

Sustainable Alternatives to Industrial Printing Practices: A Case Study Analysis of *Esquire* Magazine and Electronic Paper Display

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Abstract

In October 2008, *Esquire* magazine became the first commercial publisher to utilize electronic paper display technology (EPD) for mass production and distribution of printed ephemera. Initially developed at the MIT Media Lab in 1997, E Ink displays have been integrated into a variety of hardware devices, including the Amazon Kindle and Sony Reader. However, the *Esquire* cover represents a milestone achievement in the evolution of a more sustainable, paperless print solution due to the medium's flexible nature, low power consumption, and limited circuitry requirements. 100,000 copies were sold on newsstands for the regular cover price of \$5.99 USD, proving both the economic viability and flexible application of the technology, which is impervious to ambient lighting conditions and adaptable to multiple modalities. This paper outlines the key features and benefits of E Ink, as well as the critical challenges impeding widespread adoption of EPD.

Keywords

Sustainable design (primary keyword); design and society; eco-design; communication and information; case study/studies

In response to political and consumer pressures, traditional print industries have increasingly adapted production methods to utilize more ecologically conscientious practices. Transitions to vegetable dyes, post-consumer fibres and dissolved air flotation de-inking processes have contributed to reduced environmental consequences from the paper and printing industries, but the overall output of ephemera has remained largely unchanged. The secondary carbon offset resulting from energy consumption and chemical disposal in the recycling and transportation of printed matter needs to be reconciled with advancements made in material technologies, and our cultural desire for tangible media. Clearly, a new paradigm for mass dissemination of content is required to bridge the gap between consumer demand and industrial production practices.

Challenging the Archetype: Sustainable Print

Environmental Impact and Transitional Phases

Pulp-based printing presents a number of environmental concerns, relating mostly to material pollution and energy consumption—issues that have been troubling environmental activists and earth-conscious consumers for decades. In recent years, many proactive solutions have been developed and implemented to lower the impact of mass printing. Toxic inks can now be effectively substituted with water-based pigments and vegetable dyes, with minimal investment or retrofitting of existing equipment. Virgin paper is also falling out of favour with designers and clients, steadily being replaced by post-consumer hybrids or 100% recycled paper products. Even within the recycling process, traditional bleach-based de-inking employs the use of toxic solvents and detergents. However, as the emergent technology of dissolved air flotation

becomes a more economically viable proposition, it is expected that this practice will become an industry-regulated standard. The devastating effects of clear-cutting have been partially ameliorated through public acceptance of post-consumer products, as well as through remote forestry and replanting activities. Paper processing and pulping is an unmistakably significant contributor to negative environmental consequences, as is the transportation of the paper product from the manufacturer to the consumer—both unavoidable aspects of paper production.

With an increase in recycled paper production, certain perceptual shifts have occurred in paper and printed matter consumption. The negative connotations and cut-rate image of recycled products have diminished, as the technologies for reconstituting pulp continue to improve the quality of goods. Product lifecycle is more commonly taken into account when selecting papers for specific print applications; for example, paper with degraded quality is often used for printed ephemera expected to have a shorter cultural currency. Consumers have also naturally adopted multi-modal reading practices, given the abundance and accessibility of news and other texts on the Internet. Although the advent of digital technology was thought to have led to reduced literacy rates, it seems that greater numbers of individuals are reading online, thus demonstrating increased reading rates due to the convenience and availability of reading materials.

Adoption of Digital and Paperless Print

A logical next step in the evolution of print is a transition to digital and paperless print displays. It would be naïve to suggest that traditional printing process will be completely eschewed in favour of digital modes of dissemination, but the balance is beginning to shift.

E Ink and electronic paper display technologies have been heralded as sustainable solutions to the proliferation of printed artifacts. Their key environmental benefits include the modest power usage, the reduction of printed material, the general inertia of the chemical substances used, the volume of storage available and the flexibility of application, being embedded or standalone. However, numerous economic, technical, and marketing challenges must be addressed before this technology presents a viable alternative to traditional publication. Chief among these concerns is the perceptual shift required among user-communities, who must adapt lifelong reading habits to accommodate new hardware devices and modes of content purchase or acquisition.

Case Study: E Ink Corporation

Overview and Features

E Ink was established in Cambridge, MA in 1997 as a commercialization of research incubated at the MIT Media Lab. It was, and still is, considered a proprietary technology and not an industry standard. The primary innovation of the E Ink material is that it is able to produce a digital image without the use of a constant power supply or a backlit display. The technology, as described by the E Ink corporation website, is as such (see figure 1):

The principal components of electronic ink are millions of tiny microcapsules, about the diameter of a human hair. In one incarnation, each microcapsule contains positively charged white particles and negatively charged black particles suspended in a clear fluid. When a negative electric field is applied, the white particles move to the top of the microcapsule where they become visible to the user. This makes the surface appear white at that spot. At the same time, an opposite electric field pulls the black particles to the bottom of the microcapsules where they are hidden. By reversing this process, the black particles appear at the top of the capsule, which now makes the surface appear dark at that spot. (E Ink Corporation, *How it Works*, n.d.).

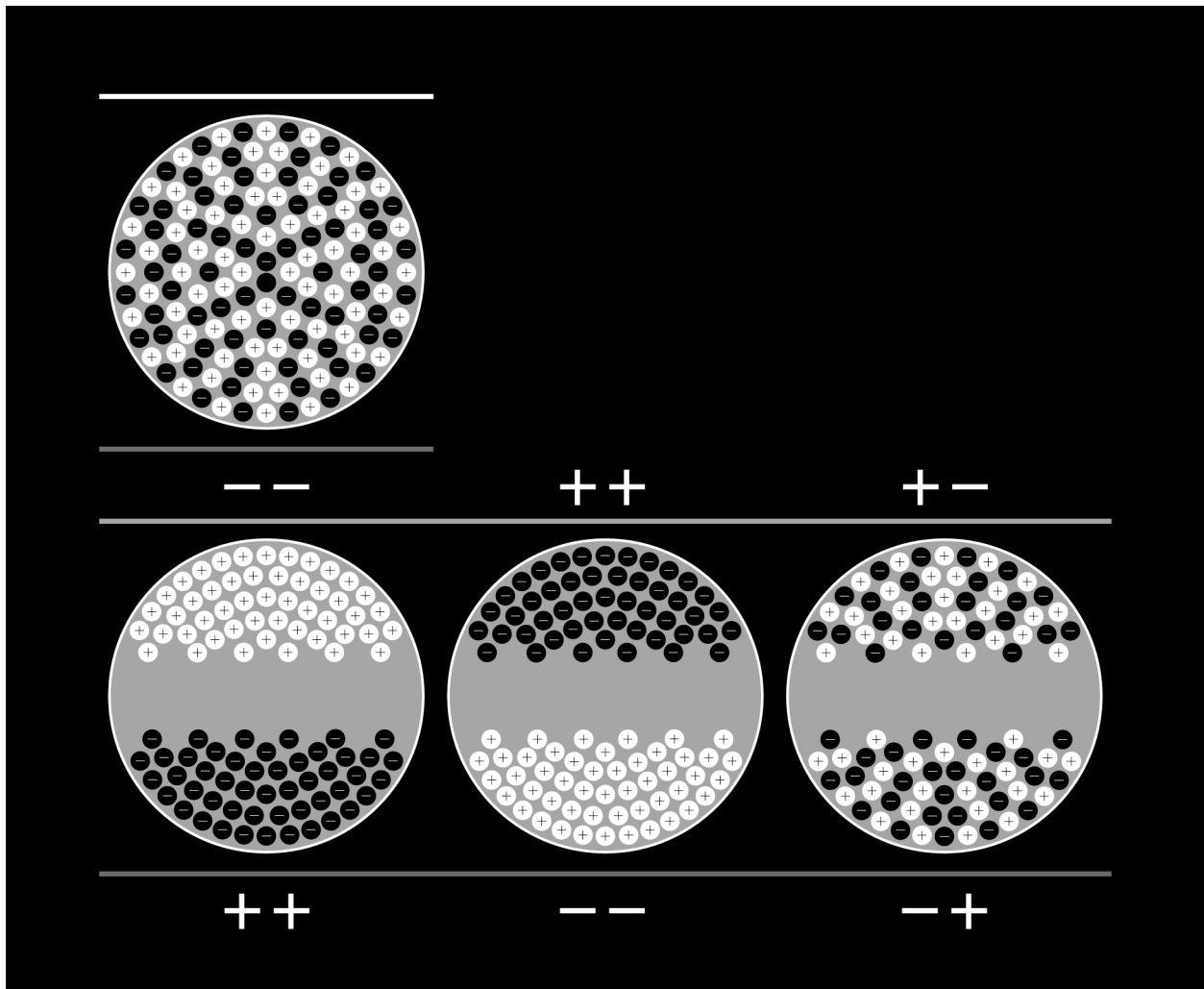


Figure 1. Charged Microcapsules, adapted by author from E Ink Corporation (*How it Works*, n.d.).

The scientific term used to describe the process making E Ink possible is electrophoresis. This refers to the separation of electrically charged substances in a solution under the influence of an electric field. It is based on the difference between the rates of migration of pigmented particles, typically Rutile, Anatase, Barium Sulfate, Kaolin, or Zinc Oxide (Albert & Gates, 2008). The microcapsules function as de-facto binary pixels, turned on or off by transmitting surges of power through embedded circuitry (see figure 2). The output is controlled by a display driver, which is activated only when the image display needs to be refreshed. Suspended in a liquid “carrier medium,” the capsules may be screen printed onto a variety of surfaces, thus freeing the electronic image from bulky hardware devices. The flexible nature of the E Ink material permits virtually any substrate to function as a display, including glass, plastic, or paper (E Ink Corporation, *How it Works*, n.d.).



Figure 2. Booken Cybook Gen3 Display Magnified 6x (Genuth, 2008)

Quality and Readability

Few reliable studies have been conducted on the legibility and long-term physiological impacts incurred from sustained use of E Ink displays. Despite dissenting research and opinions, it is widely believed that there is a reduction of eyestrain, as no backlighting is employed by the system. At the consumer level, E Ink is currently available only in black and white, although Samsung is developing colour prototypes (Unidym, 2008). In terms of output quality, the current technology can support a 3- or 4-bit greyscale display, and simulates a resolution of 150-200 DPI, depending on the display size (E Ink Corporation, *Visplex Imaging Film*, n.d.). It is said to demonstrate qualities of paper, exhibiting high contrast and reflectivity, and is not subject to legibility impairments as a result of ambient lighting conditions, unlike liquid crystal displays (Comiskey, Albert, Yoshizawa, & Jacobson, 1998).

eBook Readers: The Amazon Kindle

Market Dominance and Sales Figures

eBook readers persist as the principle commercial application of E Ink technology. Amazon Kindle is currently the leading device in this product category, although there are others—its prime competitors being the Sony Reader, the iRex iLiad, and the Plastic Logic eReader. It is estimated that around 380,000 Kindles were sold in 2007 during their first year on the market (Jackson 2008), and estimated revenues of \$1.2 billion USD are expected for Amazon, as of 2010 (Galante, 2009). These figures clearly indicate that sales have crossed the threshold of early adopters, gaining more widespread acceptance among the general consumer market.

Available exclusively in the United States during its introductory years, the Kindle was recently launched internationally in over 100 countries, offering upwards of 400,000 titles, as well as applications for personal handheld devices (Amazon.com, n.d.). In the first 14 months after Kindle's 1997 release, 10% of Amazon's sales were eBook titles, although Amazon has not been forthcoming with exact figures regarding sales of its proprietary device.

From a marketing perspective, convincing a skeptical public to invest in an underdeveloped technological platform with little seeded content, and the potential to be rendered obsolete, presents significant challenges. Elevated price-point, limited content availability, usability issues, and mixed user testimonials have primarily hindered the widespread adoption of eBook readers. Such issues are not unique to this product class, but are further amplified as the consumer's financial investment increases. One need only examine the history of photographic cameras and other durables to detect similar promotional encumbrances.

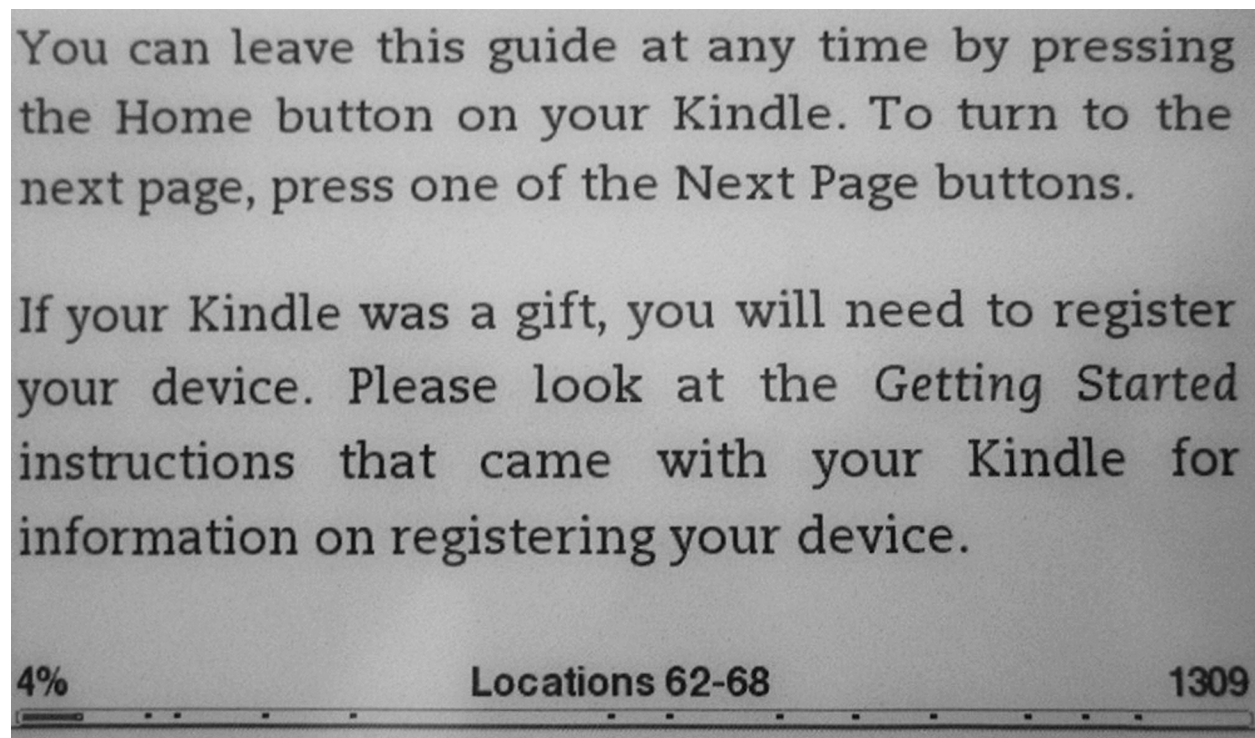


Figure 3. Kindle 2 Display (Evans, 2009)

Device-Based Applications of E Ink

As with most emergent technologies, immediate concerns regarding the viability and longevity of such a technology present major marketing problems. E Ink reinvents the paradigm of reading, and requires a pricey initial investment, both challenges on the road to public

acceptance. Many readers have reported experiencing eyestrain and fatigue from reading eBooks, as it is more taxing on the eyes than scanning a traditional printed page (see figure 3). However, this comparison does not take into account netbooks, laptops, or other self-illuminating digital displays, which incite similar criticisms. The output quality is simply not as clear as the printed counterpart, principally due primarily low resolution and reduced screen contrast.

In terms of physical design, it has been difficult to miniaturize the technology to a weight and size conducive to convenient transportability. Combined with questions of durability, the designed obsolescence of the technology has forestalled many potential consumer audiences. Inevitably, the eBook reader will need to be upgraded or replaced as new functionalities and content formats evolve. Other challenges to address include limited availability of content, as well as legislation of digital copyright and licensing, which preclude copying or lending. The latter point negates the ethos of reader culture, which predicates itself on knowledge sharing and a discursive exchange.

Usability and Accessibility Issues

The major content limitations associated with eBook readers are largely attributable to digital incompatibility and copyright issues. There has been extreme market segmentation caused by multiple proprietary file formats and limited interoperability between devices. Digital rights management software also imposes another layer of restrictions on content (Clark, Goodwin, Samuelson, & Coker, 2008), setting limits on copying, lending and reselling of eBook purchases.

There are also some issues with the look, feel and interface of the device itself, which present practicality issues for the consumer. Users have reported experiencing wrist pain caused by holding the Kindle device for prolonged periods of time, claiming it is too narrow to hold comfortably with both hands (Clark, Goodwin, Samuelson, & Coker, 2008). Other general concerns with the physical device are that the buttons are placed awkwardly, neutral space is lacking, the scroll wheel is overly sensitive and the touch screen lacks functionality. The interface is also problematic, including the inability to change the font and style of the text, the poor display resolution, and the reduced contrast caused by a middle-grey background. Practical concerns include the reportedly flimsy case, its insecure closure and the inconvenience caused by flight travel restrictions disallowing use of electronic devices during taxi, takeoff and landing (Clark, Goodwin, Samuelson, & Coker, 2008).

In Kindle's defense, it is said that use on exercise machines is more effective than books, as it lays flat more easily than a paperback. That being said, it does not provide the full immersion experience that books do, attributable to its slow response time, accidentally pressed buttons and other technical difficulties (Clark, Goodwin, Samuelson, & Coker, 2008).

Commercial Print Applications: *Esquire* and E Ink

Background and Overview

E Ink technology was employed in the production of a cover and overleaf feature for the October 2008 issue of *Esquire* magazine—a 75th Anniversary special issue that was published in an edition of 100,000 copies. Integrating a black and white E Ink display and coloured plastic overlay into a heavyweight cover, a series of words flashed on and off in a linear sequence (see figures 4-5).

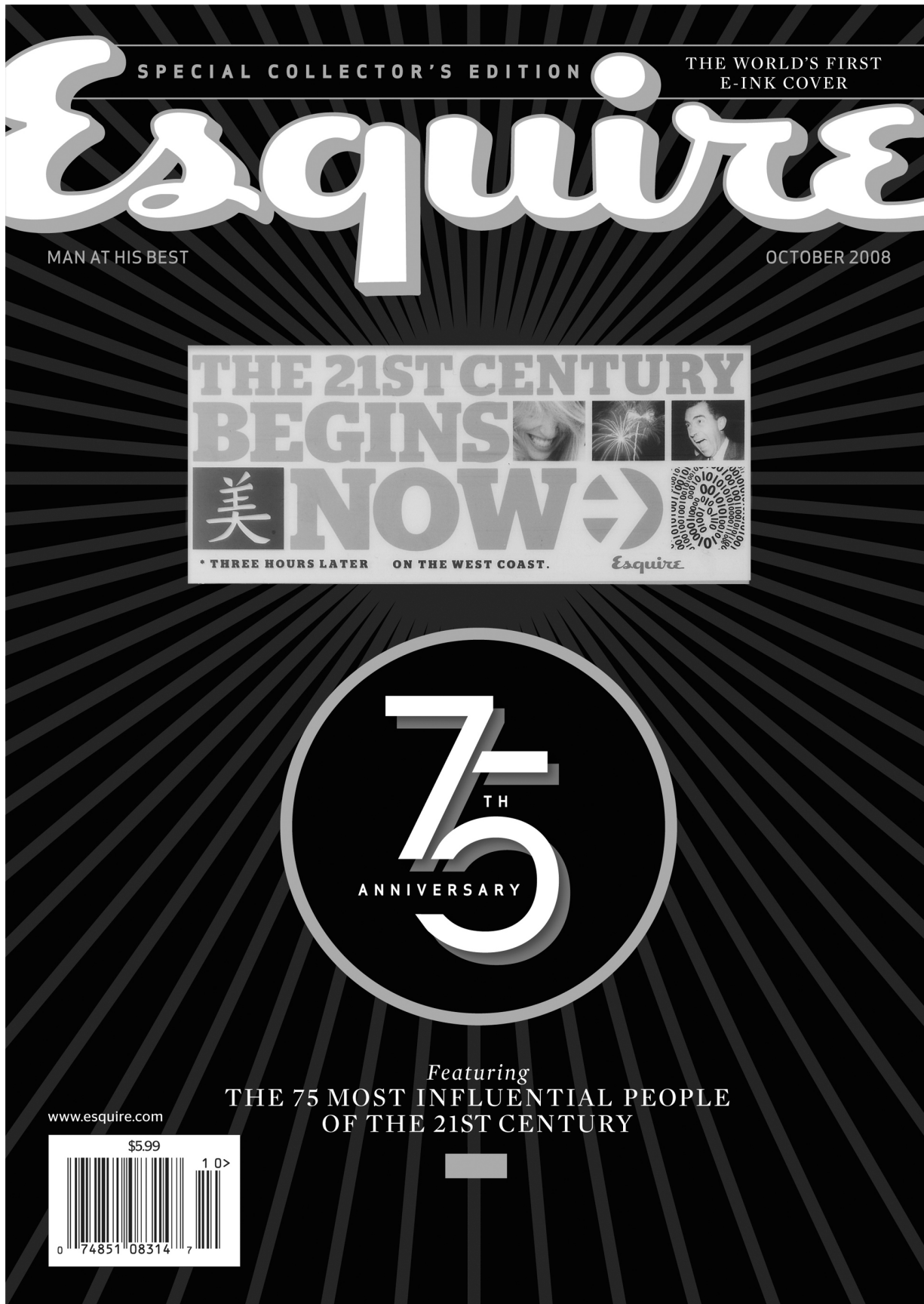


Figure 4. *Esquire* Magazine Cover, October 2008 Issue (Image by author)



Figure 5. Detail of *Esquire* Magazine Cover, October 2008 Issue (Image by author)



Figure 6. Detail of *Esquire* Magazine Internal Electronics, October 2008 Issue (Metzger, 2008)

Prototype for Commercialization of E Ink Technology

The October 2008 *Esquire* magazine cover presents a model case study alternative to embedded device-based applications of E Ink technology. Utilizing a self-powered, standalone display panel and programmed microchip, the *Esquire* cover demonstrates the possibility of implementing electronic paper display without the requirement of specialized, external hardware. As a prototype for mass dissemination of electronic content, this application signifies a shift in design approach. By divorcing the rigid structure of a device from the flexible presentation of media, the language of traditional printed matter becomes highlighted, while the technological aspects are diminished. The relationship between reader and artifact becomes reinforced, while the disintermediation of the electronics is sublimated into the tangible, material qualities of the interaction.

The paradox of the *Esquire* proposition is that it presents a pragmatic application of E Ink as a sustainable solution, but its manufacturing process results in devastating environmental consequences. With research and development sponsored by the Ford Flex SUV/mini-van, *Esquire* hired a Chinese engineer to develop a battery small enough to slip into the cover, involving a six-figure investment. The custom-designed battery carries a limited charge to power the display for a mere 90 days (Paul, 2008), and cannot be replaced, rendering the display dormant and the electronics obsolete (Carnoy, 2008) (see figure 6). Due to the fragile nature of the battery and components, each volume was hand-assembled and subsequently shipped in refrigerated vehicles throughout all stages of the product's lifespan. From the parts manufacturing in China, to Texas and on to assembly in Mexico, then to the distribution centre in Kentucky and finally, to display and consumption on the newsstand, it is estimated that the total carbon output topped 150 tons of CO₂. This amount is roughly equivalent to the output of fifteen Hummers or twenty Americans per year (Kamenetz, 2008), and does not account for the CO₂ emissions produced during the manufacturing of the devices. Given that the batteries are single-use, they will no doubt end up in a landfill, as they are nearly impossible to recycle.

Comparison and Conclusions: Disposable Versus Device

Challenges and Promises

There are benefits and disadvantages to both embedded (*Esquire*) and device-based (Kindle) applications of E Ink technology. Currently, eBook readers present a more viable, efficacious model than standalone uses, and are simply more functional. They feature rechargeable, rather than single-use batteries. They perform more complex functions, such as mobile Internet access and document editing capabilities, as well as boasting a larger storage capacity. The *Esquire* cover benefits from having a flexible form, but the lightweight Plastic Logic eReader from Barnes & Noble will challenge traditional eBook models when it is released to the general public in 2010.

Some current consumer challenges facing content and device providers include the high price of eBook readers and their duplication of services already available on other more widespread devices. The emergence of Apple's iPad and powerful portable netbooks that have the added functions of eBook accessibility have made it difficult to sell the eBook readers as a monofunctional technology. The unfamiliar interface does not replicate the familiar look and feel of paper, bringing consumers far out of their comfort zone when it comes to reading habits. The resolution requires enhancement and the screen contrast is too low. In fact, the device cannot be read in dark or even dim lighting conditions, due to the lack of a self-illuminated display. The breadth of content selection is quickly improving, but distributors will need to address licensing and copyright issues that inhibit lending or sharing, as one would with a traditional book. Furthermore, there are fragility and durability concerns, as with any electronic handheld device. All of these factors only add to consumer skepticism regarding perceived design

obsolescence—a concern similar to the iPod paradigm of rapid and successive product releases. To broaden the consumer market from early adopters to a general public, manufacturers will need to establish product confidence while responding to accumulated usability data. Positioned at a luxury goods price-point, consumers demand reassurance that their purchase is robust, and will not be superseded by a revised model in an unduly rapid product launch cycle.

Conclusion

Consumer and Sustainable Benefits Analysis

In summary, there are many promising consumer and sustainable benefits involved with the evolution and adoption of paperless print and electronic paper display. For one, the reduction of paper-based ephemera would be a significant environmental benefit if the technology were to become widespread enough to lessen traditional printing. This would result in a reduction of CO₂ emissions from the pulp and paper industry and recycling plants, as well as a reduction in solvent contamination from the de-inking process necessary in recycling. eBooks consume less power than laptops, and if one were to replace some of the functions of the laptop with an eBook reader, additional power would be conserved. Furthermore, the text size can be adjusted on an individual basis to suit readers' needs, which is especially useful for visually impaired consumers, and would eliminate the need for large print book editions. There would also be a long-term cost reduction for students, educators and other voracious readers, providing them with easier access to library collections. Ergonomic benefits include the storage of multiple titles on a single device, doing away with transportation of weighty books that can lead to back strain and related injuries. Future applications will also undoubtedly exploit E Ink's flexible options for display formats and signage, as it can be printed on any surface.

While the *Esquire* design methodology is fundamentally flawed, as a case study analysis, it provides concrete evidence and material data to assess the possibilities of an alternative to existing green printing practices.

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