

# The Future of Paper

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## Introduction

Paper as a medium for display exists in a market that is continuously evolving with respect to expectations for image quality and cost, and paper will remain competitive with other media and substrates for this end use so long as it provides the best value to the consumer. The technology underlying the performance of paper is not static and innovation will play just as big a role in the future competitiveness of paper as it does in other forms of display.

Paper began its history as a lightweight and relatively permanent recording medium that replaced thin wooden shingles as a means of registering the agricultural production for the imperial court in China. The process for making paper required great manual skill, particularly in the forming of uniform large sheets at relatively low weights of fiber per unit area. The handmaking of paper was a mildly alkaline process that employed lye from wood ash to liberate fibers from the inner bark of various bushes such as mulberry. Thus, many examples of papers from the first millennium inscribed with venerable texts such as Buddhist prayers or fine calligraphy still exist.

While paper is biodegradable under appropriate circumstances such as municipal composting, it has great durability when made under alkaline conditions and stored in a stable environment. Today, almost all paper used for digital printing is made of wood pulp under neutral or alkaline conditions and has the same inherent permanence. This provides an enduring advantage over electronic recording media which generally deteriorate within a few decades - even when stored under ideal conditions. Also, one cannot be certain that the chosen electronic medium will be available to read what has been stored decades after recording. Hence, companies like Boeing that must archive engineering drawings for their aircraft for 40 years or more choose paper copies for that purpose.

Another part of the appeal of paper comes from its natural origins - mainly trees and minerals. Papermakers grow crops of trees with rotation times that depend mainly on quantity and consistency of sunlight and rainfall, and on local soil conditions in their chosen wood lots. Improvement in the genetic stock and improvements in forestry management are contributing significantly to the continuing availability of paper products at ever improving cost/performance ratios when measured in constant dollars. Management of commercial forestlands with appropriate

thinning and controlled rotation provides the ideal situation for absorption of carbon dioxide and production of oxygen by trees. Decay in unattended forests cause the reversal of this process, so these 'lungs of the world' work best when cultivated and managed as commercial forests. Recent agreements surrounding the reduction of greenhouse gasses provide carbon tax credits for commercial forests as natural sinks for carbon dioxide. It should also be noted that the most common mineral filler used in paper to enhance opacity and brightness is precipitated calcium carbonate made by reacting flue gas at the papermill with lime...another sink for carbon dioxide.

Recovery of paper products after consumer use for recycling is also an important aspect of maintaining an unending supply of paper for the future. Today, well over half the paper consumed in the United States, Europe and Japan is recovered and recycled into new paper products. For practical reasons, recovery rates are not likely to exceed about 70 percent. However, there is no practical limit to the amount of recycled fiber that can be used in the manufacture of paper products. Any loss in strength of from repeated recycling is easily made up by appropriate fiber treatments and modest infusions of new long fiber wood pulp.

## Shifts and Substitutions Expected as the Result of Changing Patterns In Communication.

The Boston Consulting Group has done extensive modeling of the shifts and substitutions expected in various paper grades as the result of changing patterns of communication. For example, newspapers are news organizations that are not married to printing on newsprint to get their information across to subscribers. As they invoke new media such as the Internet, demand for newsprint is expected to shrink. On the other hand, with the explosion in the amount of information that is readily available on the Internet and the convenience of being able to print the most pertinent material with nonimpact printers, demand for cut sheet fine papers has been increasing. In fact, cut sheet is expected to substitute for papers used in conventional rotary presses in most printing segments. The drivers are customization, the convenience of printing only what is wanted when it is wanted, and the speed and efficiency of distributing information electronically and printing locally. This inexorable shift in the pattern of printing is not lost on major press manufacturers who have begun offering robust printing presses with sheet feeding

systems borrowed from offset lithography but which utilize electrophotographic print engines. This may further accelerate the shift to cut freesheet from conventional printing stocks in the commercial printing arena.

### **What Can We Expect In The Evolution of Paper That Will Keep It A Viable For The Future?**

While retaining its advantage of recyclability and makeup of natural materials, paper will continue to improve in terms of performance versus weight per unit area. This will be brought about mainly by incorporation of higher yield pulping processes, and via novel bonding and finishing techniques that promote higher bulk and stiffness while providing a superior printing surface with respect to flatness and uniform structure. Web fed printing technologies will see important engineering advances in paper construction that will significantly improve the fracture toughness of paper and reduce the frequency of breaks and improve press runnability.

The functionality of paper will continue to expand. For example coatings that permit quick drying, lightfast and waterfast ink jet printing will be common and affordable. The expectation that ink jet prints will be the equal of photographs in terms of color gamut and permanence will be brought about by a coordinated evolution of ink jet inks and papers. The microstructure of fine paper will be improved to permit the information carrying capacity of paper to increase for recording and display purposes.

Electronic display in the form of e-books and e-magazines have been commercial for some time. Just as hardcover books are still popular despite competition from cheaper and more conveniently carried pocket books, electronic books and newspapers will likely find a niche, but not dominate or displace paper versions. Books and magazines serve their purpose well and do not need to be updated on a time scale requiring an instant download capability.

Since paper is a very cost effective material in terms of stiffness, opacity, and convertability it may also serve as a substrate for electronic circuits. Intelligence can be incorporated into paper products in the form of a chip or by direct printing of circuits. Thus, paper and electronic display can be combined to take advantage of the mechanical, tactile and optical properties of paper while incorporating the live communication capabilities of electronic circuitry. A particularly exciting aspect of this combination is nonimpact printing of circuits onto paper. Thus, inexpensive and disposable electronic devices such as radios, cell phones and GPS units could be downloaded from the Internet and printed onto paper using appropriate combinations of conducting and semiconducting inks or toners. The

microstructure of fine paper will be controlled to accommodate high resolution circuitry, and dimensional stability under varying RH conditions will be substantially improved in order to provide the stability required.

### **Conclusions**

Debates about the future of paper tend to the extremes of the paperless office or romantic notions that paper will always be with us for cultural, historical or ergonomic reasons. In reality, paper actively competes with other substrates and means of conveying and displaying information in many markets where its future is not guaranteed. However, paper is evolving just like other media and will probably endure in most of these markets by virtue of continually improving performance and functionality.

### **Biography**

Dr. M. Bruce Lyne, Director of Research, International Paper, is located in the company's Corporate Research Center in Sterling Forest, New York. He received a B.Sc. (Physics) in 1970 and an MBA in 1984 from McGi11 University, and a Ph.D. in 1976 from the Royal Institute of Technology in Stockholm. Concurrent with his doctoral work, he held a position as staff scientist at the Swedish Forest Products Research Institute (STFI). Dr. Lyne headed the Surface Physics Section of the Pulp and Paper Research Institute of Canada and was a research associate at McGi11 University until joining International Paper in 1984. He has been a guest scientist at the Finnish Pulp and Paper Research Institute, L'Ecole Français de Papetrie, and the University of Tokyo. He is currently an adjunct professor at the University of Toronto where he lectures on research management.

Concurrent with his responsibilities at International Paper, Dr. Lyne held the Stora Guest Professorship at the Royal Institute of Technology in Stockholm from 1992 to 1993. Dr. Lyne was appointed the 1992 Australian Pulp and Paper Association Visiting Speaker and in 1994 he received the Engelhard Medallion and prize for excellence in Coating and Graphic Arts Technologies. In 1999 he was the invited lecturer at Monash University in Melbourne. He has chaired the Polymers Division, the Coating & Graphic Arts Division, the Research Committee, served on the board and is a fellow of the Technical Association of the Pulp and Paper Industry. Currently, Dr. Lyne is on the board of the Industrial Research Institute and is active in the International Committee, which provides forums for issues concerning industrial research globally.