ANALYSING THE ICT - PAPER INTERPLAY AND ITS ENVIRONMENTAL IMPLICATIONS

report for workshop on 4 May 2010

Dr. Peter Arnfalk

Preface

The organisation CEPI has commissioned the author to make a project study on the interplay between the use of paper and of information and communication technology, or ICT, with a special focus on the environmental consequences. The author's role has been to provide an objective perspective on the issue, illustrate with representative cases, and to draw conclusions based on an analysis of the existing research.

Summary

CEPI has commissioned a study on the interplay between the use of paper and of information and communication technology (ICT). It aims to explore how these two products/services can be compared from an environmental point of view. Similarities, differences and functions of ICT and paper was analysed in order to find out when it is environmentally relevant to substitute the use of paper with ICT and vice-versa. Paper and ICT services are to a large extent complementary; the objective of the report is to put the perspective on how these services can 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 email;
- technology – *the e-book reader* that undergoes a rapid development at the moment;
- concept – *higher education* being an early adaptor of technology.

Use results of LCA comparisons with great care

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 toll in manufacturing, transportation and storage. However, interpretations of the results need to be made with careful considerations as a number of methodology-technical issues must be taken into account. LCA comparing products with different types of functional systems should differ orders of magnitudes in order to be able to conclude what is environmentally preferable. Comparative LCA studies should not miss the *running target*; markets are rapidly changing and prevailing rebound effects occur. Rather, they are for optimizing the product.

When 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, the paper alternative may be the 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 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 will 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 used to using paper products are likely to stick to their habits.
- Increased focus on environmental issues in areas where paper has an advantage.
- 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 suggests that after a period of parallel growth of both paper products and the equivalent ICT applications, there is a substitution effect of ICT use on paper in several areas due to technology development. But the two options are most likely going to be two alternatives available in parallel, sharing overlapping functional areas. The rationale for selecting one or the other of the two services is depending on both contextual and situational factors and is largely an optimisation exercise considering many parameters.

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. But complementary options will probably last for long. The traditional paper version of a service will in many cases be transformed into a digital format and then re-materialise as a print-out again. 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.

Table of Content

Introduction

In this report the interplay between the use of paper and of information and communication technology, or ICT, is discussed. The aim is to explore how these two different products/services can be compared from an environmental point of view.[1] 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 different? 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 facilitating a dramatic increase in resource productivity, by a factor of four that 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 email, 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.[2]

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 then in turn be used for more or other 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 email 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:

- **Substitution**; the product is partially or fully replaced with the digital alternative
- **Complement**: the digital service is used in addition to the "traditional" product, which use is not reduced.
- **Generation**: the use of the digital alternative induces an increased use/consumption of the traditional product.

Empirical research reveals that these three effects seldom are seen exclusively but rather 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 more in detail in the following chapters. Recognising the fact that there are a large number of different 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.

[2] The environmental impact of the ICT industry, its products and services is significant, not the least its carbon footprint. The annual emissions of CO_2 has been estimated to add up to 5-600 million tons world wide , corresponding to emission from driving approximately 320 million small cars.

2. Paper and ICT Crossroads – a general perspective

2.1. Impacts of ICT on Paper Use

ICT based dematerialisation of paper has been estimated by The Climate Group (2008) to reduce global paper consumption by 13 percent, leading to an estimated annual 70 million tonnes reduction of CO_2 emissions through computer-supported digitalisation of billing, invoicing, filing, etc. This is just one of numerous estimations 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 25 percent in the Europe between 1991 and 2004, paper consumption grew about 40 percent 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 had increased with 20 percent in the period of 2000–2005, despite the fact that 70 percent 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 the 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 was a perspective dating four years ago, and since then a deep economic recession has 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 pace, 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 Swedish advertising business we can get an indication: between 2008 and 2009 they experienced a dramatic shift away from paper-based products (periodicals minus 26 percent, catalogues minus 17 percent, newspapers minus 20 percent) to mobile and internet advertising increasing 33 and 2.5 percent, respectively (Ekman 2010).

2.2. The challenge of comparison

If we try to set up some kind of correlation between ICT use 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 the paper consumption than ICT use. This makes it hard to distinguish and quantify the specific impact of ICT in these aggregated data.

Secondly, the impact of ICT use is also a very multi-facetted question: ICT consists of a countless number of different products and services, including a multitude that can replace paper, of which some are listed in Figure 1.

Figure 1. This figure represents some of the ICT-based services that have, or potentially have an impact on paper consumption. B2B: Business-to-Business, B2C: Business-to-Consumer. Source: P. Arnfalk, presentation at the European Paper week, Brussels, Nov 18, 2009.

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. email, depends on the conditions in which it is used – by whom, where, its purpose, etc. The predominant implication for theses ICT based services is that they substitute (replace) the function that traditionally is paper based, e.g. taxation forms, tickets, invoices, books, journals, manuals, letters, photos, etc. But there will also be complementary use and generating effects.

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 the traditional dictionaries: on-line dictionaries, hand-held electronic translators, translators in mobile phones, etc. In this sense we would have estimate an aggregated impact from a palette of ICT uses that rapidly grow in numbers, 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. [3]

Finally, narrowing down the analysis to look at the impact of one ICT application on one type of paper use, the outcome is most likely the result of not only one type of impact on the paper consumption, but rather three as presented in the previous section – i.e. substitution, generation and complementary use. In the dictionary case, 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.

3. Comparing environmental impacts - 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. Out of the many ICT applications, three have been selected.

- The first focuses on delivery of a specific service: *mail*. The on-going shift from traditional mail-delivery to email and other forms of electronic communication is causing a major transformation of the postal industry, as well as our private and professional communication patterns.

- The second example focuses on a specific technology: *the e-book reader*. This product is very topical and it undergoes a rapid development at the moment.

- The third ICT application is more of a concept and deals more on a way to fulfil a societal function – *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] The average replecement rate of mobile phones in Europe is 18 months, accounting for 500 million handsets replaced last year in Europe alone.

3.1. Focus on a service: sending mail

To send 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 from about 2000 BC. Today, sending mails and parcels is an impressively large and global business. The Universal Postal Union (2009) has 191 postal services members all over the world with more than five million postal employees, working in over 660,000 postal outlets. These service members deliver some 430 billion (10^9) mail items each year, including 6 billion parcels.

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

The figures surrounding email and its volumes are astounding. In 2008, 55 billion (10^9) emails were sent daily (Hoang 2009). This adds up to about 15-20 trillion (10^{12} or one million million) non-spam (legitimate) emails sent annually world wide, accompanied by a staggering 62 trillion spam emails (McAfee 2009). The amount of data sent via email across Internet has been estimated to 426 PB (PetaBytes, 10^{15} or 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" emails are sent and received.

3.1.1. Why this comparison?

Email was one of the first uses of Internet and for decades it has held the top position as the most common Internet activity (Nie and Erbring 2000; Peter 2004). It was early selected 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 paper-less office failed to (de)materialise, with parallel growth of both traditional and digital mail services. Moreover, the huge volumes and growing importance of email in business as well as private communication, makes it an interesting choice to look closer at.

3.1.2. How are emails affecting printed mail and paper consumption?

Over the last few years, there has been a decline in postal letter volume traffic as communication moves from physical to virtual, such as email. Already 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 chart, 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 percent 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 into decline, and further drop in volumes is predicted, see Figure 2. Many other postal firms expected total letter volumes to fall 5-10 percent in 2009 according to the Economist (2009).

In parallel with this development, during the last decade, the use of email has continued to increase, for instance in the UK. In 2000, only 9 percent of the UK population used email. In year 2007, the equivalent figure was 54 percent.

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

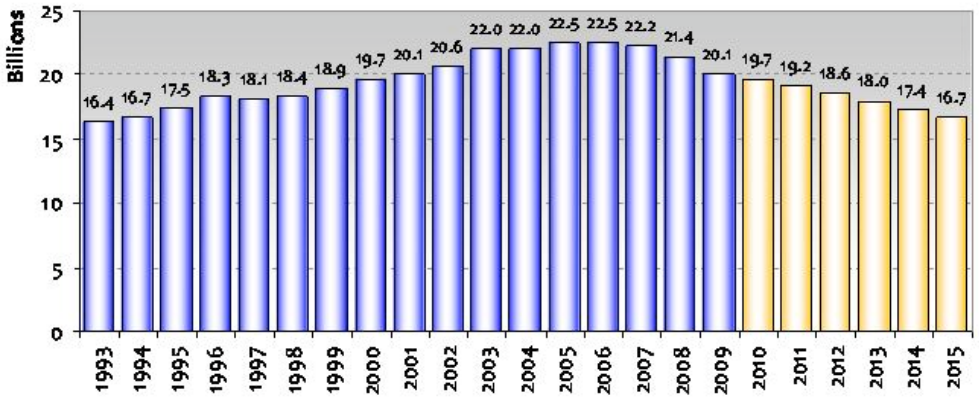

Figure 2. Annual volume of letters posted in the UK. (source: Cap Gemini)

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 line and estimates that these trends will continue to a point in 10-20 years time when letter traffic reaches a low point, becoming uneconomical to fund and to operate as a national postal infrastructure.

The impact of email on traditional postal mail can be considered as a substitution effect. However, as the volume of email is about 40 times that of traditional mail, it is clearly a complementary use as well. How about the generation effect?

Half a decade ago, the 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 emails within a few

seconds (a fact that is heavily exploited by spammers), which naturally allows volumes to go up.

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

One reason for printing emails 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 percent of the respondents said that they would read emails 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 percent) 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 emails 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 tonnes of carbon dioxide (CO_2) emissions annually, corresponding to 0.07 percent of all anthropogenic CO_2 emitted globally.[5] Europe's share of the emissions is 8 million tonnes. However, these data include only emission 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.

[4] Seemingly high percentages, but referred to as empirical data was not found (author's comment)

[5] Post in industrialised countries emitted around 11 million tonnes of CO2 or 41 percent of the total, while those in the developing countries emitted 15 million tonnes, or 59 percent of the total.

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

The CO_2 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 CO_2 (Wright 2009).

One of the draw-backs of email is the annoying and time consuming spam messages. A report from McAfee (2009) estimated that worldwide a total of 62 trillion spam emails were sent in 2008, or about 80 percent of all mails sent. As the report estimates that each spam is accountable for 0.3 grams of CO_2, spam emails would annually use 33 billion kWh, equivalent to the electricity used in 2.4 million (average US) homes.

The consultant group ICF International (who McAfee commissioned to write this report) have calculated that the average business email user is responsible for 131 kg of CO_2 per year in email related emissions, and 22 percent of that figure is due to spam. It is emphasised that much of the energy associated with spam – nearly 80 percent – comes from end users deleting spam and searching for legitimate email.[6]

So, in a direct comparison between a traditional letter and an email, the email comes out having 2–6 times less carbon footprint then its counterpart. However, taking into account that about 40 times more emails than traditional letter are being sent, the aggregated carbon footprint of "legitimate" emails is 7–20 times as big. Moreover, including the environmental cost of spam emails 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 when to send paper-based letters or an electronic communication form or when we will print an email, will likely change and be significantly different in 5-10 years. The carbon footprint of the services is not static either. For instance, the postal companies are setting up aims and programme to reduce their GHG emissions. The large German post company Deutsche Post have committed to improve their carbon efficiency by 30 percent to 2020 compared to 2007 (Deutsche Post 2009). On the other hand, email servers and services are getting more energy efficient, making the current comparison obsolete in a few years.

Another change in the postal business that the competing array of e-services may trigger is to no longer offer costly over-night delivery of mail by default, and to cut down in the number of days the postal services operate. Slower and less frequent delivery service is likely less energy intensive and with a lesser environmental cost.

[6] The report has been criticised for some of its assumptions, e.g. the time spent for handling each spam mail received, 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 consuming more energy).

Emails cannot only be seen as a direct replacement of traditional letters; they are 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 networking, etc, email 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 email 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, mainly because this is what has been available in the literature covered. 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. The company Craftbits offers guidance on how to fold a normal piece of paper into an envelope. If you print a map of a location to whish you want to invite someone, using Google Maps you to fold the map into an envelope and send it as an invitation – including a map to guide you to where to go!

Figure 3. Pre-Internet technology: paper email. Source: Think Geek.[7]

[7] http://www.thinkgeek.com/homeoffice/supplies/a4db/

3.2. Focus on 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 available in the US market already 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. There are several products on the market, e.g. Amazon's Kindle and more than 20 manufacturers and more than 40 major companies involved in the e-paper product development (NanoMarkets 2009).[8]

The on-line book retail company Amazon naturally focus 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 New York Times, Le Monde, Frankfurter Allgemeine and Time. Moreover, via Kindle you also get access to dictionaries such as New Oxford American Dictionary and Wikipedia (Lewan and Kristofersson 2009).

Figure 4.The e-book reader Kindle from Amazon.

The so-far leading brand Kindle have got a number of powerful competitors, e.g. Sony's Reader Daily Edition, that also uses e-ink, have a 3G connection and are connected to a large bookstore, Sony's eBook Store, so far only in the US. With this reader you should also be able to borrow books through the distributor Overdrive.com. A perhaps even more powerful competitor is the e-book reader Nook from the large book company Barnes and Noble. It's 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 that parts of the screen is touch sensitive and has colours. More features that speaks for the Nook is that it can read normal PDF files and that Barnes and Noble has signed an agreement with Google and Adobe giving the reader access to more than 500 000 books free of cost (Adhikari 2009).

Apple released its iPad in April 2010. 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

[8] Wikipedia presents an extensive list of producers and models: http://en.wikipedia.org/wiki/List_of_e-book_readers

creation. It runs iPad-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) that 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 United States. A number of magazines will sell iPad subscriptions and The New York Times will begin publishing daily on the iPad (2010).

Figure 5.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 of media consumption.

Google runs a project on digitalizing books, and currently they are adding 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 percent are available as e-books.

Technologies overlap: some of the e-books can not only be read from their e-book readers but can also be accessed from a normal computer, in telephones, Apple's iPhone and iPod Touch or other PDA's.

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*.[9] Although e-books do not have a major effect on paper consumption today, it is currently in an 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 effects; *the tipping point*, when e-paper is sufficiently good 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, screen fatigue is avoided, and the text stays on the screen without the need for continuous power supply. An intense development is currently developing e-paper with colours. Developers are now participating in a race to produce thinner products, weighing less, with flexible screens, at a lower cost – all of these characteristics will make e-paper a more realistic substitute for traditional paper.

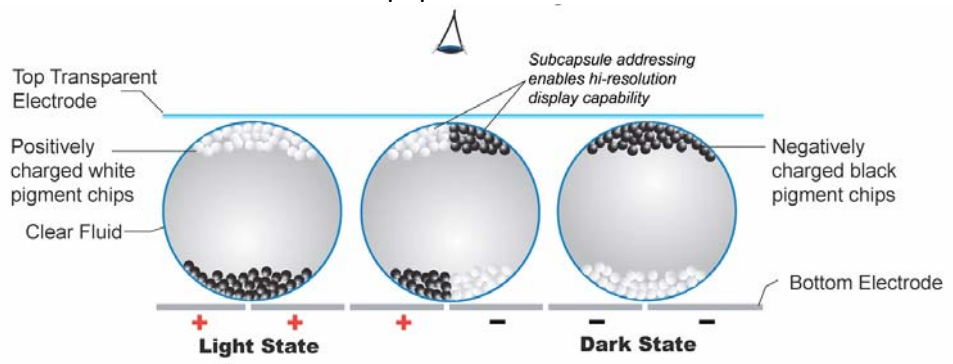

Figure 6. The e-Ink technology (Vizplex Imaging Film) used in e-readers such as Amazon's Kindle and Sony's Reader

When these certain tipping points or "iPod" moments are obtained, 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).

[9] A Google search for articles containing the both term "paper" and "e-book reader" results in 438 000 hits (December 19, 2009).

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

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

In terms of e-book sales, the United States has the largest market, where currently about 2 percent of the US $ 17 billion book market is e-books. World wide the market adds up to US $ 1.1 billion, representing about 1 percent of total sales. Overall, industry executives and analysts expect the digital books to reach about 20–25 percent on the market over the next decade (Fenton and Davoud 2009). In Figure 5, 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 e.g. 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).

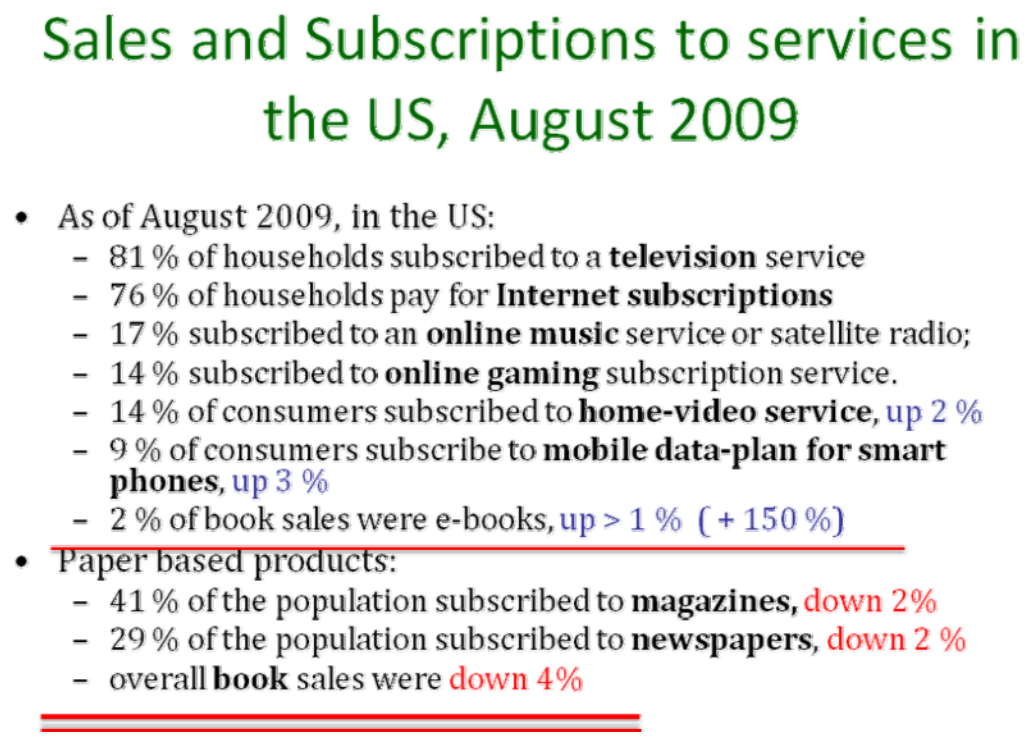

Figure 7. Sales and subscription to services in the US as of August 2009. Source: New York Times, interpreted by P. Arnfalk, in a presentation at the European Paper week, Brussels, Nov 18, 2009.

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).

Figure 8. The Espresso print-on-demand machine, printing and binding books from a digital template.

It is clear that e-books are predicted a bright future and that the growth in number 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 slightly uncertain.

Another important question is to what extent the increased sale of e-books and e-book readers actually will 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. The 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, fond the story so intriguing that they also went and bought the book in paper format. This calls for a complementary use, not only substitution.

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

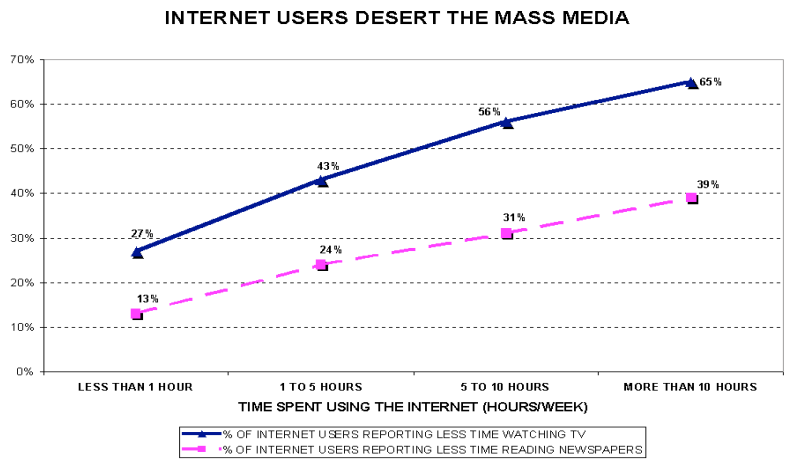

Figure9. Internet users deserts mass media. The impact of Internet use on reading newspaper and watching TV. Source: Nie and Erbing(2000)

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.[10] 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 CO_2 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 CO_2 annually compared to 27 kg for one newspaper (Ahlberg 2007).

The researchers conclude that reading the newspaper for 30 minutes a day on e-paper instead of a regular newspaper in 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 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.[11]

[10] 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.

[11] 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.

One study is comparing the environmental life-cycle impact of reading an e-book with traditional books bought via either in a traditional "bricks-and-mortar" bookshop, or ordered via an Internet bookshop. The scenario used for this comparison was based on that you would read 24 books read annually for two years, i.e. 48 books in total. The e-book came out as the "greenest" option also in this comparison, and the books bought in a traditional "bricks-and-mortar"[12] bookshop had the largest impact, see Figure 10. The break-even point, i.e. the number of books when the alternatives had the same environmental impact, was at 33 books.

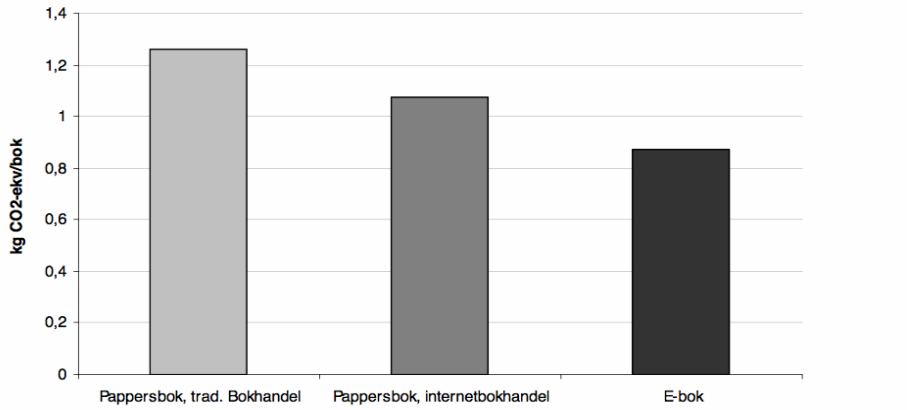

Figure 10. A comparison between the global warming potential (in CO_2 emission equivalents) from three ways of consuming a book: paper-based book via "bricks and mortar bookshop (left), paper-based book bought via Internet (middle), and e-book read on a e-book reader. (Borggren and Moberg, 2009)

Another interesting study in this respect is the Cleantech Groups' report "*The environmental Impact of Amazone's Kindle*" (Siberly 2009). The report indicates (referred to without having accessed 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 preventing more than 5 million tonnes of CO_2 in year 2012, or nearly 10 million tonnes of during the four year period 2009–2012.

These comparisons are based on a lot of assumptions and estimations, 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 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

[12] Traditional bookshops located in a building where books are on display and where people can look for and buy 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 commonly are 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, we need to consider what the e-book reader can be used for. These comparisons are based only one use of the e-paper reader e.g. reading a daily newspaper or a book. In a fair comparison we need take into account what other uses the e-paper will have.

Moreover, and equally 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 long, but then we 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 provides a useful guidance to where and how to tackle the 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 organization Greenpeace. Apple has for years been target for the organisations' 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).

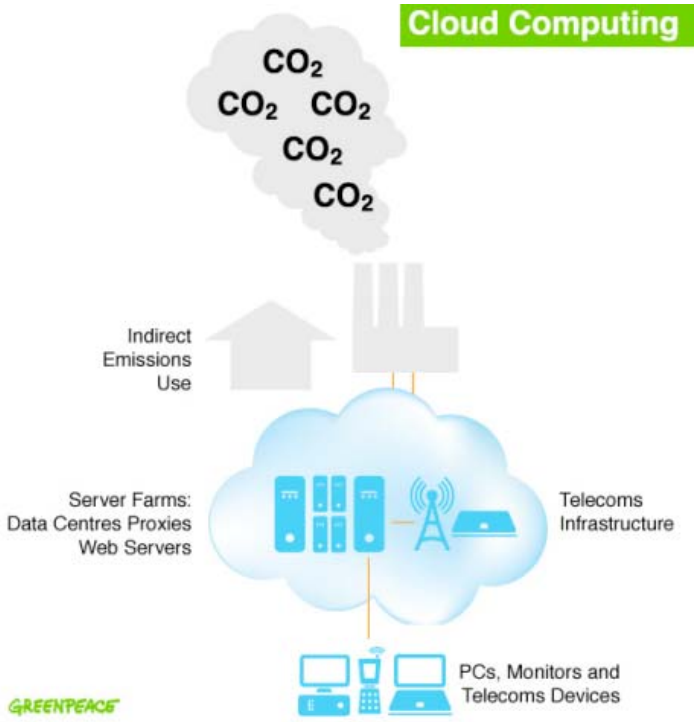

Figure11. illustration of how Cloud Computing and its supporting infrastructure contributes to the emission of greenhouse gases. Source: (Greenpeace 2010)

3.3. Focus on a sector: Higher Education

Education is a broad concept and there are many ways to educate. Most commonly ways through the traditional educational institutions, such as 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 character 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” an area 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 instances. 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 (70 Billion US$), only exceeded by the 77 Billion US$ 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 the 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 (which, in fact, may not be so disadvantageous in this area).

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 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."*[13]

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

A PhD dissertation is normally published in a number of 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 gradually are 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

13 Posted by **Rowan Hanna,** October 7, 2008: http://digitaldocuments.debenu.com/2008/10/07/electronic-readers-will-replace-paper-textbooks/ (accessed 091012)

- Wikis
- Multiple Choice Quizzes

A main concern determining the higher education sector's demand for paper is how the educational system will transform 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 multi media.

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, or 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 carbon dioxide emissions per student and educational outcome is summarised in Figure 12.

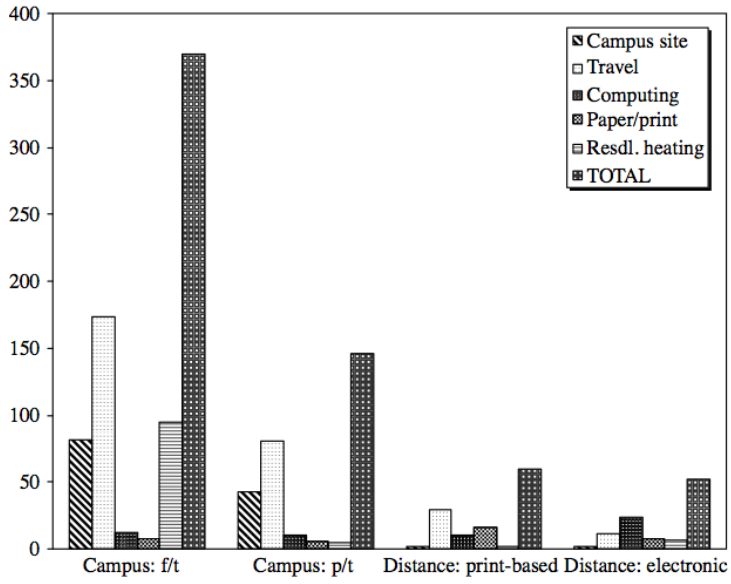

Figure13. Carbon dioxide emissions for campus and distance learning courses. Ref. Roy and Potter (2008)

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 percent less energy and 85 percent 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 as compared to print-based distance learning. On-line education used 20 percent less energy and generated 12 percent 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 1.

Table 1. Energy consumption of campus and distance learning courses. Ref. Roy and Potter (2008).

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

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:

- download and print 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 materials on the course 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 online 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 system, 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 system. The conventional books were also emitting larger quantities of ozone depleting substances and chemical associated with acidification.

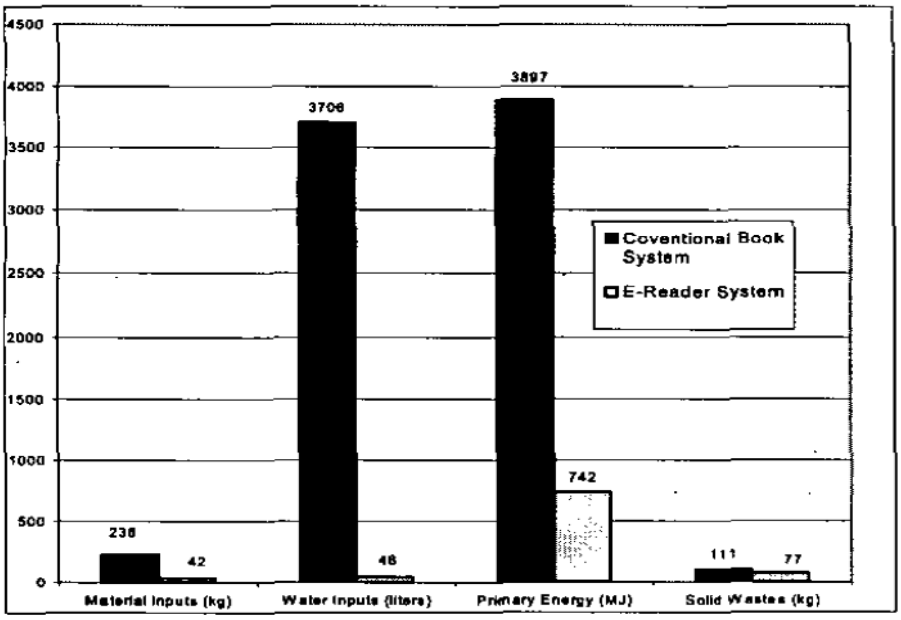

Figure14. A comparison between conventional books and e-readers in terms of material inputs (kg), water inputs (litres), primary energy (MJ) and solid waste (kg). Ref. Kozak and Keoleian (2003)

Table 2. 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)

Impact Category	Units	Traditional book system	E-reader system
Global warming	kg-CO_2 equivalents	233	60
Ozone depletion	kg-CFC-11 equivalents	1.22E-06[1]	1.14E-06[1]
Acidification	kg-SO_2 equivalents	1.15	0.39

4. Discussion

4.1.1. Some 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, and 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.

However, when we want to interpret the results, careful considerations need to be made of a number of things. Considerations are what product (version), producer, LCA border setting, assumptions made, the availability and quality of the input data, when was the study conducted, who has made the study and who has commissioned it, etc. Hence, LCA comparing products with different types of functional systems should preferably be orders of magnitudes different in order to give a strong message what is environmentally "better" or not.

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

The comparisons can miss the target as the market is changing; the product and/or services are developing into something else. One example is the mail business: as the printed mail volumes are declining, postal services are instead increasingly occupied with delivering parcels that people have ordered on eBay, Amazon and other websites (such as e-book readers).

4.2. When will paper products be a more preferable alternative?

Although the inter-correlation between ICT use and paper consumption obviously is quite complex – and this report only has looked into a few examples – some predictions about future trends will still be made. What could we learn from the e-products' and e-services' impacts 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, e.g. portability, flexibility, durability, not requiring energy when used, etc.;
    - the intrinsic value of the paper product is high, i.e. the beauty of the paper, book or picture, the nice sensation of the material, the emotional impact of a love letter, etc.;
    - the environmental impact of the paper option is considerably less, e.g. possible to re-use, recyclable, non-toxic, again not requiring energy when used;
- 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 for the electronic services fulfilling the function of the paper. These are likely 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 for 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.[14] This will act to limit rebound effects and stimulate a selection of the most resource efficient option. This, again, highlights the question of what a sustainable consumption of paper is and how the industry should respond to this question. (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 both 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 and easy access, security aspects, 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;

14 One example of a country where paper consumption has become an issue in environmental policy is Sweden. Here the 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 to measure significant environmental aspects is the amount of paper purchased per employee (Miljödepartementet 2008).

- 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;
- making the report available as PDF and printing a version as well.

And so on.

Digital and traditional paper based versions can be providing 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 long, 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 the paper and pulp production, and many paper companies have become very good at this (Arnfalk, Brorson et al. 2008). The knowledge and expertise built up within this industry on how to manage environmental issues should be used and communicated beyond the walls of the paper mill production sites. One way of extending this expertise is to use it for an advisory role throughout the entire paper life cycle, and not just limited to recycling of paper.

The pulp and paper industry however has for 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 consumption and thereby reducing 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, etc.

A possible, and perhaps likely, reaction to such situation would be to project the ICT sector and its products as equally or even more polluting, resource and energy consuming. This could perhaps in the short run win some people’s attention, and even influence (delay)

some 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. A more constructive way is 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, so far seems to have been instrumental in a net *increase* in paper demand. But these are limited trends.

The paper industry does not gain much from combat 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 the valuable raw material is used for truly beneficiary purposes, such as education, sanitation, etc., 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 suggests 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 now has 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, 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, etc.), 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 fighting 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 and prefer.

References

(2010). "iPad." Retrieved April 2010, from http://en.wikipedia.org/wiki/IPad.

Adhikari, R. (2009, July 21, 2009). "Barnes & Noble Storms In With New E-Bookstore." Retrieved April, 2010, from http://www.ecommercetimes.com/story/67652.html?wlc=1272346963.

Ahlberg, A. (2007). Dags för gröna grepp. Medievärlden.

Arnfalk, P., T. Brorson, et al. (2008). Miljöarbete inom Svensk Tillverkningsindustri. En färd från myt till verklighet Lund, IIIEE 46.

Arvidsson, H. (2006). Bloggen ny litterär arena. Dagens Nyheter. Stockholm.

Baggini, A. (2008, March 20, 2008). "New European Study on Server energy consumption." Retrieved April, 2010, from http://www.leonardo-energy.org/new-european-study-server-energy-consumption.

Bleich, H. (2000). "Das Internet erhöht den Papierverbrauch." heise online.

Campbell, A. (2004). "From Carbon Paper to Email: Changes in Methods in the Foreign Office, 1950-2000." Contemporary British History **18**(3): 168-177.

Deutsche Post (2009). Changing Ways - Sustainability Report 2009. Bonn**:** 64.
Ekman, M. (2010). Mobilen tar allt större bett av reklamkakan. Svenska Dagbladet. Stockholm**:** 30-31.

Empirica (2006). ICT and e-Business in the Pulp, Paper and Paper Products Industry. ICT adoption and e-business activity in 2006. e-Business W@tch. Bonn, Brussels, Empirica for the European Commission**:** 204.

Fenton, B. and S. Davoud (2009). Brought to Book. Financial Times.

Goldie, L. (2007). "Email marketing overtakes direct mail for the first time, reports DMA." New Media Age: 11-11.

Greenpeace (2010). Make IT Green: Cloud Computing and its Contribution to Climate Change.

HM Government (2010). Government ICT Strategy - Smarter, cheaper, greener. C. Office, Crown copyright 2010**:** 63.

Hoang, Q. (2009). On-Premises Email and Collaboration Market 2009-2013. S. Radicati. Palo Alto, CA, The Radicati Group, Inc.

IT-politiska Strategigruppen (2006). Ett miljöanpassat informationssamhälle år 2020! Stockholm, Näringsdepartementet**:** 36.

Johnson, A. (2009). Ebook Readers Set To Be $25 Billion Market By 2020. Kikabink News - Internet Marketing News.

Kovac, M. and M. K. Sebart (2007). "Books, Reading and Book Usage in the European Union." Publishing Research Quarterly(Summer 2006): 55-63.

Kozak, G. L. and G. A. Keolelan (2003). "Printed scholarly books and e-book reading devices: a comparative life cycle assessment of two book options." Electronics and the Environment, 2003. IEEE International Symposium on: 291-296.

Leiner, B. M., V. G. Cerf, et al. (2010). "A Brief History of the Internet." Retrieved April 15, 2010, from http://www.isoc.org/internet/history/brief.shtml.

Markus, L. (1994). "Electronic mail as the medium of managerial choice." Organization science(5).

McAfee (2009). The Carbon Footprint of Email Spam Report ICF International**:** 10.
Moberg, Å., M. Johansson, et al. (2007). Screening environmental life cycle assessment of printed, web based and tablet e-paper newspaper, KTH Centre for Sustainable Communications: 104.

Miljödepartementet (2008). Riktlinjer för myndigheters redovisning av miljöledningsarbetet 2008. Protokoll, § 184. Sweden**:** 13.

Moberg, Å., M. Johansson, et al. (2009). Screening environmental life cycle assessment of printed, web based and tablet e-paper newspaper. Second edition. Stockholm, KTH Centre for Sustainable Communications: 106.

Myoken, Y. (2008). Overview of ICT Strategy in Japan, British Embassy, Tokyo 17.

Negroponte, N. (1995). Being Digital, Alfred A. Knopf.

Nie, N. and L. Erbring (2000). Internet and Society. Study of the Social Consequences of the Internet, The Stanford Institute for the Quantitative Study of Society (SIQSS)**:** 43.
OTA (1982). Implications of Electronic Mail and Message Systems for the U.S. Postal Service**:** 115.

Peter, I. (2004). "The History of email." NetHistory. Retrieved April, 2010, from http://www.nethistory.info/History%20of%20the%20Internet/email.html.
Peters, S. (2009). Universities Turn to Kindle - Sometimes to Save Paper. The New York Times.

Radicati, S. (2010). Email Statistics Report. Microsoft Exchange Server and Outlook Market Analysis 2010 - 2014 Palo Alto, The Radicalti Group, Inc. .

Riley, P. (2001). Email's Contribution to Total Paper Consumption on the U.C. Berkeley Campus: An Investigation of the Printing Behavior of both Students and Staff. Berkely, CA**:** 17.

Roy, R., S. Potter, et al. (2008). "Designing low carbon higher education systems: Environmental impacts of campus and distance learning systems." International journal of sustainability in higher education. **9**(2): 116-130.

Schultz, C. v. (2009). Koppar gör pappret elektriskt. Ny Teknik.
Siberly, L. (2009). E-readers a win for carbon emissions. Cleantech Group Report, Cleantech Group.

Swartz, N. (2007). "U.S. Paper Use Shrinks, a Bit." Information Management Journal **41**(3): 16-16.

The Climate Group (2008). SMART 2020: Enabling the low carbon economy in the information age, Global eSustainability Initiative (GeSI)**:** 87.

Universal Postal Union (2009). Posts produce at least 26 million tonnes of CO2 annually, UPU's first global inventory reveals. Berne, Switzerland**:** 2.

USPS (2010). Ensuring a Viable Postal Service for America - an action plan for the future. . Washington D.C. **:** 24.

von Weizsäcker, E. U., A. B. Lovins, et al. (1997). Factor Four; Doubling Wealth - Halving Resource Use. London, Earthscan Publications.

WhatTheyThink (2009). Two out of three Americans prefer print media WhatTheyThink.com. New York.

Wright, H. (2009). Understanding the carbon impact of email in the USA - A methodology. **:** 21.

Wright, H. (2010). The impact of climate change on the postal service. Post & Parcel. **2010**.