$_2$ emissions for paper production. The emissions differ considerably between different types of paper products: producing tissue paper emits about 600 kg CO$_2$ per ton of paper, while other types of paper can emits up to 1500 kg. Depending on what figures are used for ‘CO$_2$ emissions for paper produced’, the results can therefore vary by a factor of 2.5.

\textsuperscript{13} Traditional bookshops located in a building where books are on display and where people can look for and buy books.
average number of books bought per capita and year varies between different countries in Europe – ranging from 1.4 in Greece to 7.9 in Belgium (Kovac and Sebart 2007) - figures that are considerably lower than the ones used in the analyses. Assuming an average of 5 books bought per annum, or 10 books in two years, this falls far below the break-even point of 33 books.

Then we have the assumption of the lifespan of the e-book reader. This is assumed to be at least four years in the Cleantech study, as compared to two in the KTH studies. Another critical assumption is the assumption that the paper book will only be read once. If, for instance, the book is read twice, this will reduce the impact of the paper version into half and totally reverse the outcome. Yet another parameter is how book are commonly sold today – books are not only sold in traditional, specialised bookshops, but also in supermarkets, gas stations, etc. People buying books in these places have come there for other reasons and therefore no extra travel is generated for the purchase of these books. The authors of the KTH study are well aware of these uncertainties and have made sensitivity analyses for several of these parameters.

On the other hand, and to allow fair competition, we need to consider what e-book readers can be used for. So far, these comparisons are based only on one use of the e-paper reader i.e. reading a daily newspaper or a book.

Moreover, and equally as important, we need to know whether the reading of the newspaper electronically leads to substitution or if it is a complementary use e.g. still subscribing to the newspaper but now two persons can read the same article at the kitchen table.

We can go on questioning the different assumptions and input data in the LCA for a while, but then we may miss the point. The LCAs, although flanked by limited and sometimes poor input data and awkward assumptions, still provides us with a useful indication on where the major impacts arise and provide a useful guidance to where and how to tackle environmental impacts that arise throughout the life-cycle chain. The critical thing is not the LCAs per se, but how they are being interpreted and used for decision-making.

In the case of Apples’ iPad, the product and its use of “cloud computing” has been heavily criticised by the environmental organisation Greenpeace. Apple has, for years, been its target for critique and, as a consequence, the company has made strong efforts to wash away the image of an environmental polluter. In conjunction with the launch of the iPad, Apple announced that the product is completely free from arsenic, mercury, PVC, and brominated flame retardants. Moreover, the screen is glass and the shell of recyclable aluminium. But Greenpeace does not seem willing to cease its attacks against Apple; in a recent report the iPad is pointed out as a major environmental threat (Greenpeace 2010).
3.3 Focus on a sector: higher education

Education is a broad concept and there are many ways to educate. Most commonly, it is through traditional educational institutions: elementary, high and upper high schools, colleges, universities and institutes. Other forms of education include adult and vocational education and training, professional courses and training, traineeship, apprenticeship, etc. As the various forms of education all have their different forms and ways of conveying information, we need to narrow our scope to one of these educational institutions.

Looking at where we can assume that technology penetration is at its forefront, we take a closer look at higher education (HE), such as universities and institutes of technology.

3.3.1 Why this area?

Universities were some of the earliest users of paper, and they and other higher education institutes, are still relatively intensive paper users. On the other hand, they are also often early adopters of new technology and have intensive “knowledge work” areas where the possibility for paper substitution is likely to take place.

Education is an area that nearly everyone can relate to, and that has a positive connotation in most cases. As we spend a considerable part of our life in different educational systems, particularly in our youth years, this period tend to shape our behaviours, establish routines and preferences. This is why education in general, and higher education in particular, has not only a direct impact on paper and ICT use but also plays an important strategic role. The way we learn to do things in school and university will last a long time, if not a lifetime.

Looking at market figures, nearly half of the global book market is educational books (US$70billion), only exceeded by the US$77billion consumer book market (Fenton and Davoud 2009).
3.3.2 How is paper used in higher education?

Paper plays a central role at universities and “writing papers” is one of the key objectives for many researchers. The following list presents some of the major paper use areas in higher education:

- traditional libraries
- producing and publishing academic papers, books and reports
- producing and publishing educational material, course books and compendiums, lecture handouts, articles to read
- student notes
- staff’s office printout of mail, articles, reports, administrative documents etc.

3.3.3 How is ICT affecting paper use in universities?

The e-book development is so rapid and recent that academic literature has not yet been able to study or analyse their market break-through. Instead, this paper relies mainly on newspaper articles and on blogs.

The possible entry of e-book readers in the educational system is by some seen as a thing to welcome: “The prospect of being able to carry around all of your schools books on one electronic device — with the data backed up on the web, of course — will be too great a temptation for many to resist. How long will it take? Who knows? But 5-10 years is a reasonable guess. Simply put, electronic readers in the classroom, is only a matter of time”\(^\text{14}\).

In 2009, six universities and colleges in the US have tested the Kindle e-book reader in a pilot, which included making the textbooks for certain courses available online. The pilot is described as a part in a sustainability effort from the likes of Princeton University, and the hope is to substantially reduce the use of paper (Peters 2009).

A PhD dissertation is normally published in a number of a hundred copies and handed out to potential readers and different libraries. This routine is now getting challenged as the dissertation is published electronically as a PDF file and made publicly available.

Other practices at universities that are gradually getting replaced by digital alternatives are:

- learning management systems
- digital Libraries, databases
- electronic course evaluations
- electronic grading and assessment
- electronic CV
- search Engines
- webcasting
- podcasts
- wikis
- Multiple Choice Quizzes

A main concern determining the higher education sector’s demand for paper is how the educational system will be transformed in the next decades. The trend is moving from local

on-site to world-wide and geographically independent, from a limited set of books and papers to a multitude of electronic resources, from exclusively text-based to audio-visual and multimedia.

3.3.4 What are the environmental tradeoffs?

Roy and Potter (2008) have studied the impact of different ways of teaching in higher education including distance learning and on-site education offered by universities. The different courses studied could be categorised as follows:

- full- or part time at campus
- part-time through distance learning, making use of printed materials, and
- Part-time via Internet (On-line Distance Education (ODE))

Theses courses were analysed for their impact related to paper use, but also to computing, commuting, as well as accommodation at home and on campus. The main results in terms of kg of CO$_2$ emissions are summarised in Figure 10.

Comparing the environmental impact, in terms of energy consumption and CO$_2$ emissions, between on-site HE campus teaching and distance education, Roy and Potter concludes that “distance learning courses involve 87% less energy and 85% lower CO$_2$ emissions than the full-time on-site courses, mainly due to reduction in student travel and elimination of energy consumption of students’ housing, plus economies in campus site utilisation.”

So distance education could offer an environmentally beneficial option to traditional full-time onsite education. But how do the two distance options compare?

The study reveals that online education produces only a marginal environmental improvement compared to print-based distance learning. On-line education used 20% less
energy and generated 12% less CO$_2$ emission compared to print-based distance learning courses, mainly because online learning requires more energy for computing and paper for printing. As a matter of fact, the computing in the on-line distance courses used one third more energy than what was used for paper in the paper-based distance course (see Table 3).

<table>
<thead>
<tr>
<th>Energy (MJ)</th>
<th>Campus site</th>
<th>Travel</th>
<th>Computing</th>
<th>Paper/print</th>
<th>Resld. heating</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campus: full time</td>
<td>883.0</td>
<td>2,304.4</td>
<td>119.7</td>
<td>66.3</td>
<td>1,193.5</td>
<td>4,567.0</td>
</tr>
<tr>
<td>Campus: part time</td>
<td>461.5</td>
<td>875.1</td>
<td>104.4</td>
<td>49.7</td>
<td>125.9</td>
<td>1,616.6</td>
</tr>
<tr>
<td>Distance: print-based</td>
<td>17.8</td>
<td>375.2</td>
<td>83.2</td>
<td>155.8</td>
<td>39.3</td>
<td>671.2</td>
</tr>
<tr>
<td>Distance: electronic</td>
<td>17.6</td>
<td>139.1</td>
<td>208.1</td>
<td>69.9</td>
<td>101.2</td>
<td>535.8</td>
</tr>
</tbody>
</table>


But then, we have the rebound effects. Roy and Potter found three examples of such effects among the students studying on-line courses. Some of the students:

- downloaded and printed the online learning materials for reasons of portability, ease of reading, note making and reference; two-thirds of the on-line students printed half or more of the material on the course’s web site.
- meet informally face to face, generating additional local travel.
- heat their homes more than normal for study purposes.

As a consequence, the rebound effects counteract much of the savings in energy and emissions from a reduced amount of printed matter and reductions in staff/student travel for the on-line courses compared to the print-based courses.

Another study by Kozak and Keoleian (2003) used life-cycle assessment (LCA) to compare two different book options – printed scholarly books and e-books. The comparison was based on the assumption that a college student would read either 40 scholarly textbooks or the equivalent amount of digitalised information, using a dedicated e-book device. For each of the two systems, the study assessed the use of energy, material and water, emission of air and water pollutants, and generation of solid waste.

For the conventional books, the environmental impact mainly comes from three factors:

- textbook paper production
- the relatively large amount of electricity consumed during book printing operations
- personal transportation

For the e-reader, the main impact came from the electricity generated for on-screen viewing.

In this assessment, the conventional book system came out far worse in terms of greenhouse gas (GHG) emissions, emitting almost four times the amount of GHG’s than the e-reader. Conventional books also emitted larger quantities of ozone-depleting substances and chemicals associated with acidification.
Table 4. The results of the baseline Life Cycle Inventory Assessment, comparing conventional books with e-readers in terms of impact on global warming, ozone depletion and acidification. Ref. Kozak and Keoleian (2003).

<table>
<thead>
<tr>
<th>Impact Category</th>
<th>Units</th>
<th>Traditional book system</th>
<th>E-reader system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global warming</td>
<td>kg-CO₂ equivalents</td>
<td>233</td>
<td>60</td>
</tr>
<tr>
<td>Ozone depletion</td>
<td>kg-CFC-11 equivalents</td>
<td>1.22E-06¹</td>
<td>1.14E-06¹</td>
</tr>
<tr>
<td>Acidification</td>
<td>kg-SO₂ equivalents</td>
<td>1.15</td>
<td>0.39</td>
</tr>
</tbody>
</table>

Figure 11. A comparison between conventional books and e-readers in terms of material inputs (kg), water inputs (litres), primary energy (MJ) and solid waste (kg). Ref. Kozak and Keoleian (2003).
4. Discussion

4.1 Lessons learned about LCA comparisons

Comparisons of the environmental impact can be made between ICT applications and paper products using life cycle assessment (LCA) methodology. The results are useful and interesting when we try to identify and tackle the environmental challenges throughout the life-cycle chain. The LCA studies referred to in this paper revealed where paper has its biggest environmental toll - in manufacturing, transportation and storage.

When we want to interpret the results, however, careful consideration needs to be made to a number of things: product (version), producer, LCA border setting, assumptions made, the availability and quality of the input data, the study timeframe, who conducted the study and who has commissioned it. Hence, LCA comparing products with different types of functional systems should differ largely, preferably in order of magnitudes so that it gives a strong message of “what is environmentally ‘better’ or not”.

If these methodology-technical issues have been taken into account, and the LCA results are used as a basis for decision and/or policy making, it still needs careful consideration of prevailing rebound effects. The use of empirical data from comparative ICT developments and its environmental implications can be useful when making efforts to for example optimize energy systems such as in transport, music, energy saving measures, etc.

Comparisons can miss the target as the market is ever changing – the product and/or services are developing into something else. One example is the mail business: as printed mail volumes are declining, postal services are instead increasingly occupied with delivering parcels that people have ordered on e-bookstores such as eBay, Amazon.

4.2 Will paper products be a more preferable alternative?

Although the inter-correlation between ICT use and paper consumption is obviously complex and this report only has looked into a few examples – some predictions about future trends can still be made. What could we learn from the impact of e-products’ and e-services on paper consumption and the environmental comparisons made? In a future where environmental performance is a key success factor and a situation where a choice can be made between a paper product and a digital alternative, when will the paper alternative come out on top as an environmentally preferable alternative?

• Some paper products – having ICT alternatives – are here to stay, at least for a foreseeable future. The paper product can compete with its electronic counterparts, when:
  − the paper alternative is the cheapest, most cost-effective one;
  − the characteristics and functionality of paper is superior i.e. portability, flexibility, durability, not requiring energy when used, etc.;

15) The same caution should be taken when comparing the different data presented here - CO₂ emission calculations and estimates referred to in this report have not been analyzed in depth in terms of sources, assumptions, calculation factors etc. As these background parameters most likely differ between the studies, the comparability between them and their reported data is limited.
the intrinsic value of the paper product is high i.e. the beauty of the paper, book or picture, the pleasant feel of the material, the emotional impact of a love letter;
- the environmental impact of the paper option is considerably lower e.g. possibility to re-use, recycle, non-toxic, non-energy needs;
- Along the same line of reasoning, some traditional paper based products will be marginalised by ICT services, if the criteria listed above speak in favour of the electronic services fulfilling the function of the paper. These are likely to be paper items used for plain reporting, storing, and sending non-personal messages.
- Old habits die hard. The trend of complementary use of parallel electronic and paper-based products will likely remain for decades, as people who have gotten used to use paper products are likely to stick to habits and traditions even if they use the electronic services as well. This could include books i.e. leisure reading, personal letters and postcards, artistic paper products, etc.
- More focus will be placed on environmental and climate issues. The areas where paper has an advantage will strengthen the arguments for the paper alternative.
- As environmental and climate concerns will become increasingly important, it will also lead to stronger pressure to reduce natural resource consumption, affecting the paper industry as well as the ICT industries. Natural resource intensive consumption will become more expensive as a consequence of resource scarcity, internalisation of environmental externalities, and of policy decisions\(^{16}\). This will act to limit rebound effect and stimulate a selection of the most resource efficient option. This, again, highlights the question of what is sustainable consumption of paper and how the industry should respond to this question (Miljödepartementet 2008).

4.3 ICT and paper co-existence

This report has, so far, discussed two different options – either a paper product or an electronic version. In reality we’re most likely going to find both alternatives available in parallel, sharing overlapping functional areas. Depending on contextual and situational factors, the rationale for selecting one or the other of the two alternatives is an optimisation exercise in which we not only take into account economic and environmental considerations, but also parameters such as local availability, easy access, security, personal preferences, etc.

In reality, the preferred option is not either or, but rather both. We are for example:
- carrying a credit card as well as some paper bills in our wallet;
- reading news on-line and books in the e-reader, but still subscribe to a newspaper and buy a few pocket books for our vacation trip;
- doing internet banking but prefer to also receive the quarterly or annual printed statements from the bank; and,
- making the report available as PDF and printing a version as well.

And so on.

\(^{16}\) One example of a country where paper consumption has become an issue in environmental policy is Sweden. Its government decided in 1996 that all governmental organisations must have an environmental management system (EMS) in place and, so far, over 200 state agencies have implemented an EMS. In the guidelines, one of the suggested indicators of measuring significant environmental aspects is the amount of paper purchased per employee (Miljödepartementet, Ministry of the Environment, Sweden) 2008).
Digital and traditional paper based versions can provide the same or equivalent service, side by side. Some of these parallel services are probably going to gradually shift towards the digital alternatives, as people get more used to the electronic alternatives, and as e-services improve and get more convenient and attractive. But complementary options will probably last for a while, if not forever.

The traditional paper version of a service will, in many other cases, be transformed into a digital format and then re-materialise as a print-out again. We can, for instance, imagine our digital photos being stored, shared and viewed on-line but a few of them are printed for a photo album as a gift to a friend, an extract of the digital atlas is being printed to help us finding the way, the e-book printed on demand, the scientific article found in the database is printed for the ease of reading etc.

The three cases mentioned in this report – sending mails, publishing books or providing educational material, are all functions or services that will build on product-service systems consisting of a combination of paper and digital services.

4.4 Reflections on the debate

The paper industry has decades of experience working to reduce the environmental impact from paper and pulp production, and many paper companies have become very good at this (Arnfalk, Brorson et al. 2008). The knowledge and expertise acquired within this industry on how to manage environmental issues should be used and communicated beyond the walls of paper mill production sites. One way of extending this expertise is to use it as an advisory role throughout the entire paper life cycle, and not just limited to recycling of paper.

The pulp and paper industry, however, has long been under attack from different environmental groups, sometimes being projected as a clear-cutting, polluting sector using large amounts of energy, water and other resources. The option of using ICT instead of paper – reducing the paper consumption and thereby the environmental implications of pulp and paper production – therefore attracts interest among the fast growing group of environmentally aware citizens. However, as indicated above, the direct impact of ICT products and services replacing paper is far from negligible, and the trade-off between the two “technologies” depends on conditions such as use frequency, source of energy, end-of-life management of the products.

A possible, and perhaps likely, reaction to such a situation would be to project the ICT sector and its products as equally or even more polluting, natural resource and energy consuming. This could, perhaps, in the short run, win some people’s attention, and even influence (delay) decisions on going digital, but not likely to win any sympathy or result in any increased marked shares in the long run. It could even back-fire on the paper industry itself, projecting its representatives as being unwilling to move towards becoming a more environmentally friendly industry. Probably, a more constructive way would be to cooperate with the large and powerful ICT industry. The more immediate argument for this, economically but not environmentally, is that the use of some ICT products, such as copiers and printers, thus far seems to have been instrumental in a net increase in paper demand. These are limited trends.

The paper industry does not gain much from combatting the substitution trend or denying the environmental potential in substitution. It would win much credibility if it focuses on responsibility throughout the entire paper life-cycle. This would also include promoting a
more sustainable consumption and use of paper, avoiding unnecessary wasteful usages, promoting and highlighting the areas where valuable raw material is used for truly beneficial purposes, such as education, sanitation and promoting sustainable development. A number of actors in the paper chain are already doing this but the issue would benefit from being discussed and managed on a strategic level.

5. Conclusions

The three different cases covered in this report suggest that, after a period of parallel growth of both paper products and the equivalent ICT applications, we start to see a clear substitution effect of ICT use on paper in several areas. The explanation to this shift may be that the technology has developed and has now become so accessible and user friendly that users have accepted and/or gotten used to the digital alternatives. This will have a major impact on traditional industries producing and handling paper-based products, such as book publishers and shops, postal services, schools and universities. As more services become digitalised, we also find that they re-materialise, by being printed on demand. The unique characteristics of paper still make it the most preferable alternative to read and to carry around.

In times of rapid technology change, it is probably a good strategy to accept the behavioural change, adapt to new market conditions, and to seize new opportunities. For the paper industry this could mean finding and promoting areas where paper has an environmental and sustainability advantage. Using comparative life cycle assessments studies for this is possible, but unless the two comparable options are well defined (with the same function), and that the resulting impact differ substantially, the results should be used by decision makers more as an indication and not as a ‘proof’ of what option is better or worse.

A good idea on adaptation, for example, to learn from the music business’ mistake of clinging on to only one business model, and to avoid resisting new user preferences and habits. Rather, act proactively e.g. in the publishing business, finding business models that authors’, publishing companies and customers can accept, prefer and adopt.
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