Natural Logic

TOWARDS OPTIMAL PRINT:

COMPLEMENTARY PRINT AND PIXEL SOLUTIONS

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The opinions expressed in this monograph are solely those of Natural Logic, Inc.

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Summary

Printing documents, rather than viewing them electronically, is popularly perceived as an environmentally irresponsible action. This sentiment appears in the discussion of "green" office practices and is summed up in the email signature tagline, "Please consider the impact to the environment and your responsibility before printing this email."

Manufacturers and retailers of printing equipment and paper have an opportunity to guide customers beyond a simplistic "print vs. pixel" understanding of the communications landscape, toward an optimized, cross-media ideal. Manufacturers also have an opportunity to facilitate effective communication by providing tools and best practices to help their customers get more value from a printing investment.

Based on a review of environmental and usability studies, the use of print is clearly an important communication tool, and can be an environmentally appropriate component of effective business and personal communications. While the research we evaluated doesn't agree on a universal conclusion for all use cases, it does support general principles that can guide best practices for end users.

We developed these recommendations for Optimal Print best practices based on consideration of user experience, and the purpose and intended result of communications, and a distillation of LCA studies.

Life cycle assessment (LCA) is helpful in understanding the environmental impacts of using electronic or print technologies. However, LCA studies are independent analyses, typically use widely varying data sets, and are often subject to lack of precision in fundamental driving assumptions. Since differences in assumptions and results are common, it is difficult to draw definitive conclusions from LCAs, but it is possible to use their findings to form general impressions and derive high-level guidance. This paper uses available LCAs as one basis for its recommendations. The decision criteria proposed in this article for using digital print or electronic communications are based upon qualitative (user experience) and semi-quantitative (energy consumption, waste, carbon dioxide-equivalent (CO_2e) emissions, and other product-based data) analysis drawn from existing literature.

For each type of user, decision criteria suggest optimal print solutions that utilize both electronic media tools and strategic use of print.

Optimal Print Solutions	
For all users:	• Switch to lighter paper stock (e.g. from 24lb sheet paper to 20lb stock for everyday printing) • Use paper made with responsibly sourced fiber and/or high post-consumer recycled content • Use energy efficient equipment and design tools • Print content that needs in-depth, repeated, or leisurely reading (skim other content on-screen) • Scan, store and share documents digitally • Modify the page format to use full printable area by reducing margins from 1.x" to 0.75" and type from 12-point double-spaced to 10-point single-spaced type. This will maximize efficient use of consumables (including paper and ink/toner cartridges). • Set printers to duplex (two-sided) printing as the default, not the exception
For consumers:	• Print content that you need while on the go • Use layout tools to print only the desired content from websites • Print "meaningful" information or images to archive or share
For small to medium-sized businesses:	• Purchase energy efficient equipment (and enable their energy saving features) print to collaborate and capture critical information—don't print what you can scan and send • Streamline the printer fleet to maximize utilization of energy efficient equipment • Print documents that support client relationships • Print to collaborate, markup, or edit documents • Print to revise and reflect on the document while away from the computer • Print documents that are indispensable to workflow • Print to drive sales and add value—use electronic communications to reach out to clients
For enterprises:	• Print to collaborate and capture critical information—don't print what you can scan and send • Meet document needs with solutions that address the whole document production system • Streamline the printer fleet to maximize utilization of energy efficient equipment • Design workflows to best support business functions with minimal environmental impacts
For graphic arts/ commercial print buyers and end users:	• Create integrated electronic and print communication strategies that get the best response rate in the client's target market • Use print-on-demand technologies to take advantage of variable data customization • Encourage designers to use templates that maximize printable area • Specify papers and print processes that have lower environmental impacts • Reduce the basis weight of print stock; maintain high quality look and feel with less paper content

Paper manufacturing is the main source of energy and water consumption, and greenhouse gas emissions for printed documents, in most cases. However, *the primary driver in the consideration of when and whether to print is a combination of environmental and experience-based factors.* Manufacturers can help print users make informed decisions about paper purchasing by providing information about fiber sourcing and about the appropriate high post-consumer waste (PCW) content paper stocks for the user's communication needs. Users can ask for printers that produce exceptional quality documents with high PCW stocks. In addition, print systems should be set to duplex as the default wherever feasible. Paper manufacturers – and printer manufacturers that sell branded paper products should emphasize certification of fiber from responsible sources, high PCW content, and elimination of chlorine from the bleaching process.

When considering electronic communications as an alternative to printing or in combination with printing, note that the major environmental impacts are from energy, in both product manufacturing and use, as well as the end of product's life. Because significant amounts of energy are used in operating electronic equipment, increasing energy efficiency is critical. EPA Energy Star certification is available for products that meet high performance standards. Depending on the equipment being used, reading content on-screen for long periods of time can consume more energy, and generate more energy-related emissions than would a printed document viewed for the same duration. Also, the greenhouse gas impact of energy use is highly dependent on the energy mix (percentage of renewable and non-renewable energy sources) in the user's area.

The materials, resources, and processes used during a product's manufacture also contribute to its overall environmental impact. Manufacturers can use recycled plastics in equipment and consumables to reduce impact of electronic products. The end-of-life management of electronics is a significant environmental impact when devices end up in landfills, while impacts are drastically reduced if they are recycled. Recycling rates for electronic waste (e-waste) in the US are currently low, but rapidly increasing. Manufacturers can help educate their customers to divert e-waste from landfill and can encourage users to participate in recycling or take-back programs (with manufacturers, state and local organizations, and private companies).

The design of printed materials determines, in large part, their fate: as high value documents or as waste. Teaching users how to effectively use print tools includes looking to the end of the process first; designing documents that take advantage of full-page utilization; selective printing from web-based content; and using responsibly sourced and/or high PCW content print stock.

Manufacturers can shape the dialogue around responsible printing by proposing that their customers consider the questions, "Whom do I want to reach, where is my communication going, and what's the most appropriate way to get it there?"

When users learn how to use appropriate, integrated communications solutions, they can move beyond the familiar "Please consider the impact to the environment" to practical guidance that helps both improve communications effectiveness and reduce environmental impacts.

Value to Users

Users are concerned about the environment. The popular perception that print is always the bad choice to make when communicating is part of this concern. "Green" office guides aimed at a general audience present printing as a source of both expense and wasted materials (Riley, 2009). This perspective on paper-based communications can be seen as a contributing element to the 6% decline of paper consumption in the richest countries between 2000 and 2005 (Fairfield, 2008).
There is an environmental impact when consumers and professionals print out documents, and there is also an impact from using electronic tools for communications. Users need to choose the best electronic and print technology, considering both their needs to communicate effectively (as consumers, small to medium-sized businesses (SMB), enterprises, and graphic arts/production users) as well as an awareness of the CO_2e, waste, energy and other impacts to inform their decisions about the medium to use.

Print and electronic media are complementary solutions. The technologies are less in competition than they are in relationship, since there are distinct strengths and weaknesses to each. An example of this synergy is in the response rates of direct mail solicitations, where the top lead-generating campaigns are by email and printed catalog mailings produce the greatest number of direct orders (DMA, 2007). Real estate agents, among other elite sales professionals, see well-designed printed brochures as important tools in customer relations while rapid client communications can be facilitated electronically.

Any practical communication solution must create real or perceived value for the user and, in professional applications, their clients. In some situations print generates the greatest value for all participants, based on factors such as financial cost, environmental impact, tactile experience, and speed of work. Users are gravitating toward sophisticated electronic solutions–a growing array of available communication tools (such as e-readers, online photo sharing, digital collaborative document sharing) that co-exist with print. The environmental impacts of print and electronic communications technology are discussed below. In all applications, user context and experience serves as a frame for consideration of energy consumption, CO_2e emissions, and end-of-life impacts. *For users to make considered decisions, to truly think before they print, information applicable to their context needs to be available and relevant.* Some paper industry manufacturers have made product information available (pertaining to material content and environmental impact), but gaps remain with many electronic devices and apples-to-apples comparisons are difficult, and subject to input assumptions.

However, reasonable generalizations can guide procurement and operations based on existing materials, performance, and energy data. More concrete recommendations may be possible in the future with analysis of new data, depending on the transparency of paper and electronic product manufacturers.

The User Experience

Within the surveyed research on the user experience of printed and electronic documents, opinions cluster into three main themes. *Comprehension* relates to the type of reading being done and the retention of information. *Collaboration* reflects the way information is used or developed by a group of people working on a document. *Control of knowledge* refers to the way people access information to achieve results.

Comprehension

Large amounts of data on the screen do not work very well –Jakob Neilsen writes extensively on usability and the design of online content and e-learning methodology. He suggests that electronic text is "perfect for narrow, just-in-time learning of information nuggets so long as the learner already has the conceptual framework in place to make sense of the facts" (Cairney, 2009). In Nielsen's opinion, *managing a large amount of text on the screen "does not work very well [within an educational context,] because it is painful and slow to read"* (Nichani, 2001). (Lee, et al., for example, documented eyestrain with LCD and plasma monitors.) In fact, some analysts are drawing connections between declining national reading test scores and children spending more time on the Internet. In the 2007 report from the National Endowment for the Arts, Sunil Iyengar, Director of Research and Analysis of the National Endowment for the Arts, gathers statistics from more than 40 studies on the reading habits and skills of children, teenagers, and adults. In examining test scores, students of high school-educated parents with between 26 and 100 books in the home outscored students with college-educated parents with 0-10 books. The relation of test scores and availability of books may indicate the value of literacy in the home environment, regardless of other access to written content. Dana Gioia, former NEA Chairman, notes in his introduction to the report, "Whatever the benefits of newer electronic media, they provide no measurable substitute for the intellectual and personal development initiated and sustained by frequent reading" (Iyengar, 2007).

Collaboration

Physical documents facilitate group work – When geographically dispersed co-workers collaborate on documents, such as complex reports, there are electronic tools that are well suited to the task of drafting, editing, and producing documents. However, social scientists Abigail Sellen and Richard Harper have found that *collaborative creation of documents is facilitated by paper's tangible, flexible, and editable qualities.* A high-level scan of printed content can be made by moving rapidly through the pages non-sequentially. The physical document can be spread out and arranged in a way that facilitates participation and dialogue. Notes can be written on the page without disturbing the original text. These "affordances" describe the specific kinds of uses permitted by the printed document (Gladwell, 2002).

Control of knowledge

Printed documents capture memories and cues for meaning – One of the benefits of electronic documents is their accessibility. A shared database can speed the transfer of general information. The work of Sellen and Harper describes how the printed page facilitates the control of knowledge for information workers by providing the space to capture sophisticated memory triggers and confidential notes. These written cues support the expertise of the buyers they studied at a manufacturing facility (Gladwell, 2002). Information work is part data and part narrative; and neither electronic nor printed documents can speak for themselves without context provided by the author. The nuanced information captured on physical pages triggers the memories, history, and experiences the buyers need to better connect with their suppliers. *Even though electronic archiving is very effective for access and retrieval of information, using the documents and understanding the meaning of the information is facilitated, the researchers found, with paper in hand.*

Survey of Prior Work

Although the results are not always in agreement, there is abundant LCA research on the impacts of paper. In comparison, LCA research on electronics is relatively inconclusive, especially for newer products like e-readers. In studies of electronics, there are widely varied assumptions about product lifetimes (typically ranging from one to three years), end-of-life processing, toxicity of materials, and comparable usage times to printed material. The most current available research data are used in this survey, and relevant older data are included as well. Some life cycle studies evaluate products that have become obsolete with the passage of time, but the concepts of the studies are of useful in creating general guidelines for the optimal use of print and electronic media. Scarcity of data may be attributable to manufacturer intellectual property issues.

One common theme in almost all these studies is that resource extraction and manufacturing of paper are dominant impacts for printed material; a number of studies compare the life cycle environmental impacts of books compared to e-books and print newspapers compared to e-readers or web-based news.

In a review of the following studies, we observed common "leverage points" that can affect the environmental impact of various communication methods:

- Amount of paper used (e.g. pages printed, simplex/duplex, paper waste)
- Recycled content of paper
- Forestry techniques and paper fiber sourcing
- End user travel to access printed content (e.g. to store for purchase a book, to library to read an article)
- Length of time each communication is viewed (including reading duration and degree of concentration)
- Electronic product lifetimes
- Number of views or viewers of printed documents
- Type of display (e.g. laptop, e-reader, desktop, CRT, LCD)
- Printer maintenance
- Printer consolidation
- Energy mix for manufacturing and usage phases
- Energy efficiency of equipment during use phase
- End-of-life management (of recycling, reuse, refurbish, landfill)
- Physical storage of printed material and digital material
- Product shipping or delivery (for device, document, and data)

Kozak (2003) compared the impacts of reading 40 scholarly books to an equivalent amount of digitized information (53.6-MB) using a dedicated e-book reading device. His LCA concluded that the conventionally printed books required more raw materials and water inputs, consumed more energy, and produced more air and water emissions and solid wastes than the e-reader system. The production of paper, the amount of electricity consumed during book printing operations, and personal transportation were main contributors to the larger footprint of conventional books. For the books, the material production phase (non-recycled paper) represented the books' main impact. The usage phase of the e-reader represented its largest

impacts. The author identifies the end-of-life impacts of e-readers as a source of uncertainty in the analysis and assumes the e-reader is sent to a landfill and that the books are stored by the user.

Moberg, et al. (2007) assessed the impacts of printed newspapers, web-based news, and tablet e-paper news on global warming, acidification, eutrophication, ozone layer depletion, photo oxidant formation, resource use, and toxicology. They found that when the news was read for a ten minute time period, the e-reader and the web-based newspaper had a lower environmental impact than the printed newspaper. *When the reading time was 30 minutes, the impact of the web-based newspaper was approximately the same as the printed newspaper, and the e-reader had the lowest impact.* Using an e-book reader to read newspapers had lower human toxicity impacts than reading a print newspaper. They found that for the printed newspaper, the biggest impact was from paper production, for the web-based newspaper the energy for reading created the critical impact, and for the tablet e-paper, the production of the electronic device contributed the most to the potential environmental impact.

Toffel and Horvath (2004) compared reading a newspaper on PDA with reading a print newspaper. The study found that reading the news on a PDA wirelessly results in the release of 32-140 times less CO_2, several orders of magnitude less NOx and SOx, and the use of 26-67 times less water than reading a printed paper. Emissions could be reduced 41% by using 100% recycled paper, but even 100% recycled newspaper would use significantly more resources than an e-book.

On the other hand, Gard and Keoleian (2003), who conducted a peer-reviewed comparison of reading a scholarly journal onscreen versus a laser-printed version, found that the print document had a smaller energy footprint for "slow and detailed" reading. *They assumed that a 12-page academic paper takes about one hour to read, and determined that it had a lower energy impact if printed than if it was read on a computer screen.*

Reichart, et al.'s 2003 study found that information from a print newspaper had a lower environmental impact than information from a TV news program or news website when they compared the consumption of a "single news item." They compared viewing 180 seconds of TV news, reading online news for 90 seconds, and reading a print news article for 250 seconds. This conclusion does not apply for an entire newspaper, as printed newspapers were found to have a very high environmental impact relative to watching TV news or reading on-line news, and consumers typically purchase entire newspapers.

Stobbe (2007) found that paper production creates the largest energy-related impacts for high-volume printing, while *in lower volume applications, like home or small business scenarios, energy used in the manufacture of the printer itself represents the largest impact.*

We also looked at studies that compared the environmental impacts of commercial offset lithographic printing and digital printing.

Research by Kadam, et al. compared a lithographic press (Speedmaster 74) to a digital press (HP Indigo 3000) for print runs of 500 and 3,000 impressions. In all categories evaluated (paper waste, volatile organic compounds, ink waste) the digital press had better environmental performance. (The study was not a life cycle assessment and focused solely on the use phase.) Recent research compares the "environmental breakeven" of print runs on a newer generation digital press with a competitive offset press, and comes to similar conclusions.

The Mueller Report (2001) looked at the impacts of user behavior change in reducing paper when printing. The research found that an optimized print document (by duplex printing and making slight changes to margins, spacing, and font size) used 85% fewer sheets.

Reductions in the impact of optimal print can be reached by well-implemented enterprise printing solutions. Hewlett-Packard's 2007 report, "The Top Five Most Common Hidden Imaging and Printing Infrastructure Costs" looks at five categories for increasing enterprise print efficiency: printer proliferation, printer utilization, print architectures, print drivers, and energy use of printers. HP reduced its number of printers by 54%, cut energy costs by 45%, and reduced its IT team's time spent on installing, certifying, maintaining and deploying print drivers by over 50%. HP's help desk saw a 40-50% drop in time spent resolving printer problems and a 5% drop in monthly call ticket volume.

In a case study of managed print services HP provided to 3M (Hewlett-Packard, 2009) managing the printer fleet more efficiently reduced printing energy consumption by an estimated 79.9%—saving more than $1.2 million in energy costs. The study estimates that the company reduced emissions from energy and paper by 8,240 metric tons of CO_2 equivalents per year, printed 353 million fewer pages, and diverted 17,000 print cartridges from landfill.

Synthesis of Research

These studies illuminate the environmental impacts for paper and electronic devices at each phase of that product's life cycle: resource extraction, manufacturing, shipping, use, and end of life. For printing on paper, the major LCA impacts come from resource extraction and manufacturing phases; paper, consumables and energy are used during printing. For electronic devices (like e-readers, computers, and monitors), the primary impacts during the customer use phase occur in the form of energy consumption; manufacturing and end-of-life impacts are relevant as well, though end-of-life impacts are variable and often elusive (making apples-to-apples comparisons difficult).

Paper

Significant impacts to consider, when evaluating optimal print and communication solutions, come from the manufacture of the paper, followed by energy and consumables used in the printing process. The release of VOCs from production printing may also be a consideration in some use cases. The impact of paper needs to be understood in the context of the user's utilization of the printed materials (e.g. reading duration as analyzed by Gard, et al.). These findings could be applied, for example, to home or business applications where content requiring close attention, printed with efficient laser or inkjet technology, may have lower impacts than reading those documents electronically. The environmental impacts for commercial printing, in terms of paper consumption and print processes, are greater, in small and mid-sized runs, than for home or business applications using laser or inkjet printers. In addition, experiential research (e.g. Nielsen, cited by Cairney and Nichani) supports a preference for printing from a comprehension and ease-of-use perspective.

Electronic Devices

Life cycle impacts for electronic devices are greatest for usage energy, manufacturing and at end of life. The energy-related impact for all information and communications technology (including PCs, telecoms networks and devices, printers and datacenters), according to a 2007 Gartner study, is estimated to be 2% of global carbon emissions (Gartner, 2007). . The available LCA data concerning manufacturing and end-of-life impacts of electronic products is an area of uncertainty and variability; further study is required. While e-waste currently poses an environmental problem, recovery and recycling programs are rapidly appearing and will lessen the end-of-life impacts of electronics. For example, California doubled its e-waste recycling rate from 29% in 2006 to 58% in 2008 (Californians Against Waste, 2009).

Because of the rapidly changing nature of e-waste end-of-life management, the LCA studies we examined measured the impacts of e-waste differently. Some counted e-waste simply as a mass of landfilled material while others made assumptions about recycling and toxicology. About 70 % of the heavy metals mercury and cadmium in US landfills come from electronic waste (Widmer 2005, Puckett 202)**.** As a result it is difficult to make determinations about the environmental impacts of end-of-life management of electronics.

Application of Research Findings to Customer Segments

Consumers and Small Businesses

For consumers, the common set of devices for reading content on-screen and printing documents are some combination of computer, monitor and printer. These devices were evaluated in the majority of the studies surveyed; a minority of studies examined e-readers. Other devices used by consumers include digital photo frames and personal digital assistants (PDAs) or cell phones but these were not included in the studies reviewed. Key impact points for consumers include: selection of efficient equipment and paper from responsibly sourced fiber and/or paper with high recycled content, defaulting to duplex and not defaulting to print

Medium-sized Businesses and Enterprises

For medium-sized business and enterprise applications, the energy impacts of printers and paper are costly in terms of expenses, consumables, and resources. Streamlining and managing the printer fleet to make use of centralized, networked multifunction machines, set to default duplex print, reduces energy and consumption of paper and other print consumables. Such managed print services create synergies of print and electronic document technologies to improve overall enterprise performance and efficiency.

Commercial Graphic Arts and Print Production

In commercial graphic arts and print production settings, the paper resource and manufacturing impacts for digital and analog offset presses are comparable. What is significant is the reduction by digital in consumables and in the waste paper associated with offset make-ready and overruns, with subsequent warehousing, which occurs in analog printing. Digital presses allow for print-on-demand which produces a fraction of the paper waste compared to offset printing, and are more efficient than analog presses for smaller print quantities. (Some analysts put the threshold between 3,000 and 5,000 copies or more using a 30" digital press, but this may vary by the nature of the job and may increase as technology improves (Tribute, 2009).) This cost-effectiveness and flexibility in printing technologies provides attractive offerings for the printer's clients, the print service providers.

Considerations for Optimized Print Solutions

"Good communication" depends on effectiveness as well as environmental-sensitivity—Basic qualitative and experiential considerations must be taken into account to determine the best solution for each user. The most appropriate technologies must produce content in the most efficient and effective way possible. The content must communicate clearly and transmit value from user to audience. The presentation of the content must also amplify the value inherent in the material. The communications tools are instruments to broadcast what is important to the user and persuade the audience. Optimized print solutions achieve this with a combination of print and electronic technologies working together. Appropriate printing depends on a range of variables, both experience-based and quantitative; key considerations are summarized below.

To evaluate the continuum of communication technologies, it's useful to consider three different categories that we call Old Print, Pixel, and Optimal Print.

Old Print refers to static content printed on paper with a sense of permanence that can be wasteful in terms of the impacts of paper, over-printing and chemical processes for print production applications. *Pixel* represents up-to-date, varied, real-time content consumed on-screen, with considerable energy consumption and equipment manufacturing/end-of-life footprint. *Optimal Print* is the integration of real-time content mashed up and personalized in new and creative ways. It combines searchable, scanable, consumable content on-screen with high-value content printed by the user—creating permanence when needed, and minimizing waste with appropriate technology and resource use.

Proposed experiential and quantitative considerations to guide appropriate selection of these categories include:

Table 1.1: Consumer Printing Considerations

Solution	Action	Experience	Outcome	Quantifiable Impacts
Old Print	Print all online content of interest	Portability, familiar behavior	More pages printed due to formatting issues	***Common Impacts*** Computer, monitor (and server) manufacturing and operation footprint ***Specific Impacts*** Old Print & Optimal Print: Paper and other consumables, paper manufacturing, printer manufacturing and operation footprint Pixel: E-reader usage energy and manufacturing footprint; eyestrain, reduced comprehension?
Pixel	Read online content with desktop computer and monitor	Stationary reading at computer, difficult over long periods	Doesn't meet portability needs, possibly reduced comprehension	
Optimal Print	Read general content on e-reader, use photo sharing websites (i.e. Snapfish), print "meaningful" content that requires reflection	Portability, tactile, durable, custom communications	Good use of resources, maximized print area on pages	

Consumers (Table 1.1) use their printers for a wide range of communications. Some communications, like special invitations or photographs, are best printed on appropriate stocks that help convey their aesthetic and sentimental value. While digital photo frames are an alternative to printed images, the user experience of the electronic products is significantly different from the traditional photograph and, like all electronics, consumes energy while in use. *Optimal print solutions include using formatting programs that help users print only online content that is meaningful to them and designing documents to use paper efficiently.* This can be done by reducing margins, using smaller type, printing on both sides of the page, and single-spacing text. A university study found that by making these simple page layout changes (reducing margins from 1.x" to 0.75" and type from 12-point double-spaced with simplex printing to 10-point, single-spaced type with duplex printing) reduced a 100-page document to 15 pages—an 85% savings in paper (Mueller 2001).

Table 1.2: Small to Medium-sized Business Printing Considerations

Solution	Action	Experience	Outcome	Quantifiable Impacts
Old Print	Order large run on offset presses for marketing materials and brochures	Challenge to create real-time customized content	Process tends towards overprinting	***Common Impacts*** Computer, monitor (and server) manufacturing and operation footprint ***Specific Impacts*** Old Print: Offset press energy costs, paper, inks and cleaning solvents, make-ready and overrun, cost to warehouse overstock, shipping , printer manufacturing and operation footprint Pixel: Potential loss of sales due to ineffective communications Old Print & Optimal Print: Paper and other consumables, paper manufacturing, binding, shipping
Pixel	Generate web-based brochure content, create email outreach campaign	Loss of tangibility to sales process and value communication	Difficulty in connecting with all clients	
Optimal Print	Combine personalized direct mail outreach with related web-based content, digital printing of high quality marketing materials, general content viewed on-screen, selective printing for impact	Effective communications and workflow	Customized and personalized content, more cost-effective and efficient printing	

Small to medium-sized business (Table 1.2) print communications, like all commercial print, need to be cost effective and communicate value to clients. Printing high value promotional materials on lighter stocks can save printing costs and shipping, but the trade-off in tactile quality may offset any savings. For larger documents printed in-house, like policies or proposals to clients, a strategic use of print is often appropriate. An Optimal Print solution to client presentations would include personalized, on-screen content—tailored specifically to the client's needs, coupled with customized content printed as needed. More frequent communications can be facilitated through electronic communications via email newsletters and targeted outreach. Using a broad-based print and electronic approach to reach customers gets the best results. In evaluating the response rates of digital and print communication strategies, the Direct Marketing Agency reports that electronic lead generation produces a higher response rate than other outreach and printed catalog mailings are the top driver for direct orders (DMA, 2007).

Table 1.3: Enterprise Printing Considerations

Solution	Action	Experience	Outcome	Quantifiable Impacts
Old Print	Print, scan, and send functions on multiple machines	Hard to manage dispersed machines, increased reliance on personal machines to function properly	High costs for equipment, consumables, and maintenance,	***Common Impacts*** Computer, monitor (and server) manufacturing and operation footprint, procurement and repair costs, downtime ***Specific Impacts*** Old Print & Optimal Print: Paper and other consumables, paper manufacturing, printer manufacturing and operation footprint Pixel: Potential loss of productivity due to unmanaged process change
Pixel	Scan and send electronic documents	Unmanaged learning curve as company shifts from Old Print to Pixel solutions	Inefficient use of technology	
Optimal Print	Utilize managed print services	Improved productivity with uptime and options to print or scan and send	Appropriate technology that fits business needs	

The cost of printing includes many factors: paper costs, equipment replacement, maintenance, consumables, storage. Enterprise users (Table 1.3) need to control document production costs and facilitate staff productivity. Managed print services facilitate strategic use of printing. By working with a managed print service provider, a system-wide strategy is developed to ensure efficient use of equipment and management of document machine fleets. 3M Company optimized its worldwide printing infrastructure and was able to reduce per page costs up to 90%, reduced their carbon footprint by 8,240 metric tons, and saved more than $1.2 M in energy costs (Hewlett-Packard, 2009). Improved print management systems allow staff to control the fleet, print what's essential, and scan and send what's necessary.

Table 1.4: Print Buyer Printing Considerations

Solution	Action	Experience	Outcome	Quantifiable Impacts
Old Print	Order large print runs on offset presses	Overstock to be warehoused and inventoried	Paper waste and warehousing costs	***Common Impacts*** Computer and monitor manufacturing and operation footprint ***Specific Impacts*** Old Print & Optimal Print: Offset press energy costs, paper, inks and cleaning solvents, make-ready and overrun, cost to warehouse overstock, shipping, printer manufacturing and operation footprint Optimal Print: Digital press operational footprint, shipping Pixel: Potentially lower response rate to marketing pieces
Pixel	Send digitally-delivered outreach	Easily customized content, loss of tactile product	Cost savings, lower response rate than print	
Optimal Print	Combine print from offset and digital presses with electronic communications	Personalized content, short print-on-demand runs	Reduced costs and waste, higher response rates with targeted print and electronic campaigns	

For print buyers and commercial graphic arts/print production users (Table 1.4), Old Print—in the form of offset machines, will remain a part of their experience. Offset printing offers a lower cost per unit for offset print for very large print runs of non-personalized documents. However, digital presses give print buyers the flexibility to personalize and target their print campaigns and allow print-on-demand for custom material. *From an environmental standpoint, digital printing uses resources (ink and paper) more efficiently, generates less air pollutants or hazardous waste, and creates less waste paper from set up and overrun printing than offset presses* (Kadam 2009). This savings in resources can translate to cost savings for buyers who are paying for more product and less waste.

Recommendations

Based on a review of environmental, LCA and usability studies, the use of print is clearly an important communication tool, and can be an environmentally appropriate component of effective business and personal communications. While the research we evaluated doesn't agree on a universal conclusion for all use cases, it does support general principles that can guide best practices for end users.

We derived the following recommendations for Optimal Print best practices based on consideration of user experience, and the purpose and intended result of communications, and a distillation of LCA studies.

For each type of user, decision criteria suggest optimal print solutions that utilize both electronic media tools and strategic use of print.

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For small to medium-sized businesses:	• Purchase energy efficient equipment (and enable their energy saving features) print to collaborate and capture critical information—don't print what you can scan and send • Streamline the printer fleet to maximize utilization of energy efficient equipment • Print documents that support client relationships • Print to collaborate, markup, or edit documents • Print to revise and reflect on the document while away from the computer • Print documents that are indispensable to workflow • Print to drive sales and add value—use electronic communications to reach out to clients
For enterprises:	• Print to collaborate and capture critical information—don't print what you can scan and send • Meet document needs with solutions that address the whole document production system • Streamline the printer fleet to maximize utilization of energy efficient equipment • Design workflows to best support business functions with minimal environmental impacts
For graphic arts/ commercial print buyers and end users:	• Create integrated electronic and print communication strategies that get the best response rate in the client's target market • Use print-on-demand technologies to take advantage of variable data customization • Encourage designers to use templates that maximize printable area • Specify papers and print processes that have lower environmental impacts • Reduce the basis weight of print stock—maintain high quality look and feel with less paper content

In most cases, paper manufacturing is the main source of energy and water consumption, and greenhouse gas emissions for printed documents. However, *the primary driver in the consideration to print is a combination of environmental and experience-based factors.* Manufacturers can help print users make informed decisions about paper purchasing by providing information about fiber sourcing and about the appropriate high post-consumer waste (PCW) content paper stocks for the user's communication needs. Users can ask for printers that produce exceptional quality documents with high PCW stocks. In addition, print systems should be set to duplex as the default wherever feasible. Paper manufacturers – and printer manufacturers that sell branded paper products – should emphasize certification of fiber from responsible sources, high PCW content, and elimination of chlorine from the bleaching process.

When looking at electronic communications as an alternative to printing or in combination with printing, the major environmental impacts are from energy in both manufacturing and product use, as well as the end of product's life. Because significant amounts of energy is used in operating electronic equipment, increasing energy efficiency is critical. EPA Energy Star certification is available for products that meet high performance standards. Depending on the equipment being used,

reading content on-screen for long periods of time can consume more energy, and generate more energy-related emissions, than would a printed document viewed for the same duration. Also, the greenhouse gas impact of energy use is highly dependent on the energy mix (percentage of renewable and non-renewable energy sources) in the user's area. The materials, resources, and processes used during a product's manufacture also contribute to its overall environmental impact. Manufacturers can use recycled plastics in equipment and consumables to reduce impact of electronic products. The end-of-life management of electronics is a significant environmental impact when devices end up in landfills, while impacts are drastically reduced if they are recycled. Recycling rates for electronic waste (e-waste) in the US are currently low, but rapidly increasing. Manufacturers can help educate their customers to divert e-waste from landfill and can encourage users to participate in recycling or take-back programs (with manufacturers, state and local organizations, and private companies).

The design of printed materials determines, in large part, their fate: as high value documents or as waste. Teaching users how to effectively use print tools includes looking to the end of the process first; designing documents that take advantage of full-page utilization; selective printing from web-based content; and using post-consumer waste/recyclable print stock.

Manufacturers can shape the dialogue around responsible printing by proposing that their customers consider the questions, "Whom do I want to reach, where is my communication going, and what's the most appropriate way to get it there?"

When users learn how to use appropriate, integrated communications solutions, they can move beyond the familiar "Please consider the impact to the environment" to practical guidance that helps both improve communications effectiveness and reduce environmental impacts.

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